U.S. Fish and Wildlife Service
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# Sitkoh Lake Sockeye Stock Assessment, 2010


2010 Annual Report for Study 10-605

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(Cover photo:  Jonathon Zuboff (Angoon Community Association) takes a sockeye salmon out of the beach seine at Sitkoh Lake.)

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## ABSTRACT

We estimated the annual abundance of sockeye spawning in a "study area" of Sitkoh Lake in 2010 using data from four, two-day, mark-recapture trips. The numbers of beach spawners in this "study area" adjacent to the West U.S. Forest Service cabin was then compared to similar modified Jolly-Seber mark-recapture estimates from 1997 to 2006 to assess the relative strength of the 2010 escapement. In 2010, 9,665 (CV=7%) sockeye spawned in the study area which was the second highest on record. Other indices computed using the mark-recapture data also show a high relative abundance of Sitkoh sockeye spawners in 2010.

## INTRODUCTION

Sitkoh sockeye salmon have long been an important subsistence resource for residents of Angoon and other rural communities in northern Southeast Alaska and this stock has been fished commercially beginning in the late 1800s (de Laguna 1960, George and Bosworth 1988, Goldschmidt and Haas 1998, Thornton et al., 1990). Sitkoh Lake is near the junction of Chatham and Peril Straits (Figure 1) and sockeye salmon returning to Sitkoh Lake contribute to the commercial purse seine and troll fisheries that target pink, chum and other salmon species returning to, or transiting, Chatham and Peril Straits.

The Alaska Department of Fish and Game and the U.S. Forest Service have funded weir projects to estimate the Sitkoh sockeye escapement in 1982 and 1996 (Kelley and Josephson 1997) and spawning area mark-recapture projects to index the annual escapement into the lake from 1997 through 2006 (Cook 1998; Crabtree 2000; Crabtree 2001; Conitz and Cartwright 2002, 2003, 2005, 2007; Burril and Conitz 2007; and Conitz and Burril 2008).

These spawning area mark-recapture estimates have helped in monitoring the annual escapement of sockeye salmon into Sitkoh Lake. Project findings have shown abundances to be variable and without trend – "study area" abundances from 1997 to 2006 ranged from a low of 2,100 in 2004 to a high of 12,300 in 2000.

This project was reinstated in 2010 since it is important to know if escapements are adequate to sustain runs and subsistence opportunity and to assess consequences of management actions related to both fishing and land use activities. This indexing project works well for this location because the sockeye do not spawn in inlet streams and there appears to be a single run of sockeye salmon with spawning concentrated in seineable beaches near the West Forest Service cabin "study area".

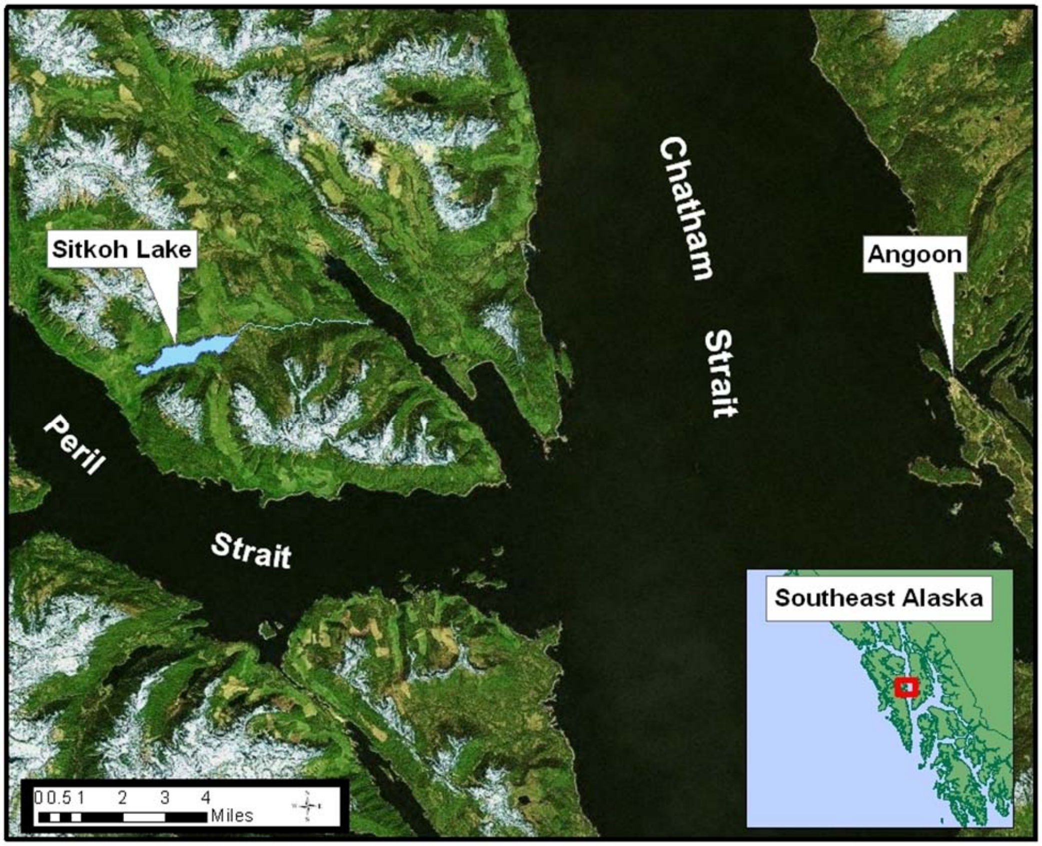


Figure 1. Map of Sitkoh Lake and the surrounding area.

In past years the number of fish estimated in the study area was also expanded by the fraction of fish observed in the rest of the lake but these boat surveys around the perimeter of the lake were not done in 2010 since the expanded estimates were highly correlated with the study area estimates and the counting rates were affected by differences in fish densities in and out of the study area.

## OBJECTIVES

1. Index the annual escapement of sockeye salmon into Sitkoh Lake using mark-recapture methods so that the estimated coefficient of variation is less than 20%.
2. Estimate the age, sex, and length composition of the sockeye salmon spawning in Sitkoh Lake with a coefficient of variation less than 20% for the principal age class.

## METHODS

This project uses mark-recapture methods to index the abundance of sockeye spawning in the "study area" adjacent to the U.S. Forest Service's West Cabin (Cook 1998; Crabtree 2000, 2001; Conitz and Cartwright 2003, 2005, 2007; Burril and Conitz 2007; and Conitz and Burril 2008). Sockeye salmon were also sampled for scale (age), sex, and length (ASL) data using standard ADF&G methods.

### Mark-Recapture

In 2010, four, two-day mark-recapture trips were made to beach seine and mark-recapture sockeye salmon in the predefined "study area". Sampling trips were on September 6-7, September 20-21, October 4-5, and October 19-20 in 2010. These dates correspond to when approximately 20%, 40%, 60%, and 80% of the sockeye salmon have been observed in the study area.

The "study area" extended along the beach from just east of the island approximately 57.503265°N latitude, -135.097682°W longitude (WGS84 datum) to one set east of the West Forest Service cabin at 57.506710°N latitude, -135.091936°W longitude. This is the same basic study area used in past years although in 1999 and 2000 some additional sets were also made farther east along the beach in an area called "Clyde's Hole".

The Forest Service has two public use cabins on Sitkoh Lake, one at the lake outlet, the "East" cabin and one on the Northwest side of the lake, the "West" cabin. Project personnel were able to reserve and stay at the "West" cabin which is immediately adjacent to the defined "study area". The cabin rental includes the use of a 16' aluminum flat-bottom skiff.

Each sampling trip took two days. A series of 9 to 13 beach seine hauls were made to capture fish each day in the pre-defined "study area". The seine sets were done in a relatively consistent manner on each beach, on each day, and on each trip. Along much of the study area, the next set would begin where the prior set ended whenever there were fish to be caught. The fish were captured by setting a beach seine off the bow of the cabin skiff powered either by a small outboard or oars. The seine measured 60' x 10' and had black 2" stretch-measure nylon webbing made with #13 twine.

Sockeye captured the first day of a trip were given a left opercule punch mark. Sockeye captured the second day were given a right opercule punch mark and a left opercule punch mark if it was not already marked the day before. A different punch was used each trip – round, square, triangle, and heart. Records were kept of the number of fish marked and recaptured each set. Sampling was done without replacement.

I expect that some new fish migrate into the study area between the marking day and the recapture day. Thus, the mark-recapture estimate is the abundance in the study area on the second day, the day of recapture. The estimates are not affected if marked and unmarked fish die at the same rate but fish were not marked on the first day if they were so old and weak that they would likely die before being sampled the following day.

I used Chapman's (1952, Page 287-288) "inverse sampling" formulas, converted here to the notation of Ricker (1975), to get unbiased estimates of the population size ( $\hat{N}$ ) and variance $(Var(\hat{N}))$ when recaptures (*R*) number 3-4 or more (Chapman, 1952, Ricker 1975, and Seber 2002). The number of fish to mark (*M*) were the number marked in the 9 to 13 seine sets on the first day of each trip. The unknown variable was how many fish need to be examined for marks (*C*) on the second day of each trip to get enough recaptures (*R*). Past studies have found that nearly half of the sockeye present in the study area can be captured and marked or examined for marks in the series of seine hauls made from one end of the study area to the other. The high marking and recapture rates yield estimates with low variances and coefficient of variations.

Sampling with or without replacement, the formula for $\hat{N}$ is the same as for the simple Petersen (aka. Lincoln-Petersen) estimate, which is:

$$\hat{N} = \frac{M * C}{R} \qquad (1)$$

and, the unbiased estimate of variance is:

$$Var(\hat{N}) = \frac{CM^2(C-R)}{R^3} \qquad (2)$$

And, the coefficient of variation is:

$$CV\% = \frac{\sqrt{Var(\hat{N})}}{\hat{N}} * 100 \qquad (3)$$

In this study, I expect the coefficient of variation for the escapement estimate to be less than 15% when more than 40 fish are recaptured (Table 1) regardless of the population size. In reality, with up to 50% of the sockeye marked and examined for marks in the study area we expect hundreds of recoveries each trip that fish are relatively abundant.

Table 1. Sampling goals for the number you need to recapture (*R*), and number you'll probably examine for marks (*C*), at different marked rates and levels of precision (CV%) around the population estimate ( $\hat{N}$ ) for direct or indirect sampling with or without replacement (modified from Table 1 in Appendix C in Van Alen 2008).

| Marked Rate[a] (intended or observed) | Desired CV% | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 5% | | 10% | | 15% | | 20% | | 25% | | 30% | |
| | Sampling Goals for Recaptures (*R*) and the expected number to examine for marks (*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 statistical bias of *R* < 1 (Ricker 1975 p. 79).

Calculations:
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

The Peterson estimates of sockeye abundance each trip ( $\hat{N}_i$ ) and the number of recaptures from previous trips were used in a modified Jolly-Seber estimator (Cook 1998) to estimate the total spawning population (N*) within the study area. These calculations are detailed in the column headings of Table 2. Prior studies (Conitz and Cartwright 2002, 2003, 2005, 2007; Burril and Conitz 2007; Conitz and Burril 2008) used a parametric bootstrap method to estimate confidence intervals and the coefficient of variation (CV) around N*. We were unable to repeat those calculations but we show that these CV's are close to the sum of the Standard Error of $\hat{N}_i$ divided by the sum of $\hat{N}_i$ 's (Table 2).

### Age, Sex, and Length

Three hundred and twenty four sockeye salmon were sampled from the study area for scale (age), sex, and length data (ASL). Samples were collected roughly in proportion to abundance with 64, 120, 100, and 40 fish sampled in trips one to four, respectively. Scale sampling and processing methods followed standard ADF&G procedures (ADF&G 2001). Tweezers were used to pluck three scales from the preferred area on the left side of the each fish (INPFC 1963). Scales were mounted on gummed "scale cards" (Clutter and Whitesel 1956) and sex and length data recorded directly on optical scanner data forms. Mid-eye to fork length was measured to the nearest half-centimeter by laying each fish on a fixed ruler on a measuring board. Scales were aged at the ADF&G, Commercial Fisheries Division, Salmon Aging Laboratory in Douglas, Alaska. Age classes were recorded in European notation where a period separates the number of fresh water and marine annuli (Koo 1962). The total age of the fish is the sum of these two numbers plus one – the first year (winter) when the fish was an egg/alevin in the redd.

## RESULTS

### Mark-Recapture

Four, two-day, mark-recapture trips were made in 2010 (Table 2). The 2-day Peterson estimates of sockeye spawning in the study area were 543 (CV 6%), 587 (CV 4%), 1,363 (CV 9%) and 839 (CV 6%) for September 7, September 21, October 5, and October 20, respectively. The modified Jolly-Seber estimate of the total number of sockeye spawning in the study area (N*) was 9,665 with an approximate coefficient of variation of 7%. This was the second highest abundance observed since this study was initiated in 1997 (Table 2 and 3). If we had expanded this estimate by boat survey counts around the perimeter of the lake the escapement into the lake would be indexed at 15,000, again, the second highest observed since 1997 (Table 3, Figure 2).

Table 2. Modified Jolly-Seber mark-recapture estimates (N*) of the number of sockeye spawning in the study area adjacent to the West Sitkoh Lake Forest Service cabin, 1997 to 2006 and 1010.

| Year | Trip # | Dates | New Fish Marked on Day 1 (M) | New Fish Marked on Day 2 | Recap-tures on Day 2 (R) | Total Caught on Day 2 (C) | 2-Day Petersen Estimate $(N_i)$[a] | Variance of $N_i$[a] | Std. Error of $N_i$ | 95% CI (lower)[b] | 95% CI (upper)[b] | cv($N_i$) | Marks from Trip 1 | Marks from Trip 2 | Marks from Trip 3 | m = total number recaps this trip | n = total caught (and marked) each trip | M = $m^*N_i/n$ | $\phi = M_{i+1}$ / (M-m+n) | B = $N_{i+1}$ - $\phi$N | B* = B log($\phi$)/($\phi$-1) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1997 | 1 | 8/25-26 | 75 | 116 | 61 | 177 | 218 | 509 | 23 | 169 | 280 | 10.4% | | | | 0 | 191 | 0 | 0.340 | 329 | 660 |
| | 2 | 9/8-10 | 264 | 84 | 159 | 243 | 403 | 354 | 19 | 345 | 471 | 4.7% | 56 | | | 56 | 348 | 65 | 0.093 | 980 | 2,569 |
| | 3 | 9/24-25 | 630 | 262 | 426 | 688 | 1,017 | 925 | 30 | 925 | 1,119 | 3.0% | 0 | 29 | | 29 | 892 | 33 | 0.028 | 344 | 1,264 |
| | 4 | 10/15-16 | 217 | 95 | 133 | 228 | 372 | 434 | 21 | 314 | 441 | 5.6% | 0 | 0 | 21 | 21 | 312 | 25 | 0.000 | 0 | |
| | | | | | | | Approximated CV% (sum of S.E./sum of $N_i$) = | | | | | 5% | | | | | | | | N* for 1997 = | 4,493 |
| 1998 | 1 | 9/9-10 | 410 | 101 | 113 | 214 | 776 | 2,518 | 50 | 646 | 933 | 6.5% | | | | 0 | 511 | 0 | 0.103 | 534 | 1,556 |
| | 2 | 9/28-29 | 283 | 208 | 178 | 386 | 614 | 1,140 | 34 | 530 | 711 | 5.5% | 42 | | | 42 | 491 | 52 | 0.000 | 0 | |
| | | | | | | | Approximated CV% (sum of S.E./sum of $N_i$) = | | | | | 6% | | | | | | | | N* for 1998 = | NA (<3 trips) |
| 1999 | 1 | 9/15-16 | 601 | 258 | 350 | 608 | 1,044 | 1,322 | 36 | 940 | 1,159 | 3.5% | | | | 0 | 859 | 0 | 0.024 | 1,403 | 5,453 |
| | 2 | 10/4-5 | 717 | 387 | 390 | 777 | 1,428 | 2,606 | 51 | 1,294 | 1,577 | 3.6% | 16 | | | 16 | 1,104 | 21 | 0.138 | 1,247 | 2,866 |
| | 3 | 10/20-21 | 802 | 274 | 342 | 616 | 1,445 | 2,714 | 52 | 1,299 | 1,606 | 3.6% | 0 | 114 | | 114 | 1,076 | 153 | 0.000 | 0 | |
| | | | | | | | Approximated CV% (sum of S.E./sum of $N_i$) = | | | | | 4% | | | | | | | | N* for 1999 = | 8,319 |
| 2000 | 1 | 8/22-24 | 328 | 112 | 203 | 315 | 509 | 454 | 21 | 444 | 584 | 4.2% | | | | 0 | 440 | 0 | 0.046 | 1,412 | 4,646 |
| | 2 | 9/15-17 | 488 | 365 | 188 | 553 | 1,435 | 7,234 | 85 | 1,244 | 1,656 | 5.9% | 12 | | | 12 | 860 | 20 | 0.356 | 767 | 1,230 |
| | 3 | 9/27-29 | 389 | 411 | 180 | 591 | 1,277 | 6,302 | 79 | 1,104 | 1,478 | 6.2% | 0 | 224 | | 224 | 927 | 309 | 0.017 | 1,564 | 6,487 |
| | 4 | 10/16-18 | 767 | 430 | 403 | 833 | 1,585 | 3,220 | 57 | 1,438 | 1,748 | 3.6% | 0 | 1 | 12 | 13 | 1,203 | 17 | 0.000 | 0 | |
| | | | | | | | Approximated CV% (sum of S.E./sum of $N_i$) = | | | | | 5% | | | | | | | | N* for 2000 = | 12,364 |
| 2001 | 1 | 8/28-29 | 281 | 171 | 125 | 296 | 665 | 2,046 | 45 | 559 | 793 | 6.8% | | | | 0 | 452 | 0 | 0.303 | 372 | 984 |
| | 2 | 9/9-10 | 277 | 134 | 125 | 259 | 574 | 1,363 | 37 | 482 | 684 | 6.4% | 98 | | | 98 | 411 | 137 | 0.042 | 1,092 | 3,623 |
| | 3 | 9/26-27 | 679 | 215 | 334 | 549 | 1,116 | 1,461 | 38 | 1,003 | 1,242 | 3.4% | 0 | 15 | | 15 | 894 | 19 | 0.070 | 1,022 | 2,917 |
| | 4 | 10/10-11 | 370 | 239 | 121 | 360 | 1,101 | 6,649 | 82 | 921 | 1,315 | 7.4% | 0 | 3 | 32 | 35 | 609 | 63 | 0.063 | 434 | 1,279 |
| | 5 | 10/25-25 | 149 | 164 | 69 | 233 | 503 | 2,582 | 51 | 398 | 637 | 10.1% | 0 | 2 | 4 | 25 | 313 | 40 | 0.000 | 0 | |
| | | | | | | | Approximated CV% (sum of S.E./sum of $N_i$) = | | | | | 6% | | | | | | | | N* for 2001 = | 8,803 |
| | | | | | | | | | | | | | | | | | | | | Bootstrap Calculated CV = | not reported |
| 2002 | 1 | 8/20-22 | 77 | 83 | 38 | 121 | 245 | 1,085 | 33 | 179 | 337 | 13.4% | | | | 0 | 160 | 0 | 0.278 | 429 | 881 |
| | 2 | 9/4-6 | 252 | 105 | 108 | 213 | 497 | 1,127 | 34 | 412 | 600 | 6.8% | 32 | | | 32 | 357 | 45 | 0.077 | 573 | 1,593 |
| | 3 | 9/19-21 | 358 | 116 | 164 | 280 | 611 | 944 | 31 | 525 | 712 | 5.0% | 1 | 21 | | 22 | 474 | 28 | 0.143 | 677 | 1,538 |
| | 4 | 10/2-4 | 387 | 159 | 163 | 322 | 765 | 1,771 | 42 | 656 | 891 | 5.5% | 0 | 7 | 42 | 49 | 546 | 69 | 0.055 | 705 | 2,167 |
| | 5 | 10/17-19 | 342 | 213 | 180 | 393 | 747 | 1,679 | 41 | 645 | 864 | 5.5% | 0 | 0 | 0 | 23 | 555 | 31 | 0.006 | 211 | 1,093 |
| | 6 | 11/4-5 | 83 | 48 | 30 | 78 | 216 | 955 | 31 | 151 | 308 | 14.3% | 0 | 0 | 0 | 2 | 131 | 3 | 0.000 | 0 | |
| | | | | | | | Approximated CV% (sum of S.E./sum of $N_i$) = | | | | | 7% | | | | | | | | N* for 2002 = | 7,272 |
| | | | | | | | | | | | | | | | | | | | | Bootstrap Calculated CV = | 6% |

(continued)

Table 2. (Continued, page 2 of 2)

| Year | Trip # | Dates | New Fish Marked on Day 1 (M) | New Fish Marked on Day 2 | Recap-tures on Day 2 (R) | Total Caught on Day 2 (C) | 2-Day Petersen Estimate $(N_i)^a$ | Variance of $N_i^a$ | Std. Error of $N_i$ | 95% CI (lower)[b] | 95% CI (upper)[b] | $cv(N_i)$ | Marks from Trip 1 | Marks from Trip 2 | Marks from Trip 3 | Marks from Trip 4 | Marks from Trip 5 | m = total number recaps this trip | n = total caught (and marked) each trip | M = $m*N_i/n$ | $\phi = M_{i+1}/(M-m+n)$ | $B = N_{i+1} - \phi N$ | $B^* = B \log(\phi)/(\phi-1)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2003 | 1 | 8/28-29 | 131 | 131 | 59 | 190 | 422 | 2,080 | 46 | 327 | 544 | 10.8% | | | | | | 0 | 262 | 0 | 0.113 | 656 | 1,728 |
| | 2 | 9/11-12 | 434 | 158 | 254 | 412 | 704 | 748 | 27 | 623 | 796 | 3.9% | 25 | | | | | 25 | 592 | 30 | 0.094 | 740 | 1,933 |
| | 3 | 9/26-27 | 472 | 133 | 188 | 321 | 806 | 1,431 | 38 | 699 | 930 | 4.7% | 5 | 37 | | | | 42 | 605 | 56 | 0.093 | 460 | 1,204 |
| | 4 | 10/9-10 | 248 | 133 | 115 | 248 | 535 | 1,334 | 37 | 446 | 642 | 6.8% | 0 | 1 | 40 | | | 41 | 381 | 58 | 0.037 | 70 | 240 |
| | 5 | 10/22-23 | 45 | 16 | 16 | 32 | 90 | 253 | 16 | 55 | 146 | 17.7% | 0 | 0 | 0 | 10 | | 10 | 61 | 15 | 0.000 | 0 | |
| | | | | | | | Approximated CV% (sum of S.E./sum of $N_i$) = | | | | | 6% | | | | | | | | | | N* for 2003 = | 5,105 |
| | | | | | | | | | | | | | | | | | | | | | | Bootstrap Calculated CV = | 5% |
| 2004 | 1 | 9/6-7 | 134 | 41 | 53 | 94 | 238 | 465 | 22 | 182 | 311 | 9.1% | | | | | | 0 | 175 | 0 | 0.103 | 363 | 981 |
| | 2 | 9/17-18 | 186 | 93 | 86 | 179 | 387 | 905 | 30 | 313 | 478 | 7.8% | 13 | | | | | 13 | 279 | 18 | 0.085 | 331 | 892 |
| | 3 | 10/1-2 | 232 | 69 | 121 | 190 | 364 | 398 | 20 | 305 | 435 | 5.5% | 0 | 20 | | | | 20 | 301 | 24 | 0.153 | 112 | 249 |
| | 4 | 10/15-16 | 71 | 26 | 19 | 45 | 168 | 860 | 29 | 108 | 263 | 17.4% | 0 | 0 | 27 | | | 27 | 97 | 47 | 0.000 | 0 | |
| | | | | | | | Approximated CV% (sum of S.E./sum of $N_i$) = | | | | | 9% | | | | | | | | | | N* for 2004 = | 2,121 |
| | | | | | | | | | | | | | | | | | | | | | | Bootstrap Calculated CV = | 9% |
| 2005 | 1 | 9/2-3 | 240 | 57 | 123 | 180 | 351 | 318 | 18 | 294 | 419 | 5.1% | | | | | | 0 | 297 | 0 | 0.216 | 779 | 1,671 |
| | 2 | 9/13-14 | 419 | 181 | 174 | 355 | 855 | 2,141 | 46 | 737 | 992 | 5.4% | 45 | | | | | 45 | 600 | 64 | 0.375 | 704 | 1,105 |
| | 3 | 9/22-23 | 452 | 223 | 176 | 399 | 1,025 | 3,334 | 58 | 884 | 1,188 | 5.6% | 8 | 145 | | | | 153 | 675 | 232 | 0.125 | 631 | 1,501 |
| | 4 | 10/5-6 | 498 | 156 | 298 | 454 | 759 | 664 | 26 | 677 | 850 | 3.4% | 0 | 1 | 80 | | | 81 | 654 | 94 | 0.076 | 610 | 1,703 |
| | 5 | 10/18-19 | 388 | 166 | 230 | 396 | 668 | 813 | 29 | 587 | 760 | 4.3% | 0 | 0 | 0 | 42 | | 42 | 554 | 51 | 0.048 | 134 | 429 |
| | 6 | 11/2-3 | 58 | 41 | 22 | 63 | 166 | 816 | 29 | 110 | 252 | 17.2% | 0 | 0 | 0 | 3 | 13 | 16 | 99 | 27 | 0.000 | 0 | |
| | | | | | | | Approximated CV% (sum of S.E./sum of $N_i$) = | | | | | 5% | | | | | | | | | | N* for 2005 = | 6,409 |
| | | | | | | | | | | | | | | | | | | | | | | Bootstrap Calculated CV = | 3% |
| 2006 | 1 | 8/25-26 | 108 | 44 | 71 | 115 | 175 | 165 | 13 | 139 | 221 | 7.3% | | | | | | 0 | 152 | 0 | 0.505 | 414 | 693 |
| | 2 | 9/8-9 | 329 | 109 | 207 | 316 | 502 | 420 | 21 | 438 | 575 | 4.1% | 67 | | | | | 67 | 438 | 77 | 0.423 | 455 | 679 |
| | 3 | 9/20-21 | 467 | 115 | 268 | 383 | 667 | 499 | 22 | 592 | 752 | 3.3% | 1 | 164 | | | | 165 | 582 | 189 | 0.118 | 961 | 2,330 |
| | 4 | 10/3-4 | 442 | 388 | 287 | 675 | 1,040 | 2,164 | 47 | 926 | 1,167 | 4.5% | 0 | 1 | 56 | | | 57 | 830 | 71 | 0.081 | 632 | 1,729 |
| | 5 | 10/16-17 | 376 | 200 | 221 | 421 | 716 | 1,103 | 33 | 628 | 817 | 4.6% | 0 | 0 | 0 | 55 | | 55 | 576 | 68 | 0.009 | 226 | 1,084 |
| | 6 | 11/2-3 | 206 | 23 | 182 | 205 | 232 | 33 | 6 | 201 | 268 | 2.5% | 0 | 0 | 0 | 3 | 2 | 5 | 229 | 5 | 0.000 | 0 | |
| | | | | | | | Approximated CV% (sum of S.E./sum of $N_i$) = | | | | | 4% | | | | | | | | | | N* for 2006 = | 6,514 |
| | | | | | | | | | | | | | | | | | | | | | | Bootstrap Calculated CV = | 4% |
| 2010 | 1 | 9/6-7 | 279 | 121 | 128 | 249 | 543 | 1,118 | 33 | 457 | 645 | 6.2% | | | | | | 0 | 400 | 0 | 0.194 | 482 | 1,195 |
| | 2 | 9/20-21 | 366 | 119 | 197 | 316 | 587 | 659 | 26 | 511 | 675 | 4.4% | 64 | | | | | 64 | 485 | 77 | 0.018 | 1,353 | 5,555 |
| | 3 | 10/4-5 | 330 | 288 | 92 | 380 | 1,363 | 15,305 | 124 | 1,111 | 1,672 | 9.1% | 2 | 2 | | | | 4 | 618 | 9 | 0.029 | 799 | 2,915 |
| | 4 | 10/19-20 | 357 | 247 | 183 | 430 | 839 | 2,209 | 47 | 726 | 970 | 5.6% | 0 | 1 | 12 | | | 13 | 604 | 18 | 0.000 | 0 | |
| | | | | | | | Approximated CV% (sum of S.E./sum of $N_i$) = | | | | | 7% | | | | | | | | | | N* for 2010 = | 9,665 |

[a] Petersen, direct sampling with or without replacement (Ricker 1975, page 78, equations 3.5 and 3.6):

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

[b] Confidence interval for R>50:

$$-95\%CI = M * C/(R + 1.92 + 1.960 * \sqrt{R + 1.0}) \qquad +95\%CI = M * C/(R + 1.92 - 1.960 * \sqrt{R + 1.0})$$

[c]The numbers reported for 1997 are from Appendix 5 in Cook (1998). These numbers differ slightly from those in report tables but the total estimate (N*) of 4,488 is close to the 4, 493 reported here.

Table 3. Abundance indices for sockeye salmon in Sitkoh Lake, 1997 to 2006 and 2010.

| Year | Modified Jolly-Seber Mark-Recapture Estimate in Study Area (as previously reported) | Modified Jolly-Seber Mark-Recapture Estimate in Study Area (as reported here) | Expanded Estimate for the Whole Lake Based on Boat Survey Counts (as previously reported) | Study Area Abundance on 9/7 | Study Area Abundance on 9/21 | Study Area Abundance on 10/5 | Study Area Abundance on 10/22 | Sum of Study Area Abundance Estimates on 9/7, 9/21, 10/5, and 10/22. | Sum of Interpolated Daily Estimates from August 1 to November 30 |
|---|---|---|---|---|---|---|---|---|---|
| 1997 | 4,488 | 4,493 | 5,984 | 338 | 906 | 807 | 304 | 2,355 | 37,360 |
| 1998 | | **4,047** [a] | 6,649 | 770 | 701 | 560 | 430 | 2,461 | 53,759 |
| 1999 | 8,318 | 8,319 | 10,499 | 852 | 1,157 | 1,428 | 1,461 | 4,899 | 107,824 |
| 2000 | 12,362 | 12,364 | 17,040 | 1,146 | 1,403 | 1,345 | 1,584 | 5,478 | 118,616 |
| 2001 | 8,788 | 8,803 | 14,134 | 574 | 938 | 1,170 | 774 | 3,457 | 66,042 |
| 2002 | 7,254 | 7,272 | 11,915 | 508 | 611 | 771 | 747 | 2,637 | 46,765 |
| 2003 | 5,100 | 5,105 | 8,700 | 615 | 807 | 667 | 206 | 2,295 | 38,467 |
| 2004 | 2,100 | 2,121 | 3,700 | 238 | 401 | 332 | 135 | 1,106 | 17,438 |
| 2005 | 6,400 | 6,409 | 13,400 | 534 | 1,011 | 775 | 668 | 2,988 | 45,579 |
| 2006 | 6,700 | 6,514 | 14,800 | 461 | 667 | 1,038 | 661 | 2,827 | 45,630 |
| 2010 | | 9,665 | **15,324** [b] | 543 | 587 | 1,363 | 873 | 3,366 | 64,972 |

[a]Estimated from the linear regression on the whole lake estimate.

[b]Estimated from the linear regression on the modified Jolly-Seber estimate.

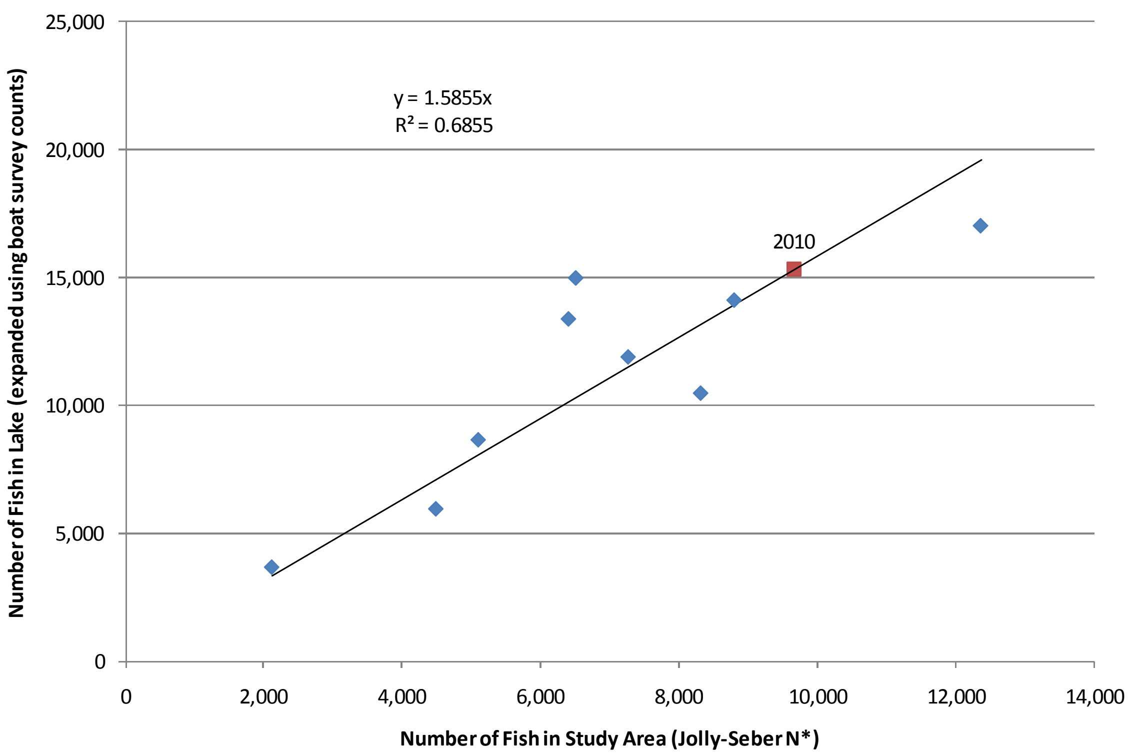


Figure 2. Relationship between the estimated number of sockeye salmon in Sitkoh Lake and the estimated number in the study area in 1997 and 1999 to 2006 and what the prediction would be for 2010.

Assuming that nearly all the sockeye salmon are in the study area from August 1 to November 30 each year, I interpolated the daily abundances between these dates using the 2-day Peterson estimates (Table 4) and summed the four estimates obtained every 14th day from September 7 to September 22 as another standardized index of abundance (Table 3). Both the sum of these estimates and the sum of the daily interpolated estimates from August 1 to November 30 find the 2010 abundance the fourth highest in the past 11 years (Table 3). Excluding 1999 and 2000, when the study area was extended to include “Clyde’s Hole”, there is a good correlation ($R^2$ = 0.96) between these daily interpolated estimates and the modified Jolly-Seber estimate of the number of sockeye salmon in the study area (Figure 3). Run strength and timing differences are evident between years (Figures 4 and 5).

Table 4. Direct (bold) and interpolated estimates of the daily number of sockeye salmon in the study area in Sitkoh Lake, 1997 to 2006 and 2010.

| Date | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8/1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | 0 |
| 8/2 | 7 | 38 | 24 | 14 | 45 | 9 | 12 | 1 | | | 23 |
| 8/3 | 13 | 75 | 49 | 30 | 88 | 18 | 24 | 2 | | | 45 |
| 8/4 | 20 | 111 | 73 | 45 | 130 | 27 | 36 | 4 | | | 67 |
| 8/5 | 27 | 146 | 97 | 62 | 170 | 37 | 49 | 6 | | | 89 |
| 8/6 | 35 | 180 | 121 | 79 | 209 | 47 | 61 | 8 | | | 110 |
| 8/7 | 42 | 213 | 145 | 97 | 246 | 57 | 74 | 11 | | | 130 |
| 8/8 | 50 | 245 | 169 | 116 | 281 | 68 | 88 | 14 | | | 150 |
| 8/9 | 57 | 276 | 193 | 135 | 315 | 79 | 101 | 17 | | 0 | 170 |
| 8/10 | 65 | 307 | 217 | 155 | 348 | 90 | 115 | 21 | | 3 | 189 |
| 8/11 | 74 | 336 | 241 | 176 | 379 | 101 | 129 | 24 | | 7 | 208 |
| 8/12 | 82 | 364 | 264 | 197 | 408 | 113 | 143 | 28 | | 12 | 226 |
| 8/13 | 91 | 392 | 288 | 219 | 435 | 125 | 158 | 33 | | 19 | 244 |
| 8/14 | 99 | 418 | 311 | 242 | 462 | 137 | 172 | 37 | | 26 | 261 |
| 8/15 | 108 | 444 | 335 | 266 | 486 | 149 | 187 | 42 | | 33 | 278 |
| 8/16 | 117 | 468 | 358 | 290 | 509 | 162 | 203 | 48 | | 42 | 295 |
| 8/17 | 127 | 492 | 381 | 315 | 530 | 175 | 218 | 53 | | 52 | 311 |
| 8/18 | 136 | 515 | 405 | 341 | 550 | 189 | 234 | 59 | | 62 | 326 |
| 8/19 | 146 | 537 | 428 | 367 | 569 | 202 | 250 | 65 | | 73 | 341 |
| 8/20 | 155 | 557 | 451 | 394 | 585 | 216 | 266 | 72 | 0 | 85 | 356 |
| 8/21 | 165 | 577 | 474 | 422 | 600 | 230 | 282 | 78 | 5 | 98 | 370 |
| 22-Aug | 176 | 596 | 497 | 450 | 614 | **245** | 299 | 85 | 22 | 112 | 384 |
| 23-Aug | 186 | 614 | 519 | 479 | 626 | 260 | 316 | 93 | 41 | 126 | 397 |
| 24-Aug | 196 | 631 | 542 | **509** | 636 | 276 | 333 | 100 | 61 | 142 | 410 |
| 25-Aug | 207 | 647 | 565 | 541 | 645 | 294 | 350 | 108 | 83 | 158 | 423 |
| 26-Aug | **218** | 662 | 587 | 577 | 653 | 311 | 368 | 116 | 106 | **175** | 435 |
| 27-Aug | 228 | 677 | 610 | 617 | 658 | 329 | 386 | 125 | 131 | 194 | 446 |
| 28-Aug | 237 | 690 | 632 | 659 | 662 | 348 | 404 | 134 | 158 | 214 | 457 |
| 29-Aug | 246 | 702 | 655 | 704 | **665** | 366 | **422** | 143 | 186 | 237 | 468 |
| 30-Aug | 253 | 714 | 677 | 751 | 664 | 385 | 441 | 152 | 216 | 261 | 478 |
| 31-Aug | 261 | 724 | 699 | 799 | 658 | 403 | 461 | 162 | 247 | 286 | 488 |
| 1-Sep | 268 | 733 | 721 | 849 | 649 | 421 | 483 | 172 | 280 | 311 | 497 |
| 2-Sep | 277 | 742 | 743 | 899 | 637 | 438 | 504 | 182 | 315 | 337 | 506 |
| 3-Sep | 286 | 750 | 765 | 950 | 623 | 454 | 527 | 193 | **351** | 363 | 514 |
| 4-Sep | 296 | 756 | 787 | 1,001 | 609 | 470 | 549 | 204 | 391 | 389 | 522 |
| 5-Sep | 308 | 762 | 809 | 1,050 | 596 | 484 | 571 | 215 | 435 | 414 | 529 |
| 6-Sep | 322 | 767 | 831 | 1,099 | 584 | **497** | 593 | 226 | 483 | 439 | 536 |
| 7-Sep | 338 | 770 | 852 | 1,146 | 574 | 508 | 615 | **238** | 534 | 461 | **543** |
| 8-Sep | 357 | 773 | 874 | 1,191 | 569 | 519 | 635 | 251 | 585 | 483 | 547 |
| 9-Sep | 378 | 775 | 896 | 1,234 | 569 | 528 | 655 | 265 | 637 | **502** | 548 |
| 10-Sep | **403** | **776** | 917 | 1,274 | **574** | 536 | 673 | 280 | 688 | 519 | 545 |
| 11-Sep | 433 | 776 | 938 | 1,310 | 586 | 543 | 689 | 296 | 736 | 534 | 541 |
| 12-Sep | 470 | 773 | 960 | 1,343 | 605 | 549 | **704** | 312 | 781 | 547 | 535 |
| 13-Sep | 513 | 770 | 981 | 1,372 | 630 | 555 | 718 | 327 | 821 | 559 | 530 |
| 14-Sep | 559 | 765 | 1,002 | 1,396 | 660 | 561 | 731 | 342 | **855** | 570 | 525 |
| 15-Sep | 609 | 758 | 1,023 | 1,415 | 695 | 567 | 745 | 356 | 885 | 580 | 522 |
| 16-Sep | 661 | 751 | **1,044** | 1,428 | 732 | 573 | 758 | 368 | 913 | 591 | 521 |
| 17-Sep | 713 | 742 | 1,065 | **1,435** | 772 | 579 | 770 | 379 | 939 | 603 | 524 |
| 18-Sep | 765 | 733 | 1,088 | 1,435 | 813 | 586 | 781 | **387** | 961 | 616 | 531 |
| 19-Sep | 815 | 722 | 1,110 | 1,429 | 855 | 593 | 791 | 393 | 981 | 631 | 543 |
| 20-Sep | 863 | 712 | 1,134 | 1,418 | 897 | 602 | 800 | 398 | 998 | 648 | 562 |
| 21-Sep | 906 | 701 | 1,157 | 1,403 | 938 | **611** | 807 | 401 | 1,011 | **667** | **587** |
| 22-Sep | 945 | 689 | 1,181 | 1,385 | 978 | 622 | 813 | 403 | 1,020 | 691 | 623 |
| 23-Sep | 977 | 678 | 1,204 | 1,365 | 1,014 | 633 | 816 | 403 | **1,025** | 720 | 670 |
| 24-Sep | 1,001 | 666 | 1,228 | 1,344 | 1,047 | 646 | 817 | 403 | 1,024 | 754 | 727 |
| 25-Sep | **1,017** | 655 | 1,251 | 1,325 | 1,076 | 660 | 816 | 401 | 1,016 | 790 | 791 |
| 26-Sep | 1,024 | 644 | 1,274 | 1,307 | 1,099 | 674 | 813 | 398 | 1,001 | 827 | 860 |
| 27-Sep | 1,023 | 633 | 1,296 | 1,292 | **1,116** | 688 | **806** | 395 | 982 | 866 | 932 |
| 28-Sep | 1,014 | 623 | 1,317 | 1,282 | 1,129 | 702 | 797 | 390 | 959 | 903 | 1,006 |
| 29-Sep | 999 | **614** | 1,337 | **1,277** | 1,141 | 715 | 784 | 385 | 933 | 938 | 1,077 |
| 30-Sep | 978 | 605 | 1,356 | 1,278 | 1,151 | 728 | 770 | 378 | 905 | 970 | 1,146 |

-Continued-

Table 4. (Continued, page 2 of 2)

| Date | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2010 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-Oct | 952 | 596 | 1,374 | 1,284 | 1,159 | 739 | 753 | 372 | 876 | 997 | 1,209 |
| 2-Oct | 921 | 587 | 1,390 | 1,294 | 1,165 | 749 | 734 | **364** | 848 | 1,019 | 1,264 |
| 3-Oct | 886 | 578 | 1,404 | 1,308 | 1,169 | 758 | 713 | 355 | 821 | 1,034 | 1,310 |
| 4-Oct | 848 | 569 | 1,417 | 1,325 | 1,171 | **765** | 691 | 344 | 796 | **1,040** | 1,343 |
| 5-Oct | 807 | 560 | **1,428** | 1,345 | 1,170 | 771 | 667 | 332 | 775 | 1,038 | **1,363** |
| 6-Oct | 764 | 551 | 1,437 | 1,367 | 1,166 | 776 | 642 | 319 | **759** | 1,029 | 1,369 |
| 7-Oct | 720 | 542 | 1,446 | 1,390 | 1,160 | 782 | 616 | 304 | 747 | 1,014 | 1,362 |
| 8-Oct | 675 | 533 | 1,453 | 1,414 | 1,150 | 786 | 590 | 289 | 739 | 993 | 1,346 |
| 9-Oct | 630 | 524 | 1,460 | 1,439 | 1,137 | 790 | 562 | 273 | 733 | 968 | 1,321 |
| 10-Oct | 586 | 515 | 1,465 | 1,464 | 1,121 | 793 | **535** | 256 | 729 | 939 | 1,288 |
| 11-Oct | 543 | 505 | 1,470 | 1,488 | **1,101** | 795 | 505 | 240 | 726 | 908 | 1,249 |
| 12-Oct | 502 | 496 | 1,473 | 1,510 | 1,076 | 796 | 473 | 224 | 724 | 875 | 1,205 |
| 13-Oct | 464 | 487 | 1,475 | 1,531 | 1,044 | 795 | 437 | 209 | 721 | 841 | 1,157 |
| 14-Oct | 429 | 477 | 1,476 | 1,549 | 1,007 | 792 | 399 | 194 | 718 | 808 | 1,108 |
| 15-Oct | 398 | 468 | 1,476 | 1,564 | 966 | 788 | 360 | 180 | 714 | 775 | 1,057 |
| 16-Oct | **372** | 459 | 1,474 | 1,575 | 921 | 781 | 321 | **168** | 707 | 744 | 1,007 |
| 17-Oct | 349 | 449 | 1,471 | 1,582 | 874 | 772 | 281 | 157 | 698 | **716** | 959 |
| 18-Oct | 326 | 440 | 1,467 | **1,585** | 824 | 761 | 243 | 146 | 685 | 689 | 914 |
| 19-Oct | 304 | 430 | 1,461 | 1,584 | 774 | **747** | 206 | 135 | **668** | 661 | 873 |
| 20-Oct | 283 | 421 | 1,454 | 1,581 | 724 | 729 | 172 | 125 | 646 | 631 | **839** |
| 21-Oct | 263 | 411 | **1,445** | 1,577 | 674 | 707 | 140 | 115 | 620 | 601 | 808 |
| 22-Oct | 243 | 401 | 1,435 | 1,571 | 627 | 682 | 113 | 105 | 590 | 571 | 778 |
| 23-Oct | 224 | 392 | 1,423 | 1,563 | 582 | 653 | **90** | 96 | 557 | 540 | 748 |
| 24-Oct | 205 | 382 | 1,410 | 1,554 | 540 | 621 | 72 | 87 | 521 | 509 | 719 |
| 25-Oct | 187 | 372 | 1,396 | 1,543 | **503** | 587 | 57 | 78 | 484 | 477 | 690 |
| 26-Oct | 170 | 363 | 1,381 | 1,530 | 469 | 551 | 45 | 70 | 445 | 447 | 662 |
| 27-Oct | 154 | 353 | 1,364 | 1,515 | 436 | 515 | 35 | 62 | 406 | 416 | 634 |
| 28-Oct | 138 | 343 | 1,346 | 1,499 | 404 | 477 | 28 | 54 | 366 | 386 | 607 |
| 29-Oct | 123 | 333 | 1,326 | 1,481 | 374 | 440 | 22 | 47 | 327 | 357 | 580 |
| 30-Oct | 109 | 323 | 1,305 | 1,461 | 344 | 402 | 18 | 40 | 290 | 329 | 554 |
| 31-Oct | 95 | 313 | 1,283 | 1,440 | 316 | 366 | 14 | 34 | 254 | 303 | 529 |
| 1-Nov | 82 | 303 | 1,259 | 1,416 | 289 | 331 | 11 | 28 | 222 | 277 | 504 |
| 2-Nov | 70 | 293 | 1,235 | 1,392 | 262 | 298 | 8 | 22 | 192 | 254 | 479 |
| 3-Nov | 58 | 283 | 1,208 | 1,365 | 238 | 268 | 5 | 16 | **166** | **232** | 455 |
| 4-Nov | 47 | 273 | 1,181 | 1,337 | 214 | 240 | **0** | 11 | 143 | 212 | 431 |
| 5-Nov | 37 | 263 | 1,152 | 1,307 | 191 | **216** | | 6 | 121 | 192 | 408 |
| 11/6 | 27 | 253 | 1,122 | 1,275 | 170 | 194 | | 2 | 101 | 174 | 386 |
| 11/7 | 18 | 243 | 1,091 | 1,242 | 149 | 174 | | 0 | 82 | 156 | 364 |
| 11/8 | 10 | 233 | 1,058 | 1,206 | 130 | 155 | | | 64 | 139 | 342 |
| 11/9 | 2 | 223 | 1,024 | 1,170 | 112 | 136 | | | 47 | 124 | 321 |
| 11/10 | 0 | 212 | 988 | 1,131 | 95 | 119 | | | 32 | 109 | 301 |
| 11/11 | | 202 | 951 | 1,091 | 80 | 103 | | | 18 | 95 | 281 |
| 11/12 | | 192 | 913 | 1,049 | 65 | 88 | | | 5 | 81 | 261 |
| 11/13 | | 181 | 874 | 1,005 | 52 | 74 | | | 0 | 69 | 242 |
| 11/14 | | 171 | 833 | 960 | 40 | 61 | | | | 58 | 224 |
| 11/15 | | 161 | 791 | 912 | 29 | 49 | | | | 48 | 206 |
| 11/16 | | 150 | 747 | 864 | 19 | 38 | | | | 38 | 189 |
| 11/17 | | 140 | 703 | 813 | 10 | 28 | | | | 29 | 172 |
| 11/18 | | 129 | 657 | 761 | 2 | 20 | | | | 22 | 156 |
| 11/19 | | 118 | 609 | 707 | 0 | 12 | | | | 15 | 140 |
| 11/20 | | 108 | 560 | 651 | | 6 | | | | 9 | 125 |
| 11/21 | | 97 | 510 | 594 | | 0 | | | | 4 | 110 |
| 11/22 | | 87 | 459 | 535 | | | | | | 0 | 95 |
| 11/23 | | 76 | 406 | 474 | | | | | | | 82 |
| 11/24 | | 65 | 352 | 411 | | | | | | | 69 |
| 11/25 | | 54 | 297 | 347 | | | | | | | 56 |
| 11/26 | | 44 | 240 | 281 | | | | | | | 44 |
| 11/27 | | 33 | 182 | 213 | | | | | | | 32 |
| 11/28 | | 22 | 123 | 144 | | | | | | | 21 |
| 11/29 | | 11 | 62 | 73 | | | | | | | 10 |
| 11/30 | | 0 | 0 | 0 | | | | | | | 0 |
| Total | 37,360 | 53,759 | 107,824 | 118,616 | 66,042 | 46,765 | 38,467 | 17,438 | 45,579 | 45,630 | 64,972 |

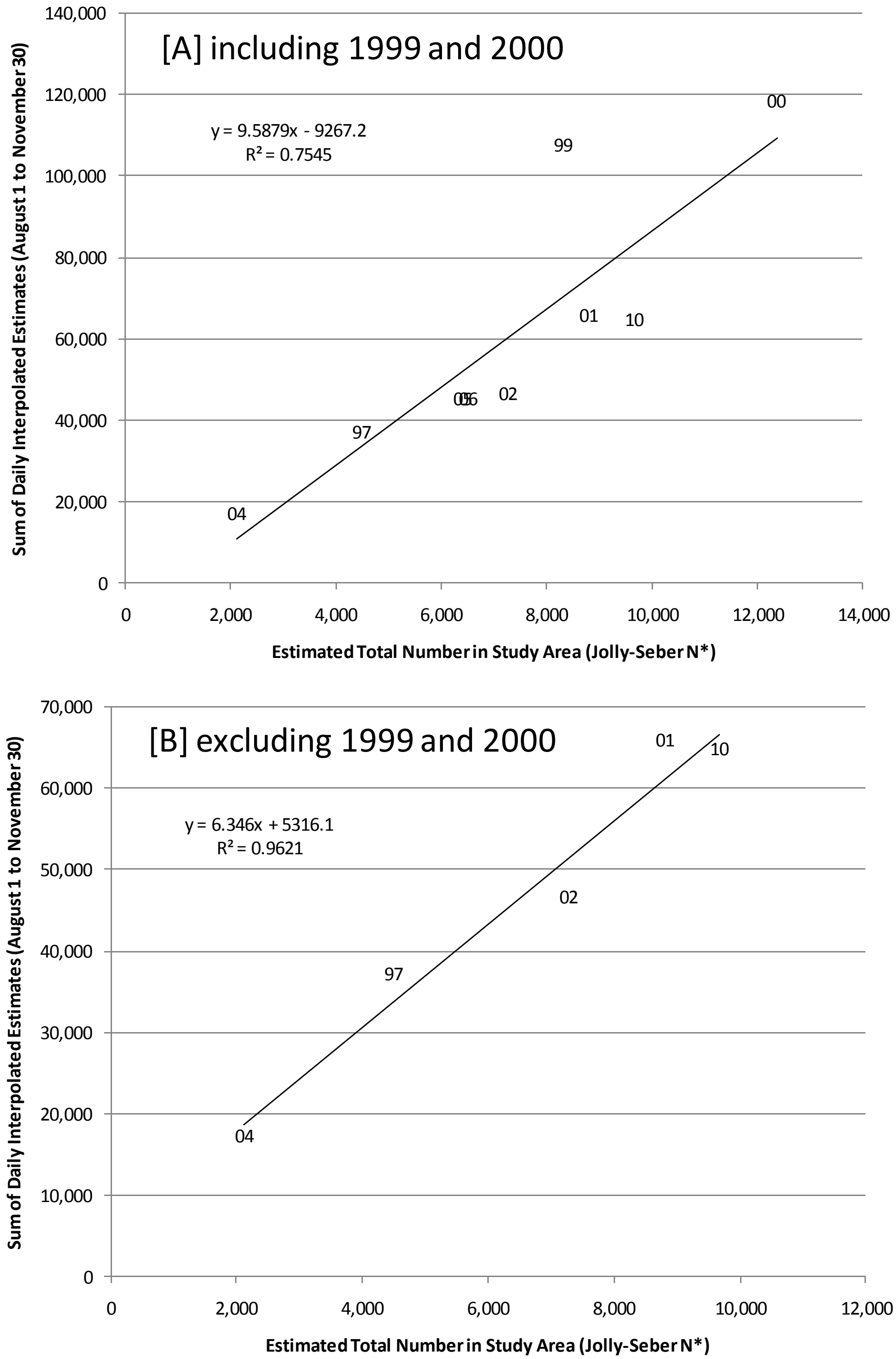


Figure 3. Regression of the sum of the daily interpolated estimates from August 1 to November 30 on the modified Jolly-Seber estimate of the total number in the study area (N*) including [A] and excluding [B] years 1999 and 2000 when "Clyde's Hole" was included in the study area.

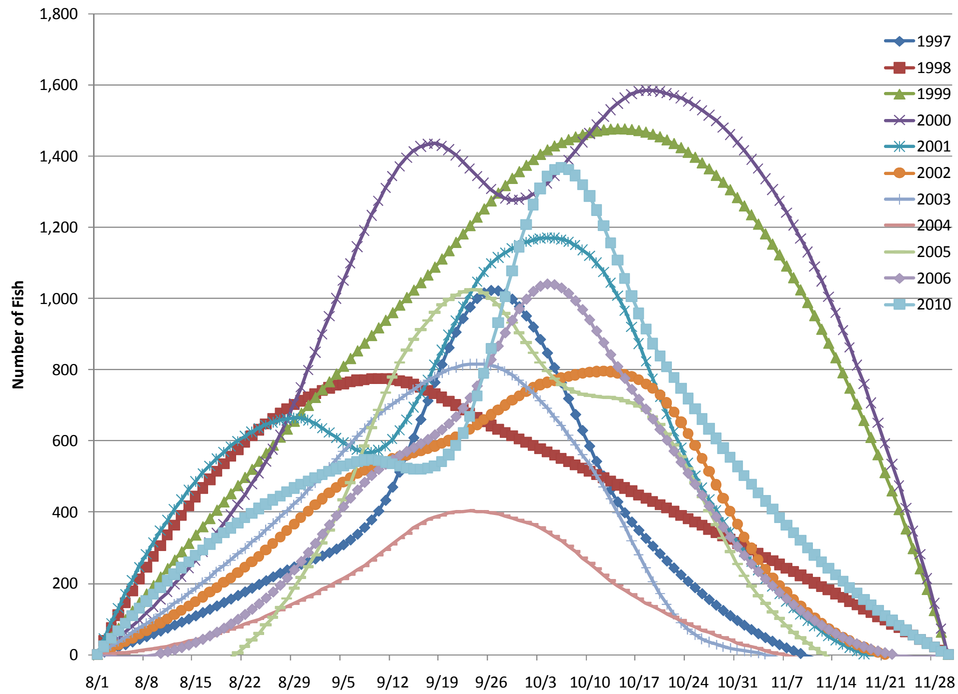


Figure 4. Estimated daily abundance of sockeye salmon in the study area adjacent to the West Sitkoh Lake Forest Service cabin, 1997 to 2006 and 2010.

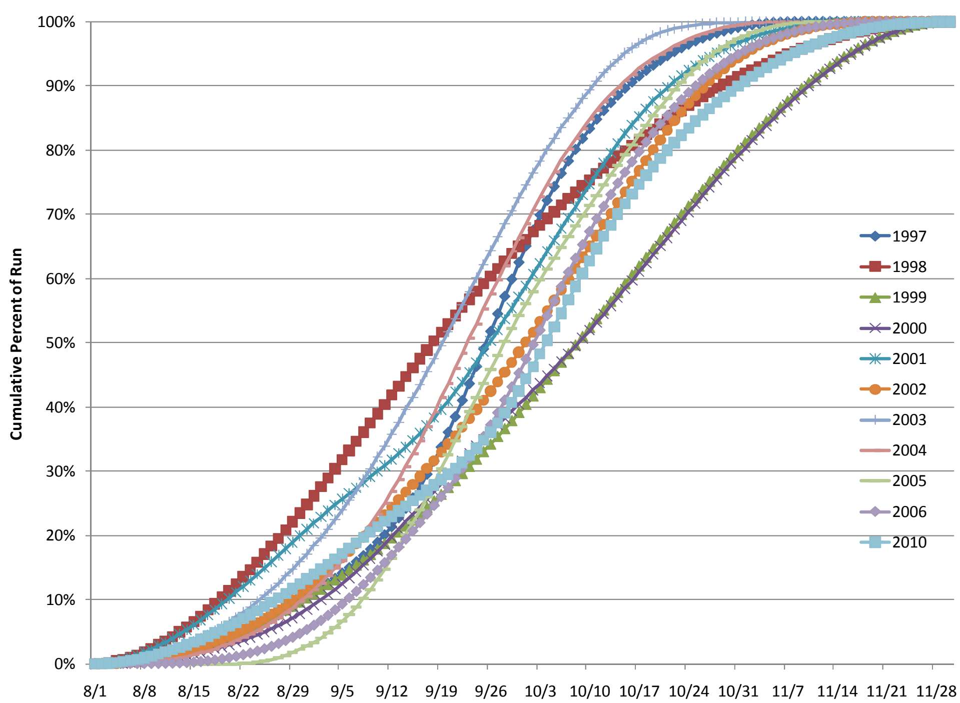


Figure 5. Timing of sockeye spawning in the index area of Sitkoh Lake, 1997 to 2006 and 2010.

## Age, Sex, and Length

Of the 324 sockeye salmon sampled for age, sex, and length data, 230 (71%) had ageable scales, and 99.5% were age-1.-. Age classes 1.2 and 1.3 were the dominant age classes comprising 52% and 47% of the sockeye salmon sampled, respectively (Table 5). The sex composition was 59% males. Two "jacks" (age-.1) and one "two-check" (age 2.-) fish were sampled.

Table 5. Age and length composition, by sex, of sockeye salmon in the Sitkoh Lake escapement, 2010.

| | Brood Year and Age Class | | | | |
|---|---|---|---|---|---|
| | 2007 | 2006 | 2005 | 2005 | |
| | 1.1 | 1.2 | 1.3 | 2.2 | Total |
| Male | | | | | |
| Sample Size | 2 | 63 | 71 | | 136 |
| Percent | 1% | 27% | 31% | | 59% |
| SE | 0.6% | 2.9% | 3.0% | | 3.2% |
| Ave. Length | 350 | 499 | 546 | | 521 |
| SE | 10.0 | 3.0 | 2.0 | | 3.2 |
| CV | 4% | 5% | 3% | | 7% |
| Female | | | | | |
| Sample Size | | 56 | 37 | 1 | 94 |
| Percent | | 24% | 16% | 0% | 41% |
| SE | | 2.8% | 2.4% | 0.4% | 3.2% |
| Ave. Length | | 491 | 534 | 440 | 508 |
| SE | | 2.8 | 2.6 | | 3.0 |
| CV | | 4% | 3% | | 6% |
| All Fish | | | | | |
| Sample Size | 2 | 119 | 108 | 1 | 230 |
| Percent | 1% | 52% | 47% | 0% | 100% |
| SE | 0.6% | 3.3% | 3.3% | 0.4% | 0.0% |
| Ave. Length | 350 | 495 | 542 | 440 | 516 |
| SE | 10.0 | 2.1 | 1.7 | | 2.3 |
| CV | 4% | 5% | 3% | | 7% |

## DISCUSSION

In 2010, the modified Jolly-Seber estimate was 9,665 (CV=7%) sockeye salmon in the study area of Sitkoh Lake (Tables 2). For comparison, index area estimates from previous years include 4,493 in 1997, 8,319 in 1999, 12,364 in 2000, 8,803 in 2001, 7,272 in 2002, 5,105 in 2003, 2,121 in 2004, 6,409 in 2005, and 6,514 in 2006 (Table 3). If the estimate had been expanded by boat survey counts for the proportion of fish in and out of the study area, the indexed escapement for the entire lake would have been around 15,000 sockeye salmon (Figure 3 and Table 3). Annual runs are dependent on brood year escapements and climate and ocean conditions affecting survivals. The annual escapements are certainly dependent on the commercial purse seine effort in Icy, Chatham, and Peril Straits and the subsistence/personal use effort in Sitkoh Bay. A relatively high seine effort in 2004 likely contributed to that year's low escapement and a relatively low seine effort in 2010 was likely a factor in this year's high escapement.

The reliability of this escapement index depends on a consistent distribution of the annual escapement in and out of the study area. However, in the past 10 years there have been hydrological changes affecting the study area and, possibly, the distribution of spawners. The water flowing out of the valley above the study area used to percolate underground though a broad alluvial fan and upwell along the lake shore throughout the study area. There were no perennial or intermittent/seasonal streams in the study area, or elsewhere around the lake - except for a small intermittent stream near the East Forest Service cabin. The only surface flows into the lake observed 10 years ago were from heavy rain-on-snow events in the spring or heavy rains in the fall. The study area was centered in the middle of this alluvial fan where the sockeye spawners were most abundant. This upwelling of water through the sand and gravel substrate in the study area likely contributed to higher survival of the sockeye salmon spawning in this index area and the high proportion of sockeye spawning in the index area.

There is now a stream that bisects the alluvial fan and flows directly into the study area (Figures 6 and 7). This perennial stream reduces the amount of water upwelling along the shore. The formation of this stream is likely a result of the clear-cut logging and roading that has been done in the watershed (Figure 8). There is a possibility that this hydrologic change could lower survivals of fish in the study area and change the distribution of spawners in the lake and the usefulness of these annual escapement indices. We recommend that this project be expanded to also estimate the total escapement of sockeye salmon into Sitkoh Lake to better calibrate past and present index counts with actual escapements. The potential of using a redundant net weir and video system (Van Alen 2008; Van Alen and Mahara 2011) at the outlet of the lake should be evaluated.

Figure 6. Picture of the beach in front of Sitkoh Lake's West Forest Service cabin prior to formation of an inlet stream, August 28, 2001.

Figure 7. Picture of the beach in front of Sitkoh Lake's West Forest Service cabin after formation of an inlet stream, September 7, 2010.

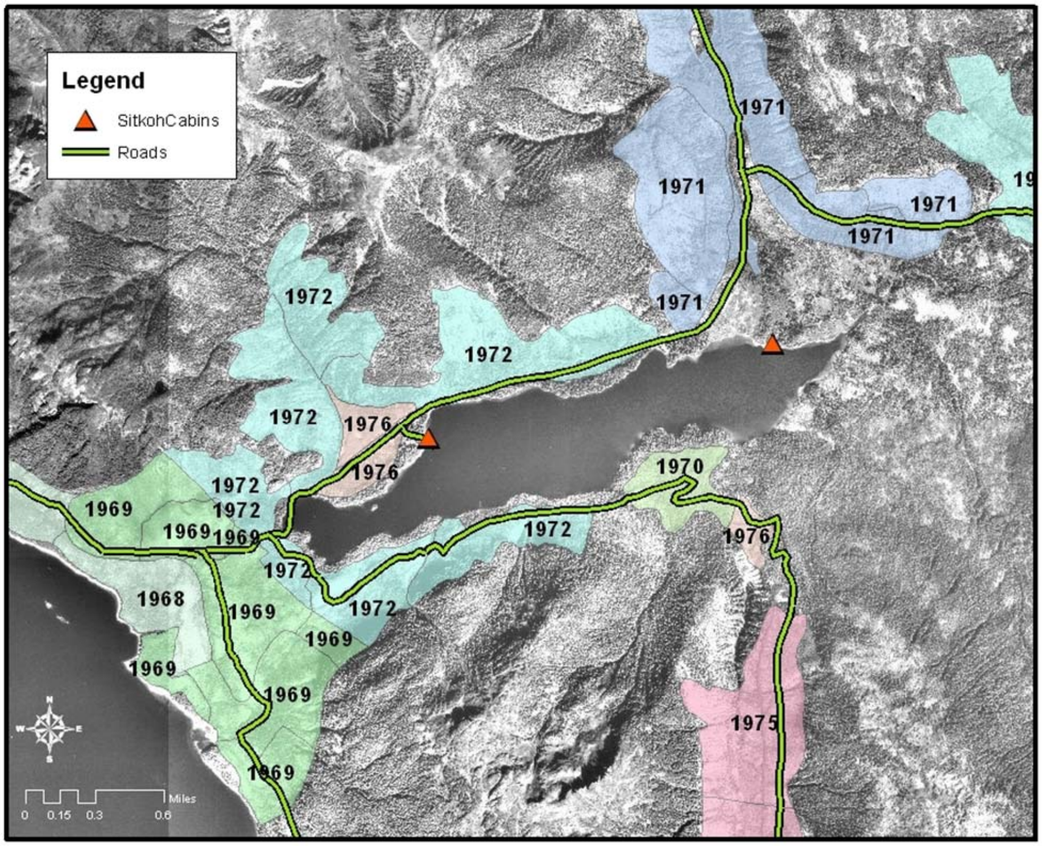


Figure 8. Map showing the clear-cuts (with year logged) and roads in the Sitkoh Lake watershed. The roads on the south side of the lake have not been maintained.


## ACKNOWLEDGEMENTS

Much of the field work was accomplished by Angoon Community Association employees Jason Frank, Marcus Jamestown, Donald Johnson, Roger Williams, Sr., and Jonathan Zuboff. Their ability to get the job done, and done right, is most appreciated. The U. S. Forest Service provided $71,481 in funding support for this project through the Fisheries Research Monitoring Program (Study Number 10-605) administered by the U.S. Fish and Wildlife Service, Office of Subsistence Management.

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