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Office of Subsistence Management
Fisheries Resource Monitoring Program

# Kook Lake Sockeye Salmon Stock Assessment, 2005 to 2007

Final Report for Study 05-601

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## ABSTRACT

Sockeye salmon (*Oncorhynchus nerka*) returns to Kook Lake have long been an important subsistence resource for Tlingit families living in the Angoon area. This report summarizes the sockeye stock assessment findings for years 2005 to 2007 of a cooperative Angoon Community Association, Alaska Department of Fish and Game, and USDA Forest Service study. This project used a weir and mark-recapture methods to estimate the sockeye escapement into Kook Lake. Age, sex, and length data, limnology data, stream temperature, and spawning distribution (radio tagging) data were also collected to help assess the status of Kook Lake sockeye salmon. This project also included testing of a floating wall tent camp, testing of an adjustable weir bipod, testing of a lake "net weir", and testing of a mini-digital video recorder fish counting system.

The escapement of sockeye salmon into Kook Lake was estimated to be 1,994 fish in 2005, 10,165 in 2006, and 2,958 in 2007. Weir to spawning ground mark-recapture studies validated the accuracy of the weir counts. The 2006 escapement estimate was based on mark-recapture since the weir was damaged by an extreme high water event in early-September. Sockeye passed into the lake from late-June through mid-September. There were distinct populations of earlier-running inlet stream spawners and later-running beach spawners. Spawning was observed in the main inlet stream between late-July and early-September and along lake beaches in September and October. In 2005, half of the sockeye salmon entered the lake after August 25 and there were few inlet stream spawners. Only two of the twenty-one sockeye salmon that were radio tagged at the weir in 2005 spawned in the main inlet stream and these fish were tagged in the first 26% of the run. In 2006, there appeared to be a healthy distribution and abundance of both inlet stream and beach spawners. Both populations were present at modest levels in 2007. Age-1. fish dominated the escapements with an equal number of age-1.2 and age-1.3 fish in 2005, 80% age-1.2 fish in 2006, and 92% age-1.3 fish in 2007. *Bosmina* were the dominant zooplankton in an August 9, 2005 sample. Sockeye production from the Kook Lake system appears to be escapement limited.



**Key Words:** Sockeye salmon, *Oncorhynchus nerka*, Kook Lake, Basket Bay, escapement, mark-recapture, age composition, limnology, net weir, video counting.

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## INTRODUCTION

The current status of the Kook Lake (Basket Bay; ADF&G stream no. 112-12-027; Figure 1) sockeye run is poorly understood and of concern. The U.S. Fish and Wildlife, Office of Subsistence Management, Fishery Resource Monitoring Program funded a cooperative ADF&G, Angoon Community Association, USDA Forest Service project to use mark-recapture and visual survey methods to index the escapement of sockeye salmon in the Kook Lake system in 2001, 2002, and 2003 (Conitz and Cartwright 2002, 2003, 2005a).

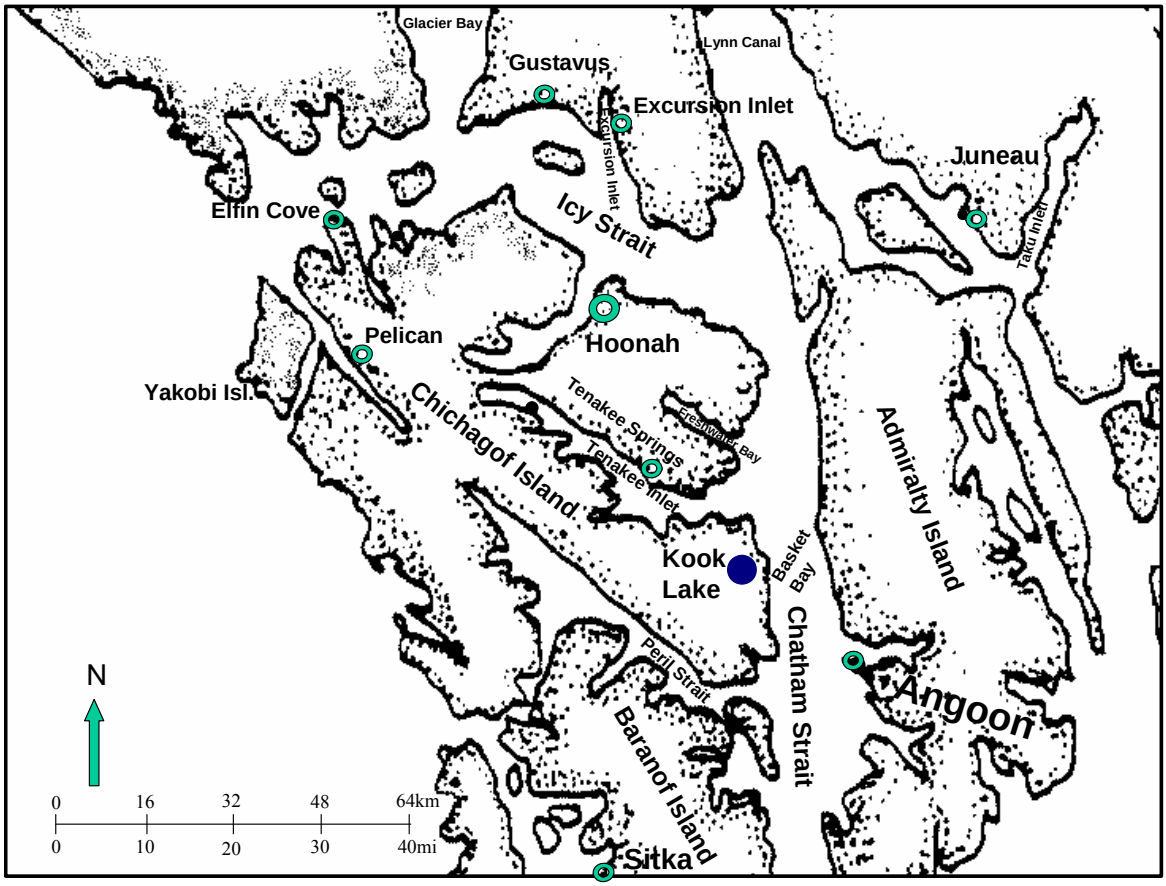



Figure 1. Map of the Northern Chatham Strait area of Southeast Alaska showing the location of Kook Lake and Basket Bay on Chichagof Island.

Project personnel were unable to capture many sockeye salmon in beach spawning areas in 2001 and 2002 (Figure 2). Conitz and Cartwright (2003) reported that "Mark-recapture sampling continued to present difficulties in this lake; sample sizes were small, and some of the mark-recapture assumptions may not have been met due to the difficulties in capturing fish." It was difficult to seine the salmon due to steep drop-offs, logs, and low concentrations of fish dispersed among several spawning areas on the

eastern half of the lake. The milling of salmon in deep water also made it difficult to count them by eye.

In 2001, the mark-recapture estimate of 230 sockeye salmon in a two-part beach spawning area expanded to 380 sockeye salmon in the whole lake based on the proportion of fish observed in and out of the study areas (Conitz and Cartwright 2002, 2005a). In 2002, a beach study area abundance of 590 sockeye expanded to 3,600 sockeye spawners in the lake (Conitz and Cartwright 2003, 2005a). These estimates might not be directly comparable between years due to annual changes in study areas, expansion factors, and spawning distributions. Conitz and Cartwright (2005a) described the expanded estimates as a "best educated guess". We can conclude that there were more beach spawners in 2002 than in 2001 but have little confidence that continuing these in-lake surveys will yield escapement indices that reliably reflect the annual escapement. A larger proportion of the beach spawners needs to be sampled to reliably index or estimate this part of the run and completely separate mark-recapture studies are needed to estimate the abundance of the earlier running spawners in the main inlet stream.

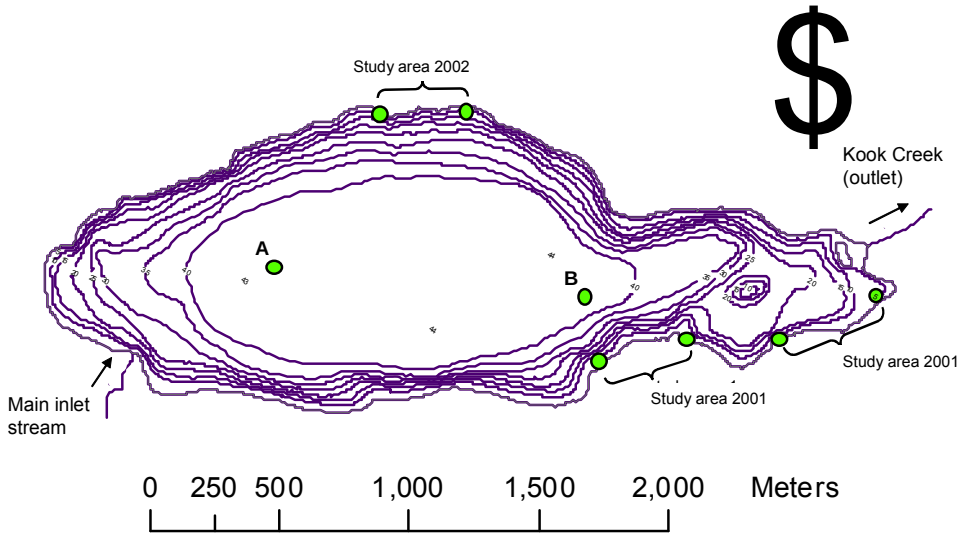



Figure 2. Bathymetric map of Kook Lake, showing 5 m depth contours, limnology sampling stations A and B, and the beach mark-recapture study areas used in 2001 and 2002 (adapted from Conitz and Cartwright 2005a).

In 2003, subsistence project personnel from Angoon (ACA) and Hoonah (Hoonah Indian Association) worked together to mark and recapture sockeye spawners in the main inlet stream. Only 180 (CV 9%) sockeye salmon were present (Conitz and Cartwright 2005a). The abundance of inlet stream spawners was much higher 10-20 years ago based on aerial and foot surveys and the numbers of fish that could be sampled in a day for age, sex, and length data (ADF&G, Alexander database; Figure 3).

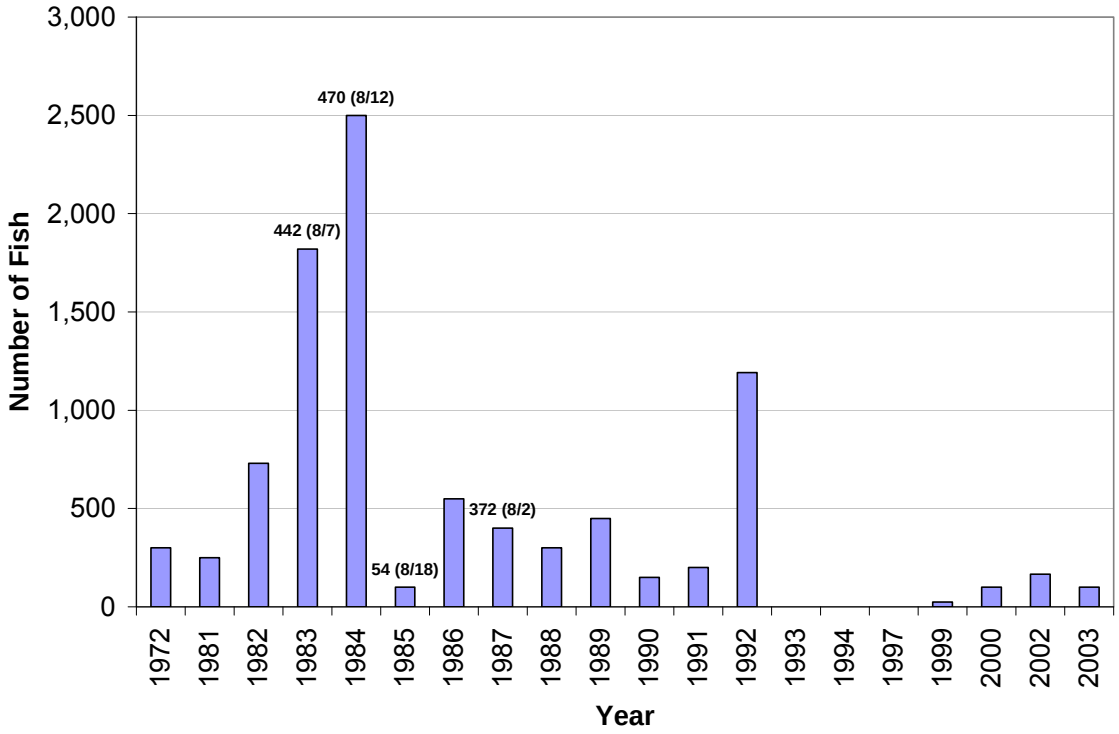



Figure 3. Number of sockeye salmon counted in aerial and foot surveys of Kook Lake's main inlet stream, 1972 to 2003. The number of ageable scales sampled, and sampling date, is also listed for the four years that this data was collected.

From the few fish handled or estimated in the 2001, 2002, and 2003 studies, and the logistical complications of different stream and beach spawning populations, it was clear that a weir project is needed to get a reliable estimate of the total sockeye escapement into the Kook Lake system. This report summarizes results from a three year study, 2005 to 2007, that used a weir at the lake outlet, and mark-recapture validation, to estimate the sockeye escapement into Kook Lake. These escapement estimates help us understand the current status of Kook Lake sockeye salmon and ability to meet subsistence needs.

A USFS-funded, ADF&G project had successfully operated an adult sockeye weir on the outlet of Kook Lake in 1994 and 1995. Weir counts were 1,817 in 1994 and 5,817 in 1995 (ADF&G Alexander Database). Weir counts had not trailed off when the weir was pulled on September 1, 1994 and August 31, 1995 (Figure 4). Actual escapements were probably a little higher and mark-recapture studies were not done to estimate if fish had entered the lake uncounted. The midpoint of these weir counts, and peak counts, was around July 27-28.

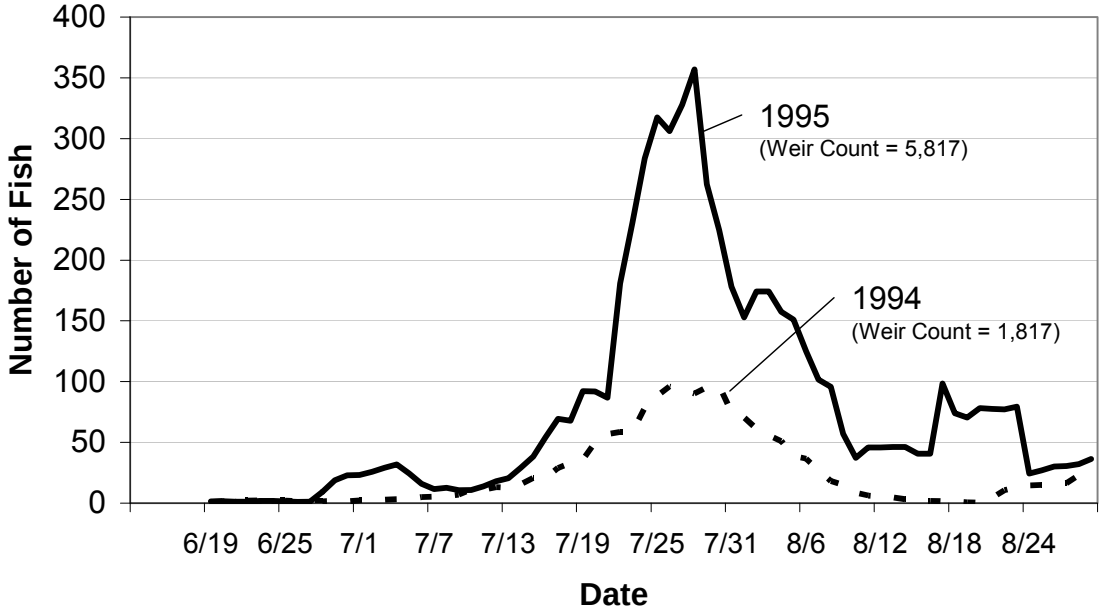
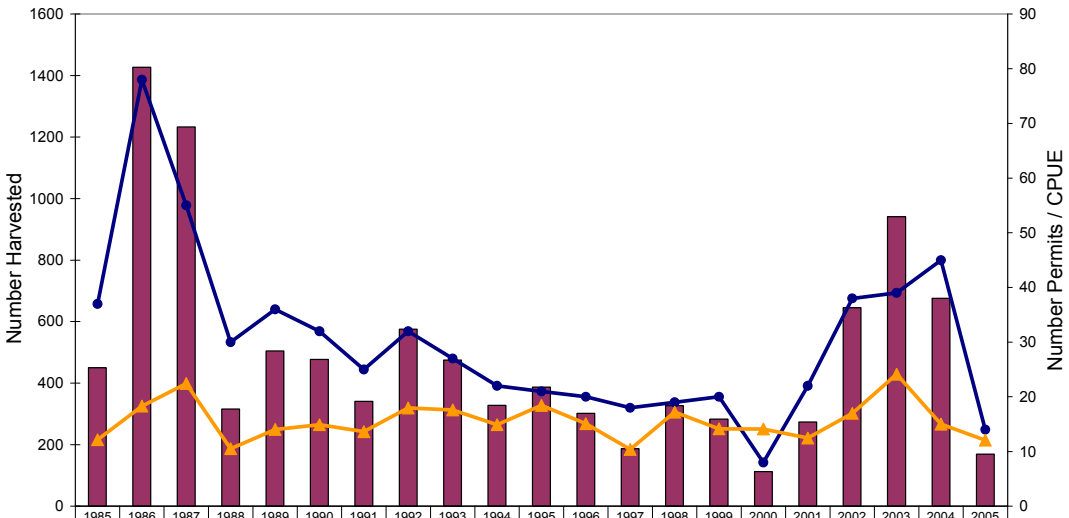



Figure 4. Daily counts of sockeye salmon through the Kook Lake weir, 1994 and 1995 (7-d, date-centered, moving averages).

Sockeye salmon returns to Kook Lake have long been an important subsistence resource for Tlingit families living in the Angoon area (de Laguna 1960; George and Bosworth 1988; Moss 1989; Goldschmidt et al. 1998). Basket Bay is a traditional subsistence salmon fishing location and a group of the Angoon Deisheetan, the Kak'w.wedi, lived there until the early 1900s (de Laguna 1960). Residents of Hoonah, Tenakee, and Juneau also use Basket Bay (Kook) sockeye for subsistence and personal use. Sockeye salmon were traditionally harvested from a hole in the lower part of the outlet stream. Most subsistence fishing is currently done using beach seines and gill nets at the head of Basket Bay. George and Bosworth (1988) estimated that 21% of the Angoon households used Basket Bay for subsistence.

Federal and State biologists cooperate in the management of the subsistence fishery. A permit is required to take salmon for subsistence and all harvesters have used the State permit and subsistence fished with gillnets or beach seines in marine (State) waters in recent years. ADF&G has records of over 1,500 sockeye harvested annually from 1981 to 1984. The current system of collecting the voluntary subsistence harvest records which started in 1985 (ADF&G, Alexander database) shows subsistence harvests of over 1,200 in 1986 and 1987, and harvests higher in 2002, 2003, and 2004 than they've been since 1987 (Figure 5).




| | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sum of sockeye | 450 | 1427 | 1233 | 316 | 505 | 477 | 341 | 575 | 475 | 328 | 387 | 302 | 187 | 327 | 283 | 113 | 274 | 645 | 941 | 676 | 169 |
| Sum of permits | 37 | 78 | 55 | 30 | 36 | 32 | 25 | 32 | 27 | 22 | 21 | 20 | 18 | 19 | 20 | 8 | 22 | 38 | 39 | 45 | 14 |
| Fish/Permit | 12 | 18 | 22 | 11 | 14 | 15 | 14 | 18 | 18 | 15 | 18 | 15 | 10 | 17 | 14 | 14 | 12 | 17 | 24 | 15 | 12 |

Figure 5. Subsistence/personal use effort and harvest of sockeye salmon in Basket Bay (Kook Lake outlet) from 1985 to 2005 as reported on permits returned to ADF&G (ADF&G, Division of Commercial Fisheries, Alexander Database, March 2007).

The increased harvest in recent years reflects a shift in subsistence fishing effort from Kanalku to Kook and other sockeye systems in the Angoon area. Kanalku is the preferred location for Angoon residents to harvest their subsistence sockeye but an estimated escapement of less than 250 sockeye salmon in Kanalku Lake in 2001 (Conitz and Cartwright 2002, 2005a) prompted community leaders and ADF&G management to implement a voluntary closure of subsistence fishing at Kanalku in years 2002 to 2005. This makes it even more important to monitor escapements of the Kook sockeye stock and to know if conservation actions are needed to keep this stock healthy.

In recent years, there has been an increase in the commercial purse seine effort and sockeye harvest in traditional and hatchery fisheries in the adjacent Chatham Strait area (District 112). The seine effort in District 112 is timed with the abundance of sockeye in the district whereas most of the District 114 (Icy Strait) and District 109 (lower Chatham Strait) effort is before or after the peak in sockeye abundance (Figure 6). Thus, the seine effort in District 112 might have a more direct effect on sockeye runs in the area. Commercial and sport fish managers have closed waters adjacent to Basket Bay in recent years to protect Kook Lake sockeye salmon (Conitz and Cartwright 2002).

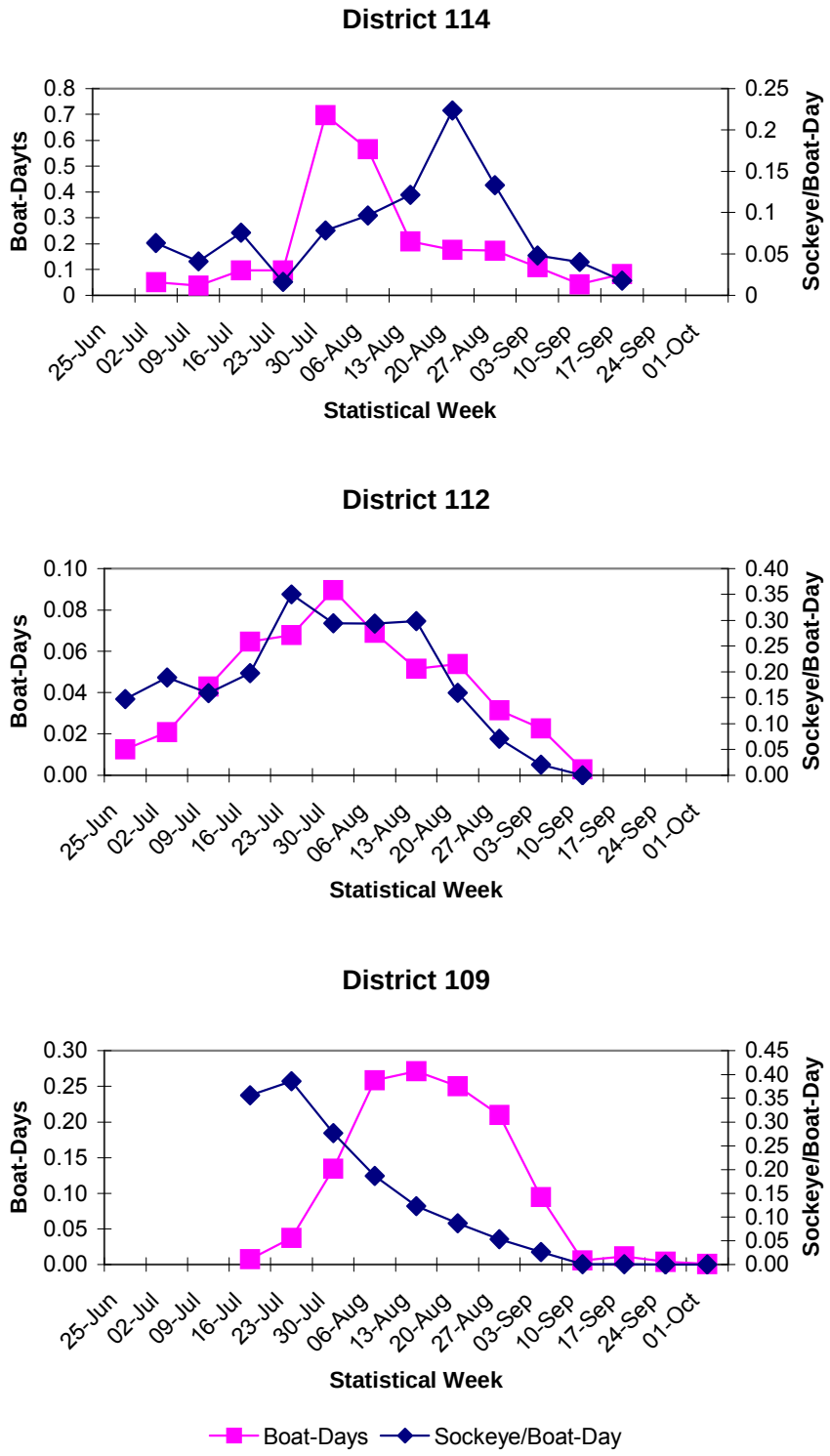



Figure 6. Relative timing of purse seine effort (boat-days) and sockeye abundance (sockeye/boat-day) in District 114 (Icy Strait), 112 (Upper Chatham Strait), and 109 (Lower Chatham Strait). The averages of the weekly proportions for the 10-year, 1991-2000, period is plotted.

An unusual feature of the Kook Lake system might also be a factor in the health of the sockeye run. The 1.2 km long outlet stream flows through two caverns in-route to the ocean and, on a July 30, 2001 foot survey, I found woody debris in these cavern entrances *potentially* blocking the upstream migration of salmon during low flow conditions. I was aware that in 1969, an ADF&G/USFS crew had also cleared debris from these cavern entrances (Dave Cantillon, NOAA/National Marine Fisheries Service, Seattle, personal communication). On August 17, 2001, I returned with three ACA employees and we cleared, by hand, lots of branches, sticks, and small trees from five cavern entrances in three locations of Kook Creek. There was evidence in the form of blood and fish parts that bears were preying on salmon at one of the cavern entrances. This was the most obstructed cavern entrance (Figure 7). We saw three adult sockeye salmon and 12 adult pink salmon in the stream above all potential blockages so these debris jams were certainly not a complete barrier during all flow conditions. We have found little or no debris to clear in subsequent surveys done in June or July in 2002 through 2007. I am concerned that reports by Conitz and Cartwright (2002, 2003, and 2005a) have overstated the likelihood that debris jams had blocked the migration of salmon into Kook Lake.

Before (July 30, 2001)

After (August 17, 2001)

Figure 7. Before (top) and after (bottom) photos showing the branches, sticks, small trees, and a log round that was cleared by hand from a cavern entrance on Kook Creek, 2001.

Large portions of the Kook Lake watershed had been clear-cut logged in 1970s, 1980s, and 1990s. There is no road access directly to the lake or outlet stream but maintained roads cross the tributary streams on the North side and West end of the lake. These roads connect to the log transfer site and Forest Service camp in Corner Bay (Tenakee Inlet).

## OBJECTIVES

The contracted project objectives were:

1. Estimate the total escapement of sockeye salmon into Kook Lake with a weir/mark-recapture project such that the estimated coefficient of variation is less than 15%.
2. Estimate the age, length, and sex composition of the Kook Lake sockeye escapement so that the estimated coefficient of variation is less than 10%.
3. Clear debris from the cavern entrances on the outlet stream.

The distribution of spawning sockeye salmon within the Kook Lake system was also estimated with a radio tagging study in 2005. Vertical zooplankton tows and vertical temperature, dissolved oxygen, and light profile measurements were taken in the lake in August in 2005 and 2006. Data loggers were deployed to measure stream and air temperatures. Appendix C provides sampling guidelines for weir to above-weir mark-recapture studies. The performance of an adjustable bipod weir design was tested (Appendix D) as was the performance of a floating wall tent (Van Alen 2004), a net weir (Appendix E), and a mini-DVR (digital video recorder) video fish counting system (Appendix F).

## METHODS

### Study Area

Kook Lake (outlet at 57.66563°N, 134.95710°W; NAD83/WGS84 datum) is on the southeast side of Chichagof Island about 26 km northeast across Chatham Strait from Angoon (Figure 1). Kook Lake has an elevation of 12.5 m, a surface area of about 240 ha, a mean depth of 30 m, and a maximum depth of 44 m (Contz and Cartwright 2003; Figure 2). The drainage area of the watershed is about 54 $km^2$. There is one main inlet stream that flows into the southwest end of the lake at 57.66255°N and 135.00394°W. The 1.2 km long outlet stream, Kook Creek, flows through two natural caverns between the Northeast end of the lake and the head of Basket Bay.

The Kook Lake system supports anadromous runs of sockeye, coho, pink, and chum salmon and resident populations of Dolly Varden char (*Salvelinus malma*), cutthroat trout (*O. clarki*), three spine stickleback (*Gasterosteus aculeatus*), and sculpin (*Cottis* sp.).

## Sockeye Escapement Assessment

The escapement of adult sockeye salmon into Kook Lake was estimated using the combination of a weir and mark-recapture. Validating weir counts with a companion mark-recapture study is to assure that Objective #1, the estimate of total escapement, is accurate. Only the fish observed at a weir are counted and fish could pass uncounted before or after the weir is operated, at times when the weir is not operational, or through unknown breaks in the weir

### *Weir*

Upstream migrating adult salmon, trout, and Dolly Varden char were counted as they were passed upstream out of a trap on the face of a weir installed across the outlet of Kook Lake. The weir was operated continuously from mid to late-June through mid-September in years 2005, 2006, and 2007. Separate counts were kept for adult and jack sockeye salmon.

The weir was constructed using an aluminum bipod and channel superstructure and 19.05 mm x 305 cm (3/4 in x 10 ft) EMT conduit pickets. The bipods were adjustable so they would fit over the uneven bedrock sill at the outlet of the lake and collapse to fit in a DeHavilland Beaver float plane (Appendix D). Nine bipods were used to support the 23 m (75.5 ft) wide weir.

Upstream migrating fish were counted and sampled from a 152.5 x 243.4 x 304.8 cm (5 x 8 x 10 ft), bear proof, trap attached to the front of the weir (Van Alen 2004). The maximum gap between pickets in the weir and trap was 2.54 cm. Sandbags were laid, end-to-end, along the face of the weir and around the base of the trap. A plastic "crab finger" frame was fit over the "V" entrance to the trap to keep salmon from swimming back downstream out of the trap.

Fish were dipnetted and passed out of the trap through a "fish door" that opens in the side of the trap just above the water level. A plastic fish tub, aluminum fish-measuring trough, and scale card/data holder were mounted on the side of the trap next to the fish door. A labeled array of hand tally counters was use to initially record the number of adult and jack, marked and unmarked, salmon, trout, and char passed upstream of the weir. The crew lived in a floating wall tent that could be pulled up to the trap during the day and away from the trap, and terrestrial critters, at night (Figure 8; Van Alen 2004).

Figure 8. Photo of the Kook Lake weir, trap, and floating wall tent, 2005.

***Weir-to-Spawning Ground Mark-Recapture***

The accuracy of the sockeye weir count was checked by marking fish at the weir and examining them for marks upstream from the weir (see Appendix C for details on weir to above-weir mark-recapture studies). Dipnets and a small seine was used to capture sockeye salmon in the main inlet stream and a seine was used to capture fish in beach spawning locations. If initial sampling finds a lower marking rate than that applied at the weir then a more intensive recovery effort will be needed. A one-tailed binomial test (Zar 1984), with $P < 0.05$, was used to determine if the sockeye sampled upstream from the weir were marked in the same proportion as those counted through the weir.

The study plan was to mark a consistent percentage of the adult sockeye and jacks that were passed through the weir. In all years the fish were marked with an adipose finclip. In 2005, marked fish were also given either a left axillary clip in the first third of the run, a left ventral clip in the middle third of the run, or a dorsal clip in the last third of the run. The dates for each third of the run were approximated as start-of-run through July 25, July 26 through August 10, and August 11 to end-of-run based on each third of the 1994 and 1995 weir counts. These finclips involved severing the entire adipose fin, the entire left axillary fin, the lower two-thirds of the left ventral fin, and cutting across the posterior base of the last four dorsal fin rays. Scissors were used to do the finclips. Most

clips were done with the fish's head still in the water. The marked fish were released into quiet water at the upper (lake) end of the trap.

### *Age, Sex, and Length Sampling*

Adult and jack sockeye salmon were sampled at the weir for age (scales), sex, and length data following standard ADF&G sampling procedures (ADF&G 2001). Three scales were sampled from two rows above the lateral line on the left side of the fish in the area posterior to the dorsal fin and anterior to the anal fin (INPFC 1963). Scales from this "preferred area" were mounted on gummed scale cards then a hot press was used to make impressions of the scales so they could be read (aged) using a microfilm reader (Clutter and Whitesel 1956). The seasonal sampling goals were 600 fish in 2005 and 2006 and 480 fish in 2007. Weekly sampling goals were established based on the average weekly proportions of past weir counts.

Tweezers were used to pull three scales from each fish sampled. Scales were pulled from the "preferred area" on the left side of the fish, two rows above the lateral line, in the area between the dorsal and anal fins. Lengths were measured from mid-eye to fork-of-tail by laying the fish on a ruler in a fish "measuring trough". Sex was determined from external morphometric characteristics. Scales were aged at the ADF&G, Commercial Fisheries Division, Aging Lab in Juneau. Age classes were recorded in European notation where a period separates the number of fresh water and marine annuli (Koo 1962).

After the scales were aged, the scale samples were stratified by age and week as described by Conitz and Cartwright (2003). Let $n$ be the total number of samples aged, $n_k$ be the number of samples in stratum $k$, and $N$ be the estimated escapement. The proportion of each stratum $k$ was calculated by

$$\hat{p}_k = \frac{n_k}{n} \tag{1}$$

The estimated standard error was derived from the binomial formula with correction for finite population size (Thompson 1992, p. 35-36):

$$SE(\hat{p}_k) = \sqrt{\left(1 - \frac{n}{N}\right)\frac{\hat{p}_k(1-\hat{p}_k)}{n-1}} \tag{2}$$

The estimated mean length and associated standard error for stratum $k$ were calculated as the sample mean of a simple random sample (Thompson 1992, p. 42-43):

$$\bar{y}_k = \frac{1}{n_k}\sum_{i=1}^{n_k} y_{ki} \text{ , and } SE(\bar{y}_k) = \sqrt{\frac{1}{n_k}}\sqrt{\left(\frac{1}{n_k - 1}\right)\sum_{i=1}^{n_k}(y_{ki} - \bar{y}_i)^2} \tag{3}$$

### *Spawning Distribution*

Twenty-one adult sockeye salmon were radio tagged at the weir in 2005 to better understand their entry pattern and spawning distribution. The study design called for radio tagging one out of every 100 adult sockeye passed upstream of the trap. The radio tags (transmitters) were manufactured by Advanced Telemetry Systems.[1] The Model F1845 transmitters were bottle shaped, weighed 24 g, and were 51 mm long and 20 mm in diameter with a 30.5 cm long wire antenna. Their pulse rate was 65 $min^{-1}$. Inserting these "esophageal" transmitters involved threading the antenna through a 3 x 20 cm plastic tube and using this tube to gently push the transmitter through the fish's mouth and into its stomach. The antenna was left sticking out of the mouth. Fish were quickly tagged, measured for mid-eye-to-fork length, and released. Tagged fish were watched till they swam out of sight above the trap for any evidence of tag loss or handling mortality. Tracking of radio tagged fish was done on foot in conjunction with the mark-recapture studies in the main inlet stream in August and September and from a fixed wing surveys on September 23 and October 6, 2005.

## Limnology Sampling

### *Weather, Stream Depth, and Water and Air Temperature Measurements*

The weather (clear, partly cloudy, overcast, showers, rain), stream depth, and water and air temperature was recorded at a gauging station near the weir each morning between 0800 and 0900 hour. Recording thermometers (Onset Computer Corporation, "Tidbit" loggers[1]) were also deployed on July 3, 2005 in the outlet and July 4, 2005 in the main inlet stream. A temperature data logger was also deployed at the outlet to record air temperatures. They were programmed to record the temperature every four hours.

### *Light, Temperature, and Dissolved Oxygen Profiles*

On August 9, 2005 and August 23, 2006, vertical dissolved oxygen, temperature, and light intensity measurements were taken at Station A (57.66472°N, 134.99462°W) over the deepest part of the lake.

The subsurface light intensity was measured at 1.0-meter intervals from just below the surface (5 cm) down to less than one percent of the surface light reading using a Licor LI-250 submarine photometer. Readings were in μmol $s^{-1}$ $m^{-2}$. The vertical light extinction coefficient ($K_d$) and euphotic zone depth (EZD) was calculated following procedures described by Conitz and Cartwright (2002a). The vertical light extinction coefficient ($K_d$) was calculated as the slope of the light intensity (natural log of percent subsurface light) versus depth. The euphotic zone depth (EZD) was calculated as EZD = $4.6205/K_d$ and is defined as the part of the lake where photosynthesis is possible. Water transparency was also measured with a 20 cm diameter Secchi disk (Koenings *et al.* 1987).

[1] The use of trade names does not constitute their endorsement.

All vertical temperature and dissolved oxygen (DO) measurements were made with a Yellow Springs Instruments Model 58 DO meter and probe. The Model 58 DO meter was calibrated each trip by taking the average value of two 30 ml Winker titrations from a water sample collected at 1 m (Koenings *et al.* 1987). Readings were taken at one-meter intervals down to 20 meters then at five-meter intervals to within 2 m of the bottom or 50 meters, whichever is less. Dissolved oxygen (DO) readings were in mg $L^{-1}$ and temperature readings were in $^{o}C$. The mg $L^{-1}$ DO readings were converted to percent $O_2$ saturation using the following formula:

$$\%O_2 saturation = (DO/(0.004399 * temp^2 - 0.381784 + 14.571252)) * 100 \qquad (4)$$

The parameters in this equation were computed from data presented in Table 6.1 of Wetzel and Likens (2000). This regression of the solubility of $O_2$ on temperature had a correlation coefficient of 0.9998. No adjustment was made for altitude (barometric pressure) since Kook Lake is a low elevation lake at 12.5 meters above sea level.

### *Zooplankton Composition and Density*

On August 9, 2005 and August 23, 2006, vertical zooplankton tows were made at both stations A and B (57.66492°N, 134.97751°W). A 0.5 m diameter, 153 um mesh, 1:3 conical net was used. Vertical tows were pulled from 2 m from the bottom of the lake at 0.5 m $sec^{-1}$. Specimens were preserved in neutralized 10% formalin (Koenings *et al.* 1987). The 2005 zooplankton samples were analyzed at the ADF&G Commercial Fisheries Division Limnology Laboratory in Kodiak Alaska. The 2006 zooplankton samples have not been analyzed. The identification to genus or species, enumeration, and density and biomass estimates were done as described by Conitz *et al.* 2002 and Koenings *et al.* 1987). The zooplankton density (individuals $m^{-2}$ surface area) and biomass (weight $m^{-2}$ surface area) were estimated by species and by the sum of all species (referred to as total zooplankton density or biomass).

## RESULTS

### Sockeye Escapement Assessment

### *Weir and Weir-based Mark-Recapture Estimate of Total Escapement*

***2005.*** The adult salmon weir was installed at the outlet of Kook Lake and operated continuously from mid-day on June 17 through mid-day on September 16. (Figure 9; Table 1; Appendix A.1.). Weir counts totaled 1,994 sockeye salmon - 1,923 adults and 71 jacks. There were five additional adult sockeye salmon that died at the weir. The first sockeye passed on July 1 and the last on September 16. Half of the sockeye passed after August 25 and 80 percent passed between July 25 and September 3. Counts of other

species totaled 509 coho salmon, 1,883 pink salmon, 2 chum salmon, 1 Chinook salmon, 35 Dolly Varden, and 7 cutthroat trout (Appendix A.1).

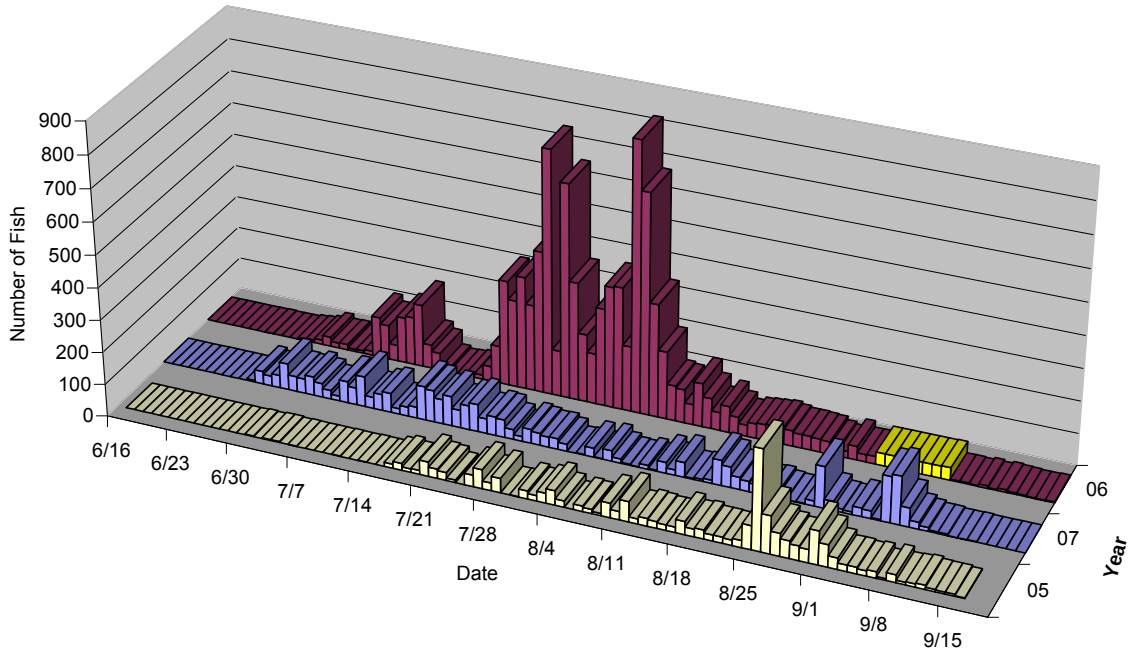



Figure 9. Estimated daily escapement of sockeye salmon into Kook Lake, June 16 to September 19, 2005 to 2007.

Table 1. Estimated daily escapement of sockeye salmon into Kook Lake, June 16 to September 19, 2005 to 2007.

| | 2005 | | | 2006 | | | 2007 | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Number | Cumulative Number | Cumulative Proportion[a] | Number[b] | Cumulative Number | Cumulative Proportion | Number | Cumulative Number | Cumulative Proportion |
| Jun-16 | | 0 | 0.000 | 0 | 0 | 0.000 | | 0 | 0.000 |
| Jun-17 | 0 | 0 | 0.000 | 0 | 0 | 0.000 | | 0 | 0.000 |
| Jun-18 | 0 | 0 | 0.000 | 0 | 0 | 0.000 | | 0 | 0.000 |
| Jun-19 | 0 | 0 | 0.000 | 0 | 0 | 0.000 | | 0 | 0.000 |
| Jun-20 | 0 | 0 | 0.000 | 0 | 0 | 0.000 | | 0 | 0.000 |
| Jun-21 | 0 | 0 | 0.000 | 0 | 0 | 0.000 | | 0 | 0.000 |
| Jun-22 | 0 | 0 | 0.000 | 0 | 0 | 0.000 | | 0 | 0.000 |
| Jun-23 | 0 | 0 | 0.000 | 1 | 1 | 0.000 | | 0 | 0.000 |
| Jun-24 | 0 | 0 | 0.000 | 0 | 1 | 0.000 | | 0 | 0.000 |
| Jun-25 | 0 | 0 | 0.000 | 0 | 1 | 0.000 | | 0 | 0.000 |
| Jun-26 | 0 | 0 | 0.000 | 0 | 1 | 0.000 | 5 | 5 | 0.002 |
| Jun-27 | 0 | 0 | 0.000 | 5 | 6 | 0.001 | 40 | 45 | 0.015 |
| Jun-28 | 0 | 0 | 0.000 | 8 | 14 | 0.001 | 31 | 76 | 0.026 |
| Jun-29 | 0 | 0 | 0.000 | 14 | 28 | 0.003 | 39 | 115 | 0.039 |
| Jun-30 | 0 | 0 | 0.000 | 29 | 57 | 0.006 | 82 | 197 | 0.067 |
| Jul-01 | 2 | 2 | 0.001 | 16 | 73 | 0.007 | 47 | 244 | 0.082 |
| Jul-02 | 0 | 2 | 0.001 | 17 | 90 | 0.009 | 45 | 289 | 0.098 |
| Jul-03 | 3 | 5 | 0.003 | 7 | 97 | 0.010 | 58 | 347 | 0.117 |
| Jul-04 | 3 | 8 | 0.004 | 8 | 105 | 0.010 | 43 | 390 | 0.132 |
| Jul-05 | 0 | 8 | 0.004 | 13 | 118 | 0.012 | 27 | 417 | 0.141 |
| Jul-06 | 1 | 9 | 0.005 | 127 | 245 | 0.024 | 15 | 432 | 0.146 |
| Jul-07 | 0 | 9 | 0.005 | 107 | 352 | 0.035 | 67 | 499 | 0.169 |
| Jul-08 | 0 | 9 | 0.005 | 50 | 402 | 0.040 | 53 | 552 | 0.187 |
| Jul-09 | 0 | 9 | 0.005 | 143 | 545 | 0.054 | 94 | 646 | 0.218 |
| Jul-10 | 0 | 9 | 0.005 | 150 | 695 | 0.068 | 35 | 681 | 0.230 |
| Jul-11 | 1 | 10 | 0.005 | 195 | 890 | 0.088 | 50 | 731 | 0.247 |
| Jul-12 | 0 | 10 | 0.005 | 74 | 964 | 0.095 | 60 | 791 | 0.267 |
| Jul-13 | 0 | 10 | 0.005 | 53 | 1017 | 0.100 | 17 | 808 | 0.273 |
| Jul-14 | 1 | 11 | 0.006 | 8 | 1025 | 0.101 | 28 | 836 | 0.283 |
| Jul-15 | 0 | 11 | 0.006 | 0 | 1025 | 0.101 | 34 | 870 | 0.294 |
| Jul-16 | 0 | 11 | 0.006 | 2 | 1027 | 0.101 | 105 | 975 | 0.330 |
| Jul-17 | 13 | 24 | 0.012 | 7 | 1034 | 0.102 | 98 | 1073 | 0.363 |
| Jul-18 | 22 | 46 | 0.023 | 13 | 1047 | 0.103 | 76 | 1149 | 0.388 |
| Jul-19 | 11 | 57 | 0.029 | 46 | 1093 | 0.108 | 92 | 1241 | 0.420 |
| Jul-20 | 12 | 69 | 0.035 | 116 | 1209 | 0.119 | 55 | 1296 | 0.438 |
| Jul-21 | 45 | 114 | 0.057 | 327 | 1536 | 0.151 | 75 | 1371 | 0.463 |
| Jul-22 | 29 | 143 | 0.072 | 271 | 1807 | 0.178 | 85 | 1456 | 0.492 |
| Jul-23 | 25 | 168 | 0.084 | 350 | 2157 | 0.212 | 46 | 1502 | 0.508 |
| Jul-24 | 8 | 176 | 0.088 | 268 | 2425 | 0.239 | 58 | 1560 | 0.527 |
| Jul-25 | 0 | 176 | 0.088 | 440 | 2865 | 0.282 | 55 | 1615 | 0.546 |
| Jul-26 | 36 | 212 | 0.106 | 758 | 3623 | 0.356 | 31 | 1646 | 0.556 |
| Jul-27 | 59 | 271 | 0.136 | 142 | 3765 | 0.370 | 15 | 1661 | 0.562 |
| Jul-28 | 24 | 295 | 0.148 | 665 | 4430 | 0.436 | 44 | 1705 | 0.576 |
| Jul-29 | 45 | 340 | 0.171 | 367 | 4797 | 0.472 | 38 | 1743 | 0.589 |
| Jul-30 | 0 | 340 | 0.171 | 211 | 5008 | 0.493 | 32 | 1775 | 0.600 |
| Jul-31 | 1 | 341 | 0.171 | 157 | 5165 | 0.508 | 33 | 1808 | 0.611 |
| Aug-01 | 25 | 366 | 0.184 | 303 | 5468 | 0.538 | 22 | 1830 | 0.619 |
| Aug-02 | 17 | 383 | 0.192 | 376 | 5844 | 0.575 | 0 | 1830 | 0.619 |

-Continued-

Table 1. Continued.

| | 2005 | | | 2006 | | | 2007 | | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Number | Cumulative Number | Cumulative Proportion[a] | Number[b] | Cumulative Number | Cumulative Proportion | Number | Cumulative Number | Cumulative Proportion |
| Aug-03 | 31 | 414 | 0.208 | 381 | 6225 | 0.612 | 2 | 1832 | 0.619 |
| Aug-04 | 45 | 459 | 0.230 | 203 | 6428 | 0.632 | 28 | 1860 | 0.629 |
| Aug-05 | 20 | 479 | 0.240 | 838 | 7266 | 0.715 | 2 | 1862 | 0.629 |
| Aug-06 | 0 | 479 | 0.240 | 687 | 7953 | 0.782 | 33 | 1895 | 0.641 |
| Aug-07 | 17 | 496 | 0.249 | 352 | 8305 | 0.817 | 13 | 1908 | 0.645 |
| Aug-08 | 13 | 509 | 0.255 | 210 | 8515 | 0.838 | 3 | 1911 | 0.646 |
| Aug-09 | 7 | 516 | 0.259 | 110 | 8625 | 0.848 | 1 | 1912 | 0.646 |
| Aug-10 | 45 | 561 | 0.281 | 104 | 8729 | 0.859 | 12 | 1924 | 0.650 |
| Aug-11 | 26 | 587 | 0.294 | 63 | 8792 | 0.865 | 3 | 1927 | 0.651 |
| Aug-12 | 63 | 650 | 0.326 | 135 | 8927 | 0.878 | 34 | 1961 | 0.663 |
| Aug-13 | 16 | 666 | 0.334 | 94 | 9021 | 0.887 | 17 | 1978 | 0.669 |
| Aug-14 | 24 | 690 | 0.346 | 56 | 9077 | 0.893 | 46 | 2024 | 0.684 |
| Aug-15 | 21 | 711 | 0.357 | 81 | 9158 | 0.901 | 3 | 2027 | 0.685 |
| Aug-16 | 17 | 728 | 0.365 | 54 | 9212 | 0.906 | 6 | 2033 | 0.687 |
| Aug-17 | 17 | 745 | 0.374 | 35 | 9247 | 0.910 | 10 | 2043 | 0.691 |
| Aug-18 | 41 | 786 | 0.394 | 45 | 9292 | 0.914 | 78 | 2121 | 0.717 |
| Aug-19 | 24 | 810 | 0.406 | 49 | 9341 | 0.919 | 64 | 2185 | 0.739 |
| Aug-20 | 28 | 838 | 0.420 | 51 | 9392 | 0.924 | 38 | 2223 | 0.752 |
| Aug-21 | 19 | 857 | 0.430 | 55 | 9447 | 0.929 | 32 | 2255 | 0.762 |
| Aug-22 | 19 | 876 | 0.439 | 48 | 9495 | 0.934 | 27 | 2282 | 0.771 |
| Aug-23 | 17 | 893 | 0.448 | 43 | 9538 | 0.938 | 12 | 2294 | 0.776 |
| Aug-24 | 22 | 915 | 0.459 | 43 | 9581 | 0.943 | 14 | 2308 | 0.780 |
| Aug-25 | 74 | 989 | 0.496 | 41 | 9622 | 0.947 | 4 | 2312 | 0.782 |
| Aug-26 | 312 | 1301 | 0.652 | 39 | 9661 | 0.950 | 1 | 2313 | 0.782 |
| Aug-27 | 117 | 1418 | 0.711 | 28 | 9689 | 0.953 | 2 | 2315 | 0.783 |
| Aug-28 | 70 | 1488 | 0.746 | 21 | 9710 | 0.955 | 16 | 2331 | 0.788 |
| Aug-29 | 54 | 1542 | 0.773 | 43 | 9753 | 0.959 | 128 | 2459 | 0.831 |
| Aug-30 | 45 | 1587 | 0.796 | 23 | 9776 | 0.962 | 28 | 2487 | 0.841 |
| Aug-31 | 41 | 1628 | 0.816 | 24 | 9800 | 0.964 | 10 | 2497 | 0.844 |
| Sep-01 | 104 | 1732 | 0.869 | 40 | 9840 | 0.968 | 8 | 2505 | 0.847 |
| Sep-02 | 69 | 1801 | 0.903 | 40 | 9880 | 0.972 | 26 | 2531 | 0.856 |
| Sep-03 | 35 | 1836 | 0.921 | 40 | 9920 | 0.976 | 24 | 2555 | 0.864 |
| Sep-04 | 20 | 1856 | 0.931 | 40 | 9960 | 0.980 | 4 | 2559 | 0.865 |
| Sep-05 | 20 | 1876 | 0.941 | 40 | 9999 | 0.984 | 142 | 2701 | 0.913 |
| Sep-06 | 16 | 1892 | 0.949 | 40 | 10039 | 0.988 | 150 | 2851 | 0.964 |
| Sep-07 | 20 | 1912 | 0.959 | 40 | 10079 | 0.992 | 59 | 2910 | 0.984 |
| Sep-08 | 6 | 1918 | 0.962 | 41 | 10120 | 0.996 | 22 | 2932 | 0.991 |
| Sep-09 | 24 | 1942 | 0.974 | 4 | 10124 | 0.996 | 12 | 2944 | 0.995 |
| Sep-10 | 8 | 1950 | 0.978 | 4 | 10128 | 0.996 | 5 | 2949 | 0.997 |
| Sep-11 | 10 | 1960 | 0.983 | 2 | 10130 | 0.997 | 5 | 2954 | 0.999 |
| Sep-12 | 13 | 1973 | 0.989 | 8 | 10138 | 0.997 | 1 | 2955 | 0.999 |
| Sep-13 | 7 | 1980 | 0.993 | 3 | 10141 | 0.998 | 1 | 2956 | 0.999 |
| Sep-14 | 6 | 1986 | 0.996 | 8 | 10149 | 0.998 | 2 | 2958 | 1.000 |
| Sep-15 | 6 | 1992 | 0.999 | 5 | 10154 | 0.999 | | 2958 | 1.000 |
| Sep-16 | 2 | 1994 | 1.000 | 4 | 10158 | 0.999 | | 2958 | 1.000 |
| Sep-17 | | 1994 | 1.000 | 2 | 10160 | 1.000 | | 2958 | 1.000 |
| Sep-18 | | 1994 | 1.000 | 2 | 10162 | 1.000 | | 2958 | 1.000 |
| Sep-19 | | 1994 | 1.000 | 3 | 10165 | 1.000 | | 2958 | 1.000 |

[a]The boxed areas in the Cumulative Proportion columns show the median and second and third quartiles and 80% of the fish escaped between the lines.

[b]The entries in the shaded cells for the number that escaped from September 1 to 8, 2006, when high water flooded the weir, is an equal daily allocation of the 319 fish difference between the 9,846 weir count and the 10,165 mark-recapture estimate.

The weir held well all season and there were no instances that the weir operators suspected that salmon passed through the weir uncounted. Daily sockeye counts had trailed off when the weir was pulled on September 16 but there were probably a few sockeye salmon that escaped after that date.

A weir-to-spawning area mark-recapture study was done to evaluate the accuracy of the weir count. The weir crew marked 1,737 (87%) of the 1,994 sockeye salmon that they passed through the weir (Appendix A.1.). The cumulative proportion marked was in the 70 to 90 percent range for most of the season. This marking rate was higher than the 50 percent called for in the Investigation Plan, which is fine, but a more consistent marking rate is preferred.

Adult sockeye salmon were examined for adipose clips in the main inlet stream on three occasions and 132 fish were recaptured (Table 2). The proportion of adipose-clipped sockeye salmon in these samples was not significantly less ($P < 0.05$) than the 0.8711 (87%) marked at the weir and the simple Peterson (Ricker 1975) mark-recapture estimate of 2,105 fish (CV=4%) was only 109 fish greater than the 1,994 weir count. Given that the percent of marked fish in the inlet stream was similar to the percent marked at the weir, that the percent marked was relatively consistent each sampling trip, and that there were no known breaks in the weir, I consider the 1,994 weir count as the best estimate of the sockeye escapement in 2005.

Table 2. Mark-recapture data and estimate for validation of the Kook Lake weir count of sockeye salmon, 2005.

Marking Data - from the weir at the outlet of Kook Lake:

| Dates | Weir Count | Number Marked (M) | Percent Marked |
|---|---|---|---|
| Jun-17 to Sep-16 | 1,994 | 1,737 | 87% |

Recapture Data - from main inlet stream:

| Date | Number Examined (C) | Number with Marks (R) | Percent Marked | One-Tailed Binomial Test *P*-value |
|---|---|---|---|---|
| Aug-24 | 46 | 36 | 78% | 0.07 |
| Aug-30 | 52 | 43 | 83% | 0.22 |
| Sep-05 | 62 | 53 | 85% | 0.41 |
| Total | 160 | 132 | 83% | 0.06 |

| Peterson Estimate[a]: | | | 95% Confidence Limits[b] | |
|---|---|---|---|---|
| Number | S.E. | CV | Lower | Upper |
| 2,105 | 77 | 4% | 1,776 | 2,497 |

[a] Simple Peterson (Ricker 1975, p. 78, eq. 3.5 and 3.6):

$$\hat{N} = \frac{M * C}{R} \qquad \mathrm{var}\left(\hat{N}\right) = \frac{\left(M^2 * C * (C - R)\right)}{R^3}$$

$$SE = \sqrt{\mathrm{var}(\hat{N})} \qquad CV = \frac{SE}{\hat{N}}$$

Where :

$\hat{N}$ = estimated escapement

$M$ = number marked

$C$ = number examined for marks

$R$ = number recaptured

[b]The 95% Confidence Limits were calculated using Appendix II in Ricker (1975, p. 343): Since R>50, the upper and lower limits of R were calculated using the formula

$$\pm R = R + 1.92 \pm 1.960\sqrt{R + 1.0}$$

and used in the M*C/R calculations of the lower and upper confidence limits.

We were unable to examine lake spawners for weir marks in 2005 due to conflicting personnel schedules and workloads. This would have been quite important if the proportion of fish marked in the main inlet stream samples had been less than the proportion marked at the weir or if we knew that fish were able to pass through the weir uncounted. Sampling beach spawners has proven to be difficult in the past (Conitz and Cartwright 2002, 2003, and 2005a) due to logs, deep water, low concentrations of fish, poor weather conditions during the September to November spawning period, and cost of extending project activities after mid-September.

***2006.*** In 2006, the weir was operated at the outlet of Kook Lake from June 16 through September 19. Weir counts totaled 9,846 sockeye salmon (9,839 adults and 7 jacks), 121 coho salmon, 18 pink salmon, 3 Chinook salmon, 4 cutthroat trout, and 337 Dolly Varden char (Appendix A.2). There were 21 sockeye salmon that died in the trap or shortly after being released into the lake. Most of these fish had been gravely injured by bears or river

otters fishing at the weir. Project personnel observed more bear and otter activity at the weir in 2006 than in 2005 or 2007.

On September 1, the weir was topped and damaged (Figure 10) following a period of extremely heavy rainfall. This deluge also topped the Klag Bay weir and put the Redoubt weir out of commission for the season (personnel communication, T. Suminski, Forest Service, Sitka). The water remained too high to safely repair and operate the picket weir for several days. Fortunately, on August 21, I had installed an experimental "net" weir on the lake side of the picket weir (Figure 10;Appendix B). The net weir was undamaged by the flood and, after building and installing a floating trap on the net weir, we used it to count fish into the lake from September 8 until we pulled the whole project for the season on September 19.

Figure 10. Photo of Kook Lake weir damaged by rising water levels the afternoon of September 1, 2006.

There were fish that passed into the lake during the eight day break in weir operations from September 1 to 8. Sockeye, coho, and pink salmon, and Dolly Varden, were counted into the lake in the days before and after the weir failure and these were the species that likely passed during the break in operations. Fortunately a backup weir-to-spawning area mark-recapture study was also in done in 2006 (Table 3). The weir crew consistently marked a running average of 66% (6,515) of the 9,846 sockeye salmon that they passed through the weir through the season (Appendix A.3.). An average of 64% (257) of the 401 sockeye examined for marks in the main inlet stream and beach spawning areas were marked yielding a simple Peterson estimate of the total sockeye escapement into the lake of 10,165 (CV=4%; Table 3).

Table 3. Mark-recapture data and estimate for validation of the Kook Lake weir count of sockeye salmon, 2006.

Marking Data - from the weir at the outlet of Kook Lake:

| Dates | Trap Count | Number Marked | Percent Marked |
|---|---|---|---|
| Jun-16 to Sep-19 | 9,846 | 6,515 | 66% |

Recapture Data - from main inlet stream on 8/22 and SE beaches 9/12, 14, and 20:

| Date | Number Examined | Number with Marks | Percent Marked | One-Tailed Binomial Test *P*-value |
|---|---|---|---|---|
| Aug-22 | 70 | 44 | 63% | 0.32 |
| Sep-12 | 80 | 46 | 58% | 0.07 |
| Sep-14 | 76 | 52 | 68% | 0.70 |
| Sep-20 | 175 | 115 | 66% | 0.48 |
| Total | 401 | 257 | 64% | 0.20 |

| Peterson Estimate[a]: | | | 95% Confidence Limits[b] | |
|---|---|---|---|---|
| Number | SE | CV | Lower | Upper |
| 10,165 | 380 | 4% | 8,996 | 11,487 |

[a] Simple Peterson (Ricker 1975, p. 78, eq. 3.5 and 3.6):

$$\hat{N} = \frac{M * C}{R} \qquad \mathrm{var}\left(\hat{N}\right) = \frac{\left(M^2 * C * (C - R)\right)}{R^3}$$

$$SE = \sqrt{\mathrm{var}(\hat{N})} \qquad CV = \frac{SE}{\hat{N}}$$

Where :

$\hat{N}$ = estimated escapement

$M$ = number marked

$C$ = number examined for marks

$R$ = number recaptured

[b]The 95% Confidence Limits were calculated using Appendix II in Ricker (1975, p. 343): Since R>50, the upper and lower limits of R were calculated using the formula

$$\pm R = R + 1.92 \pm 1.960\sqrt{R + 1.0}$$

and used in the M*C/R calculations of the lower and upper confidence limits.

The proportion of adipose-clipped sockeye salmon in these samples was not significantly less ($P < 0.05$) than the 66% marked at the weir (Table 3; Appendix A.3.). However, knowing that sockeye salmon passed into the lake uncounted, and knowing that there was a high and consistent marking rate (66%), ample number of recaptures (257), consistent proportion marked in both the inlet stream and beach spawning locations, and a low coefficient of variation around the estimate (4%), I consider the 10,165 mark-recapture estimate to be the best estimate of the sockeye escapement in 2006. The mark-recapture estimate is 319 fish greater than the weir count. I apportioned these fish evenly for the September 1 to 8 days that the weir was out (Table 1).

The midpoint of the 2006 run was on July 30 and 80 percent of the sockeye passed between July 12 and August 12. The first sockeye passed through the weir on June 23 and counts were less than five fish per day after September 15.

***2007.*** In 2007, the picket weir was operated from June 26 through September 14. Weir counts totaled 2,958 sockeye salmon (2,950 adults and 8 jacks), 269 coho salmon, 8 pink salmon, 2 chum salmon, 4 cutthroat trout, and 56 Dolly Varden char (Appendix A.3). There were 15 adult sockeye salmon that died at the weir this year. Many of these fish were mortally wounded by bears fishing below the weir. The weir-to-above-weir mark-recapture Peterson estimate of the sockeye escapement was 3,036 (CV=13%; 95% CI = 2,291 to 4,128; Table 4) which is 2.6% (78 fish) more than the 2,958 counted through the weir. The percent of marked fish in the six above-weir samples was not significantly less ($p>0.05$) than the percent marked at the weir and there was no increasing or decreasing trend in these percents (Spearman's rho nonparametric trend test; Conover 1980). I consider the 2,958 weir count as the best estimate of the escapement of sockeye salmon in 2007. There were no high water events or situations that compromised the integrity of the weir in 2007 and there is no indication that the mark-recapture estimate could be significantly greater than the weir count.

In 2007, the midpoint of the escapement into the lake was on July 23rd, the earliest observed midpoint in five years of weir operations, and 80% of the run passed between July 2 and September 4, the most protracted run observed in five years of weir operations (Table 1). The daily escapement into the lake was less than 100 fish on all but four days in 2007.

Table 4. Mark-recapture data and estimate for validation of the Kook Lake weir count of sockeye salmon, 2007.

Marking Data - from the weir at the outlet of Kook Lake:

| Dates | Trap Count | Number Marked | Percent Marked |
|---|---|---|---|
| Jun-26 to Sep-14 | 2,958 | 567 | 19% |

Recapture Data - Oct-16 sample from SE beaches, all others from off or in main inlet stream.

| Date | Number Examined | Number with Marks | Percent Marked | One-Tailed Binomial Test *P*-value |
|---|---|---|---|---|
| Jul-26 | 18 | 5 | 28% | 0.89 |
| Aug-01 | 14 | 2 | 14% | 0.48 |
| Aug-09 | 36 | 7 | 19% | 0.62 |
| Aug-15 | 159 | 29 | 18% | 0.43 |
| Aug-21 | 14 | 2 | 14% | 0.48 |
| Oct-16 | 16 | 3 | 19% | 0.63 |
| Total | 257 | 48 | 19% | 0.46 |

| Peterson Estimate[a]: | | | 95% Confidence Limit[b] | |
|---|---|---|---|---|
| Number | SE | CV | Lower | Upper |
| 3,036 | 395 | 13% | 2,291 | 4,128 |

[a] Simple Peterson (Ricker 1975, p. 78, eq. 3.5 and 3.6):

$$\hat{N} = \frac{M * C}{R} \qquad \mathrm{var}\left(\hat{N}\right) = \frac{\left(M^2 * C * (C - R)\right)}{R^3}$$

$$SE = \sqrt{\mathrm{var}(\hat{N})} \qquad CV = \frac{SE}{\hat{N}}$$

Where :

$\hat{N}$ = estimated escapement

$M$ = number marked

$C$ = number examined for marks

$R$ = number recaptured

[b]The 95% Confidence Limits were calculated using Appendix II in Ricker (1975, p. 343): Since R≤50, the tabled values for the upper and lower limits of R of 63.6 and 35.3 were used in the M*C/R calculations of the lower and upper confidence limits.

### *Age, Sex, and Length Composition*

The age composition of the 2005 sockeye escapement was split between age-1.2 (47.3%) and age-1.3 (46.3%) fish. (Table 5; Appendix B.1.). Jacks (age-1.1 fish) comprised 3.5% and age-2.2 fish comprised 2.9%. The average length of the age-1.2 and age-1.3 fish was 489 mm and 549, respectively (Table 6; Appendix B.2.).

Table 5. Age and sex composition of adult sockeye salmon sampled at the Kook Lake weir, 2005.

| | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|
| | 2002 | 2001 | 2000 | 2000 | |
| | 1.1 | 1.2 | 1.3 | 2.2 | Total |
| Combined Periods (Percentages are weighted by period escapements) | | | | | |
| Male | | | | | |
| Sample Size | 34 | 156 | 101 | 22 | 313 |
| Percent | 3.5 | 27.2 | 21.1 | 1.5 | 53.3 |
| Std. Error | 0.9 | 3.8 | 4.0 | 0.2 | 4.7 |
| Escapement | 70 | 541 | 422 | 30 | 1,063 |
| Female | | | | | |
| Sample Size | | 116 | 57 | 9 | 182 |
| Percent | | 20.1 | 25.2 | 1.4 | 46.7 |
| Std. Error | | 3.6 | 4.6 | 0.8 | 4.7 |
| Escapement | | 399 | 502 | 28 | 929 |
| All Fish | | | | | |
| Sample Size | 34 | 273 | 158 | 31 | 496 |
| Percent | 3.5 | 47.3 | 46.3 | 2.9 | 100.0 |
| Std. Error | 0.8 | 4.5 | 4.5 | 0.8 | |
| Escapement | 70 | 943 | 923 | 58 | 1,994 |

Table 6. Length composition, by sex, of adult sockeye salmon sampled at the Kook Lake weir, 2005.

| | | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|---|
| | | 2002 | 2001 | 2000 | 2000 | |
| | | 1.1 | 1.2 | 1.3 | 2.2 | Total |
| Combined Periods (Lengths weighted by period escapements) | | | | | | |
| Male | Avg. Length | 379 | 495 | 552 | 507 | 513 |
| | Std. Error | 2.3 | 2.3 | 3.1 | 4.3 | 3.2 |
| | Sample Size | 34 | 156 | 101 | 22 | 313 |
| Female | Avg. Length | | 483 | 545 | 492 | 516 |
| | Std. Error | | 2.2 | 2.7 | 11.0 | 2.7 |
| | Sample Size | | 116 | 57 | 9 | 182 |
| All Fish | Avg. Length | 379 | 489 | 549 | 498 | 514 |
| | Std. Error | 2.3 | 1.6 | 2.2 | 4.4 | 2.3 |
| | Sample Size | 34 | 273 | 158 | 31 | 496 |

The 2006 sockeye escapement was 80.1% age-1.2 fish and 16.3% age-1.3 fish. The rest were composed of age-2.2 and 2.3 fish (Table 7; Appendix B.3.). The average length of the age-1.2 and age-1.3 fish was 488 mm and 540, respectively (Table 8; Appendix B.4.).

Table 7. Age and sex composition of adult sockeye salmon sampled at the Kook Lake weir, 2006.

| | Brood Year and Age Class | | | | | |
|---|---|---|---|---|---|---|
| | 2002 | 2001 | 2001 | 2000 | 2000 | |
| | 1.2 | 1.3 | 2.2 | 1.4 | 2.3 | Total |
| Combined Periods (Percentages are weighted by period escapements) | | | | | | |
| Male | | | | | | |
| Sample Size | 139 | 53 | 3 | | 3 | 198 |
| Percent | 34.4 | 10.7 | 0.3 | | 2.5 | 47.8 |
| Std. Error | 4.8 | 3.7 | 0.3 | | 2.4 | 5.5 |
| Escapement | 3,487 | 1,085 | 35 | | 251 | 4,858 |
| Female | | | | | | |
| Sample Size | 164 | 36 | 1 | 1 | 2 | 204 |
| Percent | 45.8 | 5.6 | 0.7 | <0.1 | <0.1 | 52.2 |
| Std. Error | 5.3 | 2.8 | 0.7 | <0.1 | <0.1 | 5.5 |
| Escapement | 4,648 | 571 | 71 | 4 | 2 | 5,296 |
| All Fish | | | | | | |
| Sample Size | 303 | 89 | 4 | 1 | 5 | 402 |
| Percent | 80.1 | 16.3 | 1.0 | <0.1 | 2.5 | 100.0 |
| Std. Error | 4.2 | 4.2 | 0.8 | <0.1 | 2.4 | |
| Escapement | 8,134 | 1,656 | 106 | 4 | 253 | 10,153 |

Table 8. Length composition, by sex, of adult sockeye salmon sampled at the Kook Lake weir, 2006.

| | | Brood Year and Age Class | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2002 | 2001 | 2001 | 2000 | 2000 | |
| | | 1.2 | 1.3 | 2.2 | 1.4 | 2.3 | Total |
| Combined Periods (Lengths weighted by period escapements) | | | | | | | |
| Male | Avg. Length | 507 | 539 | 512 | | 551 | 516 |
| | Std. Error | 2.3 | 3.6 | 9.3 | | 5.8 | 2.7 |
| | Sample Size | 139 | 53 | 3 | | 3 | 198 |
| Female | Avg. Length | 475 | 536 | 495 | 540 | 538 | 482 |
| | Std. Error | 1.7 | 4.7 | | | 32.5 | 2.2 |
| | Sample Size | 163 | 36 | 1 | 1 | 2 | 203 |
| All Fish | Avg. Length | 488 | 540 | 502 | 540 | 550 | 499 |
| | Std. Error | 1.5 | 3.2 | 9.4 | | 12.1 | 1.8 |
| | Sample Size | 302 | 89 | 4 | 1 | 5 | 401 |

The 2007 sockeye escapement was 91.7% age-1.3 fish. The rest were age-1.2 (6.8%) and age-2.2 and 2.3 (Table 9; Appendix B.5.). The average length of the age-1.2 and age-1.3 fish was 512 mm and 546 mm, respectively (Table 10; Appendix B.6.).

Table 9. Age and sex composition of adult sockeye salmon sampled at the Kook Lake weir, 2007.

| | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|
| | 2003 | 2002 | 2002 | 2001 | |
| | 1.2 | 1.3 | 2.2 | 2.3 | Total |
| Combined Periods (Percentages are weighted by period escapements) | | | | | |
| Male | | | | | |
| Sample Size | 11 | 164 | 2 | 1 | 178 |
| Percent | 1.5 | 47.5 | 0.4 | 0.3 | 49.8 |
| Std. Error | 0.4 | 7.3 | 0.3 | 0.3 | 7.3 |
| Escapement | 40 | 1,254 | 11 | 8 | 1,313 |
| Female | | | | | |
| Sample Size | 14 | 138 | 7 | | 159 |
| Percent | 5.9 | 43.5 | 0.9 | | 50.2 |
| Std. Error | 5.0 | 7.3 | 0.3 | | 7.3 |
| Escapement | 155 | 1,147 | 22 | | 1,324 |
| All Fish | | | | | |
| Sample Size | 25 | 304 | 9 | 1 | 339 |
| Percent | 6.8 | 91.7 | 1.2 | 0.3 | 100.0 |
| Std. Error | 3.9 | 3.9 | 0.4 | 0.3 | |
| Escapement | 195 | 2,622 | 33 | 8 | 2,858 |

Table 10. Length composition, by sex, of adult sockeye salmon sampled at the Kook Lake weir, 2007.

| | | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|---|
| | | 2003 | 2002 | 2002 | 2001 | |
| | | 1.2 | 1.3 | 2.2 | 2.3 | Total |
| Combined Periods (Lengths weighted by period escapements) | | | | | | |
| Male | Avg. Length | 502 | 557 | 511 | 590 | 555 |
| | Std. Error | 7.1 | 1.8 | 7.5 | | 2.0 |
| | Sample Size | 11 | 164 | 2 | 1 | 178 |
| Female | Avg. Length | 512 | 535 | 524 | | 534 |
| | Std. Error | 8.2 | 1.7 | 8.4 | | 1.9 |
| | Sample Size | 14 | 136 | 7 | | 157 |
| All Fish | Avg. Length | 512 | 546 | 518 | 590 | 544 |
| | Std. Error | 5.4 | 1.4 | 6.7 | | 1.5 |
| | Sample Size | 25 | 300 | 9 | 1 | 335 |

### *Spawning Distribution*

In 2005, twenty-one sockeye salmon were radio tagged and released at the Kook Lake weir through the first two-thirds of the run. Two of these fish spawned in the main inlet stream and the remainder spawned in the lake. The two that spawned in the main inlet stream were tagged in the first 26 percent of the run. We were unable to track eight of the transmitters. The aerial and foot surveys confirmed they were not in an inlet stream so they must have still been too deep in the lake to detect when the last survey was flown on October 6.

Table 11. Disposition of sockeye salmon radio tagged at the Kook Lake weir, 2005.

| Date Released | Sex | Length | Cum. Weir Count | Cum. Prop. Weir Count | Disposition |
|---|---|---|---|---|---|
| 22-Jul | F | 515 | 143 | 7% | Lake, SW shore |
| 27-Jul | F | 547 | 271 | 14% | MIS, below bridge |
| 29-Jul | M | 553 | 340 | 17% | not detected |
| 08-Aug | M | 585 | 509 | 26% | MIS, below bridge |
| 09-Aug | M | 480 | 516 | 26% | Lake, NE shore |
| 09-Aug | M | 545 | 516 | 26% | Lake, NE Shore |
| 11-Aug | F | 540 | 587 | 29% | Lake, SE shore |
| 12-Aug | M | 540 | 650 | 33% | not detected |
| 14-Aug | M | 560 | 690 | 35% | Lake, SW shore |
| 18-Aug | F | 550 | 786 | 39% | Lake, SE shore |
| 20-Aug | M | 545 | 838 | 42% | not detected |
| 24-Aug | M | 525 | 915 | 46% | not detected |
| 25-Aug | M | 560 | 989 | 50% | not detected |
| 25-Aug | F | 545 | 989 | 50% | not detected |
| 26-Aug | M | 540 | 1301 | 65% | Lake, SW shore |
| 26-Aug | F | 530 | 1301 | 65% | Lake, SE shore |
| 26-Aug | F | 525 | 1301 | 65% | Lake, SE shore |
| 26-Aug | F | 530 | 1301 | 65% | Lake, SW shore |
| 26-Aug | M | 460 | 1301 | 65% | not detected |
| 26-Aug | M | 540 | 1301 | 65% | not detected |
| 26-Aug | F | 530 | 1301 | 65% | Lake, SE shore |

In boat surveys around the shore of the lake and in beach seining for the mark-recapture studies in 2006 and 2007, we found the greatest number and density of beach spawning sockeye salmon along the Southeast shore of the lake between 57.66255°N, 134.96810°W and 57.66376°N, 134.95634°W. These fish were relatively easy to capture with a beach seine although the lead line was well off the steeply angled bottom or snagging lots of sticks and branches in most sets. In the main inlet stream, we observed most of the sockeye spawning between the lake and the road.

## Limnology

### *Stream and Air Temperatures*

Data loggers recorded the water temperature of the main inlet stream and the outlet stream (Kook Creek), and the air temperature at the outlet, every four hours (six times a day) starting July 4, 2005 to July 4, 2006 (Figure 11). The inlet stream temperatures were consistently the coldest (Figure 12) except on November 22-24, 2005, when there was a spike in inlet stream temperatures following an extreme rainfall event. In July and August 2005, the main inlet stream averaged 10˚C and the outlet stream averaged 16˚C. From September 2005 through April 2006, the main inlet stream averaged 1.4˚C colder than the outlet stream. Water temperatures in the inlet stream varied more each day than those in the outlet stream (Figure 11).

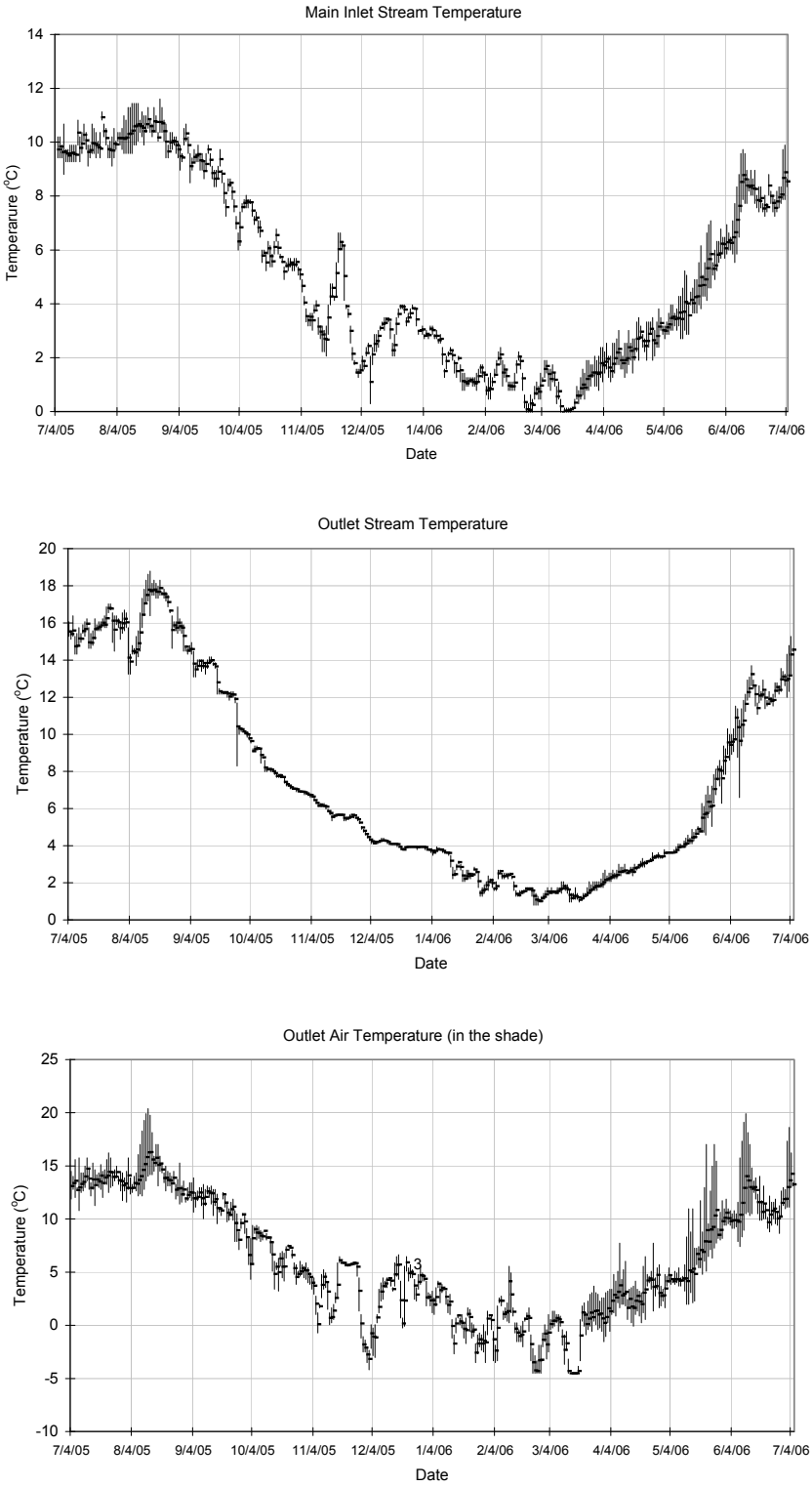



Figure 11. High, low, and average daily temperatures in Kook Lake's main inlet stream, outlet stream, and air, July 4, 2005 to July 4, 2006.

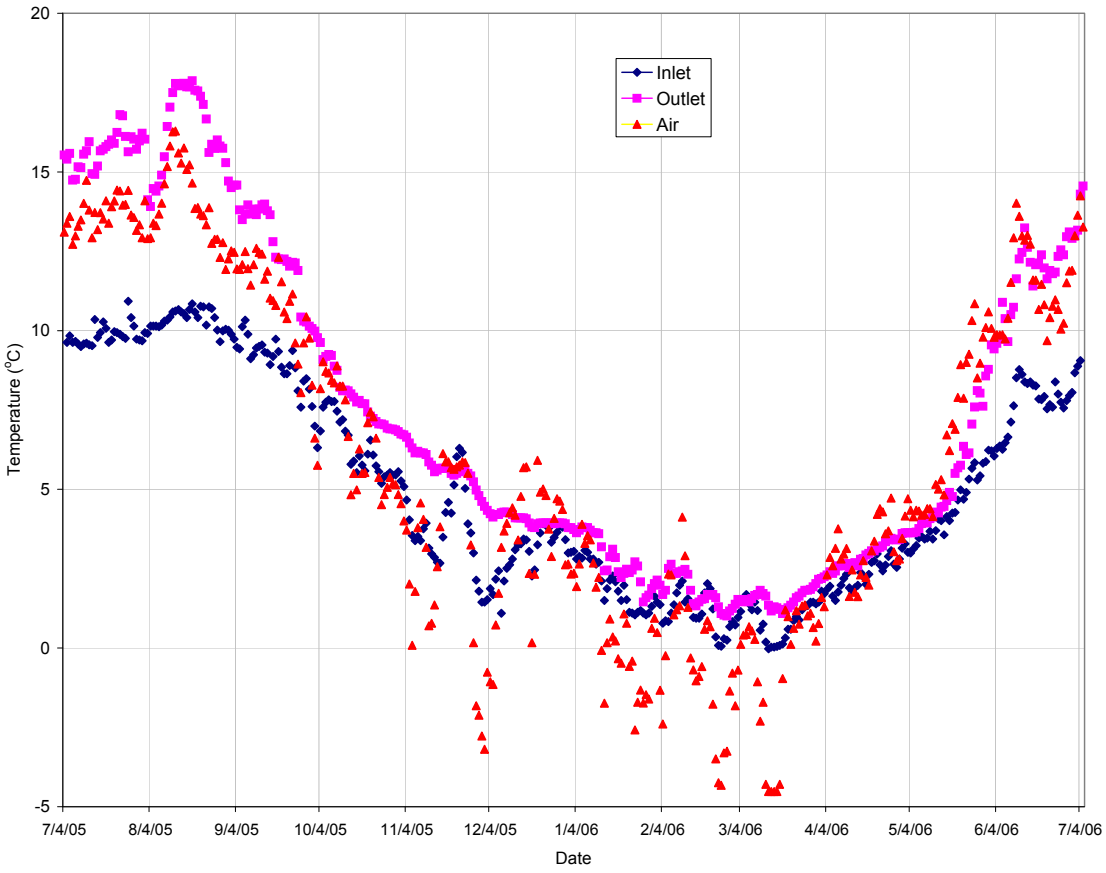



Figure 12. Average daily temperature of Kook Lake's main inlet stream, outlet stream, and air, July 4, 2005 to July 4, 2006.

### *Light, Temperature, and Dissolved Oxygen Profiles*

An underwater photometer was used to record the incident light levels at Station A in Kook Lake at from just below the lake surface (5 cm depth) to the depth with less than 1% of this subsurface reading. These readings were measured on August 9, 2005 and August 23, 2006. Euphotic zone depths were 6.8 in 2005 and 7.7 in 2006 (Table 12).

Table 12. Light meter and secchi disk readings, and euphotic zone depth calculation, Station A, Kook Lake, August 9, 2005 and August 23, 2006.

| Light Meter Readings ($\mu$mol $s^{-1}$ $m^{-2}$): | Date and Hour | |
|---|---|---|
| Depth (m) | 8/9/05 12:00 | 8/23/06 14:00 |
| 0 | -1621.7 | -179.5 |
| 1 | -729.1 | -88.6 |
| 2 | -300.8 | -49.8 |
| 3 | -128.8 | -26.5 |
| 4 | -60.6 | -14.8 |
| 5 | -32.9 | -8.6 |
| 6 | -26.5 | -4.7 |
| 7 | -11.5 | -2.6 |
| 8 | -6.0 | -1.3 |
| 9 | | -0.7 |
| Euphotic Zone Depth Calculation (m) | 6.8 | 7.7 |
| Secchi Disk Readings (m): | | |
| Disappear | 6.8 | 6.5 |
| Reappear | 6.8 | 5.8 |
| Average | 6.8 | 6.1 |

Vertical temperature and dissolved oxygen profiles at Station A were vertically stratified on the August 9, 2005 and August 23, 2006 sampling dates. The epilimnion extended down to around 5 m and the metalimnion down to 16-17 m (Table 13; Figure 13).

Table 13. Temperature and dissolved oxygen profiles for Kook Lake, Station A, August 9, 2005 and August 23, 2006.

| | Temperature (°C) | | Dissolved Oxygen (mg $L^{-1}$) | | Percent $O_2$ Saturation[a] | |
|---|---|---|---|---|---|---|
| Depth (m) | 8/9/2005 | 8/23/2006 | 8/9/2005 | 8/23/2006 | 8/9/2005 | 8/23/2006 |
| 1 | 16.7 | 15.4 | 7.4 | 8.1 | 76% | 81% |
| 2 | 15.8 | 15.4 | 7.9 | 8.6 | 80% | 86% |
| 3 | 15.6 | 15.4 | 8.1 | 8.6 | 82% | 86% |
| 4 | 15.3 | 15.3 | 8.1 | 8.6 | 81% | 86% |
| 5 | 14.6 | 14.0 | 8.2 | 9.5 | 81% | 93% |
| 6 | 14.1 | 13.5 | 8.2 | 9.7 | 80% | 93% |
| 7 | 14.1 | 13.0 | 8.2 | 10.2 | 80% | 97% |
| 8 | 13.5 | 12.7 | 8.2 | 10.6 | 79% | 100% |
| 9 | 13.0 | 12.2 | 8.0 | 10.8 | 76% | 101% |
| 10 | 12.9 | 11.0 | 7.7 | 10.8 | 73% | 98% |
| 11 | 12.5 | 9.8 | 7.3 | 10.6 | 69% | 94% |
| 12 | 11.1 | 8.8 | 7.1 | 7.5 | 65% | 65% |
| 13 | 10.0 | 7.8 | 5.8 | 6.3 | 51% | 53% |
| 14 | 9.1 | 7.2 | 5.3 | 6.0 | 46% | 50% |
| 15 | 8.1 | 6.5 | 4.9 | 5.6 | 41% | 46% |
| 16 | 7.4 | 6.0 | 4.5 | 5.4 | 37% | 43% |
| 17 | 6.9 | 5.9 | 3.9 | 5.2 | 32% | 42% |
| 18 | 6.5 | 5.7 | 3.5 | 5.0 | 28% | 40% |
| 19 | 6.4 | 5.6 | 3.1 | 4.9 | 25% | 39% |
| 20 | 6.3 | 5.5 | 2.5 | 4.8 | 20% | 38% |
| 25 | 5.9 | 5.2 | 1.4 | 4.5 | 11% | 36% |
| 30 | 5.5 | 4.9 | 1.0 | 4.3 | 8% | 34% |
| 35 | 5.1 | 4.6 | 0.5 | 4.1 | 4% | 32% |
| 40 | 4.7 | 4.5 | 0.1 | 4.0 | 1% | 31% |

[a]%$O_2$ saturation = (dissolved oxygen)/(0.005399 * temperature$^2$ - 0.381784 * temperature + 14.571252)

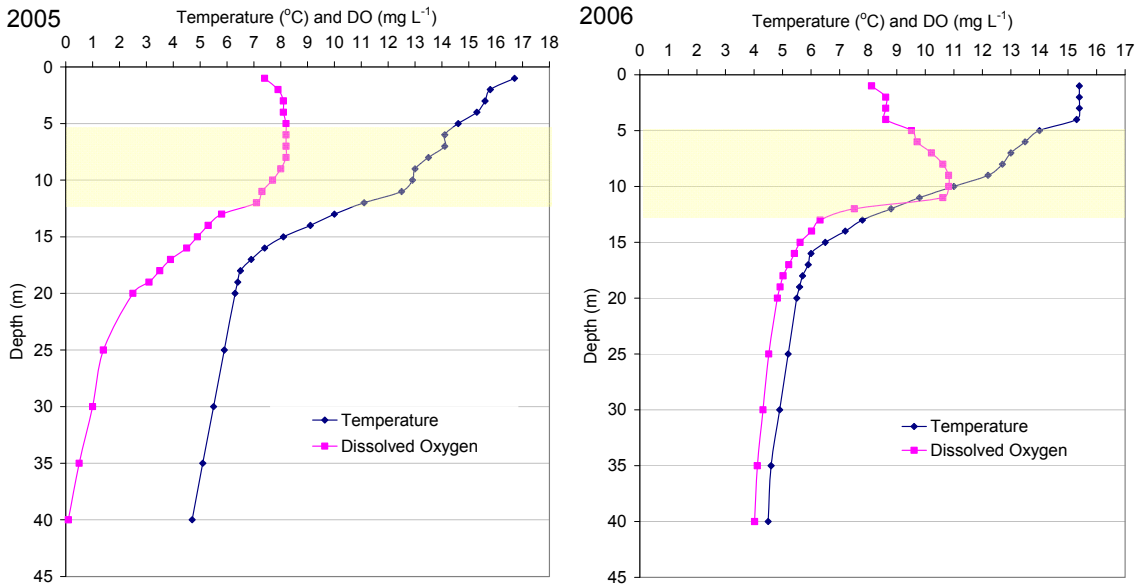



Figure 13. Vertical water temperature and dissolved oxygen profiles, Kook Lake, Station A, August 9, 2005 and August 23, 2006.

We would expect the preferred growth conditions for rearing sockeye juveniles at temperatures below 15°C (Brett 1952, Bjornn and Reiser 1991, State of Alaska, Department of Environmental Conservation, Water Quality Standard 18 AAC 70) and dissolved oxygen levels above 6.0 mg $L^{-1}$ (WOW 2004, State of Alaska, Department of Environmental Conservation, Water Quality Standard 18 AAC 70). These conditions were found at depths between about 4 and 13 m.

### *Zooplankton Composition and Density*

*Bosmina* were the most abundant zooplankton, by number and biomass, in Kook Lake on August 9, 2005 (Table 14). The density and biomass of zooplankton, and specifically *Daphina* sp., was greater in this August 9, 2005 sample than in the seasonal means of samples collected from Kook Lake in 1992, 1994, 1995, 2001, and 2002 (see Table 17 in Conitz and Cartwright 2005). This suggests that sockeye fry were less abundant in 2005 and that fewer adults escaped in the parent years.

Table 14. Species composition, density, size, and biomass of zooplankton in Kook Lake, August 9, 2005.

| | Station A | | | | | Station B | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Taxa | Density (no. $m^{-2}$) | Percent of Total Number | Mean Wet Length (mm) | Biomass (mg/m^2) | Percent of Total Biomass | Density (no. $m^{-2}$) | Percent of Total Number | Mean Wet Length (mm) | Biomass (mg/m^2) | Percent of Total Biomass |
| Ergasilis | | | | | | | | | | |
| Epischura | | | | | | | | | | |
| Ovig. Epischura | | | | | | | | | | |
| Diaptomus | 1,019 | 1% | 0.76 | 2 | 0% | 1,274 | 1% | 1.38 | 14 | 2% |
| Ovig Diaptomus | | | | | | | | | | |
| Cyclops | 9,849 | 6% | 1.03 | 38 | 7% | 24,622 | 15% | 1.14 | 117 | 21% |
| Ovig. Cyclops | 679 | 0% | 1.34 | 5 | 1% | 1,274 | 1% | 1.15 | 6 | 1% |
| Harpaticus | | | | | | | | | | |
| Nauplii | 340 | 0% | | | 0% | 1,698 | 1% | | | |
| Bosmina | 95,093 | 59% | 0.53 | 254 | 45% | 137,120 | 85% | 0.53 | 366 | 65% |
| Ovig. Bosmina | | | | | | 425 | 0% | 0.66 | 2 | 0% |
| Daphnia l. | 24,452 | 15% | 0.83 | 75 | 13% | 17,405 | 11% | 0.75 | 43 | 8% |
| Ovig. Daphnia l. | | | | | | | | | | |
| Daphnia r. | | | | | | 28,018 | 17% | 0.80 | 60 | 11% |
| Holopedium | 27,849 | 17% | 0.81 | 190 | 34% | 22,924 | 14% | 0.83 | 166 | 29% |
| Ovig. Holopedium | | | | | | | | | | |
| Chydorinae | | | | | | | | | | |
| Polyphemus | | | | | | | | | | |
| Immature Cladocera | 1,358 | 1% | | | | 4,670 | 3% | | | |
| Totals | 160,639 | | | 563 | | 239,430 | | | 774 | |
| Tow Depth (m) | 47.5 | | | | | 42 | | | | |
| Density (no. $m^{-3}$) or Biomass (mg $m^{-3}$) | 3,382 | | | 12 | | 5,701 | | | 18 | |

## DISCUSSION

Looking at results from this three year study (2005 to 2007), and the results from past surveys and studies, it appears that the production of sockeye salmon from Kook Lake has been limited in recent years by low escapements in one or both of the inlet stream or

beach spawning groups. Fortunately, escapement levels appear high enough, and the lake productive enough, to readily yield larger sockeye returns with only a moderate rebuilding of escapements. It will be important to manage for the best natural distribution of earlier-running inlet stream spawners and later-running beach spawners.

There were differences each year in the relative composition and abundance of the earlier-running inlet stream spawners and the later-running lake (beach) spawners (Figure 9). This change in entry pattern/spawning distribution and abundance most likely reflects both the magnitude of the parent year escapements into the inlet stream and beach spawning areas and the magnitude and timing of the commercial purse seine fishery in Icy and Chatham Strait. The purse seine fishery targets pink and chum salmon but these species must have broadly overlapping migration routes and timing as the Kook Lake sockeye salmon (Figures 6). In 2005, the escapement was small (1,994 fish) and half of the fish entered the lake after August 24 and after an intensive pink salmon-directed commercial seine fishery wrapped up for the season (Bachman et al. 2005). In 2006, there was a weak run of pink salmon and limited seine openings throughout the season (Tingley and Davidson 2007; ADF&G News Releases and Fishery Updates) and a strong, well distributed escapement of 10,152 sockeye escapement into the lake. Likewise, in 2007 the purse seine effort was moderated early in the season as the pink salmon run strength was assessed and late in the season in response to a poor return of late-run pink salmon (ADF&G News Releases and Fishery Updates). Consequently, the Kook sockeye escapement was protracted, bimodal, and moderate (2,958 fish; Figure 9). The subsistence harvest was relatively small and constrained to the months of June and July and is unlikely to cause the large observed changes in the entry pattern of sockeye salmon into Kook Lake. More analysis is needed to better understand the relationship between the commercial seine fishing effort in Icy and Chatham Straits, the subsistence fishing effort in Basket Bay, and the entry pattern, abundance, and production of Kook Lake sockeye salmon.

All the sockeye marked at the weir in 2005 were given a "primary" adipose fin clip plus a "secondary" left axillary, left ventral, or dorsal fin clip in each approximate third of the run (Appendix A.1.). These secondary fin clips were to allow use of a Darroch stratified abundance estimator (Arnason et al. 1996). However, the use of a stratified estimator was not possible since the fish were not always examined for the secondary marks or this data was not properly recorded on one or more sampling trips. The accurate reporting of secondary marks has been a problem in other projects too. Efforts to use a stratified estimate in 2006 were abandoned mid-season when high passage rates precluded clipping more than just the adipose fin to keep up with a consistent 66% marking rate. However, we observed in prior studies (Conitz and Cartwright 2005b; Conitz et al. 2005; Conitz et al. 2006; McPherson et al. 1996; Tydingco et al. 2006; Van Alen 2004, 2005, and 2008) that as long as the fish are marked roughly in proportion to their abundance throughout run that the stratified estimates are the same as the simple pooled Peterson estimates and the pooled estimates are more precise. This is reasonable since the study plan calls for marking a consistent proportion of the fish observed at the weir and there is a good natural mixing of fish in the weeks between the time they enter the lake and the time they are sampled on the spawning grounds. Furthermore, enough fish are marked and

examined for marks to assure a reliable estimate of the marking fraction. We can expect escapement estimates to vary little if fish are marked roughly in proportion to their abundance, if the proportion of marked fish varies little in the recovery samples, and if more than 40 fish are recaptured in several recovery trips and locations (Appendix C).

Tagging of salmon is unnecessary for these mark-recapture abundance estimates. If fish are tagged they also need a physical mark to estimate tag loss - so the final abundance estimate would be based on the physical mark anyway. Tag loss biases estimates upward, especially if there are few recaptures. The consequences of management actions are usually riskier if escapements are overestimated. Tag loss is seldom estimated adequately since the tendency is to examine fish for tags when they should be examined first for the physical mark (finclip) and then for the tag. With the adipose finclip, and other finclips or opercule punch marking options available for salmon mark-recapture studies, it is unnecessary and unwise to buy and use tags.

The floating wall tent served as a great, self contained, field camp for four (Figure 8). I had first used this floating camp at Pavlof Lake in 2002 to 2004 (Van Alen 2004, 2005, and 2008). It is now dismantled and ready to use at another location. The aluminum channel and Styrofoam log platform is quick to assemble as is the aluminum tube frame for the tent. The 14' x 16' wall tent (with 6' high walls) had room for two 4' x 8' bunk beds, a 4' x 4' dining table, a 3' x 6' cooking counter/shelf, a 2' x 3' data desk/shelf, and propane powered wall heater, cook stove, refrigerator, and lamps. Living and working out of this floating camp minimized onshore habitat disturbances. The outhouse was the only onshore structure aside from the weir. For safety and convenience, the tent platform was rigged on a pulley system so it could be pulled back and forth from the shore or weir trap and always secured to land in two places. In the future, for portability, durability, and reusability, I would use interlocking composite decking on the floor instead of painted 5/8" plywood. A wall tent with full height (6') walls and a 1' vinyl skirt would also avoid the need for the 3/16" plywood walls that we used. There would be no need to tarp over the tent if it had a built-in 6' awning over the porch and waterproof coating on the roofing material. The tent platform could be oversized to handle rougher sea conditions.

The lake "net weir" and floating trap (Appendix E) also performed well and proved superior to the traditional channel and picket weir design for counting salmon as they enter a lake of this size. The net weir costs less, fits in a DeHavilland Beaver float plane, takes only hours to deploy and pull, and is fish and operator friendly – especially when combined with a floating tent camp and mini-digital video recorder fish counting system (Appendix F). The redundant, mini-DVR, camera system enabled project personnel to efficiently and accurately count the number of salmon entering the lake. Such a system should be incorporated into future escapement enumeration projects.

## CONCLUSIONS

1. This is the final report for U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program Study 05-601. This report summarizes the sockeye stock assessment project findings from a cooperative Angoon Community Association, Alaska Department of Fish and Game, and U.S. Forest Service project. This project used a weir and mark-recapture methods to estimate the escapement of sockeye salmon into Kook Lake in 2005, 2006, and 2007. Age, sex, and length data, spawning distribution, and limnological data was also collected to help assess the status of this stock. The performance of a floating wall tent camp, adjustable weir bipod, lake "net weir", and video fish counting system was also tested.
2. The escapement of sockeye salmon into Kook Lake was estimated to be 1,994 fish in 2005, 10,165 fish in 2006, and 2,958 fish in 2007. For comparison, weir counts were 1,817 in 1994 and 5,817 in 1995, the only other years when the total sockeye escapement was estimated. Sockeye escape into the lake from late-June through mid-September.
3. The earlier-running sockeye salmon tend to spawn in the main inlet stream that flows into the Southwest end of the lake from late-July through early-September. Later-running sockeye spawn in several lake (beach) spawning areas in September and October. The highest concentration of beach spawners was observed along the Southwest shore of the lake.
4. Age-1.- fish dominated the escapement with an equal number of age-1.2 and age 1.3 fish in 2005, 80% age-1.2 fish in 2006, and 92% age-1.3 fish in 2007.
5. Vertical plankton tows on August 9, 2005 found the zooplankton composition dominated by *Bosmina*. *Daphina* sp., *Holopedium*, and *Cyclops* were also relatively abundant. The density and biomass of zooplankton in the lake was higher in 2005 than it was in 1992, 1994, 1995, 2001, and 2002. This indicates a reduction in the numbers of spawners and fry.
6. The sockeye production from Kook Lake appears to be spawning limited. Management needs to seek the best natural distribution of early-run, inlet stream spawners, and late-run, beach spawners.

## RECOMMENDATIONS

1. Continue estimating the annual escapement of sockeye salmon into Kook Lake.
2. Use a lake "net weir" (Appendix E) and mini-DVR-based video system (Appendix F) to count the escapement of sockeye salmon into Kook Lake.
3. Experiment with the use of a stream "net weir" and mini-DVR system to estimate the escapement of sockeye salmon into the main inlet stream.
4. Study the relationship between the commercial purse seine fishing effort and harvest in Icy Strait and Chatham Strait, the subsistence fishing effort and harvest

in Basket Bay, and the entry pattern and abundance of sockeye salmon into Kook Lake.

5. Use this information to set and manage for escapement targets needed to sustain customary and traditional subsistence needs.

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# APPENDICES

Appendix A.1. Detailed daily weir counts and weather and stream measurements, Kook Lake weir, 2005.

| | Weather and Stream Measurements at 0900hr | | | | | Sockeye Counted | | | | Sockeye Finclipped | | | | | | Number of Other Species Counted | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Weather | Water Level (Ft.) | Water Temp. (˚C) | Air Temp. (˚C) | Mark Used (adipose+) | Adults | Jacks | Total | Weir Morts [a] | Adults | Cum. % Adults Marked | Jacks | Cum. % Jacks Marked | Total | Cum. % Total Marked | Coho | Pink | Chum | Chinook | Dolly Varden | Cutthroat |
| Jun-17 | Clear | | | | left axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-18 | Clear | | | | left axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-19 | Showers | | | | left axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-20 | Rain | | | | left axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-21 | Showers | | | | left axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-22 | Overcast | 0.68 | 15 | 13 | left axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-23 | Partly Cloudy | 0.68 | 14 | 11 | left axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-24 | Partly Cloudy | 0.75 | 14 | 14 | left axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-25 | Clear | 0.75 | 15 | 13 | left axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-26 | Overcast | 0.75 | 15 | 14 | left axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-27 | Clear | 0.73 | 15 | 14 | left axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-28 | Rain | 0.73 | 15 | 13 | left axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-29 | Rain | 0.75 | 15 | 15 | left axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-30 | Clear | 0.85 | 15 | 14 | left axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-01 | | 0.88 | 15 | 15 | left axillary | 2 | 0 | 2 | 0 | 0 | 0% | 0 | | 0 | 0% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-02 | Showers | 0.88 | 15 | 13 | left axillary | 0 | 0 | 0 | 0 | 0 | 0% | 0 | | 0 | 0% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-03 | Rain | 0.95 | 15 | 14 | left axillary | 3 | 0 | 3 | 0 | 3 | 60% | 0 | | 3 | 60% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-04 | Partly Cloudy | 1.34 | 15 | 13 | left axillary | 3 | 0 | 3 | 1 | 2 | 63% | 0 | | 2 | 63% | 0 | 0 | 0 | 0 | 1 | 0 |
| Jul-05 | Showers | 1.36 | 15 | 13 | left axillary | 0 | 0 | 0 | 0 | 0 | 63% | 0 | | 0 | 63% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-06 | Partly Cloudy | 1.42 | 15 | 14 | left axillary | 1 | 0 | 1 | 0 | 1 | 67% | 0 | | 1 | 67% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-07 | Showers | 1.46 | 15 | 13 | left axillary | 0 | 0 | 0 | 0 | 0 | 67% | 0 | | 0 | 67% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-08 | Partly Cloudy | 1.42 | 15 | 14 | left axillary | 0 | 0 | 0 | 0 | 0 | 67% | 0 | | 0 | 67% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-09 | Overcast | 1.44 | 14 | 14 | left axillary | 0 | 0 | 0 | 0 | 0 | 67% | 0 | | 0 | 67% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-10 | Partly Cloudy | 1.38 | 14 | 15 | left axillary | 0 | 0 | 0 | 0 | 0 | 67% | 0 | | 0 | 67% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-11 | Partly Cloudy | 1.28 | 14 | 16 | left axillary | 1 | 0 | 1 | 0 | 1 | 70% | 0 | | 1 | 70% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-12 | Overcast | 1.10 | 14 | 14 | left axillary | 0 | 0 | 0 | 0 | 0 | 70% | 0 | | 0 | 70% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-13 | Partly Cloudy | 1.00 | 14 | 14 | left axillary | 0 | 0 | 0 | 0 | 0 | 70% | 0 | | 0 | 70% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-14 | Rain | 1.02 | 14 | 14 | left axillary | 1 | 0 | 1 | 0 | 1 | 73% | 0 | | 1 | 73% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-15 | Overcast | 1.25 | 14 | 13 | left axillary | 0 | 0 | 0 | 0 | 0 | 73% | 0 | | 0 | 73% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-16 | | 1.45 | 15 | 12 | left axillary | 0 | 0 | 0 | 0 | 0 | 73% | 0 | | 0 | 73% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-17 | Overcast | 1.45 | 15 | 12 | left axillary | 12 | 1 | 13 | 0 | 8 | 70% | 0 | 0% | 8 | 67% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-18 | | 1.50 | 15 | 12 | left axillary | 20 | 2 | 22 | 1 | 10 | 60% | 0 | 0% | 10 | 57% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-19 | Overcast | 1.60 | 15 | 13 | left axillary | 11 | 0 | 11 | 0 | 10 | 67% | 0 | 0% | 10 | 63% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-20 | Clear | 1.50 | 16 | 12 | left axillary | 12 | 0 | 12 | 1 | 12 | 73% | 0 | 0% | 12 | 70% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-21 | Overcast | 1.42 | 16 | 12 | left axillary | 41 | 4 | 45 | 0 | 41 | 83% | 3 | 43% | 44 | 81% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-22 | Overcast | 1.38 | 15 | 13 | left axillary | 25 | 4 | 29 | 0 | 25 | 86% | 4 | 64% | 29 | 85% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-23 | Overcast | 1.28 | 16 | 15 | left axillary | 21 | 4 | 25 | 0 | 21 | 88% | 4 | 73% | 25 | 87% | 0 | 0 | 0 | 0 | 1 | 0 |
| Jul-24 | Clear | 1.28 | 16 | 14 | left axillary | 7 | 1 | 8 | 0 | 7 | 89% | 1 | 75% | 8 | 88% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-25 | Partly Cloudy | 1.18 | 15 | 14 | left ventral | 0 | 0 | 0 | 0 | 0 | 89% | 0 | 75% | 0 | 88% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-26 | Rain | 1.18 | 15 | 14 | left ventral | 28 | 8 | 36 | 0 | 28 | 90% | 8 | 83% | 36 | 90% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-27 | Partly Cloudy | 1.43 | 15 | 14 | left ventral | 56 | 3 | 59 | 0 | 56 | 93% | 3 | 85% | 59 | 92% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-28 | Overcast | 1.43 | 15 | 14 | left ventral | 22 | 2 | 24 | 0 | 22 | 93% | 2 | 86% | 24 | 93% | 0 | 0 | 0 | 0 | 2 | 0 |
| Jul-29 | Overcast | 1.66 | 16 | 13 | left ventral | 42 | 3 | 45 | 0 | 42 | 94% | 3 | 88% | 45 | 94% | 0 | 0 | 0 | 0 | 6 | 0 |
| Jul-30 | Rain | 1.54 | 17 | 13 | left ventral | 0 | 0 | 0 | 0 | 0 | 94% | 0 | 88% | 0 | 94% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-31 | | 1.44 | 15 | 13 | left ventral | 1 | 0 | 1 | 0 | 1 | 94% | 0 | 88% | 1 | 94% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-01 | | 1.40 | 17 | 12 | left ventral | 23 | 2 | 25 | 0 | 0 | 88% | 0 | 82% | 0 | 87% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-02 | | 1.30 | 15 | 13 | left ventral | 15 | 2 | 17 | 0 | 12 | 87% | 2 | 83% | 14 | 87% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-03 | Rain | 1.20 | 14 | 12 | left ventral | 26 | 5 | 31 | 0 | 26 | 88% | 5 | 85% | 31 | 88% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-04 | | 1.31 | 14 | 12 | left ventral | 42 | 3 | 45 | 0 | 39 | 89% | 3 | 86% | 42 | 88% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-05 | | 1.40 | 15 | 13 | left ventral | 20 | 0 | 20 | 0 | 20 | 89% | 0 | 86% | 20 | 89% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-06 | Overcast | 1.44 | 15 | 13 | left ventral | 0 | 0 | 0 | 0 | 0 | 89% | 0 | 86% | 0 | 89% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-07 | | 1.42 | 15 | 13 | left ventral | 17 | 0 | 17 | 0 | 17 | 90% | 0 | 86% | 17 | 89% | 0 | 0 | 0 | 0 | 0 | 0 |

-Continued-

| | Weather and Stream Measurements at 0900hr | | | | | Sockeye Counted | | | | Sockeye Finclipped | | | | | | Number of Other Species Counted | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Weather | Water Level (Ft.) | Water Temp. (˚C) | Air Temp. (˚C) | Mark Used (adipose+) | Adults | Jacks | Total | Weir Morts [a] | Adults | Cum. % Adults Marked | Jacks | Cum. % Jacks Marked | Total | Cum. % Total Marked | Coho | Pink | Chum | Chinook | Dolly Varden | Cutthroat |
| Aug-08 | Clear | 1.34 | 15 | 13 | left ventral | 13 | 0 | 13 | 0 | 0 | 87% | 0 | 86% | 0 | 87% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-09 | Overcast | 1.34 | 15 | 13 | left ventral | 7 | 0 | 7 | 0 | 2 | 86% | 0 | 86% | 2 | 86% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-10 | Clear | 1.26 | 17 | 13 | left ventral | 44 | 1 | 45 | 0 | 19 | 83% | 1 | 87% | 20 | 83% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-11 | Clear | 1.16 | 17 | 14 | left ventral | 26 | 0 | 26 | 0 | 16 | 82% | 0 | 87% | 16 | 82% | 0 | 2 | 2 | 0 | 0 | 0 |
| Aug-12 | Clear | 1.12 | 18 | 14 | left ventral | 61 | 2 | 63 | 0 | 31 | 78% | 2 | 87% | 33 | 79% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-13 | Clear | 1.05 | 17 | 14 | left ventral | 16 | 0 | 16 | 0 | 13 | 79% | 0 | 87% | 13 | 79% | 0 | 2 | 0 | 0 | 0 | 0 |
| Aug-14 | Overcast | 1.02 | 18 | 18 | left ventral | 24 | 0 | 24 | 1 | 18 | 78% | 0 | 87% | 18 | 79% | 0 | 1 | 0 | 0 | 0 | 1 |
| Aug-15 | Showers | 1.06 | 18 | 16 | dorsal | 21 | 0 | 21 | 0 | 10 | 77% | 0 | 87% | 10 | 78% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-16 | Overcast | 1.00 | 18 | 16 | dorsal | 17 | 0 | 17 | 0 | 10 | 77% | 0 | 87% | 10 | 78% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-17 | Overcast | 0.94 | 17 | 17 | dorsal | 16 | 1 | 17 | 0 | 16 | 77% | 1 | 88% | 17 | 78% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-18 | Showers | 1.02 | 17 | 16 | dorsal | 40 | 1 | 41 | 0 | 23 | 76% | 0 | 86% | 23 | 77% | 0 | 0 | 0 | 1 | 0 | 0 |
| Aug-19 | Partly Cloudy | 1.60 | 18 | 18 | dorsal | 24 | 0 | 24 | 0 | 0 | 74% | 0 | 86% | 0 | 75% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-20 | Overcast | 1.60 | 18 | 16 | dorsal | 27 | 1 | 28 | 0 | 27 | 75% | 0 | 84% | 27 | 75% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-21 | Partly Cloudy | 1.60 | 17 | 14 | dorsal | 18 | 1 | 19 | 0 | 18 | 75% | 1 | 84% | 19 | 76% | 0 | 3 | 0 | 0 | 0 | 1 |
| Aug-22 | Showers | 2.40 | 16 | 13 | dorsal | 19 | 0 | 19 | 0 | 14 | 75% | 0 | 84% | 14 | 76% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-23 | Showers | 2.80 | 17 | 13 | dorsal | 17 | 0 | 17 | 0 | 0 | 74% | 0 | 84% | 0 | 74% | 1 | 15 | 0 | 0 | 0 | 0 |
| Aug-24 | Overcast | 1.36 | 18 | 13 | dorsal | 20 | 2 | 22 | 0 | 5 | 73% | 2 | 85% | 7 | 73% | 0 | 50 | 0 | 0 | 1 | 0 |
| Aug-25 | Rain | 1.50 | 17 | 13 | dorsal | 73 | 1 | 74 | 0 | 68 | 74% | 1 | 85% | 69 | 75% | 0 | 84 | 0 | 0 | 3 | 0 |
| Aug-26 | Overcast | 1.90 | 17 | 13 | dorsal | 312 | 0 | 312 | 0 | 312 | 81% | 0 | 85% | 312 | 81% | 10 | 99 | 0 | 0 | 0 | 0 |
| Aug-27 | Showers | 1.80 | 15 | 13 | dorsal | 111 | 6 | 117 | 0 | 111 | 82% | 6 | 87% | 117 | 83% | 4 | 131 | 0 | 0 | 1 | 1 |
| Aug-28 | Clear | 1.80 | 16 | 13 | dorsal | 68 | 2 | 70 | 0 | 68 | 83% | 2 | 87% | 70 | 83% | 5 | 116 | 0 | 0 | 3 | 0 |
| Aug-29 | Rain | 1.66 | 16 | 13 | dorsal | 52 | 2 | 54 | 0 | 52 | 84% | 2 | 88% | 54 | 84% | 2 | 57 | 0 | 0 | 0 | 0 |
| Aug-30 | Rain | 1.60 | 15 | 12 | dorsal | 42 | 3 | 45 | 0 | 41 | 84% | 3 | 88% | 44 | 84% | 7 | 59 | 0 | 0 | 4 | 0 |
| Aug-31 | Overcast | 1.68 | 15 | 12 | dorsal | 41 | 0 | 41 | 1 | 41 | 85% | 0 | 88% | 41 | 85% | 12 | 69 | 0 | 0 | 1 | 0 |
| Sep-01 | Overcast | 2.08 | 15 | 12 | dorsal | 102 | 2 | 104 | 0 | 102 | 86% | 2 | 88% | 104 | 86% | 31 | 81 | 0 | 0 | 0 | 0 |
| Sep-02 | Overcast | 2.04 | 15 | 10 | dorsal | 68 | 1 | 69 | 0 | 68 | 86% | 1 | 89% | 69 | 86% | 22 | 91 | 0 | 0 | 3 | 0 |
| Sep-03 | Overcast | 1.90 | 15 | 10 | dorsal | 35 | 0 | 35 | 0 | 35 | 86% | 0 | 89% | 35 | 86% | 18 | 104 | 0 | 0 | 1 | 1 |
| Sep-04 | Partly Cloudy | 1.74 | 15 | 10 | dorsal | 19 | 1 | 20 | 0 | 19 | 86% | 1 | 89% | 20 | 87% | 8 | 52 | 0 | 0 | 2 | 0 |
| Sep-05 | Overcast | 1.60 | 15 | 14 | dorsal | 20 | 0 | 20 | 0 | 20 | 87% | 0 | 89% | 20 | 87% | 11 | 75 | 0 | 0 | 0 | 0 |
| Sep-06 | Rain | 2.42 | 14 | 13 | dorsal | 16 | 0 | 16 | 0 | 16 | 87% | 0 | 89% | 16 | 87% | 3 | 51 | 0 | 0 | 0 | 0 |
| Sep-07 | Rain | 2.60 | 15 | 13 | dorsal | 20 | 0 | 20 | 0 | 20 | 87% | 0 | 89% | 20 | 87% | 52 | 190 | 0 | 0 | 0 | 0 |
| Sep-08 | Overcast | 2.82 | 15 | 14 | dorsal | 6 | 0 | 6 | 0 | 0 | 87% | 0 | 89% | 0 | 87% | 58 | 147 | 0 | 0 | 0 | 0 |
| Sep-09 | Clear | 2.80 | 15 | 15 | dorsal | 24 | 0 | 24 | 0 | 24 | 87% | 0 | 89% | 24 | 87% | 63 | 119 | 0 | 0 | 0 | 0 |
| Sep-10 | Overcast | 2.46 | 15 | 14 | dorsal | 8 | 0 | 8 | 0 | 8 | 87% | 0 | 89% | 8 | 87% | 28 | 69 | 0 | 0 | 0 | 0 |
| Sep-11 | Overcast | 2.00 | 15 | 15 | dorsal | 10 | 0 | 10 | 0 | 10 | 87% | 0 | 89% | 10 | 87% | 29 | 61 | 0 | 0 | 0 | 0 |
| Sep-12 | Overcast | 2.00 | 14 | 13 | dorsal | 13 | 0 | 13 | 0 | 13 | 87% | 0 | 89% | 13 | 87% | 33 | 61 | 0 | 0 | 0 | 0 |
| Sep-13 | Overcast | 1.86 | 14 | 13 | dorsal | 7 | 0 | 7 | 0 | 7 | 87% | 0 | 89% | 7 | 87% | 43 | 9 | 0 | 0 | 0 | 0 |
| Sep-14 | Overcast | 1.40 | 15 | 13 | dorsal | 6 | 0 | 6 | 0 | 6 | 87% | 0 | 89% | 6 | 87% | 43 | 9 | 0 | 0 | 0 | 0 |
| Sep-15 | Overcast | 1.49 | 15 | 13 | dorsal | 6 | 0 | 6 | 0 | 6 | 87% | 0 | 89% | 6 | 87% | 20 | 48 | 0 | 0 | 4 | 3 |
| Sep-16 | Overcast | 1.40 | 14 | 10 | dorsal | 2 | 0 | 2 | 0 | 0 | 87% | 0 | 89% | 0 | 87% | 6 | 28 | 0 | 0 | 2 | 0 |
| Totals for Season: | | | | | | 1,923 | 71 | 1,994 | 5 | 1,674 | | 63 | | 1,737 | | 509 | 1,883 | 2 | 1 | 35 | 7 |

Totals for Marking Periods:

| Period Dates | Mark | Sockeye Counted Adults | Jacks | Total | % | Sockeye Finclipped Adults | % | Jacks | % | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jun-17 to Jul-24 | left axillary | 160 | 16 | 176 | 9% | 142 | 89% | 12 | 75% | 154 | 88% |
| Jul-25 to Aug-14 | left ventral | 483 | 31 | 514 | 26% | 362 | 75% | 29 | 94% | 391 | 76% |
| Aug-15 to Sep-16 | dorsal | 1,280 | 24 | 1,304 | 65% | 1,170 | 91% | 22 | 92% | 1,192 | 91% |
| Total | | 1,923 | 71 | 1,994 | 100% | 1,674 | 87% | 63 | 89% | 1,737 | 87% |

[a] "Weir Morts" are adult sockeye salmon that died in the trap or as a result of weir operations. These fish were not included in the totals.

Appendix A.2. Detailed daily weir counts and weather and stream measurements, Kook Lake weir, 2006.

| | Weather and Stream Measurements at 0900hr | | | | | Sockeye Counted | | | | Sockeye Finclipped | | | | | | Number of Other Species Counted | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Weather | Water Level (Ft.) | Water Temp. (˚C) | Air Temp. (˚C) | Mark Used (adipose+) | Adults | Jacks | Total | Weir Morts [a] | Adults | Cum. % Adults Marked | Jacks | Cum. % Jacks Marked | Total | Cum. % Total Marked | Coho | Pink | Chum | Chinook | Dolly Varden | Cutthroat | Rainbow |
| Jun-16 | Rain | | | | l. axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-17 | | | | | l. axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-18 | | | | | l. axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-19 | Overcast | | | | l. axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-20 | Overcast | | | | l. axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-21 | Overcast | | | | l. axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-22 | Rain | | | | l. axillary | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-23 | Overcast | | | | l. axillary | 1 | 0 | 1 | 0 | 1 | 100% | 0 | | 1 | 100% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-24 | Overcast | | | | l. axillary | 0 | 0 | 0 | 0 | 0 | 100% | 0 | | 0 | 100% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-25 | Showers | | 12 | 19 | l. axillary | 0 | 0 | 0 | 0 | 0 | 100% | 0 | | 0 | 100% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-26 | Partly Cloudy | | 12 | 19 | l. axillary | 0 | 0 | 0 | 0 | 0 | 100% | 0 | | 0 | 100% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-27 | Partly Cloudy | | 12 | 20 | l. axillary | 5 | 0 | 5 | 0 | 5 | 100% | 0 | | 5 | 100% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-28 | Rain | | 12 | 10 | l. axillary | 8 | 0 | 8 | 0 | 8 | 100% | 0 | | 8 | 100% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-29 | Overcast | 3.15 | 12 | 14 | l. axillary | 14 | 0 | 14 | 0 | 14 | 100% | 0 | | 14 | 100% | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Jun-30 | Overcast | 3.10 | 13 | 14 | l. axillary | 29 | 0 | 29 | 0 | 29 | 100% | 0 | | 29 | 100% | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Jul-01 | Overcast | 3.00 | 13 | 16 | l. axillary | 16 | 0 | 16 | 0 | 16 | 100% | 0 | | 16 | 100% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-02 | Partly Cloudy | 2.90 | 13 | 16 | l. axillary | 17 | 0 | 17 | 0 | 10 | 92% | 0 | | 10 | 92% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-03 | Clear | 2.85 | 14 | 14 | l. axillary | 7 | 0 | 7 | 0 | 0 | 86% | 0 | | 0 | 86% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-04 | Partly Cloudy | 2.80 | 14 | 16 | l. axillary | 8 | 0 | 8 | 0 | 0 | 79% | 0 | | 0 | 79% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-05 | Overcast | 2.70 | 14 | 16 | l. axillary | 13 | 0 | 13 | 0 | 8 | 77% | 0 | | 8 | 77% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-06 | Overcast | 2.64 | 14 | 14 | l. axillary | 126 | 1 | 127 | 0 | 64 | 64% | 0 | 0% | 64 | 63% | 0 | 0 | 0 | 0 | 8 | 4 | 4 |
| Jul-07 | Overcast | 2.60 | 15 | 12 | l. axillary | 107 | 0 | 107 | 0 | 72 | 65% | 0 | 0% | 72 | 64% | 0 | 0 | 0 | 0 | 18 | 0 | 0 |
| Jul-08 | Rain | 2.60 | 16 | 11 | l. axillary | 50 | 0 | 50 | 0 | 34 | 65% | 0 | 0% | 34 | 65% | 0 | 0 | 0 | 0 | 17 | 0 | 0 |
| Jul-09 | Overcast | 2.80 | 15 | 12 | l. axillary | 143 | 0 | 143 | 0 | 96 | 66% | 0 | 0% | 96 | 66% | 0 | 0 | 0 | 0 | 10 | 0 | 0 |
| Jul-10 | Overcast | 2.85 | 15 | 10 | l. axillary | 150 | 0 | 150 | 1 | 101 | 66% | 0 | 0% | 101 | 66% | 0 | 0 | 0 | 0 | 13 | 0 | 2 |
| Jul-11 | Overcast | 2.80 | 15 | 10 | l. axillary | 195 | 0 | 195 | 0 | 128 | 66% | 0 | 0% | 128 | 66% | 0 | 0 | 0 | 0 | 16 | 0 | 0 |
| Jul-12 | Overcast | 2.78 | 15 | 11 | l. axillary | 74 | 0 | 74 | 0 | 47 | 66% | 0 | 0% | 47 | 66% | 0 | 0 | 0 | 0 | 13 | 0 | 0 |
| Jul-13 | Overcast | 2.70 | 15 | 12 | l. axillary | 53 | 0 | 53 | 0 | 36 | 66% | 0 | 0% | 36 | 66% | 0 | 0 | 0 | 0 | 17 | 0 | 0 |
| Jul-14 | Overcast | 2.69 | 15 | 12 | l. axillary | 8 | 0 | 8 | 0 | 6 | 66% | 0 | 0% | 6 | 66% | 0 | 0 | 0 | 0 | 6 | 0 | 0 |
| Jul-15 | Overcast | 2.68 | 15 | 12 | l. axillary | 0 | 0 | 0 | 0 | 0 | 66% | 0 | 0% | 0 | 66% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-16 | Overcast | 2.61 | 15 | 13 | l. axillary | 2 | 0 | 2 | 0 | 1 | 66% | 0 | 0% | 1 | 66% | 0 | 0 | 0 | 0 | 7 | 0 | 0 |
| Jul-17 | Overcast | 2.60 | 15 | 13 | l. axillary | 7 | 0 | 7 | 0 | 5 | 66% | 0 | 0% | 5 | 66% | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| Jul-18 | Overcast | 2.58 | 15 | 13 | l. axillary | 13 | 0 | 13 | 0 | 10 | 66% | 0 | 0% | 10 | 66% | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| Jul-19 | Partly Cloudy | 2.51 | 15 | 13 | l. axillary | 46 | 0 | 46 | 0 | 31 | 66% | 0 | 0% | 31 | 66% | 0 | 0 | 0 | 0 | 5 | 0 | 0 |
| Jul-20 | Showers | 2.50 | 14 | 13 | l. axillary | 116 | 0 | 116 | 1 | 78 | 66% | 0 | 0% | 78 | 66% | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Jul-21 | Rain | 2.57 | 15 | 13 | l. axillary | 327 | 0 | 327 | 1 | 223 | 67% | 0 | 0% | 223 | 67% | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| Jul-22 | Overcast | 2.76 | 15 | 13 | l. axillary | 271 | 0 | 271 | 0 | 159 | 65% | 0 | 0% | 159 | 65% | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Jul-23 | Overcast | 2.80 | 15 | 13 | l. axillary | 350 | 0 | 350 | 0 | 204 | 64% | 0 | 0% | 204 | 64% | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Jul-24 | Overcast | 2.79 | 15 | 12 | l. axillary | 268 | 0 | 268 | 0 | 133 | 63% | 0 | 0% | 133 | 63% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-25 | Overcast | 2.76 | 15 | 13 | l. axillary | 440 | 0 | 440 | 0 | 309 | 64% | 0 | 0% | 309 | 64% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-26 | Showers | | 15 | | l. axillary | 756 | 2 | 758 | 8 | 592 | 67% | 0 | 0% | 592 | 67% | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Jul-27 | Clear | | 15 | | adipose | 142 | 0 | 142 | 0 | 139 | 68% | 0 | 0% | 139 | 68% | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Jul-28 | Clear | | 15 | | adipose | 664 | 1 | 665 | 0 | 398 | 67% | 0 | 0% | 398 | 67% | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Jul-29 | Clear | 2.70 | 15 | | adipose | 367 | 0 | 367 | 3 | 252 | 67% | 0 | 0% | 252 | 67% | 0 | 0 | 0 | 0 | 4 | 0 | 0 |
| Jul-30 | Partly Cloudy | | 16 | | adipose | 211 | 0 | 211 | 0 | 129 | 67% | 0 | 0% | 129 | 67% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-31 | Showers | | | | adipose | 157 | 0 | 157 | 1 | 0 | 65% | 0 | 0% | 0 | 65% | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Aug-01 | Overcast | | | | adipose | 303 | 0 | 303 | 0 | 251 | 66% | 0 | 0% | 251 | 66% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-02 | Overcast | | | | adipose | 376 | 0 | 376 | 0 | 304 | 67% | 0 | 0% | 304 | 67% | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Aug-03 | Overcast | | | | adipose | 381 | 0 | 381 | 0 | 215 | 66% | 0 | 0% | 215 | 66% | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Aug-04 | Rain | | | | adipose | 203 | 0 | 203 | 0 | 194 | 67% | 0 | 0% | 194 | 67% | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| Aug-05 | Showers | 1.80 | | | adipose | 838 | 0 | 838 | 0 | 470 | 66% | 0 | 0% | 470 | 66% | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Aug-06 | Showers | | 14 | 12 | adipose | 687 | 0 | 687 | 2 | 478 | 66% | 0 | 0% | 478 | 66% | 0 | 0 | 0 | 0 | 4 | 0 | 0 |
| Aug-07 | | 1.90 | 14 | 12 | adipose | 352 | 0 | 352 | 0 | 243 | 66% | 0 | 0% | 243 | 66% | 0 | 0 | 0 | 0 | 9 | 0 | 0 |

-Continued-

| | Weather and Stream Measurements at 0900hr | | | | | Sockeye Counted | | | | Sockeye Finclipped | | | | | | Number of Other Species Counted | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Weather | Water Level (Ft.) | Water Temp. (˚C) | Air Temp. (˚C) | Mark Used (adipose+) | Adults | Jacks | Total | Weir Morts [a] | Adults | Cum. % Adults Marked | Jacks | Cum. % Jacks Marked | Total | Cum. % Total Marked | Coho | Pink | Chum | Chinook | Dolly Varden | Cutthroat | Rainbow |
| Aug-08 | Overcast | 1.89 | 14 | 12 | adipose | 210 | 0 | 210 | 1 | 144 | 66% | 0 | 0% | 144 | 66% | 0 | 0 | 0 | 0 | 7 | 0 | 0 |
| Aug-09 | Partly Cloudy | 1.80 | 14 | 12 | adipose | 110 | 0 | 110 | 0 | 75 | 66% | 0 | 0% | 75 | 66% | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Aug-10 | Overcast | 1.70 | 14 | 12 | adipose | 104 | 0 | 104 | 0 | 69 | 66% | 0 | 0% | 69 | 66% | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Aug-11 | Overcast | 1.62 | 14 | 12 | adipose | 63 | 0 | 63 | 1 | 42 | 66% | 0 | 0% | 42 | 66% | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Aug-12 | Overcast | 1.66 | 15 | 15 | adipose | 135 | 0 | 135 | 1 | 91 | 66% | 0 | 0% | 91 | 66% | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-13 | Overcast | 1.59 | 15 | 14 | adipose | 94 | 0 | 94 | 0 | 64 | 66% | 0 | 0% | 64 | 66% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-14 | Partly Cloudy | 1.58 | 15 | 14 | adipose | 56 | 0 | 56 | 0 | 47 | 66% | 0 | 0% | 47 | 66% | 0 | 1 | 0 | 0 | 2 | 0 | 0 |
| Aug-15 | Partly Cloudy | 1.52 | 16 | 15 | adipose | 80 | 1 | 81 | 1 | 59 | 66% | 1 | 20% | 60 | 66% | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Aug-16 | Showers | 1.48 | 15 | 15 | adipose | 54 | 0 | 54 | 0 | 38 | 66% | 0 | 20% | 38 | 66% | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-17 | | 1.46 | 15 | 16 | adipose | 35 | 0 | 35 | 0 | 23 | 66% | 0 | 20% | 23 | 66% | 1 | 0 | 0 | 0 | 2 | 0 | 0 |
| Aug-18 | Showers | 1.50 | 15 | 15 | adipose | 45 | 0 | 45 | 0 | 32 | 67% | 0 | 20% | 32 | 66% | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| Aug-19 | Partly Cloudy | 1.50 | 15 | 12 | adipose | 49 | 0 | 49 | 0 | 40 | 67% | 0 | 20% | 40 | 67% | 2 | 0 | 0 | 2 | 2 | 0 | 0 |
| Aug-20 | Partly Cloudy | 1.48 | 14 | 13 | adipose | 51 | 0 | 51 | 0 | 40 | 67% | 0 | 20% | 40 | 67% | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| Aug-21 | Overcast | 1.42 | 14 | 12 | adipose | 55 | 0 | 55 | 0 | 44 | 67% | 0 | 20% | 44 | 67% | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-22 | Overcast | 1.38 | 15 | 13 | adipose | 47 | 1 | 48 | 0 | 46 | 67% | 1 | 33% | 47 | 67% | 1 | 0 | 0 | 0 | 2 | 0 | 0 |
| Aug-23 | Rain | 1.34 | | | adipose | 43 | 0 | 43 | 0 | 0 | 67% | 0 | 33% | 0 | 67% | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-24 | Overcast | 1.33 | | | adipose | 43 | 0 | 43 | 0 | 0 | 66% | 0 | 33% | 0 | 66% | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-25 | Overcast | 1.40 | | | adipose | 41 | 0 | 41 | 0 | 30 | 66% | 0 | 33% | 30 | 66% | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-26 | Overcast | 1.40 | | | adipose | 39 | 0 | 39 | 0 | 0 | 66% | 0 | 33% | 0 | 66% | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-27 | Overcast | 1.41 | | | adipose | 27 | 1 | 28 | 0 | 27 | 66% | 1 | 43% | 28 | 66% | 3 | 1 | 0 | 0 | 4 | 0 | 0 |
| Aug-28 | Partly Cloudy | 1.70 | | | adipose | 21 | 0 | 21 | 0 | 21 | 66% | 0 | 43% | 21 | 66% | 2 | 2 | 0 | 0 | 2 | 0 | 0 |
| Aug-29 | Partly Cloudy | 1.72 | | | adipose | 43 | 0 | 43 | 0 | 43 | 66% | 0 | 43% | 43 | 66% | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| Aug-30 | Partly Cloudy | 1.72 | | | adipose | 23 | 0 | 23 | 0 | 0 | 66% | 0 | 43% | 0 | 66% | 0 | 4 | 0 | 0 | 4 | 0 | 0 |
| Aug-31 | Rain | 1.85 | | | adipose | 24 | 0 | 24 | 0 | 0 | 66% | 0 | 43% | 0 | 66% | 13 | 3 | 0 | 0 | 3 | 0 | 0 |
| Sep-01 | Flood | | | | | | | | | | 66% | | 43% | | 66% | | | | | | | |
| Sep-02 | Flood | | | | | | | | | | 66% | | 43% | | 66% | | | | | | | |
| Sep-03 | Flood | | | | | | | | | | 66% | | 43% | | 66% | | | | | | | |
| Sep-04 | | | | | | | | | | | 66% | | 43% | | 66% | | | | | | | |
| Sep-05 | | | | | | | | | | | 66% | | 43% | | 66% | | | | | | | |
| Sep-06 | | | | | | | | | | | 66% | | 43% | | 66% | | | | | | | |
| Sep-07 | | | | | | | | | | | 66% | | 43% | | 66% | | | | | | | |
| Sep-08 | | | | | adipose | 1 | 0 | 1 | 0 | 0 | 66% | 0 | 43% | 0 | 66% | 13 | 0 | 0 | 0 | 8 | 0 | 0 |
| Sep-09 | Rain | | | | adipose | 4 | 0 | 4 | 0 | 3 | 66% | 0 | 43% | 3 | 66% | 4 | 2 | 0 | 0 | 11 | 0 | 0 |
| Sep-10 | Showers | | | | adipose | 4 | 0 | 4 | 0 | 4 | 66% | 0 | 43% | 4 | 66% | 5 | 0 | 0 | 0 | 18 | 0 | 0 |
| Sep-11 | Overcast | | | | adipose | 2 | 0 | 2 | 0 | 2 | 66% | 0 | 43% | 2 | 66% | 7 | 1 | 0 | 0 | 29 | 0 | 0 |
| Sep-12 | Rain | | | | adipose | 8 | 0 | 8 | 0 | 8 | 66% | 0 | 43% | 8 | 66% | 13 | 2 | 0 | 0 | 8 | 0 | 0 |
| Sep-13 | Partly Cloudy | | 12 | 11 | adipose | 3 | 0 | 3 | 0 | 3 | 66% | 0 | 43% | 3 | 66% | 11 | 1 | 0 | 0 | 12 | 0 | 0 |
| Sep-14 | Clear | | | | adipose | 8 | 0 | 8 | 0 | 8 | 66% | 0 | 43% | 8 | 66% | 7 | 0 | 0 | 0 | 12 | 0 | 0 |
| Sep-15 | Clear | | 12 | 9 | adipose | 5 | 0 | 5 | 0 | 5 | 66% | 0 | 43% | 5 | 66% | 4 | 0 | 0 | 0 | 4 | 0 | 0 |
| Sep-16 | Clear | | 12 | 9 | adipose | 4 | 0 | 4 | 0 | 4 | 66% | 0 | 43% | 4 | 66% | 3 | 0 | 0 | 0 | 10 | 0 | 0 |
| Sep-17 | | | 12 | 10 | adipose | 2 | 0 | 2 | 0 | 2 | 66% | 0 | 43% | 2 | 66% | 4 | 0 | 0 | 0 | 3 | 0 | 0 |
| Sep-18 | | | | | adipose | 2 | 0 | 2 | 0 | 2 | 66% | 0 | 43% | 2 | 66% | 0 | 0 | 0 | 0 | 3 | 0 | 0 |
| Sep-19 | Partly Cloudy | | 12 | 12 | adipose | 3 | 0 | 3 | 0 | 3 | 66% | 0 | 43% | 3 | 66% | 18 | 0 | 0 | 0 | 9 | 0 | 0 |
| Totals for Season: | | | | | | 9,839 | 7 | 9,846 | 21 | 6,512 | | 3 | | 6,515 | | 121 | 18 | 0 | 3 | 337 | 4 | 6 |

Totals for Marking Periods:

| Period Dates | Mark | Sockeye Counted Adults | Jacks | Total | % | Sockeye Finclipped Adults | % | Jacks | % | Total | % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jun-16 to Jul-26 | left axillary | 3,620 | 3 | 3,623 | 37% | 2,420 | 67% | 0 | 0% | 2,420 | 67% |
| Jul-27 to Sept-19 | adipose | 6,219 | 4 | 6,223 | 63% | 4,092 | 66% | 3 | 75% | 4,095 | 66% |
| Total | | 9,839 | 7 | 9,846 | 100% | 6,512 | 66% | 3 | 43% | 6,515 | 66% |

[a] "Weir Morts" are adult sockeye salmon that died in the trap or as a result of weir operations. These fish were not included in the totals.

Appendix A.3. Detailed daily weir counts and weather and stream measurements, Kook Lake weir, 2007.

| | Weather and Stream Measurements at 0900hr | | | | | Sockeye Counted | | | | Sockeye Finclipped | | | | | | Number of Other Species Counted | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Weather | Water Level (Ft.) | Water Temp. (˚C) | Air Temp. (˚C) | Mark Used (adipose+) | Adults | Jacks | Total | Weir Morts [a] | Adults | Cum. % Adults Marked | Jacks | Cum. % Jacks Marked | Total | Cum. % Total Marked | Coho | Pink | Chum | Chinook | Dolly Varden | Cutthroat |
| Jun-26 | Partly Cloudy | | | | adipose | 5 | 0 | 5 | 0 | 1 | 20% | 0 | | 1 | 20% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-27 | Partly Cloudy | | | | adipose | 40 | 0 | 40 | 0 | 35 | 80% | 0 | | 35 | 80% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-28 | Overcast | 2.00 | 13 | | adipose | 31 | 0 | 31 | 0 | 23 | 78% | 0 | | 23 | 78% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-29 | Clear | 2.10 | 12 | 12 | adipose | 39 | 0 | 39 | 0 | 38 | 84% | 0 | | 38 | 84% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jun-30 | Partly Cloudy | 2.10 | 13 | 12 | adipose | 82 | 0 | 82 | 0 | 28 | 63% | 0 | | 28 | 63% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-01 | Showers | 2.00 | 14 | 12 | adipose | 47 | 0 | 47 | 0 | 8 | 55% | 0 | | 8 | 55% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-02 | Partly Cloudy | 2.00 | 13 | 14 | adipose | 45 | 0 | 45 | 0 | 8 | 49% | 0 | | 8 | 49% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-03 | Rain | 2.00 | 13 | 11 | adipose | 58 | 0 | 58 | 0 | 6 | 42% | 0 | | 6 | 42% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-04 | Overcast | 2.10 | 12 | 11 | adipose | 42 | 1 | 43 | 0 | 0 | 38% | 0 | 0% | 0 | 38% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-05 | Showers | 2.30 | 10 | 10 | adipose | 27 | 0 | 27 | 0 | 0 | 35% | 0 | 0% | 0 | 35% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-06 | Overcast | 2.50 | 10 | 10 | adipose | 15 | 0 | 15 | 0 | 0 | 34% | 0 | 0% | 0 | 34% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-07 | Overcast | 2.20 | 13 | 10 | adipose | 67 | 0 | 67 | 0 | 0 | 30% | 0 | 0% | 0 | 29% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-08 | Overcast | 2.10 | 12 | 10 | adipose | 53 | 0 | 53 | 0 | 10 | 28% | 0 | 0% | 10 | 28% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-09 | Rain | 2.00 | 10 | 10 | adipose | 94 | 0 | 94 | 0 | 0 | 24% | 0 | 0% | 0 | 24% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-10 | Showers | 2.40 | 10 | 10 | adipose | 35 | 0 | 35 | 1 | 0 | 23% | 0 | 0% | 0 | 23% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-11 | Rain | 2.40 | 10 | 10 | adipose | 50 | 0 | 50 | 0 | 0 | 22% | 0 | 0% | 0 | 21% | 0 | 0 | 0 | 0 | 2 | 0 |
| Jul-12 | Showers | 2.90 | 10 | 10 | adipose | 60 | 0 | 60 | 0 | 0 | 20% | 0 | 0% | 0 | 20% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-13 | Overcast | 2.80 | | | adipose | 17 | 0 | 17 | 0 | 0 | 19% | 0 | 0% | 0 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-14 | Overcast | 2.50 | 10 | 10 | adipose | 28 | 0 | 28 | 0 | 0 | 19% | 0 | 0% | 0 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-15 | Overcast | 2.20 | 10 | 10 | adipose | 34 | 0 | 34 | 0 | 0 | 18% | 0 | 0% | 0 | 18% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-16 | Rain | 2.10 | 10 | 10 | adipose | 105 | 0 | 105 | 0 | 17 | 18% | 0 | 0% | 17 | 18% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-17 | Overcast | 2.20 | 10 | 10 | adipose | 98 | 0 | 98 | 0 | 22 | 18% | 0 | 0% | 22 | 18% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-18 | | 2.00 | 10 | 10 | adipose | 75 | 1 | 76 | 0 | 27 | 19% | 1 | 50% | 28 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-19 | Partly Cloudy | 1.90 | 10 | 11 | adipose | 91 | 1 | 92 | 0 | 18 | 19% | 0 | 33% | 18 | 20% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-20 | Rain | 1.80 | 10 | 11 | adipose | 55 | 0 | 55 | 0 | 10 | 19% | 0 | 33% | 10 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-21 | | 1.70 | 12 | | adipose | 75 | 0 | 75 | 4 | 15 | 19% | 0 | 33% | 15 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-22 | Overcast | 1.50 | 12 | 14 | adipose | 85 | 0 | 85 | 1 | 15 | 19% | 0 | 33% | 15 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-23 | Overcast | 1.60 | 14 | 14 | adipose | 46 | 0 | 46 | 1 | 11 | 19% | 0 | 33% | 11 | 20% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-24 | Partly Cloudy | 1.50 | 14 | 13 | adipose | 58 | 0 | 58 | 0 | 10 | 19% | 0 | 33% | 10 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-25 | Partly Cloudy | 1.40 | 14 | 13 | adipose | 55 | 0 | 55 | 0 | 8 | 19% | 0 | 33% | 8 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-26 | Overcast | 1.40 | 13 | 12 | adipose | 31 | 0 | 31 | 0 | 7 | 19% | 0 | 33% | 7 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-27 | Overcast | 1.35 | 12 | 14 | adipose | 15 | 0 | 15 | 0 | 3 | 19% | 0 | 33% | 3 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-28 | Partly Cloudy | 1.35 | 13 | 14 | adipose | 44 | 0 | 44 | 1 | 8 | 19% | 0 | 33% | 8 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-29 | | 1.30 | 14 | 14 | adipose | 38 | 0 | 38 | 0 | 5 | 19% | 0 | 33% | 5 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-30 | Overcast | 1.30 | 14 | 14 | adipose | 30 | 2 | 32 | 0 | 4 | 19% | 0 | 20% | 4 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Jul-31 | Overcast | 1.20 | 14 | 14 | adipose | 33 | 0 | 33 | 0 | 6 | 19% | 0 | 20% | 6 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-01 | Overcast | 1.10 | 15 | 15 | adipose | 22 | 0 | 22 | 1 | 3 | 19% | 0 | 20% | 3 | 19% | 0 | 0 | 0 | 0 | 3 | 0 |
| Aug-02 | Overcast | 1.10 | 14 | 15 | adipose | 0 | 0 | 0 | 0 | 0 | 19% | 0 | 20% | 0 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-03 | Partly Cloudy | 1.00 | 15 | 14 | adipose | 2 | 0 | 2 | 0 | 2 | 19% | 0 | 20% | 2 | 19% | 0 | 0 | 0 | 0 | 1 | 0 |
| Aug-04 | Overcast | 1.00 | 13 | 15 | adipose | 28 | 0 | 28 | 4 | 6 | 19% | 0 | 20% | 6 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-05 | Overcast | 1.00 | 13 | 15 | adipose | 2 | 0 | 2 | 0 | 1 | 19% | 0 | 20% | 1 | 19% | 0 | 0 | 0 | 0 | 1 | 0 |
| Aug-06 | Overcast | 0.90 | 13 | 15 | adipose | 32 | 1 | 33 | 1 | 16 | 20% | 1 | 33% | 17 | 20% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-07 | Overcast | 0.90 | 13 | 15 | adipose | 13 | 0 | 13 | 0 | 4 | 20% | 0 | 33% | 4 | 20% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-08 | | 0.90 | 15 | 13 | adipose | 3 | 0 | 3 | 0 | 0 | 20% | 0 | 33% | 0 | 20% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-09 | Partly Cloudy | 0.90 | 15 | 15 | adipose | 1 | 0 | 1 | 1 | 0 | 20% | 0 | 33% | 0 | 20% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-10 | Partly Cloudy | 0.85 | 15 | 14 | adipose | 12 | 0 | 12 | 0 | 9 | 20% | 0 | 33% | 9 | 20% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-11 | Clear | 0.86 | 15 | 14 | adipose | 2 | 1 | 3 | 0 | 0 | 20% | 0 | 29% | 0 | 20% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-12 | Clear | 0.80 | 16 | 15 | adipose | 34 | 0 | 34 | 0 | 6 | 20% | 0 | 29% | 6 | 20% | 0 | 0 | 0 | 0 | 2 | 0 |
| Aug-13 | Clear | 0.79 | 16 | 12 | adipose | 17 | 0 | 17 | 0 | 0 | 20% | 0 | 29% | 0 | 20% | 0 | 0 | 0 | 0 | 4 | 0 |
| Aug-14 | Clear | 0.76 | 16 | 14 | adipose | 46 | 0 | 46 | 0 | 0 | 19% | 0 | 29% | 0 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-15 | | 0.76 | 16 | 12 | adipose | 3 | 0 | 3 | 0 | 0 | 19% | 0 | 29% | 0 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-16 | Clear | 0.76 | 16 | 13 | adipose | 6 | 0 | 6 | 0 | 0 | 19% | 0 | 29% | 0 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |

-Continued-

Appendix A.3. Page 2 of 2.

| | Weather and Stream Measurements at 0900hr | | | | | Sockeye Counted | | | | Sockeye Finclipped | | | | | | Number of Other Species Counted | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | Weather | Water Level (Ft.) | Water Temp. (˚C) | Air Temp. (˚C) | Mark Used (adipose+) | Adults | Jacks | Total | Weir Morts [a] | Adults | Cum. % Adults Marked | Jacks | Cum. % Jacks Marked | Total | Cum. % Total Marked | Coho | Pink | Chum | Chinook | Dolly Varden | Cutthroat |
| Aug-17 | Showers | 0.80 | 16 | 14 | adipose | 10 | 0 | 10 | 0 | 0 | 19% | 0 | 29% | 0 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-18 | Overcast | 0.80 | 17 | 14 | adipose | 78 | 0 | 78 | 0 | 19 | 19% | 0 | 29% | 19 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-19 | Rain | 0.85 | 17 | 14 | adipose | 64 | 0 | 64 | 0 | 10 | 19% | 0 | 29% | 10 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-20 | Overcast | 0.90 | 17 | 14 | adipose | 38 | 0 | 38 | 0 | 6 | 19% | 0 | 29% | 6 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-21 | Rain | 0.90 | 16 | 13 | adipose | 32 | 0 | 32 | 0 | 0 | 19% | 0 | 29% | 0 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-22 | Partly Cloudy | 0.90 | 16 | 13 | adipose | 27 | 0 | 27 | 0 | 4 | 19% | 0 | 29% | 4 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-23 | Partly Cloudy | 0.90 | 16 | 10 | adipose | 12 | 0 | 12 | 0 | 2 | 19% | 0 | 29% | 2 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-24 | Overcast | 0.90 | 16 | 12 | adipose | 14 | 0 | 14 | 0 | 2 | 19% | 0 | 29% | 2 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-25 | Overcast | 0.95 | 16 | 12 | adipose | 4 | 0 | 4 | 0 | 0 | 19% | 0 | 29% | 0 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-26 | | 0.95 | 16 | 12 | adipose | 1 | 0 | 1 | 0 | 0 | 19% | 0 | 29% | 0 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-27 | Partly Cloudy | 1.00 | 16 | 12 | adipose | 2 | 0 | 2 | 0 | 0 | 19% | 0 | 29% | 0 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-28 | Partly Cloudy | 0.90 | 15 | 9 | adipose | 15 | 1 | 16 | 0 | 2 | 19% | 0 | 25% | 2 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-29 | Partly Cloudy | 0.80 | 15 | 12 | adipose | 128 | 0 | 128 | 0 | 24 | 19% | 0 | 25% | 24 | 19% | 2 | 0 | 0 | 0 | 1 | 0 |
| Aug-30 | Overcast | 0.80 | 15 | 11 | adipose | 28 | 0 | 28 | 0 | 1 | 19% | 0 | 25% | 1 | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Aug-31 | Overcast | 0.72 | 15 | 11 | adipose | 10 | 0 | 10 | 0 | 1 | 19% | 0 | 25% | 1 | 19% | 1 | 0 | 0 | 0 | 0 | 1 |
| Sep-01 | Overcast | 0.74 | 13 | 11 | adipose | 8 | 0 | 8 | 0 | 2 | 19% | 0 | 25% | 2 | 19% | 0 | 0 | 0 | 0 | 2 | 0 |
| Sep-02 | Overcast | 0.76 | 15 | 11 | adipose | 26 | 0 | 26 | 0 | 5 | 19% | 0 | 25% | 5 | 19% | 2 | 0 | 0 | 0 | 0 | 0 |
| Sep-03 | Clear | 0.78 | 14 | 9 | adipose | 24 | 0 | 24 | 0 | 4 | 19% | 0 | 25% | 4 | 19% | 4 | 0 | 1 | 0 | 0 | 1 |
| Sep-04 | Showers | 0.82 | 14 | 9 | adipose | 4 | 0 | 4 | 0 | 0 | 19% | 0 | 25% | 0 | 19% | 1 | 0 | 0 | 0 | 0 | 1 |
| Sep-05 | Overcast | 0.90 | 14 | 10 | adipose | 142 | 0 | 142 | 0 | 21 | 18% | 0 | 25% | 21 | 18% | 4 | 0 | 0 | 0 | 0 | 0 |
| Sep-06 | Showers | 1.40 | 14 | 10 | adipose | 150 | 0 | 150 | 0 | 52 | 19% | 0 | 25% | 52 | 19% | 17 | 0 | 0 | 0 | 3 | 0 |
| Sep-07 | Overcast | 1.60 | 15 | 10 | adipose | 59 | 0 | 59 | 0 | 10 | 19% | 0 | 25% | 10 | 19% | 30 | 2 | 0 | 0 | 8 | 0 |
| Sep-08 | | 1.60 | 15 | 10 | adipose | 22 | 0 | 22 | 0 | 4 | 19% | 0 | 25% | 4 | 19% | 17 | 3 | 0 | 0 | 10 | 0 |
| Sep-09 | Partly Cloudy | 1.48 | 14 | 12 | adipose | 12 | 0 | 12 | 0 | 3 | 19% | 0 | 25% | 3 | 19% | 39 | 0 | 0 | 0 | 12 | 1 |
| Sep-10 | Overcast | 1.40 | 14 | 13 | adipose | 5 | 0 | 5 | 0 | 1 | 19% | 0 | 25% | 1 | 19% | 29 | 2 | 1 | 0 | 3 | 0 |
| Sep-11 | | 1.34 | 14 | 13 | adipose | 5 | 0 | 5 | 0 | 2 | 19% | 0 | 25% | 2 | 19% | 42 | 0 | 0 | 0 | 1 | 0 |
| Sep-12 | Overcast | 1.25 | 14 | 10 | adipose | 1 | 0 | 1 | 0 | 0 | 19% | 0 | 25% | 0 | 19% | 33 | 0 | 0 | 0 | 2 | 0 |
| Sep-13 | Partly Cloudy | 1.26 | 14 | 11 | adipose | 1 | 0 | 1 | 0 | 0 | 19% | 0 | 25% | 0 | 19% | 14 | 0 | 0 | 0 | 1 | 0 |
| Sep-14 | Overcast | 1.80 | 14 | 10 | adipose | 2 | 0 | 2 | 0 | 0 | 19% | 0 | 25% | 0 | 19% | 34 | 1 | 0 | 0 | 0 | 0 |
| Sep-15 | Rain | 2.40 | 14 | 12 | adipose | | | | 0 | | 19% | | 25% | | 19% | 0 | 0 | 0 | 0 | 0 | 0 |
| Totals for Season: | | | | | | 2,950 | 8 | 2,958 | 15 | 565 | | 2 | | 567 | | 269 | 8 | 2 | 0 | 56 | 4 |

[a] "Weir Morts" are adult sockeye salmon that died in the trap or as a result of weir operations. These fish were not included in the totals.

Appendix B.1. Age composition, by period and sex, of sockeye salmon sampled at the Kook Lake weir, 2005.

| | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|
| | 2002 | 2001 | 2000 | 2000 | |
| | 1.1 | 1.2 | 1.3 | 2.2 | Total |
| June 26 - July 16 | | | | | |
| Male | | | | | |
| Sample Size | | | 1 | | 1 |
| Percent | | | 50.0 | | 50.0 |
| Std. Error | | | 45.2 | | 45.2 |
| Escapement | | | 6 | | 6 |
| Female | | | | | |
| Sample Size | | | 1 | | 1 |
| Percent | | | 50.0 | | 50.0 |
| Std. Error | | | 45.2 | | 45.2 |
| Escapement | | | 6 | | 6 |
| All Fish | | | | | |
| Sample Size | | | 2 | | 2 |
| Percent | | | %100.0 | | 100.0 |
| Std. Error | | | | | |
| Escapement | | | 11 | | 11 |
| July 17 - 23 | | | | | |
| Male | | | | | |
| Sample Size | 10 | 40 | 28 | 10 | 88 |
| Percent | 8.9 | 35.7 | 25.0 | 8.9 | 78.6 |
| Std. Error | 1.4 | 2.4 | 2.2 | 1.4 | 2.1 |
| Escapement | 14 | 56 | 39 | 14 | 123 |
| Female | | | | | |
| Sample Size | | 14 | 9 | 1 | 24 |
| Percent | | 12.5 | 8.0 | 0.9 | 21.4 |
| Std. Error | | 1.7 | 1.4 | 0.5 | 2.1 |
| Escapement | | 20 | 13 | 1 | 34 |
| All Fish | | | | | |
| Sample Size | 10 | 54 | 37 | 11 | 112 |
| Percent | 8.9 | 48.2 | 33.0 | 9.8 | 100.0 |
| Std. Error | 1.4 | 2.5 | 2.4 | 1.5 | |
| Escapement | 14 | 76 | 52 | 15 | 157 |
| July 24 - 30 | | | | | |
| Male | | | | | |
| Sample Size | 16 | 47 | 21 | 10 | 94 |
| Percent | 10.3 | 30.3 | 13.5 | 6.5 | 60.6 |
| Std. Error | 0.8 | 1.2 | 0.9 | 0.6 | 1.2 |
| Escapement | 18 | 52 | 23 | 11 | 104 |
| Female | | | | | |
| Sample Size | | 46 | 10 | 5 | 61 |
| Percent | | 29.7 | 6.5 | 3.2 | 39.4 |
| Std. Error | | 1.2 | 0.6 | 0.4 | 1.2 |
| Escapement | | 51 | 11 | 6 | 68 |
| All Fish | | | | | |
| Sample Size | 16 | 93 | 31 | 15 | 155 |
| Percent | 10.3 | 60.0 | 20.0 | 9.7 | 100.0 |
| Std. Error | 0.8 | 1.2 | 1.0 | 0.7 | |
| Escapement | 18 | 103 | 34 | 17 | 172 |

(continued)

Appendix B.1. Page 2 of 3.

| | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|
| | 2002 | 2001 | 2000 | 2000 | |
| | 1.1 | 1.2 | 1.3 | 2.2 | Total |
| July 31 - August 6 | | | | | |
| Male | | | | | |
| Sample Size | 4 | 18 | 9 | 1 | 32 |
| Percent | 8.9 | 40.0 | 20.0 | 2.2 | 71.1 |
| Std. Error | 3.5 | 6.1 | 5.0 | 1.8 | 5.6 |
| Escapement | 12 | 55 | 27 | 3 | 97 |
| Female | | | | | |
| Sample Size | | 11 | 1 | 1 | 13 |
| Percent | | 24.4 | 2.2 | 2.2 | 28.9 |
| Std. Error | | 5.3 | 1.8 | 1.8 | 5.6 |
| Escapement | | 33 | 3 | 3 | 39 |
| All Fish | | | | | |
| Sample Size | 4 | 30 | 10 | 2 | 46 |
| Percent | 8.7 | 65.2 | 21.7 | 4.3 | 100.0 |
| Std. Error | 3.4 | 5.8 | 5.0 | 2.5 | |
| Escapement | 12 | 91 | 30 | 6 | 139 |
| August 7 - 13 | | | | | |
| Male | | | | | |
| Sample Size | 2 | 13 | 9 | | 24 |
| Percent | 4.3 | 28.3 | 19.6 | | 52.2 |
| Std. Error | 2.6 | 5.8 | 5.1 | | 6.5 |
| Escapement | 8 | 53 | 37 | | 98 |
| Female | | | | | |
| Sample Size | | 12 | 10 | | 22 |
| Percent | | 26.1 | 21.7 | | 47.8 |
| Std. Error | | 5.7 | 5.3 | | 6.5 |
| Escapement | | 49 | 40 | | 89 |
| All Fish | | | | | |
| Sample Size | 2 | 25 | 19 | | 46 |
| Percent | 4.3 | 54.3 | 41.3 | | 100.0 |
| Std. Error | 2.6 | 6.4 | 6.4 | | |
| Escapement | 8 | 102 | 77 | | 187 |
| August 14 - 20 | | | | | |
| Male | | | | | |
| Sample Size | 1 | 24 | 23 | 1 | 49 |
| Percent | 1.2 | 28.2 | 27.1 | 1.2 | 57.6 |
| Std. Error | 0.8 | 3.5 | 3.4 | 0.8 | 3.8 |
| Escapement | 2 | 48 | 47 | 2 | 99 |
| Female | | | | | |
| Sample Size | | 24 | 11 | 1 | 36 |
| Percent | | 28.2 | 12.9 | 1.2 | 42.4 |
| Std. Error | | 3.5 | 2.6 | 0.8 | 3.8 |
| Escapement | | 49 | 22 | 2 | 73 |
| All Fish | | | | | |
| Sample Size | 1 | 48 | 34 | 2 | 85 |
| Percent | 1.2 | 56.5 | 40.0 | 2.4 | 100.0 |
| Std. Error | 0.8 | 3.8 | 3.8 | 1.2 | |
| Escapement | 2 | 97 | 69 | 4 | 172 |

(continued)

| | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|
| | 2002 | 2001 | 2000 | 2000 | |
| | 1.1 | 1.2 | 1.3 | 2.2 | Total |
| **August 21 - 27** | | | | | |
| Male | | | | | |
| Sample Size | 1 | 12 | 7 | | 20 |
| Percent | 2.7 | 32.4 | 18.9 | | 54.1 |
| Std. Error | 2.6 | 7.5 | 6.3 | | 8.0 |
| Escapement | 16 | 188 | 110 | | 314 |
| Female | | | | | |
| Sample Size | | 7 | 9 | 1 | 17 |
| Percent | | 18.9 | 24.3 | 2.7 | 45.9 |
| Std. Error | | 6.3 | 6.9 | 2.6 | 8.0 |
| Escapement | | 109 | 141 | 16 | 266 |
| All Fish | | | | | |
| Sample Size | 1 | 19 | 16 | 1 | 37 |
| Percent | 2.7 | 51.4 | 43.2 | 2.7 | 100.0 |
| Std. Error | 2.6 | 8.1 | 8.0 | 2.6 | |
| Escapement | 16 | 297 | 251 | 16 | 580 |
| **August 28 - Sept. 17** | | | | | |
| Male | | | | | |
| Sample Size | | 2 | 3 | | 5 |
| Percent | | 15.4 | 23.1 | | 38.5 |
| Std. Error | | 10.3 | 12.0 | | 13.9 |
| Escapement | | 89 | 133 | | 222 |
| Female | | | | | |
| Sample Size | | 2 | 6 | | 8 |
| Percent | | 15.4 | 46.2 | | 61.5 |
| Std. Error | | 10.3 | 14.2 | | 13.9 |
| Escapement | | 88 | 266 | | 354 |
| All Fish | | | | | |
| Sample Size | | 4 | 9 | | 13 |
| Percent | | 30.8 | 69.2 | | 100.0 |
| Std. Error | | 13.2 | 13.2 | | |
| Escapement | | 177 | 399 | | 576 |
| **Combined Periods (Percentages are weighted by period escapements)** | | | | | |
| Male | | | | | |
| Sample Size | 34 | 156 | 101 | 22 | 313 |
| Percent | 3.5 | 27.2 | 21.1 | 1.5 | 53.3 |
| Std. Error | 0.9 | 3.8 | 4.0 | 0.2 | 4.7 |
| Escapement | 70 | 541 | 422 | 30 | 1,063 |
| Female | | | | | |
| Sample Size | | 116 | 57 | 9 | 182 |
| Percent | | 20.1 | 25.2 | 1.4 | 46.7 |
| Std. Error | | 3.6 | 4.6 | 0.8 | 4.7 |
| Escapement | | 399 | 502 | 28 | 929 |
| All Fish | | | | | |
| Sample Size | 34 | 273 | 158 | 31 | 496 |
| Percent | 3.5 | 47.3 | 46.3 | 2.9 | 100.0 |
| Std. Error | 0.8 | 4.5 | 4.5 | 0.8 | |
| Escapement | 70 | 943 | 923 | 58 | 1,994 |

Appendix B.2. Length composition, by period and sex, of sockeye salmon sampled at the Kook Lake weir, 2005.

| | | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|---|
| | | 2002 | 2001 | 2000 | 2000 | |
| | | 1.1 | 1.2 | 1.3 | 2.2 | Total |
| June 26 - July 16 | | | | | | |
| Male | Avg. Length | | | 640 | | 640 |
| | Std. Error | | | | | |
| | Sample Size | | | 1 | | 1 |
| Female | Avg. Length | | | 555 | | 555 |
| | Std. Error | | | | | |
| | Sample Size | | | 1 | | 1 |
| All Fish | Avg. Length | | | 598 | | 598 |
| | Std. Error | | | 42.5 | | 42.5 |
| | Sample Size | | | 2 | | 2 |
| July 17 - 23 | | | | | | |
| Male | Avg. Length | 379 | 503 | 539 | 506 | 501 |
| | Std. Error | 4.3 | 4.9 | 8.8 | 5.8 | 6.2 |
| | Sample Size | 10 | 40 | 28 | 10 | 88 |
| Female | Avg. Length | | 491 | 557 | 485 | 516 |
| | Std. Error | | 7.0 | 4.8 | | 7.9 |
| | Sample Size | | 14 | 9 | 1 | 24 |
| All Fish | Avg. Length | 379 | 500 | 543 | 504 | 504 |
| | Std. Error | 4.3 | 4.1 | 6.9 | 5.6 | 5.2 |
| | Sample Size | 10 | 54 | 37 | 11 | 112 |
| July 24 - 30 | | | | | | |
| Male | Avg. Length | 374 | 491 | 558 | 513 | 488 |
| | Std. Error | 3.3 | 4.2 | 4.4 | 7.5 | 6.5 |
| | Sample Size | 16 | 47 | 21 | 10 | 94 |
| Female | Avg. Length | | 476 | 533 | 511 | 488 |
| | Std. Error | | 4.0 | 5.6 | 18.3 | 4.5 |
| | Sample Size | | 46 | 10 | 5 | 61 |
| All Fish | Avg. Length | 374 | 483 | 550 | 512 | 488 |
| | Std. Error | 3.3 | 3.0 | 4.0 | 7.5 | 4.3 |
| | Sample Size | 16 | 93 | 31 | 15 | 155 |
| July 31 - August 6 | | | | | | |
| Male | Avg. Length | 383 | 483 | 549 | 510 | 490 |
| | Std. Error | 11.1 | 6.8 | 5.4 | | 9.9 |
| | Sample Size | 4 | 18 | 9 | 1 | 32 |
| Female | Avg. Length | | 475 | 510 | 470 | 477 |
| | Std. Error | | 7.8 | | | 7.1 |
| | Sample Size | | 11 | 1 | 1 | 13 |
| All Fish | Avg. Length | 383 | 481 | 546 | 490 | 487 |
| | Std. Error | 11.1 | 5.1 | 6.2 | 20.0 | 7.2 |
| | Sample Size | 4 | 30 | 10 | 2 | 46 |

Appendix B.2. Page 2 of 3.

| | | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|---|
| | | 2002 | 2001 | 2000 | 2000 | |
| | | 1.1 | 1.2 | 1.3 | 2.2 | Total |
| August 7 - 13 | | | | | | |
| Male | Avg. Length | 375 | 493 | 550 | | 505 |
| | Std. Error | 5.0 | 5.6 | 6.0 | | 10.5 |
| | Sample Size | 2 | 13 | 9 | | 24 |
| Female | Avg. Length | | 500 | 544 | | 520 |
| | Std. Error | | 4.4 | 7.0 | | 6.2 |
| | Sample Size | | 12 | 10 | | 22 |
| All Fish | Avg. Length | 375 | 496 | 547 | | 512 |
| | Std. Error | 5.0 | 3.6 | 4.6 | | 6.3 |
| | Sample Size | 2 | 25 | 19 | | 46 |
| August 14 - 20 | | | | | | |
| Male | Avg. Length | 385 | 499 | 553 | 500 | 522 |
| | Std. Error | | 4.8 | 4.0 | | 5.7 |
| | Sample Size | 1 | 24 | 23 | 1 | 49 |
| Female | Avg. Length | | 489 | 542 | 485 | 505 |
| | Std. Error | | 2.7 | 6.9 | | 4.9 |
| | Sample Size | | 24 | 11 | 1 | 36 |
| All Fish | Avg. Length | 385 | 494 | 549 | 493 | 515 |
| | Std. Error | | 2.8 | 3.5 | 7.5 | 4.0 |
| | Sample Size | 1 | 48 | 34 | 2 | 85 |
| August 21 - 27 | | | | | | |
| Male | Avg. Length | 380 | 488 | 556 | | 506 |
| | Std. Error | | 6.4 | 5.7 | | 10.7 |
| | Sample Size | 1 | 12 | 7 | | 20 |
| Female | Avg. Length | | 491 | 556 | 495 | 525 |
| | Std. Error | | 4.7 | 6.8 | | 9.0 |
| | Sample Size | | 7 | 9 | 1 | 17 |
| All Fish | Avg. Length | 380 | 489 | 556 | 495 | 515 |
| | Std. Error | | 4.3 | 4.4 | | 7.2 |
| | Sample Size | 1 | 19 | 16 | 1 | 37 |
| August 28 - Sept. 17 | | | | | | |
| Male | Avg. Length | | 505 | 550 | | 532 |
| | Std. Error | | 25.0 | 10.0 | | 14.6 |
| | Sample Size | | 2 | 3 | | 5 |
| Female | Avg. Length | | 470 | 543 | | 525 |
| | Std. Error | | 20.0 | 7.1 | | 13.6 |
| | Sample Size | | 2 | 6 | | 8 |
| All Fish | Avg. Length | | 488 | 546 | | 528 |
| | Std. Error | | 16.5 | 5.6 | | 9.8 |
| | Sample Size | | 4 | 9 | | 13 |

Appendix B.2. Page 3 of 3.

| | | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|---|
| | | 2002 | 2001 | 2000 | 2000 | |
| | | 1.1 | 1.2 | 1.3 | 2.2 | Total |
| Combined Periods (Lengths weighted by period escapements) | | | | | | |
| Male | Avg. Length | 379 | 495 | 552 | 507 | 513 |
| | Std. Error | 2.3 | 2.3 | 3.1 | 4.3 | 3.2 |
| | Sample Size | 34 | 156 | 101 | 22 | 313 |
| Female | Avg. Length | | 483 | 545 | 492 | 516 |
| | Std. Error | | 2.2 | 2.7 | 11.0 | 2.7 |
| | Sample Size | | 116 | 57 | 9 | 182 |
| All Fish | Avg. Length | 379 | 489 | 549 | 498 | 514 |
| | Std. Error | 2.3 | 1.6 | 2.2 | 4.4 | 2.3 |
| | Sample Size | 34 | 273 | 158 | 31 | 496 |

Appendix B.3. Age composition, by period and sex, of sockeye salmon sampled at the Kook Lake weir, 2006.

| | Brood Year and Age Class | | | | | |
|---|---|---|---|---|---|---|
| | 2002 | 2001 | 2001 | 2000 | 2000 | |
| | 1.2 | 1.3 | 2.2 | 1.4 | 2.3 | Total |
| June 18 - July 1 | | | | | | |
| Male | | | | | | |
| Sample Size | 16 | 28 | 1 | | 2 | 47 |
| Percent | 26.7 | 46.7 | 1.7 | | 3.3 | 78.3 |
| Std. Error | 2.4 | 2.7 | 0.7 | | 1.0 | 2.3 |
| Escapement | 19 | 34 | 1 | | 3 | 57 |
| Female | | | | | | |
| Sample Size | 4 | 7 | | | 2 | 13 |
| Percent | 6.7 | 11.7 | | | 3.3 | 21.7 |
| Std. Error | 1.4 | 1.8 | | | 1.0 | 2.3 |
| Escapement | 5 | 9 | | | 2 | 16 |
| All Fish | | | | | | |
| Sample Size | 20 | 35 | 1 | | 4 | 60 |
| Percent | 33.3 | 58.3 | 1.7 | | 6.7 | 100.0 |
| Std. Error | 2.6 | 2.7 | 0.7 | | 1.4 | |
| Escapement | 24 | 43 | 1 | | 5 | 73 |
| July 2 - 22 | | | | | | |
| Male | | | | | | |
| Sample Size | 1 | 2 | | | 1 | 4 |
| Percent | 14.3 | 28.6 | | | 14.3 | 57.1 |
| Std. Error | 14.3 | 18.4 | | | 14.3 | 20.2 |
| Escapement | 248 | 495 | | | 248 | 991 |
| Female | | | | | | |
| Sample Size | 2 | 1 | | | | 3 |
| Percent | 28.6 | 14.3 | | | | 42.9 |
| Std. Error | 18.4 | 14.3 | | | | 20.2 |
| Escapement | 495 | 248 | | | | 743 |
| All Fish | | | | | | |
| Sample Size | 3 | 3 | | | 1 | 7 |
| Percent | 42.9 | 42.9 | | | 14.3 | 100.0 |
| Std. Error | 20.2 | 20.2 | | | 14.3 | |
| Escapement | 743 | 743 | | | 248 | 1,734 |
| July 23 - 29 | | | | | | |
| Male | | | | | | |
| Sample Size | 18 | 2 | | | | 20 |
| Percent | 42.9 | 4.8 | | | | 47.6 |
| Std. Error | 7.7 | 3.3 | | | | 7.7 |
| Escapement | 1,281 | 143 | | | | 1,424 |
| Female | | | | | | |
| Sample Size | 20 | 1 | 1 | | | 22 |
| Percent | 47.6 | 2.4 | 2.4 | | | 52.4 |
| Std. Error | 7.7 | 2.4 | 2.4 | | | 7.7 |
| Escapement | 1,424 | 71 | 71 | | | 1,566 |
| All Fish | | | | | | |
| Sample Size | 38 | 3 | 1 | | | 42 |
| Percent | 90.5 | 7.1 | 2.4 | | | 100.0 |
| Std. Error | 4.6 | 4.0 | 2.4 | | | |
| Escapement | 2,705 | 214 | 71 | | | 2,990 |

Appendix B.3. Page 2 of 4.

| | Brood Year and Age Class | | | | | |
|---|---|---|---|---|---|---|
| | 2002 | 2001 | 2001 | 2000 | 2000 | |
| | 1.2 | 1.3 | 2.2 | 1.4 | 2.3 | Total |
| July 30 - August 5 | | | | | | |
| Male | | | | | | |
| Sample Size | 7 | 3 | | | | 10 |
| Percent | 30.4 | 13.0 | | | | 43.5 |
| Std. Error | 9.8 | 7.1 | | | | 10.5 |
| Escapement | 751 | 322 | | | | 1,073 |
| Female | | | | | | |
| Sample Size | 12 | 1 | | | | 13 |
| Percent | 52.2 | 4.3 | | | | 56.5 |
| Std. Error | 10.6 | 4.3 | | | | 10.5 |
| Escapement | 1,289 | 107 | | | | 1,396 |
| All Fish | | | | | | |
| Sample Size | 19 | 4 | | | | 23 |
| Percent | 82.6 | 17.4 | | | | 100.0 |
| Std. Error | 8.0 | 8.0 | | | | |
| Escapement | 2,040 | 429 | | | | 2,469 |
| August 6 - 12 | | | | | | |
| Male | | | | | | |
| Sample Size | 23 | 1 | 1 | | | 25 |
| Percent | 41.1 | 1.8 | 1.8 | | | 44.6 |
| Std. Error | 6.5 | 1.8 | 1.8 | | | 6.6 |
| Escapement | 682 | 30 | 30 | | | 742 |
| Female | | | | | | |
| Sample Size | 29 | 2 | | | | 31 |
| Percent | 51.8 | 3.6 | | | | 55.4 |
| Std. Error | 6.6 | 2.5 | | | | 6.6 |
| Escapement | 860 | 59 | | | | 919 |
| All Fish | | | | | | |
| Sample Size | 52 | 3 | 1 | | | 56 |
| Percent | 92.9 | 5.4 | 1.8 | | | 100.0 |
| Std. Error | 3.4 | 3.0 | 1.8 | | | |
| Escapement | 1,542 | 89 | 30 | | | 1,661 |
| August 13 - 19 | | | | | | |
| Male | | | | | | |
| Sample Size | 38 | 9 | | | | 47 |
| Percent | 35.5 | 8.4 | | | | 43.9 |
| Std. Error | 4.0 | 2.3 | | | | 4.2 |
| Escapement | 147 | 35 | | | | 182 |
| Female | | | | | | |
| Sample Size | 49 | 11 | | | | 60 |
| Percent | 45.8 | 10.3 | | | | 56.1 |
| Std. Error | 4.2 | 2.5 | | | | 4.2 |
| Escapement | 190 | 42 | | | | 232 |
| All Fish | | | | | | |
| Sample Size | 87 | 20 | | | | 107 |
| Percent | 81.3 | 18.7 | | | | 100.0 |
| Std. Error | 3.3 | 3.3 | | | | |
| Escapement | 337 | 77 | | | | 414 |

| | Brood Year and Age Class | | | | | |
|---|---|---|---|---|---|---|
| | 2002 | 2001 | 2001 | 2000 | 2000 | |
| | 1.2 | 1.3 | 2.2 | 1.4 | 2.3 | Total |
| **August 20 - 26** | | | | | | |
| Male | | | | | | |
| Sample Size | 29 | 5 | 1 | | | 35 |
| Percent | 39.2 | 6.8 | 1.4 | | | 47.3 |
| Std. Error | 5.0 | 2.6 | 1.2 | | | 5.1 |
| Escapement | 125 | 22 | 4 | | | 151 |
| Female | | | | | | |
| Sample Size | 32 | 6 | | 1 | | 39 |
| Percent | 43.2 | 8.1 | | 1.4 | | 52.7 |
| Std. Error | 5.1 | 2.8 | | 1.2 | | 5.1 |
| Escapement | 139 | 26 | | 4 | | 169 |
| All Fish | | | | | | |
| Sample Size | 61 | 11 | 1 | 1 | | 74 |
| Percent | 82.4 | 14.9 | 1.4 | 1.4 | | 100.0 |
| Std. Error | 3.9 | 3.7 | 1.2 | 1.2 | | |
| Escapement | 264 | 48 | 4 | 4 | | 320 |
| **August 27 - Sept. 9** | | | | | | |
| Male | | | | | | |
| Sample Size | 1 | | | | | 1 |
| Percent | 50.0 | | | | | 50.0 |
| Std. Error | 49.9 | | | | | 49.9 |
| Escapement | 226 | | | | | 226 |
| Female | | | | | | |
| Sample Size | 1 | | | | | 1 |
| Percent | 50.0 | | | | | 50.0 |
| Std. Error | 49.9 | | | | | 49.9 |
| Escapement | 226 | | | | | 226 |
| All Fish | | | | | | |
| Sample Size | 2 | | | | | 2 |
| Percent | 100.0 | | | | | 100.0 |
| Std. Error | | | | | | |
| Escapement | 451 | | | | | 451 |
| **Sept. 10 - 16** | | | | | | |
| Male | | | | | | |
| Sample Size | 6 | 3 | | | | 9 |
| Percent | 23.1 | 11.5 | | | | 34.6 |
| Std. Error | 4.1 | 3.1 | | | | 4.6 |
| Escapement | 8 | 4 | | | | 12 |
| Female | | | | | | |
| Sample Size | 12 | 5 | | | | 17 |
| Percent | 46.2 | 19.2 | | | | 65.4 |
| Std. Error | 4.8 | 3.8 | | | | 4.6 |
| Escapement | 16 | 6 | | | | 22 |
| All Fish | | | | | | |
| Sample Size | 18 | 8 | | | | 26 |
| Percent | 69.2 | 30.8 | | | | 100.0 |
| Std. Error | 4.5 | 4.5 | | | | |
| Escapement | 24 | 10 | | | | 34 |

| | Brood Year and Age Class | | | | | |
|---|---|---|---|---|---|---|
| | 2002 | 2001 | 2001 | 2000 | 2000 | |
| | 1.2 | 1.3 | 2.2 | 1.4 | 2.3 | Total |
| Sept. 17 - 23 | | | | | | |
| Male | | | | | | |
| Sample Size | | | | | | 0 |
| Percent | | | | | | 0.0 |
| Std. Error | | | | | | 0.0 |
| Escapement | | | | | | 0 |
| Female | | | | | | |
| Sample Size | 3 | 2 | | | | 5 |
| Percent | 60.0 | 40.0 | | | | 100.0 |
| Std. Error | 13.1 | 13.1 | | | | 0.0 |
| Escapement | 4 | 3 | | | | 7 |
| All Fish | | | | | | |
| Sample Size | 3 | 2 | | | | 5 |
| Percent | 60.0 | 40.0 | | | | 100.0 |
| Std. Error | 13.1 | 13.1 | | | | |
| Escapement | 4 | 3 | | | | 7 |
| Combined Periods (Percentages are weighted by period escapements) | | | | | | |
| Male | | | | | | |
| Sample Size | 139 | 53 | 3 | | 3 | 198 |
| Percent | 34.4 | 10.7 | 0.3 | | 2.5 | 47.8 |
| Std. Error | 4.8 | 3.7 | 0.3 | | 2.4 | 5.5 |
| Escapement | 3,487 | 1,085 | 35 | | 251 | 4,858 |
| Female | | | | | | |
| Sample Size | 164 | 36 | 1 | 1 | 2 | 204 |
| Percent | 45.8 | 5.6 | 0.7 | <0.1 | <0.1 | 52.2 |
| Std. Error | 5.3 | 2.8 | 0.7 | <0.1 | <0.1 | 5.5 |
| Escapement | 4,648 | 571 | 71 | 4 | 2 | 5,296 |
| All Fish | | | | | | |
| Sample Size | 303 | 89 | 4 | 1 | 5 | 402 |
| Percent | 80.1 | 16.3 | 1.0 | <0.1 | 2.5 | 100.0 |
| Std. Error | 4.2 | 4.2 | 0.8 | <0.1 | 2.4 | |
| Escapement | 8,134 | 1,656 | 106 | 4 | 253 | 10,153 |

Appendix B.4. Length composition, by period and sex, of sockeye salmon sampled at the Kook Lake weir, 2006.

| | | Brood Year and Age Class | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2002 | 2001 | 2001 | 2000 | 2000 | |
| | | 1.2 | 1.3 | 2.2 | 1.4 | 2.3 | Total |
| June 18 - July 1 | | | | | | | |
| Male | Avg. Length | 529 | 566 | 540 | | 565 | 553 |
| | Std. Error | 5.8 | 5.1 | | | 5.0 | 4.4 |
| | Sample Size | 16 | 28 | 1 | | 2 | 47 |
| Female | Avg. Length | 526 | 555 | | | 538 | 543 |
| | Std. Error | 5.5 | 9.3 | | | 32.5 | 7.3 |
| | Sample Size | 4 | 7 | | | 2 | 13 |
| All Fish | Avg. Length | 529 | 564 | 540 | | 551 | 551 |
| | Std. Error | 4.8 | 4.5 | | | 15.6 | 3.8 |
| | Sample Size | 20 | 35 | 1 | | 4 | 60 |
| July 2 - 22 | | | | | | | |
| Male | Avg. Length | 530 | 580 | | | 550 | 560 |
| | Std. Error | | 10.0 | | | | 12.9 |
| | Sample Size | 1 | 2 | | | 1 | 4 |
| Female | Avg. Length | 475 | 540 | | | | 497 |
| | Std. Error | 5.0 | | | | | 21.9 |
| | Sample Size | 2 | 1 | | | | 3 |
| All Fish | Avg. Length | 493 | 567 | | | 550 | 533 |
| | Std. Error | 18.6 | 14.5 | | | | 16.7 |
| | Sample Size | 3 | 3 | | | 1 | 7 |
| July 23 - 29 | | | | | | | |
| Male | Avg. Length | 505 | 538 | | | | 508 |
| | Std. Error | 6.4 | 12.5 | | | | 6.2 |
| | Sample Size | 18 | 2 | | | | 20 |
| Female | Avg. Length | 480 | 565 | 495 | | | 484 |
| | Std. Error | 5.1 | | | | | 6.1 |
| | Sample Size | 20 | 1 | 1 | | | 22 |
| All Fish | Avg. Length | 492 | 547 | 495 | | | 496 |
| | Std. Error | 4.5 | 11.7 | | | | 4.7 |
| | Sample Size | 38 | 3 | 1 | | | 42 |
| July 30 - August 5 | | | | | | | |
| Male | Avg. Length | 510 | 537 | | | | 518 |
| | Std. Error | 9.3 | 7.3 | | | | 7.7 |
| | Sample Size | 7 | 3 | | | | 10 |
| Female | Avg. Length | 469 | 510 | | | | 472 |
| | Std. Error | 7.9 | | | | | 7.9 |
| | Sample Size | 12 | 1 | | | | 13 |
| All Fish | Avg. Length | 484 | 530 | | | | 492 |
| | Std. Error | 7.5 | 8.4 | | | | 7.3 |
| | Sample Size | 19 | 4 | | | | 23 |

Appendix B.4. Page 2 of 3.

| | | Brood Year and Age Class | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2002 | 2001 | 2001 | 2000 | 2000 | |
| | | 1.2 | 1.3 | 2.2 | 1.4 | 2.3 | Total |
| August 6 - 12 | | | | | | | |
| Male | Avg. Length | 488 | 500 | 510 | | | 490 |
| | Std. Error | 4.0 | | | | | 3.8 |
| | Sample Size | 23 | 1 | 1 | | | 25 |
| Female | Avg. Length | 475 | 525 | | | | 479 |
| | Std. Error | 3.5 | 15.0 | | | | 4.1 |
| | Sample Size | 28 | 2 | | | | 30 |
| All Fish | Avg. Length | 481 | 517 | 510 | | | 484 |
| | Std. Error | 2.8 | 12.0 | | | | 2.9 |
| | Sample Size | 51 | 3 | 1 | | | 55 |
| August 13 - 19 | | | | | | | |
| Male | Avg. Length | 487 | 541 | | | | 498 |
| | Std. Error | 2.6 | 4.5 | | | | 3.8 |
| | Sample Size | 38 | 9 | | | | 47 |
| Female | Avg. Length | 481 | 510 | | | | 486 |
| | Std. Error | 2.5 | 9.4 | | | | 3.0 |
| | Sample Size | 49 | 11 | | | | 60 |
| All Fish | Avg. Length | 483 | 524 | | | | 491 |
| | Std. Error | 1.8 | 6.5 | | | | 2.4 |
| | Sample Size | 87 | 20 | | | | 107 |
| August 20 - 26 | | | | | | | |
| Male | Avg. Length | 487 | 553 | 515 | | | 498 |
| | Std. Error | 4.7 | 9.7 | | | | 5.7 |
| | Sample Size | 29 | 5 | 1 | | | 35 |
| Female | Avg. Length | 471 | 528 | | 540 | | 481 |
| | Std. Error | 3.9 | 6.1 | | | | 4.9 |
| | Sample Size | 32 | 6 | | 1 | | 39 |
| All Fish | Avg. Length | 479 | 540 | 515 | 540 | | 489 |
| | Std. Error | 3.2 | 6.5 | | | | 3.8 |
| | Sample Size | 61 | 11 | 1 | 1 | | 74 |
| August 27 - Sept. 9 | | | | | | | |
| Male | Avg. Length | 510 | | | | | 510 |
| | Std. Error | | | | | | |
| | Sample Size | 1 | | | | | 1 |
| Female | Avg. Length | 470 | | | | | 470 |
| | Std. Error | | | | | | |
| | Sample Size | 1 | | | | | 1 |
| All Fish | Avg. Length | 490 | | | | | 490 |
| | Std. Error | 20.0 | | | | | 20.0 |
| | Sample Size | 2 | | | | | 2 |

| | | Brood Year and Age Class | | | | | |
|---|---|---|---|---|---|---|---|
| | | 2002 | 2001 | 2001 | 2000 | 2000 | |
| | | 1.2 | 1.3 | 2.2 | 1.4 | 2.3 | Total |
| Sept. 10 - 16 | | | | | | | |
| Male | Avg. Length | 475 | 553 | | | | 501 |
| | Std. Error | 15.0 | 13.3 | | | | 16.7 |
| | Sample Size | 6 | 3 | | | | 9 |
| Female | Avg. Length | 468 | 524 | | | | 485 |
| | Std. Error | 6.0 | 8.1 | | | | 7.9 |
| | Sample Size | 12 | 5 | | | | 17 |
| All Fish | Avg. Length | 471 | 535 | | | | 490 |
| | Std. Error | 6.2 | 8.5 | | | | 7.7 |
| | Sample Size | 18 | 8 | | | | 26 |
| Sept. 17 - 23 | | | | | | | |
| Male | Avg. Length | | | | | | |
| | Std. Error | | | | | | |
| | Sample Size | | | | | | |
| Female | Avg. Length | 497 | 540 | | | | 514 |
| | Std. Error | 14.5 | 20.0 | | | | 14.7 |
| | Sample Size | 3 | 2 | | | | 5 |
| All Fish | Avg. Length | 497 | 540 | | | | 514 |
| | Std. Error | 14.5 | 20.0 | | | | 14.7 |
| | Sample Size | 3 | 2 | | | | 5 |
| Combined Periods (Lengths weighted by period escapements) | | | | | | | |
| Male | Avg. Length | 507 | 539 | 512 | | 551 | 516 |
| | Std. Error | 2.3 | 3.6 | 9.3 | | 5.8 | 2.7 |
| | Sample Size | 139 | 53 | 3 | | 3 | 198 |
| Female | Avg. Length | 475 | 536 | 495 | 540 | 538 | 482 |
| | Std. Error | 1.7 | 4.7 | | | 32.5 | 2.2 |
| | Sample Size | 163 | 36 | 1 | 1 | 2 | 203 |
| All Fish | Avg. Length | 488 | 540 | 502 | 540 | 550 | 499 |
| | Std. Error | 1.5 | 3.2 | 9.4 | | 12.1 | 1.8 |
| | Sample Size | 302 | 89 | 4 | 1 | 5 | 401 |

Appendix B.5. Age composition, by period and sex, of sockeye salmon sampled at the Kook Lake weir, 2007.

| | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|
| | 2003 | 2002 | 2002 | 2001 | |
| | 1.2 | 1.3 | 2.2 | 2.3 | Total |
| Statistical Weeks 26 - 28 (June 24 - July 14) | | | | | |
| Male | | | | | |
| Sample Size | 2 | 55 | 1 | 1 | 59 |
| Percent | 2.0 | 55.0 | 1.0 | 1.0 | 59.0 |
| Std. Error | 1.3 | 4.7 | 0.9 | 0.9 | 4.6 |
| Escapement | 17 | 460 | 8 | 8 | 493 |
| Female | | | | | |
| Sample Size | 2 | 38 | 1 | | 41 |
| Percent | 2.0 | 38.0 | 1.0 | | 41.0 |
| Std. Error | 1.3 | 4.6 | 0.9 | | 4.6 |
| Escapement | 17 | 318 | 8 | | 343 |
| All Fish | | | | | |
| Sample Size | 4 | 93 | 2 | 1 | 100 |
| Percent | 4.0 | 93.0 | 2.0 | 1.0 | 100.0 |
| Std. Error | 1.8 | 2.4 | 1.3 | 0.9 | |
| Escapement | 34 | 778 | 16 | 8 | 836 |
| Statistical Week 29 (July 15 - 21) | | | | | |
| Male | | | | | |
| Sample Size | | 15 | | | 15 |
| Percent | | 44.1 | | | 44.1 |
| Std. Error | | 8.4 | | | 8.4 |
| Escapement | | 236 | | | 236 |
| Female | | | | | |
| Sample Size | | 19 | | | 19 |
| Percent | | 55.9 | | | 55.9 |
| Std. Error | | 8.4 | | | 8.4 |
| Escapement | | 299 | | | 299 |
| All Fish | | | | | |
| Sample Size | | 34 | | | 34 |
| Percent | | 100.0 | | | 100.0 |
| Std. Error | | | | | |
| Escapement | | 535 | | | 535 |
| Statistical Week 30 (July 22 - 28) | | | | | |
| Male | | | | | |
| Sample Size | 7 | 52 | 1 | | 60 |
| Percent | 5.8 | 43.3 | 0.8 | | 50.0 |
| Std. Error | 1.7 | 3.6 | 0.7 | | 3.7 |
| Escapement | 19 | 145 | 3 | | 167 |
| Female | | | | | |
| Sample Size | 6 | 51 | 3 | | 60 |
| Percent | 5.0 | 42.5 | 2.5 | | 50.0 |
| Std. Error | 1.6 | 3.6 | 1.1 | | 3.7 |
| Escapement | 17 | 142 | 8 | | 167 |
| All Fish | | | | | |
| Sample Size | 13 | 103 | 4 | | 120 |
| Percent | 10.8 | 85.8 | 3.3 | | 100.0 |
| Std. Error | 2.3 | 2.6 | 1.3 | | |
| Escapement | 36 | 287 | 11 | | 334 |

| | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|
| | 2003 | 2002 | 2002 | 2001 | |
| | 1.2 | 1.3 | 2.2 | 2.3 | Total |
| **Statistical Week 31 (July 29 - August 4)** | | | | | |
| Male | | | | | |
| Sample Size | 2 | 39 | | | 41 |
| Percent | 2.6 | 51.3 | | | 53.9 |
| Std. Error | 1.3 | 4.1 | | | 4.1 |
| Escapement | 4 | 80 | | | 84 |
| Female | | | | | |
| Sample Size | 5 | 27 | 3 | | 35 |
| Percent | 6.6 | 35.5 | 3.9 | | 46.1 |
| Std. Error | 2.0 | 3.9 | 1.6 | | 4.1 |
| Escapement | 10 | 55 | 6 | | 71 |
| All Fish | | | | | |
| Sample Size | 7 | 66 | 3 | | 76 |
| Percent | 9.2 | 86.8 | 3.9 | | 100.0 |
| Std. Error | 2.4 | 2.8 | 1.6 | | |
| Escapement | 14 | 135 | 6 | | 155 |
| **Statistical Weeks 32 - 37 (August 5 - Sept. 15)** | | | | | |
| Male | | | | | |
| Sample Size | | 3 | | | 3 |
| Percent | | 42.9 | | | 42.9 |
| Std. Error | | 20.1 | | | 20.1 |
| Escapement | | 333 | | | 333 |
| Female | | | | | |
| Sample Size | 1 | 3 | | | 4 |
| Percent | 14.3 | 42.9 | | | 57.1 |
| Std. Error | 14.2 | 20.1 | | | 20.1 |
| Escapement | 111 | 333 | | | 444 |
| All Fish | | | | | |
| Sample Size | 1 | 8 | | | 9 |
| Percent | 11.1 | 88.9 | | | 100.0 |
| Std. Error | 11.1 | 11.1 | | | |
| Escapement | 111 | 887 | | | 998 |
| **Combined Periods (Percentages are weighted by period escapements)** | | | | | |
| Male | | | | | |
| Sample Size | 11 | 164 | 2 | 1 | 178 |
| Percent | 1.5 | 47.5 | 0.4 | 0.3 | 49.8 |
| Std. Error | 0.4 | 7.3 | 0.3 | 0.3 | 7.3 |
| Escapement | 40 | 1,254 | 11 | 8 | 1,313 |
| Female | | | | | |
| Sample Size | 14 | 138 | 7 | | 159 |
| Percent | 5.9 | 43.5 | 0.9 | | 50.2 |
| Std. Error | 5.0 | 7.3 | 0.3 | | 7.3 |
| Escapement | 155 | 1,147 | 22 | | 1,324 |
| All Fish | | | | | |
| Sample Size | 25 | 304 | 9 | 1 | 339 |
| Percent | 6.8 | 91.7 | 1.2 | 0.3 | 100.0 |
| Std. Error | 3.9 | 3.9 | 0.4 | 0.3 | |
| Escapement | 195 | 2,622 | 33 | 8 | 2,858 |

Appendix B.6. Length composition, by period and sex, of sockeye salmon sampled at the Kook Lake weir, 2007.

| | | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|---|
| | | 2003 | 2002 | 2002 | 2001 | |
| | | 1.2 | 1.3 | 2.2 | 2.3 | Total |
| Statistical Weeks 26 - 28 (June 24 - July 14) | | | | | | |
| Male | Avg. Length | 498 | 570 | 515 | 590 | 567 |
| | Std. Error | 17.5 | 2.7 | | | 3.2 |
| | Sample Size | 2 | 55 | 1 | 1 | 59 |
| Female | Avg. Length | 488 | 551 | 530 | | 548 |
| | Std. Error | 12.5 | 2.5 | | | 3.3 |
| | Sample Size | 2 | 38 | 1 | | 41 |
| All Fish | Avg. Length | 493 | 563 | 523 | 590 | 559 |
| | Std. Error | 9.2 | 2.1 | 7.5 | | 2.5 |
| | Sample Size | 4 | 93 | 2 | 1 | 100 |
| Statistical Week 29 (July 15 - 21) | | | | | | |
| Male | Avg. Length | | 561 | | | 561 |
| | Std. Error | | 5.0 | | | 5.0 |
| | Sample Size | | 15 | | | 15 |
| Female | Avg. Length | | 534 | | | 534 |
| | Std. Error | | 4.1 | | | 4.1 |
| | Sample Size | | 18 | | | 18 |
| All Fish | Avg. Length | | 546 | | | 546 |
| | Std. Error | | 3.9 | | | 3.9 |
| | Sample Size | | 33 | | | 33 |
| Statistical Week 30 (July 22 - 28) | | | | | | |
| Male | Avg. Length | 506 | 549 | 500 | | 544 |
| | Std. Error | 10.0 | 3.2 | | | 3.6 |
| | Sample Size | 7 | 52 | 1 | | 60 |
| Female | Avg. Length | 523 | 537 | 513 | | 534 |
| | Std. Error | 14.1 | 2.9 | 12.0 | | 3.0 |
| | Sample Size | 6 | 50 | 3 | | 59 |
| All Fish | Avg. Length | 514 | 543 | 510 | | 539 |
| | Std. Error | 8.4 | 2.3 | 9.1 | | 2.4 |
| | Sample Size | 13 | 102 | 4 | | 119 |

Appendix B.6. Page 2 of 2.

| | | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|---|
| | | 2003 | 2002 | 2002 | 2001 | |
| | | 1.2 | 1.3 | 2.2 | 2.3 | Total |
| Statistical Week 31 (July 29 - August 4) | | | | | | |
| Male | Avg. Length | 515 | 548 | | | 546 |
| | Std. Error | 15.0 | 3.7 | | | 3.7 |
| | Sample Size | 2 | 39 | | | 41 |
| Female | Avg. Length | 498 | 536 | 513 | | 529 |
| | Std. Error | 11.6 | 3.9 | 17.6 | | 4.3 |
| | Sample Size | 5 | 27 | 3 | | 35 |
| All Fish | Avg. Length | 503 | 543 | 513 | | 538 |
| | Std. Error | 9.2 | 2.8 | 17.6 | | 3.0 |
| | Sample Size | 7 | 66 | 3 | | 76 |
| Statistical Weeks 32 - 37 (August 5 - Sept. 15) | | | | | | |
| Male | Avg. Length | | 548 | | | 548 |
| | Std. Error | | 3.3 | | | 3.3 |
| | Sample Size | | 3 | | | 3 |
| Female | Avg. Length | 530 | 520 | | | 523 |
| | Std. Error | | 8.7 | | | 6.6 |
| | Sample Size | 1 | 3 | | | 4 |
| All Fish | Avg. Length | 530 | 534 | | | 534 |
| | Std. Error | | 7.6 | | | 6.4 |
| | Sample Size | 1 | 6 | | | 7 |
| Combined Periods (Lengths weighted by period escapements) | | | | | | |
| Male | Avg. Length | 502 | 557 | 511 | 590 | 555 |
| | Std. Error | 7.1 | 1.8 | 7.5 | | 2.0 |
| | Sample Size | 11 | 164 | 2 | 1 | 178 |
| Female | Avg. Length | 512 | 535 | 524 | | 534 |
| | Std. Error | 8.2 | 1.7 | 8.4 | | 1.9 |
| | Sample Size | 14 | 136 | 7 | | 157 |
| All Fish | Avg. Length | 512 | 546 | 518 | 590 | 544 |
| | Std. Error | 5.4 | 1.4 | 6.7 | | 1.5 |
| | Sample Size | 25 | 300 | 9 | 1 | 335 |

Appendix C.

# Sampling Guidelines for Weir to Above-Weir Mark-Recapture Studies.

Benjamin W. Van Alen
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April 2008

The principal objective of most weir projects is to get an accurate count of the escapement of one or more species of salmon that pass a weir site. Only the fish that are seen are counted. There is an inherent negative bias in weir counts if fish pass uncounted through known or unknown breaks in the weir. Undercounting at weirs occurs more frequently than we would like to admit, it can be quite high, and it can be either persistent or infrequent depending on location and operational factors. A mark at the weir and examine above-the-weir mark-recapture study is needed to meet the principal project objective. Fortunately, weir projects serve as great platforms for marking fish in proportion to their abundance and the mark and recapture sampling can often be accomplished with the existing weir personnel and little increase in project cost.

The intent of our mark-recapture studies, where we mark salmon as they pass through a weir and examine them for marks upstream from the weir, is to get a reliable estimate of the total escapement. We can then compare this estimate with the total number counted through the weir. If the mark-recapture estimate is not greater than the total weir count then we can assume that the daily weir counts are the actual number that passed through the weir each day. These guidelines also apply to studies that capture, count, and mark a representative portion of the fish entering a system.

The accuracy of the simple Peterson mark-recapture estimate (N; where $N = M * C/R$) is dependent both on how well we meet the **basic assumptions** inherent in mark-recapture studies and, most importantly, on the **numbers of fish** we mark (M), examine for marks (C), and recapture (R).

The **basic assumptions** are met if marked fish behave the same as unmarked fish, have marks that are recognizable, and have a roughly equal probability of being marked, examined for marks, or both. These assumptions are easy to meet at weir projects for two reasons. First, thanks to the salmon's vestigial appendage, the adipose fin, we can quickly and harmlessly adipose-clip salmon with a recognizable mark.[2] Most marking

[2] Darroch stratified estimates often perform poorly in weir mark-recapture studies since there is a tremendous natural mixing of fish in the time between when there are marked at the weir and examined for marks in and off the spawning grounds. Stratified estimates will be the same, and less precise, than the simple Peterson estimate if these guidelines are followed. A known (or unknown) breach in the weir would require a more extensive recovery effort regardless of the estimator used. The Darroch stratified estimator (Arnason et al. 1996) is often mathematically challenged (i.e., yields negative strata estimates) by the

can be done with the fishes head still in the water. Secondly, weir crews can assure that fish have a roughly equal probability of being marked by marking a consistent proportion of the fish that they pass through a weir (i.e., a running weekly average of 10%, 20%, 33% or 50%). After passing through the weir, the fish help improve the likelihood that they have an equal probability of being examined for marks by mixing and milling for days, weeks, or months before we examine them for marks at different places and times.

Every effort should be made to have a "fish tight" weir. This necessitates quality weir engineering, installation, maintenance, and operation. Weir operations should extend through the middle 90+% of the run. If only early-run fish were marked, the "closed" population Peterson estimates would be biased up if only late-run fish were sampled and down if only early-run fish were sampled. These biases would be switched if only late-run fish were marked. A little recruitment before and after weir operations will not affect estimates with adequate numbers of recaptures.

Every effort should be made to mark all sizes, sexes, and ages of fish in proportion to their abundance at the weir. This is easily done at weir sites by marking all fish in the trap (instead of the next largest male dipnetted) or by marking one-of-every-x, where x = 2, 3, 4, 5, or $10^{th}$, fish. Separate marking and recovery counts should be kept for jacks because they might be small enough to sneak through the weir uncounted and marked at a different rate than the adults, or be captured at different rates than the adults.

Recovery sampling should be directed to the times and places with the greatest numbers of fish and usually involves sampling through time in, and off, the major spawning areas. The use of seines and multiple capture methods will improve the chance that all fish have an equal probability of being examined for marks although this is not so important if fish were representatively marked at the weir.

Recovery sampling can be approached in a two-step manner. First, sample a couple of places and times to see if the proportion marked in the sample is less than the proportion marked at the weir. This can be done with a one-tailed binomial test (Zar 1984)[3]. If these proportions are the same then continue sampling only to meet minimum recapture goals. Only if the proportion of marked fish above the weir is less than that marked at the weir, or if there were known undercounting problems at the weir, will you need to do an intensive recovery effort to recapture more critters in more times and places.

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marking of fish through time at one location then sampling them for marks at different times and locations after they've mixed and milled for weeks and weeks. However, secondary marking with other fin clips (i.e., axillary, ventral, or partial dorsal) or opercule punches (i.e., round, square, triangle) is possible, frequently done, and can yield information on the timing and distribution of spawners.

[3] The one-tailed exact binomial test of goodness-of-fit test can be done in Microsoft Excel using the function "=BINOMDIST(number with marks (R), number examined for marks (C), proportion marked at the weir, TRUE)". The p-value returned is the probability that the observed proportion of marked fish above the weir is equal or greater than the expected proportion marked at the weir. A p-value $<0.05$ says that there is less than a 5% chance that the observed proportion equals or exceeds the expected proportion, that fish likely passed the weir uncounted, and that the mark-recapture study is needed to estimate the total escapement.

This brings us to the all important consideration of the **numbers of fish** needed to be marked, examined for marks, and recaptured. I focus on two key considerations drawn from a wealth of analytical work on the subject as summarized and extended by Ricker 1975 and Seber 1982. The bottom line is that the more critters that are marked and/or examined for marks, the more accurate and precise will be the estimate, and the less chance that the estimates will be biased by any violations in the above assumptions. Simply put, the accuracy of our mark-recapture estimates is strongly dependent on the percent of the population marked and the number of marked individuals recaptured[4] regardless of the population size (Figure 1). There is clearly a marginal improvement in estimate precision with more than 100 recaptures and a marked degredation in estimate precision with fewer than 20 recaptures (Figure 1). Fortunately, the percent marked and numbers of recaptures are two variables that we have *some* control over. We cannot control or reasonably predict the actual population size, and, the number of fish we can or should mark and examine for marks is largely dependent on the population size.

The assumptions inherent with these mark-recapture studies can be put in two bias groups: 1) over-estimate biases; and 2) potential up or down biases. The over-estimate biases are the handling induced mortality of marked fish, tag loss, or undetected tags/marks. Fortunately, we can assure that marked fish behave the same as unmarked fish and have obvious marks with the quick and apparently harmless adipose clip[5]. Thus we only need to be concerned with the potential up or down biases that result from non random marking, or mixing, or sampling of the fish. We resolve this by marking fish roughly in proportion to their abundance at the weir.

We can assume that the potential up or down bias is also strongly related to the number of recaptures and in the same way that marking, sampling, and recapturing few fish does. If few critters are marked, sampled, and recaptured the potential for non-random marking, sampling, or mixing biases is certainly high. These potential biases dissipate as marks, captures, or recaptures approach the population size as I hypothesize in Figure 2.

Project objectives should state the desired precision of the abundance estimate (i.e., "estimate the escapement with a coefficient of variation less than 15%"). The appropriate level of precision depends on the intensity and targeting of harvest and the use of the information. The most efficient allocation of effort is then needed between marking fish at the weir and examining them for marks above the weir. It is almost always more efficient to mark fish at a weir and the key to this study design is indeed <u>to mark a relatively high and consistent portion of the fish at the weir</u>. Given the protracted duration of salmon runs, and use of fish and operator friendly weir traps, it is reasonable

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[4] Ricker (1975, page 79) acknowledges this minimum R approach when evaluating statistical bias in Peterson estimates - "Since true N is unknown it is more convenient to have a rule based on an observed statistic, the number of recaptures (R)". He concludes, "Thus the probability of statistical bias can be ignored if recaptures number 3-4 or more." Ricker (page 80) also uses the number to mark, number to examine for marks, given an estimate of N, graphs of Robson and Regier (1964) more to glean numbers of recaptures needed (i.e., 25 to 75) than to set up study plans. Seber (1982, page 61) states that "the "accuracy" of N* is almost solely dependent on the number of recaptures".

[5] There is no need to tag fish. Tagged fish also need to be physically marked (or double tagged) so tag loss can be estimated so the physical mark is used to estimate C/R proportions anyway.

for weir personnel to mark a consistent running weekly average of 10, 20, 25, 33, and even 50% or more of the salmon passing through most weir sites in Southeast Alaska. When this is done, the accuracy of the estimate depends on the number of recaptures.

Figure 3 and Table 1 can be used to set sampling goals in Peterson mark-recapture studies. For example, if the project objectives call for an estimate of N with a CV less than 10%, and if 20% of the fish were marked at the weir (or observed in initial recovery samples), then project personnel would be on a mission to get at least 80 recaptures (R) and be prepared to examine (C) 400 fish. I say at least 80 because more recaptures would be needed if fish passed through the weir uncounted. To be conservative, I recommend assuming that the proportion marked at the weir is half of what you expect. In this example, to get a CV less than 10%, we would assume that 10% (not 20%) of the fish were marked at the weir and R would be 90 and C would be 900. The number of recaptures needed is independent of the size of the population, but, the lower the proportion of fish marked at the weir the greater the number of fish that will need to be sampled above the weir. Again, it is almost always more efficient to mark fish at a weir.

Confidence limits (95% and 99%) around estimates of N can be calculated using Appendix II in Ricker (1975). When $R \leq 50$, the tabled values for the upper and lower limits of R can be read from the table in Ricker's Appendix II and used in the M*C/R calculations of the lower and upper confidence limits around the estimate of N. When $R > 50$, the upper and lower 95% or 99% confidence limits of R can be calculated using the formula (1) and used in the M*C/R calculations of the lower and upper confidence limits around the estimate of N:

$$\pm 95\% R = R + 1.92 \pm 1.960\sqrt{R + 1.0}; or \pm 99\% R = R + 3.32 \pm 2.576\sqrt{R + 1.7} \qquad (1)$$

Figure 3 and Table 1 can also be used inseason to guide recapture sampling efforts in mark-recapture studies. This is simply done by using the C/R marked rate observed in initial samples in Figure 3 or Table 1 to determine how many recaptures are needed to achieve the desired CV.

Carlson et al.'s (1998) estimates of the sample size of salmon smolts to mark in mark-recapture experiments (Table 2; Page 94) have a pattern reassuringly consistent with the numbers in my Table 1. Their sampling goals could have been for R (termed $m_h$) based on the observed marked rates ($m_h/u_h$) and their desired CV using Table 1. When they recaptured 86 to 112 fish the CV's around their strata estimates was a relatively precise 10% and dependent on the number of recaptures.

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Arnason, A. N., C. W. Kirby, C. J. Schwarz, and J. R. Irvine. 1996. Computer analysis of data from stratified mark-recovery experiments for estimation of salmon escapements and other populations. Canadian Technical Report of Fisheries and Aquatic Sciences No. 2106, 28 pp.

Carlson, S. R., L. G. Coggins Jr., and C. O. Swanson. 1998. A simple stratified design for mark-recapture estimation of salmon smolt abundance. Alaska Fishery Research Bulletin 5(2):88-102.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada No. 191, 382 pp.

Robson, D. S. and Regier, H. A. 1964. Sample size in Peterson mark-recapture experiments. Transactions of the American Fisheries Society 93:215-226.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters, 2nd ed. The Blackburn Press, New Jersey. 654 pp.

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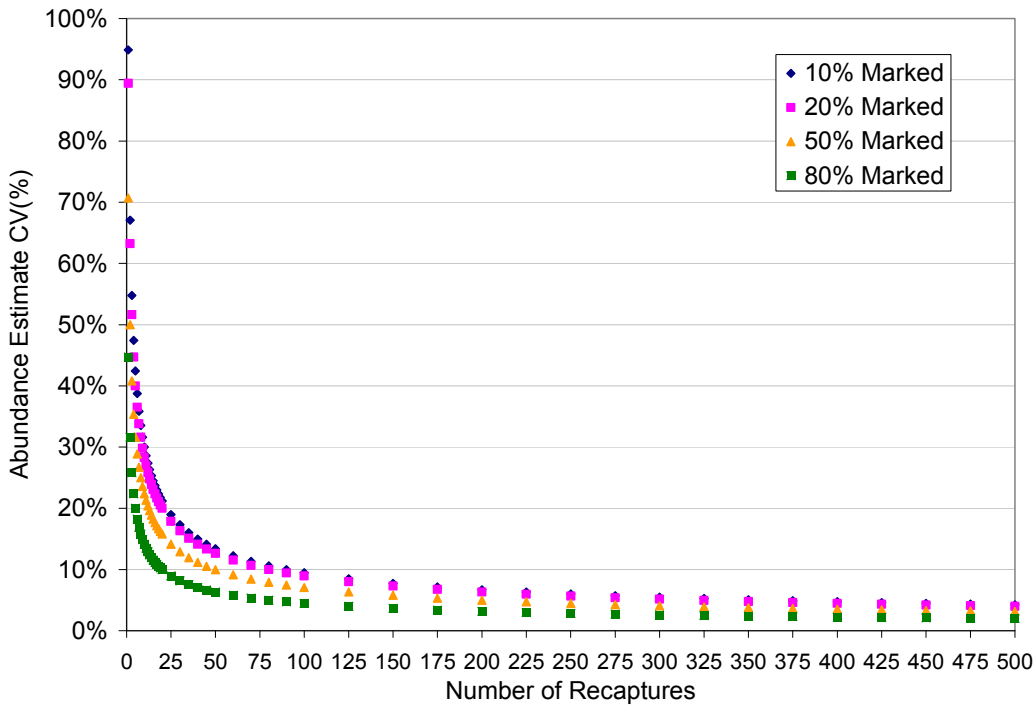



Figure 1. Relationship between an abundance estimate's coefficient of variation (CV %) and the number of recaptures at marking rates of 10, 20, 50, and 80% using the simple Peterson estimate and up to 500 recaptures (Ricker 1975, eq. 3.5 and 3.6

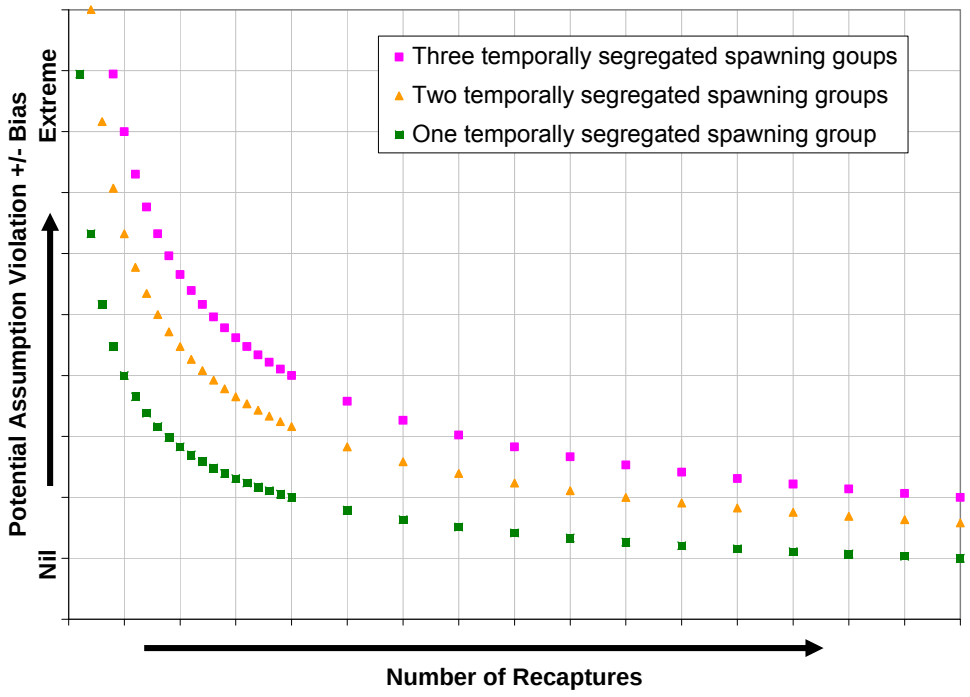



Figure 2. Hypothetical relationship between the potential positive or negative biases of non random marking, capture, or mixing of marked and unmarked fish and the number of recaptures in simple Peterson estimates.

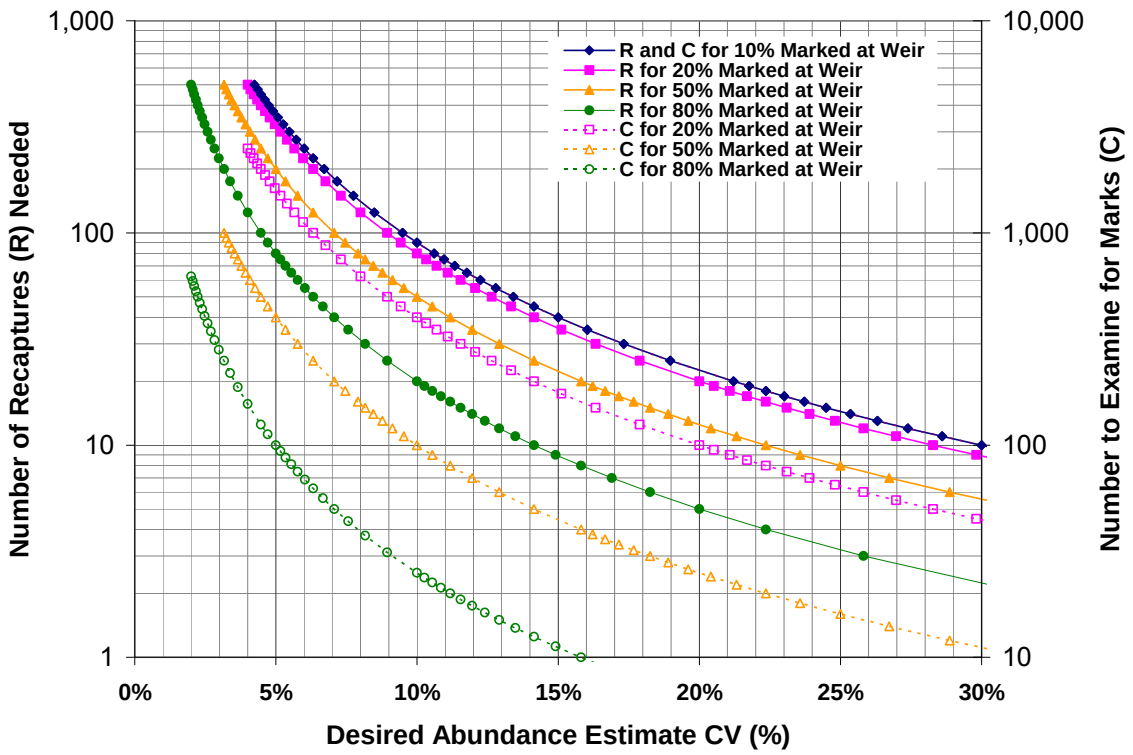



Figure 3. Sampling goals for the number of critters you need to recapture (R), and number you'll probably examine for marks (C), for different marked rates and levels of precision (coefficient of variation; CV%) for the simple Peterson population estimate (N).

Table 1. Sampling goals for the number of critters you need to recapture (R), and number you'll probably examine for marks (C), at different marked rates and levels of precision (coefficient of variation; CV%) for the simple Peterson population estimate (N).

| Marked Rate[a] (intended or observed) | Desired CV% | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5% | | 10% | | 15% | | 20% | | 25% | | 30% | |
| | Sampling Goals for Recaptures (R) and Captures (C)[b] | | | | | | | | | | | |
| | R | C | R | C | R | C | R | C | R | C | R | C |
| 0.25% | 399 | 159,600 | 100 | 39,900 | 44 | 17,733 | 25 | 9,975 | 16 | 6,384 | 11 | 4,433 |
| 0.50% | 398 | 79,600 | 100 | 19,900 | 44 | 8,844 | 25 | 4,975 | 16 | 3,184 | 11 | 2,211 |
| 0.75% | 397 | 52,933 | 99 | 13,233 | 44 | 5,881 | 25 | 3,308 | 16 | 2,117 | 11 | 1,470 |
| 1% | 396 | 39,600 | 99 | 9,900 | 44 | 4,400 | 25 | 2,475 | 16 | 1,584 | 11 | 1,100 |
| 2% | 392 | 19,600 | 98 | 4,900 | 44 | 2,178 | 25 | 1,225 | 16 | 784 | 11 | 544 |
| 5% | 380 | 7,600 | 95 | 1,900 | 42 | 844 | 24 | 475 | 15 | 304 | 11 | 211 |
| 10% | 360 | 3,600 | 90 | 900 | 40 | 400 | 23 | 225 | 14 | 144 | 10 | 100 |
| 15% | 340 | 2,267 | 85 | 567 | 38 | 252 | 21 | 142 | 14 | 91 | 9 | 63 |
| 20% | 320 | 1,600 | 80 | 400 | 36 | 178 | 20 | 100 | 13 | 64 | 9 | 44 |
| 25% | 300 | 1,200 | 75 | 300 | 33 | 133 | 19 | 75 | 12 | 48 | 8 | 33 |
| 30% | 280 | 933 | 70 | 233 | 31 | 104 | 18 | 58 | 11 | 37 | 8 | 26 |
| 33% | 268 | 812 | 67 | 203 | 30 | 90 | 17 | 51 | 11 | 32 | 7 | 23 |
| 35% | 260 | 743 | 65 | 186 | 29 | 83 | 16 | 46 | 10 | 30 | 7 | 21 |
| 40% | 240 | 600 | 60 | 150 | 27 | 67 | 15 | 38 | 10 | 24 | 7 | 17 |
| 45% | 220 | 489 | 55 | 122 | 24 | 54 | 14 | 31 | 9 | 20 | 6 | 14 |
| 50% | 200 | 400 | 50 | 100 | 22 | 44 | 13 | 25 | 8 | 16 | 6 | 11 |
| 55% | 180 | 327 | 45 | 82 | 20 | 36 | 11 | 20 | 7 | 13 | 5 | 9 |
| 60% | 160 | 267 | 40 | 67 | 18 | 30 | 10 | 17 | 6 | 11 | 4 | 7 |
| 65% | 140 | 215 | 35 | 54 | 16 | 24 | 9 | 13 | 6 | 9 | 4 | 6 |
| 66% | 136 | 206 | 34 | 52 | 15 | 23 | 9 | 13 | 5 | 8 | 4 | 6 |
| 70% | 120 | 171 | 30 | 43 | 13 | 19 | 8 | 11 | 5 | 7 | | |
| 75% | 100 | 133 | 25 | 33 | 11 | 15 | 6 | 8 | 4 | 5 | | |
| 80% | 80 | 100 | 20 | 25 | 9 | 11 | 5 | 6 | | | | |
| 85% | 60 | 71 | 15 | 18 | 7 | 8 | 4 | 4 | | | | |
| 90% | 40 | 44 | 10 | 11 | 4 | 5 | | | | | | |
| 95% | 20 | 21 | 5 | 5 | | | | | | | | |
| 100% | | | | | | | | | | | | |

[a]The "Marked Rate" could be the intended percentage of fish that were marked or the observed percentage of fish that have marks. Actual marking rates might be less so be conservative and use a marked rate 50% less than the intended or observed marking rate.
[b]Recapture goals for R<4 are omitted from the table to minimize the inherent bias of R actually being less than one (Ricker 1975 p. 79).

Calculations:

Population Size = N = M * C/R (Ricker 1975, p. 78, eq. 3.5)
Variance = V(N) = (M^2 * C * (C - R))/R^3 (Ricker 1975, p. 78, eq. 3.6)
Coefficient of Variation = CV (%) = Sqrt(V(N))/N * 100
Marked Rate expected = number marked/number counted (i.e., at a weir project)
Marked Rate observed = R/C
R = (1-marked rate)/CV^2; C = R/marked rate
C = R/marked rate

The 95% and 99% Confidence Limits around the estimate of N can be calculated using Appendix II in Ricker (1975, p. 343):
When R ≤ 50, the tabled values for the upper and lower limits of R can be used in the N = M*C/R calculations of the lower and upper confidence limits.

When R>50, the upper and lower limits of R can be calculated using the formula:

$$\pm 95\% R = R + 1.92 \pm 1.960\sqrt{R + 1.0}; or \pm 99\% R = R + 3.32 \pm 2.576\sqrt{R + 1.7}$$

and used in the N = M*C/R calculations of the lower and upper confidence limits.

Appendix D. Design for an adjustable and collapsible weir bipod.

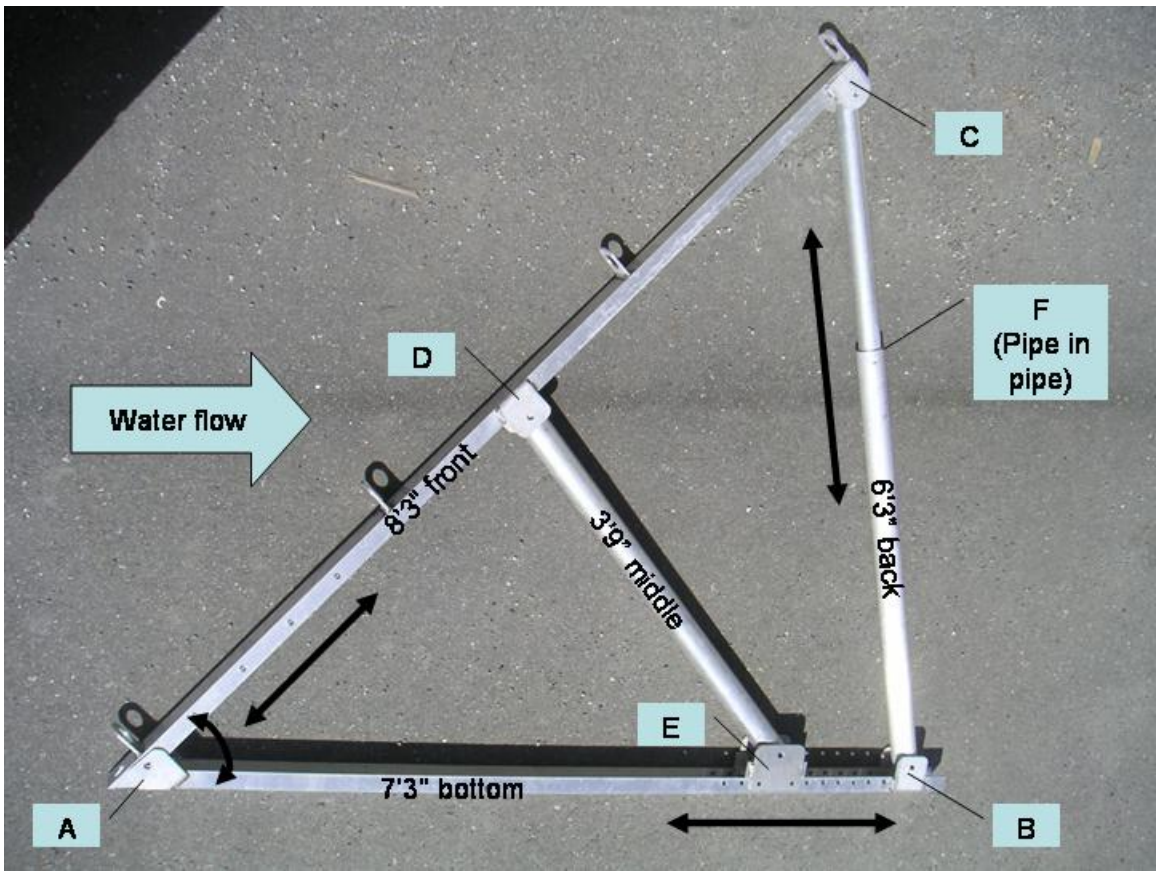



Figure 1. Photo of adjustable weir bipod design 1.1. Hinges A, E, and F can be bolted in different holes as needed to position the weir over an uneven bottom or at an angle less than 45°. The bipod can be collapsed for transport by pulling the bolts from B and D.

Figure 2. Photos of the downstream side of the Kook Lake weir showing the bipods adjusted to fit over the uneven bedrock sill at the outlet of Kook Lake.

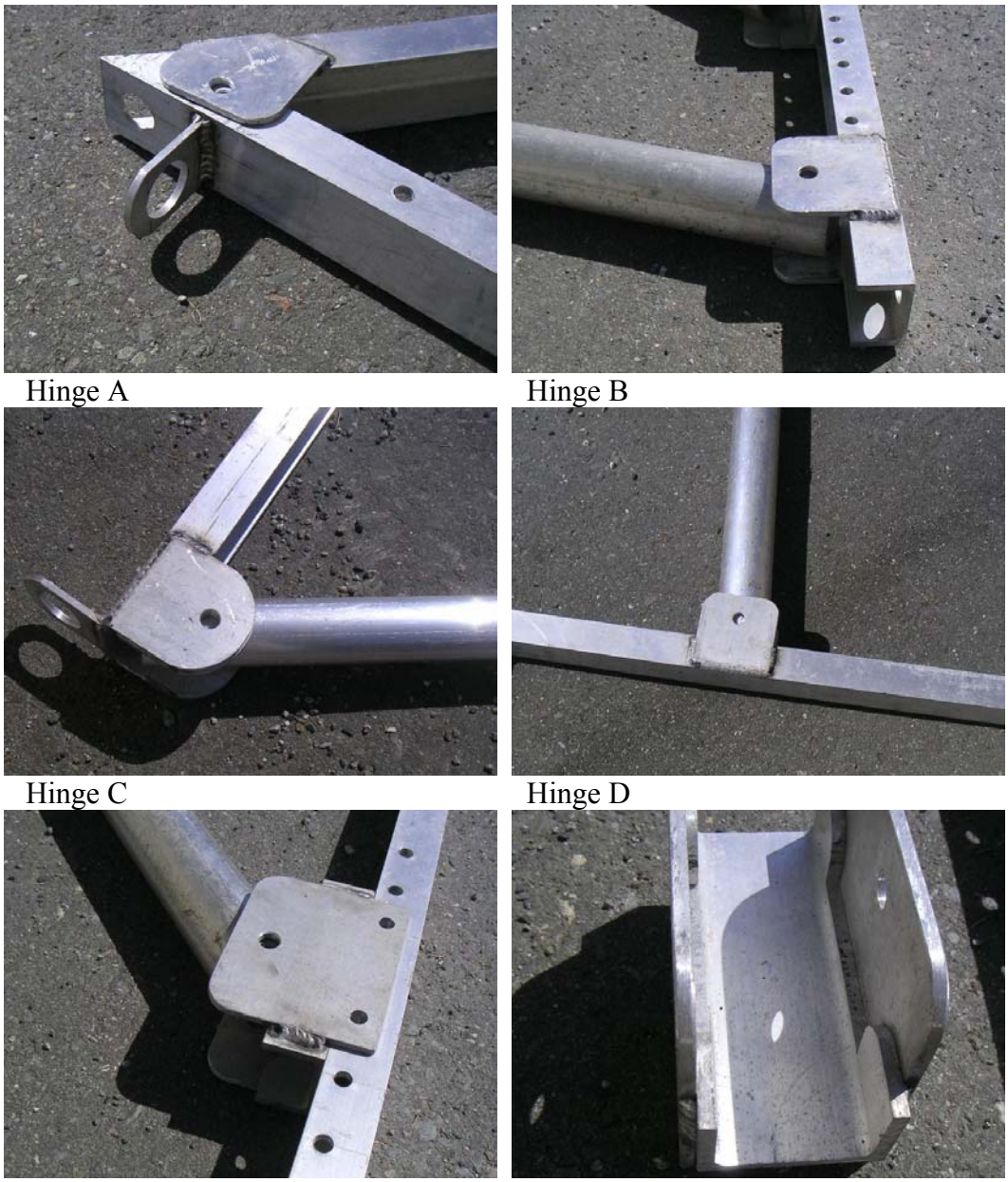



Figure 3. Close-up photos of hinges A, B, C, D, and E.

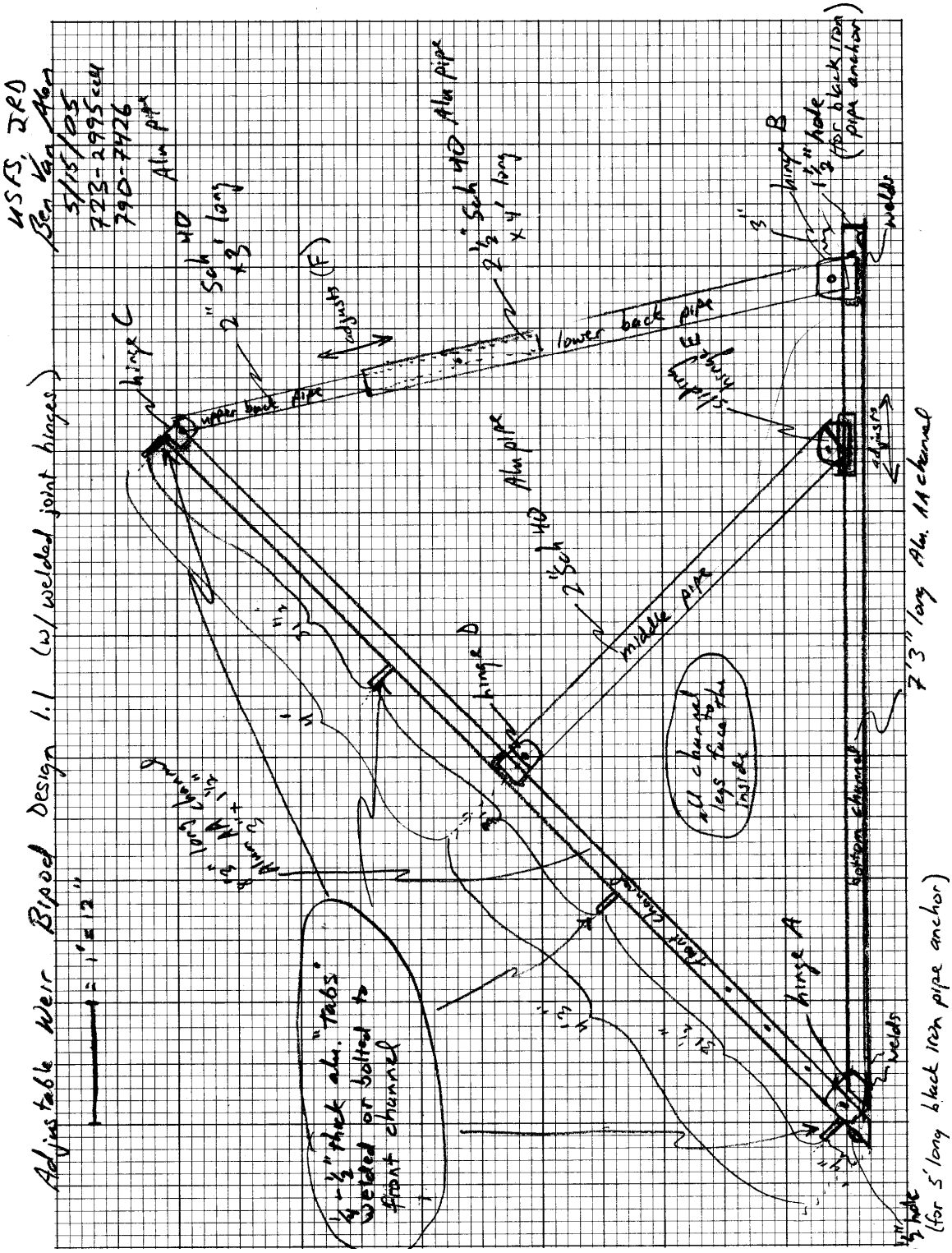



Figure 4. Line drawing of adjustable weir bipod design 1.1 with welded hinge joints.

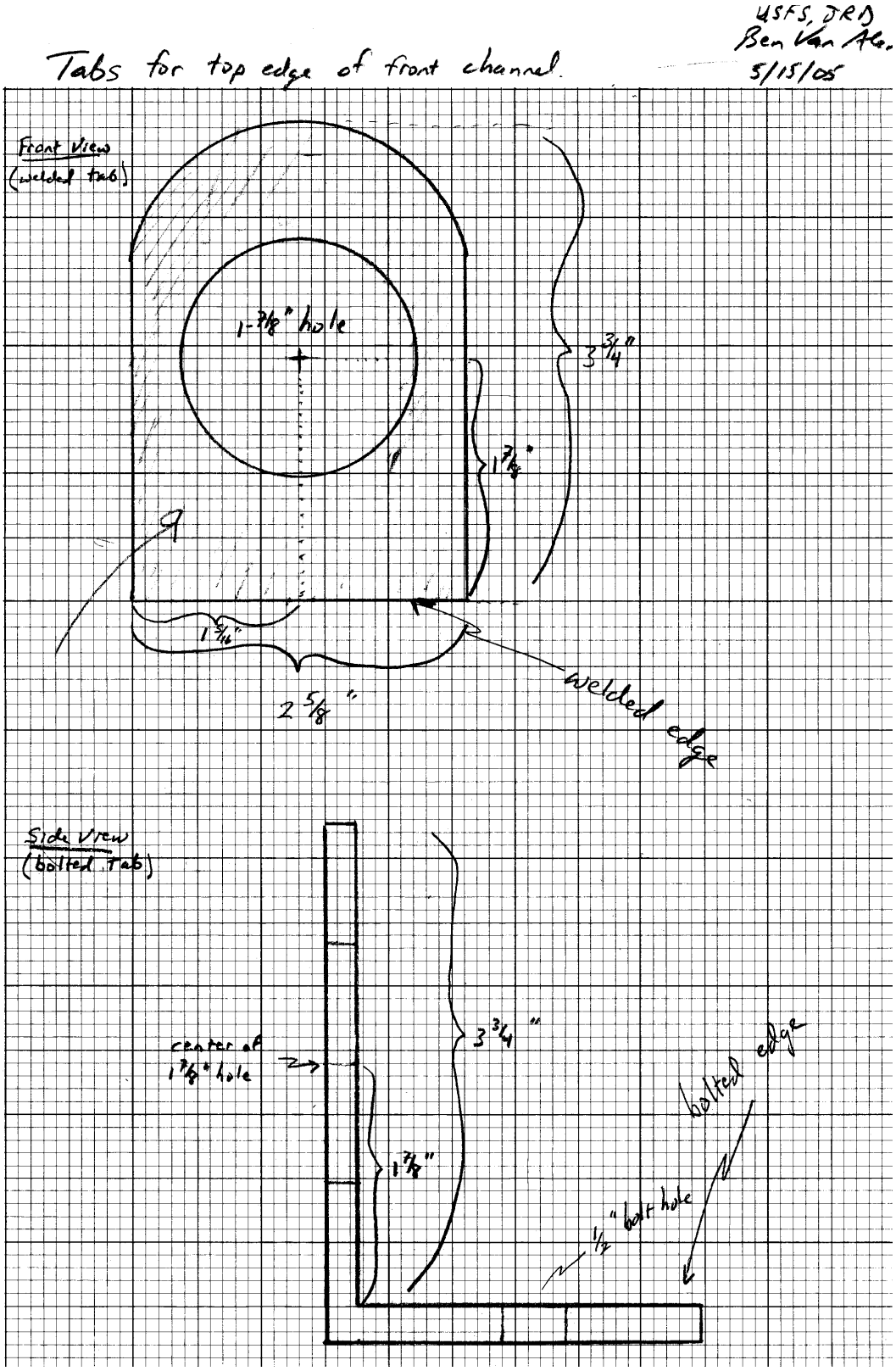



Figure 5. Line drawing of one of the four "tabs" to be welded (or bolted) on the front channel.

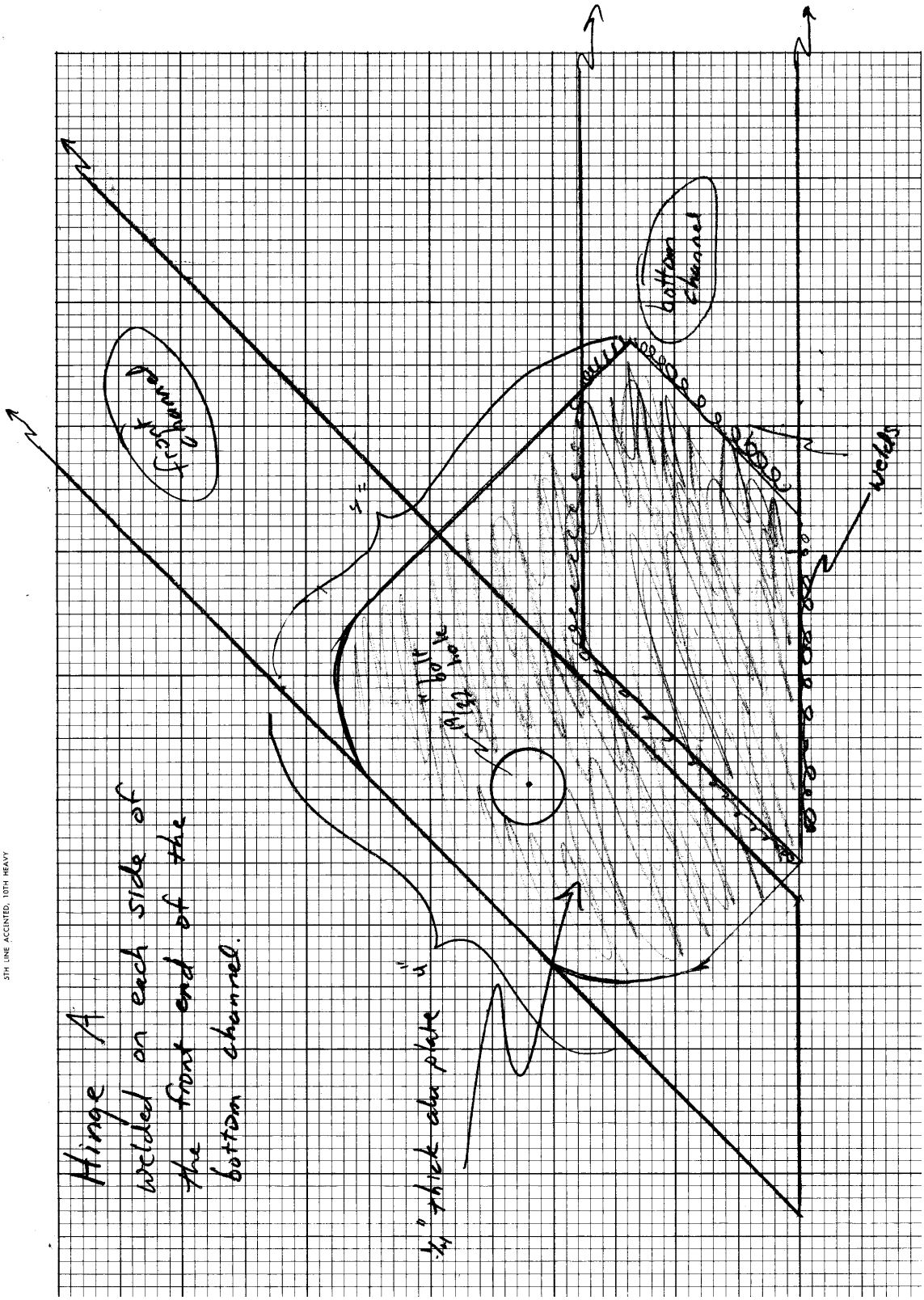



Figure 6. Line drawing of hinge A.

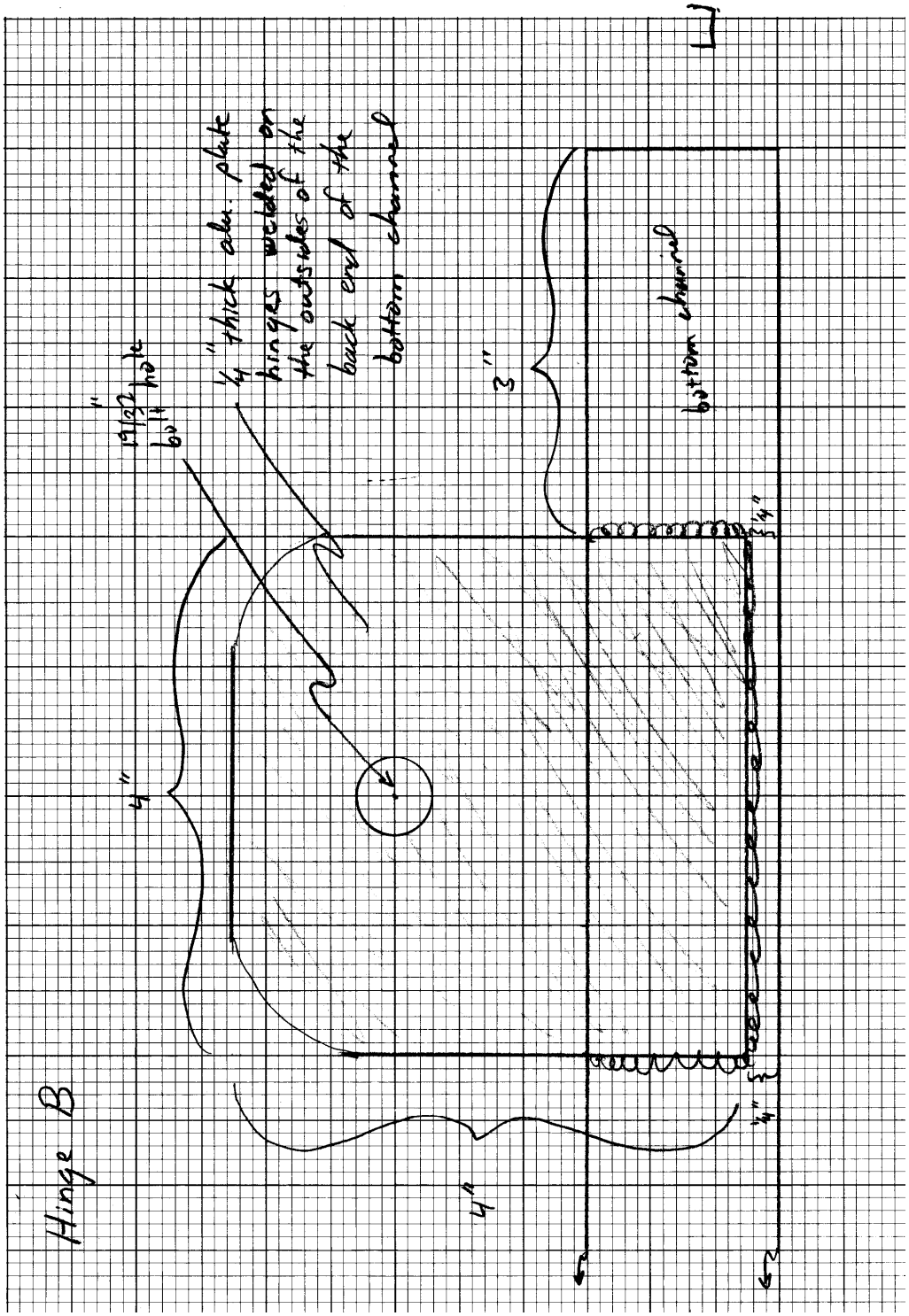



Figure 7. Line drawing of hinge B.

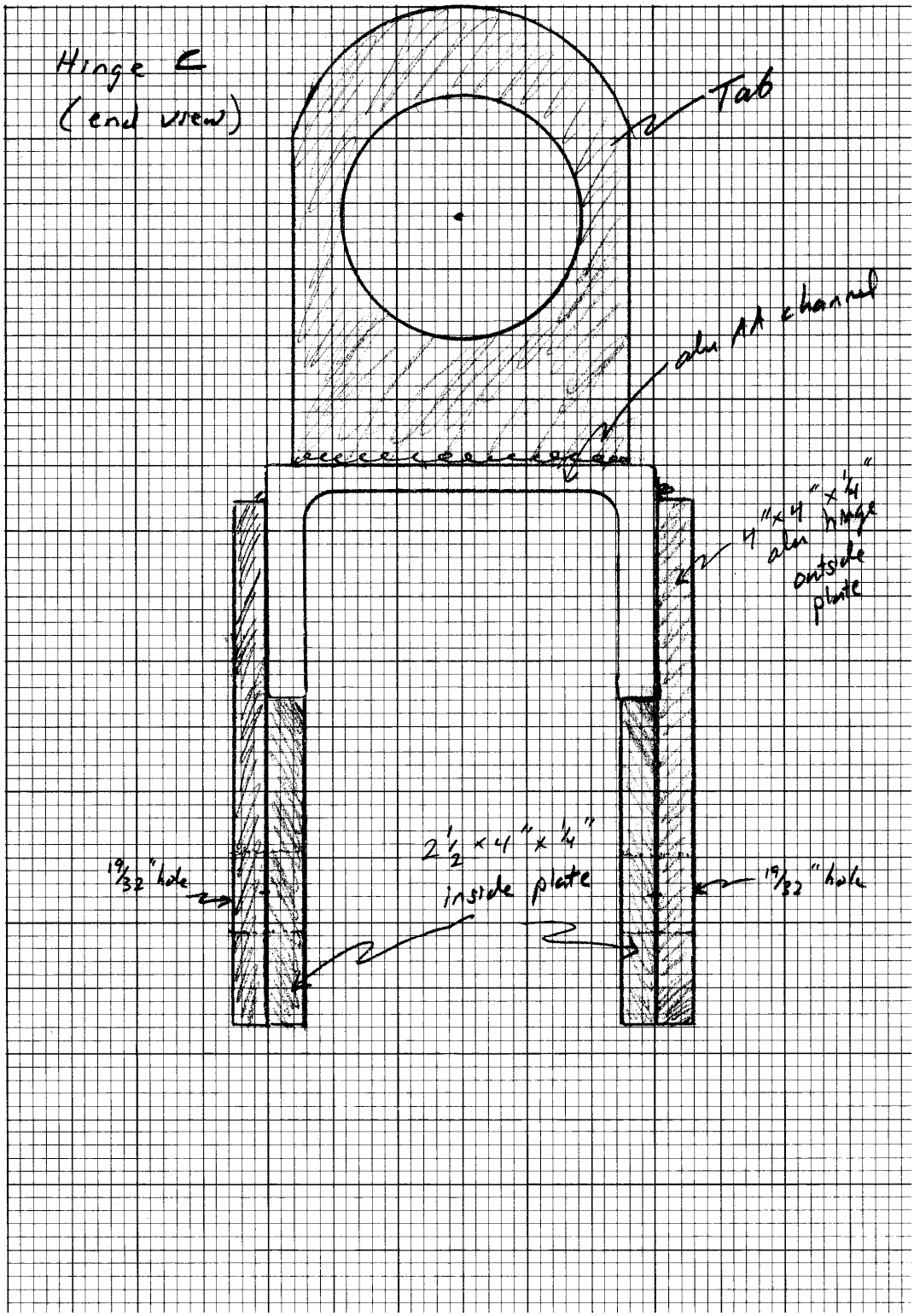



Figure 8. Line drawing of hinge C.

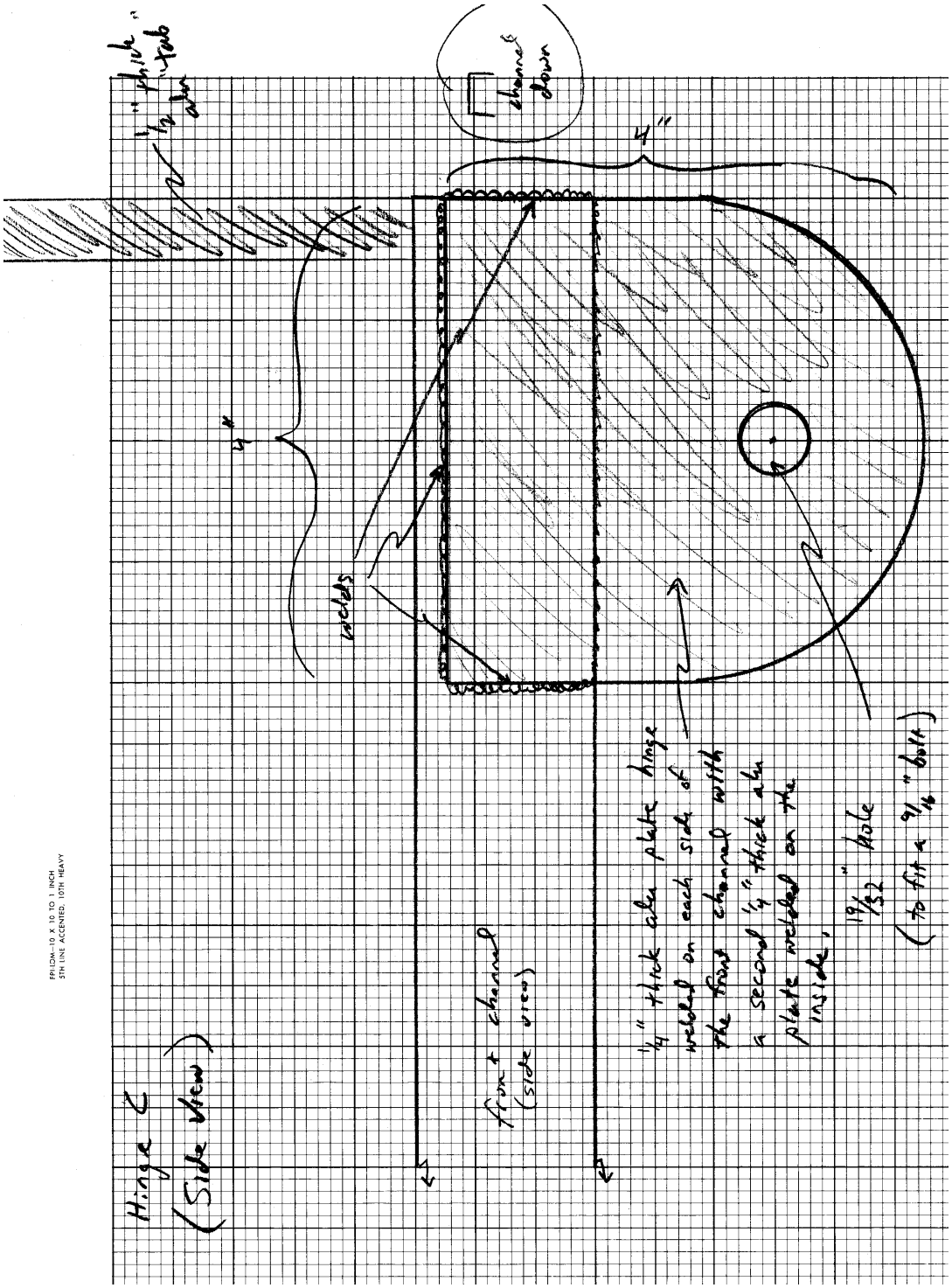



Figure 9. Line drawing of hinge C (side view).

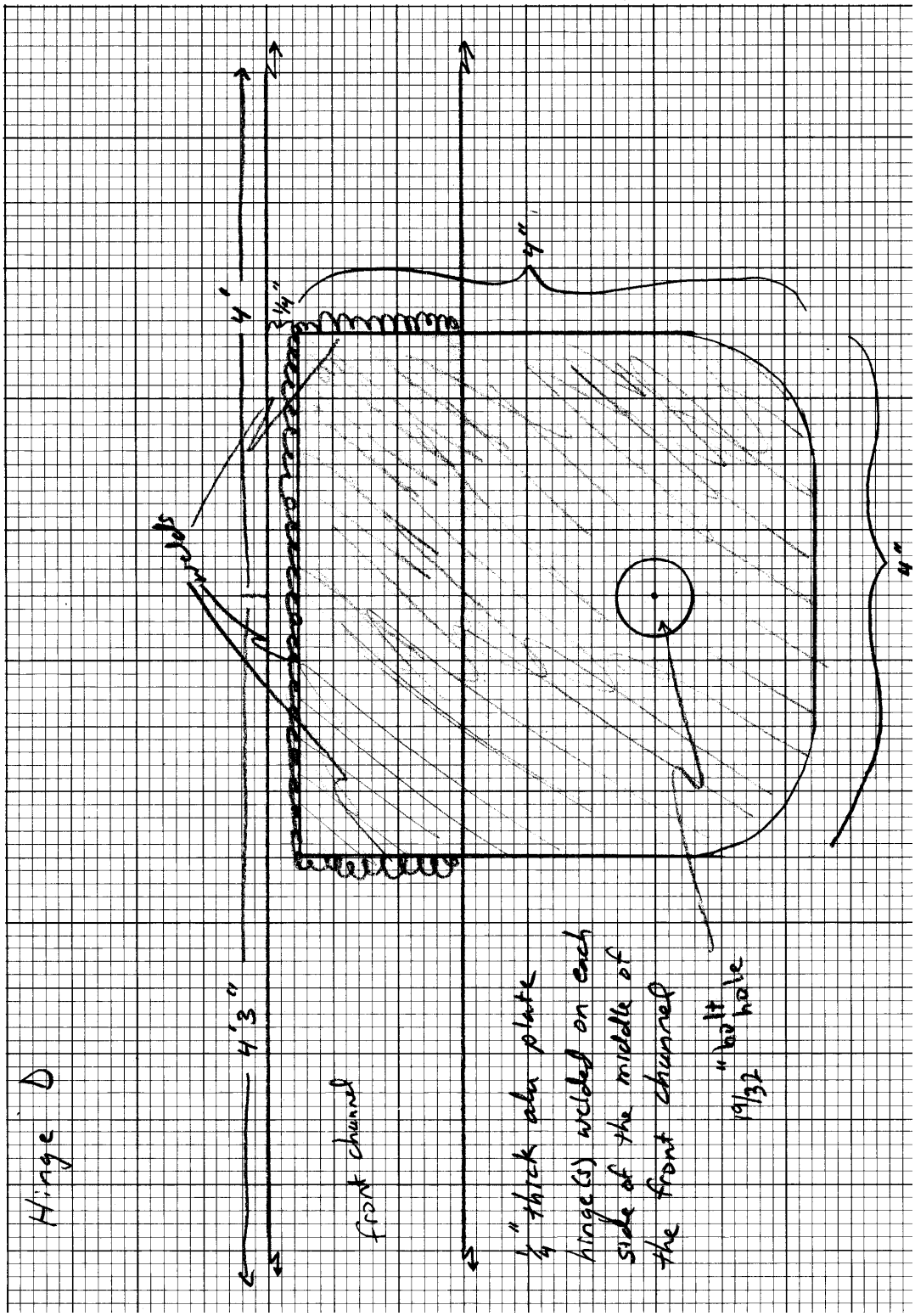



Figure 10. Line drawing of hinge D.

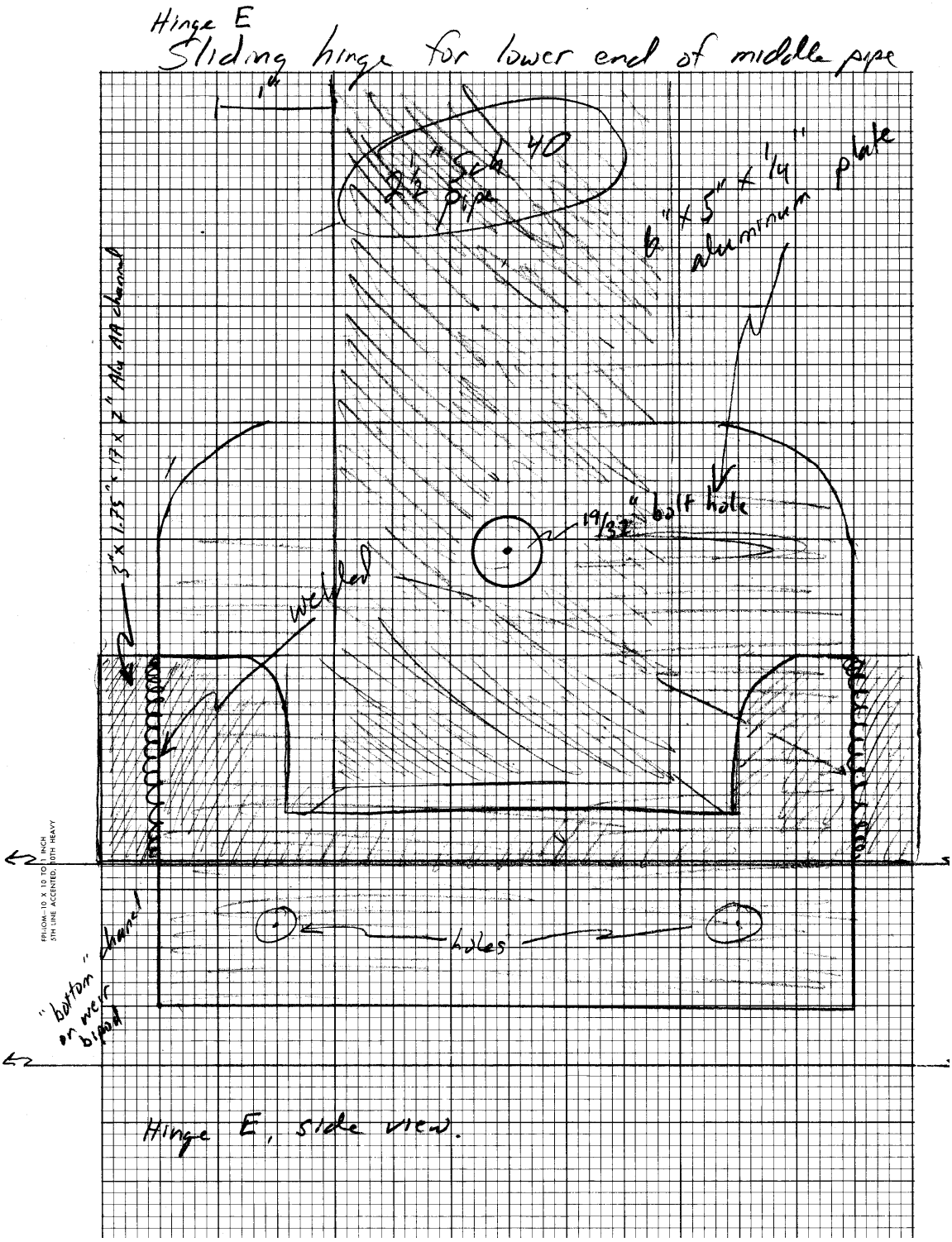



Figure 11. Line drawing of hinge E.

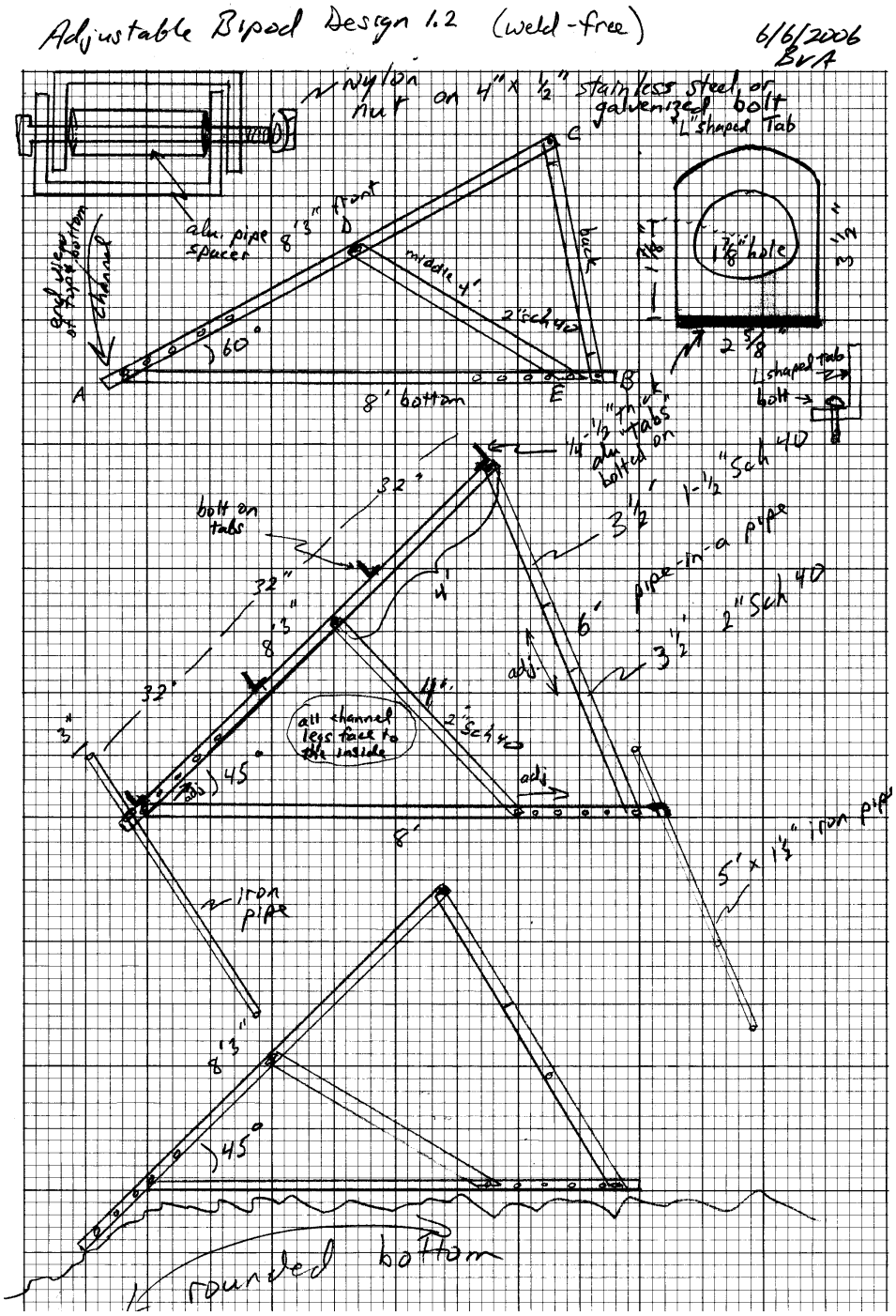


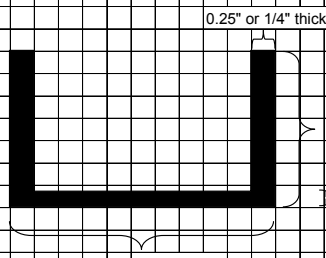

Figure 12. Line drawing of adjustable weir bipod design 1.2. This design has no welded hinge joints and is not as strong as design 1.1. The bipod can be collapsed for transport by pulling bolts at hinges B and D. The bipod can be further simplified by using channel instead of pipe for the middle and back legs. A 25' stick of aluminum AA channel will make a bipod if the front, bottom, back, and middle channel lengths are cut at 8', 7', 6'3", and 3'9", respectively.

**Specifications for aluminum channel, pipe, and plate used to make adjustable bipods (and other weir, trap, and floating wall tent parts):**

each square = 1/4" x 1/4"

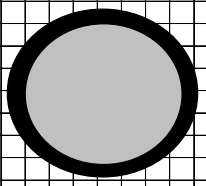
(1) Heavy aluminum channel - for weir channels, weir pannels, trap pannels, front and bottom channels and Hinge "E" of adjustable bipods, and frame of floating wall tent.

6061 Aluminum Channel T6 Aluminum Association (AA) Channel, 3" x 0.17" x 1.75" (comes in 25' long "sticks" weighing 40 pounds/stick)




(2) 1-1/2" sch 40 aluminum structural pipe - for tent poles and vertical ends of weir and trap panels (if you don't want to use the 3"x0.17"x1.75" alu. AA channel)

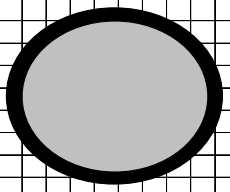
6061 Aluminum Pipe T6 structural 1.5 Schedule 40 (comes in 20' sticks weighing 18.8 pounds/stick)



| | |
|---|---|
| nominal size = | 1-1/2" |
| OD inches = | 1.90" |
| ID inches = | 1.61" |
| Wall thickness = | 0.145" |
| Pounds/foot = | 0.9402 |
| Pounds/20' stick = | 18.8 |

(3) 2" sch 40 aluminum structural pipe - for upper back pipes on adjustable weir bipods and tent frame stantions and connectors

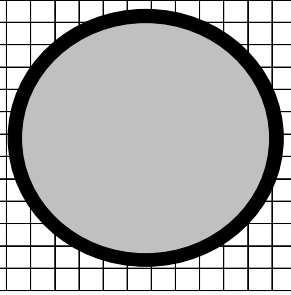
6061 Aluminum Pipe T6 structural 2" Schedule 40 (comes in 20' sticks weighing 25.28 pounds/stick)



| | |
|---|---|
| nominal size = | 2" |
| OD inches = | 2.375" |
| ID inches = | 2.067" |
| Wall thickness = | 0.154" |
| Pounds/foot = | 1.264 |
| Pounds/20' stick = | 25.28 |

(3) 2-1/2" sch 40 aluminum structural pipe - for middle and lower back pipes on adjustable weir bipods.

6061 Aluminum Pipe T6 structural 2-1/2" Schedule 40 (comes in 20' sticks weighing 40.08 pounds/stick)



| | |
|---|---|
| nominal size = | 2-1/2" |
| OD inches = | 2.875" |
| ID inches = | 2.469" |
| Wall thickness = | 0.203" |
| Pounds/foot = | 2.004 |
| Pounds/20' stick = | 40.08 |

(4) Aluminum Plate - for tabs and hinges on adjustable weir bipods

Aluminum Plate 1/4" x 12" x 24" 6061-T651

(5) Standard Galvenized or Black Iron Pipe - 3/4" x 10' for trap door hinge, 1" x 10' for trap corner posts and 1" x 5' for anchoring at front and back of bottom bipod

Pipe size = 3/4", OD = 1.050", Wall = 0.113, Nom. ID = 0.824, weight/foot = 1.13 pounds, weight/10' length= 11.3 pounds

Pipe size - 1", OD = 1.315", Wall = 0.133, Nom. ID = 1.049, weight/foot = 1.68 pounds, weight/10' length = 16.8 pounds

Figure 13. Specifications of the aluminum channel, pipe, and plate used to make the adjustable bipods (and other weir, weir trap, and floating wall tent parts).

Appendix E.

# Testing a "Lake Net Weir" at Kook Lake, 2006 and 2007[6].

Ben Van Alen
U.S. Forest Service, Juneau Ranger District
April 2008

## Introduction

In 2006 and 2007, I tested the performance of an experimental "lake net weir" at the outlet of Kook Lake (Figures 1 to 9). This testing was done in conjunction with the counting of adult salmon through a traditional channel and picket weir (this report), a mark-recapture study (this report and Appendix D), and the testing of a mini-DVR fish video system (Appendix F). I designed and built the trawl-shaped net to funnel upstream migrating fish into a trap or past video cameras so they could be counted. The net is held out in the lake by cables that "Y" off to each side of the outlet. In our situation, the net weir was set just on the lake side of the picket weir that was set across the bedrock sill at the outlet of the lake. The Angoon Community Association employees working on this Office of Subsistence Management, Fisheries Resource Monitoring Program (FRMP) project assisted in the operation of the net weir.

## Background

Purse seines, gill nets, dip nets, and various configurations of fyke nets have long been used to capture migrating fish in rivers and lakes. However, if the intention is to visually count all the migrating fish then a fixed channel and picket weir has been the only practical and proven method - although mark-recapture studies are usually needed to validate weir counts. These rigid weirs work great in many locations throughout Southeast Alaska due to the relatively small size of the island and coastal lake/stream systems that many of the sockeye and coho spawn in.

However, rigid weirs have their shortcomings. Rigid weirs are relatively expensive to construct, deploy, and pull. Weir projects often spend $15,000 to $50,000 or more to construct and deploy a weir. The aluminum and steel used to make the channel, pickets, and superstructure is expensive and prices are rising as is the welding shop time needed to fabricate the channel and superstructure. The weir materials are bulky and heavy and helicopters are often needed to sling weir and camp material in and out. Funding constraints and information needs and findings often result in weir projects that last only a few seasons so the expense to deploy and pull a weir is significant. Storing of weir parts is usually a challenge as is disposing of rusted pickets and rotting wood supports.

[6] Disclaimer: the use of trade names, manufacturers, or suppliers of commercial products in this report does not constitute endorsement or recommendation for use by the federal government.

There is not a standard design for rigid weirs and parts from different weirs are seldom interchangeable.

Bears are often attracted to the concentration of fish around a weir and their presence brings safety and anxiety issues for the field personnel (not to mention what they do to the fish). Especially since weirs are often placed in a deep dark wooded section of a stream. Bears have damaged weir and trap structures and have compromised the ability to count all the passing fish.

In some locations it is difficult to keep weirs fish tight due to fluctuations and extremes in stream flows, unstable, rocky, or uneven stream bottoms and banks, and the insidious erosional power of moving water and amorous salmon. Rigid weirs really need to be overbuilt to handle the inevitable worst-case-scenarios.

There are many systems in Southeast Alaska where we count the number of sockeye and coho salmon escaping into a lake. These salmon eventually spawn in the lake or in tributaries or other lakes upstream in the system. If a lake's outlet is relatively small and relatively clear of logs and other obstructions then a net that funnels the upstream migrating salmon into a trap, or past a camera, might be better that a rigid weir and trap.

Variations of the lake net weir can be used to count and capture salmon in streams and rivers. In 2007, Admiralty National Monument biologists Lance Lerum and Robbie Piehl and I tested a "stream net weir" in the outlet stream from Kanalku Lake (Figure 10). This cable and net weir was set at a 45° angle across the stream and worked well to guide upstream migrating salmon into a trap for a mark and recapture study. More testing is needed to assess the workable designs, applications, and limitations of stream net weirs.

## Objectives

The net weir testing was intended to answer the following questions:

1. How practical is it to build and install a net weir?
2. How well does a net weir fish with respect to design, durability, flow conditions, fish movement, and debris?
3. Can a floating trap be used to sample fish out of a net weir? and,
4. Is the net weir at Kook Lake better than the picket weir?

## Design and Fabrication of the Net Weir

This lake net weir is a trawl-shaped funnel net tensioned between wire cables. These 4.76mm (3/16") stainless steel "net" cables are secured to the shore on each side of the outlet and join to a "main" cable or cables that holds the cod end of the net out in the lake. At Kook Lake the main cables were secured to trees on an island that sits just off the outlet of the lake but this cable could be attached to anchors out in the lake with a bipod support to hold the cod end of the net at the desired depth. In a relatively narrow outlet, the net weir could also be suspended from cables that extend to each shore.

I designed the net so the web would be tensioned between the cable, float, and lead lines that branch to each shore of the outlet. The current pulls the web back from the net cables and the amount of webbing, weight on the lead line, and floats on the float line is sufficient to keep the net on the bottom and surface regardless of flow conditions. If flows should pull the bottom up or sink the floats then we could simply add more weight (sandbags) on the lead line or floats to the float line. This "go-with-the-flow" design makes no effort to hold the web open to the current. The steep angle to the net sheds floating debris and funnels fish through the opening at the lake end of the net. A taut net greatly reduces the risk of gilling small fish. The deep funnel shape of the net has the fish well upstream of the float and lead lines before they know they are even in a net.

The netting is square mesh, black, 25 mm (sq. measure) x 400 denier x 20 ply (1.7mm twine thickness) twisted knotless PE (polyethylene) manufactured by Nitto Seimo in Japan (www.iijnet.or.jp/nittoseimo/english/) and sold on this continent by Smart Net Systems Ltd. in Comox, British Columbia, Canada (www.smart-net-systems.com; Doug Dickson, e-mail: doug@smart-net-systems.com). This webbing is used in modern trawl nets, purse seine nets, traps, and barriers. Compared to traditional knotted or woven nylon or polyester netting, this twisted knotless PE netting is stronger, more abrasion resistant, and has less resistance to current. It is also not as heavy, bulky, stretchy, or absorbent. It is highly UV resistant and resistant to growth of aquatic vegetation. The webbing floats and is relatively stiff which is fine for this net weir application. The entire 27.4+ meter (90+ foot) long by 24.4+ meter (80+ foot) wide net with cables and galvanized chain "lead" line was bundled up in a tarp that easily fit into a DeHavilland Beaver without pulling the center seat (Figure 1).

The net was assembled from four panels each with a length of 27.4+ meter (90+ feet) and maximum width of 6.7 meter (22 feet) (Figures 11, 12, and 13). The netting comes 200 meshes deep or about 5 meters (16.4 feet) wide. I was able to cut the four panels without much scrap webbing (Figure 13). The net cables were slipped inside 9.525 mm (3/8") braided polypro line before being half-hitched into the side seams that connects the top and bottom halves of the net. The net was hung on a 1:1- basis so it will fish taut. The same 9.525 mm braided polypro line was used for the cork line which was fitted with 50 foam "gillnet" floats. Leaded ground line (7.9375 mm ; 5/16") was used for the lead line which was fitted with 8.8 meter (29 feet) of 7.9375 mm and 19.2 meter (63 feet) of 6.35 mm (¼") galvanized chain. A string of 30 floats and an 11 m length of 9.525 chain was also put on the midline of the net to better hold the net open and webbing taut. In 2006, the fish swam out the cod (lake) end of the net through a bottomless 6-gal bucket (Figure 6) before we installed a trap to capture and count them. In 2007, they swam through a 40.64cm x 40.64 cm (16" x 16") aluminum frame opening, or through a video chute (Figure 6), or into, or through, a floating trap (Figures 3 and 8).

When laying flat, the cod end of the net angles back 35˚ from the centerline of the net (Figure 13). This angle might be a little steeper than needed and future nets might angle back as shallow as 45˚ so it will be easier to layout, cut, and join this square mesh webbing. A 45˚ angle would shorten the depth of the funnel, and put it at a steeper angle to the current resulting in more water pressure on the webbing and need for more weight

on the lead line and floats on the float line. We found that the current did not put much tension on the 35˚ net at Kook Lake. Most of the tension on the cables was to hold the net taut.

The net materials cost $1,795 which includes $1,215 for the webbing, $213 for the galvanized chain, $200 for the 3/16" stainless steel cable, $78 for the line, $73 for the corks, and $16 for thimbles and cable sleeves. The webbing came with a big spool of 1.7mm twisted PE twine which I used to sew the four panels together.

It took four people half a day to lay the webbing out (on a ball field) and measure and cut the panels (with the aid of survey stakes, line, and a long tape measure). It then took me three long days to half-hitch ad nauseam the net together with a little design-build as this first-time net builder worked. I received a quote for $3,200 (plus shipping) from a net manufacturer in Canada for the netting and fabrication (w/o the net cable and chain). If I could have gotten two other bids I would probably have had this net made professionally since my spending authority is $2,500 FOB Juneau. Having handcrafted this "experimental" net myself will help me formalize design specifications for future nets.

**Design and Fabrication of the Floating Trap**

In order to mark, measure, and scale sample a representative proportion of the salmon escapement we need to trap them. In 2006, we built a plywood, 2x4", and Styrofoam log raft to hold a PVC frame and netting trap at the lake end of the net weir. In 2007, we replaced the temporary PVC and netting trap with a 2.4 m long x 0.9 m wide x 1.2 m high (8' x 3' x 4') trap. The trap had an 3.81 cm x 3.81 cm (1-1/2" x 1-1/2") angle aluminum frame, Aquamesh™ plastic coated wire with 1.27 cm x 1.27 cm (½" x ½") mesh walls, and marine plywood floor trap (Figures 3 and 8). The new trap could be disassembled to fit in a DeHavilland Beaver float plane. The Aquamesh came 0.61 meters (2 feet) wide and the two sections of Aquamesh in the 1.2 m high side panels were sewn together with seine twine so the panel could be folded in half. An aluminum channel collar connected the floating trap to the net weir. There were channel and picket ends on the trap. The weir operators had the option of closing the trap, capturing fish in the trap, or letting them swim freely through the trap. An aluminum channel and Aquamesh panel was also used to as a divider in the trap so fish could be counted from the front of the trap to the back of the trap where cameras could film them swimming out into the lake. We could either video fish as they entered the trap or as they swam out through pulled picket(s) on the front of the trap. When we trapped and sampled fish at the floating trap we used a single "crab finger" "V" entrance on the trap (Figures 3 and 8). We also covered the trap with netting to keep fish from jumping out.

**Installation, Maintenance, and Removal**

The net weir was quick and easy to deploy. It took a half-day to set the net and parts of several days to properly sandbag the lead line and make other adjustments to keep the webbing taut. Setting the net involved cabling the cod end of the net to trees on the island and rolling the net off the bow of a 4.27 m (14-foot) flat-bottom skiff backing

toward the outlet of the lake. The net cables, and lead and float lines, on the wings of the net were then secured to trees on each side of the outlet to pull the net tight. The corks on the float line did not extend up on the banks since they would make excellent chew toys for bears. The ends of the lead line were not pulled as tight since we want the lead (chain) line to meld over rocks and other undulations along the sill on the outlet of the lake. Sandbags were laid along the lead line to make sure it stays on the bottom during high water periods. We also laid sand bags on the net cables near shore so floating debris would float over the net. The wings of the net were longer that we needed at this location but this is not a problem since they simply extend up on each bank. We removed the net at the end of each season by disconnecting the wings of the net from shore and pulling the net into the skiff from downstream to upstream.

The floating trap fit nicely between the two cables that hold the net out into the lake and was connected to the net weir with the aluminum channel coupling. At the end of the project we dismantled the trap by removing the plywood floor and the eight bolts holding the four trap panels together.

**Performance of the Net Weir and Floating Trap**

The net weir performed well in 2006 and 2007. We had it in the water from August 21 to September 19, 2006 and again from July 13 to September 15, 2008. During these times we tested how far in or out of the outlet to position the net, different cable tensions to best hold the trawl-shape of the net, different openings and floating traps on the cod (lake) end of the net, and different depths for the cod end of the net.

We specifically compared picket weir counts with net weir counts during testing of a mini-DVR video fish counting system (Appendix F). There was no evidence of fish passing through the net weir anywhere but through the cod end of the net. We did not observe salmon trying to pass over the float line or under the lead line. The salmon tended to hold behind the net in the deeper water near the middle of the net where the current is the slowest and the water the coolest. The quiet, low flow, water in the whole middle of the net offered little incentive for the fish to swim over the corks or under the lead line. The fish were probably well into the net before they realized they were in a net.

After the 2006 season we simply rolled the net weir up in a tarp and left it out in the elements on the floating wall tent platform. The net weir appeared no worse for wear when we unrolled it in 2007. In two seasons we only had to repair two small holes in the web - one from an accidental prop strike and the other from the abrasion of a rough nub of bedrock at the waters edge. We used sand bag steps to protect the net where we had to walk across it to access the picket weir trap. Such a net-weir would probably last many years when used in slow flow conditions like we did. The UV-resistant webbing is set below the waters surface so it is unlikely that the net will deteriorate in the sun. The wings of the net would probably suffer the most wear since they are in the highest flows, sunlight, and foot traffic. Nevertheless, the webbing on the wings of the net would be the easiest to replace.

The water at Kook Lake was clear enough to visually inspect the net from the surface wearing a swim mask. Inspecting the net in murky water would present challenges similar to inspecting a picket weir in murky water. The water would be deeper but the flow much reduced. Any holes on the upper panels of the net could be repaired working out of a skiff or raft. It would not be so easy to repair holes in the lower panels of webbing. The crew would probably need to release tension on the net, take any sandbags off the lead line, and slide the net up over a skiff to expose the mesh needing repair. It would be unlikely for a properly constructed net to get holes in the webbing in deep and slow moving water. I suspect that land or sea mammals would be the likely, but unlikely, source of deep water holes.

When we set the net weir we did not disturb the large logs and branches that were under the cod end of the net since only the downstream, chain/lead line, part of the net is in contact with the lake bottom. These logs and branches stayed put and never entangled the net weir. If a submerged log had drifted toward the outlet, it would most likely pass under the net until the water got shallow enough for roots and branches to snag. The water would probably then be shallow enough to disentangle the log wearing waders or from a boat.

Once set the net weir required little maintenance. Lilly pads, weeds, and other floating debris only accumulated along the float line. This debris would clear itself or could be easily cleared by dunking the floats under water.

An extreme high water event on September 1, 2006 was a fine test of the net weir. Unusually heavy rain rose lake levels well above the top of the picket weir. Some pickets on the picket weir were bent, some weir channel was bent, some un-anchored bipods were shifted and tilted, and the weir trap was toppled (Figure 14 and 15). The picket weir failed mostly because floating leaves from this fall storm gradually clogged up the weir as the water rose which exacerbated the water height and pressure on the weir. The high flows pulled the float line of the net weir underwater, and lifted up the lead line in places, but the net weir came through the flood clean and unscathed (Figure 15). In fact, once we fitted a floating trap on the net weir we used it to count salmon into the lake rather than rebuild the channel and picket weir. On September 7, for good measure, I also added a second cable to the single 6.35mm cable that was holding the net weir out in the lake.

One of my first concerns with use of this net weir was if small Dolly Varden char and cutthroat trout would get gilled and killed in the 25mm sq. mesh webbing. This was not a problem. The char and trout would swim along the net but it was rare to find one that tried to swim through it since the webbing was tailored and set to be taught. In 2007, only one char was found gilled in the net. There was a little algal growth on the webbing (Figures 7 and 9) and this probably further discouraged char and trout from trying to swim through the net. A net weir should be thoroughly washed and dried before use in another lake. I understand that 19mm sq. mesh webbing is now available from Smart-Net-Systems and this smaller mesh size might be a better compromise to allow

downstream passage of fry and smolts, avoid entrapment of resident trout, and have an acceptable resistance to water flow and bulk.

Another concern is will the net weir interfere with the normal movement of fish (i.e., steelhead trout, rainbow trout, cutthroat trout, and Dolly Varden char) between the lake and outlet stream. The presence of the net weir right at the outlet of the lake certainly affects the movement of fish right at that location. Trout and char were observed swimming all around the vicinity of the net weir just like they would be seen hanging out under the floating tent platform. They were making no apparent attempts to go downstream but some Dolly Varden were filmed swimming downstream through the net weir video chute in 2007. The video footage also showed many more Dolly Varden entering the lake than were observed in the picket weir trap so these smaller fish were certainly passing through the picket weir uncounted. In July 2007, we weighted down a couple of corks in the middle of the cork line so out migrating steelhead could pass but, wearing swim masks, we never saw any steelhead between the picket and net weirs. Nevertheless, the upstream migrating salmon seldom swam up near the float line and there was no indication from fish counts that dipping the float line for downstream moving fish allowed upstream moving fish to pass uncounted. A downstream trap could certainly be designed into a net weir.

The adult sockeye salmon the weir personnel passed through the channel and picket weir mostly swam through the net weir with less than a 48-hr delay. I think the sockeye salmon would not have spent a day or more below the net weir if they had not just been trapped and handled at the picket weir. Even before the net weir was installed, we observed that salmon passed through the weir each morning were still hanging out near the lake outlet that evening. Coho salmon were more reluctant to pass through the net weir. They appeared to move at night, in batches, and in response to rainfall events. They would frequently swim up to the opening of the net weir then turn back, especially when they had to swim through a lighted video chute (Appendix F). I recommend enlarging the opening on the net weir and counting the passing coho salmon with camera mounted white or infrared LED lighting and no video chute. I also do not recommend physically handling the salmon, like we did at the picket weir, and expect them to pass through a net weir without delay.

## Conclusions

Looking back at our objectives, I'd say the net weir and floating trap proved to be much less costly to build, transport, deploy, and operate than a picket weir and that the net weir and floating trap designs worked as well or better for counting salmon into Kook Lake than the picket weir did. Unlike the picket weir, the net weir and trap fished properly at a wide range of flow conditions, required little maintenance, and appeared to enable a better total count of the trout and Dolly Varden char entering the system. Bears were not attracted to the fish around the net weir and it is unlikely that bears would be able to feed on salmon at a net weir as easy as they can at most picket weirs. With a mini-DVR video counting system (Appendix F), and crew quarters on an adjacent floating wall tent camp,

the whole weir operation would be more fish, operator, and "leave-no-trace" friendly than a traditional picket weir and on shore camp.

In Southeast Alaska, this net weir/video/floating camp setup would work well at most locations that we have or are running FRMP-funded sockeye escapement projects. These include Neva Lake, Hoktaheen Lake, Klag Lake, Salmon Lake, Pavlof Lake, Kook Lake, Sitkoh Lake, Kanalku Lake, Falls Lake, Kutlaku Lake, and Gut Bay Lake in northern Southeast Alaska. I realize that in some locations like Klag Lake or Gut Bay Lake that you might not want to count fish at the outlet of the lake if it is not practical and safe to get to these locations. A net weir would not work at lakes outlets like Tumakof Lake (Redfish Bay) where there are logs jamming the outlet. However, in some situations like Lake Leo and Neva Lake, one could use the logs that are there to help guide fish past video cameras. I'm not as familiar with sockeye systems in southern Southeast Alaska, Prince William Sound, Kodiak, the Alaska Peninsula, and elsewhere but know that net weirs would work well at many locations to count migrating fish into small and moderate sized lakes. The remoteness of some lake outlets might preclude use of a lake net weir but there is potential for using a different design of a net weir in a stream (Figure 10).

The building of additional net weirs is challenging since the webbing is available from a single source and the nets are not commercially available. I was unable to secure three quotes from commercial net builders so the only option was to build it myself. This was not hard but it would probably be cost effective to have future nets professionally built. As mentioned above, net construction would be much easier with this square mesh net if the cod end angled back 45° rather than 35°. The layout and cutting of the net should be by counting web rather than measuring web. A web-count pattern needs to be computed (or reverse engineered) along with the complete design specification and parts list for the net and its attachments.

Boats could be rowed, paddled, pulled, or floated over a net weir if they passed where they could not snag webbing lying right at the surface. A double set of corks might be put in this "boat passage" section of the float line. It would be much harder to facilitate the passage of a boat with a propeller in the water but such a fish passage area would probably need to be similar to those used on some floating weirs.

The worst case scenarios for a net weir would probably be a failure in the cables or anchors that hold the net and floating trap out in the lake or a hole in the lower panels of webbing. It should be standard practice to secure the net between more than one cable and more than one anchor. It would also be wise to have a spare net weir available if one is worn from years of use or if the agency had several net weirs deployed.

Different lake outlet configurations will require different sizes of net weirs but the net weir used at Kook Lake would certainly work at a wide range of outlet depths and widths. The deeper and wider the outlet the closer you would probably need to set the net into the outlet. Extending the lengths of the wings is another option. A double redundant combination of lake or stream net weirs and mini-DVR video units (Appendix F) could be used to get validated escapement estimates with out handling fish.

Figure 1. The "Net Weir" bundled up in a blue tarp and ready to fly to Kook Lake, 10 A.M. August 21, 2006. The corks for the net are in the white bag. All this fit in a DeHavilland Beaver with out removal of the middle seat.

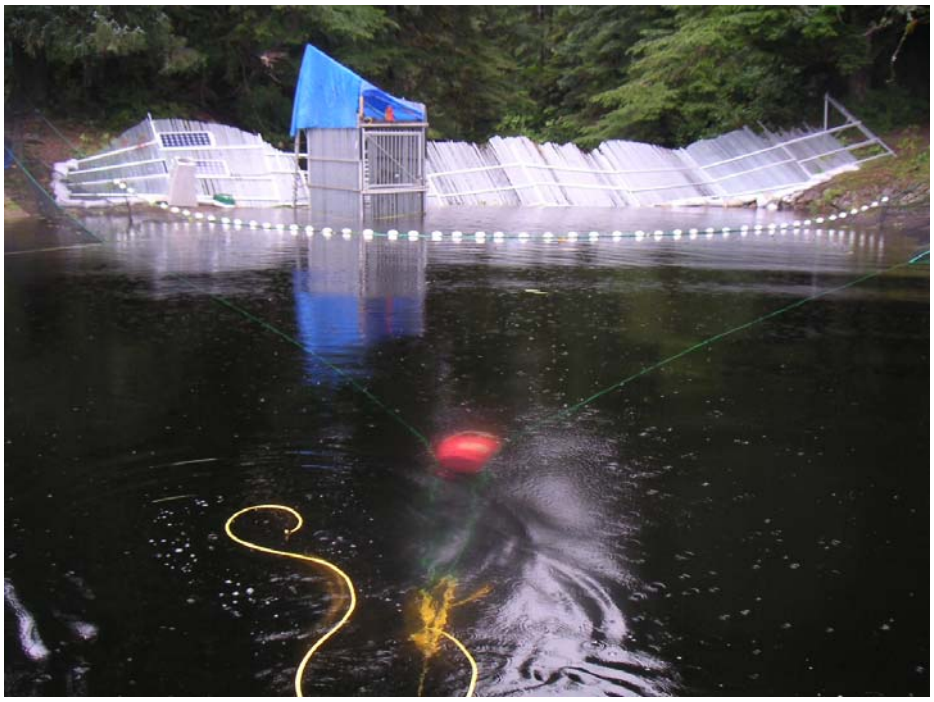


Figure 2. "Net Weir" installed just upstream from the fixed "channel and picket" weir at the outlet of Kook Lake, 5 P.M. August 21, 2006. At this time, the fish would swim through a bottomless bucket and out into the lake.

Figure 3. Floating trap, net weir, and picket weir, Kook Lake outlet, July 13, 2007. Reggie Nelson, Jr. (Angoon Community Association) holds the crab pot "crab fingers" entrance we will put on the entrance to trap.

Figure 4. The picket weir (front), the net weir and floating trap (left), and the floating wall tent camp (right), Kook Lake, July 19, 2007.

Figure 5. Aerial views of the picket weir, picket trap, net weir, floating trap, and floating tent on August 7, 2007 (left) and September 14, 2007 (right). The floating trap in the left photo was configured to sample and physically count or video count fish out of the net weir. In the right photo, the floating trap was secured to the picket trap so fish could be video counted when they pass through the picket weir and again, when they swim out of the net weir.

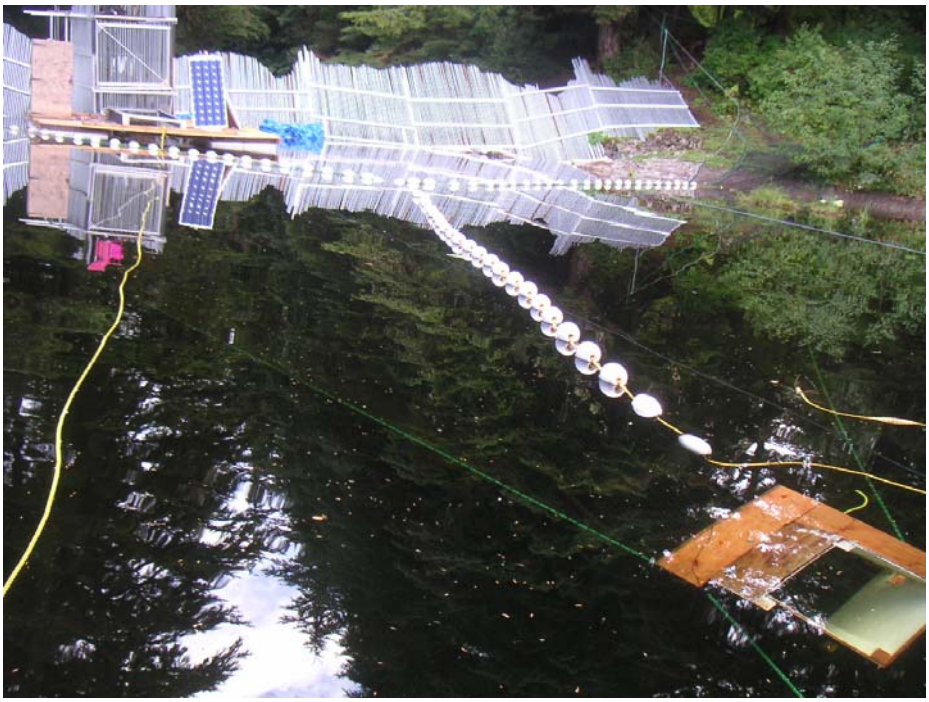


Figure 6. Net weir with a video chute at the cod end of the net and the floating trap moved next to the picket weir trap for video counting of salmon that swim into the net weir, August 24, 2007.

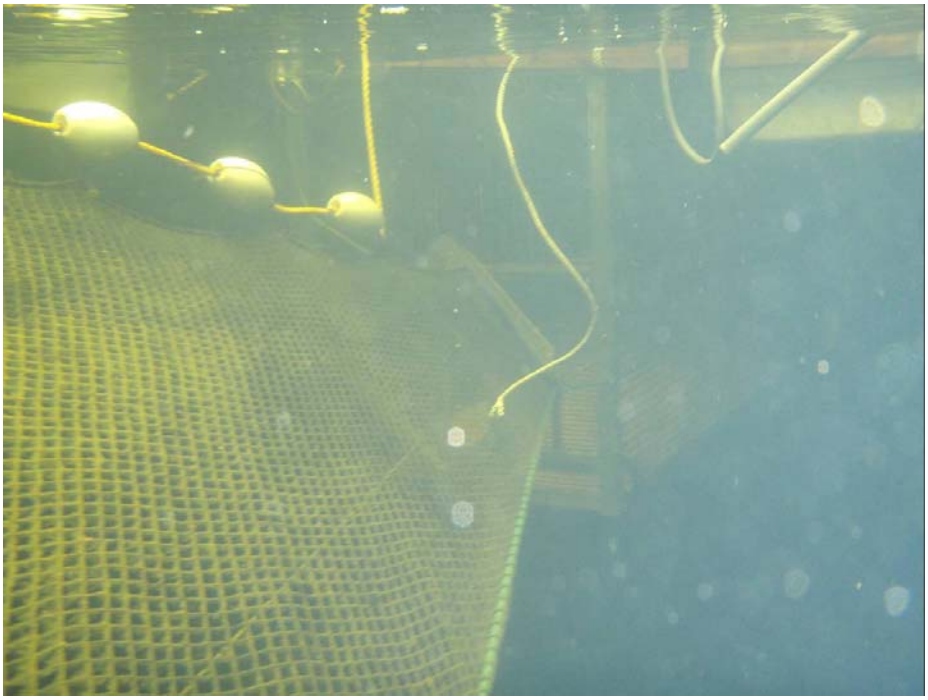


Figure 7. Underwater photo of the cod end of the net weir and floating trap, Kook Lake, August 7, 2007. (photo by David Beatley, Juneau Ranger District)

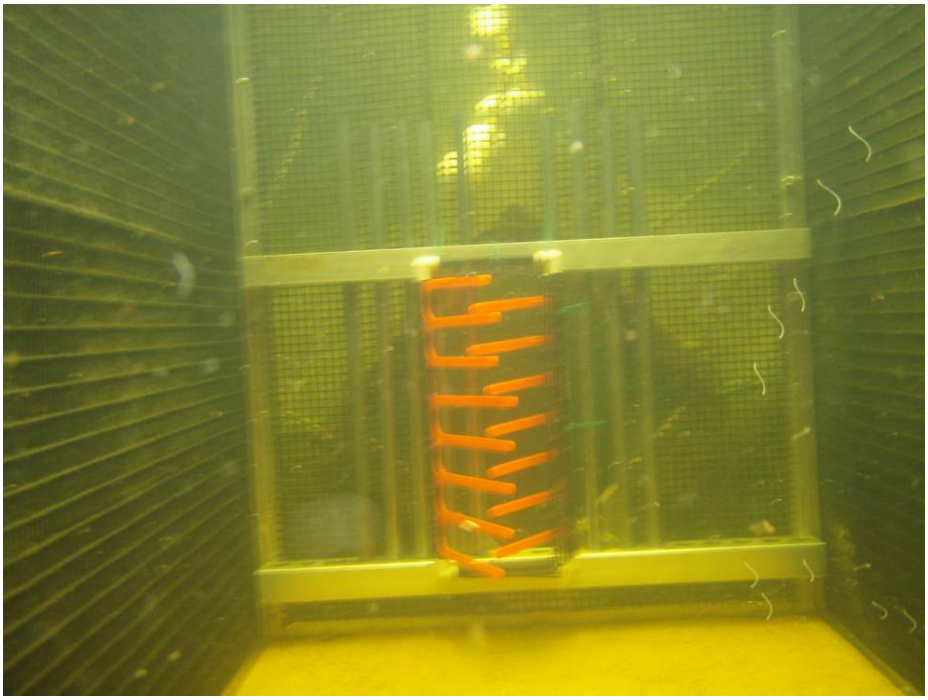


Figure 8. Underwater photo from inside the floating trap showing the trap entrance and cod end of the net weir, Kook Lake, August 8, 2007. (photo by David Beatley, Juneau Ranger District)

Figure 9. Underwater photo of a male sockeye salmon swimming over the lead line of the net weir, August 8, 2007. (photo by David Beatley, Juneau Ranger District)

Figure 10. Photo of a "Stream Net Weir" used at Kanalku Lake's outlet stream in July and August 2007.

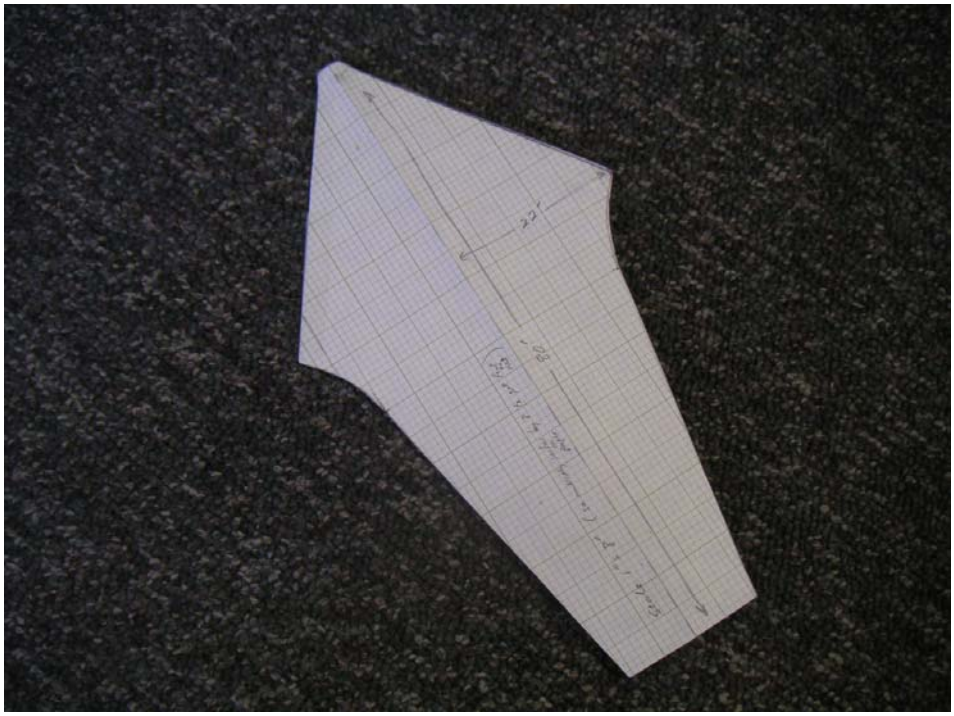


Figure 11. Paper model of two mirror-image quarters of the net weir template.

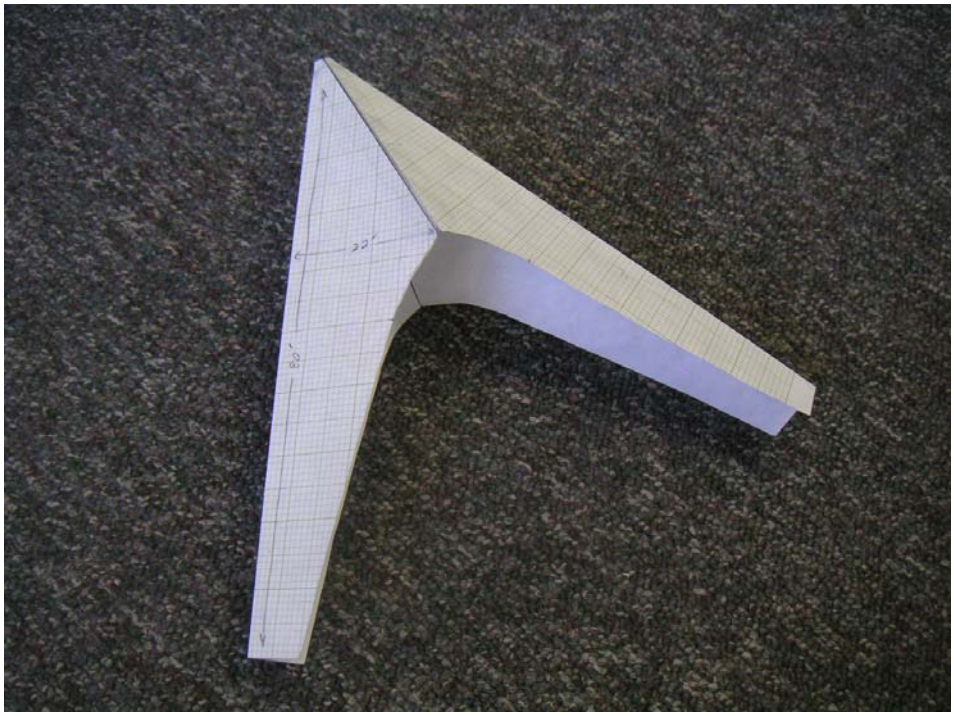


Figure 12. Paper model of the net weir shown in fishing configuration.

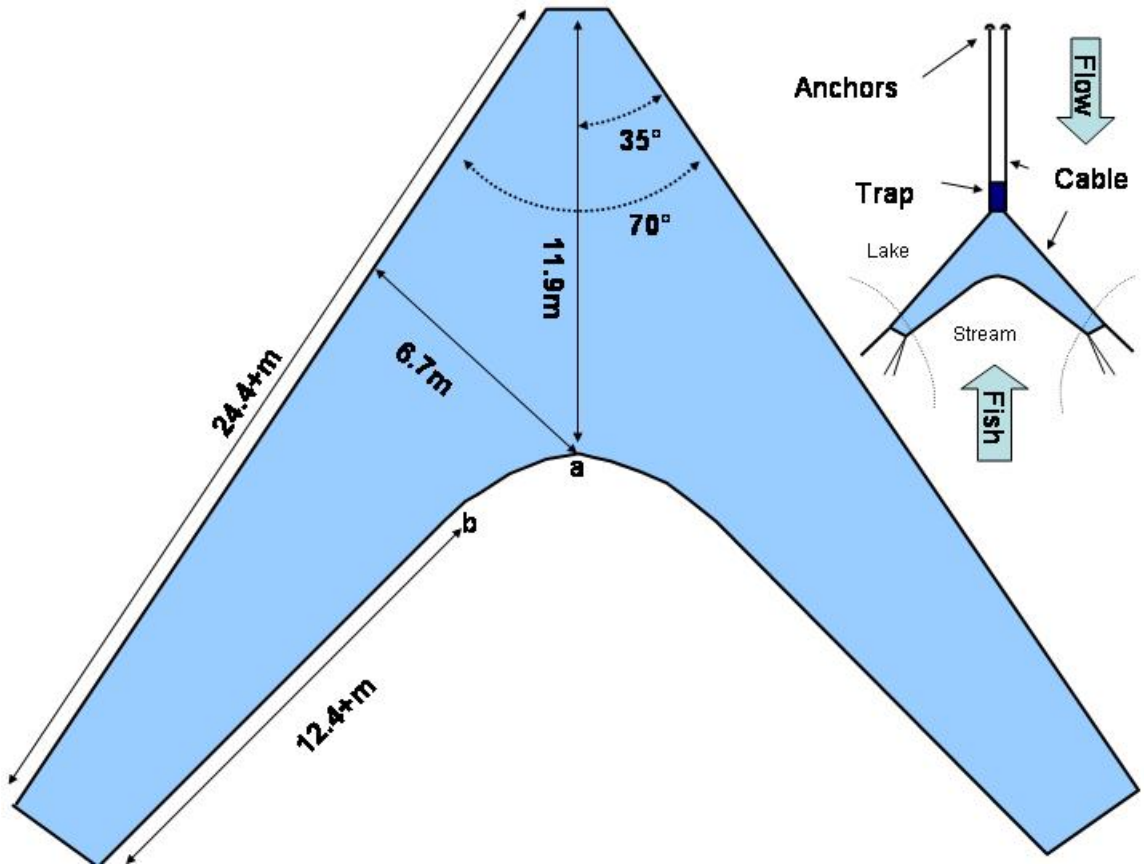



Figure 13. Template of two top or bottom panels of the lake net weir. The only curved cuts are between (a) and (b).

Figure 14. Extreme rain and high water damaged the picket weir, Kook Lake outlet, September 1, 2007. The corks on the net weir are just visible below the surface at the middle left side of this photo.

Figure 15. Aftermath of the extreme high water event on September 1, 2006 that damaged the picket weir but not the net weir, Kook Lake outlet, September 7, 2006.

Appendix F.

# The Development and Testing of a Mini-DVR Fish Video Counting System at the Kook Lake Salmon Weir, 2007[7]

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April 2008

Management of salmon fisheries always boils down to assessing if enough fish escape to spawn. In Southeast Alaska, sockeye escapements are counted as fish pass through weirs/traps and the counts are validated with mark-recapture methods. These projects often involve handling a fair proportion of the run and passing fish during the day when many naturally migrate at night. These weir/mark-recapture projects yield reliable estimates but fish handling, migration delays, and project costs are a concern. Counting fish with video equipment works well when the water is clear enough to see the fish, the lighting is good enough to see the fish, and they pass close enough to the camera(s). Unfortunately power demands, system complexity, and costs have compromised the practicality and reliability of past systems - especially those used in remote settings.

In 2007, I developed and tested a mini-DVR (digital video recorder) and underwater CCD camera-based system in conjunction with the 2007 Kook sockeye weir project. This system proved easy to use, reliable, and inexpensive.

The video set up included two independent battery/camera/recorder units to count fish through a picket weir (Figures 1 to 11; Table 1) and two independent battery/camera/recorder units to count these fish again through an experimental "net" weir (Appendix E). During testing of this equipment, the project personnel from the Angoon Community Association counted all the sockeye and coho salmon that they dipnetted out of the trap on the picket weir and into a floating trap tied to the front of the weir trap (Figure 1). These salmon then swam, on their own, out of the floating trap past two cameras and then out the net weir past two cameras on their spawning migration into the lake. This double-redundant camera setup allowed us to validate the accuracy of the camera counts, the accuracy of the weir count, and the performance of the net weir (Figure 12, Table 2). We could assume that the cameras are counting all the fish that pass by them if the counts are the same between each pair of cameras. We could also assume that we're counting all salmon entering the lake if the counts were the same between the picket weir and net weir cameras. We also had the traditional weir count and weir-to-above-weir mark-recapture study (Appendix D) to help validate these counts.

Each video unit consisted of an underwater CCD camera feeding continuous video to a mini-DVR (Figure 2) and the mini-DVR saving only the frames with motion detected on

[7] Disclaimer: the use of trade names, manufacturers, or suppliers of commercial products in this report does not constitute endorsement or recommendation for use by the federal government.

SD (Secure Digital) memory cards. The commercially available mini-DVR "SecuMate Mini Portable Security Recorder" units are solid state, pocket size (90x65x37mm/150g), consume less than 2.5 Watts (0.5 Amp) of power (Table 3), and cost less than $200. They have 3.5 mm "mini-plug" AV (audio-video) in/out ports and RCA plugs that are compatible with most cameras and monitor connections. They have an internal compartment for 2 AA batteries and a plug-in for external 5VDC power. I used external 12VDC to 5VDC converted power from 88Ah 12VDC AGM (Absorption Glass Mat) sealed batteries to power the mini-DVR. I also put a 12VDC to 12VDC converter on the power supply for the camera and LED lights (Figures 4 and 5). The ≥ 79% efficient converters provide the closely regulated (±0.3%) power to the DVR, camera, and lights that they need for optimum reliability and performance.

The mini-DVR's are easy to setup and only need to be connected to power to begin recording. LED's on the mini-DVR indicate when the unit is on, recording, or has a full, missing, or unformatted memory card. An external monitor does not need to be connected to make sure that motion detected recording is working although you would want to be looking at a monitor to properly set the motion detection threshold and camera angle. These mini-DVR's could be used for time lapse recording or multiple units could be set up for extended remote sensing applications by using a timer to turn on (and off) recorders in a timed sequence. A video splitter can be used to connect one camera to two DVR's.

The video is easily reviewed using the unit's playback controls when connected to any monitor with RCA-plug inputs. I used a portable 5.6" TFT 12VDC color monitor (Figure 3, Table 1) which worked well for aiming the cameras in the field and the counting of fish back in the camp or office. The mini-DVR has full feature playback controls with onscreen displays of files searchable by day and type and the ability to fast forward or reverse at up to 32x speed. The playback controls are easy to use and with a little practice weir personnel were able to view the fish triggered video at 2x or even 4x speed while using hand tally counters to count the number of sockeye and coho salmon that passed the camera. The weir personnel recorded their fish counts on the daily weir data forms along with the time it took to review the files on each SD card. It usually took 10 to 15 minutes to review the prior day's video on each SD card. This mini-DVR system avoids the complexity and cost of having a computer in the field camp.

The operator can select image quality, image size, and frame rate. A motion detection features allow the saving of date/time-stamped video only when fish pass. The motion detection threshold and area is user selectable. The record time between events can be set as short as 5 seconds. The real-time MPEG4-SF compressed Windows Media .ASF files are saved on Secure Digital (SD) or Secure Digital High Capacity (SDHC) cards with capacities up to 8GB. Not all SD or SDHC cards are compatible. All the 1GB and 2GB 60x SD cards I've tried have worked well but I could not get a 150x 2GB card to format and a 4GB SD card did not reliably save and replay files. The supplier provides a table of SDHC cards known to be compatible on their website (www.supercircuits.com) and the firmware needed to use these high capacity cards. I have not tested SDHD cards yet.

With the low cost of SD cards (Table 1) full cards should probably be kept intact rather than re-formatted. This will maintain a complete video record of all fish counted.

The supplier also provides a table of the continuous recording times per gigabyte at low, medium, and high resolutions at the maximum frame rates of 30 fps (frames/second) for a 352x240 pixel image, 24 fps for a 704x 240 pixel image, and 12 fps for a 704x480 pixel image. At 30 fps and 352x240 pixels they report recording times of 6.66, 5.0, and 2.5 hours at low, medium and high resolution settings, respectively. I found continuous recording times for a medium quality 352x240 pixel image at half the fps (15 fps instead of 30 fps) to be over 10 hours for a 1GB SD card, over 22 hours for a 2GB SD card, and over 50 hours for a 4GB SD card. Likewise, I found card capacities to be almost three times longer at 5 fps than at 15 fps. Fish detection and fish review worked great with frame rates between 10 and 15 fps at 352x240 pixels and medium quality resolution. I anticipate that an 8 GB SDHC card would have the capacity to store several weeks of motion triggered fish footage at most weir projects – unless recording is constantly triggered by moving debris, shadows, or bubbles.

With redundant camera setups the operator has the option of setting the controls for each pair of recorders differently to validate that all passing fish are videoed. For example, one recorder can be set to record continuously (or at a low motion detection threshold) at the lowest acceptable image quality (low) , size (352x240), and frame rate (5 fps) and the other recorder set to record at a more desirable motion detection threshold and at the desirable 10-15 fps, 352x240, and medium quality setting. If there were the same number of fish counted on the motion triggered 10-15 fps unit as on the continuous recording unit then all fish did indeed trigger the motion detection. I found it difficult to accurately count fish in continuous recordings when there were minutes or hours between fish. However, I found no problems capturing all passing fish on video using the unit's motion detection features and review of the fish-only kept the operator's attention on counting fish.

The underwater CCD cameras I used are available commercially for less than $400 (Table 1). They are in stainless steel 34mm diameter x 60mm long housings with six internal bright white LED lights and have a detachable cable. The cameras were color, 1/3" Sony super HAD, 420 TVL, 0.01 Lux with 3.6mm wide angle lenses. The 12VDC camera power consumption is 1.8 Watts (0.15 Amps) with the LED's on (Table 3).

No "video chute" was used at the floating trap. The fish were filmed when they swam through a gap of two pulled pickets on the lower front side of the trap. This opening was approximately 15 cm wide by 30 cm high. The cameras were in 1-1/2" ABS pipe brackets secured on the front side of the trap on each side of the opening about 100 cm apart (Figure 6). The cameras were 14 cm away from the trap and aimed strait across the face of the trap at a slight downward angle (Figures 7, 8, and 9). This camera configuration worked great for motion detection recording of fish. The salmon would find and swim through the gap in the pickets without delay, turning back, or loitering in front of the camera. Double counting of fish was not an issue. Fish probing their heads up into the opening would sometimes trigger recording but you could always be sure you

were counting passing fish if you waited till their tails swam past to count them. Adipose clipped fish were also quite visible from this angle.

The built-in bright white LED lights on each camera at the picket weir provided adequate illumination for filming at night (Figure 9) but supplemental lighting is recommended for locations where the water is not as clear or species identification is an issue. It would have been nice to reduce the glare of the bright white LED's on the video by dimming them with a PWM (pulse width modulation) dimmer (www.theledlight.com) but this was not possible since the camera and lights were wired with a common ground. The camera's wide-angle (90° field-of-view) and close (40-50 cm) distance to the passing fish also helped reduce false recordings since the fish would fill a reasonably large part of the image. The slight downward angle of the cameras helped to count fish swimming side-by-side and the presence or absence of adipose clips appeared observable.

A diamond shaped video chute was attached to the diamond shaped opening at the lake end of the net weir. The inside of the 50mm long x 40mm/side video chute was painted off-white and the cameras were mounted to film through holes on each side of the diamond (Figures 1 and 10). The video chute was illuminated at night using a 10 Watt HID (high intensity discharge) light in an opaque gallon milk jug secured about a meter in front of the video chute. The video chute was well illuminated and the quality of the night video was excellent (Figure 11). The sockeye salmon would mostly pass during the day and were not obviously affected by the light at night. However, coho salmon would mostly move at night and were reluctant to move through the lighted chute and out into the lake (Table 2). A bigger opening on the net weir might encourage coho salmon to pass and infrared and other lighting options should be tested.

Project personnel used a long handled boat brush to keep the camera lenses clean of algae and the trap face clean of debris. There was little or no problem with debris interfering with camera operation since the trap opening was a meter or more below the surface and most of the debris floating out of the lake was floating on the surface. However, we did have false triggers with the cameras at the picket weir in two situations related to sunlight and shadows. The first is when grass, Lilly pad stems, and other floating debris would wrap around lines at the surface, wave in the current, and cast moving shadows on the trap and substrate. A bright sun shining on a rippled water surface would also cast moving shadows and false recordings. We resolved the first problem by moving lines away from the front of the trap. The sun was seldom intense enough to cause the second problem but this could be resolved if the area in front of the trap was shaded.

The AGM batteries were kept charged using different power sources depending on the location. At the picket weir, an AquaAir ™ hydrogenerator in a custom aluminum housing (on loan from Peter Schneider, Forest Service, personal communication) with a rectifier and charge controller was used to trickle charge batteries for one of the DVR/camera units and two 80W solar panels, and a charge controller, was used to trickle charge batteries for the other unit. The solar panels were able to keep battery voltages above 12 V. The hydrogenerator was also able to keep battery voltages above the desired 12 V level but only when the unit was positioned in the highest flows below the weir. I

understand that the service life of AGM batteries is much longer when they are kept charged above 12 V. A gas generator and a 40 Amp battery charger was used to charge the batteries for the two DVR/camera units at the net weir.

These low cost, low power consumption, solid state, portable "surveillance" mini-DVR's have much potential for true remote counting applications and other fish and wildlife monitoring uses. Their best feature is that they just work.

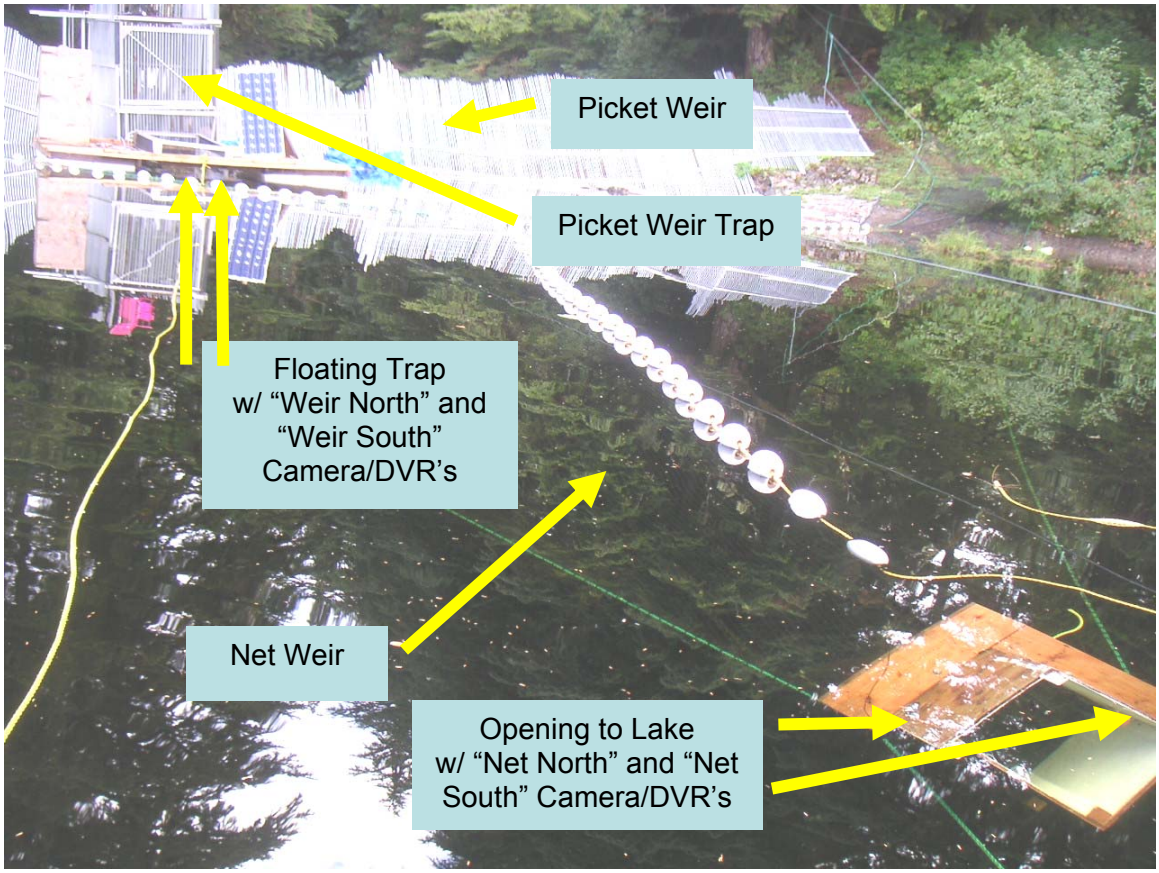


Figure 1. The picket weir and net weir components of the fish video setup used at the outlet of Kook Lake, 2007.

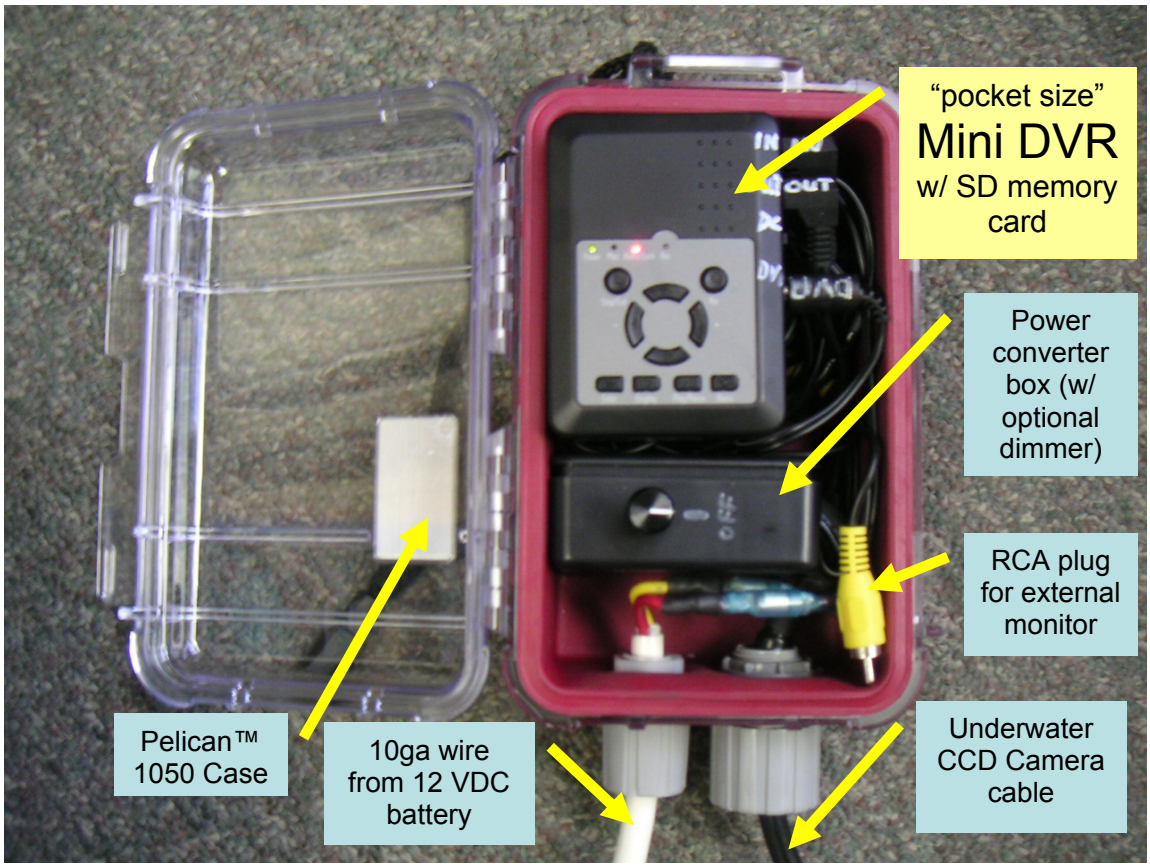


Figure 2. Pelican 1050 Micro Series case holding the power converter box (with optional dimmer) and mini-DVR. The Pelican case is fitted with "cord grip" connectors for the power (white) and camera (black) cables.

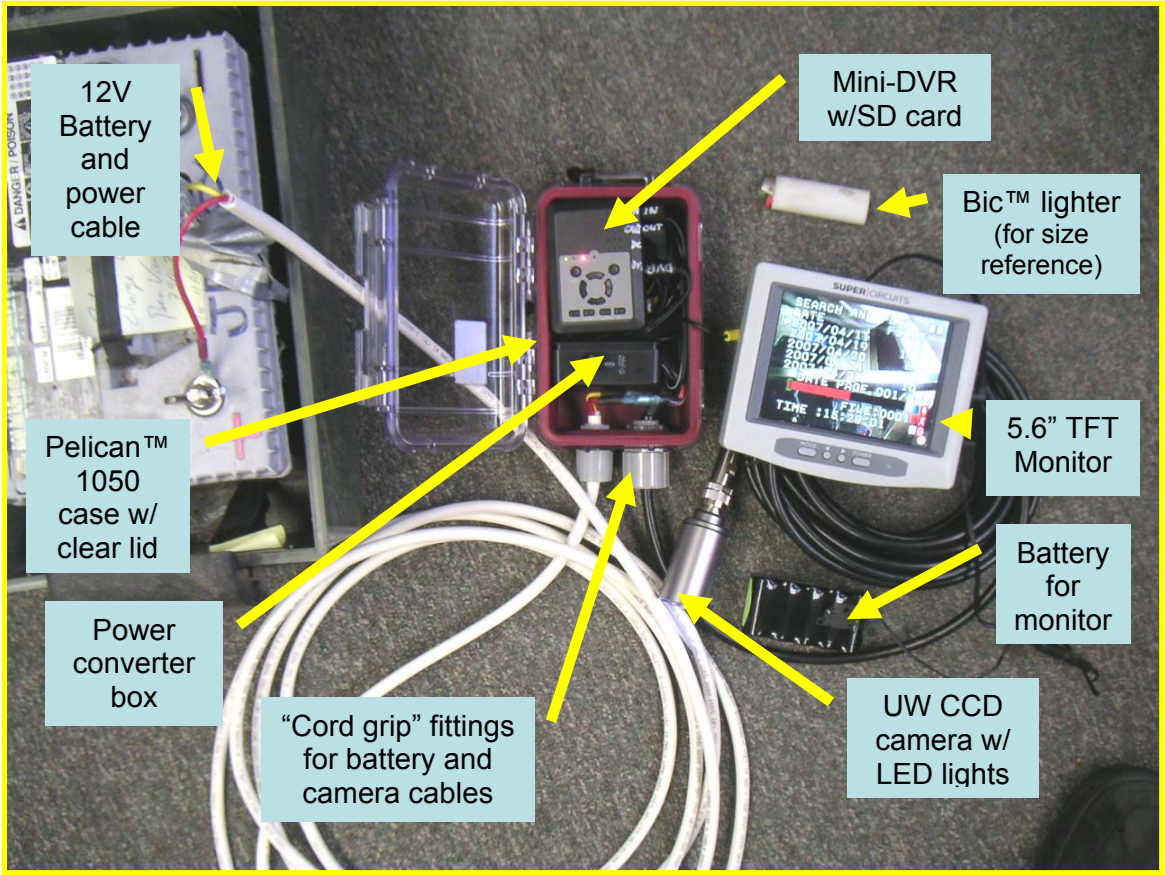


Figure 3. Mini-DVR fish video system Version 1.1 showing the mini-DVR and power converter box in a Pelican 1050 Micro Series case, the underwater CCD camera, a 12V battery, and the external monitor and battery.

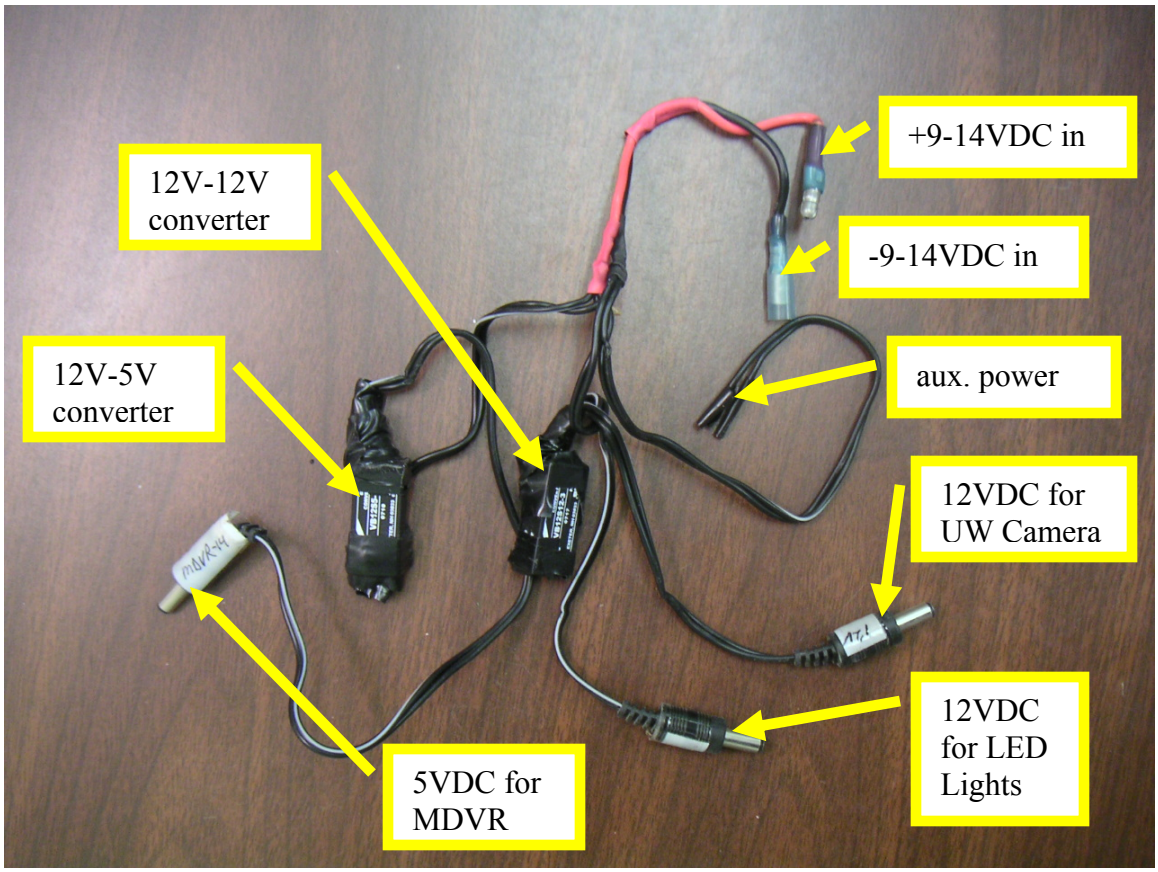


Figure 4. Layout of the wiring and voltage converters in the "power converter box" that input 9 to 14VDC power and output conditioned 12±0.5%VDC power to the underwater CCD camera and LED lights and 5±0.5%VDC power to the mini-DVR.

Figure 5. Power converter box with inputs and outputs.

Figure 6. Mini-DVR fish video system Version 1.1 with the underwater CCD camera in a 1-1/2” ABS pipe housing for securing to the face of a picket weir or trap.

Figure 7. The first frame of a motion triggered video of an adult sockeye salmon swimming with due haste out of the floating trap past the picket weir North camera. The mini-DVR was set to record at 10 fps at a size of 352x240 pixels and medium quality resolution. The picket weir South camera also filmed this fish at the same slight downward angle from the opposite side of the trap opening.

Figure 8. The first frame of a motion triggered video of an adult coho salmon swimming out of the floating trap past the picket weir South camera. The lead line for the net weir is just visible in the background.

Figure 9. Night image of an adult coho salmon swimming out of the floating trap past the picket weir North camera. The only lighting used at the picket weir was the white LED lights built into each camera.

Figure 10. Daylight video image of two sockeye salmon entering the video chute at the lake end of the net weir. The hole in the background of the chute is for a second underwater camera.

Figure 11. Night video of coho salmon entering the video chute at the lake end of the net weir. The chute was painted off-white and illuminated by a 10 Watt HID (high intensity discharge) light secured about one meters out in the lake

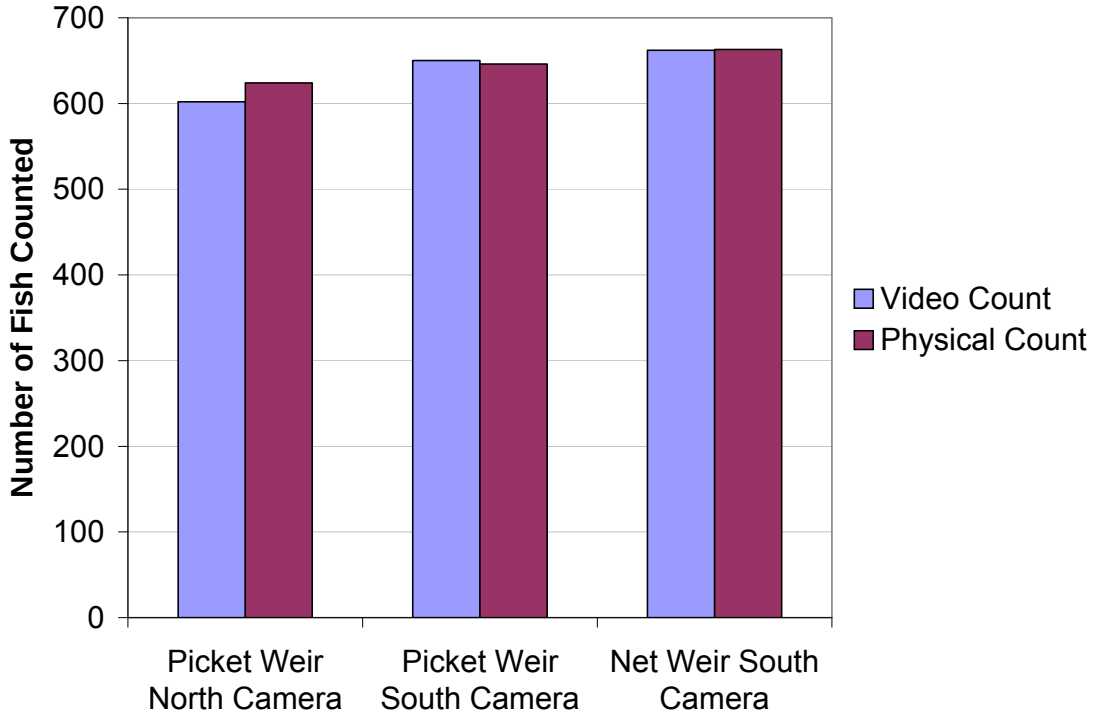


Figure 12. Video counts and physical counts of sockeye salmon at the two picket weir cameras and a camera at the net weir, August 24 to September 14, 2007.

Table 1. Components and prices for the Mini-DVR (Digital Video Recorder) Fish Video System Version 1.1.

| | Item Description | Model No. and Supplier | Price Each (+shipping) |
|---|---|---|---|
| 1 | Mini-DVR (digital video recorder, aka. "SecuMate Mini Portable Security Recorder"). Portable, pocket size, solid state, DVR for compressed motion detect recording and full-featured playback of video files in non-proprietary format. | MDVR-14 from www.supercircuits.com. Comes with AC plug in and RCA to 3.5mm mini-plug A/V adapter cables. An external monitor is needed to select recording options and view video. Images are stored real-time on a SD or SDHC (secure digital) memory card in non-proprietary MPEG4-SP compressed .ASF files. | $190 |
| 2 | SD and SDHC (Secure Digital) memory card. MDVR-14 will store images on most 1GB, 2GB, and 4GB 60X SD cards. There is a firmware update for the MDVR-14 to use SDHC cards up to 8GB. | Available from various local and web sources. The following SD cards work: - ATP AF1GSD 1GB Waterproof High-Speed 60x Digital SD Card -Sandisk 2GB SD OEM Card SDSD-2048-A10 - See www.supercircuits.com for table of SDHC cards known to work | 1GB <$10, 2GB <$20, 8GB <$30 |
| 3 | Monitor. Portable monitor to connect to A/V out of mini-DVR. Monitor is used to view and position the camera field-of-view, select frame rate, image quality/size, motion detection threshold, etc., and review video files using the mini-DVR's full-feature, on screen, play back controls. | MON5TFT3-KIT from www.supercircuits.com. (5.6 inch TFT monitor kit. Comes with battery pack, batter charger, AC plug-in, and carrying case) -Any monitor, TV, portable DVD player, LCD projector w/ RCA inputs will work. -Only one monitor (+ a backup) is needed per project site. | $219 |
| 4 | Camera. Color underwater CCD camera and cable with integrated bright white LED lights. | YCC-350LWW-6S w/ 10m cable from www.jetsecurityusa.com. - 1/3" Sony super-HAD color CCD camera, 420 TVL resolution, 0.01 lux, 3.6mm lens w/ 6 built-in bright white LED lamps in a metal anodized 50M underwater housing. Unit comes with a 10M detachable cable with standard A/V and power plugs on the mini-DVR end. (LED's can be turned on/off but are not dimmable since CCD and LED share a common ground.) | $300 ($240 for camera and $60 for 10 meter cable; other lengths available) |
| 5 | 12V-5VDC Converter. For converting and regulating 9-18VDC power from the battery to 5VDC power used by the mini-DVR | VB12S5-3 from www.wallindustries.com. (9-18VDC input,5VDC±0.3%, 600mA output, 32.3x14.8x10.2 mm, 79% efficient, water washable) | $27 |
| 6 | 12V-12V DC Converter. For regulating 9-18VDC power from the battery to 12VDC power used by the camera and lights. | VB12S12-3 from www.wallindustries.com. (9-18VDC input, 12VDC±0.3%, 250mA output, 32.3x14.8x10.2 mm, 82% efficient, water washable. | $27 |
| 7 | Weatherproof Housing. For protecting mini-DVR and a 75x50x30mm "project" box securing voltage converters and wiring. | Pelican 1050 Micro Series Case with a clear lid, available from various local and web sources. Inside dimensions = 16 x 9.3 x 7 cm. | $18 |
| **Lighting Options: (in addition to the LED lights on the cameras)** | | | |
| 1 | Underwater LED strip lighting. | YL-FS-120-WH-1 from www.theledlight.com. (120cm long waterproof white 120 LED flex strip) | $75 |
| 2 | Driver for 12VDC LED lights | NW-AU12A-4 from www.theledlight.com. (four pack of 14VDC-12VDC, 800mA, drivers for 12VDC LED fixtures) | $45 |
| 3 | Underwater HID (high intensity discharge) lighting. (borrowed from Pete Schneider, USFS, Juneau Ranger District) | SC-MISC from Ocean Systems, 425-258-0778, Jason@oceansystemsinc.com. (12V DC HID light with 50 ft. cable. 10-watt HID ~40-watt halogen – cig. adapter, bulb part number= H10 HID lamp) | $480 |
| **Power Options: (for remote locations)** | | | |
| 1 | 12VDC AGM Battery. (keep battery charged above 12VDC for a long service life) | DCS-88BT from local Interstate Battery dealer. (88.0Ah sealed AGM battery w/ bolt terminals and handle) | $167 |
| 2 | Solar panel(s). (needs charge controller) | Two 80W panels at lake outlet kept the AGM battery >12VDC for one mini-DVR/camera/LED fish video system from July-September. | <$500 |
| 3 | Hydrogenerator (needs rectifier and charge controller; borrowed from JRD) | One Aquair™ generator in a custom aluminum housing set in high flow kept the AGM battery >12VDC for one fish video system | $1,500 |
| 4 | Wind Generator | (not tested - wind limited) | |
| 5 | Charge controller | - Morningstar ProStar-15, 12VDC, 15 amp | $100 |
| 6 | | - Morningstar SunSaver 6, 12VDC, 6.5 amp | $45 |
| 7 | Gas generator | Yamaha EF2400is | $1,200 |
| 8 | Thermal Electric Generator (TEG) | (not tested) | |
| 9 | Battery charger | - Xantrex Truecharge 40+ Multistage Battery Charger | $450 |
| | | - Schumacher SC-8000A | $110 |

Table 2. Comparison between the number of sockeye and coho salmon physically counted at the Kook Lake picket weir and the number counted past video cameras at the picket weir and at the net weir, 2007.

| | Physical Count into video trap:[a] | | Picket Weir North Camera | | Picket Weir South Camera | | Net Weir North Camera | | Net Weir South Camera | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date | Sockeye | Coho | Sockeye | Coho | Sockeye | Coho | Sockeye | Coho | Sockeye | Coho |
| Aug-24 | 14 | 0 | | | | | | | | |
| Aug-25 | 4 | 0 | 4 | 0 | | | 1 | 0 | | |
| Aug-26 | 1 | 0 | 1 | 0 | 1 | 0 | 7 | 0 | 7 | 0 |
| Aug-27 | 2 | 0 | 2 | 0 | 2 | 0 | camera fault [b] | | 2 | 0 |
| Aug-28 | 16 | 0 | 17 | 0 | 19 | 0 | | | 21 | 0 |
| Aug-29 | 128 | 2 | 114 | 0 | 132 | 2 | | | 106 | 0 |
| Aug-30 | 28 | 0 [c] | 27 | 0 | 30 | 0 | | | 43 | 0 |
| Aug-31 | 10 | 1 | 10 | 1 | 10 | 1 | | | 9 | 1 |
| Sep-01 | 8 | 0 | 8 | 0 | 8 | 0 | | | 9 | 4 |
| Sep-02 | 26 | 2 | lost data [d] | | 26 | 2 | | | 44 | 1 |
| Sep-03 | 24 | 4 | 21 | 4 | 22 | 4 | | | 23 | 2 |
| Sep-04 | 4 | 1 | 4 | 1 | 4 | 1 | | | 3 | 1 |
| Sep-05 | 142 | 4 | 141 | 3 | 144 | 4 | | | 139 | 4 |
| Sep-06 | 150 | 17 | 150 | 17 | 149 | 15 | | | 161 | 10 |
| Sep-07 | 59 | 30 | 57 | 30 | 59 | 28 | | | 65 | 8 |
| Sep-08 | 22 | 17 | 21 | 17 | 19 | 19 | | | 19 | 8 |
| Sep-09 | 12 | 39 | 12 | 36 | 12 | 39 | | | 2 | 6 |
| Sep-10 | 5 | 27 | 5 | 27 | 5 | 27 | | | 4 | 10 |
| Sep-11 | 5 | 42 | 4 | 39 | 4 | 39 | | | 3 | 16 |
| Sep-12 | 1 | 33 | 1 | 36 | 1 | 36 | | | 2 | 14 |
| Sep-13 | 1 | 14 | 1 | 14 | 1 | 14 | | | camera fault [e] | |
| Sep-14 | 2 | 34 | 2 | 33 | 2 | 34 | | | | |
| | Video count total = | | 602 | 258 | 650 | 265 | | | 662 | 85 |
| | Physical count total = | | 624 | 265 [f] | 646 | 267 [g] | | | 663 | 219 [h] |
| | Relative Difference = | | -4% | -3% | 1% | -1% | | | 0% | -61% |

[a] Fish were counted as they were dipnetted from the picket weir trap into a floating trap with the video cameras.
[b] This was an inexpensive B&W CCD board camera in a custom ABS housing with a slow but debilitating water leak.
[c] Thirty sockeye salmon were counted through the weir and twenty eight of them were put in the video trap.
[d] The battery cables were accidentally crossed when the MDVR was recording which made the SD card inoperable.
[e] The camera quit working, suspect water in the connection between the camera and cable.
[f] Sum of physical counts from Aug. 25 to Sept. 1 and Sept. 3 to Sept. 14.
[g] Sum of physical counts from Aug. 26 to Sept. 14.
[h] Sum of weir counts from Aug. 24 to Sept. 12. The sockeye tended to hold between the picket weir and the net weir a couple of days in the late-August period. The coho salmon did not readily move through the net weir until 14 and 15 September during a period of heavy rain and rising water levels.

Table 3. Daily power requirements for each mini-DVR fish video unit used at Kook Lake, 2007.

| Item | Watts[a] (max) | Amps[a] (max) | Hours/Day | Wh/day (max) | Ah/Day (max) |
|---|---|---|---|---|---|
| Mini-DVR (MDVR-14; 5VDC) | 2.5 | 0.5 | 24 | 60 | 12 |
| Underwater camera w/ 6 LED's (YCC-350LWW-6S; 12VDC) | 1.8 | 0.15 | 24 | 43.2 | 3.6 |
| Total mini-DVR+Camera (w/ LED's on 24hr/day) | 4.3 | 0.65 | 24 | 103.2 | 15.6 |
| Monitor (MON5TFT3; 12VDC) | 8 | 0.7 | 1 | 8 | 0.7 |
| Additional Lighting: | | | | | |
| HID light (12VDC) | 10 | 1 | 10 | 100 | 10 |
| 120 LED light strip (12VDC) | 6.72 | 0.56 | 10 | 67.2 | 5.6 |

[a]OHMS Law is AMPS = WATTS/VOLTS (and WATTS = AMPS x VOLTS).

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