Fish Resources Permit Study Plan

Stock Assessment of Salmon Lake Coho

2009

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INTRODUCTION

Information from a past study (Schmidt 1996) described the potential for a declining trend in coho escapement to Salmon Lake and an increasing trend in exploitation for this stock, and suggested that the sustainability of Salmon Lake coho salmon may have been at risk from overharvest. Of the coho salmon stocks produced in Sitka Sound, Salmon Lake coho salmon are of particular concern due to the stock's proximity to concentrated commercial effort on hatchery stocks, increasing sport fishing effort, and a recently established federal coho subsistence fishery. In October 2000, the Southeast Regional Advisory Council (SERAC) recommended that subsistence-fishing opportunity be provided for coho salmon in Southeast Alaska, thereby heightening the existing concern for Salmon Lake coho and increasing the need to assess the status of this stock.

In response to these concerns, from 2001 to 2005, the Alaska Department of Fish and Game (ADF&G) operated a floating weir and conducted mark-recapture experiments at Salmon Lake in order to determine total coho escapements into the lake. Results from these studies (Tydingco et al. 2006, Tydingco et al. 2008) have reported that total estimated escapements into Salmon Lake ranged from 1,717 coho in 2001 to 2,843 coho in 2005 (total fish, adults and jacks). The Northern Southeast Regional Aquaculture Association (NSRAA) renewed these investigations in 2007 and 2008, and found the total estimated coho salmon escapement to be 3,111 (SE = 468) and 2,851 (SE = 56) fish, respectively (Sheridan et al. 2008, Sheridan 2009).

In January of 2007, the Sawmill Creek Hatchery's Basic Management Plan was approved by ADF&G, which stipulated that NSRAA assume operation of the Salmon Lake weir beginning in 2007 and continuing through 2010. The operational plan for the weir was to follow that which was developed and used during the years 2002 through 2004 (ADF&G 2007) by ADF&G, NSRAA, Sitka Tribe of Alaska (STA), and the U.S. Forest Service (USFS).

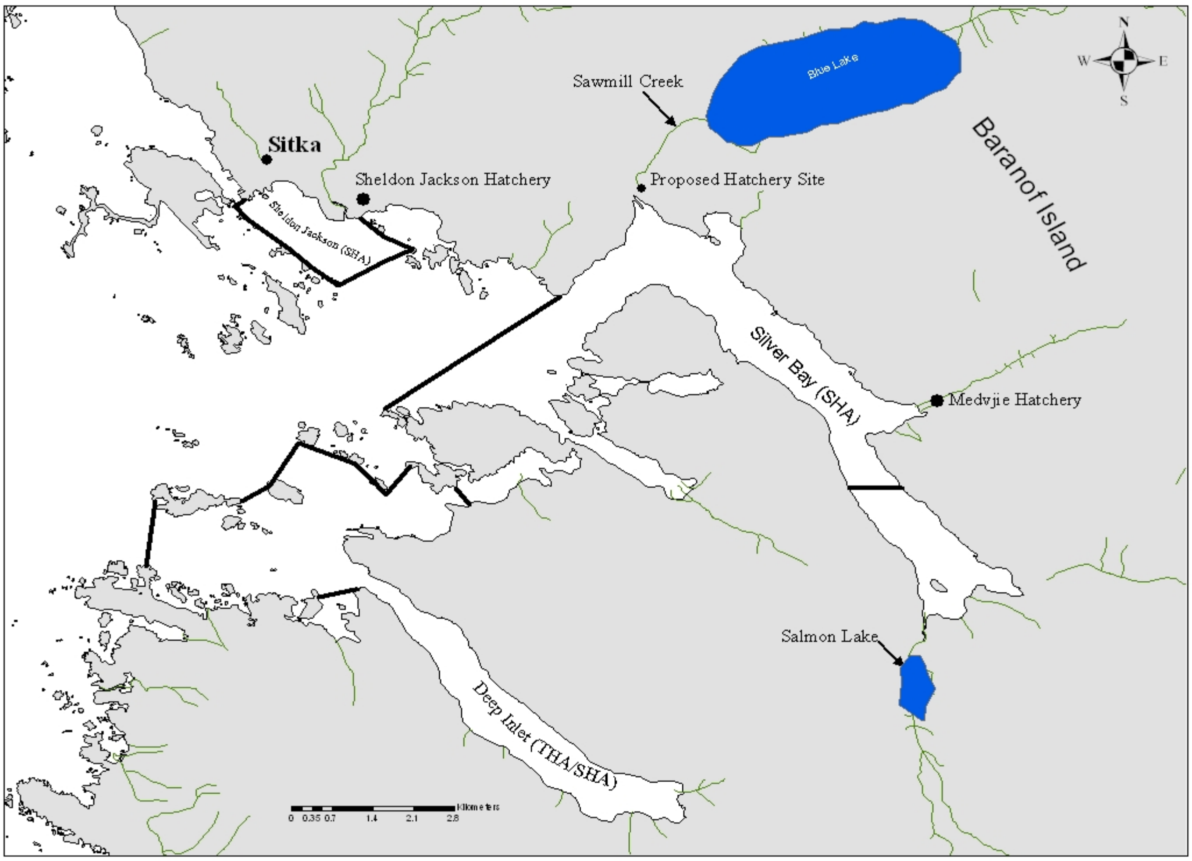
Two thousand nine will be the third year of NSRAA's direct involvement with this renewed multi-year study designed to assess the status of coho salmon at Salmon Lake, and to monitor for hatchery produced coho salmon straying into the system. The long-term objectives of this study are:

1. Estimate the escapement of coho salmon into Salmon Lake such that the estimates are within 10 percentage points of the true value 90% of the time;
2. Estimate the length, and sex composition of coho salmon in Salmon Lake such that each multinomial proportion is within 5 percentage points of the true value 95% of the time; collect scale samples from 325 coho salmon in Salmon Lake for purposes of analysis by ADF&G staff;
3. Monitor for hatchery-produced coho salmon (adipose fin-clipped fish), destroy such fish, and submit suspected coded wire tagged heads to ADF&G's Mark, Tag and Age Laboratory for further identification;

STUDY AREA

Salmon Lake is located 15.2 kilometers southeast of Sitka at the terminus of Silver Bay in eastern Sitka Sound (Figure 1). The lake lies at 17 meter elevation and is fed primarily by two inlet streams opposite the 1.4 kilometer outlet stream. The lake is accessible by floatplane or by boat and foot. The U.S. Forest Service maintains a recreational use cabin on the lake and a foot trail that provides access to Salmon and Redoubt lakes from Silver Bay. Salmon Lake supports populations of sockeye (*Oncorhynchus nerka)*, pink (*O. gorbuscha*), chum (*O. keta*), and coho salmon; Dolly Varden (*Salvelinus malma*); cutthroat trout (*O. clarki*); stickleback (*Gasterosteus aculeatus*); sculpin; and steelhead (*O. mykiss*).

Figure 1. Areas of Significance to Monitoring Efforts at Salmon Lake



METHODS

WEIR COUNTS AND TAGGING

A floating weir will be installed in late June 2009 to capture, count, and tag immigrating coho salmon. NSRAA staff will operate the weir between July 1 and October 31, 2009, or until coho immigration comes to a conclusion. NSRAA's primary focus will be coho enumeration, sampling and tagging, but staff at the weir will enumerate and pass all pink, chum and sockeye salmon encountered at the weir, along with Dolly Varden and steelhead. Chinook salmon are presumed to be of hatchery origin and will be sacrificed, with carcasses being deposited downstream of the weir. Every coho salmon encountered at the weir will be tagged to provide the means to estimate escapement with mark-recapture methods in the event of a weir failure, or in the event that fish pass upstream of the weir without detection. The weir, located at the outlet of Salmon Lake, is fashioned after a weir described in Tobin (1994). It consists of hollow high-density polyethylene (HDPE) panels attached to an anchored cable laid across the stream channel, with a fixed live box attached on the upstream side. One-inch diameter schedule 40 HDPE will be used as the weir pickets. In 2001, the picket spacing was 18 pickets per 4-foot panel that were 20-feet long (Tydingco et al. 2006). In 2004, the picket spacing was reduced for the floating portion of the weir, thereby increasing the pickets to 19 per 4-foot panel (Tydingco et al. 2008). A rigid weir will be established on either side of the 40 feet of floating weir. The rigid weir is supported by bipods and consists of 3-inch aluminum channel with hole spacing of 49 per 8 feet. The pickets used for the rigid weir is composed of ¾-inch galvanized conduit.

All coho salmon captured in the live box will enumerated. Every coho salmon captured in the live box will be sampled for sex, condition, fin clip status, and length, with each fish being measured to the nearest 5 mm MEF. Every coho salmon captured in the live box will be tagged with a uniquely numbered and colored t-bar anchor Floy™ tag. Coho salmon sampled and tagged will be given sequentially numbered tags to be inserted immediately below the middle of the dorsal fin on the left side. In addition to the tag, each fish will be given a combination of operculum punches based on the week the fish was captured (Appendix A6). The tagging guns and hole punch will be rinsed with a solution of 1-part Betadine™ to 10-parts water between sampling each fish. Each fish will be allowed to fully recover to a free swimming state in a holding box before release on the upstream side of the weir.

Daily procedures for fish passing and tagging at the weir will be as follows:

1. Record tagging site, date, and comments on the WEIR SAMPLING FORM (Appendix A3).
2. Record climatological data on the WEIR SAMPLING FORM (collect at 8 AM).
3. Visually inspect the weir for holes.
4. Tag, punch and sample all coho migrating upstream for length, sex and condition. Record sampling information and any pertinent comments on WEIR SAMPLING FORM.
5. Record summary numbers of all fish species passed upstream on the CUMULATIVE FISH PASSING SUMMARY FORM (Appendix A5).

RECAPTURE EVENTS

Recapture events will be scheduled on a weekly basis, as some fish will inevitably be able to pass by the weir undetected throughout the season. Recapture efforts will begin soon after the commencement of coho immigration, and will continue through mid-October. Coho salmon will be captured in the lake and two inlet streams using a 5-meter deep by 40-meter long beach seine modified for use at the entrance of the inlet streams. This net will be used to capture coho throughout the lake, wherever they may be found. For sampling further upstream in the inlet streams, adult coho salmon will be captured using a 3.6-meter deep by 22.5-meter long beach seine. Coho carcasses will be sampled opportunistically. Each fish captured will be examined for tags, operculum punch, and adipose fin clips. Date, tag numbers, fin clip status, and location of capture will be recorded for each fish on the Salmon Lake Coho CAPTURE/RECAPTURE FORM (Appendix A4). Fish captured during in-lake recapture events and found to be without tags will be tagged with a uniquely numbered (sequential) and colored (differing coloration and numbering than weir sampling efforts) t-bar anchor Floy™ tag. All untagged coho salmon inspected during recapture events will be sampled for sex, condition, fin clip status, and length, with each fish being measured to the nearest 5 mm MEF.

ESCAPEMENT ESTIMATION

The escapements of coho salmon will be estimated through mark-recapture experiments because untagged fish are expected to be found above the weir. Under ideal conditions, Chapman's modification of the Petersen Method (Seber 1982) will be used to estimate coho salmon escapement:

$$\hat{N}_e = \frac{(M_e+1)(C_e+1)}{(R_e+1)} - 1 \quad \textit{and,} \quad \hat{V}[\hat{N}_e] = \frac{\hat{N}_e(M_e-R_e)(C_e-R_e)}{(R_e+1)(R_e+2)} \qquad \text{(1) and (2)}$$

where:

$\hat{N}_e$ = estimated abundance;

M_e = number of coho salmon tagged and marked at the weir;

C_e = number of coho salmon inspected for Floy™ tags and marks in the lake and inlet streams, and;

R_e = number of coho salmon inspected that were tagged and/or marked;

The conditions for accurate use of this methodology are:

1. All coho salmon had an equal probability of being marked at the weir; or,
2. All coho salmon had an equal probability of being inspected for Floy™ tags in the lake and inlet streams; or,
3. Marked fish mixed completely with unmarked fish; and,
4. There was no recruitment or mortality to the population between sampling events; and,
5. There is no tagging induced behavior or mortality; and,
6. Coho salmon did not lose their marks and all marks were recognizable and reported; and,
7. Double sampling did not occur;

The experiments were designed to ensure these conditions could either be met by field procedures or evaluated with diagnostic testing postseason so the appropriate model for estimating abundance could be selected. Condition 1 requires sampling be independent of fish size, gender, and timing throughout the run. It is unlikely that condition 1 can be fully satisfied whenever fish pass the weir undetected, however some minor violations can be ameliorated by fish mixing in the lake and inlet streams. Condition 2 is dependent upon uniform efficiency of sampling gear for all size classes of fish and in deployment of sampling gear proportional to occurrence of fish in the lake and inlet streams. Significant violations of conditions 1 through 3 can be detected through diagnostic testing. Equal probability of capture can be evaluated by size, sex, and timing of sampling. The procedures to analyze sex and length data for statistical bias due to gear selectivity are described in Appendix A2, as are recommended procedures to correct for bias when estimating abundance and composition. To further evaluate conditions 1 through 3, contingency table analyses, recommended by Seber (1982) and described in Appendix A3, were used to detect significant temporal or geographic violations of assumptions of equal probability of capture. If all of conditions 1 through 3 were not satisfied due to temporal violations and/or lack of complete mixing, the partially stratified estimator described by Darroch (1961) was used to estimate abundance (see also Seber 1982, and Arnason et al. 1996). Condition 4 was satisfied because there was no meaningful recruitment added to the populations investigated and because the life history of coho salmon isolates those fish returning to Salmon Lake as a "closed" population. Trap-induced behavior (condition 5) was unlikely because different sampling gear types were used (weir and seine) and it is also unlikely that marking fish affected their susceptibility to capture in the lake. Though a rare occurrence, some marked fish were categorized as handling mortalities and censored from the experiment when tag numbers indicated tagging occurred within the previous 3 days. After accounting for these immediate deaths, it was assumed that mortality rates for marked and unmarked fish were similar. It is unlikely that any previously marked fish were not detected (condition 6) during second event sampling because operculum punches, which were also given, would be visible even if the Floy™ tag was missing. Double sampling (condition 7) would also be prevented through the application of additional mark during event 2 (Floy™ tag).

AGE, LENGTH AND SEX COMPOSITION OF COHO SALMON

Every coho salmon captured in the weir trap will be sampled for length, condition and sex. All untagged coho salmon inspected during recapture events will be sampled for length, condition and sex, and will be subsequently tagged with sequentially numbered Floy™ tags uniquely disparate from those numbers assigned to fish tagged at the weir. Each fish will be measured to the nearest 5 mm MEF. Sex will be determined from secondary maturation characteristics. NSRAA staff will collect scales from a total of 325 coho salmon at the weir throughout the course of the season. Four scales will be removed from the preferred area (one row up from the lateral line on an imaginary line between the posterior base of the dorsal fin and the anterior portion of the ventral fin, Scarnecchia 1979) on the left side of the weir captured fish. Scales will not be collected from fish during secondary capture events (in-lake recapture efforts). Scales will be mounted on gum cards and numbered consecutively. Scale cards will be submitted to ADF&G staff for age determination postseason.

If stratification by size is not necessary, proportions and their variances will be estimated according to procedures in Cochran (1977) and Appendix A2:

$$\hat{p}_k = \frac{n_k}{n} \qquad \textit{and,} \qquad \hat{V}[\hat{p}_k] = \left(1 - \frac{n}{\hat{N}}\right)\frac{\hat{p}_k(1-\hat{p}_k)}{n-1} \qquad \text{(3) and (4)}$$

where:

$\hat{p}_k$ = the proportion of the population in group k;

n_k = the number in the sample in group k;

n = the total number sampled; and,

$\hat{N}$ = estimated population size;

If stratification by size is required, length and age proportions and their variances will again be estimated according to the procedures in Cochran (1977) and Appendix A2:

$$\hat{p}_{jk} = \frac{n_{jk}}{n_j} \qquad (5)$$

where:

n_j = the number sampled from size stratum *j* in the mark-recapture experiment;

n_{jk} = the number sampled from size stratum *j* that were in group *k*; and,

$\hat{p}_{jk}$ = the estimated proportion of group *k* fish in size stratum *j*;

The variance calculation for $\hat{p}_{jk}$ is identical to equation 4 (with appropriate substitutions). The estimated abundance of fish in length category *k* in the population is then:

$$\hat{N}_k = \sum_{j=1}^{i} \hat{p}_{jk} \hat{N}_j \qquad (6)$$

where:

$\hat{N}_j$ = the estimated abundance in size stratum *j*; and

i = the number of size strata;

The variance for $\hat{N}_k$ in this case will be estimated using the formulation for the exact variance of the product of two independent random variables (Goodman 1960):

$$\hat{V}\left[\hat{N}_k\right] = \sum_{j=1}^{s} \left(\hat{V}\left[\hat{p}_{jk}\right] \hat{N}_j^2 + \hat{V}\left[\hat{N}_j\right] \hat{p}_{jk}^2 - \hat{V}\left[\hat{p}_{jk}\right] V\left[\hat{N}_j\right] \right) \qquad (7)$$

The estimated proportion of the population in group *k* $\left(\hat{p}_k\right)$ is then:

$$\hat{p}_k = \hat{N}_k \big/ \hat{N} \qquad (8)$$

where:

$$\hat{N} = \sum_{j=1}^{i} \hat{N}_j$$

Variance of the estimated proportion can be approximated with the delta method (Seber 1982):

$$\hat{V}\left[\hat{p}_k\right] \approx \sum_{j=1}^{s} \left\{ \left(\frac{\hat{N}_j}{\hat{N}} \right)^2 \hat{V}\left[\hat{p}_{jk}\right] \right\} + \frac{\sum_{j=1}^{s} \left\{ \hat{V}\left[\hat{N}_j\right] \left(\hat{p}_{jk} - \hat{p}_k \right)^2 \right\}}{\hat{N}^2} \qquad (9)$$

CODED WIRE TAG (CWT) SAMPLING

During weir operations and mark-recapture efforts at Salmon Lake, project staff will be vigilant in monitoring for coho with adipose fin clips, which signifies that those fish may be of hatchery origin. Per ADF&G policy and procedures, any coho salmon identified with an adipose fin clip will be sacrificed and beheaded, with carcasses deposited in Salmon Lake Creek, downstream of the weir, or in the lake if captured during in-lake recapture efforts. Location of fish capture will be recorded, as will fish sex, condition, fin clip status, and length, with each fish being measured to the nearest 5 mm MEF. Heads will be subsequently shipped to the ADF&G Mark, Tag and Age Laboratory for further identification.

SAWMILL COVE HATCHERY BROODSTOCK DEVELOPMENT

Based on ADF&G Sport Fish Division recommendations, Salmon Lake coho (up to 260 adults) will be collected for broodstock during lake-beach seining operations in October. Captured coho will be held for 2 to 4 weeks in net pens anchored in the lake and far from shore to discourage bear interactions. Two or three egg takes will be conducted during the last week of October and the first week of November. Gametes will be collected and transported to Medvejie for fertilization and isolated incubation. Assuming sufficient coho returns to Salmon Lake in 2009 through 2011, three successive years of egg takes will complete the broodstock development phase for NSRAA's Sawmill Cove Hatchery.

SCHEDULE

4/1/09 - 7/1/09	Hiring and purchasing
6/15/2009	Field work begins
7/1/2009	Weir operations begin
9/7/09 - 10/16/09	In-lake recapture events (once per week)
10/17/09 - 11/8/09	Salmon Lake egg-takes
11/1/2009	Weir operations end
11/1/09 - 11/30/09	Data entry completion
12/1/09-2/28/09	Data analysis
3/1/2009	Draft report
3/31/2009	Final Report

RESPONSIBILITIES

NSRAA has conducted CWT projects throughout SE Alaska since the mid-1970's, has operated adult coho and sockeye salmon weirs throughout the region, and has conducted mark-recapture studies with coho and sockeye salmon since the early 1980's. From 1998 to 2005, ADF&G and NSRAA conducted foot and snorkel surveys of Salmon Lake's inlet streams to provide a low-cost indication of abundance for coho salmon in the system. More recently, NSRAA operated the Salmon Lake weir and associated field camp in 2007 and 2008.

NSRAA will be the lead investigator for operations at Salmon Lake in 2009. Tommy Sheridan will supervise weir operations, coordinate data collection for the duration of the season, assist with data collection when necessary, and conduct data analysis and report writing. Elliot Johnson, Brian Leo and Henry Hastings will act as crew members at Salmon Lake, and will assist with any and all aspects of project operations.

PERSONNEL

Tommy Sheridan, Project Supervisor. Supervises project, writes operational plan, and assures the operational plan is followed or modified appropriately given consultation with field crew. Analyzes data and writes report. Supervises crew members. Assists with field work and ensures that operation procedures are followed. Will provide technical direction for data collection to field crew.

Chip Blair, Evaluation Projects Leader. Provides oversight of project and assists with project when necessary; reviews operational plans and reports.

Lon Garrison, Operations Manager. Provides oversight of project and assists with project when necessary; reviews operational plans and reports.

Elliot Johnson, Fisheries Technician. This position will take part in field operations, including safe operation of boats and all related equipment, weir operations, tagging, mark-recapture efforts, data collection, data recording, and general field camp duties.

Brian Leo, Fisheries Technician. This position will take part in field operations, including safe operation of boats and all related equipment, weir operations, tagging, mark-recapture efforts, data collection, data recording, and general field camp duties.

Henry Hastings, Fisheries Technician. This position will take part in field operations, including safe operation of boats and all related equipment, weir operations, tagging, mark-recapture efforts, data collection, data recording, and general field camp duties.

It is anticipated that volunteers will also contribute to this project, all of whom will be provided with the appropriate training regarding field operations, including safe operation of boats and all related equipment, weir operations, tagging, mark-recapture efforts, data collection, data recording, and general field camp duties.

REPORTS

Weekly updates will be provided to ADF&G staff throughout the course of the field season. Upon completion of this study, a final project report will be provided that describes fulfillment of the project objectives and includes a summary of methods, results, and discussion of all aspects of this project.

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APPENDIX

Appendix A1. Detection of size and/or sex selective sampling.

Size selective sampling: The Kolmogorov-Smirnov (K-S) two-sample test (Conover 1980) is used to detect significant evidence that size selective sampling occurred during the first and/or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (M) with that of marked fish recaptured during the second event (R) by using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (C) with that of R. A third test that compares M and C is then conducted and used to evaluate the results of the first two tests when sample sizes are small. Guidelines for small sample sizes are < 30 for R, and < 100 for M or C.

Sex selective sampling: Contingency table analysis (χ^2 test) is generally used to detect significant evidence that sex selective sampling occurred during the first and/or second sampling events. The counts of observed males to females are compared between M and R, C and R, and M and C using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. If the proportions by gender are estimated for a sample (usually C), rather than observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are then compared between samples using a two-sample test (e.g., Student's t-test).

M vs. R	C vs. R	M vs. C
Case I:		
Fail to reject H_o	Fail to reject H_o	Fail to reject H_o
There is no size/sex selectivity detected during either sampling event.		
Case II:		
Reject H_o	Fail to reject H_o	Fail to reject H_o
There is no size/sex selectivity detected during the first event, but there is during the second event.		
Case III:		
Fail to reject H_o	Reject H_o	Reject H_o
There is no size/sex selectivity detected during the second event but there is during the first event sampling.		
Case IV:		
Reject H_o	Reject H_o	Either result possible
There is size/sex selectivity detected during both the first and second sampling events.		
Evaluation Required:		
Fail to reject H_o	Fail to reject H_o	Reject H_o

Samples sizes and powers of tests must be considered:

A. If sample sizes for M vs. R and C vs. R tests are not small and sample sizes for M vs. C tests are very large, the M vs. C test is likely detecting small differences that have little potential to result in bias during estimation. Case I is appropriate.

B. If a) sample sizes for M vs. R are small, b) the M vs. R p-value is not large (~0.20 or less), and c) the C vs. R sample sizes are not small and/or the C vs. R p-value is fairly large (~0.30 or more), then rejection of the null hypothesis in the M vs. C test was likely the result of size/sex selectivity during the second event, which the M vs. R test was not powerful enough to detect. Case I may be considered but Case II is the recommended (conservative) interpretation.

C. If a) sample sizes for C vs. R are small, b) the C vs. R p-value is not large (~0.20 or less) and c) the M vs. R sample sizes are not small and/or the M vs. R p-value is fairly large (~0.30 or more), then rejection of the null hypothesis in the M vs. C test was likely the result of size/sex selectivity during the first event, which the C vs. R test ws not powerful enough to detect. Case I may be considered, but Case III is the recommended (conservative) interpretation.

D. If a) sample sizes for C vs. R and M vs. R are both small, and b) both the C vs. R and M vs. R p-values are not large (~0.20 or less), then rejection of the null hypothesis in the M vs. C test may be the result of size/sex selectivity during both events, which the C vs. R and M vs. R tests were not powerful enough to detect. Cases I, II, or III may be considered, but Case IV is the recommended (conservative) interpretation.

Appendix A1, Page 2 of 2. Detection of size and/or sex selective sampling during a two-sample mark-recapture experiment.

Case I: Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

Case II: Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by M vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance to the formulae below.

Case III: Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by C vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance to the formulae below.

Case IV: Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

If stratification by sex or length is necessary prior to estimating composition parameters, then an overall composition parameter (P_k) is estimated by combining within stratum composition estimates using:

$$\hat{P}_k = \sum_{j=1}^{i} \frac{\hat{N}_j}{\hat{N}_\Sigma} \hat{P}_{jk} \text{; and,} \quad (1)$$

$$\hat{V}[\hat{P}_k] \approx \frac{1}{\hat{N}_\Sigma^2} \left(\sum_{j=1}^{i} \hat{N}_i^2 \, \hat{V}\left[\hat{P}_{jk}\right] + \left(\hat{P}_{ik} - \hat{P}_k\right)^2 \hat{V}\left[\hat{N}_j\right] \right) \quad (2)$$

where: i = the number of sex/size strata;

$\hat{P}_{jk}$ = the estimated proportion of fish that were age or size k among fish in stratum j;

$\hat{N}_j$ = the estimated abundance in stratum j; and,

$\hat{N}_\Sigma$ = the sum of $\hat{N}_j$ across strata;

Appendix A2. Tests of consistency for the Petersen estimator.

Tests of consistency for Petersen estimator (from Seber 1982, page 438)…

Of the following conditions, at least one must be fulfilled to meet assumptions of a Petersen estimator:

1. Marked fish mix completely with unmarked fish between events;
2. Every fish has an equal probability of being captured and marked during event 1; or,
3. Every fish has an equal probability of being captured and examined during event 2.

To evaluate these three assumptions, the χ^2 test statistic will be used to examine the following contingency tables as recommended by Seber (1982). At least one null hypothesis needs to be accepted for assumptions of the Petersen model (Bailey 1951, 1952; Chapman 1951) to be valid. If all three tests are rejected, a geographically stratified estimator (Darroch 1961) should be used to estimate abundance.

I. Test for complete mixing[a]

Area	Area Where Recaptured				Not Recaptured
Where Marked	**1**	**2**	**…**	**t**	(n_1-m_2)
1					
2					
…					
s					

II. Test for Equal Probability of capture during the first event[b]

	Area Where Examined			
	1	**2**	**…**	**t**
Marked (m_2)				
Unmarked (n_2-m_2)				

III. Test for equal probability of capture during the second event[C]

	Area Where Marked			
	1	**2**	**…**	**s**
Recaptured (m_2)				
Not Recaptured (n_1-m_2)				

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[a] This tests the hypothesis that movement probabilities (θ) from area i (i = 1, 2, ...s) to area j (j = 1, 2, ...t) are the same among areas: H_0: $\theta_{ij} = \theta_j$.

[b] This tests the hypothesis of homogeneity on the columns of the 2-by-t contingency table with respect to the marked to unmarked ratio among areas: H_0: $\Sigma_i a_i \theta_{ij} = kU_j$, where k = total marks released/total unmarked in the population, U_j = total unmarked fish in stratum j at the time of sampling, and a_i = number of marked fish released in stratum i.

[c] This tests the hypothesis of homogeneity on the columns of this 2-by-s contingency table with respect to recapture probabilities among the river areas: H_0: $\Sigma_j \theta_{ij} p_j = d$, where p_j is the probability of capturing a fish in area j during the second event, and d is a constant

Appendix A3. 2009 Salmon Lake Coho Weir Sampling Form

2009 Salmon Lake Coho Weir Sampling Form

Page __ of __

Date:____

Water depth:______________________ Weather Conditions:____

Fish #	Tag #	Tag Color	Card Fish #	CWT?	Length	Sex	Condition	Comments
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								

Notes/Comments:

1. Fish condition: bright (BRT), blush (BLU), dark (DRK), live post-spawn (LPS), dead (MORT).

2. Measure length to the nearest 5mm MEF.

Appendix A4. 2009 Salmon Lake Coho Capture/Recapture Sampling Form

Salmon Lake Coho CAPTURE/RECAPTURE FORM 2009 Page___ of___

Date: ____ Samplers:___________________

Fish #	Location	Recapture?	Tag #	Tag Color	CWT?	Sex	Length	Gear Used	Condition	Comments
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										

Notes/Comments:

1. Fish condition: bright (BRT), blush (BLU), dark (DRK), live post-spawn (LPS), dead (MORT).

2. Measure length to the nearest 5mm MEF.

Appendix A5. 2009 Salmon Lake Weir Cumulative Fish Passing Form

2009 SALMON LAKE WEIR CUMULATIVE FISH PASSING FORM									
Date	Adult Sockeye	Jack Sockeye	Adult Coho	Jack Coho	Dolly V.	Steelhead	Pink	Chum	King
Daily Total									
Daily Total									
Daily Total									
Daily Total									
Daily Total									
Daily Total									
Daily Total									
Daily Total									
Daily Total									
Daily Total									
Daily Total									
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Daily Total									
Daily Total									

Appendix A6. 2009 Salmon Lake Operculum Punch Schedule

SCHEDULE OF OPERCULUM PUNCHES AT
SALMON LAKE 2009

Week	Operculum Punch
August 14 – August 20	Lower Left
August 21 – August 27	Center Left
August 28 – September 3	Upper Left
September 4 – September 10	Lower Right
September 11 – September 17	Center Right
September 18 – September 24	Upper Right
September 25 – October 1	Lower Left Left
October 2 – October 8	Center Left Left
October 9 – October 15	Upper Left Left
October 16– October 22	Lower Right Right
October 23 – October 29	Center Right Right
October 30 – October 31	Lower Left