Fishery Data Series No. 10-67

# Kanalku Lake Subsistence Sockeye Salmon Project: 2009 Annual Report

by

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and

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October 2010

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

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**Weights and measures (metric)**

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

**Weights and measures (English)**

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

**Time and temperature**

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

**Physics and chemistry**

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

**General**

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

**Mathematics, statistics**

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

# *FISHERY DATA SERIES NO. 10-67*

# KANALKU LAKE SUBSISTENCE SOCKEYE SALMON PROJECT: 2009 ANNUAL REPORT

By
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October 2010

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# ABSTRACT

The sockeye salmon (*Oncorhynchus nerka*) run at Kanalku Lake, Southeast Alaska, has been a traditional subsistence fishery for the people of Angoon for generations. Fears of overexploitation and concerns over the sustainability of the stock brought about the establishment of a stock assessment program in 2001; mark-recapture estimates of the spawning escapement of sockeye salmon were conducted between 2001 and 2006. To add confidence to our estimates, a weir was implemented in 2007 and has continued through the 2009 field season. A substantial increase in escapement was observed in 2009, with a weir count of 2,664 sockeye salmon entering Kanalku Lake. The weir-to-spawning-grounds mark-recapture estimate of escapement into Kanalku Lake was 2,750 fish (95% confidence interval 2,500–3,200) in 2009, over twice the average escapement estimated from 2001 to 2008. We believe the observed increase in escapement can be attributed to higher success ascending the partial barrier falls on Kanalku Creek due the low water conditions that were prevalent throughout the sockeye salmon migration. An increase in age diversity was observed in 2009, with an adult age composition of 65% age-1.2, 29% age-1.3, and 6% age-2.2 fish. All aged fish were from the 2004 and 2005 brood years. Subsistence fishing effort and harvest of sockeye salmon at Kanalku Bay appeared similar to the 2008 harvest.



Key words: sockeye salmon, *Oncorhynchus nerka*, subsistence, Kanalku Lake, escapement, weir, mark-recapture, age composition, limnology.


# INTRODUCTION

The Kanalku Lake system, located on the western side of Admiralty Island, has provided a traditional sockeye salmon (*Oncorhynchus nerka)* subsistence fishery for the nearby village of Angoon, Alaska, and the use of Kanalku Bay has been documented in several historical and archaeological records (de Laguna 1960; Moss 1989; Thornton 1990; Goldschmidt and Haas 1998). Although several other fishing grounds in the vicinity are also used by the community, Kanalku Bay has been the preferred area to harvest sockeye salmon due to its proximity to the village and ease of access through sheltered waterways. Artifacts and remains of a traditional weir found near the head of Kanalku Bay provide physical evidence of continuous utilization of salmon resources for at least 1,000 years (Moss 1989).

Involvement in commercial fishing and processing has greatly influenced the lives of residents of Angoon since the early 20$^{th}$ century. Since the late 1980s, however, declining participation in commercial fisheries in Angoon has led to an increased reliance on obtaining fish in subsistence fisheries rather than retaining commercially caught salmon (Geiger et al. 2007). In 1990, 76 Angoon residents held permits and participated in salmon, halibut and other fisheries, fishing 119 permits. By 2000, however, only 24 commercial fishing permit holders were fishing 28 permits (Geiger et al. 2007). Subsequently, subsistence harvest levels at Kanalku Bay increased dramatically and reached their highest levels in the late 1990s (Figure 1).

Low returns of sockeye salmon in the late 1990s raised concerns about the long-term sustainability of the traditional fishery at Kanalku Bay. In response, ADF&G initiated an assessment program in 2001 which incorporated two-stage mark-recapture estimates to approximate the spawning population of sockeye salmon in Kanalku Lake from 2001 to 2006. The estimated a spawning population was found to be fewer than 300 sockeye salmon in both the 2001 and 2003 brood years (Conitz and Burril 2008). Escapement estimates averaged about 1,300 fish in 2002, and again from 2004 to 2006 (Conitz and Cartwright 2005).

Subsistence harvests of over 1,200 sockeye salmon were reported in the late 1990s, and in 2001 the reported harvest exceeded our mark-recapture estimate of escapement at Kanalku Lake (Conitz and Cartwright 2003). Fearing an emergency closure, ADF&G and members of the community of Angoon agreed to a voluntary slow-down of subsistence harvest in Kanalku Bay in 2002. For the most part, the voluntary closure was respected. The regular permitted

subsistence fishery was resumed in 2006, but with a later fishing season, from 20 July to 15 August, and a smaller harvest limit of 15 fish per individual and household (Conitz and Burril 2008). In 2007, the subsistence sockeye season at Kanalku Bay was shifted to an earlier season of 1 July to 31 July in an effort to increase harvest opportunities for fishermen; however, the individual and household limit remained unchanged.

Following the fishing season, subsistence fishermen are required to turn in their permits with catch and area information before they can obtain permits for the following year. The tendency to under report harvest has been observed in the past so harvest data should be considered a minimum estimate of the actual subsistence harvest (Conitz and Cartwright 2003; Lewis and Cartwright 2004; Lorrigan et al. 2004; Walker 2009). During the voluntary closure from 2002 to 2006, the reported harvest of sockeye salmon in Kanalku Bay was minimal. Harvest remained very low in 2007, but in 2008 the reported subsistence harvest of sockeye salmon was about 700 fish at Kanalku Bay.

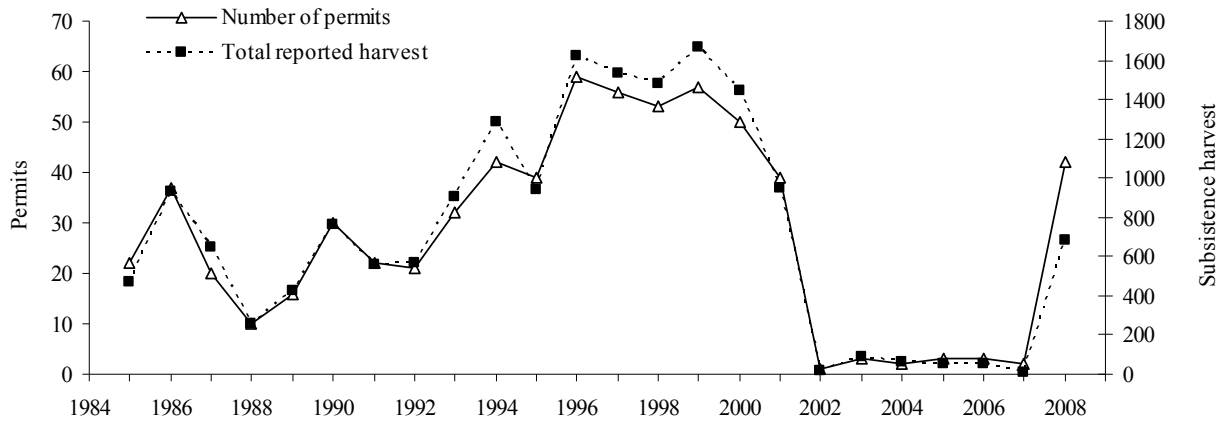


Figure 1.–Subsistence permits returned and reported subsistence harvest at Kanalku Bay, 1985–2008.

ADF&G, in cooperation with the Angoon Community Association, installed a weir directly below the outlet of Kanalku Lake beginning in 2007 to observe run timing, count the sockeye salmon escapement, and conduct a weir-to-spawning grounds mark-recapture estimate. Our work in 2007 resulted in a weir count of only 461 adult sockeye salmon and a mark-recapture estimate of 550 fish (95% confidence interval of 430 to 740) (Vinzant et al. 2009). The 2008 sockeye salmon run showed improvement, with a weir count of 967 and a mark-recapture estimate of about 1,200 fish (95% confidence interval of 1,000 to 1,500) (Vinzant et al. 2010).

Weir data from 2008, along with observations from the field, indicate that sockeye salmon migration past Kanalku Falls may be greater during periods of low water flow (Vinzant et al. 2010). Large schools of sockeye salmon, estimated in the thousands, were observed holding below the partial barrier falls in 2007 and 2008, especially during periods of high water. This supports the notion that large proportions of sockeye salmon are unable to pass the falls during high water events. A pair of net weirs fitted with dual motion-detecting video cameras were installed by U.S. Forest Service personnel below Kanalku Falls in 2008 to quantify the sockeye salmon passage rate over the falls. Combined with our escapement data from the upper creek, the results of their study suggested that fewer than half of the sockeye salmon entering the lower creek were successful in climbing the Kanalku Falls in 2008, a year of high precipitation (B. Van Alen, U.S. Forest Service biologist, personal communication, 2009; Vinzant et al. 2010).

Sockeye salmon escapement at Kanalku Lake may also be affected, to an unknown extent, by commercial fisheries in Chatham Strait, where they are harvested incidentally in purse seine fisheries targeting pink (*O. gorbuscha*) and chum (*O. keta*) salmon. The proportion of the total catch, if any, from Kanalku Lake stocks is unknown; however, the magnitude of these harvests is likely insignificant because of the earlier run timing of Kanalku Lake sockeye salmon relative to the opening date of the District 12 seine fishery (Geiger et al. 2007).

The primary focus of the sockeye salmon assessment project has been to produce reliable annual estimates of the spawning escapement at Kanalku Lake. In 2009, we continued weir operations on the outlet stream of Kanalku Lake to count fish entering the lake, observe run-timing, collect biological data, and to estimate the total escapement of sockeye salmon with a weir-to-spawning-grounds mark-recapture estimate.

### OBJECTIVES

1. Count all salmon species passed through the weir to Kanalku Lake for the duration of the sockeye salmon run, using conventional visual methods.
2. Estimate the escapement of sockeye salmon into Kanalku Lake with mark-recapture studies by marking fish at the weir and sampling for marked fish on the spawning grounds so the estimated coefficient of variation is less than 15%.
3. Estimate the age, length, and sex composition of the Kanalku Lake sockeye salmon escapement.
4. Inspect sockeye salmon at the weir for axillary process fin clips applied by the U.S. Forest Service below the Kanalku Falls.

## METHODS

### STUDY SITE

Kanalku Lake (ADF&G stream no. 112-67-58/60; lat 57$^{o}$ 29.22'N long 134$^{o}$ 21.02'W) is about 20 km southeast of Angoon (Figure 2) and lies in a steep mountainous valley within the Hood-Gambier Bay carbonates ecological subsection (Nowacki et al. 2001). The U-shaped valley and rounded mountainsides are characterized by underlying carbonate bedrock and built up soil layers supporting a highly productive spruce forest, especially over major colluvial and alluvial fans. The watershed area is approximately 32 km$^2$, with one major inlet stream draining into the east end of the lake. The lake elevation is about 28 m. The lake surface area is about 113 hectares, with mean depth of 15 m, and maximum depth of 22 m (Figure 3). The outlet stream, Kanalku Creek, is 1.7 km long and drains into the east end of Kanalku Bay. In addition to sockeye salmon spawning in the lake, large numbers of pink salmon (*O. gorbuscha*) spawn in the lower part of the outlet creek and intertidal area. A few coho (*O. kisutch*) and chum (*O. keta*) salmon spawn in the Kanalku system, and resident populations of cutthroat trout (*O. clarkii*), Dolly Varden char (*Salvelinus malma*), and sculpin (*Cottus sp.*) are found in Kanalku Lake. Kanalku Falls, a waterfall approximately 8–10 m high and about 0.8 km upstream from the tidewater, forms a partial barrier to migrating sockeye salmon. In 1970, ADFG, working with the U.S. Forest Service, blasted resting pools and a small channel in the falls bedrock to assist the migrating salmon.

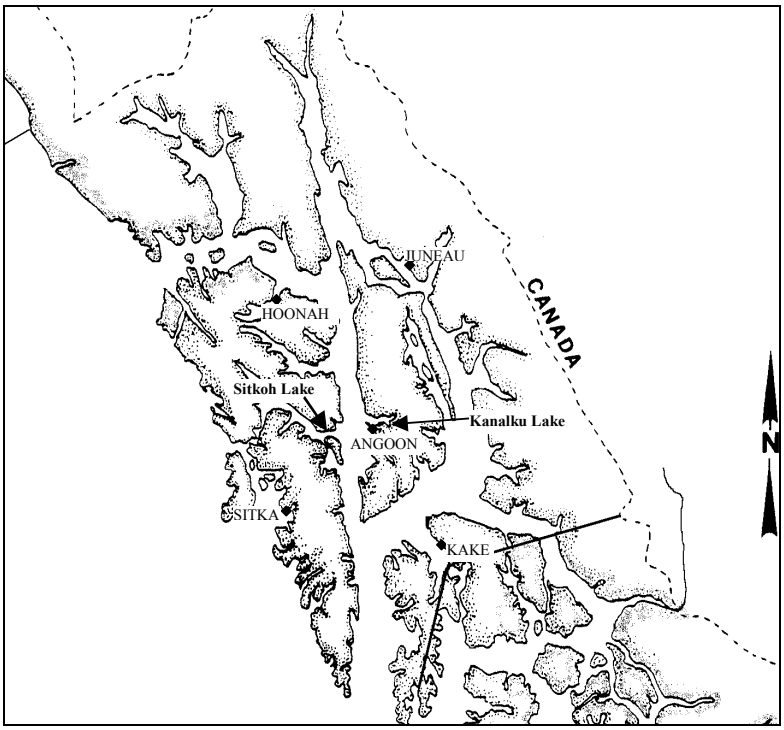


Figure 2.–Map of Southeast Alaska showing location of Kanalku Lake and the village of Angoon.

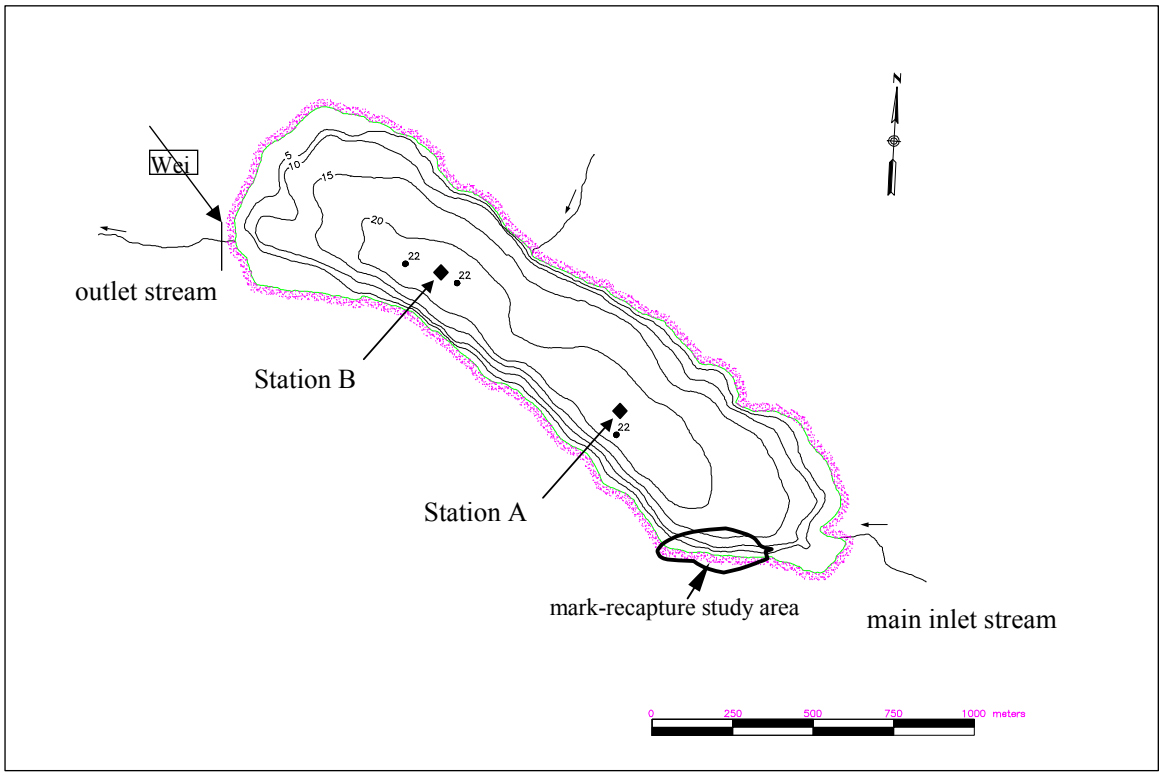


Figure 3.–Bathymetric map of Kanalku Lake, showing 5 m depth contours, the mark-recapture study area, and limnology sampling stations A and B. Arrows indicate direction of stream flow.

## SOCKEYE SALMON ESCAPEMENT ESTIMATE

### Weir Count

The Kanalku weir was located in Kanalku Creek, across the outlet stream at the west side of the lake. The weir consisted of aluminum bipod supports anchored in the stream sediment. The supports were connected by rows of stringers (aluminum channel) that extended across the entire stream bed, with pickets inserted through regularly-spaced holes in the stringers into the stream bottom. The spacing of pickets in the stringers was 1-3/4 inches (4.45 cm) on center of the pickets. This spacing, called "pink salmon spacing," allows for 52 pickets per channel with a maximum space of approximately 1-1/2 inches (3.81 cm) between pickets. Sandbags were placed across the stream along both sides of the weir to help stabilize the substrate and secure the pickets in place. A weir trap, sampling station, and catwalk were constructed and attached to the weir. Technicians inspected the weir daily for malfunction and breaches.

To minimize handling, fish were counted through the weir by pulling one or two pickets at the upstream side of the weir trap. We placed white sandbags on the bottom of the stream bed at this exit point to aid in fish identification. In addition to counting all fish by species, all sockeye salmon were visually categorized as jacks (fish less than 400 mm in length) or full-size adults. Daily observations of the water level, air and water temperature, and weather were recorded at the weir. The weir was in operation from 26 June to 2 September.

### Weir to Spawning Grounds Mark-Recapture Estimate

The total population of sockeye salmon was estimated with a stratified Petersen mark-recapture study. The mark-recapture study allowed us to determine if sockeye salmon passed through the weir undetected. Fish were marked at the weir with an adipose fin clip and a T-bar tag printed with a unique number that was later used for post-season stratification of the marking sample. The adipose fin clip facilitated easy identification of marked fish and served as the primary mark in the event of tag loss. The T-bar tags were applied to the left side of the fish, inserted at the base of the leading dorsal fin rays. The tag number and date applied was recorded for each fish successfully tagged; any fish marked only with an adipose fin clip was noted. To minimize handling, fish sampled for age, sex, and length were also tagged. The target tagging sample size was 35% of the weekly sockeye salmon escapement. Sockeye salmon that appeared unhealthy were enumerated and released without marks.

Fish were sampled for mark recovery with a beach seine in the only major spawning area found in Kanalku Lake located along the eastern shoreline and adjacent to the mouth of the inlet stream (Figure 3). No other spawning areas have been observed in Kanalku Lake (Conitz and Burril 2008). Sampling occurred on 5 September, 11 September, 23 September, and 1 October 2009. An opercular punch was applied to all sockeye salmon in these samples to prevent double sampling on that day or in subsequent sampling events.

The two-sample Petersen model provides a simple method for estimating population size, based on the number of animals marked in the first sample, the number of animals subsequently sampled for marks in the second sample, and the number of marks recovered in the second sample (Seber 1982, Pollock et al. 1990). Stratified mark-recapture models extend the two-sample Petersen method over two or more sampling events in both the marking (first) and mark-recovery (second) samples. Stratified models are widely used for estimating escapement of salmonids as they migrate into their spawning streams (Arnason et al. 1996). Spawning migrations may last for a month or more, during which time there can be substantial variation in

biological parameters such as mortality rates. A fundamental assumption of the Petersen and related mark-recapture models is that capture probabilities for individual animals are equal (Pollock et al. 1990). This assumption can be met by satisfying the following conditions: 1) all fish have an equal probability of capture in the first sample (marking), 2) all fish have an equal probability of capture in the second sample (mark-recovery), and 3) fish mix completely between the first and second sample. In stratified sampling, if one or more of these conditions is met, the marking and recovery strata can generally be pooled, thereby providing the most precise estimate. However, if none of these conditions are met, the pooled estimate can be badly biased (Arnason et al. 1996).

To test for consistency of capture probabilities in the marking and recapture strata, two chi-square tests are commonly used. A test for equal capture probability in the first sample compares observed and expected numbers of marked and unmarked fish in each recapture stratum. A test for equal capture probability in the second sample, or equivalently, complete mixing, compares observed and expected numbers of those fish marked in the initial (marking) strata which were recaptured or not recaptured. These tests are provided in the Stratified Population Analysis System (SPAS) software that we used to analyze mark-recapture data and are labeled "equal proportions" and "complete mixing," respectively (Arnason et al. 1996). We considered a test statistic with $p$-value $\leq 0.05$ to be "significant." If neither or only one test statistic was significant, we concluded that all marking and all recapture strata could be pooled without significant risk of bias and the simple Petersen ("pooled-Petersen") estimator could be used. If both test statistics were significant, we concluded the pooled estimator had a significant risk of bias and used the stratified Darroch estimator if it could be calculated. If the SPAS program was unable to develop a solution for the Darroch estimator, we followed the guidelines and suggestions in Arnason et al. (1996) to search for a partial pooling scheme that would lead to a valid estimate. We also examined the data for any obvious deficiencies or discrepancies in sample sizes and recapture numbers, and considered events during the season, such as flooding or missed sampling dates, that may have led to inconsistencies.

If a valid Darroch estimate was generated, the 95% confidence interval bounds were used to judge the accuracy of the weir count. If the weir count fell within the 95% confidence interval bounds, it was considered accurate. If the weir count was below the lower 95% confidence interval bound, we considered the possibility that the weir count was inaccurate and some fish escaped into the lake undetected. In that case, the mark-recapture estimate, if unbiased, could be more accurate. A weir count above the 95% confidence interval bounds could only indicate the mark-recapture estimate was inaccurate, because the weir count, if free of counting errors, would always represent a minimum number of fish in the lake. If a valid Darroch estimate could not be generated, the weir count was accepted as the best estimate of at least minimum escapement.

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

## VISUAL SURVEY

A visual survey of the entire lake shore was conducted just before each sampling event to quantify the number of fish available on the spawning grounds to sample. Using polarized sunglasses and hand counters, the crew counted sockeye salmon from a boat traveling slowly around the margin of the lake. The visual counts were not used in the estimation procedure because we assumed that each sockeye salmon throughout the entire spawning run was either counted or had an equal probability of being marked. The counts served only as an indicator of the number of fish available on the spawning grounds for sampling at each sampling event. The crew also surveyed up to 1 km of the inlet stream on foot to check for presence or absence of sockeye spawners.

## FALLS PASSAGE RATE ESTIMATE

The weir crew assisted efforts by U.S. Forest Service biologists to study the sockeye salmon passage rate over Kanalku Falls in 2009. The USFS crew marked adult sockeye salmon below Kanalku Falls with an axillary process fin clip, and our weir crew inspected fish captured at the weir for axillary marks. In addition, USFS personnel installed and operated a dual net-weir system fitted with motion-detecting video recorders in lower Kanalku Creek, below the falls, to count sockeye salmon entering the system. We compared their estimate of the number of sockeye salmon that entered the system with our estimate of the number of sockeye salmon that entered the lake to estimate the proportion of the run that successfully migrated past Kanalku Falls in 2009.

## ADULT POPULATION AGE AND SIZE COMPOSITION

To determine the age composition of the sockeye salmon escapement, length, sex, and scale samples were collected from 450–500 sockeye salmon at the weir. This sample size was expected to yield an adequate number of scales to estimate proportions of sockeye salmon in the major age classes (Thompson 1992). We expected an escapement of 1,000 to 2,000 fish, so we started with a daily sampling rate of 30–35% and adjusted as needed to ensure that we reached our goal of 450–500 scale samples. If the escapement appeared to be below 1,000 fish, we kept the sampling rate at or below 50%, to minimize the number of fish handled. The length of each fish was measured from mid eye to tail fork to the nearest millimeter. The sex of each fish was determined by length and shape of the kype or jaw. Length and sex data were paired by sample number with a scale sample. Three scales were taken from the preferred area of each fish (INPFC 1963) and prepared for analysis as described by Clutter and Whitesel (1956).

Scale samples were analyzed at the ADF&G salmon-aging laboratory in Douglas, Alaska. Age classes were designated by the European aging system where freshwater and saltwater years are separated by a period (e.g., 1.3 denotes a five-year-old fish with one freshwater and three ocean years; Koo 1962). The weekly age-sex distribution, the seasonal age-sex distribution weighted by week, and the mean length by age and sex weighted by week were calculated using equations from Cochran (1977; Appendix A).

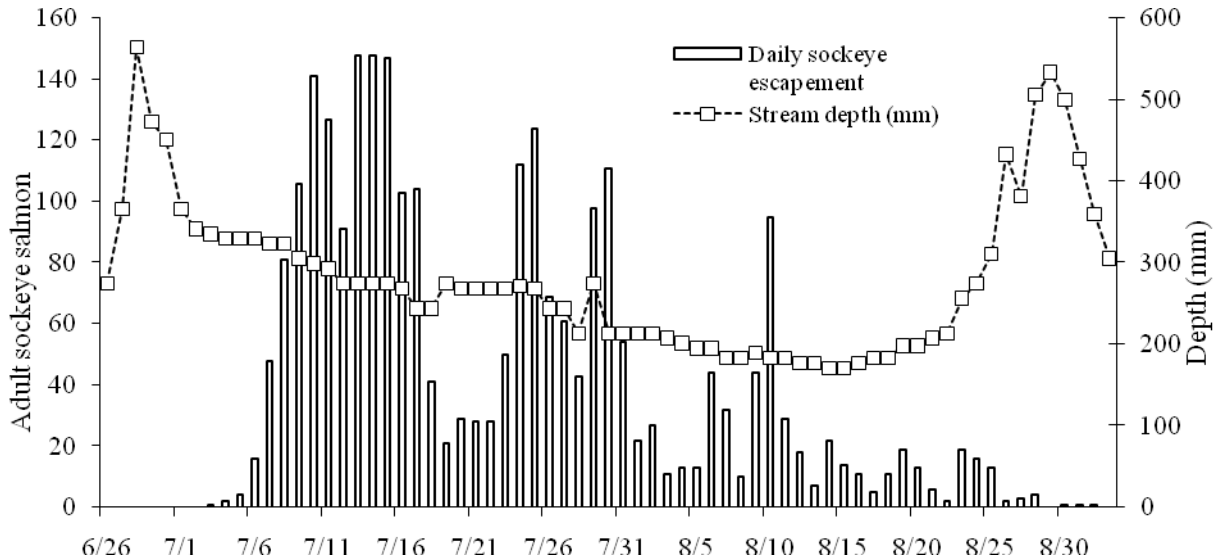


Figure 4.–Daily sockeye salmon escapement and stream depth at the Kanalku Lake weir, 2009.

# RESULTS

## SOCKEYE SALMON ESCAPEMENT ESTIMATE

### Weir Count

The crew at the Kanalku Lake weir passed a total of 2,664 adult sockeye salmon between 26 June and 2 September 2009 (Figure 4; Appendix B). No jacks were observed. The stream depth at Kanalku Lake remained very low through much of the 2009 season and high water events occurred only during the beginning and end of the field season. Daily escapements were strong throughout most of July and declined through August.

### Weir to Spawning Grounds Mark-Recapture

The sampling crew at Kanalku Lake captured and marked 1,150 adult sockeye salmon with uniquely numbered T-bar tags between 5 July and 15 August, 2009. Four recapture events were conducted on the spawning beds in Kanalku Lake on 5 September, 11 September, 23 September, and 1 October. During the recapture events, 343 adult sockeye salmon were recovered on the spawning grounds, 127 of which were weir-tagged recaptures. Of the 127 marked fish recovered, 28 (18%) had shed their T-bar tag. Sockeye salmon that had lost their T-bar tag were easily identified by the adipose fin clip (primary mark) and the residual tag hole. Since we could not determine which marking strata these fish came from, we assumed 18% of all weir-tagged sockeye salmon had lost their tag and we adjusted the marking strata accordingly (Table 1).

The recaptured sockeye salmon were stratified by tagging date (Table 1). Chi-square consistency tests were performed to determine the appropriateness of pooling strata. The result of the test of complete mixing or equal probability of capture in the second event was significant ($X^2 = 8.10$, $df = 1$; $p < 0.05$); however, the result of the test for the assumption of equal capture probability in the first event (i.e., that fish marked in a given stratum had equal probability of recovery in either recapture event) was not significant ($X^2 = 2.00$, $df = 3$, $p = 0.57$). A non-significant result for one

of these diagnostic tests indicated the pooled estimator was appropriate for estimating abundance in this study. Therefore, we pooled the data and calculated a Petersen estimate of 2,540 (SE = 165) adult sockeye salmon, with a 95% confidence interval of approximately 2,250 to 2,850 fish and a coefficient of variation of 6.5%. Since the weir count of 2,664 sockeye salmon fit within the 95% confidence interval of the mark-recapture estimate, we used the weir count as the best estimate of escapement in 2009.

Table 1.–Number of sockeye salmon marked at the weir, number sampled for marks, and number recaptured at the spawning area in Kanalku Lake in 2009 by marking stratum.

| Marking stratum end date | Number marked at weir | Count at weir | Marks recovered by sampling date | | | | Total marks recovered | Proportion of marks recovered |
|---|---|---|---|---|---|---|---|---|
| | | | 5-Sep | 11-Sep | 23-Sep | Oct-1 | | |
| 22-Jul | 470 | 1,414 | 28 | 41 | 8 | 2 | 79 | 0.17 |
| 23-Aug | 472 | 1,250 | 11 | 20 | 11 | 6 | 48 | 0.10 |
| **Totals** | 942 | 2,664 | 39 | 61 | 19 | 8 | 343 | |
| **Number sampled** | | | 110 | 170 | 45 | 18 | | |
| **Proportion marked in samples** | | | 0.35 | 0.36 | 0.42 | 0.44 | | |

## VISUAL SURVEY

Visual surveys were conducted prior to all recapture events in Kanalku Lake from 5 September to 1 October. The highest averaged count occurred on 11 September when 715 sockeye salmon were observed. The visual counts of sockeye salmon spawners in the study area of Kanalku Lake accounted for the majority of fish observed (Table 2). Foot surveys of the inlet creek on 3 September and 22 September yielded no sightings of sockeye salmon.

Table 2.–Visual counts of sockeye salmon in a designated study area and the entire lake in 2009.

| Date | Study area | Entire lake | Percentage in study area |
|---|---|---|---|
| 5 Sep | 87 | 475 | 18% |
| 11 Sep | 215 | 500 | 43% |
| 23 Sep | 104 | 112 | 93% |
| 1 Oct | 22 | 22 | 100% |

## FALLS PASSAGE RATE ESTIMATE

From 10 July to 13 August, 193 fish were captured by USFS personnel below the Kanalku falls and marked with an axillary process clip (B. Van Alen, U.S. Forest Service biologist, personal communication 2009). Our weir crew inspected a total of 2,506 sockeye salmon (94% of the weir count) for these marks, of which 69 were marked (Figure 5; Appendix C). After expanding for the total weir count, we estimate that 78 axillary-clipped fish passed the weir. Thus, 38% of the sockeye salmon marked by USFS personnel in 2009 successfully migrated over Kanalku Falls and into Kanalku Lake.

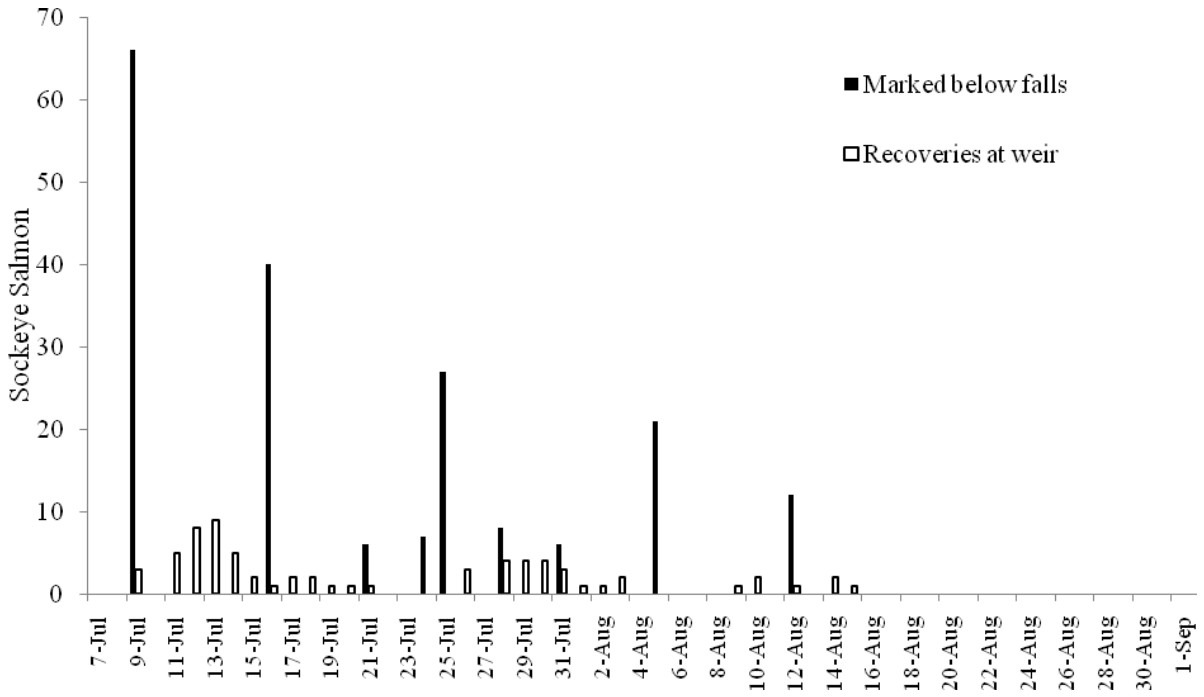


Figure 5.–Number of sockeye salmon marked by the U.S. Forest Service below Kanalku Falls and number of marked fish recovered daily at the Kanalku Lake weir in 2009.

The USFS counted 3,329 adult sockeye salmon through their net weir below the Kanalku Falls between 2 July and 12 August. They visually estimated approximately 300 to 500 fish already in the stream prior to installation of the net-weir system (Pete Schneider, U.S. Forest Service Biologist, personal communication 2010); therefore, 3,600 to 4,100 sockeye salmon are thought to have entered Kanalku Creek. Comparison of that estimate with our weir count of 2,664, suggests that 65% to 75% of the sockeye salmon that entered Kanalku Creek successfully passed the partial barrier falls and entered Kanalku Lake in 2009.

## ADULT POPULATION AGE AND SIZE COMPOSITION

The crew at Kanalku Lake sampled 524 adult sockeye salmon for age, sex, and length composition in 2009, of which 467 were successfully aged. The sockeye salmon sampled were found to be split between age-1.2 (65%) and age-1.3 (29%) with a small number of age-2.2 fish (6%). Only 2004 and 2005 brood year fish were observed in 2009 (Table 3). The mean lengths of the aged sockeye salmon corresponded to the time they spent in the marine environment. Age-1.2 and age-2.2 fish had a mean length of 500 mm and 512 mm respectively, and age-1.3 fish had a mean length of 569 mm in 2009 (Table 4).

Table 3.–Age composition of the 2009 sockeye salmon escapement at Kanalku Lake based on scale samples, weighted by statistical week.

| **Brood Year** | **2005** | **2004** | **2004** | |
|---|---|---|---|---|
| **Age** | **1.2** | **1.3** | **2.2** | **Total** |
| **Male** | | | | |
| Sample size | 117 | 158 | 18 | 293 |
| Proportion | 44.2% | 49.6% | 6.2% | |
| SE of proportion | 1.9% | 1.2% | 0.2% | |
| Est. escapement by age class | 607 | 681 | 85 | 1,373 |
| SE | 27 | 17 | 2 | |
| **Female** | | | | |
| Sample size | 148 | 15 | 11 | 174 |
| Proportion | 88.7% | 4.9% | 6.5% | |
| SE of proportion | 2.3% | 0.3% | 0.2% | |
| Est. escapement by age class | 1,029 | 56 | 75 | 1,161 |
| SE | 27 | 3 | 2 | |
| **All Fish** | | | | |
| Sample size | 265 | 173 | 29 | 467 |
| Proportion | 64.6% | 29.1% | 6.3% | |
| SE of proportion | 1.6% | 0.6% | 0.1% | |
| Est. escapement by age class | 1,636 | 737 | 161 | 2,534 |
| SE | 42 | 15 | 3 | |

Table 4.–Length composition (mm) of the 2009 sockeye salmon escapement at Kanalku Lake, weighted by statistical week.

| **Brood Year** | **2005** | **2004** | **2004** | |
|---|---|---|---|---|
| **Age** | **1.2** | **1.3** | **2.2** | **Total** |
| **Male** | | | | |
| Sample size | 117 | 158 | 18 | 293 |
| Mean length | 506 | 569 | 521 | |
| SE | 2.5 | 1.6 | 7.0 | |
| **Female** | | | | |
| Sample size | 148 | 15 | 11 | 174 |
| Mean length | 497 | 565 | 502 | |
| SE | 2.0 | 2.4 | 14.2 | |
| **All Fish** | | | | |
| Sample size | 265 | 173 | 29 | 467 |
| Mean length | 500 | 569 | 512 | |
| SE | 1.6 | 1.5 | 7.4 | |

# DISCUSSION

Our weir count of 2,664 sockeye salmon is considered the best escapement estimate for 2009 since it was within the 95% confidence interval of the mark-recapture estimate (2,400 to 3,200 adults). The 2009 escapement was well above the 2001 to 2008 average escapement of 930 adult sockeye salmon (Figure 6). Although the 2009 weir count was consistent with the mark-recapture estimate, there were discrepancies between the weir counts and escapement estimates in both 2007 and 2008. In 2007, the weir count barely fell within the 95% confidence interval of the mark-recapture estimate, and in 2008 the lower bound of the Petersen estimate was about 50 fish greater than the weir count (Vinzant et al. 2009; Vinzant et al. 2010). While it is difficult to determine the exact reasons for the differences between the weir counts and mark-recapture estimates in 2007 and 2008, the total runs were very small in those years making it particularly difficult to obtain an adequate recapture sample size to calculate an accurate escapement estimate (Vinzant et al. 2009; Vinzant et al. 2010). The larger sockeye salmon escapement observed in 2009 allowed for more marked fish recovered on the spawning grounds. We believe the observed increase in sockeye salmon escapement in 2009 was largely due to low water conditions present throughout the sockeye salmon migration that increased successful fish passage over Kanalku Falls.

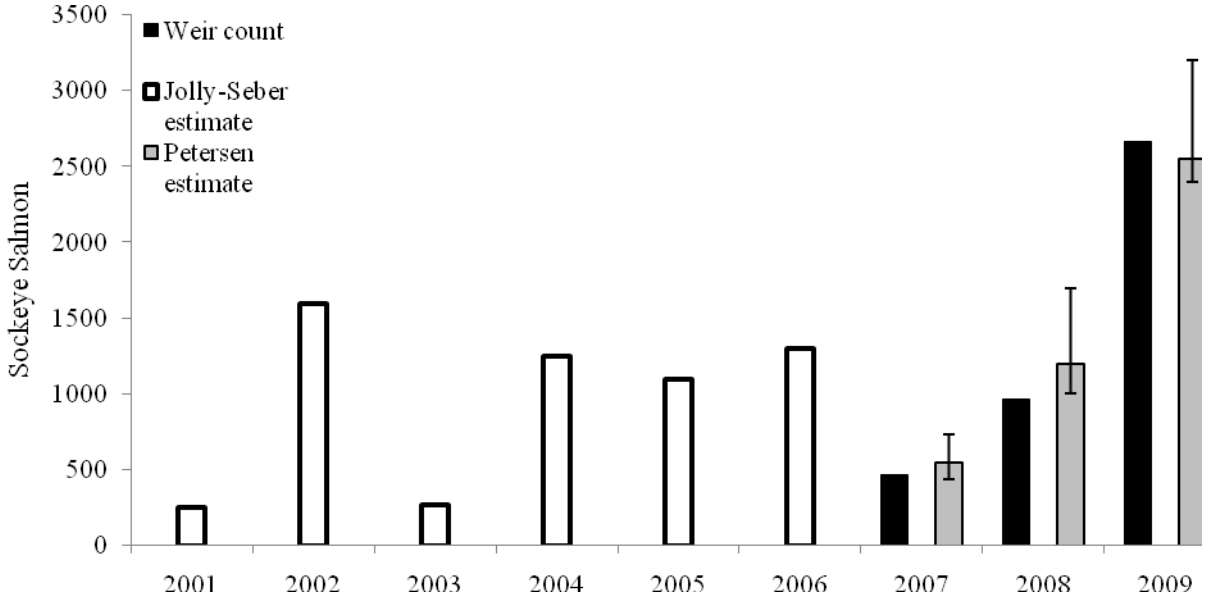


Figure 6.–Estimated adult sockeye salmon escapements from 2001 to 2009. Error bars represent the 95% confidence intervals of the Petersen mark-recapture estimates.

Prior to the inception of our 2007 weir project, the effect of stream level and water flow on sockeye salmon passage over Kanalku Falls was not well known. Initially, we assumed that fish passage would be greater during higher water conditions; however, our observations in 2008 showed that sockeye salmon passage at the weir on the upper creek was greatest during low water conditions. This suggests that lower water flow at the falls may aid in fish passage (Vinzant et al. 2010*;* Appendix B). In 2007 and 2008, large schools of sockeye salmon, estimated in the hundreds to thousands, were observed holding in several small pools below the falls throughout most of the migration period. In those years, the crew observed sockeye salmon

repeatedly and unsuccessfully attempting to jump past the large plunge pool at the base of the falls. In contrast, low water conditions in Kanalku Creek during the majority of the sockeye salmon run resulted in more sockeye salmon successfully ascending the falls in 2009 than in the previous two seasons (Figure 4). Fewer sockeye salmon were observed holding below the falls in 2009 and fish were regularly observed jumping successfully past the large plunge pool. The weir crew also noted that sockeye salmon were in much better physical condition and exhibited fewer injuries than in previous years. We assume the injuries observed in previous years were incurred from repeated unsuccessful attempts to jump the falls in high water conditions.

From 2006 to 2009, the U.S. Forest Service conducted a series of studies in an effort to estimate the natural mortality rate of sockeye salmon associated with the partial barrier falls. Radio-tagging and mark-recapture studies conducted between 2006 and 2008 suggested that sockeye salmon passage over the falls was very low during those years (Conitz and Burril 2008, Vinzant et al. 2009, Vinzant et al 2010). The effects of handling stress on tagged sockeye salmon, such as reduced success ascending Kanalku Creek falls and increased incidence of bear predation or harvest in the subsistence fishery, were not explored in these studies. In addition, U.S. Forest Service personnel used a dual net-weir system fitted with video cameras in 2008 and 2009 to count the total number of sockeye salmon entering the stream below the falls. These counts, when compared with our escapement estimates from the lake, may yield more reliable estimates of the true fish passage rate over Kanalku Falls. In 2008, a conservative estimate of 3,000 to 4,000 sockeye salmon entered Kanalku Creek, compared with our mark-recapture estimate of 1,200 sockeye salmon that successfully entered Kanalku Lake; i.e., less than 50% of the sockeye salmon that entered the creek in 2008 successfully ascended the falls (Vinzant et al. 2010; B. Van Alen, U.S. Forest Service biologist, personal communication 2009). Studies in 2009 suggested that about 75% of the sockeye salmon that entered Kanalku Creek successfully passed the falls. We feel the increased passage over the partial barrier falls was a result of the considerably lower water flow throughout the sockeye salmon migration in 2009 (Appendix B).

The age composition of sockeye salmon spawners at Kanalku Lake was split between age-1.2 and age-1.3 fish in 2009 with a very small number of age-2.2 fish. No other age classes were observed in the sample. All of the sockeye salmon aged in 2009 were returns from the 2004 and 2005 brood years (Table 3). Age diversity of Kanalku Lake sockeye salmon runs has been low from 2001 to 2009, with age-1.2 fish representing an estimated 75% of the escapement (Table 5). We believe, however, that the greatly reduced age diversity found in 2006 and 2008 was likely due to the poor parent-year escapements in 2001 and 2003 (Conitz and Cartwright 2005, Vinzant et al 2009).

Table 5.–Proportions of aged of sockeye salmon sampled at Kanalku Lake from 2001 to 2009.

| Year | 1.1 | 1.2 | 1.3 | 2.1 | 2.2 | 2.3 | Age 1.- | Age 2.- |
|---|---|---|---|---|---|---|---|---|
| 2001 | 0.00 | 0.54 | 0.44 | 0.00 | 0.02 | 0.00 | 0.98 | 0.02 |
| 2002 | 0.00 | 0.80 | 0.16 | 0.00 | 0.03 | 0.00 | 0.97 | 0.03 |
| 2003 | 0.00 | 0.87 | 0.12 | 0.00 | 0.01 | 0.00 | 0.99 | 0.01 |
| 2004 | 0.00 | 0.76 | 0.23 | 0.00 | 0.01 | 0.00 | 0.99 | 0.01 |
| 2005 | 0.00 | 0.85 | 0.11 | 0.01 | 0.03 | 0.00 | 0.96 | 0.04 |
| 2006 | 0.00 | 0.97 | 0.03 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 |
| 2007 | 0.00 | 0.37 | 0.54 | 0.00 | 0.08 | 0.01 | 0.91 | 0.09 |
| 2008 | 0.00 | 0.96 | 0.02 | 0.00 | 0.03 | 0.00 | 0.97 | 0.03 |
| 2009 | 0.00 | 0.57 | 0.37 | 0.00 | 0.06 | 0.00 | 0.94 | 0.06 |
| Average | 0.00 | 0.74 | 0.22 | 0.00 | 0.03 | 0.00 | 0.97 | 0.03 |
| SE | 0.01 | 0.15 | 0.14 | 0.02 | 0.05 | 0.02 | 0.06 | 0.06 |

Suitable spawning habitat in Kanalku Lake is limited to a very small section of the lake along the shoreline near the mouth of the main inlet stream, an area which appears to be associated with a steep drainage and perhaps some upwelling. Observations of increased sedimentation and weed growth in and around this only known sockeye salmon spawning area has raised concern in recent years (Conitz and Burril 2008, Vinzant et al. 2009, 2010), as fish have not utilized the easternmost section for spawning due to these changes (Conitz and Burril 2008). In 2008, and particularly in 2009 with the large escapement, a small number of sockeye salmon were again observed actively spawning in the affected area. It is unclear whether larger spawning populations of sockeye salmon will simply brush away the sediment built up in this section of the study area. Although there is no evidence of a cause-and-effect relationship between the recent poor sockeye salmon runs and shrinking spawning habitat, continued monitoring of the spawning grounds in Kanalku Lake should remain a priority in future field seasons.

Following the very poor escapement estimate in 2001 and the implementation of the voluntary closure of subsistence sockeye salmon fishing at Kanalku Bay in 2002, harvest levels remained near zero through 2007 (Figure 1). The traditional subsistence fishery resumed during the 2008 season with over 40 permit holders reporting a harvest of about 700 sockeye salmon. Although harvest reporting for 2009 is not yet complete, the subsistence effort and harvest at Kanalku Bay appeared similar to that of 2008.

The Kanalku Lake sockeye salmon stock continues to be an important management priority for Angoon area subsistence fisheries. Information provided by the stock assessment program, including annual observations of the spawning escapement, the quality of available spawning habitat, along with recent insights into the effects of stream flow and the associated mortality incurred by migrating sockeye salmon at the partial barrier falls, will help fishery managers provide for a sustainable balance between the escapement of spawning sockeye salmon and subsistence harvest by local residents. ADF&G has received additional funding to continue monitoring the sockeye salmon escapement at Kanalku Lake in the near future.

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# APPENDICES

The weekly age-sex distribution, the seasonal age-sex distribution weighted by week, and the mean length by age and sex weighted by week, for smolt and adults, were calculated using equations from Cochran (1977; pages 52, 107-108, and 142-144).

Let

| | | |
|---|---|---|
| $h$ | = | index of the stratum (week), |
| $j$ | = | index of the age class, |
| $p_{hj}$ | = | proportion of the sample taken during stratum $h$ that is age $j$, |
| $n_h$ | = | number of fish sampled in week $h$, and |
| $n_{hj}$ | = | number observed in class $j$, week $h$. |

Then the age distribution was estimated for each week of the escapement in the usual manner:

$$\hat{p}_{hj} = n_{hj} / n_h \ . \tag{1}$$

If $N_h$ equals the number of fish in the escapement in week $h$, standard errors of the weekly age class proportions are calculated in the usual manner (Cochran 1977, page 52, equation 3.12):

$$SE\left(\hat{p}_{hj}\right) = \sqrt{\left[\frac{\left(\hat{p}_{hj}\right)\left(1-\hat{p}_{hj}\right)}{n_h - 1}\right]\left[1 - n_h / N_h\right]} \ . \tag{2}$$

The age distributions for the total escapement were estimated as a weighted sum (by stratum size) of the weekly proportions. That is,

$$\hat{p}_j = \sum_h p_{hj}\left(N_h / N\right), \tag{3}$$

such that $N$ equals the total escapement. The standard error of a seasonal proportion is the square root of the weighted sum of the weekly variances (Cochran 1977, pages 107–108):

$$SE\left(\hat{p}_j\right) = \sqrt{\sum_j^h \left[SE\left(\hat{p}_{hj}\right)\right]^2 \left(N_h / N\right)^2} \ . \tag{4}$$

The mean length, by sex and age class (weighted by week of escapement), and the variance of the weighted mean length, were calculated using the following equations from Cochran (1977, pages 142-144) for estimating means over subpopulations. That is, let $i$ equal the index of the individual fish in the age-sex class $j$, and $y_{hij}$ equal the length of the $i$th fish in class $j$, week $h$, so that,

$$\hat{\bar{Y}}_j = \frac{\sum_h \left(N_h / n_h\right) \sum_i y_{hij}}{\sum_h \left(N_h / n_h\right) n_{hj}} \text{, and} \tag{5}$$

$$\hat{V}\left(\hat{\bar{Y}}_j\right) = \frac{1}{\hat{N}_j^2} \sum_h \frac{N_h^2\left(1 - n_h / N_h\right)}{n_h\left(n_h - 1\right)} \left[\sum_i \left(y_{hij} - \bar{y}_{hj}\right)^2 + n_{hj}\left(1 - \frac{n_{hj}}{n_h}\right)\left(\bar{y}_{hj} - \hat{\bar{Y}}_j\right)^2\right].$$

Appendix B.–Daily and cumulative counts of sockeye salmon, water depth, and temperature at Kanalku Lake in 2009. No other salmon species were observed.

| Date | Sockeye salmon | | Water depth (m) | Water temperature (°C) | Air temperature (°C) |
|---|---|---|---|---|---|
| | Daily | Cumulative | | | |
| 26-Jun | 0 | 0 | 0.27 | 11 | 13 |
| 27-Jun | 0 | 0 | 0.37 | 11 | 11 |
| 28-Jun | 0 | 0 | 0.56 | 11 | 11 |
| 29-Jun | 0 | 0 | 0.47 | 11 | 10 |
| 30-Jun | 0 | 0 | 0.45 | 12 | 10 |
| 1-Jul | 0 | 0 | 0.37 | 12 | 12 |
| 2-Jul | 0 | 0 | 0.34 | 12 | 12 |
| 3-Jul | 1 | 1 | 0.34 | 13 | 14 |
| 4-Jul | 2 | 3 | 0.33 | 14 | 15 |
| 5-Jul | 4 | 7 | 0.33 | 15 | 16 |
| 6-Jul | 16 | 23 | 0.33 | 17 | 18 |
| 7-Jul | 48 | 71 | 0.32 | 18 | 20 |
| 8-Jul | 81 | 152 | 0.32 | 18 | 20 |
| 9-Jul | 106 | 258 | 0.30 | 19 | 20 |
| 10-Jul | 141 | 399 | 0.30 | 18 | 16 |
| 11-Jul | 127 | 526 | 0.29 | 18 | 17 |
| 12-Jul | 91 | 617 | 0.27 | 17.5 | 16 |
| 13-Jul | 148 | 765 | 0.27 | 18 | 20 |
| 14-Jul | 148 | 913 | 0.27 | 17 | 12 |
| 15-Jul | 147 | 1060 | 0.27 | 18 | 15 |
| 16-Jul | 103 | 1163 | 0.27 | 18 | 15 |
| 17-Jul | 104 | 1267 | 0.24 | 18 | 16 |
| 18-Jul | 41 | 1308 | 0.24 | 18 | 16 |
| 19-Jul | 21 | 1329 | 0.27 | 18 | 15 |
| 20-Jul | 29 | 1358 | 0.27 | 18 | 16 |
| 21-Jul | 28 | 1386 | 0.27 | 16.5 | 12 |
| 22-Jul | 28 | 1414 | 0.27 | 16 | 12 |
| 23-Jul | 50 | 1464 | 0.27 | 15.5 | 14 |
| 24-Jul | 112 | 1576 | 0.27 | 15 | 13 |
| 25-Jul | 124 | 1700 | 0.27 | 18 | 15.5 |
| 26-Jul | 69 | 1769 | 0.24 | 14.5 | 14.5 |
| 27-Jul | 61 | 1830 | 0.24 | 14 | 20 |
| 28-Jul | 43 | 1873 | 0.21 | 16 | 18 |
| 29-Jul | 98 | 1971 | 0.27 | 18 | 19 |
| 30-Jul | 111 | 2082 | 0.21 | 20 | 20 |
| 31-Jul | 54 | 2136 | 0.21 | 20 | 22 |
| 1-Aug | 22 | 2158 | 0.21 | 20 | 12 |
| 2-Aug | 27 | 2185 | 0.21 | 18.5 | 16.5 |
| 3-Aug | 11 | 2196 | 0.21 | 18 | 16 |

-continued-

Appendix B.–Page 2 of 2.

| Date | Sockeye salmon | | Water depth (m) | Water temperature (°C) | Air temperature (°C) |
|---|---|---|---|---|---|
| | Daily | Cumulative | | | |
| 4-Aug | 13 | 2209 | 0.20 | 18 | 14 |
| 5-Aug | 13 | 2222 | 0.20 | 18 | 16 |
| 6-Aug | 44 | 2266 | 0.20 | 18 | 15 |
| 7-Aug | 32 | 2298 | 0.18 | 19.5 | 16.5 |
| 8-Aug | 10 | 2308 | 0.18 | 19 | 15.5 |
| 9-Aug | 44 | 2352 | 0.19 | 19.5 | 16 |
| 10-Aug | 95 | 2447 | 0.18 | 18.5 | 15 |
| 11-Aug | 29 | 2476 | 0.18 | 17 | 15 |
| 12-Aug | 18 | 2494 | 0.18 | 17 | 13 |
| 13-Aug | 7 | 2501 | 0.18 | 20 | 16 |
| 14-Aug | 22 | 2523 | 0.17 | 17 | 16 |
| 15-Aug | 14 | 2537 | 0.17 | 17 | 15 |
| 16-Aug | 11 | 2548 | 0.18 | 17 | 16 |
| 17-Aug | 5 | 2553 | 0.18 | 16 | 13 |
| 18-Aug | 11 | 2564 | 0.18 | 16 | 13 |
| 19-Aug | 19 | 2583 | 0.20 | 16.5 | 14 |
| 20-Aug | 13 | 2596 | 0.20 | 16 | 14 |
| 21-Aug | 6 | 2602 | 0.21 | 16 | 14 |
| 22-Aug | 2 | 2604 | 0.21 | 16 | 14 |
| 23-Aug | 19 | 2623 | 0.26 | 16 | 12 |
| 25-Aug | 13 | 2652 | 0.31 | 15 | 11.5 |
| 26-Aug | 2 | 2654 | 0.43 | 14.5 | 11 |
| 25-Aug | 13 | 2652 | 0.31 | 15 | 11.5 |
| 26-Aug | 2 | 2654 | 0.43 | 14.5 | 11 |
| 27-Aug | 3 | 2657 | 0.38 | 14.5 | 11.5 |
| 28-Aug | 4 | 2661 | 0.51 | 14.5 | 14 |
| 29-Aug | 0 | 2661 | 0.53 | 14.5 | 13 |
| 30-Aug | 1 | 2662 | 0.50 | 14.5 | 13 |
| 31-Aug | 1 | 2663 | 0.43 | 14 | 12 |
| 1-Sep | 1 | 2664 | 0.36 | 14 | 11 |
| 2-Sep | 0 | 2664 | 0.30 | 14 | 11 |
| Season total | | 2664 | | | |

Appendix C.–Daily sockeye salmon weir counts; sockeye salmon marked by U.S Forest Service personnel below Kanalku Falls; sockeye salmon inspected; and marked recoveries at Kanalku Lake weir.

| Date | Daily weir count | Marked below falls | Weir fish inspected for marks | Marks recovered at weir |
|---|---|---|---|---|
| 26-Jun | 0 | 0 | 0 | 0 |
| 27-Jun | 0 | 0 | 0 | 0 |
| 28-Jun | 0 | 0 | 0 | 0 |
| 29-Jun | 0 | 0 | 0 | 0 |
| 30-Jun | 0 | 0 | 0 | 0 |
| 1-Jul | 0 | 0 | 0 | 0 |
| 2-Jul | 0 | 0 | 0 | 0 |
| 3-Jul | 1 | 0 | 0 | 0 |
| 4-Jul | 2 | 0 | 0 | 0 |
| 5-Jul | 4 | 0 | 3 | 0 |
| 6-Jul | 16 | 0 | 16 | 0 |
| 7-Jul | 48 | 0 | 48 | 0 |
| 8-Jul | 81 | 0 | 81 | 0 |
| 9-Jul | 106 | 66 | 106 | 3 |
| 10-Jul | 141 | 0 | 141 | 0 |
| 11-Jul | 127 | 0 | 127 | 5 |
| 12-Jul | 91 | 0 | 91 | 8 |
| 13-Jul | 148 | 0 | 148 | 9 |
| 14-Jul | 148 | 0 | 148 | 5 |
| 15-Jul | 147 | 0 | 147 | 2 |
| 16-Jul | 103 | 40 | 103 | 1 |
| 17-Jul | 104 | 0 | 104 | 2 |
| 18-Jul | 41 | 0 | 41 | 2 |
| 19-Jul | 21 | 0 | 21 | 1 |
| 20-Jul | 29 | 0 | 29 | 1 |
| 21-Jul | 28 | 6 | 28 | 1 |
| 22-Jul | 28 | 0 | 28 | 0 |
| 23-Jul | 50 | 0 | 13 | 0 |
| 24-Jul | 112 | 7 | 77 | 0 |
| 25-Jul | 124 | 27 | 97 | 0 |
| 26-Jul | 69 | 0 | 58 | 3 |
| 27-Jul | 61 | 0 | 61 | 0 |
| 28-Jul | 43 | 8 | 43 | 4 |
| 29-Jul | 98 | 0 | 98 | 4 |
| 30-Jul | 111 | 0 | 111 | 4 |
| 31-Jul | 54 | 6 | 54 | 3 |
| 1-Aug | 22 | 0 | 22 | 1 |
| 2-Aug | 27 | 0 | 27 | 1 |
| 3-Aug | 11 | 0 | 11 | 2 |

-continued-

Appendix C.–Page 2 of 2.

| Date | Daily weir count | Marked below falls | Weir fish inspected for marks | Marks recovered at weir |
|---|---|---|---|---|
| 4-Aug | 13 | 0 | 13 | 0 |
| 5-Aug | 13 | 21 | 13 | 0 |
| 6-Aug | 44 | 0 | 10 | 0 |
| 7-Aug | 32 | 0 | 32 | 0 |
| 8-Aug | 10 | 0 | 0 | 0 |
| 9-Aug | 44 | 0 | 44 | 1 |
| 10-Aug | 95 | 0 | 95 | 2 |
| 11-Aug | 29 | 0 | 29 | 0 |
| 12-Aug | 18 | 12 | 18 | 1 |
| 13-Aug | 7 | 0 | 7 | 0 |
| 14-Aug | 22 | 0 | 22 | 2 |
| 15-Aug | 14 | 0 | 14 | 1 |
| 16-Aug | 11 | 0 | 11 | 0 |
| 17-Aug | 5 | 0 | 5 | 0 |
| 18-Aug | 11 | 0 | 11 | 0 |
| 19-Aug | 19 | 0 | 19 | 0 |
| 20-Aug | 13 | 0 | 13 | 0 |
| 21-Aug | 6 | 0 | 6 | 0 |
| 22-Aug | 2 | 0 | 2 | 0 |
| 23-Aug | 19 | 0 | 19 | 0 |
| 24-Aug | 16 | 0 | 16 | 0 |
| 25-Aug | 13 | 0 | 13 | 0 |
| 26-Aug | 2 | 0 | 2 | 0 |
| 27-Aug | 3 | 0 | 3 | 0 |
| 28-Aug | 4 | 0 | 4 | 0 |
| 29-Aug | 0 | 0 | 0 | 0 |
| 30-Aug | 1 | 0 | 1 | 0 |
| 31-Aug | 1 | 0 | 1 | 0 |
| 1-Sep | 1 | 0 | 1 | 0 |
| 2-Sep | 0 | 0 | 0 | 0 |
| Season Totals | 2,664 | 193 | 2506 | 69 |