KLAG BAY/LAKE SOCKEYE SALMON STOCK ASSESSMENT

2001 ANNUAL REPORT

by

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ABSTRACT

The return of adult sockeye salmon to Klag Lake in 2001 was estimated through a survey of subsistence and sport harvest in the terminal area at Klag Bay, and weir counts, verified with a mark-recapture study. Age, length, and sex composition of the escapement was estimated using standard measurements and scale sampling and analysis. Sockeye salmon fry populations in each lake were estimated using hydroacoustic and trawl sampling. Baseline information was collected on the physical characteristics and productivity of lake rearing habitat in each system using standard limnological sampling procedures. A healthy return of adult sockeye salmon was documented, with a total harvest estimate of about 1,700 fish, comprising 12–14% of the total return, and an escapement estimate of about 12,000 fish. The mark-recapture estimate validated the weir count and indicated that few sockeye salmon passed through the weir uncounted. The exception may have been some jacks that slipped through the weir pickets early in the season; the problem was detected and corrected about midway through the run. According to results of age and length analysis, about 10% of the adult sockeye salmon sampled at the weir were jacks. The dominant age class was age-1.3, representing 56% of the fish sampled. The next largest class was age-1.2, representing 25% of the fish sampled. Sockeye salmon fry density was only moderate, compared to that in similar Southeast Alaska sockeye salmon rearing lakes. Klag Lake has a large population of sticklebacks; according to trawl sample results, they comprised about 80% the fish detected during the hydroacoustic survey, and may be significant competitors with the sockeye salmon fry. Klag Lake has a shallow euphotic zone, averaging 4.5 m in 2001, and a thermocline at about 8 m. Good baseline information was obtained in 2001, but since little previous data exists on the Klag Lake sockeye salmon population, it is too early to draw conclusions regarding optimum harvest and escapement sizes. More years of data will be needed to show trends in population and lake productivity over time.

INTRODUCTION

Klag Lake (ADF&G stream no. 113-72-002) is one of the largest producers of subsistence sockeye salmon in Southeast Alaska and is an important resource for the people of Sitka. Klag Bay ranks third in importance, after Redoubt and Necker Bays, for subsistence users in Sitka. Its importance has increased in recent years as a consequence of conservation closures at Redoubt Lake. Pressure on this system may be expected to increase in response to increased fishing pressure in other systems closer to Sitka, and as subsistence users are able to travel farther and more safely to distant fishing areas. Historical data on sockeye salmon escapement and productivity in Klag Lake are extremely limited. Reliable estimates of sockeye salmon escapement and harvest in the subsistence and sport fisheries are needed to support continued subsistence fishing opportunities at Klag Bay and provide a sound basis for management of the Klag Lake sockeye salmon run.

Klag Bay, called Kleix', traditionally belonged to the Chookaneidi clan of the Sitka people. There were two villages there, and even after these were abandoned, a few people had homes and smokehouses there. Long used for seasonal hunting and fishing camps, the area provided a wealth of subsistence resources, including salmon, seal, and seaweed. As recently as the early 1900s the people at Klag Bay were asserting their traditional ownership rights by posting the mouth of the sockeye salmon stream, but cannery and U.S. Government officials forced them to take their signs down. Klag Bay and the surrounding areas have remained important subsistence fishing grounds for people in Sitka. In the recent past, Sheldon Jackson

School obtained salmon there for use in the school (Goldschmidt and Haas 1946; Goldschmidt et al. 1998). Klag Bay is within the federal customary and traditional use area for residents of Sitka.

Subsistence harvests of sockeye salmon at Klag Bay have increased dramatically in the past decade (Appendix A.1). Since 1992 an average annual harvest of 1,244 sockeye salmon was reported on an average of 45 permits. Between 1985–1991, the average annual sockeye salmon harvest was 457 fish on an average of 22 permits. The maximum annual harvest was reported in 1996 with a total of 3,381 sockeye salmon on 100 permits. The average number of sockeye salmon reported per permit has also increased from 21 during the 1985–1991 period to 27 during the last decade. The season was reduced starting in 1999 in attempt to protect escapement levels until the run timing and escapement could be more accurately estimated. ADF&G biologists are also concerned about possible over-limit violations and improper use of gillnets, especially the observed practice of driving fish into gillnets with skiffs. (ADF&G staff 2000).

Historical commercial fishing at Klag Bay coincided mostly with the operation of a cannery at Ford Arm, from 1911 through 1924 (Appendix A.2). Included in the historical catch record from Klag Bay were sockeye salmon from nearby areas such as Sister Lake and Lake Anna (Rich and Ball 1933). There has been no directed commercial fishery in the Klag Bay terminal area for many years. There is currently a commercial pink and chum salmon purse seine fishery centered at nearby Khaz Bay-Slocum Arm, but Klag Bay is normally closed in its entirety to this fishery, in order to provide for sockeye salmon escapement and subsistence harvest. Although some Klag Lake sockeye salmon are probably caught in commercial fisheries in nearby areas, it is impossible to separately identify the Klag Lake fish in the commercial catch.

There are no data on escapement in the Klag Lake system except for ADF&G aerial surveys of fish seen in the saltwater and intertidal areas off the mouth of the Klag Lake outlet (Appendix A.3). Although survey counts are a commonly used salmon management tool, they are subject to undercounting, bias, and variation due to habitat type, observer experience, and visibility of fish (Jones et al. 1998; Jones and McPherson 1997). The dark, organically stained water and overhanging canopy in the Klag Lake system, together with the color and behavior of migrating sockeye salmon make it very difficult to obtain reliable counts.

The Klag Lake Sockeye Salmon Project is one of eight new projects, initiated in 2001 and funded through the Federal Subsistence Fisheries Resource Monitoring Program, to assess significant subsistence sockeye salmon runs in Southeast Alaska. In addition to escapement data, fisheries harvest and lake ecology data are being collected at Klag Lake to support long-term escapement goals that incorporate lake productivity modeling. The study plan includes an assessment of the lake's physical characteristics, which support primary production, and the secondary production of its zooplankton populations. Zooplankton are the main food source for sockeye salmon, and cladocerans are their preferred food within the zooplankton community. By estimating the biomass and number of zooplankton by species, we can evaluate whether food is a limiting factor for juvenile sockeye salmon in Klag Lake. The species composition over the season and between years may provide insight into how the zooplankton community responds to different fry densities and adult escapement levels. Juvenile population parameters, including density, size, and age composition of fry, are indicators of sockeye salmon response to conditions within the lake and will be estimated. The harvest and escapement data we are collecting from returning adults will enable run reconstruction by brood year, and will indicate the overall status of the Klag Lake sockeye salmon stock. This report summarizes the sockeye salmon stock assessment data collected in the first year of the project.

OBJECTIVES

1) Estimate the escapement of sockeye salmon and other salmonids into the Klag Lake system, with the aid of a weir on the outlet stream of the lake and additional mark-recapture censuses, such that the estimates are within 10% of the actual abundance 95% of the time.
2) Estimate the subsistence harvest of sockeye salmon from Klag Bay such that estimate is within 15% of the actual harvest 90% of the time.
3) Estimate the age, length, weight, and sex composition of the sockeye salmon in the Klag Lake escapement such that these estimates are within 5%, 95% of the time.
4) Estimate a conversion between in-lake survey/mark-recapture estimates and the total estimated escapement of sockeye salmon such that the estimates have a coefficient of variation less than 20%.
5) Estimate the in-lake productivity of Klag Lake using established ADF&G limnological sampling procedures.

Secondary objectives, depending on availability of funding and characteristics of system:

6) Estimate the sockeye fry rearing density within Klag Lake, using hydroacoustic methods, if feasible, such that the estimate is within 10%, 90% of the time.
7) Estimate the age, weight, and length composition of sockeye salmon smolt such that these estimates are within 10%, 90% of the time.
8) Conduct radio tagging survey to estimate spatial distribution of spawning sockeye salmon within the Klag Lake system.

After three to five years:

9) Make initial estimates of biological escapement goal ranges and sustainable escapement thresholds for sockeye salmon based on current estimates of adult escapements, terminal runs, rearing juvenile densities, smolt age and size, in-lake productivity, and limnology-based habitat capacity modeling.

Changes to Objectives

The precision estimates for the population variables to be estimated were incorrectly stated in the original objectives listed above. Objectives 1, 2, 3, 6, and 7 will therefore be changed for the subsequent years of the project as follows:

1) Estimate the escapement of sockeye salmon and other salmonids into the Klag Lake system, with the aid of a weir on the outlet stream of the lake and additional mark-recapture censuses, so that the estimated coefficient of variation is less than 10%.
2) Estimate the subsistence harvest of sockeye salmon from Klag Bay, so that the estimated coefficient of variation is less than 15%.
3) Estimate the age, length, weight, and sex composition of the sockeye salmon in the Klag Lake escapement, so that the estimated coefficient of variation is less than 5%.
6) Estimate the sockeye salmon fry rearing density within Klag Lake, using hydroacoustic methods, so that the estimated coefficient of variation is less than 10%.

7) Estimate the age, weight, and length composition of sockeye salmon smolt, so that the estimated coefficient of variation is less than 10%.

A 95% confidence interval will be also be reported for these population estimates, where appropriate.

METHODS

Study Site

Klag Bay (N 57°38.5', W 136°42.2') is on the west coast of Chichagof Island, about 75 km from Sitka. It is the outermost bay in a system of enclosed saltwater bays or lakes, which includes Lake Anna and Sister Lake, and adjoins Khaz Bay on the Gulf of Alaska. The Klag Lake drainage is approximately 7 km^2, with a maximum elevation of about 550 m, and consists of sparsely wooded low hills with large areas of muskeg and numerous small, shallow lakes and ponds. A chain of small lakes and ponds to the northeast forms the only permanent inlet stream to Klag Lake. A 1.3 m falls in this stream forms a partial migration barrier to salmon, especially at low to moderate flows. Klag Lake lies at an elevation of about 12 m, and is about 40 m deep with a surface area of about 83 hectares (Figure 1). The outlet stream flows through a series of three large ponds into the east side of Klag Bay. The extensive network of muskegs and small ponds in the Klag Lake drainage tends to buffer the system against extreme changes in depth and flow volume. In addition to sockeye salmon (*Oncorhynchus nerka*), Klag Lake supports small runs of pink (*O. gorbusha*), and coho (*O. kisutch*) salmon, and resident populations of cutthroat trout (*O. clarki* spp.) and three spine stickleback (*Gasterosteus aculeatus*). Chum salmon (*O. keta*), Dolly Varden (*Salvelinus malma*) and steelhead (*O. mykiss*) have also been observed in the Klag Lake outlet.

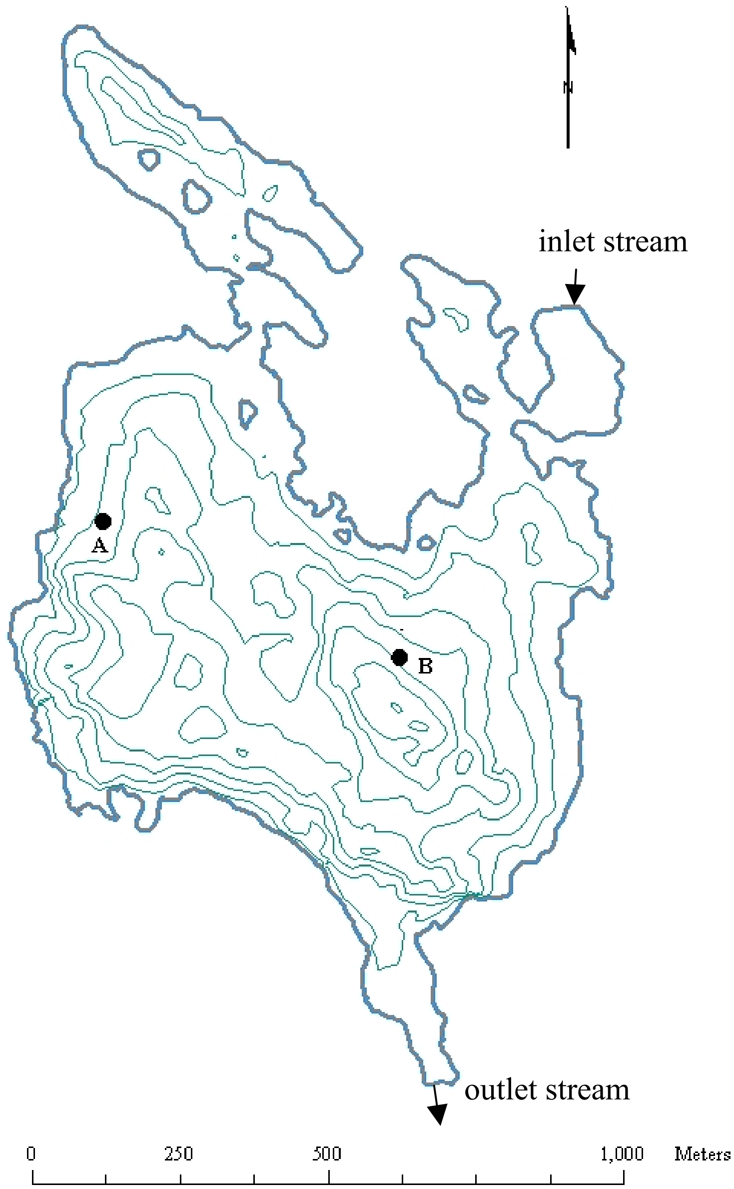

Figure 1. Bathymetric map of Klag Lake, showing 5 m depth contours and two permanent limnology sampling stations (A and B).

Sockeye Fry Population Assessment

The distribution and abundance of rearing sockeye salmon fry were estimated by hydroacoustic and mid-water trawl sampling. The sampling was conducted on 13 October 2001 in the darkest part of the night. Klag Lake was divided into ten sampling areas based on surface area for the hydroacoustic portion of the survey. Prior to conducting a survey, one orthogonal transect was randomly chosen within each of the 10 sampling areas of the lake. These cross-lake transects started and ended at a depth of 10 m and each transect was surveyed twice to get a repeated measure. A constant boat speed of about 2.0 m · sec^{-1} was attempted for all transects. A Biosonics[2] DT-4000™ scientific echosounder (420 kHz, 6° single beam transducer) was used with Biosonics Visual Acquisition© version 4.0.2 software to collect and record the data. Ping rate was set at 5 pings · sec^{-1} and pulse width at 0.4 ms. Data were analyzed using Biosonics Visual Analyzer© version 4.0.2 software. A target strength of –50 dB to –68 dB was used to represent fish within the size range of juvenile sockeye salmon and other small pelagic fish. Echo integration was used to generate a fish density (fish · m^{-2}) for each of the ten sample areas (MacLennand and Simmonds 1992). A population estimate for each of the ten sampling areas was calculated as the product of fish density and the surface area of each of the ten sampling areas. Summing the ten sampling area population estimates generated a total population estimate for the lake. A second estimate was calculated using the repeated measure transects. The average between these two estimates was used as the total population estimate for Klag Lake. A variance around the mean estimate was not possible because the survey was a repeated measures design instead of a true replicate design. We are revising our study design for hydroacoustic survey in accordance with a replicate sample design and will report a variance in the future.

Trawl sampling was conducted in conjunction with hydroacoustic surveys to determine the species composition of targets. A 2 m × 2 m elongated trawl net was used to sample pelagic fish. Trawl depths and duration were determined by fish densities and distributions throughout the lake based on observations from the hydroacoustic survey. All captured fish were euthanized with MS-222 and preserved in 90% ethanol. In the laboratory, fish were soaked in water for 60 minutes before sampling. The snout-fork length was measured to the nearest millimeter (mm) and weight was measured to the nearest tenth gram (0.1 g) on each fish. All sockeye salmon fry under 50 mm were assumed to be age- 0. Scales were collected from fish over 50 mm for age analysis. Sockeye salmon fry scale patterns were examined through the Carton microscope with a video monitor and aged using methods outlined in Mosher (1968). Two trained technicians independently aged each sample. The results of each independent scale ageing were compared, and in instances of discrepancy between the two age determinations, a third independent examination was conducted.

Adult Escapement Estimates

Weir

A weir was installed in the outlet stream of Klag Lake to directly count all salmonids entering the lake. The accuracy of the weir count of sockeye salmon was verified with a mark-recapture estimate of escapement, using the weir as a marking platform. Biological sampling was also conducted at the weir, including species identification, length measurements of sockeye and coho salmon, and scale collection for aging.

A wood tripod, picket and channel type weir was constructed across the Klag Lake outlet stream about 100 meters upstream from the estuary. Tides higher than 10.6 ft rose above the level of the weir; such tides occur on about 25% of summer days. The weir was reinforced against high water and possible washout using sandbags, and was held in place by means of cables tied to trees upstream. Seven tripods and eight picket panels were used; there were 43 pickets in each panel inserted through 11/8" diameter

[2] Mention of trade names does not constitute endorsement by ADF&G but are included for scientific completeness.

holes on 21/8" center spacing. This is the standard spacing used by ADF&G for adult salmon weirs and will retain adult sockeye salmon, but may not retain all sockeye salmon jacks. For this reason, a smaller spacing will be used in future years of weir operation. Migrating fish were funneled into a 4 ft x 4 ft x 8 ft box frame trap, from which they were counted, marked, measured, and sampled, and passed upstream (S. Freeman, USFS, personal communication, 2001). The weir was operated continuously from 12 June to 9 September.

A stratified two-sample mark-recapture study was conducted to test the integrity of the weir to provide an independent estimate of sockeye salmon escapement into Klag Lake. Marks given sockeye salmon at the weir were stratified by time, to allow separate estimation of different parts of the run, should the weir fail or violations of mark-recapture assumptions occur during some part of the run (Arnason et al. 1995; Table 1). All sockeye salmon to be marked were given an adipose fin clip as the primary mark, and an axillary, ventral, or dorsal fin clip as the secondary mark, according to stratum. A constant 50% daily marking rate was specified in the operating procedures, but the number of fish passing the weir, especially on peak days, was larger than expected, so a reduced marking fraction of 40–41% was maintained throughout the run.

Recapture events were conducted on the spawning grounds on 20–22 August and 4 September. Live and dead fish were examined in the spawning areas for marks and marked with a secondary (opercular punch) mark to prevent duplicate sampling. However, the crew was not able to distinguish between the different marking strata, and recorded these fish only as "marked" or "unmarked." Since a stratified population estimate could not be generated from these data, a "pooled Petersen" estimate was used in which all marking strata were combined into a single marking event and all recapture strata were combined into a single recapture event. Chapman's modification and the associated estimate of variance (Seber 1982, p. 61) were used with the pooled Petersen estimate. A 95% confidence interval for the number of recaptured fish (R) was estimated using the normal approximation in Seber (1982, p. 63), and the corresponding confidence interval for the population estimate (N^*) was calculated by multiplying the reciprocal of the confidence bounds for R by the total number of marked fish (M).

Adult Sockeye Salmon Population Age and Size Distribution

Age, sex, and length data were collected from adult sockeye salmon at the weir to describe the biological structure of the population. The goal was to collect 600 randomly selected samples through the season. A total of 1,134 sockeye salmon were sampled opportunistically between 8 July and 28 August. One scale was 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 and length data were paired for each fish sample. Age classes were designated by the European aging system where freshwater and saltwater years are separated by a period (e.g. 1.3 denotes 1-year freshwater and 3-years saltwater). Brood year tables were compiled by sex and brood year to describe the age structure of the returning adult sockeye salmon population. The length of each fish was measured from mid-eye to tail fork to the nearest millimeter (mm). A length frequency histogram was generated for comparison with the size structure of returning adult from previous years if available.

Spawning Grounds Mark-Recapture and Visual Survey

A mark-recapture study and visual surveys on the spawning grounds of Klag Lake and its inlet stream were planned in order to develop an independent estimate or index of escapement, which could be used in future years when a weir is no longer operated. Four two-day mark-recapture events were scheduled, with a visual survey preceding each. A beach or stream sampling design was to be chosen depending on where the majority of spawners congregated (see Conitz et al. 2002 for methods).

Six preliminary surveys of the lake and inlet stream were conducted between 16 July and 13 August, however no sockeye salmon were observed. In addition, a snorkel survey was carried out between the lake and the weir on 4 August. Again no sockeye salmon were observed except in the area directly upstream of the weir. On 19 August the first spawning sockeye salmon were observed in the inlet stream to Klag Lake. Visual counts of sockeye salmon in the inlet stream were made on 24 August and 28 August. On 4 September the first marking event was attempted, but it was unsuccessful due to a staff shortage. A second mark-recapture event was attempted on 28 September, but there were too few live sockeye salmon left to yield a useful estimate.

Subsistence Harvest Estimation Creel Survey

The study design for the Klag Bay marine subsistence fishery was originally based on a stratified two-stage sampling design (Bernard et al. 1998; Cochran 1977). The crew was able to interview all participants because the fishing grounds, or access to them was easily visible from the camp. Thus, the two-stage study design was eliminated. The creel survey was carried out between 9 June and 15 September.

Data Analysis

Boat parties were stratified by fishery type, due to relative efficiencies of gear, and differing seasons for each gear type. Sport fishers used fishing rods, which were the least efficient method of capture. Subsistence fishers used gillnets and beach seines.

Due in part to the low number of interviews, the harvest estimate for sport fishers was calculated from pooled data, and not stratified by time. All subsistence boat parties were apparently interviewed.

For strata where all boat parties were interviewed, the harvest estimate was simply the sum the harvest. No variance estimate was calculated.

$$\hat{\mathrm{H}}_{\mathrm{g}} = \sum_{i=1}^{M_g} \mathrm{h}_{\mathrm{ig}} \qquad (4)$$

where h_{jg} = harvest for boat group i in gear group g, and M_g = number of boat groups in gear group g interviewed throughout the season.

For strata where boat parties were missed, the harvest was estimated as:

$$\overline{H}_l = \frac{\sum_{i=1}^{m_l} h_{il}}{m_l} \tag{5}$$

$$\hat{H}_l = M_l \overline{H}_l \tag{6}$$

The variance of the harvest by stratum will be estimated as:

$$\text{var}\left[\hat{H}_l\right] = (1 - f_l) M_l^2 \frac{\sum_{i=1}^{m_l} (\hat{H}_{il} - \overline{H}_l)^2}{m_l (m_l \text{ -1})}, \tag{7}$$

where f_l = sampling fraction for the gear type l, m_l= number of boat parties of gear type l interviewed, and M_l= total number of boat parties for gear type l. Total harvests for the season are the sums across strata, $\sum H_h$ and $\sum V[H_h]$.

Limnology Sampling

Limnology sampling was conducted at two stations on Klag Lake on 24 May, 8 July, 3 September, and 2 October to measure euphotic zone depth, temperature and dissolved oxygen, and to collect zooplankton samples. Physical measurements were only made at Station A, the deeper of the two, while zooplankton samples were collected at Stations A and B. On 8 July, only zooplankton samples were collected.

Light

Measurements of underwater light penetration (footcandles) were recorded at 0.5 m intervals, from the surface to a depth equivalent to one percent of the subsurface light reading, using a Protomatic submarine photometer. Vertical light extinction coefficients (K_d) were calculated as the slope of the light intensity (ln of percent subsurface light) versus depth. The euphotic zone depth (EZD), the depth to which one percent of the subsurface light [phototsynthetically available radiation (400-700nm)] penetrates the lake surface (Schindler 1971), was calculated from the equation: EZD = 4.6205/ K_d (Kirk 1994).

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen profiles were measured on 3 September and 2 October using a Yellow Springs Instruments Model 58 DO meter and probe. Prior to taking electronic readings, the dissolved oxygen content of a sample of water from 1 m depth, taken with a van Dorn sampler, was determined using the Winkler titration method (Koenings et al. 1987). The meter was then calibrated to this value. Meter values for dissolved oxygen were read and recorded in both mg L^{-1} and percent saturation. Measurements of dissolved oxygen and temperature were made each meter to the first 10 m or the lower boundary of the thermocline (defined as the depth at which the change in temperature decreases to less than 1ºC per meter), and thereafter every 5 m to within 2 m of the bottom (or 50 m).

Secondary Production

Zooplankton samples were collected at two stations on Klag Lake using a 0.5 m diameter, 153 um mesh, 1:3 conical net. Vertical zooplankton tows were pulled from a depth of 27 m at station A and a depth of 16 m at station B at a constant speed of 0.5 m sec^{-1} using a 0.5 m diameter, 153 um mesh, 1:3 conical net. The net was rinsed prior to removing the organisms, and all specimens were preserved in neutralized 10% formalin (Koenings et al. 1987). Zooplankton samples were analyzed at the ADF&G, commercial fisheries limnology laboratory in Soldotna, Alaska. Cladocerans and copepods were identified using the taxonomic keys of Brooks (1978), Pennak (1978), and Yeatman (1959). Zooplankton were enumerated from three separate 1 ml subsamples taken with a Hensen-Stemple pipette and placed in a 1 ml Sedgewich-Rafter counting chamber. Zooplankton body length was measured to the nearest 0.01 mm from at least 10 organisms of each species along a transect in each of the 1 ml subsamples using a calibrated ocular micrometer (Koenings et al. 1987). Zooplankton biomass was estimated using species-specific dry weight versus zooplankter length regression equations (Koenings et al. 1987). The seasonal mean density and body size was used to calculate the seasonal zooplankton biomass (ZB) for each species. Marco-zooplankters were further separated by sexual maturity where ovigorous (egg bearing) zooplankters were also identified.

Radio Tagging Survey

Radio tags were inserted into the stomachs of six adult sockeye salmon (three females and three males) at the weir on 28–29 August. The tags were ATS transmitters Model F1845 @ 65 Pulses Per Minute (Advanced Telemetry Systems, Inc. 470 First Avenue North, P.O. Box 398, Isanti, MN 55040). Radio tags were bottle shape, 51 mm long, 20 mm in diameter, and each had a 12” (30.5 cm) antenna that extended out of the fish’s mouth. Each tag had a unique frequency between 164.103 and 164.204 Mhz. The tags were tracked with an ATS R4000 Receiver, set to operate in the 164.000-167.999 Mhz range, and a 3-element folding Yagi Antenna also tuned to 164.000-167.999 MHz. Tags were recovered on 28 September.

RESULTS

Sockeye Fry Population Assessment

A hydroacoustic survey was successfully completed in Klag Lake. Two 15-minute trawls were towed at 5 and 8 m and caught a total of 38 sockeye salmon fry and 138 stickleback (Table 1). The total lake population estimate was 73,000 sockeye salmon fry (range of repeated measure was 72,600 to 73,500 fry) with a density of 0.136 fry m^{-2} (range of repeated measure was 0.135 to 0.135 fry m^{-2}). Stickleback abundance in the lake was estimated at 265,000 or 78% of the small fish in the pelagic area of the lake. The dominant sockeye salmon fry age class was age-1 (Figure 2).

Table 1. Size and age distribution of sockeye fry and stickleback estimated from midwater trawl samples, and population estimates based on hydroacoustic surveys with species and age apportionment based on trawl samples, for Klag Lake, 2001.

Species	Age	Sample Size	Proportion of Total	Mean Length ± se (mm)	Mean Weight ± se (g)	Population Estimate by Age	Total Population
Sockeye	0	12	7%	51.3 ± 0.9	1.3 ± 0.06	23,000	
Sockeye	1	26	15%	65.8 ± 1.4	2.6 ± 0.17	50,000	73,000
Stickleback	na	138	78%	46.2 ± 0.9	1.0 ± 0.06	265,000	265,000

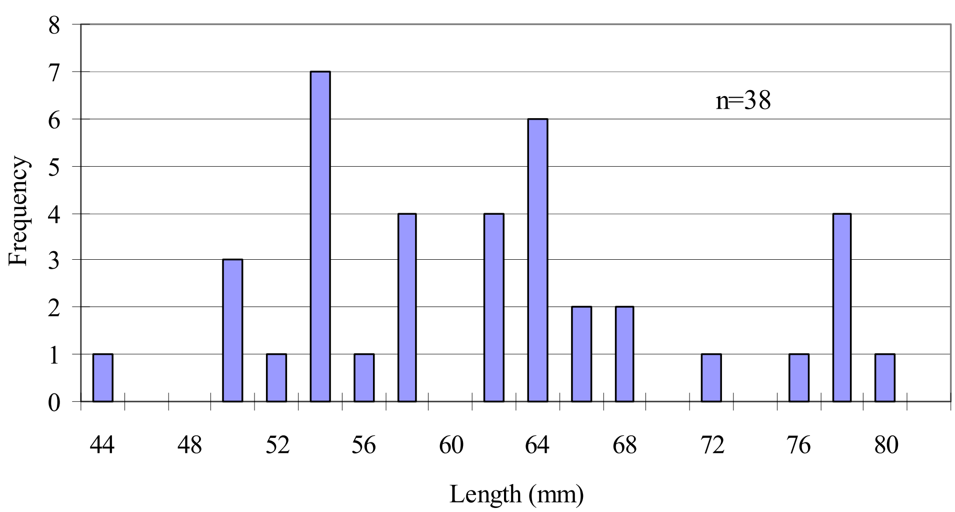

Figure 2. Length frequency distribution of sockeye salmon fry in Klag Lake, 2001. All sockeye salmon fry less than 50 mm long were assumed to be age-0; of those greater than 50 mm long, scale pattern analysis showed that eight were age-0 and 26 were age-1.

Adult Escapement Estimates

Weir

Sockeye salmon escapement into the Klag Lake stream began on 6 July and was nearly finished by the weir removal date of 9 September. A total of 12,117 sockeye salmon were counted through the Klag Lake weir (Table 2). Peak escapement days were 7 July, 26 July, 15 August and 27 August, with 907, 2,146, 1,056 and 2,481 sockeye salmon, respectively, entering the Klag Lake stream. Coho salmon entered the stream between 10 July and 28 August, with a peak escapement count on 27 August of 1,103 fish. There is the possibility of an uncounted late run of coho salmon into this system after 9 September. Peak daily escapement for all species was associated with increasing or peak flow levels in the creek, except in mid-August when large numbers of sockeye and coho salmon entered the stream despite very low flow levels (Appendix B.1).

During the mid-August peak escapement period, a large number of small sockeye salmon (300 – 400 mm) were counted. This occurred after plastic sheeting was placed over the weir pickets to increase flow through the trap, so it was likely these fish had previously been passing through the weir uncounted. Subsequently, the proportion of sockeye salmon under 400 mm ranged from 10–43% of all sockeye salmon sampled at the trap. These fish were assumed to be jacks.

Table 2. Weir counts of adult salmonids and weir mark-recapture escapement estimate of sockeye salmon for Klag Lake in 2001. Out of 903 sockeye salmon caught in the recapture sample, 379 fish had marks given at the weir.

Species	Weir Count	Petersen mark-Recapture Estimate	95% Confidence Interval
sockeye	12,117	11,870	(11,441 - 12,335)
coho	2,272		
pink	33,752		
chum	11		
steelhead	1		

To verify the accuracy of the weir count, a total of 4,989 sockeye salmon were marked with fin clips at the weir in the first sample (Table 3.a). A total of 379 marked fish were caught in the second sample of 903 fish (Table 3.b). The crew was not able to distinguish between secondary mark types, so all marked fish caught in the second sample were pooled. The pooled Petersen escapement estimate was 11,870 (95% CI 11,441–12,335) sockeye salmon, which was slightly lower but not significantly different than the weir count (Table 2). It therefore appears likely that all sockeye salmon passing through the weir were counted, except jacks as noted above. Jacks were not specifically noted in the mark-recapture samples, so the effect of these jacks on the total estimate of escapement is still unknown.

Table 3. Sample sizes and numbers of marked and recaptured fish for pooled Petersen mark-recapture estimate at the Klag Lake weir.

a) First sample: marking strata, types, dates, and number of sockeye salmon marked at the Klag Lake weir. The dorsal fin clip was incorrectly applied at first and is indicated in the table as Dorsal I; the correct mark is indicated as Dorsal II.

Stratum	Mark Type	Date Applied	Number Marked
1	Left Axillary	7/6 – 7/12	653
2	Left Pelvic	7/13 – 7/26	1,263
3a	Dorsal I	7/26 – 8/4	150
3b	Dorsal II	8/5 – 9/15	2,923
	All Marks	7/6 – 9/15	4,989

b) Second sample: dates, sample sizes, and numbers of marked and unmarked fish taken in the inlet stream (mouth to the first falls). Stratified mark types were not distinguished in the second sample, so all marked fish were pooled.

Date	Unmarked	Marked	Total Sample
8/20	28	27	55
8/22	59	26	85
9/4	109	90	199
9/4	207	146	353
	121	90	211
All	524	379	903

Adult Sockeye Salmon Population Age and Size Distribution

Age was determined for 990 sockeye salmon sampled at the weir, and the dominant class was age-1.3, representing 56% of the fish sampled. The next largest class was age-1.2, representing 25% of the fish sampled (Table 4). All sockeye salmon with only one ocean year (age-1.1 and age 2.1) were assumed to be jacks, although about half of these were mis-identified as females. Out of the 578 males sampled, 101 were jacks, and jacks comprised about 10% of all sockeye salmon sampled. The average length of 989 sockeye salmon sampled at Klag Lake weir was 508 $\pm$ 2.2 mm, but if jacks were excluded the average length was 534 mm (Table 5). The average length of males was 498 $\pm$ 3.4 mm, and the average length of females was 411 $\pm$ 1.8 mm. When jacks were excluded, the average length of males increased to 541 mm. There were 578 males, or 477 males excluding jacks, and 411 females in the sockeye salmon sampled.

Table 4. Age composition of sockeye salmon in the Klag Lake weir samples by sex and age class, 2001.

Brood Year	1998	1997	1997	1996	1996	1995	1995	1994	
Age	**1.1**	**1.2**	**2.1**	**1.3**	**2.2**	**1.4**	**2.3**	**2.4**	**Total**
Male									
Number	74	147	27	286	22	1	20	1	578
Percent	7.5	14.9	2.7	28.9	2.2	0.1	2	0.1	58.4
Std. Error	0.8	1.1	0.5	1.4	0.4	0.1	0.4	0.1	1.5
Female									
Number		101		266	25		18	1	411
Percent		10.2		26.9	2.5		1.8	0.1	41.6
Std. Error		0.9		1.4	0.5		0.4	0.1	1.5
All Fish									
Number	74	249	27	553	47	1	38	2	991
Percent	7.5	25.1	2.7	55.8	4.7	0.1	3.8	0.2	100
Std. Error	0.8	1.3	0.5	1.5	0.6	0.1	0.6	0.1	

Table 5. Length composition of sockeye salmon in Klag Lake weir samples by sex and age class, 2001.

Brood Year	1998	1997	1997	1996	1996	1995	1995	1994	
Age	**1.1**	**1.2**	**2.1**	**1.3**	**2.2**	**1.4**	**2.3**	**2.4**	**Total**
Male									
Avg. Length	336	485	355	555	498	573	547	590	498
Std. Error	2.2	2.4	3.5	1.5	5.2		5.3		3.4
Sample Size	74	147	27	286	22	1	20	1	578
Female									
Avg. Length		480		542	480		531	555	523
Std. Error		2.8		1.4	4.6		6		1.8
Sample Size		101		266	25		18	1	411
All Fish									
Avg. Length	336	483	355	549	488	573	539	573	508
Std. Error	2.2	1.8	3.5	1.1	3.6		4.1	17.5	2.2
Sample Size	74	248	27	552	47	1	38	2	989

Mark-Recapture and Visual Survey

In visual surveys, about 450 sockeye salmon were observed in the inlet stream on 24 August, and about 2,000–3,000 sockeye salmon were observed in the inlet stream on 29 August (T. Suminski, USFS, personal communication, 2002). Because of the difficulties in identifying the spawning areas of the sockeye salmon adults in the lake, staff shortages, conditions in the inlet stream, and other difficulties, we were unable to make an independent estimate of spawning grounds escapement using mark-recapture methods.

Subsistence Harvest Estimation Creel Survey

The Klag Bay subsistence fishery was open between 1 June and 24 July 2001 and the sport fishery was open year around. Subsistence boats entered the area from 4 July to 24 July, for an average of 1.09 boats per day. At most, three subsistence boats fished on any given day and no subsistence boats were seen on nine days out of 21, between 4 July and 24 July. Sport fishers participated in the fishery between 29 June and 2 September. The average daily number of sport fishers was 0.58.

Participants in the two fisheries used different gear types. Rods were used by sport fishers; gillnets and beach seines were used in the subsistence fishery. The technicians reported difficulties in viewing all areas of both fisheries, and in recording data from boats that fished at night. In the absence of other information, we will assume that the technicians interviewed all boat parties. Inconsistent recording of time fished precluded computation of catch per unit of effort estimates.

Total sockeye salmon harvest was estimated at 1,706 fish and 23 subsistence fishers harvested 1,605 fish, or 94.2% of the total catch (Table 6). Because we do not check permits on the fishing grounds, we do not know how many proxy permits were being fished by these fishers. Harvest of other salmon species was negligible. Sport fishers caught 101 sockeye salmon and 11 coho salmon.

Table 6. Estimated number of salmon caught in the Klag Lake sport and subsistence fisheries during 2001.

Gear Type	Number Counted	Number Sampled	Sockeye		Chum		Pink		Coho	
			Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
Subsistence										
Gillnet	14	14	342		2		1			
Seine	9	9	1,235		5		22			
All Gear	23	23	1,607		7		23			
Sport	36	34	101	4.88	1	0.24	4	0.58	11	1.13
Total	59	57	1,706	4.88	8	0.24	27	0.58	11	1.13

Limnology Sampling

Limnology sampling was conducted at two stations in Klag Lake on 24 May, 8 July, 3 September, and 2 October to measure euphotic zone depth, temperature and dissolved oxygen (DO) and to collect zooplankton samples. The 2001, Klag Lake euphotic zone depth (EZD) ranged from 5.82 to 3.88 m with a season mean of 4.56 m (Table 7). Typical of other Southeast lakes, this lake was clearest in the late spring, becoming more stained throughout the season.

Table 7. Euphotic zone depth in Klag Lake, 2001.

Sample Date	EZD (m)
24 May	5.82
8 July	na
3 Sept	3.99
2 Oct	3.88
Seasonal mean	4.56

Water temperature vertical profiles for Klag Lake in September 2001 at Station A show the thermal stratification pattern typical of dimictic lakes (Figure 4a). In early October, the thermocline was beginning to break down (Figure 4b); the lake would be expected to become isothermic by late fall, and inversely stratified in winter. The maximum epilimnetic temperature of 13.9° C on 3 September was probably less than the seasonal maximum temperature. Hypolimnetic temperatures were 6.1 to 6.7° C. Dissolved oxygen (DO) levels were between 8.4 and 10.9 mg · L^{-1} at all depths in September and October.

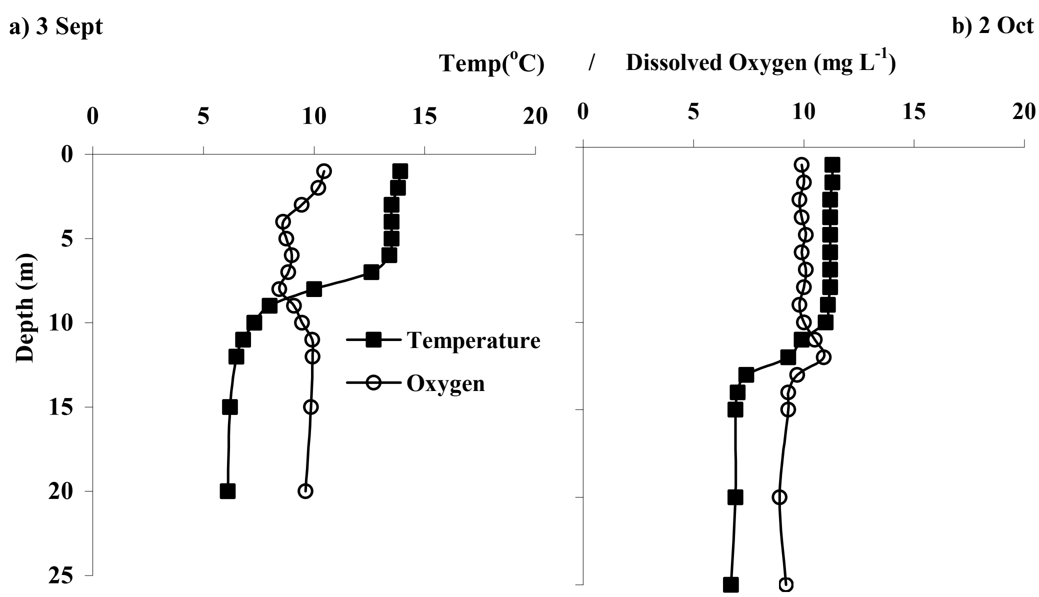

Figure 3. Temperature and dissolved oxygen profiles in Klag Lake, Station A, on a) 3 September and b) 2 October 2001.

Secondary Production

Zooplankton samples were collected at two stations in Klag Lake on all four sample dates in 2001. The macrozooplankton assemblage in Klag Lake was dominated by a species of cladoceran (*Bosmina* spp.), and a copepod at both stations (*Cyclops* spp.; Table 8 and 9). Copepod nauplii were the third most numerous group or taxon in the samples. The seasonal mean total macro-zooplankton density was 122,600 plankters · m^{-2}. The seasonal mean weighted macro-zooplankton biomass was 175 mg · m^{-2} (Table 9). The average size of the *Daphnia* spp. was greater than 0.5 mm. However, the dominant *Bosmina* spp. were less than 0.5 mm at both stations (Table 10).

Table 8. Klag Lake zooplankton species density (No./m^2) by station, date, and season mean, 2001.

Station A	4-May	8-Jul	3-Sep	2-Oct	Mean	Percent
Ergasilus					0	0.0%
Epischura	3,565	4,890	6,928	2,759	4,536	3.4%
Diaptomus					0	0.0%
Cyclops	47,165	43,267	28,273	54,041	43,187	32.0%
Ovig. Cyclops	7,589	26,286	1,426	807	9,027	6.7%
Bosmina	9,270	94,957	59,755	72,211	59,048	43.8%
Ovig. Bosmina	764	611	15,996	18,339	8,928	6.6%
Daphnia l.	204	1,698	662	382	737	0.5%
Ovig. Daphnia l.	509	679	509	382	520	0.4%
Daphnia g.					0	0.0%
Holopedium	102	272	1,681	1,231	822	0.6%
Ovig. Holopedium	51	272	458	297	270	0.2%
Chydorinae					0	0.0%
Polyphemus					0	0.0%
Copepod nauplii	30,561	1,019			7,895	5.8%
Station B	**4-May**	**8-Jul**	**3-Sep**	**2-Oct**	**Mean**	**Percent**
Ergasilus					0	0.0%
Epischura	2,241	7,336	8,287	815	4,670	4.2%
Diaptomus					0	0.0%
Cyclops	41,111	16,454	29,071	71,829	39,616	35.9%
Ovig. Cyclops	1,579	2,751	1,223	458	1,503	1.4%
Bosmina	4,789	18,136	71,523	34,233	32,170	29.2%
Ovig. Bosmina	1,426	2,649	45,441	7,743	14,315	13.0%
Daphnia l.	204	357	883	1,019	616	0.6%
Ovig. Daphnia l.	0	51	136	153	85	0.1%
Daphnia g.					0	0.0%
Holopedium	453	458	1,562	611	771	0.7%
Ovig. Holopedium	153	255	747	102	314	0.3%
Chydorinae					0	0.0%
Polyphemus					0	0.0%
Copepod nauplii	56,495	4,024		4,279	16,200	14.7%

Table 9. Klag lake zooplankton mean weighted biomass (mg/m^2) by station, species, and season mean, 2001.

Species	Station A	Percent	Station B	Percent	Mean	Percent
Epischura	19.14	8.6%	24.57	19.3%	21.85	12.5%
Cyclops	72.86	32.7%	52.50	41.2%	62.68	35.8%
Ovig. Cyclops	46.29	20.8%	5.94	4.7%	26.12	14.9%
Bosmina	67.59	30.3%	24.83	19.5%	46.21	26.4%
Ovig. Bosmina	9.52	4.3%	15.96	12.5%	12.74	7.3%
Daphnia l.	2.35	1.1%	1.12	0.9%	1.73	1.0%
Ovig. Daphnia l.	2.48	1.1%	0.29	0.2%	1.39	0.8%
Holopedium	1.68	0.8%	1.29	1.0%	1.49	0.8%
Ovig. Holopedium	0.89	0.4%	0.81	0.6%	0.85	0.5%
Total	222.81		127.32		175.06	

Table 10. Klag Lake seasonal weighted mean length by species and station.

Species	Station A Weighted Length (mm)	Station B Weighted Length (mm)
Epischura	0.98	1.06
Diaptomus		
Cyclops	0.70	0.63
Ovig. Cyclops	1.18	1.04
Bosmina	0.35	0.29
Ovig. Bosmina	0.34	0.35
Daphnia l.	0.84	0.65
Ovig. Daphnia l.	1.02	0.87
Daphnia g.		
Holopedium	0.49	0.46
Ovig. Holopedium	0.60	0.54

Radio Tagging Survey

On 6 September, the carcass of one radio tagged fish washed up on the weir. A tag recovery search of the entire lake shore was conducted on 28 September, and no radio tag signals were received in the main Klag Lake or the inlet stream. One radio tag was recovered on the shore of the pond immediately below Klag Lake. This tagged sockeye salmon was found among small groups of 6–30 sockeye salmon that were actively spawning on the beaches along the northeast end of Klag Lake and in the first pond below the outlet. Three tags were recovered from carcasses in the stream just above the weir; the signal of a fourth tag was detected upstream in the same area but the tag was not recovered. It was unknown whether these carcasses were recovered on or near their spawning grounds or had drifted downstream from a spawning area farther upstream or in the lake.

DISCUSSION

It appears that the sockeye salmon returns this year to Klag Lake were healthy and the terminal sport and subsistence fisheries harvested a relatively small proportion (12–14%) of the run. Subsistence harvest and escapement counts appear to be consistent with previous information. The average reported subsistence harvest of sockeye salmon during the last decade at Klag Lake was about 1,200 and a high harvest of about 3,400 fish was reported in 1996. Because the harvest is generally under reported on the permits, it is likely that the 2001 harvest of 1,700 fish is near the average for the decade. The mark-recapture estimate of the adult sockeye salmon returns was within the range of the number of sockeye salmon counted through the weir. Inter-annual variation of sockeye salmon escapement into Klag may be large. The degree to which sockeye salmon returns and escapements vary in strength over time and the relationship of juvenile to adult populations will not be known until we have several more years of data.

The 2001 investigation plan included an independent estimate of escapement by means of a spawning grounds mark-recapture study and a radio tagging study to collect information about distribution of sockeye salmon spawners in the Klag Lake system. By comparing this information to the weir data in years when the weir is operated, it may be possible to accurately index mark-recapture or visual survey estimates to total escapement and thus avoid the high cost of running a weir in future years (Conitz et al. 2002). For several reasons, the crew was unable to carry out the surveys and mark-recapture events according to the study design during the 2001 season. The spawning habitat in Klag Lake and its inlet stream is atypical, in that much of it consists of large cobbles and boulders on bedrock, without gravel. The margins of the lake and the ponds below the lake are heavily vegetated, making it difficult to survey and seine. However, a large inlet stream-spawning population was clearly identified, and sampling conducted for the weir mark-recapture experiment demonstrated that sockeye salmon could be captured, counted, and marked in or near the mouth of the stream. Since large numbers of sockeye salmon spawn in this small area, sampling carcasses in the mark-recapture effort could help increase sample sizes and ease of collecting samples. Sampling carcasses is specified in the field operating procedures for a mark-recapture study in an inlet stream. At least one other spawning location was identified through radio tag recovery. There appear to be at least a small beach-spawning population in this system. The possibility of conducting mark-recapture work in this area in the 2002 season should be investigated. The entire system should be surveyed at the time of each mark-recapture event. Spawning appears to begin sometime in August and end by late September, as is typical for southeast Alaska lakes. Timing of mark-recapture and survey events should bracket the beginning and end of the spawning period, between about 15 August and 1 October. The possibility of using visual surveys in conjunction with a few years' weir counts to develop an escapement index has been discussed. However, visual counts may not provide a robust, unbiased estimate, given known sources of variation in counts due to water conditions, weather conditions, and observers. Also, we will have to continue to physically sample fish in order to obtain estimates of population age structure. Fish capture methods may need to be modified to be effective in the Klag Lake habitat, but it is recommended that a mark-recapture study be attempted again in the 2002 season, with a full three-person crew and whatever necessary adaptations to the physical environment that can be made without violating the mark-recapture assumptions.

Although there are no previous estimates of sockeye salmon populations in Klag Lake, fry density this year was below the mean of 0.21 fry·m^{-2} and above the median of 0.10 fry·m^{-2} from 18 Southeast Alaska lakes surveyed this year (Table 11). This kind of a comparison is very limited, however, without additional years of data as well as information about other physical and biological variables affecting sockeye salmon fry productivity between lakes. For example, Klag Lake is more heavily stained than other Southeast lakes, which may affect the productivity of the lake (Table 12). Although light penetration and the size of the euphotic zone are reduced in a heavily stained lake, heating of the epilimnion is increased (Edmundson and Mazumder 2002). Zooplankton density was moderately high, but biomass was low, and density of large cladocerans was very low in Klag Lake samples. In comparing zooplankton abundance and species composition in Klag Lake with lakes that have similar seasonal mean EZD (Klawock, Salmon Bay, and Luck lakes), Klag Lake had the lowest seasonal mean zooplankton biomass. If top-down predators control the system, it may be more important to examine the total zooplanktivore density (sockeye fry and sticklebacks) than the sockeye salmon fry density alone. Stickleback comprised 80% of the mid-water trawl sample. As mentioned earlier, the sockeye salmon fry density at Klag Lake was below the mean. However, Klag Lake ranked third in total zooplanktivore density (0.63 fish$\cdot m^{-2}$), surpassed only by Hetta and Thoms Lakes, with 1.27 fish$\cdot m^{-2}$ and 0.92 fish $\cdot m^{-2}$, respectively, due to the high proportion of stickleback in Klag Lake.

Table 11. Fry density estimates (fry$\cdot m^{-2}$) from hydroacoustic surveys conducted in 18 sockeye rearing lakes important to subsistence users in Southeast Alaska during July – Oct, 2001.

Lake	**Density (fry$\cdot m^{-2}$)**
Kanalku	<0.01
Mahoney	<0.01
Redoubt	0.01
Chilkat	0.01
Kook	0.03
Klawock	0.07
Salmon Bay	0.07
Chilkoot	0.09
Falls	0.09
Luck	0.10
Sitkoh	0.14
Klag	0.14
Salmon	0.14
Kutlaku	0.23
Hoktaheen	0.25
Gut	0.32
Thoms	0.89
Hetta	1.20

Table 12. Summary of 2001 seasonal mean euphotic zone depths (EZD) for 12 sockeye salmon rearing lakes in Southeast Alaska.

Lake	EZD (m)
Thoms	3.00
Hoktaheen	3.16
Klawock	4.24
Klag	4.56
Salmon Bay	4.60
Luck	4.60
Kook	5.82
Sitkoh	6.69
Hetta	7.94
Falls	9.71
Gut Bay	10.91
Kanalku	11.06

Results from this project may address some of the concerns expressed by fisheries managers and subsistence users about fishing at Klag Bay. In past years, managers and fishers had observed large numbers of sockeye salmon staging off the mouth of the Klag Lake outlet stream. They were concerned that a significant terminal fishery, especially at low water, could result in over harvesting the stock. The timing of terminal area fishing with respect to escapement timing was closely observed this year and does not appear to be a problem. Almost all the subsistence fishing took place over two weeks, from 10–24 July. There were several peaks in escapement through most of July and August, including one around 10 July, during the peak of subsistence fishing. However, it does appear that escapement timing is associated with rainfall and water level in the Klag Lake stream, with fish waiting in the estuary for higher water, so it is important to continue monitoring both escapement and harvest timing to ensure that problems do not develop.

As in all the sockeye salmon projects, additional years of sampling are needed in order to define the relationship between escapement levels and lake productivity in Klag Lake. We will continue to assess sockeye salmon fry and zooplankton populations, light and temperature, and adult returns. The overlapping data collected from the various life history stages of sockeye salmon and the environmental factors that affect them will help future managers to ensure sustainable harvest levels and continued productivity of the Klag Lake sockeye salmon populations.

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Appendix A. Historical sockeye salmon harvest information from Klag Lake and vicinity.

Appendix A.1. Subsistence harvest of sockeye salmon reported on permits from Klag Bay/Fish Camp, 1985–2000. (ADF&G Alexander database, 2002). Sockeye harvest is reported on returned permits by permit holders; there is no independent validation of these figures.

Year	**Number of Permits**	**Total Sockeye Harvest**	**Average Sockeye 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	1626	28
1994	31	809	26
1995	28	1098	39
1996	100	3381	34
1997	42	1106	26
1998	33	834	25
1999	42	1048	25
2000	48	1082	23
Average	34	904	25

Appendix A.2. Record of early commercial sockeye salmon harvests in Klag Bay. These records probably include some sockeye salmon destined for streams other than the Klag Lake outlet (Rich and Ball 1933).

Year	Sockeye harvest
1911	15,269
1912	20,061
1913	6,079
1914	9,042
1915	14,538
1916	16,795
1917	6,172
1918	14,312
1919	397
1920	11,513
1921	1,500
1922	9,603
1923	4,882
1924	7,048
1925	8,615
1926	16,294
1927	5,467

Appendix A.3. Annual ADF&G escapement surveys conducted opportunistically at Klag Bay. 1960–2000. These surveys estimated an unknown portion of the escapement in each year. The peak counts are simply the highest count recorded in a given season and do not represent total or peak escapement (ADF&G Alexander Database, 2002).

Year	Date	Peak sockeye count	Survey type
1960	08/11	100	AERIAL
1962	07/27	600	AERIAL
1968	07/03	200	FOOT
1969	07/19	300	FOOT
1971	07/14	2,000	FOOT
1972	08/01	5,000	AERIAL
1973	07/05	500	AERIAL
1976	07/26	6,000	BOAT
1977	07/11	3,000	AERIAL
1979	08/10	2,000	AERIAL
1980	07/03	300	AERIAL
1981	07/22	700	AERIAL
1982	08/11	5,000	AERIAL
1983	07/19	4,000	AERIAL
1984	07/23	3,000	AERIAL
1985	07/08	500	AERIAL
1986	07/31	200	AERIAL
1987	07/30	2,000	AERIAL
1989	07/17	2,000	AERIAL
1990	07/16	30	AERIAL
1991	07/25	1,000	AERIAL
1993	07/22	6,000	AERIAL
1994	08/08	5,000	AERIAL
1995	07/14	800	AERIAL
1996	08/09	3,100	AERIAL
1997	08/09	2,000	AERIAL
1998	08/06	6,000	AERIAL
1999	07/12	1,000	BOAT
2000	07/23	1,200	AERIAL

Appendix B. Adult salmon escapement and ecological data from Klag Lake, 2001.

Appendix B.1. Daily and cumulative counts of adult salmon at Klag Lake weir and associated water levels for 2001.

Date	Sockeye		Coho		Pink		Chum		Water depth (m)
	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative	Daily	Cumulative	
6/8	0	0	0	0		0		0	
6/9	0	0	0	0		0		0	
6/10	0	0	0	0		0		0	
6/11	0	0	0	0		0		0	
6/12	0	0	0	0		0		0	
6/13	0	0	0	0		0		0	
6/14	0	0	0	0		0		0	
6/15	0	0	0	0		0		0	
6/16	0	0	0	0		0		0	
6/17	0	0	0	0		0		0	
6/18	0	0	0	0		0		0	
6/19	0	0	0	0		0		0	0.23
6/20	0	0	0	0		0		0	0.22
6/21	0	0	0	0		0		0	0.22
6/22	0	0	0	0		0		0	0.22
6/23	0	0	0	0		0		0	0.23
6/24	0	0	0	0		0		0	0.25
6/25	0	0	0	0		0		0	0.25
6/26	0	0	0	0		0		0	0.25
6/27	0	0	0	0		0		0	0.23
6/28	0	0	0	0		0		0	0.22
6/29	0	0	0	0		0		0	0.23
6/30	0	0	0	0		0		0	0.22
7/1	0	0	0	0		0		0	0.22
7/2	0	0	0	0		0		0	0.21
7/3	0	0	0	0		0		0	0.20
7/4	0	0	0	0		0		0	0.20
7/5	0	0	0	0		0		0	0.21
7/6	61	61	0	0	0	0	0	0	0.27
7/7	907	968	0	0	0	0	0	0	0.45
7/8	431	1,399	0	0	0	0	0	0	0.52
7/9	48	1,447	0	0	0	0	0	0	0.43
7/10	67	1,514	1	1	0	0	0	0	0.43
7/11	92	1,606	0	1	0	0	0	0	0.39
7/12	27	1,633	0	1	0	0	0	0	0.36
7/13	5	1,638	0	1	0	0	0	0	0.34
7/14	54	1,692	0	1	0	0	0	0	0.33
7/15	4	1,696	0	1	0	0	0	0	0.33
7/16	111	1,807	0	1	0	0	0	0	0.31
7/17	7	1,814	0	1	0	0	0	0	0.30
7/18	7	1,821	0	1	0	0	0	0	0.28
7/19	11	1,832	0	1	0	0	0	0	0.27
7/20	3	1,835	0	1	0	0	0	0	0.26
7/21	0	1,835	0	1	0	0	0	0	0.24
7/22	0	1,835	0	1	0	0	0	0	0.23
7/23	0	1,835	0	1	0	0	0	0	0.26
7/24	2	1,837	22	23	0	0	0	0	0.35
7/25	868	2,705	47	70	1	1	0	0	0.43
7/26	2,146	4,851	55	125	6	7	0	0	0.49
7/27	158	5,009			0		0		0.42

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Appendix B.1. (page 2 of 2)

Date	Sockeye Daily	Sockeye Cumulative	Coho Daily	Coho Cumulative	Pink Daily	Pink Cumulative	Chum Daily	Chum Cumulative	Water depth (m)
7/28	31	5,040	0	125	1	8	0	0	0.61
7/29	36	5,076	0	125	0	8	0	0	0.33
7/30	32	5,108	1	126	1	9	0	0	0.31
7/31	2	5,110	0	126	0	9	0	0	0.30
8/1	5	5,115	0	126	0	9	0	0	0.29
8/2	19	5,134	0	126	1	10	0	0	0.28
8/3	18	5,152	0	126	4	14	0	0	0.26
8/4	1	5,153	0	126	0	14	0	0	0.25
8/5	3	5,156	2	128	1	15	0	0	0.24
8/6	17	5,173	0	128	0	15	0	0	0.23
8/7	21	5,194	3	131	2	17	0	0	0.22
8/8	60	5,254	2	133	0	17	0	0	0.22
8/9	49	5,303	0	133	2	19	0	0	0.21
8/10	23	5,326	0	133	0	19	0	0	0.21
8/11	9	5,335	1	134	0	19	0	0	0.20
8/12	33	5,368	3	137	0	19	0	0	0.20
8/13	72	5,440	3	140	0	19	0	0	0.20
8/14	76	5,516	8	148	4	23	0	0	0.20
8/15	1,056	6,572	23	171	342	365	1	1	0.18
8/16	680	7,252	2	173	121	486	0	1	0.18
8/17	332	7,584	1	174	78	564	0	1	0.18
8/18	337	7,921	10	184	186	750	0	1	0.18
8/19	194	8,115	8	192	75	825	0	1	0.18
8/20	227	8,342	31	223	109	934	0	1	0.18
8/21	109	8,451	5	228	61	995	0	1	0.18
8/22	42	8,493	4	232	53	1,048	0	1	0.21
8/23	93	8,586	2	234	105	1,153	0	1	0.21
8/24	21	8,607	3	237	66	1,219	0	1	0.22
8/25	32	8,639	54	291	110	1,329	0	1	0.23
8/26	136	8,775	251	542	1,190	2,519	0	1	0.25
8/27	2,481	11,256	1,103	1,645	11,299	13,818	5	6	0.43
8/28	551	11,807	108	1,753	4,382	18,200	0	6	0.40
8/29	67	11,874	0	1,753	0	18,200	0	6	
8/30	31	11,905	0	1,753	0	18,200	0	6	
8/31	7	11,912	0	1,753	0	18,200	0	6	
9/1	10	11,922	0	1,753	0	18,200	0	6	
9/2	121	12,043	0	1,753	0	18,200	0	6	
9/3	9	12,052	0	1,753	0	18,200	0	6	
9/4	3	12,055	0	1,753	0	18,200	0	6	
9/5	45	12,100	0	1,753	0	18,200	0	6	
9/6	14	12,114	0	1,753	0	18,200	0	6	
9/7	1	12,115	0	1,753	0	18,200	0	6	
9/8	1	12,116	0	1,753	0	18,200	0	6	
9/9	1	12,117	0	1,753	0	18,200	0	6	
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