**Fishery Data Series No. 14-39**

# Kanalku Lake Subsistence Sockeye Salmon Project: 2013 Annual Report

**by**

**Raymond F. Vinzant**

**and**

**Steven C. Heinl**

**September 2014**

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

## Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

**Weights and measures (metric)**

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

**Weights and measures (English)**

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

**Time and temperature**

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

**Physics and chemistry**

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

**General**

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

**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. 14-39*

# KANALKU LAKE SUBSISTENCE SOCKEYE SALMON PROJECT: 2013 ANNUAL REPORT

By
Raymond F. Vinzant
Alaska Department of Fish and Game, Division of Commercial Fisheries, Douglas
and
Steven C. Heinl
Alaska Department of Fish and Game, Division of Commercial Fisheries, Ketchikan

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1565

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*Raymond F. Vinzant*
*Alaska Department of Fish and Game, Division of Commercial Fisheries,*
*802 Third Street, Douglas, Alaska 99824, USA*

*and*

*Steven C. Heinl*
*Alaska Department of Fish and Game, Division of Commercial Fisheries,*
*2030 Sea Level Drive, Suite 205, Ketchikan Alaska 99901, USA*

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# ABSTRACT

The sockeye salmon (*Oncorhynchus nerka*) run at Kanalku Lake in Southeast Alaska has provided the preferred traditional subsistence sockeye salmon stock for the people of Angoon for generations. A stock assessment program at Kanalku Lake began in 2001 in response to community concerns over declining run size and possible overexploitation by local fishermen. Annual escapements were estimated through mark–recapture studies from 2001 to 2006 and through a standard picket weir operated at the outlet of the lake since 2007. In 2013, the best estimate of *spawning* escapement was the picket weir count of 1,427 sockeye salmon, which was validated with a weir-to-spawning-grounds mark–recapture estimate of 1,440 sockeye salmon (95% CI 1,220–1,690). In 2013, we also operated a pair of video camera weirs in lower Kanalku Creek to estimate *total* sockeye salmon escapement into the Kanalku system and estimate the mortality at Kanalku Falls, a partial barrier to sockeye salmon migration. The estimate of total escapement was 1,945 fish; thus only 76% of the sockeye salmon that entered Kanalku Creek successfully ascended Kanalku Falls in 2013. Similar to previous years, the escapement was predominately age-1.2 sockeye salmon (80%).

Key words: sockeye salmon, *Oncorhynchus nerka*, subsistence, Kanalku Lake, escapement, weir, mark–recapture, age composition, Southeast Alaska, video camera.

# INTRODUCTION

The coastal village of Angoon, Alaska, located on the western side of Admiralty Island, has a long history of utilizing sockeye salmon (*Oncorhynchus nerka*) from the Kanalku Lake drainage. The use of Kanalku Bay as a traditional subsistence fishery has been documented in several historical and archaeological records, and artifacts from a traditional salmon weir at the head of Kanalku Bay provide physical evidence of the exploitation of salmon resources for at least the last 1,000 years (de Laguna 1960; Moss 1989; Thornton et al. 1990; Goldschmidt and Haas 1998). Although other sockeye salmon runs in the vicinity are available for Angoon subsistence fishermen, including Sitkoh and Basket bays (Geiger et al. 2007), Kanalku Bay remains the preferred harvest area due to its close proximity to the village and ease of access through sheltered waterways.

The introduction of the commercial fishing industry in Southeast Alaska has greatly influenced the lives of Alaska Native families since the early 20$^{th}$ century. New federal fishing laws and Alaska Native participation in the commercial fishing industry led to changes in traditional fishing practices among the Alaska Natives of Angoon and other Southeast villages (Thornton et al. 1990; Betts and Wolfe 1992; Turek et al. 2006). After the adoption of Alaska statehood, a noncommercial subsistence fishery was defined and put under a permit system (Turek et al. 2006). Residents of Angoon can obtain subsistence fishing permits for Kanalku, Sitkoh, and Basket bays, along with other nearby areas, but most people prefer to fish in Kanalku Bay (Conitz and Burril 2008). Participation in commercial fisheries by Angoon residents has declined since the 1980s. In 1980, 90 Angoon residents fished 134 commercial fisheries permits; by 1990, 76 Angoon residents fished 119 permits; by 2000, 37 Angoon residents fished 46 commercial permits; and by 2010, only six Angoon residents fished six commercial permits (data from the Commercial Fisheries Entry Commission http://www.cfec.state.ak.us/fishery_statistics/earnings.htm). This decline in participation in commercial fisheries has led to a loss in mobility, which has concentrated the Angoon community's subsistence activities closer to home (Bednarski et. al. 2013).

In the late 1990s, annual reported subsistence harvests at Kanalku Bay increased substantially at the same time abundance of Kanalku Lake sockeye salmon appeared to decline. Although reported subsistence harvest tends to underrepresent the true community harvest (Conitz and Cartwright 2003; Lewis and Cartwright 2004; Lorrigan et al. 2004; Walker 2009), the reported harvests are useful for looking at trends in subsistence catch (Geiger et al. 2007). The reported subsistence harvest at Kanalku Bay increased from an average of 580 sockeye salmon in the late 1980s to an average of 1,550 in the late 1990s (Figure 1). Some Angoon residents reported a decline in the overall abundance of Kanalku sockeye salmon in the 1990s and suggested community members "slow down" in harvesting the stock (Conitz and Cartwright 2005; Contiz and Burril 2008).

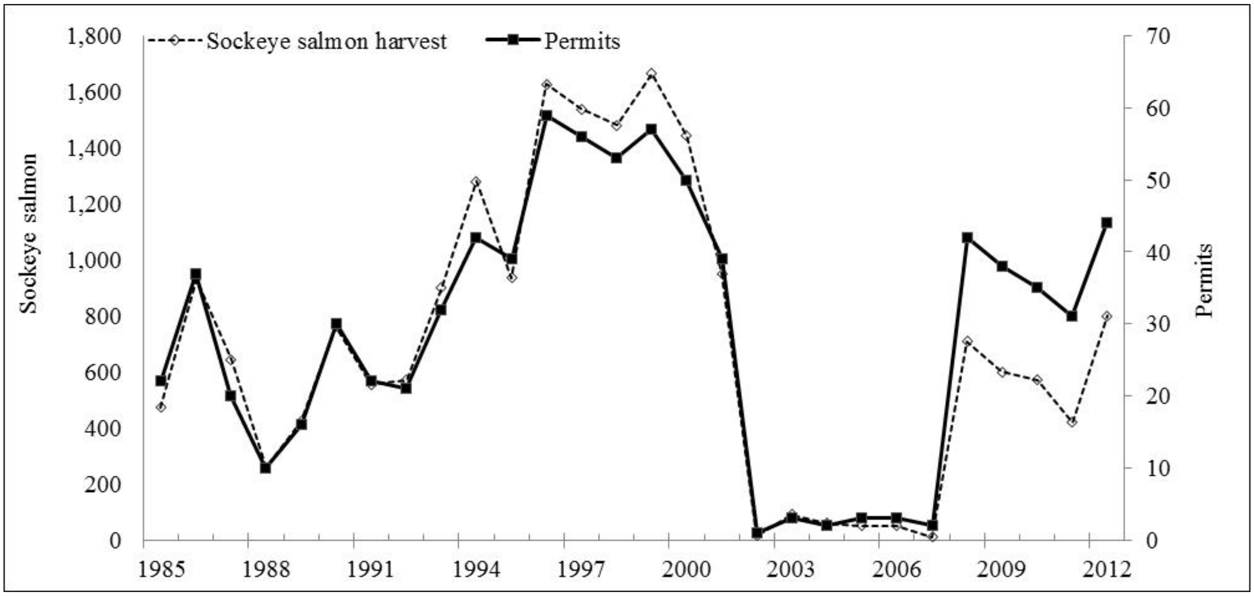


Figure 1.–Reported subsistence sockeye salmon harvest and permits issued, 1985 to 2012.

The Alaska Department of Fish and Game (ADF&G) initiated a stock assessment program in 2001 in response to the concern about declining run size and the lack of information about spawning escapements (Conitz and Cartwright 2005). From 2001 to 2006, mark–recapture studies were conducted on the spawning grounds of Kanalku Lake to estimate the spawning population of sockeye salmon. In 2001, the reported subsistence harvest of sockeye salmon at Kanalku Bay far exceeded an alarmingly low mark–recapture estimate of less than 300 sockeye salmon spawners at Kanalku Lake (Conitz and Cartwright 2005; Appendix A). The Angoon community and ADF&G fisheries managers agreed by consensus that the community would voluntarily curtail fishing in Kanalku Bay during at least the first half of the run (defined as through 14 July) for the 2002 season (Conitz and Burril 2008; Bednarski et al. 2013). In addition, harvest limits at other nearby subsistence sockeye salmon fisheries were increased to encourage fishing effort elsewhere and allow the Kanalku stock to rebuild. During the voluntary closure, 2002–2005, the reported harvest of sockeye salmon in Kanalku Bay was minimal. The escapement in 2003 was estimated to be less than 300 sockeye salmon, but escapement estimates in 2002 and from 2004 to 2006 averaged about 1,300 fish (Conitz and Cartwright 2005). In 2006, the department and the community agreed to end the voluntary closure at Kanalku. The annual limit was reduced from 25 to 15 fish per household and the fishing season was shifted from 1 June–31 July to 20 July–15 August to allow a conservative harvest and continue to rebuild the run. In 2007, the fishing season was shifted back to 1 June–31 July.

Beginning in 2007, ADF&G, in cooperation with the Angoon Community Association (ACA), improved the stock assessment project by installing a picket weir directly below the outlet of

Kanalku Lake to estimate sockeye salmon run timing, enumerate the escapement, and conduct a weir-to-spawning-grounds mark–recapture estimate of escapement. Escapements were less than 1,000 fish in both 2007 and 2008 but improved to more than 2,500 sockeye salmon in both 2009 and 2010 (Vinzant et al. 2009; Vinzant et al. 2010; Vinzant and Bednarski 2010). Escapements of sockeye salmon were lower in 2011 and 2012, 728 and 1,123 respectively, probably due to small parent-year escapements in 2007 and 2008 (Conitz and Burril 2008; Vinzant et al. 2012; Vinzant et al. 2013).

Sockeye salmon escapement into Kanalku Lake may also be affected by interception in nearby commercial fisheries conducted in Chatham Strait, where sockeye salmon are harvested incidentally in purse seine fisheries targeting pink salmon (*O. gorbuscha*). Although we have no estimates of the harvest of Kanalku sockeye salmon, management of the Chatham Strait fisheries is based on the assumption that this interception is insignificant because of the early run timing of Kanalku sockeye salmon compared to the timing of fishery openings, the distance of Kanalku Bay from these fisheries, and the nature of the mixed stock area where fishing occurs (Geiger et al. 2007). Based on subsistence harvest data collected since 1985, 87% of the total season's subsistence harvest is completed by the time the first purse seine fishery opens in Upper Chatham Strait, and 97% by the end of July (Geiger et al. 2007). In addition, the Chatham Strait shoreline along an area of approximately 9 nautical miles from Parker Point to Point Samuel, west and north of Kootznahoo Inlet and the community of Angoon and Kanalku Inlet, has been closed to the purse seine fishery.

Kanalku Falls, a partial barrier to sockeye salmon migration in Kanalku Creek, is known to have a major influence on the number of the sockeye salmon that successfully make it into Kanalku Lake to spawn. In most years, substantial numbers of sockeye salmon sit in the pools below the falls, where they are susceptible to predation and repeatedly batter themselves on the rocks as they attempt to jump the falls and migrate upstream. In 1970, the USDA Forest Service (USFS) blasted resting pools and a small channel in the bedrock at the falls to assist migrating salmon (Geiger et al. 2007), but many fish still do not successfully ascend the falls. Incomplete studies conducted in 2008 and 2009 suggested that a large portion of the sockeye salmon escapement did not migrate past the falls in those years, but these studies did not provide precise estimates of the total sockeye salmon escapement into the Kanalku system (Vinzant et al. 2010; Vinzant and Bednarski 2010).

In 2012, ADF&G initiated a study to estimate the total escapement of sockeye salmon into the Kanalku system and estimate the mortality rate at the Kanalku Falls. A total of 2,289 sockeye salmon were counted at a pair of video camera weirs below the falls, and only 1,123 sockeye salmon were counted through the picket weir above the falls at the lake outlet (Vinzant et. al 2013). Thus, the potential sockeye salmon escapement into Kanalku Lake was reduced by more than 1,100 fish, an in-river mortality rate of 51% (Vinzant et al. 2013). ADF&G and the USFS have worked to improve fish passage and increase sockeye salmon production from the drainage (Bednarski et al. 2013). The Alaska State Legislature allocated $200,000 in capital funds to begin work on further barrier modification of the falls. A National Environmental Protection Act (NEPA) review of the drainage was completed, and a Finding of No Significant Action (FONSI) was signed by the USFS Supervisor in February 2012. Phase I of the falls modification took place 28 August 2013.

The primary purpose of the sockeye salmon assessment project was to provide precise estimates of sockeye salmon *total* escapement into the Kanalku system, precise estimates of sockeye salmon *spawning* escapement at Kanalku Lake, and the mortality rate at the Kanalku Falls. In 2013, we conducted the seventh year of weir operations at the outlet stream of Kanalku Lake and counted fish that entered the lake, observed run timing, collected biological data, and estimated the *spawning* escapement of sockeye salmon. To further investigate sockeye salmon mortality associated with passage over Kanalku Falls, we operated two independent camera weirs in lower Kanalku Creek to estimate the *total* sockeye salmon escapement into the Kanalku system.

## OBJECTIVES

1. Count all salmon species entering lower Kanalku Creek, below Kanalku Falls, through a series of two double-camera weirs for the duration of the sockeye salmon run to estimate *total* escapement.
2. Count all salmon species passed through a picket weir into Kanalku Lake for the duration of the sockeye salmon run to estimate *spawning* escapement.
3. Validate the picket weir escapement count with a mark–recapture estimate of the sockeye salmon spawning population with an estimated coefficient of variation no greater than 15% of the point estimate.
4. Estimate the sockeye salmon mortality rate at Kanalku Falls.
5. Estimate the age, length, and sex composition of the Kanalku Lake sockeye salmon *spawning* escapement such that the estimated proportion of each age class is within 5% of the true value with at least 95% probability.

# METHODS

## STUDY SITE

Kanalku Lake (lat. 57° 29.22'N, long. 134° 21.02'W) is located 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 (Nowacki et al. 2001). The watershed area is approximately 32 $km^2$, with one major inlet stream (ADF&G stream no. 112-67-060) draining into the east end of the lake. The lake elevation is approximately 28 m. The lake surface area is approximately 113 hectares, with mean depth of 15 m and maximum depth of 22 m (Figure 3). The outlet stream, Kanalku Creek (ADF&G stream no. 112-67-058), 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 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.

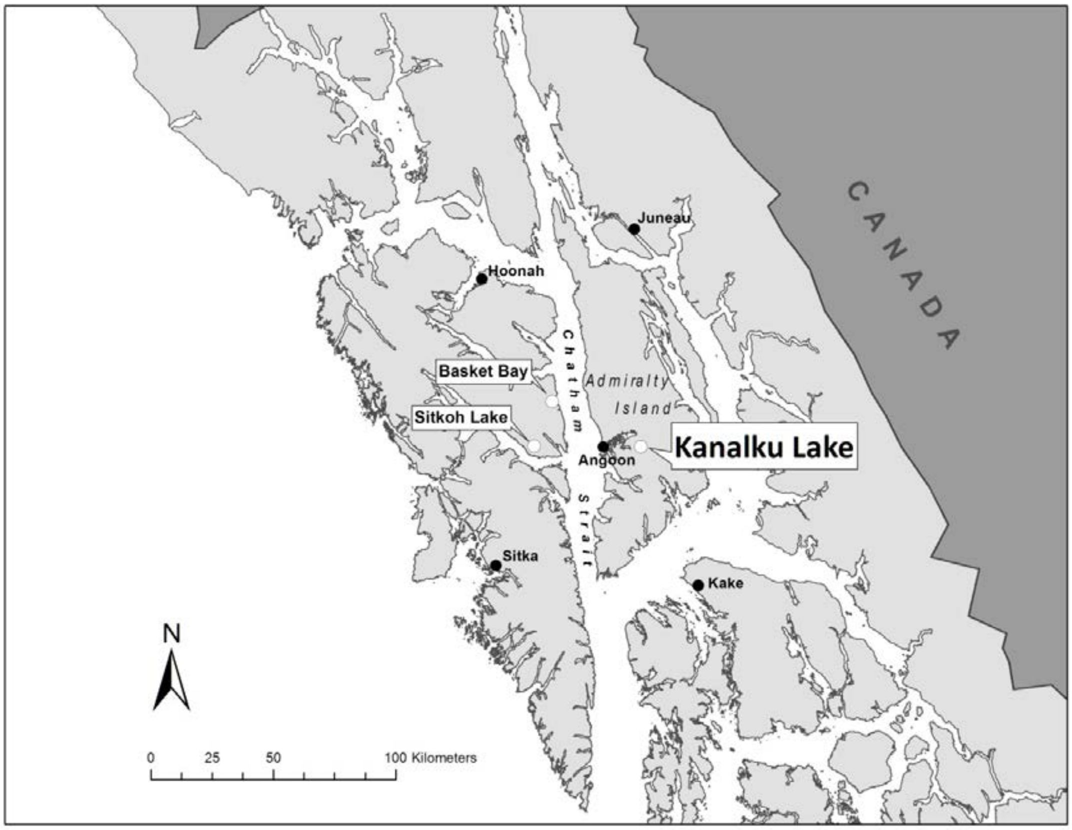


Figure 2.–Map of Southeast Alaska showing location of Kanalku Lake, the village of Angoon, and other locations mentioned in the text.

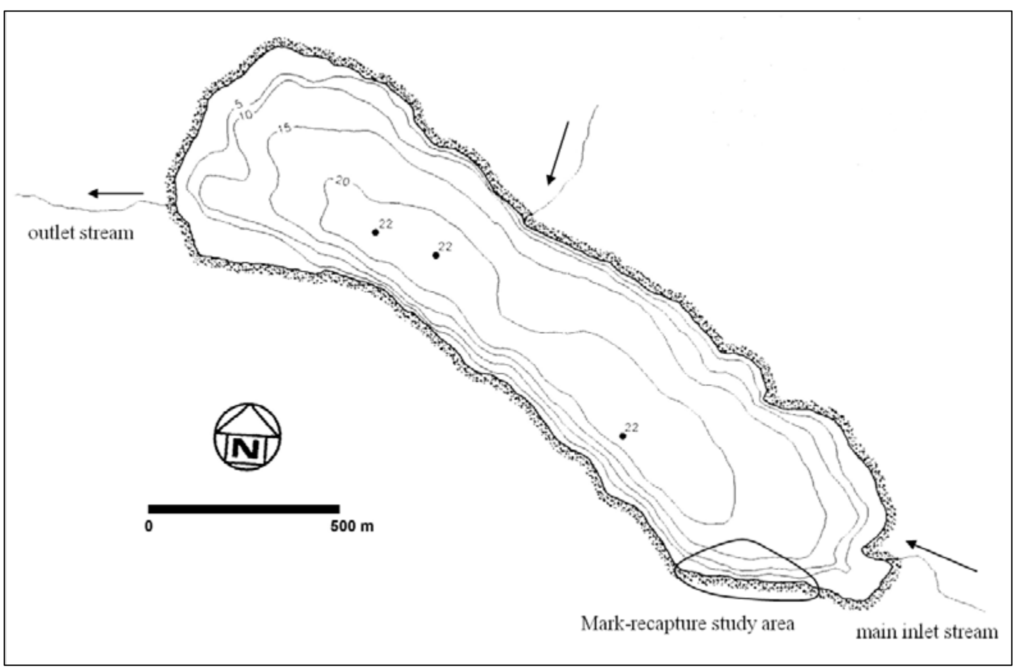


Figure 3.–Bathymetric map of Kanalku Lake showing 5-m depth contours and the mark–recapture study area. Arrows indicate direction of streamflow.

## SOCKEYE SALMON TOTAL ESCAPEMENT ESTIMATE

The *total* sockeye salmon escapement to the Kanalku system was counted through a series of two video camera weirs located approximately 0.5 km upstream from the mouth of Kanalku Creek and 0.4 km downstream of Kanalku Falls. Two video cameras were mounted to a video chute at each weir, and fish were recorded 24 hours per day as they swam through the video chutes. The double redundancy of the two-weir, four-camera system allowed us to validate fish counts and eliminated the need for a back-up mark–recapture estimate (Van Alen and Mahara 2011a).

### Lower Creek Camera Weirs

The camera weirs were operated from 18 June to 4 September. The camera weirs were constructed by anchoring an aluminum video chute to the stream bed. A series of weir panels were attached to each side of the video chute and anchored into the stream bed and aligned in a "V" shape to help guide fish quickly through the video chute (Figure 4). The weir panels were fitted with 1.5 m tall, 1.3 cm diameter EMT conduit pickets with "pink salmon" spacing of 4.45 cm on center. Vinyl-coated welded wire fencing (2.5 $cm^2$ mesh) was attached to the weir panel ends and extended to the stream banks as wings. The fencing material was supported by a series of 2 m fence posts driven into the stream bottom spaced approximately 2.4 m apart. Two rows of 1.3 cm EMT conduit were used as horizontal stringers and attached to the vertical posts. The bottom of the fencing material was also folded to form an apron on the upstream side of the weir, approximately 45 cm wide, and was secured to the stream bottom with a double row of sandbags. The fencing material was secured to the EMT stringers and posts with cable ties. The crew cleaned the weirs daily, checked for holes or scouring, and ensured the structure was fish tight.

### Camera Counts

Two underwater color video cameras containing Sony[1] 8.47 mm HAD CCD 3.6 mm sensors were installed on each video chute to observe passing fish. Video cables transferred data from the cameras to mini-DVRs (Digital Video Recorders). The video was motion-detected, 30 frames per second, and video files were stored on SD memory cards. The video chutes were lighted at night by two 25.4 cm, 14-bulb bright white LED light strips attached to the top of the chutes. Photoelectric sensors were used to turn the lights on only from dusk to dawn to conserve battery power. The paired video systems at each video chute were powered by two 140-watt solar panels that trickle-charged a 100Ah AGM (absorption glass matt) 12V DC battery through a metered 30A charge controller. The solar panels were positioned to face both the morning and afternoon sun. The mini-DVRs and a 17.78 cm color TFT monitor were housed in a Pelican case (Figure 5). DC-DC step-down voltage converters were used to regulate power to the mini-DVRs (5V DC).

At each camera station, a pair of SD cards (for left and right cameras) were changed out daily. The crew used a laptop computer to review video data back at camp. All video footage was reviewed daily by the crew, and separate counts were kept for all salmon species captured by the cameras at each of the camera weirs. Counts by hour for each camera and any other observations were recorded onto spreadsheets. Video files were backed up on a laptop computer and an external hard drive daily. At the end of the season, video files were reviewed again to corroborate inseason counts.

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[1] Product names given in this report are for completeness only and do not constitute an endorsement by the Alaska Department of Fish and Game.

Figure 4.–Camera weirs installed in lower Kanalku Creek, below Kanalku Falls, 2012. (©2012 ADF&G/photo by Raymond F. Vinzant.)


Figure 5.–Camera-weir video recording components housed in waterproof Pelican case. (©2012 ADF&G/photo by Raymond F. Vinzant.)

## SOCKEYE SALMON SPAWNING ESCAPEMENT ESTIMATE

We used a standard picket weir to estimate the *spawning* escapement of sockeye salmon into Kanalku Lake. In 2013, we also tested the application of a camera–net weir in the outlet of the lake. The camera–net weir was used to count fish into the lake, validate the picket weir count, and serve as the recapture location for a back-up mark–recapture estimate. Successful application of a camera–net weir system at Kanalku Lake would result in a reduction in both the handling of live fish on the spawning grounds and the overall cost of the project by eliminating mark–recapture work conducted on the spawning grounds in September.

### Picket 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 that extended across the entire stream bed, with pickets inserted through regularly spaced holes in the stringers and extended to the stream bottom. Picket spacing was 4.45 cm on center of the pickets. This spacing allowed for 52 pickets per channel with a maximum space of approximately 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. The field crew 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. White sandbags were placed on the bottom of the stream bed at the 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 (cm), air and water temperature (°C), and weather were recorded at the weir. The weir was in operation from 25 June to 3 September. Water level was measured daily at approximately the same location (within 1 $m^2$) as the 2007–2012 field seasons.

### Lake Camera–Net Weir

Fish were counted through a video camera–net weir placed across the outlet of Kanalku Lake, just upstream of the picket weir, and was to be operated throughout the duration of the sockeye salmon run (from the last week in June through the end of August). The net weir consisted of a 50 m × 4 m section of nylon seine netting, with 3.2 cm web, strung across the lake outlet in a "V" shape and attached to an aluminum video chute. Two video cameras were attached to either side of the video chute. A low-stretch nylon rope was attached approximately 1 m from the bottom of the netting as a tension line. The tension line was anchored tightly to the stream banks and the video chute to form the "V" shape. A heavy lead line was attached to the bottom of the netting. The area between the tension line and lead line acted as an apron to keep fish contained by the weir. A cork line was attached to the top of the netting and allowed the net to float back in the current. (See Camera Counts section above for detail on video operation and camera counts.)

## MARK–RECAPTURE POPULATION ESTIMATE

The *spawning* population of sockeye salmon was estimated with a two-event mark–recapture study for a closed population (Seber 1982). The mark–recapture study allowed us to determine whether sockeye salmon passed through the primary picket weir undetected and served as a backup estimate in the case that either the picket weir or camera–net weir was breached or damaged. In Event 1, fish were marked at the picket weir with an adipose fin clip. To minimize handling, we marked fish that were also sampled for age, sex, and length (see below). Sockeye salmon that appeared unhealthy were enumerated and released without marks. In Event 2, fish counted at the camera–net weir were examined for presence/absence of an adipose fin and mark status was recorded. Fish that could not confidently be examined for presence of an adipose fin were not included in the mark–recapture study.

If the lake camera–net weir estimate was compromised, Event 2 sampling would be conducted on the spawning grounds on at least four sampling trips between late August and late September. Fish were captured and sampled with a beach seine at the only major spawning area found in Kanalku Lake, which is located along the eastern shoreline adjacent to the mouth of the inlet stream (Figure 3; Conitz and Burril 2008). An opercular punch was applied to all sockeye salmon in these samples to prevent double sampling on that day or on subsequent sampling days. Carcasses were also sampled and marked with an opercular punch during the recovery events.

We estimated the sockeye salmon spawning escapement using Chapman's Modified Petersen estimator (Seber 1982):

$$\hat{N} = \frac{(m+1)(c+1)}{(r+1)} - 1, \tag{1}$$

where $\hat{N}$ is the estimated population size, $m$ is the estimated number of fish marked during Event 1, $c$ is the number of fish captured and sampled for marks during Event 2, and $r$ is the number of fish recaptured during Event 2 that were marked in Event 1.

We used a parametric bootstrap procedure to estimate the standard error and construct the 95% confidence intervals for the escapement estimate. We assumed that the number of marked fish recaptured ($r$) in Event 2 followed a hypergeometric probability distribution. We then used the number of fish marked ($m$) in Event 1, the number of fish caught ($c$) in Event 2, and the Petersen estimate of escapement ($\hat{N}$) to generate 5,000 simulated recapture numbers ($r$), based on the hypergeometric probability density function, $f(r|\ m, c, \hat{N})$. From the bootstrap values of $r$, we derived 5,000 Petersen escapement estimates, and then calculated the standard error of these estimates and used the 0.025 and 0.975 quantiles to construct the 95% confidence intervals. We deemed the picket weir count of sockeye salmon to be "verified" if the count fell within the 95% confidence intervals of the mark–recapture estimate.

## ESTIMATE OF MORTALITY RATE AT KANALKU FALLS

The mortality rate at the Kanalku Falls (i.e., the number of fish that did not successfully ascend the falls) was estimated by simply subtracting the best estimate of *spawning* escapement from the estimated *total* sockeye salmon escapement into the Kanalku Creek system.

## ADULT POPULATION AGE AND SIZE COMPOSITION

The age composition of the sockeye salmon escapement was determined from a minimum of 425 scale samples collected from live fish at the picket weir. Based on the work by Thompson (1992), and assuming a run of around 1,000 sockeye salmon, a sample of 338 fish was determined to be adequate to ensure estimated proportions of each age class would be within 5% of the true value with at least 95% probability. We increased our sampling goal to 425 fish to ensure we met the target sample size even if 25% of the scale samples were unreadable. We began the season with a weekly sampling goal of 30% of the cumulative weekly escapement.

Weekly sampling goals were adjusted by the project leader depending on inseason run strength. If a fish appeared overly stressed, or if the handling time exceeded 30 seconds out of the water, the fish was released without additional sampling. The length of each fish was measured from mideye to tail fork (METF) to the nearest millimeter (mm). Sex was determined by length and shape of the kype or jaw. Three scales were taken from the preferred area of each fish (INPFC 1963), mounted on a gum-card, 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). We estimated multiple age class proportions and means, together with estimates for their standard errors, as described by Thompson (1992) and Cochran (1977). 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 B).

# RESULTS

## SOCKEYE SALMON TOTAL ESCAPEMENT ESTIMATE

### Lower Creek Camera Weir Count

The dual camera weirs on lower Kanalku Creek, below Kanalku Falls, were in operation between 18 June and 4 September (Figure 6). The first sockeye salmon of the season was recorded on 19 June (Figure 6; Appendix C). A total of 1,945 adult sockeye salmon were counted through the downstream camera weir, and 1,882 adult sockeye salmon were counted through the upstream camera weir (or 3% less than the lower weir). Sockeye salmon migration into lower Kanalku Creek was greatest between 5 July and 10 August. The largest daily count occurred at the downstream camera weir on 23 July, when 156 adult sockeye salmon were recorded (Figure 6). As observed in the 2012 season, sockeye salmon primarily traveled in the darkness between 23:00 and 04:00. No jack sockeye salmon were observed.

Both camera weirs were operated without major incident throughout the season. Neither camera weir was breached by high water events, and no any holes or gaps were found in the weirs that allowed fish to pass undetected. On one occasion, however, 7–8 August, both DVR recorders on the upstream camera weir were left on an improper setting and did not record for approximately 24 hours. The downstream camera weir recorded 22 adult sockeye salmon during that time. The downstream camera weir was also blocked off with weir pickets between the afternoons of 25–29 August in order to minimize sockeye salmon mortality during the Kanalku Falls modification activity.

The difference in counts between the camera weirs was likely due to predation on sockeye salmon between the weirs by river otters (*Lontra canadensis*) or brown bears (*Ursus arctos*). Sockeye salmon traveling very quickly through the video chutes may also have been missed by the DVRs' motion sensors. Additional sockeye salmon were likely to have been present between the two camera weirs at the time they were dismantled. We chose the larger, downstream camera weir count of 1,945 sockeye salmon as the best estimate of the *total* sockeye salmon escapement for the 2013 season.

Other species of fish recorded at the camera weirs included numerous pink salmon, abundant Dolly Varden and cutthroat trout, several chum salmon, and one coho salmon. We did not enumerate fish species other than sockeye salmon, because we considered those counts to be incomplete. Pink and chum salmon primarily spawn downstream of the weir site, and coho salmon migration occurs primarily after the project ends for the season. Smaller cutthroat trout and Dolly Varden are able to pass freely through the weir fence and pickets and bypass the video cameras entirely.

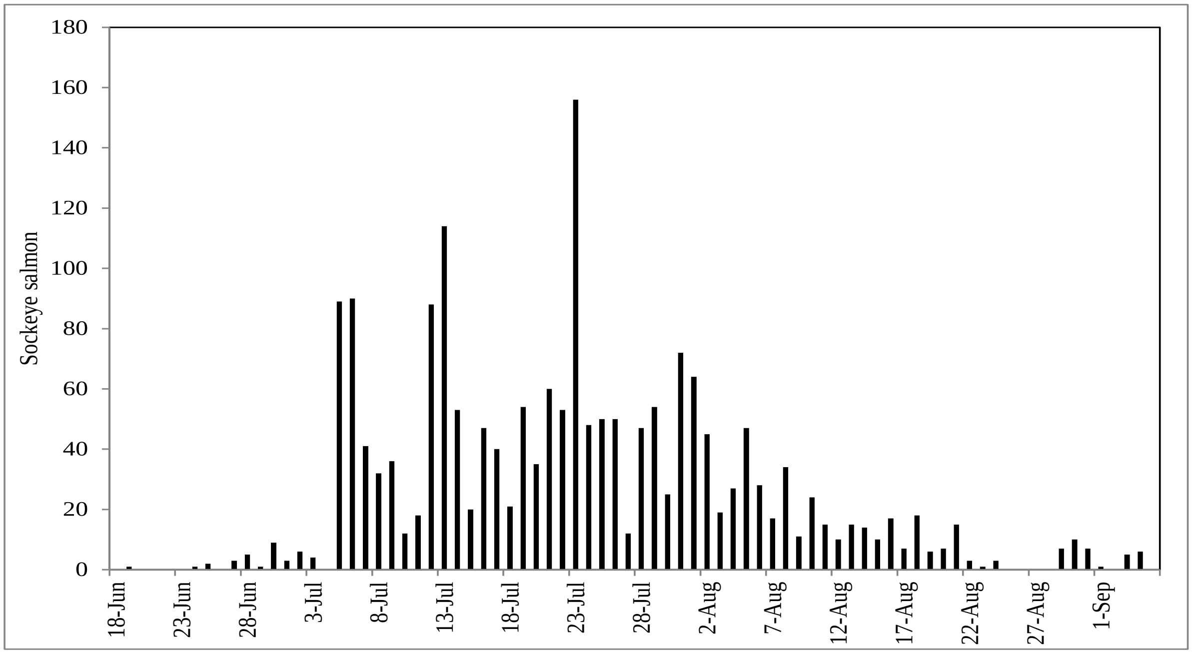


Figure 6.–Daily sockeye salmon counts at the downstream Kanalku Creek camera-weir, 2013.

## SOCKEYE SALMON SPAWNING ESCAPEMENT ESTIMATE

### Picket Weir Count

A total of 1,427 adult sockeye salmon were counted through the picket weir between 25 June and 8 September 2013 (Figure 7; Appendix D). The first day sockeye salmon were counted at the picket weir was 30 June, 11 days after fish were first observed at the camera weirs below Kanalku Falls (Figures 7 and 8). No other salmon species or jack sockeye salmon were counted at the weir. No high water events occurred and no holes were found in the weir that would have allowed fish to pass uncounted. Daily sockeye salmon counts were greatest between 7 July and 10 August, and the peak daily escapement occurred on 30 July when 79 sockeye salmon were passed through the picket weir.

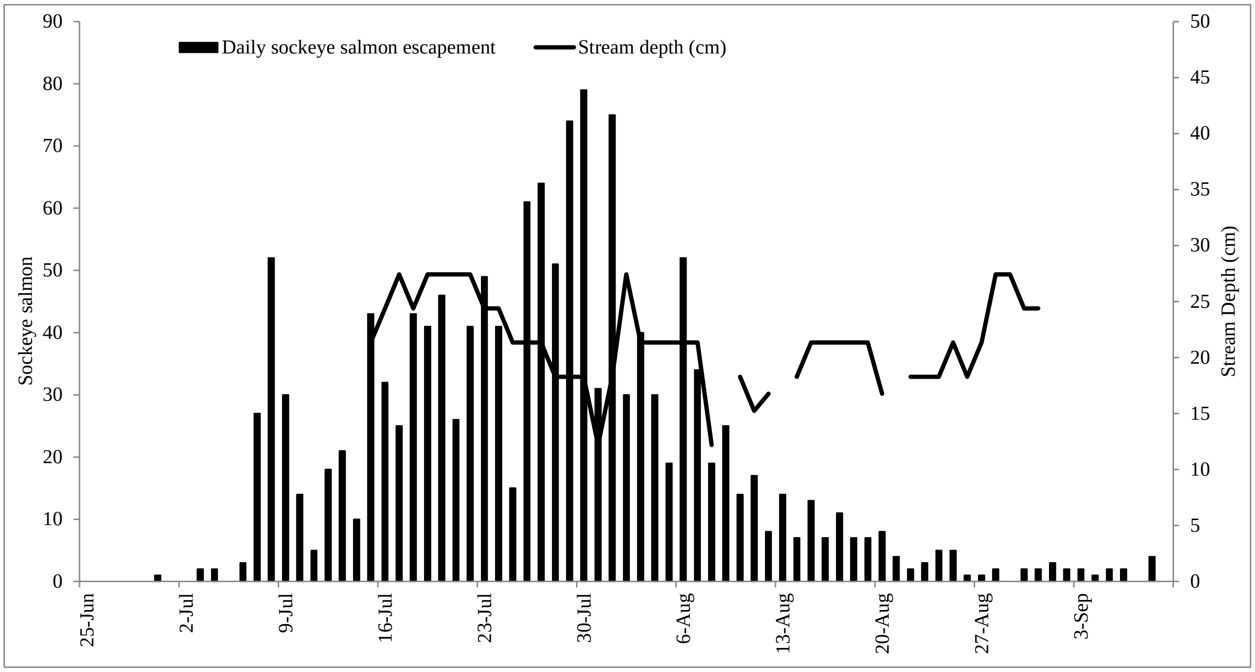


Figure 7.–Picket weir daily sockeye salmon escapement and stream depth (cm), Kanalku Lake, 2012.

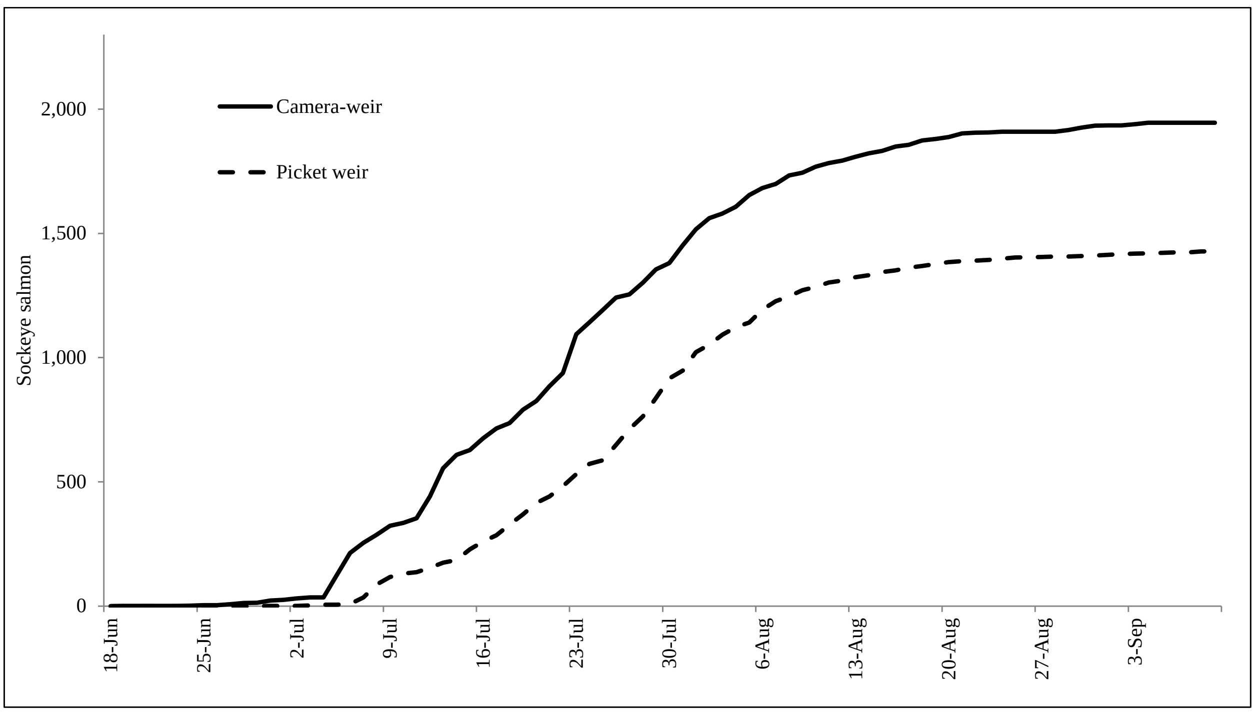


Figure 8.–Comparison of timing and cumulative escapement of sockeye salmon between the camera weirs on lower Kanalku Creek and the picket weir near Kanalku Lake, 2013.

## Mark–Recapture Population Estimate

A total of 415 adult sockeye salmon were marked with adipose fin clips at the picket weir between 7 July and 23 August 2013 (Table 1). The camera–net weir was installed above the picket weir in the outlet of the lake on 5 July 2013. Video quality was acceptable, and the crew was able to easily determine whether sockeye salmon were marked with an adipose fin clip on nearly all fish recorded. However, we dismantled the weir on 24 July after observing a high predation rate on sockeye salmon by river otters. As a result, we generated a mark–recapture population estimate from recapture sampling on the spawning grounds.

Recapture efforts were conducted on 26 August, 4 September, 10 September, and 24 September 2013. During these events, a total of 255 sockeye salmon were examined for adipose clips, of which 73 were marked (Table 1). We calculated a Petersen estimate of approximately 1,440 sockeye salmon with a 95% confidence interval of approximately 1,220 to 1,690 fish. The coefficient of variation (CV) of 8.6% met our objective of an estimate with a CV of less than 15%. Since the picket weir count of 1,427 sockeye salmon fell within the 95% confidence interval of the mark recapture estimate, we used the picket weir count as our best estimate of the *spawning* escapement in 2013.

Table 1.–Number of sockeye salmon marked at the picket weir, number sampled and recaptured on the spawning grounds, and the Petersen estimate of abundance, 2013.

| | |
|---|---|
| Count at picket weir | 1,427 |
| Marked at picket weir | 415 |
| Proportion marked at picket weir | 0.29 |
| Sampled during recapture events | 255 |
| Weir-marked recaptures | 73 |
| Proportion weir-marked in sampled | 0.29 |
| Petersen estimate of abundance | 1,440 |
| 95% CI of estimate | 1,220–1,690 |
| SE of estimate (CV) | 124 (8.6%) |

# Adult Population Age and Size Composition

A total of 415 adult sockeye salmon were sampled for age, sex, and length composition in 2013, of which 351 fish were successfully aged. Age composition was dominated by age-1.2 fish from the 2009 brood year (80%), followed by age-1.3 fish from the 2008 brood year (15%), age-2.2 fish from the 2008 brood year (3%), and age-2.3 and age-3.2 fish from the 2007 brood year (2%) (Table 2). Age-1.2 sockeye salmon had a mean length of 513 mm for males and 504 mm for females, and age-1.3 fish had a mean length of 569 mm for males and 560 mm for females (Table 3).

Table 2.–Age composition of the 2013 sockeye salmon escapement at Kanalku Lake based on scale samples, weighted by statistical week.

| Brood year | 2009 | 2008 | 2008 | 2007 | 2007 | |
|---|---|---|---|---|---|---|
| Age | 1.2 | 1.3 | 2.2 | 2.3 | 3.2 | Total |
| Sample size | 280 | 51 | 11 | 1 | 8 | 351 |
| Escapement by age class | 1,135 | 213 | 46 | 3 | 30 | 1,427 |
| SE of escapement | 26 | 23 | 12 | 3 | 9 | |
| Percent | 80% | 15% | 3% | 0% | 2% | |
| SE of % | 2% | 2% | 1% | 0% | 1% | |

Table 3.–Estimated length composition of the 2013 sockeye salmon escapement at Kanalku Lake.

| Brood year | 2009 | 2008 | 2008 | 2007 | 2007 | |
|---|---|---|---|---|---|---|
| Age | 1.2 | 1.3 | 2.2 | 2.3 | 3.2 | Total |
| Male | | | | | | |
| Sample size | 106 | 47 | 1 | 1 | 5 | 160 |
| Mean length (mm) | 513 | 569 | 500 | 560 | 526 | |
| SE | 2.1 | 3.2 | | | 9.3 | |
| Female | | | | | | |
| Sample size | 174 | 4 | 10 | 0 | 3 | 191 |
| Mean length (mm) | 498 | 561 | 523 | | 530 | |
| SE | 1.6 | 11.2 | 7.5 | | 12.0 | |
| All fish | | | | | | |
| Sample size | 280 | 51 | 11 | 1 | 8 | 351 |
| Mean length (mm) | 506 | 568 | 521 | 560 | 527 | |
| SE | 1.2 | 3.0 | 7.2 | | 7.3 | |

# DISCUSSION

Our count of 1,945 adult sockeye salmon in 2013 represents the second consecutive year we have estimated the *total* escapement of sockeye salmon into the Kanalku system. The picket weir count of 1,427 adult sockeye salmon entering Kanalku Lake was chosen as our best estimate of the 2013 *spawning* escapement because it fell within the 95% CI of the mark–recapture estimate (Figure 9). Comparison of the camera weir count from lower Kanalku Creek (1,945) and the picket weir count (1,427) at Kanalku Lake, suggests that 76% of the *total* sockeye salmon escapement successfully migrated past Kanalku Falls.

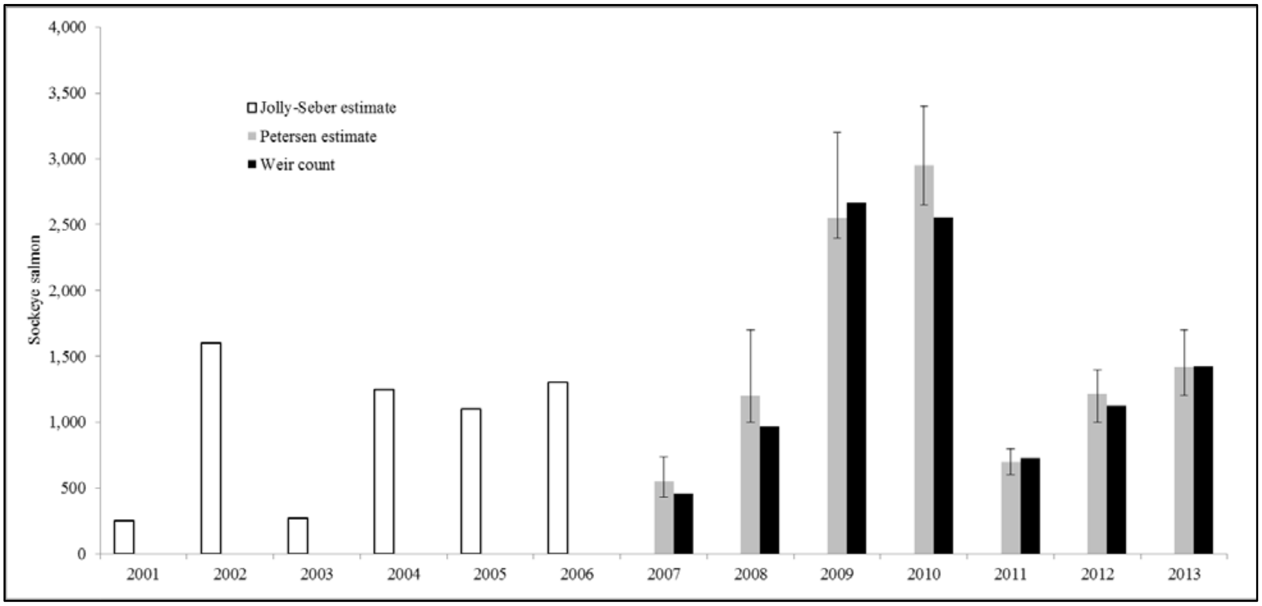


Figure 9.–Estimated sockeye salmon escapements at Kanalku Lake from 2001 to 2013. Error bars represent the 95% confidence intervals of the Petersen mark-recapture estimates.

In 2013, the much lower mortality rate of sockeye salmon (24%) suffered between our lower creek camera weirs and the picket weir at Kanalku Lake was probably due to the very low water conditions that were prevalent throughout the 2013 season. Water measurements taken at the picket weir in 2013 were lower than the 2007–2012 average for the entire season (Figure 10). Conversely, the 2012 season saw periods of low water flow, the observed water level at the picket weir was marginally higher than the 2007–2011 average, and only 49% of the *total* sockeye salmon escapement reached the picket weir at Kanalku Lake. Thus, even though the *total* escapement in 2012 was about 350 fish greater than that found in 2013, favorable conditions present throughout the summer of 2013 allowed sockeye salmon better success passing Kanalku Falls, resulting in a *spawning* escapement of about 300 fish greater than in 2012 (Figure 9; Vinzant et al. 2013). Although we only have two years of reliable estimates of *total* escapement of sockeye salmon entering the Kanalku Lake system, our studies will provide at least some baseline information with which to gauge the success of barrier modification work conducted at Kanalku Falls.

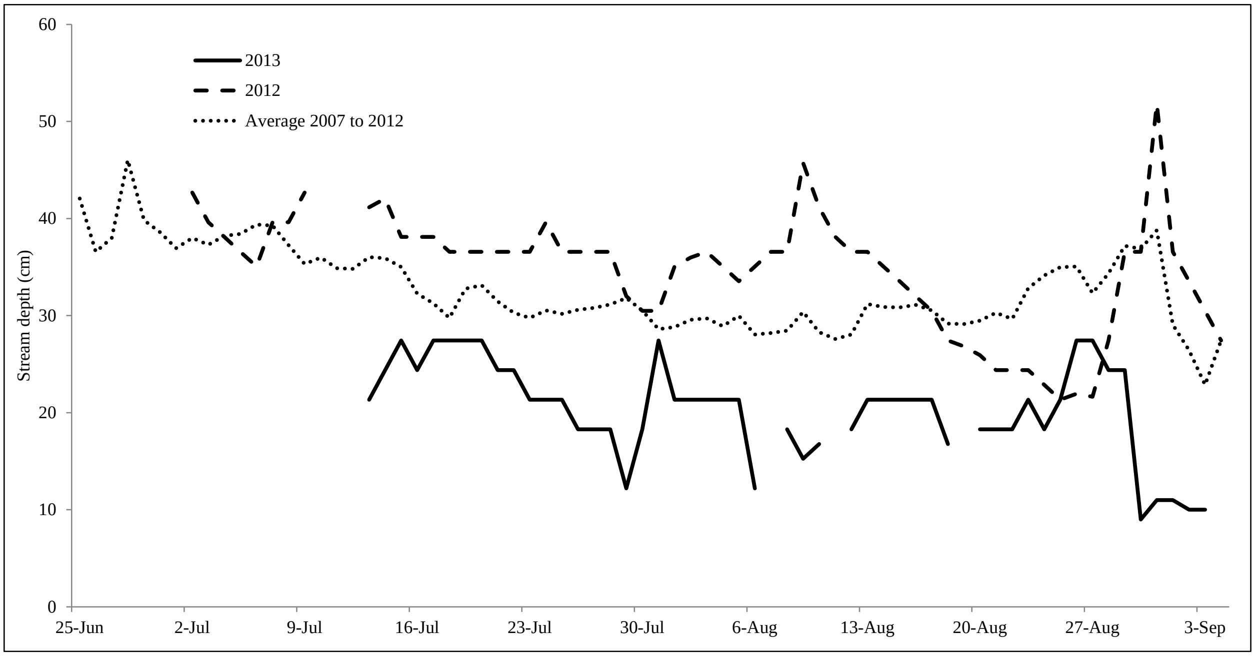


Figure 10.–Stream depth at the Kanalku Lake picket weir 2012, 2013, and 2007–2012 average (cm).

The USFS, in conjunction with ADF&G, conducted Phase I of the Kanalku Falls modification on 28 August 2013. A large shelf of bedrock was blasted out of the plunge pool at the base of Kanalku Falls to widen and deepen the pool to allow sockeye salmon a better jump at the falls (Greg Albrecht, Habitat Biologist, ADF&G, Douglas; memorandum 24 September 2013). If Phase I of the falls modification fails to improve the *spawning* escapement of sockeye salmon reaching Kanalku Lake, Phase II of the barrier modification will be implemented, and would consist of constructing an 18–24 in concrete sill that would raise the water level of the plunge pool at the base of the falls. ADF&G, in cooperation with the USFS and the Angoon Community Association, will continue to monitor the *total* sockeye salmon escapement below Kanalku Falls and the *spawning* escapement at Kanalku Lake in 2014 to assess any improvement in the ability of sockeye salmon to reach the spawning grounds of Kanalku Lake.

As observed in previous years, the sockeye salmon spawning escapement was composed primarily of age-1.2 fish (80%), followed by age-1.3 fish (15%); few other age classes were documented (Table 4). Sockeye salmon were again found to be relatively small in size in 2013, consistent with our findings that adult Kanalku Lake sockeye salmon are among the youngest at age of return and smallest in length in Southeast Alaska (Vinzant et al. 2013).

Table 4.–Estimated age composition of the Kanalku Lake sockeye salmon escapement, 2001–2013.

| | Age class | | | | | | |
|---|---|---|---|---|---|---|---|
| Year | 1.1 | 1.2 | 1.3 | 2.1 | 2.2 | 2.3 | 3.2 |
| 2001 | – | 0.55 | 0.43 | – | 0.02 | – | – |
| 2002 | – | 0.8 | 0.16 | – | 0.03 | – | – |
| 2003 | – | 0.87 | 0.11 | – | 0.01 | – | – |
| 2004 | – | 0.76 | 0.23 | – | 0.01 | – | – |
| 2005 | – | 0.85 | 0.11 | 0.01 | 0.03 | – | – |
| 2006 | – | 0.97 | 0.03 | – | – | – | – |
| 2007 | – | 0.37 | 0.54 | – | 0.08 | 0.01 | – |
| 2008 | – | 0.96 | 0.02 | – | 0.03 | – | – |
| 2009 | – | 0.57 | 0.37 | – | 0.06 | – | – |
| 2010 | – | 0.87 | 0.12 | – | 0.01 | – | – |
| 2011 | – | 0.52 | 0.43 | – | 0.04 | – | – |
| 2012 | – | 0.89 | 0.06 | – | 0.05 | – | 0.01 |
| 2013 | – | 0.80 | 0.15 | – | 0.03 | – | 0.01 |
| Mean | 0.00 | 0.75 | 0.20 | 0.00 | 0.03 | 0.00 | 0.00 |

## CAMERA WEIR OPERATIONS

The dual camera-weir video systems again proved adequate to estimate the *total* sockeye salmon escapement below Kanalku Falls in 2013. No technical failures occurred throughout the duration of the field season, and the difference in the sockeye salmon count between upstream and downstream camera weirs was low (62). Several factors probably contributed to the difference in counts. On 7–8 August, both DVRs on the upstream camera weir were accidentally left on the "menu" setting, and no recordings were made for approximately 24 hours. A total of 22 sockeye salmon were recorded at the downstream camera weir during that time, but we do not know how many fish passed through the upstream camera weir. As in 2012, sockeye salmon predation by river otters was documented in the video files, which could also account for some of the difference in the weir counts. Finally, some sockeye salmon were likely to have still been present between the weirs, milling with schools of pink salmon or hiding under debris, when the weirs were dismantled on 5 September.

Unfortunately, the camera–net weir we installed in the outlet of the lake on 5 July was abandoned after we observed intense predation on sockeye salmon by river otters. The water depth on the outlet shelf where we placed the net weir was very shallow, which caused the net weir to bag in the current and collapse on its margins, which in turn allowed river otters to corner fish in the net. Video footage also showed that otter activity dropped off in the lower creek and increased in the vicinity of the net weir after it was installed at the lake in early July. Otter activity and the frequency of observed predations on sockeye salmon continued to increase, and we removed the net weir on 24 July. The net weir would probably work better in a deeper lake outlet or slow, deep stream where the net could spread out sufficiently and not offer as much advantage to predators. Net weirs have been used successfully elsewhere in Southeast Alaska for enumerating fish without disrupting their migration (Van Alen 2008; Van Alen and Mahara 2011a-b).

In the 2014 season, we plan to replace the net weir at the lake outlet with a weir constructed of conduit weir pickets and rigid fencing similar to those we have used in the lower creek. This should reduce the incidence of predation and allow fish to move more readily into the lake. Otter activity will need to be closely monitored, and the weir will be removed if we experience any problems. If successful, this setup would enable us to validate the picket-weir escapement count by observing the marked-unmarked ratio of fish in video camera footage at the fence and reduce costs and handling of fish on the spawning grounds by eliminating the need to conduct mark–recapture trips in September.

The mini-DVR recorders worked well in 2013, with no technical failures. As in 2012, we had difficulty obtaining compatible SD cards larger than 2 GB capacity. This was not a problem at Kanalku Creek, because the number of fish encountered was relatively small and the DVRs never ran out of memory between crew checks. In 2014 we plan to replace the mini-DVRs with new units that we have tested to be fully compatible with up to 32 GB SD cards. The solar panel battery-charging system worked flawlessly, and the LED lighting system adequately illuminated the camera chute at night. Fish did not appear to shy away from the lights. The mini-DVR systems have proven to be a very effective fish-counting platform that provides a low-cost, low-maintenance, reliable underwater 24-hour fish counting system and permits the natural migration of fish traveling at night.

# REFERENCES CITED

Bednarski, J., D. K. Harris, K. Monagle, S. C. Heinl, and M. S. Kelley. 2013. Northern Chatham Strait sockeye salmon: updated stock status, fishery management, and subsistence fisheries. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report 1J12-14, Douglas.

Betts, M. F., and R. J. Wolfe. 1992. Commercialization of fisheries and the subsistence economies of the Alaska Tlingit. Society and Natural Resources 5:277–295.

Clutter, R., and L. Whitesel. 1956. Collection and interpretation of sockeye salmon scales. Bulletin of the International Pacific Salmon Fisheries Commission 9, New Westminster, Canada.

Cochran, W. G. 1977. Sampling techniques. 3rd edition. John Wiley and Sons, New York.

Conitz, J. M., and S. E. Burril. 2008. Kanalku and Sitkoh Lakes subsistence sockeye salmon project: 2006 annual report. Alaska Department of Fish and Game, Fishery Data Series No. 08-29, Anchorage.

Conitz, J. M., and M. A. Cartwright. 2003. Falls, Gut Bay, and Kutlaku Lakes subsistence sockeye salmon project: 2002 Annual Report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 1J03-42, Juneau.

Conitz, J. M., and M. A. Cartwright. 2005. Kanalku, Sitkoh, and Kook Lakes subsistence sockeye salmon project: 2003 annual report and 2001–2003 final report. Alaska Department of Fish and Game, Fisheries Data Series No. 05-57, Anchorage.

de Laguna, F. 1960. The story of a Tlingit community: A problem in the relationship between archeological, ethnological, and historical methods. Native American Book Publishers, Brighton, Michigan. U.S. Government Printing Office, Washington, D.C.

Geiger, H., and ADF&G Staff. 2007. Northern Chatham Strait sockeye salmon: stock status, fishery management, and subsistence fisheries. Alaska Department of Fish and Game, Special Publication No. 07-15, Anchorage.

Goldschmidt, W. R., and T. R. Haas. T. F. Thornton, editor. 1998. Haa Aaní, Our Land: Tlingit and Haida land rights and use. University of Washington Press, Seattle and London. Sealaska Heritage Foundation, Juneau.

INPFC (International North Pacific Fisheries Commission). 1963. Annual Report 1961. Vancouver, Canada.

Koo, T. S. Y. 1962. Age designation in salmon. Pages 37-48 [*In*] T. S. Y. Koo, editor. Studies of Alaska red salmon. University of Washington Press, Seattle.

Lewis, B. A., and M. A. Cartwright. 2004. Hetta Lake sockeye salmon stock assessment project: 2002 annual report. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 1J04-10, Juneau.

Lorrigan, J., M. Cartwright, and J. Conitz. 2004. Klag Bay sockeye stock assessment, 2002. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 1J04-18, Juneau.

Moss, M. L. 1989. Archaeology and cultural ecology of the prehistoric Angoon Tlingit. PhD dissertation, University of California, Santa Barbara.

Nowacki, G., P. Krosse, G. Fisher, D. Brew, T. Brock, M. Shephard, W. Pawuk, J. Baichtal, and E. Kissinger. 2001. Ecological subsections of Southeast Alaska and neighboring areas of Canada. U.S. Department of Agriculture, Forest Service, Alaska Region, Technical Publication No. R10-TP-75.

Seber, G. A. F. 1982. On the estimation of animal abundance and related parameters. 2nd edition. Charles Griffin and Sons Ltd., London.

Thompson, S. K. 1992. Sampling. Wiley-Interscience, New York.

Thornton, T. F., R. F. Schroeder, and R. G. Bosworth. 1990. Use of sockeye salmon at Sitkoh Bay, Alaska. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 174, Douglas.

Turek, M. F., A. Paige, E. Cheney, J. Dizard, and N. Soboleff. 2006. Kake subsistence harvest use pattern. Alaska Department of Fish and Game, Division of Subsistence, Technical Report No. 309, Juneau.

# REFERENCES CITED (Continued)

Van Alen, B. W. 2008. Kook Lake sockeye salmon stock assessment, 2005 to 2007. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fishery Resource Monitoring Program, Final Report Study No. 05-0601. Anchorage, Alaska.

Van Alen, B. W., and C. J. Mahara. 2011a. Kook Lake sockeye salmon stock assessment, 2010. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program, 2010 Annual Report (Study 10-610), Anchorage.

Van Alen, B. W., and C. J. Mahara. 2011b. Kook Lake sockeye salmon stock assessment, 2011. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program, 2011 Annual Report (Study 10-610), Anchorage.

Vinzant, R. F., and J. Bednarski. 2010. Kanalku Lake subsistence sockeye salmon project: 2009 annual report. Alaska Department of Fish and Game, Fishery Data Series No. 10-67, Anchorage.

Vinzant, R. F., S. A. Host, and J. M. Conitz. 2009. Kanalku Lake subsistence sockeye project: 2007 annual report. Alaska Department of Fish and Game, Fishery Data Series No. 09-71, Anchorage.

Vinzant, R. F., J. M. Conitz, and M. A. Blikshteyn. 2010. Kanalku Lake subsistence sockeye project: 2008 annual report. Alaska Department of Fish and Game, Fishery Data Series No. 10-13, Anchorage.

Vinzant, R. F., J. Bednarski, and S. C. Heinl. 2012. Kanalku Lake subsistence sockeye salmon project: 2011 annual report. Alaska Department of Fish and Game, Fishery Data Series No. 12-46, Anchorage.

Vinzant, R. F., J. Bednarski, and S. C. Heinl. 2013. Kanalku Lake subsistence sockeye salmon project: 2012 annual report. Alaska Department of Fish and Game, Fishery Data Series No. 13-33, Anchorage.

Walker, R. 2009. The validity and reliability of fisheries harvest monitoring methods, Southeast Alaska. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 286. Anchorage.

# APPENDICES

Appendix A.–Estimated annual *spawning* escapement and subsistence harvest of Kanalku Lake sockeye salmon 2001–2013. Escapement estimates were based on weir counts and mark–recapture estimates; annual estimates used as the final estimate are shown in bold.

| | | Mark–recapture estimate | | | | Final | |
|---|---|---|---|---|---|---|---|
| Year | Weir count | Petersen estimate[a] | Jolly-Seber estimate[b] | 95% CI | Expanded Jolly-Seber[b] | escapement estimate | Subsistence Harvest[c] |
| 2001 | – | – | 250 | 130–380 | 250 | 250 | 951 |
| 2002 | – | – | 1,300 | 1,200–1,400 | 1,600 | 1,600 | 14 |
| 2003 | – | – | 280 | 250–300 | 280 | 280 | 90 |
| 2004 | – | – | 820 | 750–900 | 1,250 | 1,250 | 60 |
| 2005 | – | – | 950 | 900–1,000 | 1,100 | 1,100 | 50 |
| 2006 | – | – | 1,100 | 1,000–1,200 | 1,300 | 1,300 | 51 |
| 2007 | 461 | 576 | – | 430–740 | – | 461 | 10 |
| 2008 | 967 | 1,200 | – | 1,000–1,500 | – | 1,200 | 708 |
| 2009 | 2,664 | 2,750 | – | 2,500–3,200 | – | 2,664 | 600 |
| 2010 | 2,555 | 2,970 | – | 2,660–3,380 | – | 2,970 | 571 |
| 2011 | 728 | 690 | – | 600–800 | – | 728 | 419 |
| 2012 | 1,123 | 1,215 | – | 1,000–1,400 | – | 1,123 | 801 |
| 2013 | 1,427 | 1,440 | – | 1,220–1,690 | – | 1,427 | NA |

[a] Chapman's modified Petersen estimate.

[b] Jolly-Seber estimates from 2001 to 2006 were expanded based on the ratio of the number of sockeye salmon observed in the mark–recapture study area to the number observed in the entire lake (see Conitz and Burril 2008).

[c] Subsistence harvest was reported from returned ADF&G subsistence salmon fishing permits. A voluntary subsistence closure was in place from 2002 to 2005. Subsistence harvest data for 2013 were not available at the time of publication.

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).

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:

$$\hat{p}_{hj} = n_{hj} / n_h \ . \qquad (1)$$

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):

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

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

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

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):

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

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,

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

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

Appendix C.–Number of sockeye salmon counted in the lower video-camera weir in Kanalku Creek, 2013. Other fish species were not enumerated.

| Date | Sockeye salmon | Date | Sockeye salmon | Date | Sockeye salmon[a] |
|---|---|---|---|---|---|
| 18-Jun | 0 | 21-Jul | 60 | 23-Aug | 1 |
| 19-Jun | 1 | 22-Jul | 53 | 24-Aug | 3 |
| 20-Jun | 0 | 23-Jul | 156 | 25-Aug | 0 |
| 21-Jun | 0 | 24-Jul | 48 | 26-Aug | 0 |
| 22-Jun | 0 | 25-Jul | 50 | 27-Aug | 0 |
| 23-Jun | 0 | 26-Jul | 50 | 28-Aug | 0 |
| 24-Jun | 1 | 27-Jul | 12 | 29-Aug | 7 |
| 25-Jun | 2 | 28-Jul | 47 | 30-Aug | 10 |
| 26-Jun | 0 | 29-Jul | 54 | 31-Aug | 7 |
| 27-Jun | 3 | 30-Jul | 25 | 1-Sep | 1 |
| 28-Jun | 5 | 31-Jul | 72 | 2-Sep | 0 |
| 29-Jun | 1 | 1-Aug | 64 | 3-Sep | 5 |
| 30-Jun | 9 | 2-Aug | 45 | 4-Sep | 6 |
| 1-Jul | 3 | 3-Aug | 19 | Total | 1,945 |
| 2-Jul | 6 | 4-Aug | 27 | | |
| 3-Jul | 4 | 5-Aug | 47 | | |
| 4-Jul | 0 | 6-Aug | 28 | | |
| 5-Jul | 89 | 7-Aug | 17 | | |
| 6-Jul | 90 | 8-Aug | 34 | | |
| 7-Jul | 41 | 9-Aug | 11 | | |
| 8-Jul | 32 | 10-Aug | 24 | | |
| 9-Jul | 36 | 11-Aug | 15 | | |
| 10-Jul | 12 | 12-Aug | 10 | | |
| 11-Jul | 18 | 13-Aug | 15 | | |
| 12-Jul | 88 | 14-Aug | 14 | | |
| 13-Jul | 114 | 15-Aug | 10 | | |
| 14-Jul | 53 | 16-Aug | 17 | | |
| 15-Jul | 20 | 17-Aug | 7 | | |
| 16-Jul | 47 | 18-Aug | 18 | | |
| 17-Jul | 40 | 19-Aug | 6 | | |
| 18-Jul | 21 | 20-Aug | 7 | | |
| 19-Jul | 54 | 21-Aug | 15 | | |
| 20-Jul | 35 | 22-Aug | 3 | | |

[a] The lower camera-weir was closed during Phase I of the Kanalku Falls Barrier Modification 25–29 August 2013.

Appendix D.–Daily and cumulative counts of sockeye salmon, water depth, and air and water temperature at the Kanalku Lake picket weir in 2013. No other salmon species were observed.

| | Sockeye salmon | | Water | Water | Air |
|---|---|---|---|---|---|
| Date | Daily | Cumulative | depth (cm) | temperature (°C) | temperature (°C) |
| 25-Jun | 0 | 0 | ND | ND | ND |
| 26-Jun | 0 | 0 | ND | ND | ND |
| 27-Jun | 0 | 0 | ND | ND | ND |
| 28-Jun | 0 | 0 | ND | ND | ND |
| 29-Jun | 0 | 0 | ND | ND | ND |
| 30-Jun | 1 | 1 | ND | 15 | 19 |
| 1-Jul | 0 | 1 | ND | 18 | 16 |
| 2-Jul | 0 | 1 | ND | 16 | 14 |
| 3-Jul | 2 | 3 | ND | 16 | 12 |
| 4-Jul | 2 | 5 | ND | 16 | 15 |
| 5-Jul | 0 | 5 | ND | ND | ND |
| 6-Jul | 3 | 8 | ND | 14 | 18 |
| 7-Jul | 27 | 35 | ND | 15 | 17 |
| 8-Jul | 52 | 87 | ND | 15 | 17 |
| 9-Jul | 30 | 117 | ND | 14 | 15 |
| 10-Jul | 14 | 131 | ND | 15 | 16 |
| 11-Jul | 5 | 136 | ND | ND | ND |
| 12-Jul | 18 | 154 | ND | 14 | 16 |
| 13-Jul | 21 | 175 | ND | 14 | 15 |
| 14-Jul | 10 | 185 | ND | 15 | 20 |
| 15-Jul | 43 | 228 | ND | 15 | 16 |
| 16-Jul | 32 | 260 | 27 | 15.5 | 19.5 |
| 17-Jul | 25 | 285 | ND | 17 | 21 |
| 18-Jul | 43 | 328 | 21 | 17 | 16 |
| 19-Jul | 41 | 369 | 24 | 17 | 18 |
| 20-Jul | 46 | 415 | 27 | 17 | 18 |
| 21-Jul | 26 | 441 | 24 | 16 | 17 |
| 22-Jul | 41 | 482 | 27 | 17 | 14 |
| 23-Jul | 49 | 531 | 27 | 16 | 17 |
| 24-Jul | 41 | 572 | 27 | 17 | 18 |
| 25-Jul | 15 | 587 | 27 | 15 | 16 |
| 26-Jul | 61 | 648 | 24 | 17 | 18 |
| 27-Jul | 64 | 712 | 24 | 17 | 18 |
| 28-Jul | 51 | 763 | 21 | 18 | 21 |
| 29-Jul | 74 | 837 | 21 | 18 | 20 |
| 30-Jul | 79 | 916 | 21 | 19 | 22 |

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| | Sockeye salmon | | Water | Water | Air |
|---|---|---|---|---|---|
| Date | Daily | Cumulative | depth (cm) | temperature (°C) | temperature (°C) |
| 31-Jul | 31 | 947 | 18 | 19 | 21 |
| 1–Aug | 75 | 1,022 | 18 | 19 | 16 |
| 2–Aug | 30 | 1,052 | 18 | 19 | 18 |
| 3-Aug | 40 | 1,092 | 12 | 18 | 18 |
| 4-Aug | 30 | 1,122 | 18 | 19 | 17 |
| 5-Aug | 19 | 1,141 | 27 | 18 | 18 |
| 6-Aug | 52 | 1,193 | 21 | 19 | 18 |
| 7-Aug | 34 | 1,227 | 21 | 20 | 22 |
| 8-Aug | 19 | 1,246 | 21 | 19 | 19 |
| 9-Aug | 25 | 1,271 | 21 | 18 | 19 |
| 10-Aug | 14 | 1,285 | 21 | 18 | 19 |
| 11-Aug | 17 | 1,302 | 12 | 18 | 20 |
| 12-Aug | 8 | 1,310 | ND | 18 | 17 |
| 13-Aug | 14 | 1,324 | 18 | 19 | 18 |
| 14-Aug | 7 | 1,331 | 15 | 19 | 19 |
| 15-Aug | 13 | 1,344 | 17 | 19 | 21 |
| 16-Aug | 7 | 1,351 | ND | 18 | 19 |
| 17-Aug | 11 | 1,362 | 18 | 17 | 16 |
| 18-Aug | 7 | 1,369 | 21 | 17 | 16 |
| 19-Aug | 7 | 1,376 | 21 | 18 | 16 |
| 20-Aug | 8 | 1,384 | 21 | 17 | 15 |
| 21-Aug | 4 | 1,388 | 21 | 16 | 16 |
| 22-Aug | 2 | 1,390 | 21 | 16 | 15 |
| 23-Aug | 3 | 1,393 | 17 | 18 | 18 |
| 24-Aug | 5 | 1,398 | ND | 16 | 15 |
| 25-Aug | 5 | 1,403 | 18 | 17 | 16 |
| 26-Aug | 1 | 1,404 | 18 | 16 | 15 |
| 27-Aug | 1 | 1,405 | 18 | 17 | 15 |
| 28-Aug | 2 | 1,407 | 21 | 16 | 14 |
| 29-Aug | 0 | 1,407 | 18 | 16 | 14 |
| 30-Aug | 2 | 1,409 | 21 | 16 | 15 |
| 31-Aug | 2 | 1,411 | 27 | 17 | 17 |
| 1-Sep | 3 | 1,414 | 27 | 16 | 16 |
| 2-Sep | 2 | 1,416 | 24 | 16 | 18 |
| 3-Sep | 2 | 1,418 | 24 | 16 | 17 |
| 4-Sep | 1 | 1,419 | ND | ND | ND |
| 5-Sep | 2 | 1,421 | ND | ND | ND |
| 6-Sep | 2 | 1,423 | ND | ND | ND |
| 7-Sep | 0 | 1,423 | ND | ND | ND |
| 8-Sep | 4 | 1,427 | ND | ND | ND |
| 9-Sep | 0 | 1,427 | ND | ND | ND |