KLAWOCK LAKE

SOCKEYE SALMON (*Oncorhynchus nerka)* STOCK ASSESSMENT PROJECT

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ABSTRACT

Klawock Lake sockeye salmon (*Oncorhynchus nerka*) are an important subsistence resource for the people of Klawock and Prince of Wales Island. The Klawock Lake Sockeye Salmon Stock Assessment Project was initiated because of concerns about the apparent declines in sockeye salmon returning to Klawock Lake. The project evaluates sockeye salmon production at various life stages and assesses lake productivity. This annual report summarizes work conducted during the first full year of project operations, 2001. A hydroacoustic and trawl survey estimated a sockeye salmon fry density of 0.07 fry per m^2 and a total lake population of 718,000 fry. All sockeye salmon fry captured in the mid-water trawl were age-0 except for one age-1 fry. A subsample of 576 emigrating sockeye salmon smolt was composed of 87% age-1 and 13% age-2 fish. Smolt otolith analysis determined that 2.4% emigrating smolt were hatchery produced. A mark-recapture study estimated a sockeye salmon escapement of 14,000 fish into Klawock Lake, but only 7,200 sockeye salmon were counted at the weir. The subsistence harvest was estimated to be 6,400 sockeye salmon. Klawock Lake had a seasonal mean zooplankton density of 125,000 plankters per m^2 and a seasonal mean weighted biomass of 217 mg per m^2. The seasonal mean euphotic zone depth was 4.25 m. This year's results provide the foundation for a multiple-year study to assess the health of the sockeye salmon stock and to set a range of escapement goals capable of sustaining this population for many generations

KEY WORDS: sockeye salmon, *Oncorhynchus nerka*, Klawock River, Klawock Lake, Prince of Wales Island, stock assessment, limnology, zooplankton, hatchery, harvest, subsistence, escapement, hydroacoustic

INTRODUCTION

Klawock Lake is one of the few major sockeye salmon *(Oncorhynchus nerka*) producers in southern Southeast Alaska. This sockeye salmon stock is an important subsistence resource for the people of Klawock and Prince of Wales Island. However, annual Klawock River sockeye salmon escapement estimates have decreased during the past 20 years (Lewis and Zadina 2001). The residents of Klawock and the Alaska Department of Fish and Game (ADF&G) are concerned about the decline of sockeye salmon in this system. Numerous human activities have most likely contributed to this decline (Lewis and Zadina 2001). A substantial commercial harvest of sockeye salmon has existed in the area since the early 1900s, although it is difficult to quantify the Klawock component of the catch. Significant habitat alterations include extensive timber harvests and associated road building, a causeway blocking one of two historic estuary connections, a water diversion on Half-Mile Creek, a subdivision on Three-Mile Creek, and a paved highway. In addition, this system has a long history of enhancement activities with very little assessment of their positive and negative contribution to the productivity of sockeye salmon and other fish.

Although stock assessment activities have been performed at Klawock Lake intermittently for the last 20 years, much of the data is unreliable, collected inconsistently between years, and objectives changed with each new project or hatchery manager (Lewis and Zadina 2001). For example, in the past, the weir was operated solely for brood stock collection and was not in place at the beginning and end of the run. Consequently, there is no reliable accounting of the adult escapement to the lake prior to 2001. Limnology information, fry abundance, age and size data, and smolt age and size data were collected only periodically in the last 20 years (Lewis and Zadina 2001). In addition, the subsistence harvest, determined from responses on a mail-in permit, had never been estimated from an independent source.

The success of the enhancement activities is unknown because they have not been adequately monitored (Lewis and Zadina 2001). Hatchery-produced sockeye salmon fry, for example, were not distinguishable from the wild stock until a thermal marking program was started in 1999. The number of coded wire tags recovered in the commercial fishery was low most years and were collected in mixed-stock fisheries from multiple subdistrict landings on fish tenders. Collection of tagged fish from spawning adults was not done consistently throughout the run during the ten years coded wire tags were returning to this system. Apparently the nature of the fisheries (mixed-stock) and the cost of observing returning fish for tags did not allow for a successful coded-wire tag study in the Klawock system. Despite assessment and enhancement efforts in the Klawock watershed, sockeye salmon returns to the lake continue to remain below historical levels.

The Klawock Lake Sockeye Salmon Stock Assessment Project (FIS 00-043) is one of eight projects, initiated in 2001 and funded through the U.S. Fish & Wildlife Service Fisheries Resource Monitoring Program, to assess significant subsistence sockeye salmon runs in Southeast Alaska. The Klawock Lake Project identifies and outlines a set of objectives to begin assessing the state of this sockeye salmon stock. In 2001, the project collected lake ecology, escapement, and subsistence harvest data 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 juvenile 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. 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, are indicators of sockeye salmon

response to conditions within the lake and were estimated. The proportion of hatchery-produced sockeye salmon smolt was estimated using otolith analysis. A two-sample mark-recapture study was conducted to test the integrity of the weir and to provide an independent estimate of sockeye salmon escapement. The mark-recapture component was considered especially important due to the history of incomplete sockeye salmon escapement counts at the Klawock weir (Lewis and Zadina 2002). We used a creel survey to estimate the subsistence harvest of sockeye salmon in Klawock Inlet. The subsistence harvest combined with escapement and age-composition data enables us to estimate spawner-recruit relationships. This report summarizes the sockeye salmon stock assessment data collected in 2001.

OBJECTIVES

1. To estimate subsistence harvest of sockeye salmon in Klawock Inlet through an on-site survey.
2. To estimate escapement of sockeye salmon into Klawock Lake through a weir and mark-recapture experiment.
3. To estimate rearing density of sockeye salmon fry in Klawock Lake using hydroacoustic and trawl survey methods.
4. To estimate and evaluate lake productivity.
5. To describe the size and age structure of sockeye salmon fry, smolt, and adult populations.

STUDY SITE

The Klawock River system (ADF&G stream number 103-60-047) is located on the southwestern side of Prince of Wales Island (55°32'58" N., 133°02'39" W.; Figure 1). The lake has a surface area of 11.9 km^2, an elevation of 9.1 m, a mean depth of 17.7 m, a maximum depth of 49.0 m and a volume of 209 x 10^6 m^3 (Figure 2). This dimictic lake is organically stained with a mean euphotic-zone depth of 4.2 m based on the 1986–1988 limnological data.

Klawock Lake is divided into two basins: Basin A and Basin B. Basin A, near the outlet, contains sample stations A and C, and Basin B contains sample stations B and D (Figure 2). Basin A has a maximum depth of 30 m and is generally shallower than Basin B. Basin B has a maximum depth of 49 m. There are four main tributaries to Klawock Lake: Hatchery Creek, Half-Mile Creek, Three-Mile Creek, and an unnamed creek at the head of the lake referred to herein as Inlet Creek (Figure 2). Basin A is fed by three of the four larger inlet streams in Klawock Lake. Except for several small-unnamed tributaries, only Inlet Creek at the head of the lake flows into Basin B. The drainage area for Basin A and B are 76.1 km^2 and 37.6 km^2 respectively. The lake empties into Klawock Inlet via the Klawock River (2.85 km). The Prince of Wales hatchery, adult weir, and smolt trap are located on the Klawock River approximately 300 m below the lake.

Native fish species include cutthroat trout (*Oncorhynchus clarki* spp.), Dolly Varden (*Salvelinus malma*), three spine stickleback (*Gasterosteus aculeatus*), cottids (*Cottus* sp.), steelhead (*O. mykiss*), pink (*O.*

gorbusha), chum (*O. keta*), coho (*O. kisutch*), and sockeye (*O. nerka*) salmon. A species of mysid shrimp (*Neomysis mercedis*) is also present in the lake.

METHODS

Sockeye Fry Assessment

The distribution and abundance of sockeye salmon fry were estimated by hydroacoustic and mid-water trawl sampling. Klawock 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 sampling area to survey. These cross-lake transects started and ended at a depth of 10 m and each transect was surveyed twice to get a repeated measure. Sampling was conducted in the darkest part of the night. A constant boat speed of about 2.0 m $\cdot$ sec^{-1} was attempted for all transects. The acoustic equipment consisted of a Biosonics[2] DT-4000™ scientific echosounder[2] (420 kHz, 6° single beam transducer) and Biosonics Visual Acquisition© version 4.0.2 software was used to record the data. Ping rate was set at 5 pings $\cdot$ sec^{-1} and pulse width at 0.4 ms. 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. Data were analyzed using Biosonics Visual Analyzer© version 4.0.2 software. Echo integration was used to generate a fish density (fish $\times$ m^{-2}) for each of the ten sample areas (MacLennand and Simmonds 1992). A population estimate for each of the ten sample areas was calculated as the product of fish density and the surface area of each of the ten sample 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 of transects. The average between these two estimates was used as the total population estimate for Klawock 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. We also compared fish densities between lake basins for 1986, 1987, 1988, 2000, and 2001.

Trawl sampling was conducted in conjunction with hydroacoustic surveys to determine the species composition of targets. A 2 m $\times$ 2 m elongated trawl net was used for pelagic fish sampling. Trawl depths and duration were determined by fish densities and distributions observed during 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 (0.1g) 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 further 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. In instances of discrepancy between the two age determinations, a third independent examination was conducted. The species and age composition of the trawl sample was used to apportion the hydroacoustic population estimate.

[2] Product names used in this publication are included for scientific completeness but do not constitute product endorsement.

Sockeye Salmon Smolt Age, Length, and Otolith Characteristics

Sockeye salmon smolts were collected and preserved from the Klawock River from 24 April through 8 June 2001 to determine stock age structure, size distribution, and to determine the proportions of natural and hatchery produced sockeye salmon smolt. All trapping efforts were conducted at the weir located adjacent to the Prince of Wales Hatchery on the Klawock River. Smolts were collected with a fyke net during the early part of the sampling effort due to low river discharge. As spring discharge increased an eight-foot diameter screw trap was used in place of the fyke net. An estimate of the total smolt population was not determined. Twenty smolts were sub-sampled daily for biological characteristics. If less than twenty fish were caught in a day all smolts were sampled. Smolts were weighed to the nearest 0.1 g and snout-fork length was measured to the nearest mm. Scales were collected and mounted on microscope slides for subsequent ageing.

Sockeye salmon smolt ageing was conducted through the microscopic examination and interpretation of scale growth patterns per Mosher (1968). Two trained technicians using a Carton microscope with a video monitor independently aged each smolt. The results of each independent scale ageing were compared and where instances of discrepancy between the age determinations was observed a third independent examination was conducted.

In 1999 the Prince of Wales Hatchery began thermally marking otoliths of all hatchery-produced sockeye salmon fry to distinguish hatchery fry from wild fry. Each year, a distinct circuli pattern is set on the otolith by altering incubation temperatures (John Bruns PWHA, personal communication). The otoliths of sockeye salmon smolts were examined by the ADF&G otolith laboratory staff to determine the proportion of hatchery versus naturally-produced sockeye salmon smolts left in the Klawock system.

Sockeye Escapement Estimates

The Klawock River weir is owned and operated by the Prince of Wales Hatchery. In conjunction with a mark-recapture program, daily counts of all fish species were conducted at the Klawock River weir to estimate sockeye salmon escapement. Additional biological data was collected on sockeye salmon including sex, mid-eye to fork length, and scales for ageing. The weir is located next to the Prince of Wales Hatchery, approximately 300 m below Klawock Lake. The weir is 49 m long, 3–4 m high and has a picket spacing of 2.54 cm. Pickets are composed of rigid 2.54 cm aluminum conduit. Three horizontal channels hold the pickets in place. An additional channel is added to the bottom of the pickets in deeper sections of the river. The substrate under the pickets is composed of cobble and gravel. Visual inspections of the weir were conducted on a daily basis in addition to a couple early season scuba and snorkel inspections.

A two-sample mark-recapture study was conducted to test the integrity of the weir and to provide an independent estimate of sockeye salmon into Klawock Lake. The mark-recapture component was considered especially important due to the history of incomplete sockeye salmon escapement counts at the Klawock weir (Lewis and Zadina 2002). Sockeye salmon were marked daily at the weir at a rate of 30% throughout the duration of the run. Marking was stratified through time: a left ventral fin clip was used from 20 June to 17 July, a right ventral fin clip from 18 July to 17 August, and a dorsal fin clip during the remainder of the run. The recapture portion of the study was conducted on the spawning grounds every

two weeks in Half-Mile, Three-Mile, and Inlet creeks beginning on 15 August. Hatchery Creek was not included in the study of low fish counts. Live and dead fish were counted and examined for marks. Each fish captured was given a second mark (opercle punch) to prevent duplicate sampling in a later sampling period. Stream counts of spawning sockeye salmon were also used to describe the spawning distribution between tributaries of Klawock Lake. We used Stratified Population Analysis System (SPAS) software (Arnason et al. 1996) to generate a Darroch estimate of sockeye escapement with data stratified by Three-Mile and a pooled Half-Mile and Inlet creek strata and no time stratification SPAS program.

Escapement Age and Length Distribution

Age and size characteristics of the adult sockeye salmon were collected at the weir during the mark-recapture study to describe the biological structure of the population. The goal was to collect 600 samples through the spawning season. 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 aged at the ADF&G Salmon Aging Laboratory in Douglas, Alaska. Age classes were designated following 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).

Subsistence Harvest Estimate

During the 2001 sockeye salmon subsistence fishery season a single stage study design creel census was conducted. Klawock Cooperative Association personnel conducted all creel survey interviews. Three sample days were randomly selected for each five-weekday opening. Each sample day was divided into two periods, morning (0800-1500) and evening (1500-2200). Both morning and evening shifts were sampled on the randomly selected days. The creel census operational plan is presented in Appendix 4.

Data Analysis

Equations for estimation of harvest were those for a single stage study design (Bernard et al. 1998; Cochran 1977). The harvest data was pooled for the entire season, and the total harvest (by species) was estimated as:

$$\overline{H} = \frac{\sum_{i=1}^{m} h_1}{m} \qquad (1)$$

$$\hat{H} = M\overline{H} \qquad (2)$$

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

$$\mathrm{var}\left[\hat{H}\right] = (1 - f)M^2 \frac{\sum_{i=1}^{m} (\hat{H}_1 - \overline{H})^2}{m(m-1)}, \qquad (3)$$

where f = fraction of days that were sampled, M = number of days in the season, and m = number of days in the season that were sampled.

Limnology

Limnology sampling was conducted at stations A and B on Klawock Lake on 9 May, 12 June, 26 July, 6 September, and 18 October to measure euphotic zone depth, temperature, and dissolved oxygen by depth and collect water samples for chemical analysis. Zooplankton were sampled on the same dates at all four stations.

General Water Quality, Metals, and Nutrients

A Van Dorn sampler was used to collect water quality samples from the epilimnion at the 1 m depth, mid-euphotic depth, euphotic depth, and mid-hypolimnion. Mid-euphotic and euphotic sample depths were calculated from on-site light meter measurements. Eight liters of water were collected from each depth, stored in pre-cleaned polyethylene carboys, transported to Ketchikan, and then filtered or preserved for laboratory analysis. Separate sub-samples from each carboy were: (1) refrigerated for general tests and metals; (2) frozen for nitrogen and phosphorus analysis; and (3) filtered through 0.7 µm particle retention glass fiber filters and frozen for analysis of dissolved nutrients and chlorophyll *a* (Koenings et al. 1987). Water quality parameters, as defined by Koenings et al. 1987, included conductivity, pH, alkalinity, turbidity, color, calcium, magnesium, iron, total phosphorous (TP), total filterable phosphorous (TFP), filterable reactive phosphorous (FRP), total particulate phosphorous (TPP), total kjeldhal nitrogen (TKN), ammonia, nitrate plus nitrite, reactive silica (RSi), and carbon (C). In addition, total nitrogen (TN) was calculated by summing the total Kjeldhal nitrogen (TKN) and nitrate plus nitrite from each sample (Appendix 1).

Vertical Light Penetration, Temperature, and Dissolved Oxygen

Measurements of under-water light penetration (footcandles) were taken at 0.5 m intervals, from the surface to a depth equivalent to one percent of the subsurface light reading (5 cm), using a Protomatic International Light submarine photometer. Vertical light extinction coefficients (K_d) were calculated as the slope of the light intensity (natural log of percent subsurface) versus depth. The euphotic zone depth

= 4.6205/ K_d (Kirk 1994). Euphotic volume (EV) is the product of the EZD and lake surface area and represents the volume of water capable of photosynthesis.

Temperature (^oC) was measured at 1 m intervals from the lake surface to generate a vertical temperature profile and to measure the depth of the thermocline. Dissolved oxygen (mg x L^{-1}) was measured at 1 m depth intervals from the lake surface to within 2 m of the lake bottom, with an YSI model 58 meter dissolved oxygen and temperature meter. Dissolved oxygen was calibrated each sampling trip with a 60 ml Winkler field titration (Koenings et al. 1987).

Secondary Production

Zooplankton are the primary food for sockeye salmon and cladocerans are their preferred food within the zooplankton community. By estimating the biomass and number of zooplankton by species throughout the season, we can observe how the species composition changes over the season and between years. This information may provide insight into how the zooplankton community responds to different fry densities and adult escapement levels. Zooplankton samples were collected at four stations on Klawock Lake with a 0.5 m diameter, 153 um mesh, 1:3 conical net. Vertical zooplankton tows were pulled from 1 m above the station depth at a constant speed of 0.5 m sec^{-1}. 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 (1957), Pennak (1978), Wilson (1959), and Yeatman (1959). Zooplankton were counted 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 (Y-axis) regressed against zooplankter length (X-axis; 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.

Zooplankton density data from the four sample stations were analyzed with a repeated measures analysis of variance. Four sample dates in 2000 and five sample dates in 2001 were analyzed and reported below. Variance was calculated for the paired stations in each basin. Zooplankton were reported by species and by the sum of all species (referred to as total zooplankton density).

RESULTS

Sockeye Fry Assessment

The Prince of Wales Hatchery released 317,000 emergent sockeye salmon fry into Klawock Lake on 3 April 2001 (ADF&G tag lab data base January 2002). All hatchery produced sockeye salmon fry had

thermally marked otoliths (John Bruns, PWHA, personal communication). A hydroacoustic survey and two 30-minute mid-water trawls at a depth of 10 m were conducted on 10 July 2001. The two tows caught a total of 121 sockeye salmon fry. All fish caught, except one (which was age 1), were less then 50 mm, thus assumed to be age 0 (Figure 3). The sockeye salmon fry had a mean snout-fork length of 31.6 mm (SE = 0.5) and a mean weight of 0.24 g (SE = 0.01) (Table 1). Since no other species of fish were sampled in our trawls, we assumed that all targets that fell within target strength range of –50 dB to –68 dB during hydroacoustics were sockeye salmon fry. A total lake population of 718,000 sockeye salmon fry (range of repeated measure was 704,000 to 747,000 fry) with a density of 0.068 fry $\cdot$ m^{-2} (range of repeated measure was 0.065 to 0.070 fry $\cdot$ m^{-2}) was estimated from the hydroacoustic survey (Table 1). In the between basin comparison, sockeye salmon fry densities were higher in Basin B compared to Basin A in all years except 1986 (Table 2).

Sockeye Smolt Age, Length, and Otolith Characteristics

Of the 568 sockeye salmon smolts aged, 87% were age 1 (n = 494) and 13% were age 2 (n =74). The mean fork length of age-1 and age-2 smolts was 79.4 mm (SE = 0.3) and 127.7 mm (SE = 1.7) respectively. The mean weight of age-1 and age-2 smolts was 4.25 g (SE = 0.05) and 17.39 g (SE = 0.58) respectively. Age distribution determined by scale analysis was corroborated by the bimodal sockeye salmon smolt length frequency distribution (Figure 4).

The Prince of Wales Hatchery released 353,000 thermally marked fed sockeye salmon fry: 18,000 on 29 April and 335,000 on 18 May 2000. In addition, 6,000 fry with no thermal mark were released on 18 May 2000 (ADF&G tag lab database 2002). A year later, a total of fourteen age-1 sockeye salmon smolts (2.4%) had hatchery thermally marked otoliths out of 576 otolith samples collected at the smolt trap (Figure 4). The thermally-marked sockeye smolts were all age 1.

Sockeye Escapement Estimates

Of the total 7,236 sockeye salmon adults counted through the Klawock River weir from 20 June to 10 October 2001, 2,213 were marked and released above the Klawock River weir for the mark-recapture population estimate (Table 3; Appendix 1). The following marks were applied based on season: 187 left ventral (LV) fin clips, 1,638 right ventral (RV) fin clips, and 388 dorsal (D) fin clips (Table 3). A total of 737 sockeye salmon were examined in three inlet streams of which 96 were marked (9 LV, 82 RV, and 5 D; Table 4). A Darroch estimate of a total of 14,057 (SE = 2,543, 95% normal confidence interval 9,073 to 19,041) sockeye salmon was generated by SPAS.

Foot escapement surveys in Three-Mile, Half-Mile, Hatchery, and Inlet creeks yielded peak spawning sockeye salmon counts. Three-Mile Creek had the highest sockeye salmon peak count of 2,277, followed by Inlet Creek with 356, and Half-Mile Creek with 129 (Table 5). Hatchery Creek had a peak count of 11 sockeye salmon on 11 September. In-stream sockeye salmon spawning densities appear to have peaked during the early part of September. No significant beach spawning was observed in Klawock Lake during 2001 during periodic shoreline surveys.

Escapement Age and Length Distribution

A total of 604 total adult sockeye salmon were sampled for sex, length, and scales at the Klawock River weir during 2001 field activities. The dominant age class of adult sockeye salmon weighted by statistical week was age-1.3 fish (53.6%) followed by age 2.3 (24.4%) (Table 6). The mean fork length of age-1.3 fish was 573 mm (SE = 2 mm; n = 297) and 572 mm (SE = 2 mm; n = 166) for age-2.3 fish (Table 7).

Subsistence Harvest Estimate

The estimated harvest of sockeye salmon in the subsistence fishery creel survey was 6,355 (95% confidence interval ± 1,056 fish) (Table 8). A total of 210 creel survey interviews were conducted during the open subsistence-fishing season. The pattern of harvest through time for each sample day varied throughout the fishery (Figure 5). The proportion of harvest and effort was evenly distributed between statistical weeks while the subsistence harvest fishery was open (Table 9). All sockeye salmon were caught in the estuary area near the bridge in the town of Klawock. The reported harvest from returned subsistence permits is not available at this time.

Limnology

General Water Chemistry

Typical of lakes in Southeast Alaska, Klawock Lake is a stained, oligotrophic, dimictic lake. Although multiple water properties were analyzed, only a select number of parameters are presented in the results and discussion sections of this report (see Appendix 2 for details). Similar to other Southeast lakes, phosphorus levels in Klawock Lake appear to limit production because phosphorus was the least abundant element of the nutrients required for algal growth. Seasonal mean total phosphorous (TP) concentrations were higher in Basin A than in Basin B. The seasonal mean concentration of TP at Station A was 5.8 $ug \cdot L^{-1}$ and ranged from 3.5 to 24.7 $ug \cdot L^{-1}$. The seasonal mean concentration of TP at Station B was 5.1 $ug \cdot L^{-1}$ and ranged from 3.2 to 12.9 $ug \cdot L^{-1}$. Nitrogen is also essential for phytoplankton production. Similarly, seasonal mean TKN concentrations were higher in Basin A than in Basin B. The concentration of TKN at Station A was 104.6 $ug \cdot L^{-1}$ and ranged from 23.9 to 244.0 $ug \cdot L^{-1}$. The concentration of TKN at Station B was 95 $ug \cdot L^{-1}$ and ranged from 64.7 to 139.4 $ug \cdot L^{-1}$ (Appendix 2).

Primary productivity parameters include chlorophyll *a* (chl *a*) and phaeophyton *a*. Algal biomass, essential for sockeye salmon nursery lakes, is defined as the phytoplankton standing crop and is represented by the algal pigment production of chlorophyll *a*. The seasonal mean epilimnetic Chl *a* concentration at Station A was 0.47 $ug \cdot L^{-1}$ and ranged from 0.32 to 0.59 $ug \cdot L^{-1}$ (Table 10). The seasonal mean epilimnetic Chl *a* concentration at Station B was 0.53 $ug \cdot L^{-1}$ and ranged from 0.31 to 0.92 $ug \cdot L^{-1}$ (Table 10). These low concentrations are typical of Southeast Alaska stained lakes with shallow euphotic zones (Zadina and Heinl 1999, Zadina and Weller 1999). However, chl *a* degrades to

phaeophyton *a* from changes in light, temperature, and pH. This inactive pigment can bias estimates of chl *a* and was therefore included in the tests. Phaeophyton *a* concentrations ranged from 0.06 to 0.34 $ug \cdot L^{-1}$ at Station A and 0.06 to 0.41 $ug \cdot L^{-1}$ at Station B (Table 10).

Vertical Light Penetration , Temperature, and Dissolved Oxygen

Vertical light penetration is measured to define the depth to which photosynthesis occurs. At Station A, the 2001 euphotic zone depth (EZD) ranged from 3.67 to 4.71 m with a season mean of 3.97 m (Table 11). At Station B, the 2001 EZD ranged from 3.83 to 4.98 m with a season mean of 4.50 m (Table 11). The mean EZD for Station A for five years (1986–1988 and 2000–2001) was 4.09 m with a range of 2.76 to 6.12 m (Table 11). The five-year-mean EZD for Station B (1986–1988 and 2000–2001) was 4.31 m with a range of 2.67 to 5.66 m (Table 11).

Water temperature and dissolved oxygen vertical profiles for Stations A and B in 2001 showing the stratification pattern are presented in Figures 6 and 7. Seasonal temperature profiles indicated that Klawock Lake was generally stratified during the summer. Peak epilimnetic temperature in the entire lake was 16.5^{o} C on 26 July 2001 at Station B. Hypolimnetic temperatures varied between 5.9 and 6.6^{o} C at Station B, located at the deeper of the two lake basins. Klawock Lake is stratified in the summer, inversely stratified in the winter, and becoming a free-flowing, isothermic water body in the fall and spring. Dissolved oxygen (DO) levels for 2001 ranged between 8.4 and 10.7 $mg \cdot L^{-1}$ at Station A and 8.7 and 11.0 $mg \cdot L^{-1}$ at Station B.

Secondary Production

In 2001, the macrozooplankton assemblage in Klawock Lake was composed of two species of copepod (*Cyclops* sp. and *Epischura* sp.), and three species of cladocerans (*Bosmina* sp., *Daphnia rosea*, and *Holopedium* sp.). At all stations the dominant form by biomass and density was *Cyclops* sp. (Tables 12 and 13). The seasonal mean total macro-zooplankton density in Basin A was 61,000 plankters $\cdot m^{-2}$ (Station A) and 78,000 plankters $\cdot m^{-2}$ (Station C). The seasonal mean weighted macro-zooplankton biomass in Basin A was 117 $mg \cdot m^{-2}$ (Station A) and 160 $mg \cdot m^{-2}$ (Station C) (Table 12). The seasonal mean total macro-zooplankton density in Basin B was 190,000 plankters $\cdot m^{-2}$ (Station B) and 120,000 plankters $\cdot m^{-2}$ (Station D) (Table 13). The seasonal mean weighted macro-zooplankton biomass in Basin B was 350 $mg \cdot m^{-2}$ (Station B) and 241 $mg \cdot m^{-2}$ (Station D) in 2001 (Table 13).

A repeated measures analysis of 2000 zooplankton density data revealed statistically significant higher densities of Epischura (p=0.02), Cyclopoid (p=0.01), Bosmina (p<0.01), and total zooplankton (p=0.02)in Basin B compared to Basin A (Table 14). The analysis found no significant difference between basins for Daphnia (p=0.11; Table 14).

The repeated measures of 2001 zooplankton density data revealed statistically significant higher densities of Bosmina (p=0.0) and Daphnia (p=0.03) in Basin B compared to Basin A (Table 14). The analysis found no significant difference between basins for Epischura (p=0.49), Cyclopoid (p=0.62), and total zooplankton (p=0.28; Table 14).

DISCUSSION

In the first year of sockeye salmon stock assessment in Klawock Lake, the Subsistence Sockeye Salmon Project completed its objectives to estimate the subsistence harvest, the adult sockeye salmon escapement, and the sockeye salmon fry population as well as to describe the size and age structure of fry, smolt, and adult sockeye salmon populations and the productivity of Klawock Lake. In addition to the standard stock assessment methods used in other years, this study added a creel survey to directly estimate the subsistence harvest and a mark-recapture study to estimate adult sockeye salmon escapement.

We compared the biological characteristics of juvenile and adult sockeye salmon collected in 2001 to other years to determine if the length and age structure of the population is changing. The mean length and weight of sockeye salmon fry caught in the hydroacoustic survey tows were smaller than the range caught in 1986–1988 and 2000 fall surveys (46.1–66.8 mm). However, the survey in 2001 was performed mid-summer and we would expect substantial growth between July and September. In 1987, the only other year a mid-summer survey was performed, the average fry length was 37.0 mm compared to 31.6 mm in 2001. The age-1 sockeye salmon smolt in 2001 (79.4 mm) appeared to be on the low end of the length range compared to previous years (79.2–87.0 mm). However, 2001 age-2 smolt were larger than previous years. Consistent with other years, the majority of sockeye salmon smolt leaving Klawock Lake were age 1 and the dominant adult sockeye salmon returning was age 1.3.

The sampling of juvenile and adult sockeye salmon for thermally marked otoliths is an important component of the project. Monitoring the ratio of hatchery versus naturally produced sockeye salmon will provide insight into the survival rates of different life stages of hatchery and naturally produced sockeye salmon. Otolith analysis of fry captured in the mid-water trawl will provide a population estimate of hatchery-produced fry. The fry population estimate will be compared to the known number of fish stocked to determine the stocked fry to fall fry survival rate. Smolt otolith analysis will compare the ratio of hatchery to naturally produced smolt and fry and identify differences in over-winter survival rates. Adult otoliths analysis will quantify potential differences in ocean survival rates and an evaluation of enhancement activities.

Fry density is an indicator of sockeye salmon response to conditions within the lake. The sockeye fry assessment allows us to look at fry distribution throughout the lake; providing insight into nursery habitat utilization. Although the majority of the fry enter the lake in Basin A (hatchery and wild), estimates of fry density was higher in Basin B in four of five years (Table 2). This suggests that fry migrate to Basin B upon entering the lake. Higher densities of zooplankton in Basin B in this year and previous years (Lewis and Zadina 2001) could explain this potential migration pattern. In addition, Basin B is deeper, perhaps providing a better over-wintering habitat.

Comparisons of lake productivity between years and basins may be compromised by the close proximity (10 m) of net-pens to Station A in 2001. Large numbers of coho salmon are reared in the net-pens. The concentration of uneaten food and waste associated with rearing large numbers of coho salmon fry may distort water chemistry results. In addition, high concentrations of unused food and waste could affect lake productivity. For example the concentrations of TP (24.7 $ug \cdot L^{-1}$) and TKN (244 $ug \cdot L^{-1}$) on 14 June 2001 water chemistry were elevated compared to samples taken in Basin B (Appendix 2). However, water chemistry differences were not expressed at higher trophic levels. In prior years the net pens were located further away from the sampling station.

There was a substantial discrepancy between the weir (7,000) and the mark-recapture estimate (14,000) of the number of sockeye salmon adults returning to Klawock Lake. The difference is either due to

uncounted fish through the weir or a failure of standard mark-recapture assumptions. The uncounted fish through the weir hypothesis is supported by the decline of the marked/unmarked ratio observed on the spawning grounds before and after a high water event on 27 August last year. Prior to 27 August, 29% of the sockeye salmon spawners observed in Three-mile Creek were marked compared to 30% marked at the weir. The 1% difference was consistent with handling mortality observed on other ADF&G weirs (Steve Heinl, ADF&G, personal communication). Fish were observed passing uncounted through a gap in the weir on 27 August when the water was high. Although the gap in the weir was quickly mended, it was unknown how long fish passed through the gap undetected. After the high water event, the marked/unmarked ratio declined to 21% by 13 September and to 10% in subsequent recapture sampling events before leveling off. We know from decades of operating salmon weirs in Southeast Alaska, that large numbers of fish tend to pulse through a weir during high water periods. We have also documented through mark-recapture studies at other weirs that weirs are difficult to keep fish-tight even when high water events do not occur and the weir crew inspects the weir daily (Ben Van Alen, ADF&G, personal communication). Consequently, it is possible that roughly 7,000 sockeye salmon swam by the weir undetected when the water was high or through unidentified gaps. The crew will perform more frequent scuba dives to check weir integrity and possibly set up the underwater video in strategic or problem areas where splayed pickets or gaps may be a concern.

A mark-recapture process must meet the underlying assumptions in order for the estimate to be considered unbiased. Violations of the assumptions could inflate the mark-recapture estimate if: 1) the population is not closed, 2) the mark effects catchability of marked fish during the recapture sampling event, 3) the fish looses the mark, 4) there is substantial handling-induced mortality, 5) marked and unmarked fish do not mix, or 6) marks are missed or not recorded during the recovery phase of the study. Klawock River is the only outlet to the lake and no marked fish were observed backing out of the system through the weir. Therefore, it is safe to assume that the unmarked sockeye salmon were leaving the population undetected. Different catchability rates between marked and unmarked fish are not likely a problem because the fish are caught (weir trap) and recaptured (seine net) with different gear. Because the fish were marked with a fin clip, mark loss is not probable unless the entire fin is missing or mangled. The lack of opportunity for marked and unmarked fish to mix is difficult to prove but there was no indication that the marks were not distributed randomly in the recapture event. Although it is possible that marks were missed on the spawning grounds, this was not likely due to the training and experience of the technicians. Handling mortality occurring between the marking and recapture events could elevate the population estimate. The crew did not examine dead sockeye salmon on the weir for spawning condition or marks. In 2002, the crew will examine all dead sockeye salmon washed up against the weir to determine if they have spawned or died prior to spawning and if a mark is present. In addition, a subset of marked sockeye salmon will be held for 24-hours to document any short-term mortality.

A potential future impact on Klawock Lake sockeye salmon is a proposed water diversion on Three-Mile Creek for Klawock city water. Peak foot escapement surveys confirmed that Three-Mile Creek was the primary spawning stream for sockeye salmon in 2001. A review of historical fisheries data found no documentation, beyond anecdotal accounts, identifying the primary sockeye salmon spawning habitat in Klawock Lake (Lewis and Zadina 2001). Three-Mile Creek has the largest amount of spawning habitat (5,800 m^{-2}) of any of the main tributaries to Klawock Lake.

Despite assessment and enhancement efforts in the Klawock watershed, sockeye salmon returns to the lake continue to remain below historical levels. We think the enhancement objectives and activities must take into account information gathered during stock assessment research and, if necessary, be modified, We will continue to develop cooperative partnerships, job, and training opportunities with the community of Klawock. Restoration of the riparian areas and stabilization of the stream hydrology are also essential elements of the recovery of healthy stocks in Klawock Lake and these activities are being initiated by other agencies. None of these research and project directions can be completed in a few years. Instead,

they require consistent attention, on-going re-evaluation and coordination with the community to work toward rebuilding sockeye salmon returns to Klawock Lake that are sustainable for many years to come.

NOTE: Additional project benefits beyond those originally identified in the proposal obtained in 2001 included the determination of the proportions of hatchery versus naturally produced sockeye salmon smolts. Mary Edenshaw of the Klawock Cooperative Association (KCA) initiated a trial cooperative agreement with the ADF&G to issue subsistence permits from the KCA offices in Klawock. This successful agreement was well received by KCA staff and the public. We intend to continue this cooperative effort during the 2002 subsistence fishery.

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Table 1. Summary of hydroacoustic population and mid-water trawl abundance estimates of rearing sockeye salmon fry and other captured species in Klawock Lake, 1986–2001.

Sample Date	Total Population Estimate	Species	Percent of Species	Total No. of Species	Age (*n*)	Mean Length (mm)	Mean Weight (g)
9/21/86	1,009,000	Sockeye	90.38%	912,000	0	46.1	1.04
		Stickleback	7.69%	78,000	N/A	74.3	6.50
		Cottids	1.92%	19,000	N/A	66.0	3.00
3/24/87	503,000	Sockeye	92.59%	466,000	0	31.3	0.23
					1	52.6	1.48
					3	110.0	14.40
		Stickleback	3.70%	19,000	N/A	96.0	10.10
		Coho	3.70%	19,000	2	130.0	24.00
7/08/87	Tow Net	Sockeye	95.65%		0	37.0	0.55
	Only	Cottids	4.35%		N/A	35.0	0.40
10/22/87	311,000	Sockeye	87.50%	272,000	0	58.1	2.24
		Stickleback	12.50%	39,000	N/A	93.0	8.60
4/14/88	350,000	Sockeye	100.00%	350,000	0	29.5	0.21
					1	52.6	1.37
					2	101.0	9.70
10/26/88	375,000	Sockeye	97.06%	364,000	0	66.8	3.24
					1	87.3	7.53
		Stickleback	2.94%	11,000	N/A	108.0	12.70
4/20/95	383,000	Sockeye	84.09%	322,000	0 (18)	36.1	0.39
					1 (14)	70.9	3.04
					2 (5)	94.6	7.78
		Stickleback	15.91%	61,000	N/A (7)	82.9	5.73
9/7/2000	311,000	Sockeye	100.00%	311,000	0 (5)	48.0	0.84
7/10/2001	718,000	Sockeye	100.00%	718,000	0 (121)	31.6	0.24

N/A – not available

Table 2. Hydroacoustic sockeye salmon fry densities (fry · m^{-2}) estimates in Basin A and Basin B in Klawock Lake.

Year	Date	Basin A	Basin B
1986	21 Sept	0.096	0.091
1987	22 Oct	0.025	0.064
1988	26 Oct	0.023	0.035
2000	7 Nov	0.024	0.036
2001	9 July	0.055	0.079

Table 3. Summary of adult sockeye salmon marking at the Klawock River weir by date and mark type, 2001.

Date	Clip	Marked	Unmarked	Total
20 Jun-17 Jul	LV	187	392	579
18 Jul-17 Aug	RV	1,638	3,536	5,174
18 Aug-10 Oct	D	388	1,095	1,483
Total		2,213	5,023	7,236

Table 4. Mark recovery data for Klawock Lake adult sockeye salmon by stream, date, and mark type, 2001.

Creek	Date	LV	RV	Dorsal	Unmarked	Total	%Marked
Three-Mile	15-Aug	0	0	0	6	6	0%
	27-Aug	3	8	0	27	38	29%
	13-Sep	0	12	1	68	81	16%
	25-Sep	4	6	0	100	110	9%
	26-Sep	0	5	0	70	75	7%
	1-Oct	0	5	0	50	55	9%
	9-Oct	0	0	1	9	10	10%
	11-Oct	0	0	0	2	2	0%
	12-Oct	0	3	0	55	58	5%
	22-Oct	0	0	0	7	7	0%
Half-Mile	10-Sep	1	14	1	68	84	19%
	24-Sep	0	4	0	28	32	13%
	4-Oct	0	1	1	6	8	25%
	9-Oct	0	0	0	7	7	0%
	11-Oct	0	0	0	7	7	0%
	22-Oct	0	0	0	2	2	0%
Inlet	31-Aug	1	12	0	57	70	19%
	17-Sep	0	9	0	45	54	17%
	26-Sep	0	3	1	27	31	13%

Table 5. Peak escapement counts of adult sockeye salmon in the Klawock Lake system by stream and date, 2001.

Creek	Date	Live Count	Dead Count
Three-Mile	15-Aug	11	0
	27-Aug	30	0
	9-Sep	2,277	12
	18-Sep	533	68
	26-Sep	105	62
	9-Oct	35	3
	22-Oct	21	1
Half-Mile	28-Aug	16	0
	30-Aug	90	0
	9-Sep	129	18
	24-Sep	59	7
	4-Oct	13	2
	22-Oct	13	1
Inlet	23-Aug	33	0
	30-Aug	181	0
	10-Sep	356	15
	17-Sep	152	14
	26-Sep	44	7
	4-Oct	4	1
Hatchery	11-Sep	11	7
	25-Sep	0	2

Table 6. Age composition of Klawock Lake adult sockeye salmon weighted by statistical week, brood year, and age class, for weir count and expanded escapement, 1 July to 22 September 2001.

Brood Year	1998	1997	1997	1996	1996	1995	1995	
Age	1.1	1.2	2.1	1.3	2.2	1.4	2.3	Total
Percent	0.7%	9.5%	0.2%	53.6%	11.5%	0.1%	24.4%	100.0%
Std. Error	0.3	1.5	0.2	2.5	1.5	0.1	2.2	
Weir Count	49	690	18	3,876	835	4	1,764	7,236
Escapement Estimate	98	1,335	28	7,535	1,617	14	3,430	14,057

Table 7. Mean fork length (mm) of adult sockeye salmon in the Klawock Lake escapement by sex, brood year, and age class, 1 July to 22 September 2001.

Brood year	1998	1997	1997	1996	1996	1995	1995	
Age	1.1	1.2	2.1	1.3	2.2	1.4	2.3	Total
Male Length	376	522	423	584	536		587	570
Std. Error	13.8	4.2	3	2.1	4.6		3	2.6
Sample Size	5	29	2	157	23		76	292
Female Length		506		561	526	535	559	549
Std. Error		4.8		2	3.2		2.3	1.7
Sample Size		29		139	52	1	90	311
All Fish Length	376	514	423	573	529	535	572	560
Std. Error	13.8	3.4	3	1.6	2.7		2.1	1.6
Sample Size	5	58	2	297	75	1	166	604

Table 8. Estimated number of salmon caught by species in the Klawock Inlet subsistence fishery during 2001 based on creel census.

	Total Catch	Lower Confidence Interval	Upper Confidence Interval
Sockeye	6,355	5,297	7,412
Chum	7	2	13
Pink	22	0	46
Coho	21	7	37

Table 9. Proportions of catch and participant count in the Klawock subsistence fishery during 2001 based on creel census.

Stat Week	Week Ending	Proportion of Catch	Proportion of Fishers	Count of Fishers
28	14-Jul	0.30	0.29	35
29	21-Jul	0.20	0.23	27
30	28-Jul	0.36	0.28	33
31[a]	4-Aug	0.14	0.20	24

[a] Fishery closed July 31.

Table 10. Chlorophyll *a* and phaeophyton concentrations for Klawock Lake by station, date and strata, 2001

Station A	9 May	13 June	26 July	6 Sept	18 Oct
EPI/Depth (m)	1	1	1	1	1
CHL A ($ug * L^{-1}$)	0.59	0.59	0.44	0.32	0.40
PHAEO ($ug * L^{-1}$)	0.06	0.34	0.16	0.15	0.12
MEU/Depth (m)	2	2.75	2.3	2	2
CHL A ($ug * L^{-1}$)	0.55	0.60	0.41	0.21	0.44
PHAEO ($ug * L^{-1}$)	0.09	0.34	0.14	0.21	0.13
EZD/Depth (m)	4	5.5	4.75	4	4
CHL A ($ug * L^{-1}$)	0.54	0.61	0.44	0.30	0.23
PHAEO ($ug * L^{-1}$)	0.09	0.33	0.18	0.24	0.38
HYPO/Depth (m)	20	25	20	22	20
CHL A ($ug * L^{-1}$)	0.48	0.12	0.08	0.21	0.33
PHAEO ($ug * L^{-1}$)	0.11	0.17	0.19	0.24	0.16
Station B					
EPI/Depth (m)	1	1	1	1	1
CHL A ($ug * L^{-1}$)	0.45	0.92	0.54	0.31	0.43
PHAEO ($ug * L^{-1}$)	0.06	0.19	0.23	0.41	0.14
MEU/Depth (m)	2.5	2.5	2.25	1.75	2.5
CHL A ($ug * L^{-1}$)	0.38	0.87	0.53	0.32	0.30
PHAEO ($ug * L^{-1}$)	0.09	0.27	0.27	0.23	0.13
EZD/Depth (m)	4.5	4.75	4.5	3.5	5
CHL A ($ug * L^{-1}$)	0.45	0.71	0.41	0.31	0.26
PHAEO ($ug * L^{-1}$)	0.09	0.20	0.25	0.23	0.12
HYPO/Depth (m)	35	35	30	40	40
CHL A ($ug * L^{-1}$)	0.28	0.08	0.08	0.05	0.17
PHAEO ($ug * L^{-1}$)	0.09	0.10	0.13	0.15	0.14

EPI=epilimnion, CHL A= chlorophyll *a*, PHAEO=phaeophyton, MEU=mid-euphotic zone, EZD=euphotic zone depth, HYPO=hypolimnion

Table 11. Euphotic zone depth (m) of Klawock Lake by year at Station A and B, 1986–2001.

1986	Station A	Station B
19-May	6.12	NA
4-Nov	3.14	2.67
Mean	4.63	2.67
1987		
27-Apr	4.60	5.66
20-Nov	2.79	2.50
Mean	3.69	4.08
1988		
15-Mar	3.31	NA
11-Aug	NA	4.01
16-Nov	3.78	4.77
Mean	3.55	4.39
2000		
19-May	4.72	4.54
27-Jun	5.21	5.00
17-Aug	4.07	4.72
26-Sep	3.62	3.95
Mean	4.41	4.55
2001		
9-May	3.72	3.83
12-Jun	NA	4.48
26-Jul	4.71	4.98
6-Sep	3.67	4.47
16-Oct	3.76	4.75
Mean	3.97	4.50

Table 12. Seasonal mean macro-zooplankton density (No. · m^{-2}) and mean weighted biomass (mg · m^{-2}) distributions by species in Basin A (Station A and C) of Klawock Lake, 2001.

Station A	Density	Percent	Biomass	Percent
Epischura	3,230	5.3%	28.6	24.4%
Cyclops	42,255	69.3%	62.9	53.8%
Ovigorous Cyclops	197	0.3%	0.6	0.5%
Bosmina	11,384	18.7%	12.3	10.5%
Ovigorous Bosmina	109	0.2%	0.2	0.2%
Daphnia r.	2,670	4.4%	8.6	7.4%
Ovigorous Daphnia r.	116	0.2%	0.7	0.6%
Holopedium	1,005	1.6%	2.3	2.0%
Ovigorous Holopedium	51	0.1%	0.8	0.7%
Station C				
Epischura	7,210	9.3%	43.6	27.2%
Cyclops	48,168	62.0%	69.5	43.5%
Ovigorous Cyclops	574	0.7%	1.6	1.0%
Bosmina	15,422	19.8%	15.8	9.9%
Ovigorous Bosmina	65	0.1%	0.2	0.1%
Daphnia r.	4,262	5.5%	12.3	7.7%
Ovigorous Daphnia r.	513	0.7%	2.8	1.8%
Holopedium	1,270	1.6%	9.5	5.9%
Ovigorous Holopedium	255	0.3%	4.5	2.8%

Table 13. Seasonal mean macro-zooplankton density (No. · m^{-2}) and mean weighted biomass (mg · m^{-2}) distributions by species in Basin B (Station B and D) of Klawock Lake, 2001.

Station B	Density	Percent	Biomass	Percent
Epischura	5,434	2.9%	50.7	14.5%
Cyclops	155,765	82.1%	248.5	71.0%
Ovigorous Cyclops	476	0.3%	1.4	0.4%
Bosmina	21,667	11.4%	24.7	7.0%
Ovigorous Bosmina	34	0.0%	0.1	0.0%
Daphnia r.	4,076	2.1%	12.0	3.4%
Ovigorous Daphnia r.	289	0.2%	1.8	0.5%
Holopedium	1,358	0.7%	7.7	2.2%
Ovigorous Holopedium	526	0.3%	3.4	1.0%
Station D				
Epischura	4,629	3.8%	46.4	19.3%
Cyclops	87,458	72.3%	139.1	57.7%
Ovigorous Cyclops	197	0.2%	0.6	0.2%
Bosmina	22,153	18.3%	27.3	11.3%
Ovigorous Bosmina	20	0.0%	0.0	0.0%
Daphnia r.	4,578	3.8%	14.2	5.9%
Ovigorous Daphnia r.	1,138	0.9%	6.4	2.7%
Holopedium	696	0.6%	5.1	2.1%
Ovigorous Holopedium	115	0.1%	1.8	0.7%

Table 14. Results of the repeated of mean zooplankton density (No. · m^{-2}) by year, species, and basin (± 1 standard error). Density is reported in thousands.

Year	Species	Basin A	Basin B	*df*	*F*-value	*P*-value
2000	Epischura	4.7 ± 1.5	9.4 ± 2.2	3	6.86	0.0229
	Cyclopoid	149.61 ± 27.7	307.4 ± 46.6	3	7.70	0.0176
	Bosmina	31.9 ± 13.1	44.8 ± 17.7	3	17.71	0.0022
	Daphnia	2.2 ± 13.1	4.7 ± 17.7	3	3.92	0.1108
	Total Zoop	320.7 ± 55.8	637.7 ± 110.6	3	7.11	0.0212
2001	Epischura	5.2 ± 1.9	5.0 ± 1.2	4	0.93	0.4907
	Cyclopoid	45.2 ± 12.1	121.6 ± 17.3	4	0.69	0.6213
	Bosmina	13.4 ± 3.8	21.9 ± 7.9	4	22.58	0.0013
	Daphnia	3.5 ± 1.8	4.3 ± 1.6	4	7.08	0.0315
	Total Zoop	67.3 ± 14.8	152.9 ± 21.1	4	1.55	0.2777

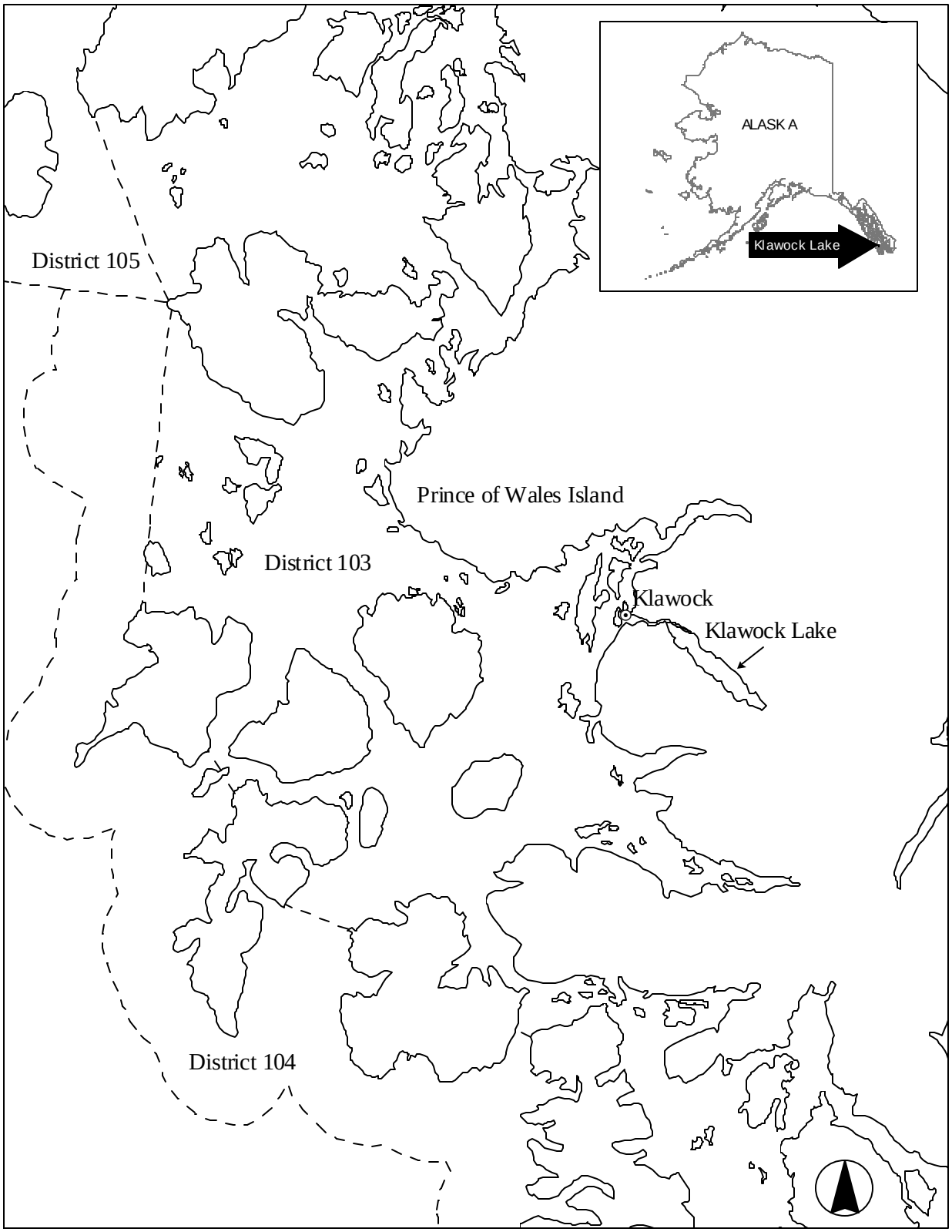

Figure 1. The geographic location of Klawock Lake, within the State of Alaska, and relative to commercial fishing districts 103 and 104 on west Prince of Wales Island.

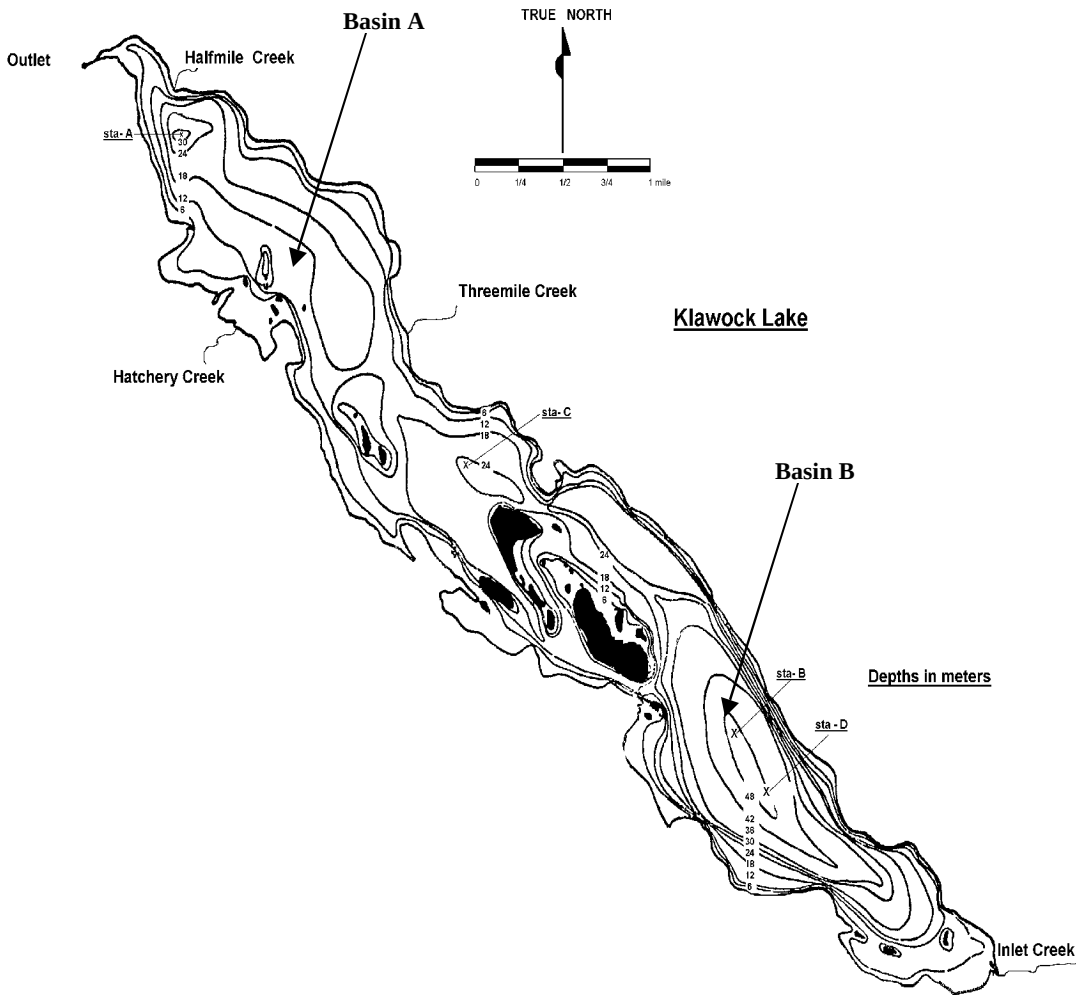

Figure 2. Bathymetric map of Klawock Lake, Southeast Alaska with limnological sampling stations and inlet stream references.

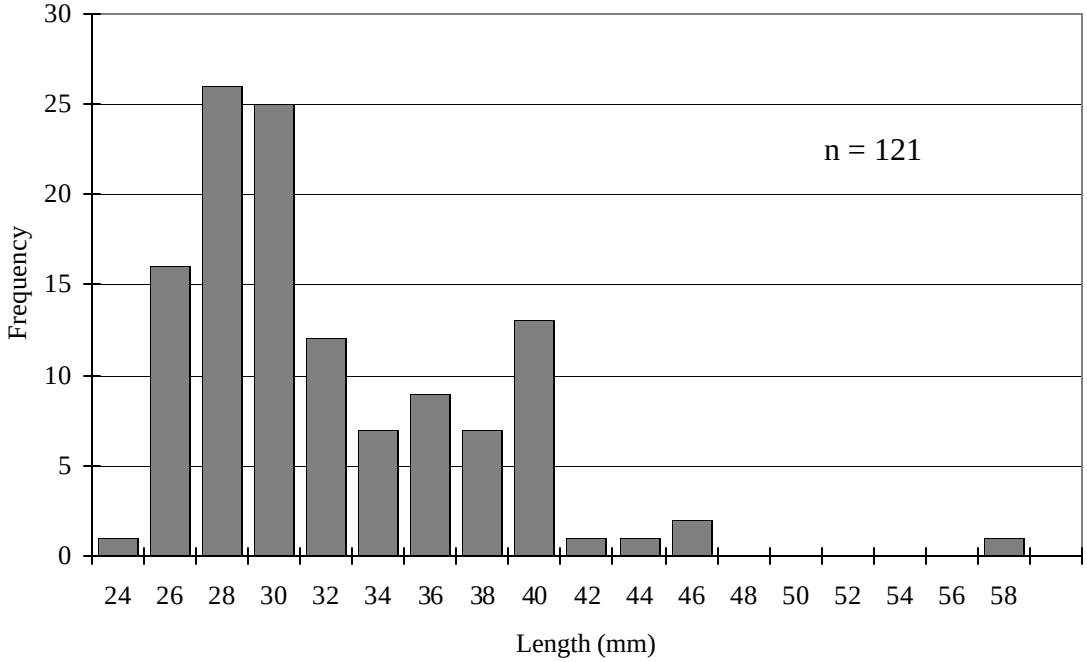

Figure 3. Length frequency distribution for sockeye salmon fry captured in the mid-water trawl during the 2001 hydroacoustic population survey.

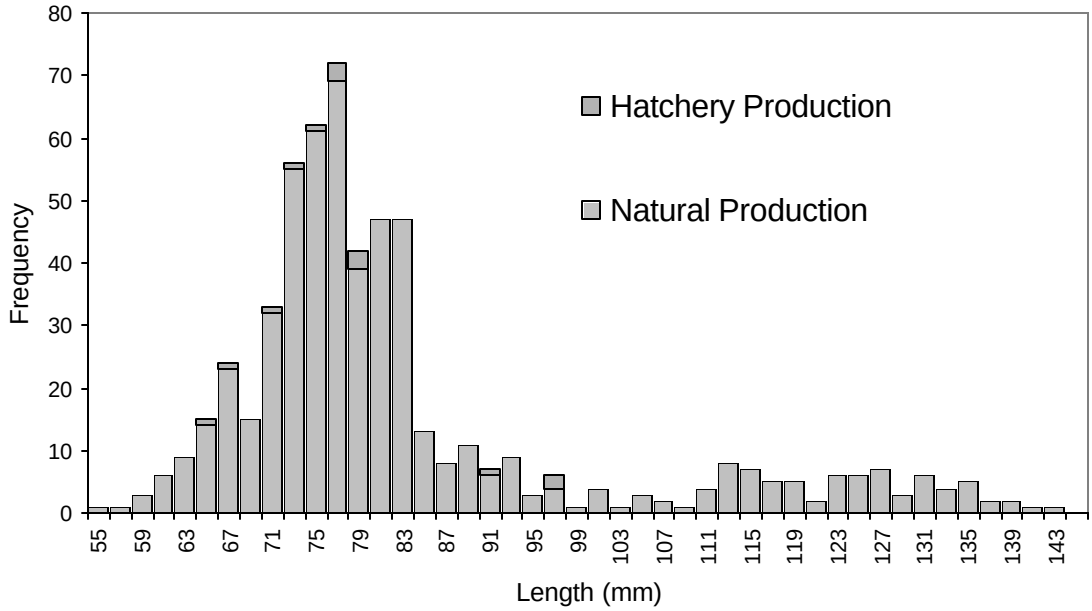

Figure 4. Length frequency histogram of Klawock Lake sockeye smolts with the proportion of hatchery and naturally produced fish determined through otolith thermal mark identification, 2001.

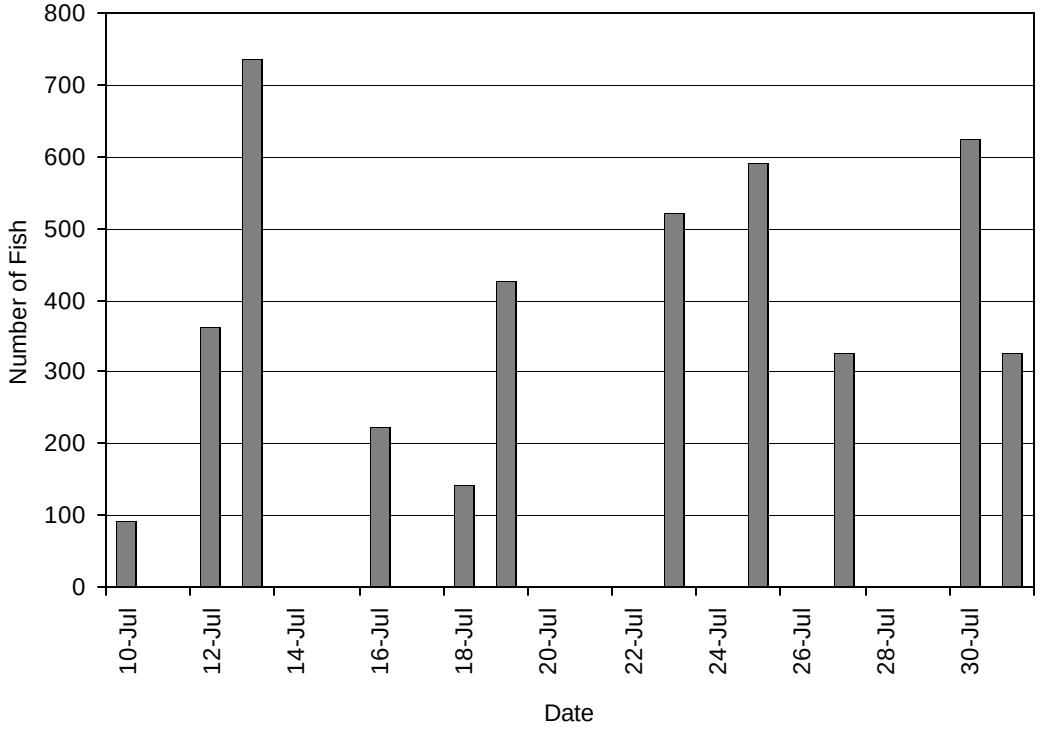

Figure 5 Estimated Klawock Inlet subsistence harvest of sockeye salmon on sampled dates in 2001.

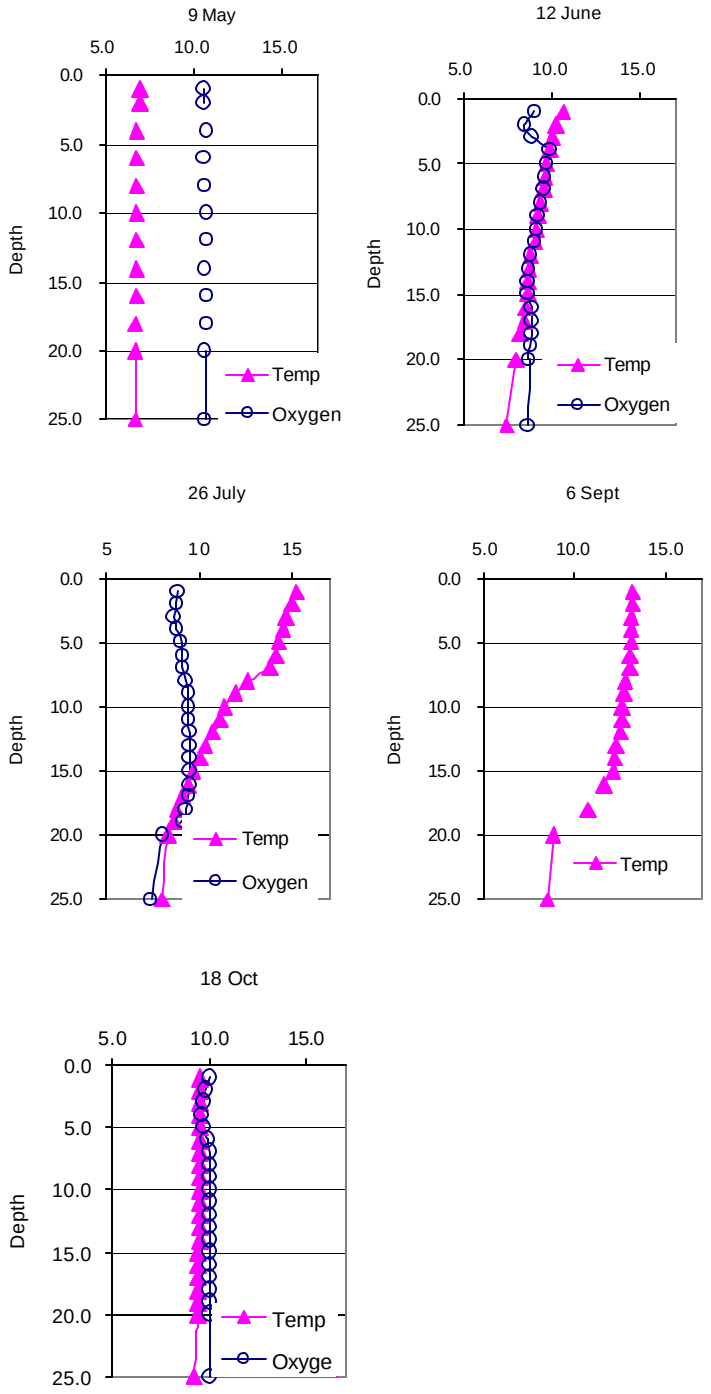

Figure 6. Temperature (°C) and dissolved oxygen (mg · L^{-1}) vertical (in meters) profiles by date at Station A in Klawock Lake, 2001.

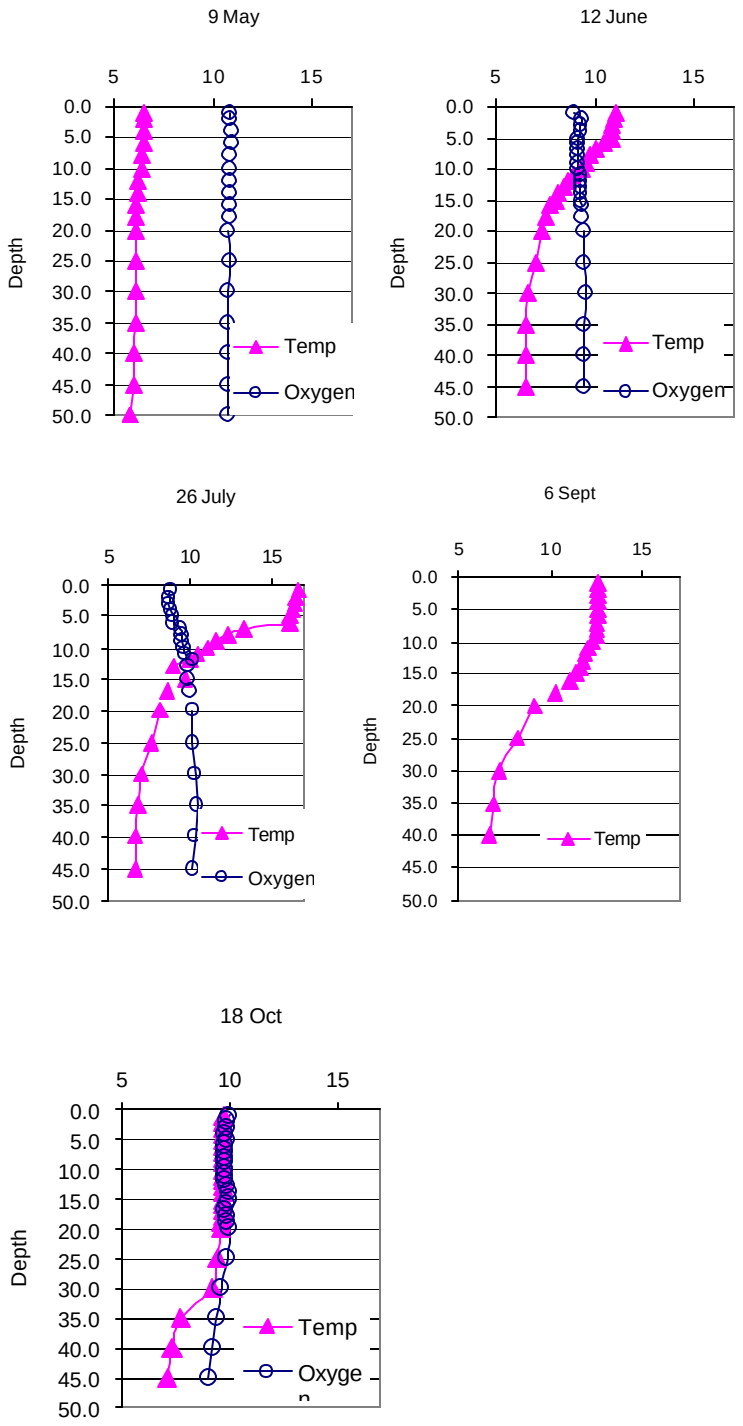

Figure 7. Temperature (°C) and dissolved oxygen (mg · L^{-1}) vertical (in meters) profiles by date at Station B in Klawock Lake, 2001.

APPENDIX

Appendix 1. Sockeye salmon counts at the Klawock River weir during 2001.

Date	Mark Type	Daily Mark	Cumulative Mark	Daily Unmark	Cumulative Unmark	Daily Total	Cumulative Total	% Marked
21-Jun	LV	0	0	0	2	0	2	0%
22-Jun	LV	0	0	2	4	2	4	0%
23-Jun	LV	0	0	2	6	2	6	0%
24-Jun	LV	0	0	0	6	0	6	0%
25-Jun	LV	0	0	0	6	0	6	0%
26-Jun	LV	0	0	0	6	0	6	0%
27-Jun	LV	0	0	0	6	0	6	0%
28-Jun	LV	0	0	2	8	2	8	0%
29-Jun	LV	0	0	7	15	7	15	0%
30-Jun	LV	1	1	0	15	1	16	6%
1-Jul	LV	1	2	0	15	1	17	12%
2-Jul	LV	12	14	32	47	44	61	23%
3-Jul	LV	8	22	2	49	10	71	31%
4-Jul	LV	25	47	38	87	63	134	35%
5-Jul	LV	12	59	41	128	53	187	32%
6-Jul	LV	58	117	68	196	126	313	37%
7-Jul	LV	6	123	18	214	24	337	36%
8-Jul	LV	0	123	0	214	0	337	36%
9-Jul	LV	3	126	11	225	14	351	36%
10-Jul	LV	0	126	0	225	0	351	36%
11-Jul	LV	0	126	0	225	0	351	36%
12-Jul	LV	0	126	2	227	2	353	36%
13-Jul	LV	0	126	2	229	2	355	35%
14-Jul	LV	30	156	75	336	137	492	32%
15-Jul	LV	18	174	43	379	61	553	31%
16-Jul	LV	0	174	6	385	6	559	31%
17-Jul	LV	13	187	7	392	20	579	32%
18-Jul	RV	13	200	14	406	27	606	33%
19-Jul	RV	0	200	0	406	0	606	33%
20-Jul	RV	0	200	11	417	11	617	32%
21-Jul	RV	0	200	0	417	0	617	32%
22-Jul	RV	0	200	3	420	3	620	32%
23-Jul	RV	31	231	73	493	104	724	32%
24-Jul	RV	67	298	216	709	283	1,007	30%
25-Jul	RV	21	319	12	721	33	1,040	31%
26-Jul	RV	3	322	23	744	26	1,066	30%
27-Jul	RV	4	326	14	758	18	1,084	30%
28-Jul	RV	0	326	0	758	0	1,084	30%
29-Jul	RV	0	326	0	758	0	1,084	30%
30-Jul	RV	30	356	73	831	103	1,187	30%
31-Jul	RV	12	368	39	870	51	1,238	30%
1-Aug	RV	86	454	213	1,083	299	1,537	30%
2-Aug	RV	218	672	744	1,827	1,084	2,621	26%

-continued-

Appendix 1. (page 2 of 3)

Date	Mark Type	Daily Mark	Cumulative Mark	Daily Unmark	Cumulative Unmark	Daily Total	Cumulative Total	% Marked
3-Aug	RV	280	952	863	2,690	1,143	3,764	25%
4-Aug	RV	0	952	0	2,690	207	3,971	24%
5-Aug	RV	61	1,013	8	2,698	69	4,040	25%
6-Aug	RV	199	1,212	114	2,812	353	4,393	28%
7-Aug	RV	190	1,402	223	3,035	413	4,806	29%
8-Aug	RV	42	1,444	22	3,057	64	4,870	30%
9-Aug	RV	20	1,464	13	3,070	33	4,903	30%
10-Aug	RV	20	1,484	33	3,103	53	4,956	30%
11-Aug	RV	25	1,509	69	3,172	94	5,050	30%
12-Aug	RV	24	1,533	4	3,176	28	5,078	30%
13-Aug	RV	97	1,630	75	3,251	172	5,250	31%
14-Aug	RV	45	1,675	79	3,330	124	5,374	31%
15-Aug	RV	54	1,729	76	3,406	130	5,504	31%
16-Aug	RV	59	1,788	91	3,497	150	5,654	32%
17-Aug	RV	37	1,825	62	3,559	99	5,753	32%
18-Aug	D	0	1,825	99	3,658	99	5,852	31%
19-Aug	D	89	1,914	104	3,762	193	6,045	32%
20-Aug	D	32	1,946	64	3,826	96	6,141	32%
21-Aug	D	87	2,033	260	4,086	347	6,488	31%
22-Aug	D	52	2,085	101	4,187	173	6,661	31%
23-Aug	D	11	2,096	28	4,215	39	6,700	31%
24-Aug	D	7	2,103	24	4,239	31	6,731	31%
25-Aug	D	28	2,131	51	4,290	79	6,810	31%
26-Aug	D	15	2,146	47	4,337	62	6,872	31%
27-Aug	D	42	2,188	105	4,442	167	7,039	31%
28-Aug	D	4	2,192	29	4,471	33	7,072	31%
29-Aug	D	0	2,192	9	4,480	9	7,081	31%
30-Aug	D	0	2,192	5	4,485	5	7,086	31%
31-Aug	D	8	2,200	0	4,485	8	7,094	31%
1-Sep	D	0	2,200	40	4,525	40	7,134	31%
2-Sep	D	1	2,201	3	4,528	4	7,138	31%
3-Sep	D	0	2,201	7	4,535	7	7,145	31%
4-Sep	D	0	2,201	2	4,537	2	7,147	31%
5-Sep	D	0	2,201	2	4,539	2	7,149	31%
6-Sep	D	0	2,201	0	4,539	0	7,149	31%
7-Sep	D	0	2,201	0	4,539	0	7,149	31%
8-Sep	D	0	2,201	0	4,539	0	7,149	31%
9-Sep	D	0	2,201	2	4,541	2	7,151	31%
10-Sep	D	0	2,201	4	4,545	4	7,155	31%
11-Sep	D	0	2,201	6	4,551	6	7,161	31%
12-Sep	D	0	2,201	8	4,559	8	7,169	31%
13-Sep	D	0	2,201	3	4,562	3	7,172	31%
14-Sep	D	0	2,201	4	4,566	4	7,176	31%

-continued-

Appendix 1. (page 3 of 3)

Date	Mark Type	Daily Mark	Cumulative Mark	Daily Unmark	Cumulative Unmark	Daily Total	Cumulative Total	% Marked
15-Sep	D	0	2,201	2	4,568	2	7,178	31%
16-Sep	D	1	2,202	6	4,574	7	7,185	31%
17-Sep	D	6	2,208	6	4,580	12	7,197	31%
18-Sep	D	0	2,208	5	4,585	5	7,202	31%
19-Sep	D	0	2,208	12	4,597	12	7,214	31%
20-Sep	D	4	2,212	3	4,600	7	7,221	31%
21-Sep	D	0	2,212	0	4,600	0	7,221	31%
22-Sep	D	0	2,212	1	4,601	1	7,222	31%
23-Sep	D	0	2,212	6	4,607	6	7,228	31%
24-Sep	D	0	2,212	2	4,609	2	7,230	31%
25-Sep	D	0	2,212	1	4,610	1	7,231	31%
26-Sep	D	0	2,212	0	4,610	0	7,231	31%
27-Sep	D	0	2,212	0	4,610	0	7,231	31%
28-Sep	D	0	2,212	0	4,610	0	7,231	31%
29-Sep	D	0	2,212	2	4,612	2	7,233	31%
30-Sep	D	1	2,213	0	4,612	1	7,234	31%
1-Oct	D	0	2,213	2	4,614	2	7,236	31%
2-Oct	D	0	2,213	0	4,614	0	7,236	31%
3-Oct	D	0	2,213	0	4,614	0	7,236	31%
4-Oct	D	0	2,213	0	4,614	0	7,236	31%
5-Oct	D	0	2,213	0	4,614	0	7,236	31%
6-Oct	D	0	2,213	0	4,614	0	7,236	31%
7-Oct	D	0	2,213	0	4,614	0	7,236	31%
8-Oct	D	0	2,213	0	4,614	0	7,236	31%
9-Oct	D	0	2,213	0	4,614	0	7,236	31%

Appendix 2. Klawock Lake epilimnetic water quality data by date, station, and depth, 2001.

Date	9-May	14-Jun	26-Jul	6-Sep	18-Oct	9-May	12-Jun	26-Jul	6-Sep	18-Oct
Station	A	A	A	A	A	B	B	B	B	B
Depth (m)	1	1	1	1	1	1	1	1	1	1
Conductivity (umhos·cm^{-1})	34	36	37	36	36	35	36	37	37	37
pH	6.7	6.5	6.7	6.4	6.6	6.7	6.5	6.7	6.4	6.6
Alkalinity (mg·l^{-1})	11.3	11.1	12.8	11.8	12.1	11.0	10.8	12.4	11.6	12.0
Turbidity (ntu)	0.6	1.2	0.4	0.6	1.4	0.6	1.3	0.4	0.6	1.5
Color (pt units)	35	29	29	39	37	32	31	30	30	33
Calcium (mg·l^{-1})	4.5	5.4	4.9	5.2	5.0	5.1	4.9	4.9	5.3	4.9
Magnesium (mg·l^{-1})	1.0	0.4	1.1	0.7	1.0	0.7	0.5	1.1	0.6	1.0
Iron (ug · l^{-1})	110	85	98	64	99	89	73	82	66	72
TP (ug · l^{-1})	5.3	24.7	3.5	5.5	6.5	5.5	3.5	5.8	3.6	5.0
TFP (ug · l^{-1})	3.6	2.8	1.8	7.1	7.9	4.3	1.8	3.0	1.8	7.2
FRP (ug · l^{-1})	2.0	1.6	1.8	6.2	4.0	2.5	1.6	2.8	1.6	2.5
TKN (ug · l^{-1})	93.7	244.0	99.6	125.6	119.6	89.5	90.5	111.6	94.5	95.6
Ammonia(ug · l^{-1})	2.3	9.0	15.3	38.0	17.7	7.0	8.3	9.7	9.2	9.8
Nitrate+Nitrite (ug · l^{-1})	46.0	31.0	8.8	5.8	24.3	54.0	18.0	5.0	9.8	27.7
TN (ug · l^{-1})	139.7	275.0	108.4	131.4	143.9	143.5	108.5	116.6	104.3	123.3
RSi (ug · l^{-1})	1,054	1,067	1,098	1,120	1,067	1,075	1,092	1,078	1,139	1,082
Carbon (ug · l^{-1})	133	90	106	141	130	115	141	96	107	98

Appendix 3. Klawock Lake hypolimnetic water quality data by date, station, and depth, 2001.

Date	9-May	14-Jun	26-Jul	6-Sep	18-Oct	9-May	12-Jun	26-Jul	6-Sep	18-Oct
Station	A	A	A	A	A	B	B	B	B	B
Depth (m)	20	25	20	22	20	35	35	30	40	40
Conductivity (umhos·cm^{-1})	34	37	39	37	37	36	36	37	37	37
PH	6.7	6.4	6.7	6.4	6.6	6.7	6.4	6.6	6.3	6.5
Alkalinity (mg·l^{-1})	10.6	11.2	12.9	11.3	12.1	11.2	10.8	11.3	10.6	12.0
Turbidity (ntu)	0.6	0.9	0.4	0.6	1.1	0.5	1.3	0.3	0.4	0.9
Color (pt units)	32	32	35	36	37	32	31	30	30	32
Calcium (mg·l^{-1})	4.4	4.7	5.5	5.0	4.7	4.6	4.8	4.5	5.0	4.6
Magnesium (mg·l^{-1})	0.9	0.5	1.0	0.9	1.0	0.7	0.3	1.1	0.6	0.9
Iron ($ug \cdot l^{-1}$)	108	89	93	82	113	90	77	72	47	65
TP ($ug \cdot l^{-1}$)	6.0	4.9	3.6	4.4	10.0	6.3	3.2	4.4	3.4	6.2
TFP ($ug \cdot l^{-1}$)	3.0	4.1	4.3	2.0	4.0	3.7	1.8	1.9	3.1	2.8
FRP ($ug \cdot l^{-1}$)	1.8	2.8	4.2	1.9	2.5	2.0	1.5	1.5	2.6	2.0
TKN ($ug \cdot l^{-1}$)	94.7	136.3	85.5	104.6	149.7	96.7	85.5	85.5	83.5	113.6
Ammonia($ug \cdot l^{-1}$)	0.1	10.2	14.6	12.3	15.2	2.6	7.9	11.5	11.5	11.0
Nitrate+Nitrite (ug $\cdot$ l^{-1})	34.0	51.0	20.3	16.0	28.8	54.0	31.2	25.4	40.7	31.6
TN ($ug \cdot l^{-1}$)	128.7	187.3	105.8	120.6	178.5	150.7	116.7	110.9	124.2	145.2
RSi ($ug \cdot l^{-1}$)	1,027	1,114	1,134	1,164	1,046	1,086	1,118	1,132	1,190	1,125
Carbon ($ug \cdot l^{-1}$)	164	101	88	158	127	87	107	58	135	124

Appendix 4. Klawock River subsistence creel census operational plan.

OPERATIONAL PLAN

2001 KLAWOCK RIVER SUBSISTENCE FISHERY EFFORT AND HARVEST STUDY

PERIOD COVERED: 2001 FIELD SEASON

Principal Investigators:

Meg Cartwright, Fishery Biologist, Alaska Dept. of Fish and Game

Bert Lewis, Fishery Biologist, Alaska Dept. of Fish and Game

Assisting Personnel:

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INTRODUCTION

The Klawock River system (Alaska Department of Fish and Game (ADF&G stream #103-60-047) is located on the southwestern side of the Prince of Wales Island (55°32'58" N., 133°02'39" W.). The lake has a surface area of 1,176 hectares an elevation of 9.1 meters, a mean depth of 17.7 meters and a max depth of 49 meters.

A three-year cooperative project between the Klawock Cooperative Association, ADF&G, and the Forest Service was initiated in 2000 to assess the sockeye salmon stock status and trends and to monitor the subsistence and sport fish harvest in the terminal marine waters. This operation plan outlines the protocol for the creel surveys designed to estimate the harvest of sockeye salmon in the subsistence and sport fish fisheries in this terminal area.

OBJECTIVE

Estimate the subsistence harvest of sockeye salmon from Klawock River.

STUDY DESIGN

Klawock River
Subsistence fishing open July 1 to July 31, Monday at 0800 through Friday at 1700

Each day is divided into two periods; morning (0800-1500) and evening (1500-2200)

Sample: Randomly select three days to be sampled
Sample both morning and evening periods

STUDY DESIGN

This direct expansion creel survey design will be used to estimate fishing effort and sockeye salmon harvest at the survey site from 1 July through 31 July, 2001. The creel census is based on the assumption that all fishers are interviewed and that all sockeye salmon harvested from the Klawock River stock are accounted for on the randomly selected days. Days will be primary sampling units and anglers within days will be secondary units. The sampling day begins at 0700, and ends at 2200. Days will be divided into two periods, morning (0700–1500) and evening (1500–2200). During each sampling period, a technician will interview anglers at the Klawock River outlet. In each interview, anglers will be asked to report the location of their effort, effort, and sockeye salmon harvest. As many completed-trip interviews as possible will be obtained during each interview period and day selected for sampling.

Boat parties will be interviewed as/after they complete fishing in the fishery(s). Data collected during each sampling day for each fishery will be continuous and include the number of boats interviewed, and for each interview, the hours fished by each boat and the number of fish kept by species. Fishery interview data will be recorded on a daily interview form (Figure 2). During each sampling day, technicians will attempt to interview all subsistence boats. If a boat leaves without an interview or the fishers refuse to be interviewed, they are accounted for by giving them an interview number as a "missed interview" noted on the data form (Figure 2). **It is critical that every boat that exits the fishery be interviewed or counted as a missed interview during a sample day.** In the case of a boat that refuses to give you any information, write down (*in the comment section*) any information you know. For example, the approximate number of hours fished by the boat and the number of people or gear units (i.e., rods or gillnets) observed may be helpful. If you are unable to interview because two or more boats are leaving at the same time, randomly choose which one to interview (see below).

Only record data from boats that actually fished (i.e. retrieved nets).

DATA COLLECTION

Samplers will maintain a full view of the fishing as it occurs during the sampling hours (Table 1). This doesn't mean other chores cannot be performed during the day, but as a general rule samplers must station themselves in the area so that all exiting boats will at least be tallied according to the fishery they participated in.

As a boat arrives in the area to fish, samplers will motor out to the boat and:

a. introduce themselves;
b. explain that we are conducting a creel survey and that we will ask about the number of fish they harvested and the number of hours they fished (minus lunch, naps, etc.) as they leave. Explain to them that the information is confidential, and that no identification of fishers will be recorded;
c. ask them to signal you from their boat when they are getting ready to leave or ask them to call you on the CB or VHF and let them know the numbers of the stand-by stations;
d. if you do not know the answer to regulation questions, write down the questions and tell them you will call them on the radio after discussing the questions with Cameron. If they ask you about being fined or cited for violations, explain to them that we are researchers, not law enforcement officers, and we are only interested in the number of fish harvested.

Make every effort to interview ALL boats as they complete fishing and prepare to leave the area. If samplers cannot contact all exiting boats completing their trips, there must be no selection of boats to

interview based on harvest or lack of harvest. Each boat should have about the same chance of being interviewed. If boats to interview are selected based on their perceived catch, boat size, time of the day, port of origin/destination, time spent in the area, etc, the sampling data may be biased. In the case that several parties exit the fishery simultaneously so that some interviews will be missed, use a systematic (e.g., every-other boat) sampling procedure if possible to choose the boat to interview.

As boats are preparing to leave the area, samplers will contact each boat and verify that they fished (if that was not obvious) and if they are done fishing for the day in this (sport or subsistence) fishery. If they did not fish or are not done fishing, do not conduct an interview. Otherwise:

1. ask how many **total** hours they fished (not to include time spent cleaning fish, taking breaks, etc.) and how many fish they harvested. Record both totals on the custom form (Figure 2; Appendix 1). If a boat reports fishing effort by piece of gear record that data in appropriate columns, then compute the total (see examples in Figure 2).

2. once you have recorded their fishing time, ask them how many fish they harvested by species. **It is critical that we know harvest by species;**

3. do not volunteer any information about how other fishers did or where they fished — remember this information is confidential;

4. after the interview is over, thank them for their time and information;

5. if there are no boats present in a given sample day for one or both fisheries, write "0" in the "Interview #" column and initial the page.

If a boat (that fishes) leaves the fishery without being interviewed, add a sequential interview number, time, fishery code, a sequential *missed* interview #, and any comments to the custom form (Figure 2; Appendix 1).

DATA REDUCTION

Creel samplers will check their data for completeness and accuracy on a daily basis, then turn it in to the field supervisor. The field supervisor will recheck the data forms for completeness and consistency with the experimental design and provide guidance to technicians (or request help from the project leader) as needed to insure the design is correctly implemented. The ADF&G project biologist will review sampling procedures and results as needed to insure overall consistency and quality.

APPENDIX 1. INSTRUCTIONS FOR COMPLETING CREEL SURVEY FORMS

Data from angler counts and interviews will be recorded on the same form (see example of form following these instructions).

Interview Number: Use a separate number for each angler interviewed, starting with 1.

Date: Use the month-day-year format.

Location Fished: Where fish were caught in relation to bridge (A, B, or C — see map).

Residency: Where does the fisher live (city).

Interview Time (Hours:Minutes): Record the time (hour:minutes) of the day when the interview took place-use military time format (0600 to 2400). For example, 2:15 p.m. would be recorded as 1415.

Time Fished: Record the amount of time spent fishing, rounded off to the nearest ¼ hour using decimal format (i.e. 0.25). For a fishing trip of less than one hour, precede the fractional hour with a zero (e.g., 0.75 for ¾ hour or 45 minutes).

Number of Interviews Missed: Record the number of interviews missed while conducting an interview. Missed interviews may occur when a group of anglers leave all at once and head in various directions.

Fish Harvest: Record the number of each species kept. If none write 0.

Klawock River Sockeye Subsistence Creel Survey **Interviewer initials_____**

Interview Number	**Date/Time**	**Location Fished** (A,B, or C)	**Residency** (City)	**Interview Time** (Military time)	**Time Fished** (Start/Finish)	**Number of Interviews Missed**	**Fish Harvest**

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