Fishery Data Series No. 94-35

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[1] This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-8, Job No. R-1-1.

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ABSTRACT

Mark-recapture experiments were conducted to estimate the abundance of cutthroat trout *Oncorhynchus clarki* in Florence Lake on Admiralty Island, near Juneau, in 1993. The abundance of cutthroat trout in Florence Lake was an estimated 8,382 (SE = 818) for fish ≥180 mm fork length. Baited funnel traps and hook and line were used to capture fish during four sampling trips between April 22 and June 12, 1993. To capture ripe cutthroat trout for disease and fecundity sampling, two weirs were operated on inlet streams between April 22 and June 10, 1993. We captured 98 cutthroat trout: 81 immigrants and 17 emigrants.

KEY WORDS: Cutthroat trout, *Oncorhynchus clarki*, Florence Lake, Southeast Alaska, abundance, harvest, exploitation, age composition, catch, postal survey, Dolly Varden char, *Salvelinus malma*, kokanee, *Oncorhynchus nerka*, catch per unit effort, CPUE.

## INTRODUCTION

Combined harvests of anadromous and resident cutthroat trout *Oncorhynchus clarki* in Southeast Alaska have declined from about 23,000 fish in 1977 to about 13,000 fish in 1992 (Mills 1993; Appendix A1). Declining harvests may be a sign that abundance of cutthroat trout regionwide is being reduced. As a result, studies were begun to develop sampling methods for estimating trout abundance in large lakes. These studies will lead to an understanding of the abundance of cutthroat in lakes, estimates of survival and recruitment rates, and establishment of sustainable harvest in Southeast Alaska.

This paper reports findings from the fourth year of study at Florence Lake. Florence Lake lies approximately 50 km southwest of Juneau, on the west side of Admiralty Island at long. 134°4′ W, lat. 58°3′ N (Figure 1); the lake is narrow (<1 km wide) and about 7.2 km long, with a maximum depth of approximately 27 m (Figure 2). The lake outlet flows about 1 km into Chatham Strait and passes over a barrier falls about 400 m upstream of tidewater, blocking the lake to anadromous species.

Turner and Hasselborg lakes (Figure 1) receive some of the most concentrated angling pressure for cutthroat trout in Southeast Alaska (Jones *In press*). Florence Lake was extremely popular until 1991, when extensive clear-cut logging began at the lake. Since then angling interest in Florence Lake has dropped substantially.

Our research objectives in 1993 were:

1. to estimate the abundance of cutthroat trout ≥180 mm fork length (FL) in Florence Lake; and

2. to estimate fecundity by fork length for cutthroat trout > 180 mm FL in Florence Lake.

Additional tasks in 1993 were the collection of length frequency data and scales from small-sized fish in Florence Lake, and collection of ripe female cutthroat trout for disease samples. Disease sampling was conducted in response to a proposal to stock cutthroat trout from Florence Lake into Juneau area waters. This proposal is contingent upon the Florence Lake fish being disease-free. Cutthroat trout were sampled for infectious hematopoietic necrosis (IHN), hemorrhagic septicemia (VHS), and bacterial kidney disease (BKD).

## METHODS

### Abundance

The abundance of cutthroat trout in Florence Lake was estimated by using two-event mark-recapture experiments. Sampling took place between April 23 and May 14 (marking event) and between May 21 and June 12 (recapture event). Large, baited (with Betadine-treated salmon eggs) minnow (or funnel) traps, as well as hook and line, were used to capture cutthroat during each sampling event. Minnow traps were 1.5 m long and 0.6 m in diameter, with a 9-cm opening in each end of the trap and a mesh size of 1 cm.

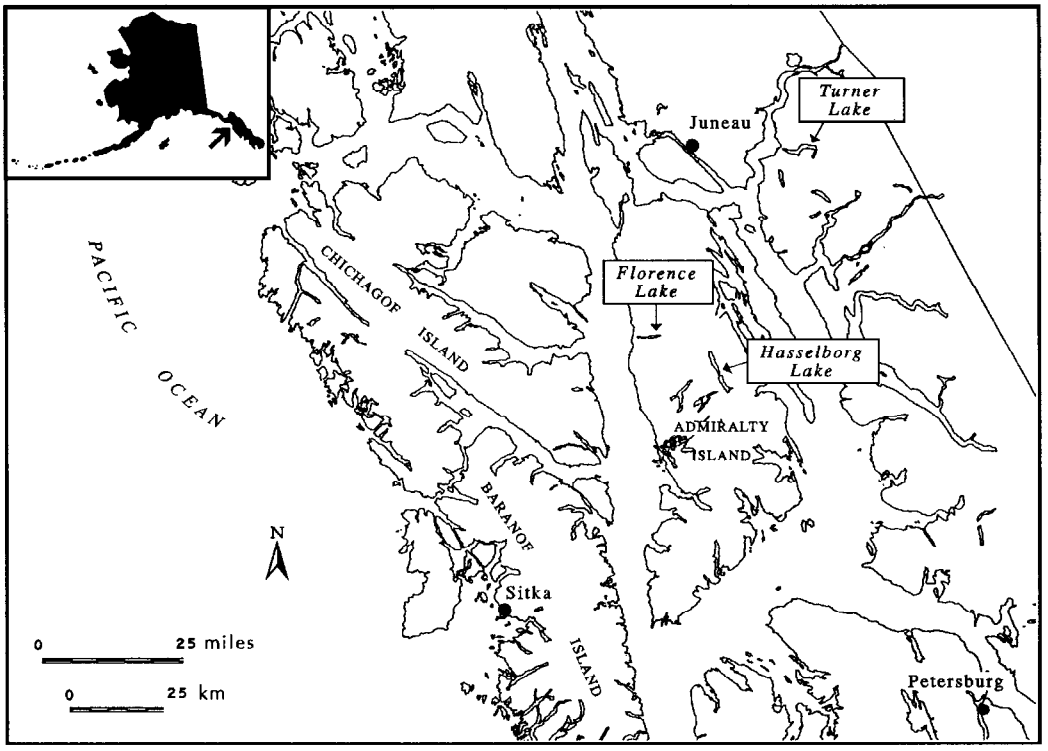



Figure 1. Location of Florence Lake on Admiralty Island, northern Southeast Alaska.

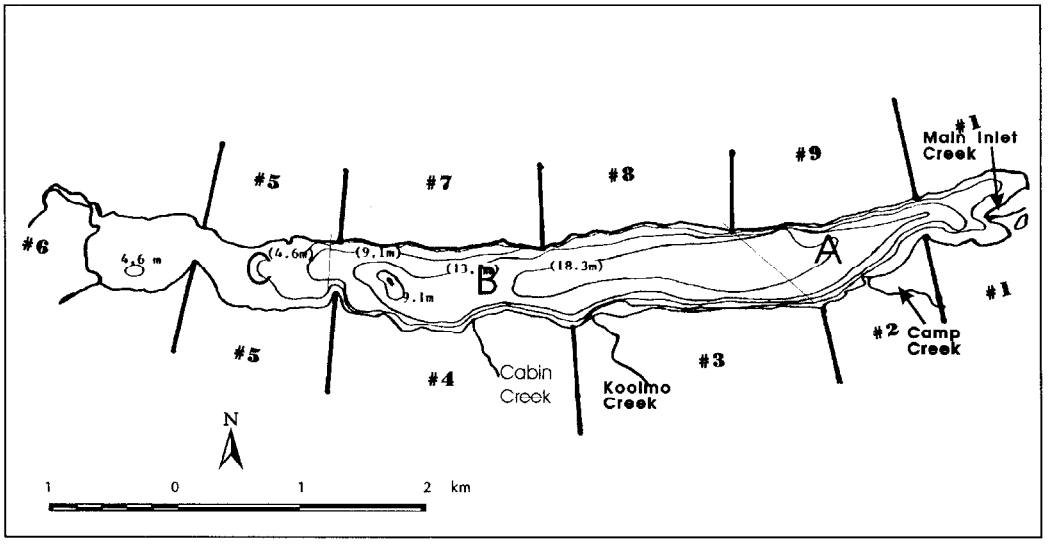



Figure 2. Bathymetric map of Florence Lake on Admiralty Island, Southeast Alaska, showing location of large sampling areas and study zones. Sampling area "A" comprises zones 1, 2, and 9; sampling area "B" comprises zones 3, 4, 7, and 8; and sampling area "C" comprises zones 5 and 6.

Captured, untagged cutthroat trout ≥180 mm FL in good physical condition were tagged with a uniquely numbered T-bar (Floy) anchor tag, sampled for scales, andmeasured to the nearest mm FL, then returned to the lake. The ≥180 mm size category was selected to match the size ranges anglers tend to keep; cutthroat trout <180 mm FL were simply counted and returned to the lake.

The funnel traps were rotated between nine study areas, or zones, in the lake (Figure 2) during each of four 10-day sampling periods. Periods 1 and 2 were combined to form "event" 1 (marking); periods 3 and 4 were combined to form event 2 (recapture). The number of traps set in each zone was based on the proportion of total lake surface in each area (Table 1). Traps were set roughly uniform across each zone without regard to depth. As time permitted, hook and line sampling was done with sport fishing gear, using small lures, flies, or spinners.

The hypothesis that fish of different sizes were captured with equal probability during the second sampling event was tested with a Kolmogorov-Smirnov (K-S) two-sample test ($\alpha = 0.05$) that compared lengths of fish marked in event 1 against lengths of fish recaptured in event 2. If size selectivity was indicated, the experiment was stratified by size groups, using a series of chi-square tests to determine suitable cut-points.

The assumption that fish had an equal chance of being marked or that complete mixing (of marks) occurred between sampling events was evaluated by testing if, given *some* mixing between areas, marked fish were recovered with equal probability in each of the three large sampling areas (see Figure 2) of the lake. If this was not so, a Darroch estimator (Seber 1982, Darroch 1961) was used to estimate abundance

$$\underline{U} = \mathbf{D}_u \mathbf{M}^{-1} \underline{a} \qquad (1)$$

where $\underline{U}$ = vector of the estimated number of *unmarked* fish in each area during the second sampling event, $\mathbf{D}_u$ = diagonal matrix of the number of *unmarked* fish captured in each area during the second sampling event, $\mathbf{M}$ = matrix $(m_{ij})$ of the number of tagged fish recovered in area (j) which were released in area i, and$\underline{a}$ = vector of the number of tagged fish released in area i;

and abundance $\hat{\underline{N}} = \underline{U} + \underline{a}$.

The variance-covariance matrix for $\underline{U}$ was estimated using the approximation for the expected value $E[(\hat{\underline{U}} - \underline{U})(\hat{\underline{U}} - \underline{U})^T]$ as explained by Seber (1982, page 433).

Statistical bias and variance of the estimate were estimated using the bootstrap technique (Efron 1982). Tag histories were resampled 2,500 times, and abundance was estimated for each sample. Bias was estimated as the difference between the mean of the bootstrap estimates and the Darroch estimate.

If marking ratios were equal across areas, the Chapman estimators (Seber 1982) were used to estimate abundance:

$$\hat{N} = \frac{(n_1+1)\,(n_2+1)}{(m_2+1)} - 1 \qquad (2)$$

$$V[\hat{N}] = \frac{(n_1+1)\,(n_2+1)\,(n_1-m_2)\,(n_2-m_2)}{(m_2+1)^2(m_2+2)} \qquad (3)$$

where $\hat{N}$ = abundance of cutthroat trout, $n_1$ = number of fish marked and released in the first sampling event, $n_2$ = number of fish inspected for marks in the second sampling event, and $m_2$ = number of marked fish recaptured in the second sampling event.

Secondary marks (adipose finclips) were applied to trout tagged in each event to provide means for estimating tag loss. Records were also kept of the numbers of Dolly Varden *Salvelinus malma* and kokanee *Oncorhynchus nerka* captured in Florence Lake, by area and gear type.

Spawning Migrations and Fecundity

Small immigrant/emigrant weirs were built on two inlet streams to capture ripe females for fecundity and disease samples and obtain information about the timing of spawning immigrants. The two-way weirs were built on Cabin Creek and Koolmo Creek, each ≈1.5 m wide (Figure 2), to capture immigrant and emigrant cutthroat trout >100 mm FL. Cabin Creek weir was operated April 21 through June 8, but was not fish-tight from May 21-22 because of high water. Koolmo Creek weir was operated April 22 through June 10. All immigrant and emigrant cutthroat trout captured were counted, tagged with a numbered T-bar anchor tag, sampled as described above, and allowed to continue their migration. Fish tagged at the weir were not used in the abundance experiment.

Ripe female cutthroat captured at the two weirs and in the lake near other inlet streams were sacrificed for disease and fecundity sampling. All sacrificed fish were sampled for length, weight, scales, otoliths, and fecundity, and an attempt was made to collect three fish per 10 mm size class between 180 and 400 mm FL.

Fish selected for sampling were kept alive in large traps and sent to Juneau for further sampling each week. Tissue samples were collected from freshly killed cutthroat trout and immediately transported to the ADF&G Pathology Laboratory in Juneau, where they were sampled for infectious IHN, VHS, and BKD. Eggs were removed from the body cavity of each fish, then counted and weighed.

Angler Interviews

Anglers using two U.S. Forest Service (USFS) cabins at Florence Lake were contacted about their effort and harvest as part of a postal survey (Jones *In press*). We presume that there is only a small number of anglers at Florence Lake who do not use the USFS cabins, and we investigated this by contacting anglers we observed.

Between April 20 and June 10, 1993, anglers who were not USFS cabin users were asked to record their catch and effort on a form we provided and return it to us at the end of their fishing trip.

Table 1. Florence Lake surface area ($km^2$), proportion of surface area in each sampling zone, and number of traps set in each zone.

| Sampling zone | Surface area ($km^2$) | Proportion in zone | Number of traps |
|---|---|---|---|
| 1 | 0.35 | 0.08 | 9 |
| 2 | 0.40 | 0.09 | 10 |
| 3 | 0.58 | 0.13 | 15 |
| 4 | 0.60 | 0.14 | 15 |
| 5 | 0.55 | 0.13 | 14 |
| 6 | 0.48 | 0.11 | 12 |
| 7 | 0.46 | 0.11 | 11 |
| 8 | 0.61 | 0.14 | 15 |
| 9 | 0.29 | 0.07 | 7 |
| Total | 4.31 | 1.00 | 108 |

If they had completed fishing, however, we filled in the form and kept it. If the anglers were registered users of a USFS cabin at the lake, they were not given a form but were informed that they would receive a survey questionnaire in the mail as part of the cabin survey (Jones *In press*). Reported effort and harvest were totaled for comparison to the survey results for cabin users taken from Jones (*In press*).

## RESULTS

### Abundance

We captured 3,515 cutthroat trout ≥180 mm FL with large traps and hook and line (Table 2). Ninety-two cutthroat trout captured with weirs on the inlet streams between April 21 and June 10 may not have returned to the lake after spawning, or may have had a higher mortality than cutthroat captured in the lake, and were not included in the abundance estimates (Appendix A2). Cutthroat trout length frequency by gear type is presented in Figure 3.

In the first sampling event, 1,848 cutthroat trout between 180 mm and 382 mm FL (all but two fish measured) were newly tagged (or recaptured from a previous year) (Table 3). During the second sampling event, 1,117 cutthroat trout between 180 mm FL and 382 mm FL were inspected for marks; all but six fish were measured, and 316 of these fish had been "marked" in the first sampling event.

The distribution of lengths of fish recaptured in event 2 was similar to the distribution of lengths marked in event 1 (Figure 4), suggesting the second sampling event was not size selective ($d_{max}$ = 0.42, P = 0.357) (Figure 4). Therefore the abundance estimate was not stratified by length. In contrast, the distribution of lengths of fish captured in event 1 was different from the distribution of lengths of all fish captured in event 2 ($d_{max}$ = 0.069, P = 0.001) (Figure 4), suggesting size selectivity during event 1; thus, only data for event 2 should be used to estimate proportions for composition estimates.

Some mixing of fish between sampling areas did occur between sampling events (Table 4). However, the hypothesis of equal probability of capture by area is soundly rejected (Table 5), suggesting that Darroch's estimators should be used to estimate abundance.

Darroch's model estimated the abundance for trout ≥180 mm FL at 8,382 (SE = 818). The bootstrap method estimated abundance of fish 0.5% above the Darroch estimate, but the bootstrap estimates were unstable. Relative precision for the estimate is ± 19%, for a 95% confidence interval.

Five hundred and twenty-seven (527) cutthroat trout ranging from 97 to 315 mm FL (mean = 195 mm, SD = 34.8) were also measured for total length (tip of snout to tip of caudal fin). Regression of fork length against total length shows that fork length is an excellent predictor of total length ($R^2$=0.999) (Figure 5); we needed a means to convert FL measurements to total length measurements for regulations, board reports, and the like.

### Spawning Migrations and Fecundity

Ninety-eight (98) cutthroat trout were captured in Cabin and Koolmo Creek weirs; 81 were immigrants, and 17 were emigrants (Figure 6). Immigration occurred from

Table 2. Sampling effort (hours), catch, and catch per unit effort (CPUE, fish per hour) by period, gear and species, Florence Lake, 1993.

| Period[a] | Gear | Effort | Cutthroat trout ≥180 mm | | Cutthroat trout <180 mm | | Dolly Varden | |
|---|---|---|---|---|---|---|---|---|
| | | | Catch | CPUE | Catch | CPUE | Catch | CPUE |
| 1 | Hook and line | 4 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| | Large trap | 2,509 | 1,308 | 0.52 | 608 | 0.24 | 3,789 | 1.52 |
| 2 | Hook and line | 15 | 49 | 3.23 | 5 | 0.33 | 4 | 0.26 |
| | Large trap | 2,278 | 822 | 0.36 | 546 | 0.24 | 3,933 | 1.73 |
| 3 | Hook and line | 16 | 56 | 3.50 | 16 | 1.00 | 10 | 0.63 |
| | Large trap | 2,341 | 709 | 0.30 | 379 | 0.16 | 2,227 | 0.95 |
| 4 | Hook and line | 16 | 35 | 2.19 | 27 | 1.68 | 8 | 0.50 |
| | Large trap | 2,590 | 536 | 0.21 | 324 | 0.13 | 2,457 | 0.95 |
| Total | Hook and line | 51 | 140 | 2.75 | 48 | 0.94 | 22 | 0.43 |
| | Large trap | 9,718 | 3,375 | 0.35 | 1,857 | 0.19 | 12,406 | 1.28 |

[a] Period 1 = 23 April-1 May; Period 2 = 5 May-14 May; Period 3 = 21 May-30 May; Period 4 = 3 June-12 June.

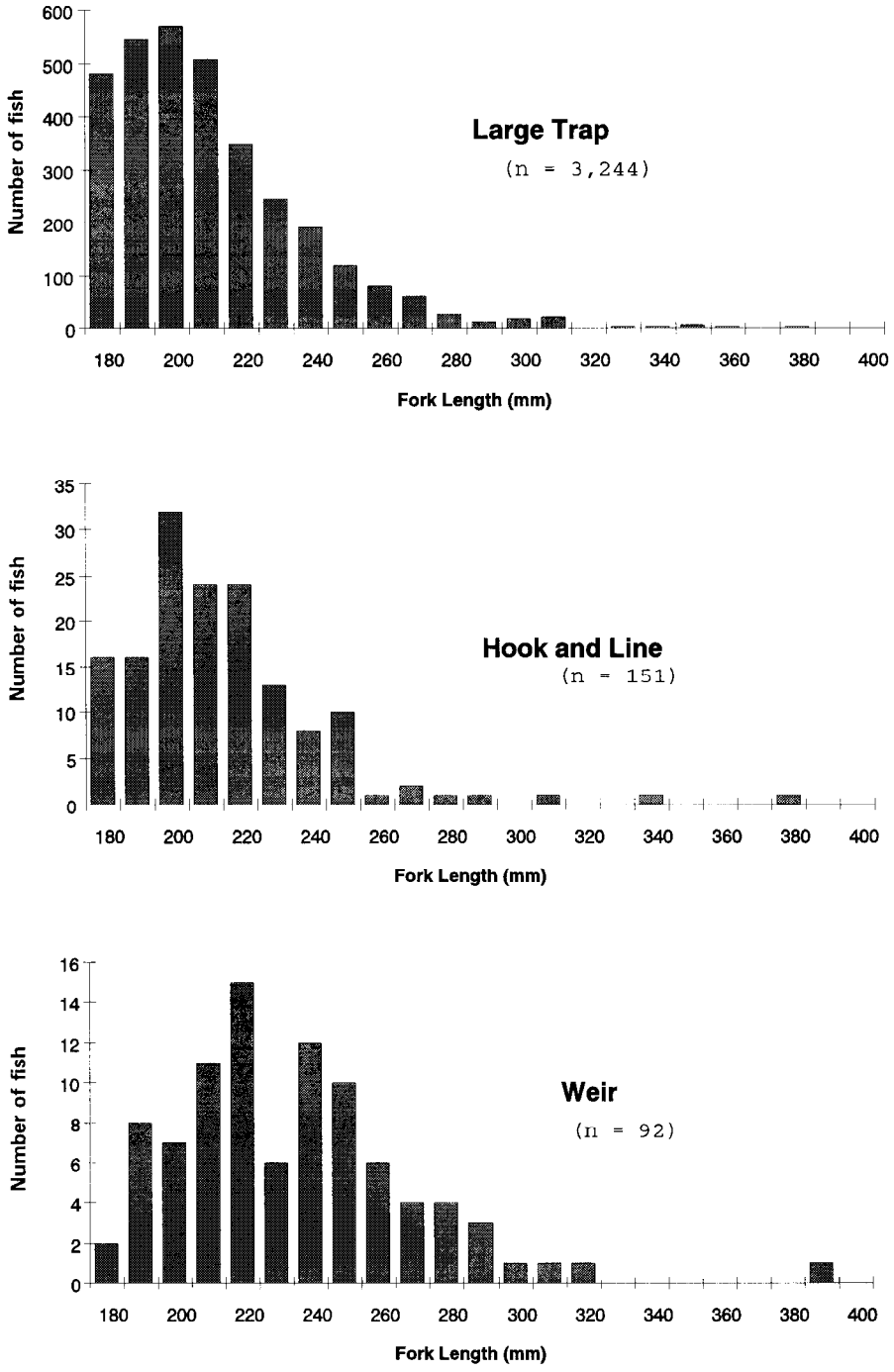
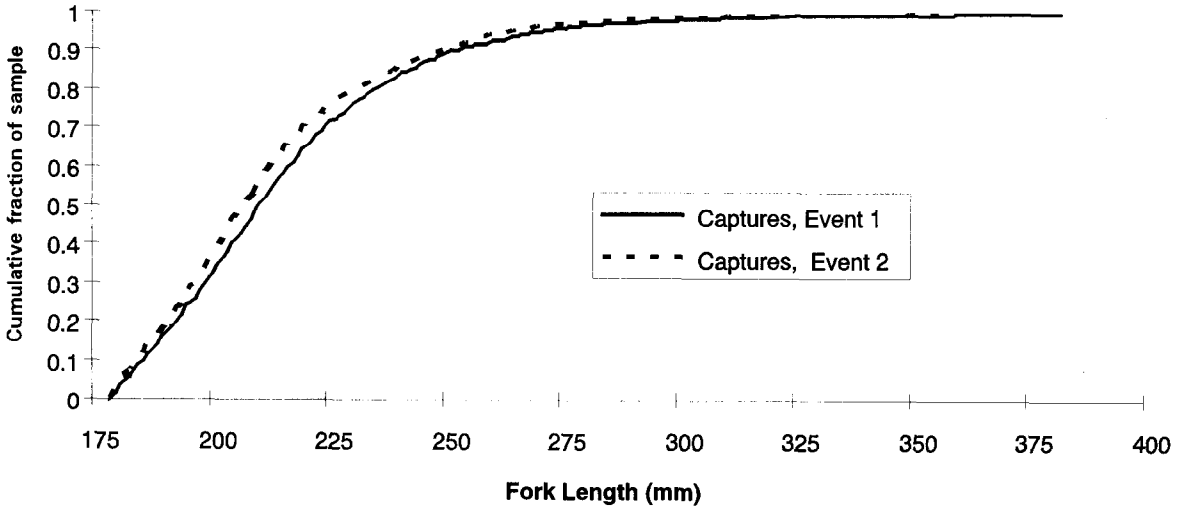



Figure 3. Length frequency of cutthroat trout captured at Florence Lake, by gear type, 1993.

Table 3. Summary of cutthroat trout tagging and recovery data for all fish, Florence Lake, 1993. Event 1 is periods 1 and 2; event 2 is periods 3 and 4.

| | 1993 Sampling periods | | | |
|---|---|---|---|---|
| | Period 1 4/22 - 5/1 | Period 2 5/5 - 5/14 | Period 3 5/21 - 5/30 | Period 4 6/3 - 6/12 |
| Newly tagged fish released alive | 913 | 541 | 368 | 230 |
| Recaptured fish tagged in: | | | | |
| 1988 | 0 | 0 | 0 | 0 |
| 1989 | 6 | 2 | 4 | 1 |
| 1990 | 27 | 16 | 22 | 5 |
| 1991 | 85 | 52 | 74 | 35 |
| 1992 | 119 | 85 | 103 | 51 |
| 1993 - event 1 | | | 150 | 63 |
| Captured, not tagged | 1 | 1 | 7[a] | 4[b] |
| Redundant catch; within period | 49 | 28 | 41 | 32 |
| Redundant catch; within event | | 134 | | 141 |
| Total catch | 1,200 | 859 | 769 | 562 |

[a] 3 morts, 4 fish untagged.
[b] 2 morts, 2 fish untagged.



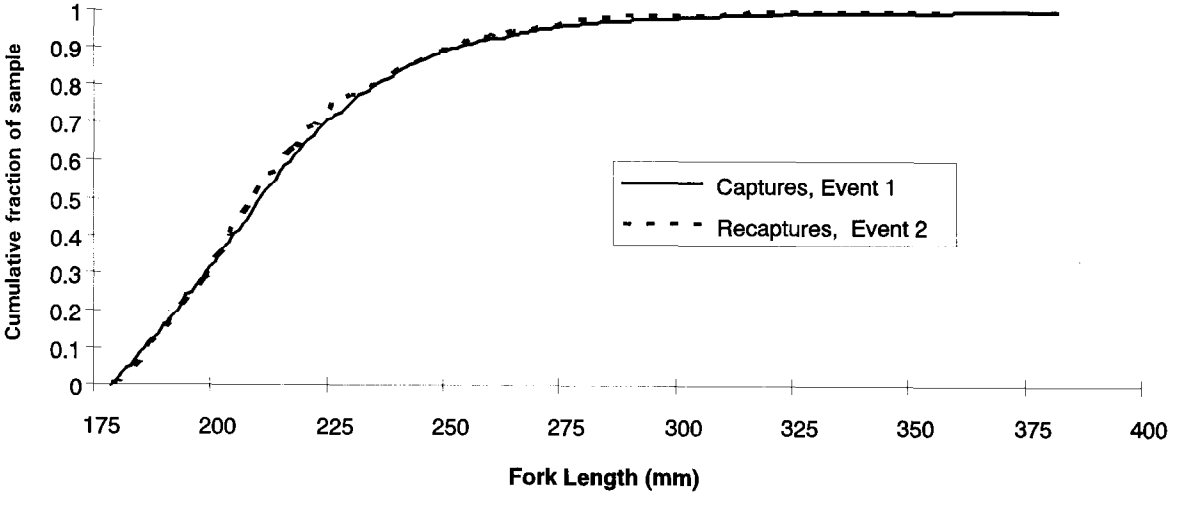




Figure 4. Cumulative histogram of lengths of cutthroat trout marked versus lengths of cutthroat trout examined for marks (upper panel) and versus lengths of cutthroat trout recaptured (lower panel), Florence Lake, 1993.

Table 4. Numbers of all cutthroat trout recovered by tagging and recovery area ($m_{ij}$), marked by area ($a_i$), and unmarked captures by area ($u_j$), sampling event 2, Florence Lake, 1993.

| | Recovery area | | | |
|---|---|---|---|---|
| Tagging area | A[a] | B[b] | C[c] | $a_i$ |
| A | 41 | 35 | 3 | 676 |
| B | 27 | 171 | 19 | 934 |
| C | 1 | 5 | 14 | 238 |
| $u_j$ | 205 | 399 | 197 | |

[a] Study zones 1,2, and 9; $\hat{N}_A$ = 3,851 ±682 at time of sampling (bootstrap SE = 485).

[b] Study zones 3, 4, 7, and 8; $\hat{N}_B$ = 931 ±565 at time of sampling (bootstrap SE = 220).

[c] Study zones 5 and 6; $\hat{N}_C$ = 3,600 ±971 at time of sampling (bootstrap SE = 781).

Table 5. Numbers of marked and unmarked cutthroat trout captured in sampling event 2, by recovery area, Florence Lake, 1993.

| | Recovery area | | | |
|---|---|---|---|---|
| | A[a] | B[b] | C[c] | |
| Marked fish | 69 | 211 | 36 | 801 |
| Unmarked fish | 205 | 399 | 197 | 316 |
| | 274 | 610 | 233 | 1,117 |

$\chi^2$ = 32.2, df = 2, $P < 0.001$

[a] Study zones 1, 2, and 9.

[b] Study zones 3, 4, 7, and 8.

[c] Study zones 5 and 6.

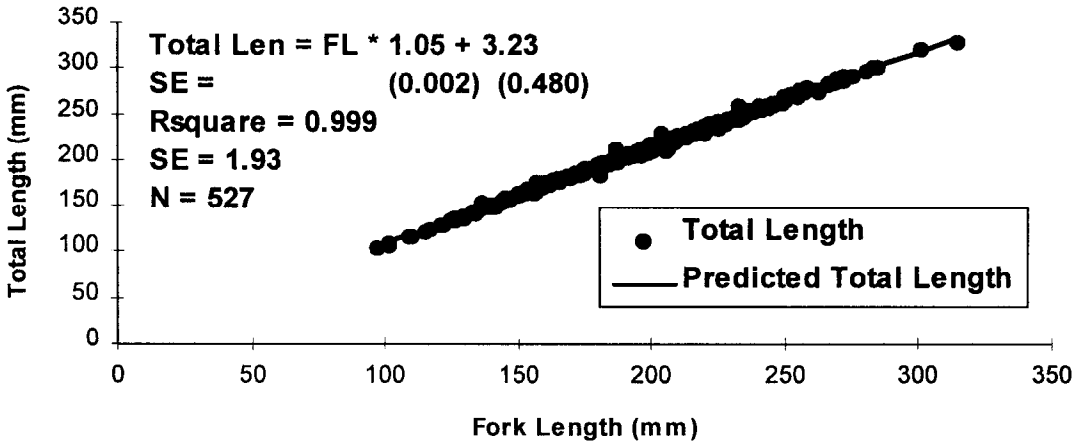



Figure 5. Regression of cutthroat trout fork length (mm) and total length (mm) at Florence Lake, 1993. The SE for each variable is in parentheses under each variable.

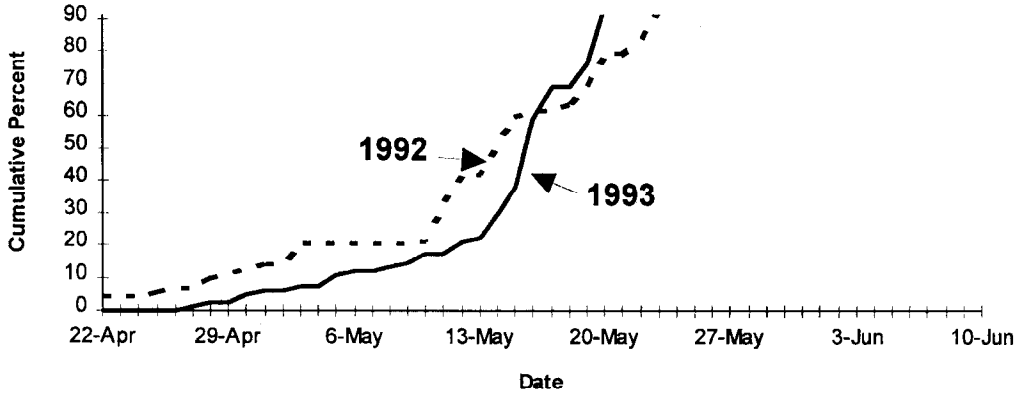



Figure 6. Cumulative percent of cutthroat trout immigrating through the Cabin and Koolmo Creek weirs in 1993 and through Camp, Main Inlet, and Koolmo Creeks in 1992, at Florence Lake. All immigrant data from each year is combined.

April 27 through May 23, 1993, dates that are similar to dates of immigration in three Florence Lake inlet streams in 1992 (Figure 6). Forty-eight percent (39) of the immigrants were classified as females and averaged 248 mm FL (SE = 6 mm); 36 immigrants were classified as males (mean length of 223 mm FL, SE = 5 mm).

Fork length (mm) and weight (g) for fish between 186 mm and 386 mm FL were regressed (separately and combined) against the number of eggs per female (Figure 7). As a preliminary analysis, simple linear regression was used to explore the data; more fish will be collected in 1994 (i.e., larger sample size). Weight was a better predictor of the number of eggs ($R^2$ = 0.778) than length ($R^2$ = 0.641) (Figure 7); combining length with weight in a multiple regression did not improve the predictive power ($R^2$ = 0.782).

Fifty-nine cutthroat trout from Florence Lake were tested for the presence of infectious hematopoietic necrosis (IHN), hemorrhagic septicemia (VHS), and bacterial kidney disease (BKD). None of the trout carried IHN or VHS virus, but 94% tested positive at low levels for BKD.

Angler Interviews

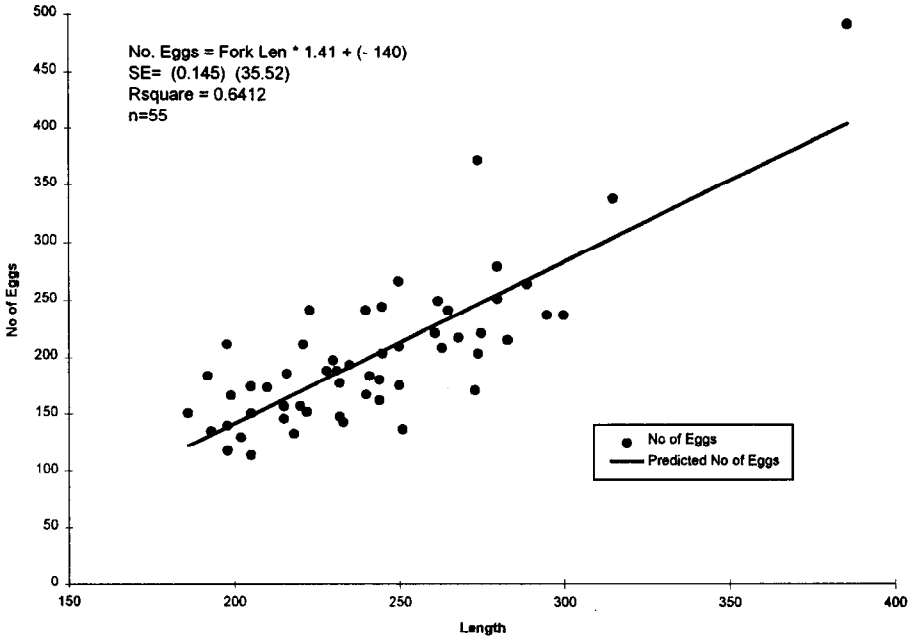
Fifteen anglers who had completed their trips were interviewed at Florence Lake between April 22 and June 15, 1993. These anglers fished a total of 21.3 hours, kept 20 cutthroat trout <18 inches, released 3 cutthroat trout <18 inches, kept 3 cutthroat trout ≥18 inches, and released 2 cutthroat trout ≥18 inches (Table 6). This compares to the USFS cabin survey, which reports a total of 26 anglers, who fished 296 hours, kept 138 cutthroat <18 inches, released 1,367 cutthroat <18 inches, kept no fish ≥18 inches, and released 36 ≥18 inches (Jones *In press*). Less than 7% of total angler effort (hours) reported at Florence Lake came from non-USFS cabin users.

## DISCUSSION

The estimated abundance of cutthroat trout ≥180 mm FL in Florence Lake in 1993 was 8,382 (SE = 818), 2,204 fish fewer than the 1992 estimate of 10,586 (SE = 1,536), and 541 fewer than the 1991 estimate of 8,924 (SE = 1,052). The 1993 estimate was within the 95% CI for 1990, 1991 and 1992. The breakdown of the Darroch estimates by year and area is presented in Table 7. The estimate of cutthroat trout abundance decreased 47% between 1992 and 1993 in Area C and 29% in Area B, while increasing by 35% in Area A.

Since estimates are for the number of trout remaining in an area at the conclusion of the experiment, low abundance in Area B is probably due to movement of fish out of Area B and into Area A between the mark and recapture events. The 1993 experiment was conducted early in the year to capture and mark fish before they mixed and thereby to improve mixing and permit abundance estimation with an estimator other than a Darroch; despite our efforts, there was still insufficient mixing, and a Darroch estimator was used.

The 1993 abundance estimate was not stratified by length, because size selectivity was not detected during event 2 (recapture event). This is the first year that the abundance estimate has not been stratified by length; abundance estimates in 1991 and 1992 were for cutthroat trout between 180 and 350 mm (Jones et al. 1992, Harding and Jones 1993).



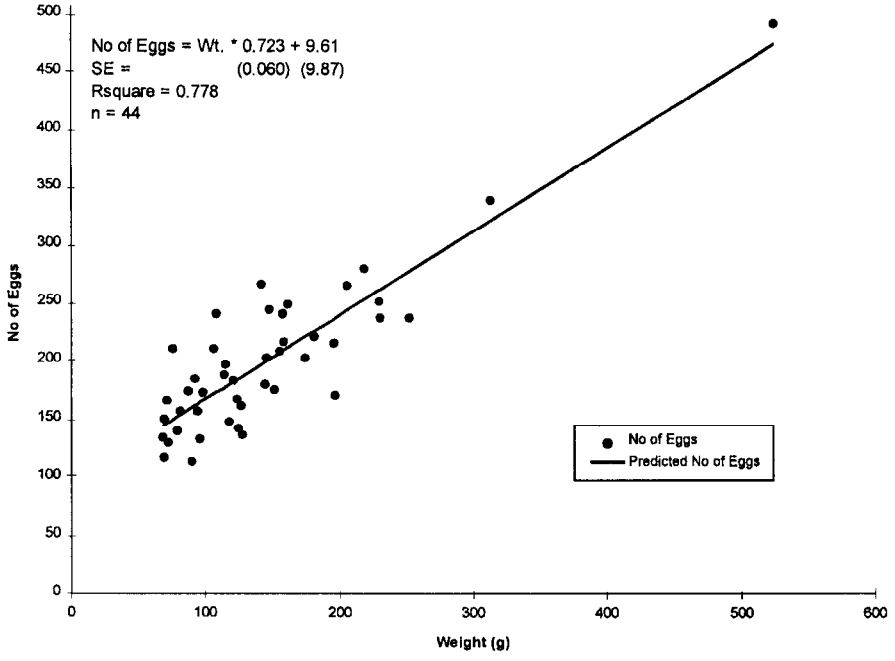




Figure 7. Regression of fork length (mm) and the number of eggs (top), and weight (g) and number of eggs (bottom) at Florence Lake, 1993. The SE for each variable is in parentheses under each variable.

Table 6. Interview data for observed non-USFS cabin users who accessed Florence Lake via new logging road (between Cube Cove and Florence Lake), 1993.

| Date | Angler number | Days fished | Hours fished | Cutthroat trout <18" Number kept | Cutthroat trout <18" Number rel. | Cutthroat trout ≥18" Number kept | Cutthroat trout ≥18" Number rel. | Dolly Varden Number kept | Dolly Varden Number rel. |
|---|---|---|---|---|---|---|---|---|---|
| 5/29/93 | 1 | 1 | 2.0 | 0 | 0 | 0 | 2 | 0 | 2 |
| 5/29/93 | 2 | 1 | 2.0 | 0 | 0 | 3 | 0 | 0 | 2 |
| 5/30/93 | 1 | 1 | 1.5 | 3 | 2 | 0 | 0 | 1 | 0 |
| 5/30/93 | 2 | 1 | 1.5 | 3 | 2 | 0 | 0 | 0 | 0 |
| 6/1/93 | 1 | 1 | 0.8 | 0 | 4 | 0 | 0 | 0 | 0 |
| 6/1/93 | 2 | 1 | 0.8 | 0 | 2 | 0 | 0 | 0 | 0 |
| 6/1/93 | 3 | 1 | 0.8 | 0 | 4 | 0 | 0 | 0 | 0 |
| 6/11/93 | 1 | 1 | 2.0 | 3 | 6 | 0 | 0 | 0 | 0 |
| 6/12/93 | 2 | 1 | 2.0 | 1 | 5 | 0 | 0 | 0 | 0 |
| 6/13/93 | 1 | 1 | 1.0 | 2 | 5 | 0 | 0 | 0 | 0 |
| 6/13/93 | 2 | 1 | 1.0 | 2 | 5 | 0 | 0 | 0 | 0 |
| 6/13/93 | 3 | 1 | 1.0 | 2 | 3 | 0 | 0 | 0 | 0 |
| 6/13/93 | 3 | 1 | 2.0 | 2 | 7 | 0 | 0 | 0 | 0 |
| 6/14/93 | 4 | 1 | 1.5 | 2 | 2 | 0 | 0 | 0 | 0 |
| 6/15/93 | 5 | 1 | 1.5 | 0 | 2 | 0 | 0 | 0 | 0 |
| Total | 15 | 15 | 21.3 | 20 | 49 | 3 | 2 | 1 | 4 |

Table 7. Summary of cutthroat trout (≥180 mm FL) abundance estimates conducted at Florence Lake during 1990 through 1993.

| Year | Mid-point of recap. event | Lake area A | Lake area B | Lake area C | Total | RP[a] | Sizes (mm) of abund. estimate |
|---|---|---|---|---|---|---|---|
| 1990 | 26 Aug | | | | 6,787[b] | 34% | 180-300 |
| 1991 | 28 Jul | 1,610 | 1,450 | 5,863 | 8,924[b] | 23% | 180-350 |
| 1992 | 18 Jun | 2,493 | 1,307 | 6,786 | 10,586[c] | 28% | 180-350 |
| 1993 | 1 Jun | 3,851 | 931 | 3,600 | 8,382 | 19% | ≥180 |

[a] Relative precision for a 95% CI.

[b] Jones et al. (1992).

[c] Harding and Jones (1993).

Weirs were operated on two inlet streams to Florence Lake to capture ripe and ripening female cutthroat trout for disease and fecundity samples and to investigate the location and time period cutthroat trout spawn. The first mature fish was captured at the Koolmo Creek weir on April 27, 1993; the last fish (spawned-out male) was passed downstream on June 4, 1993. While the weirs were not fish tight during the entire immigration/emigration period in 1991 or 1992 (i.e., Cabin Creek weir open May 21-22, 1992), the weir data does provide basic cutthroat immigration timing (Figure 6).

Disease screening of Florence Lake cutthroat trout was conducted to assess future transport of cutthroat trout from Florence Lake to Juneau area waters. No IHN or VHS was detected in the cutthroat trout, but BKD was detected in 94% of trout tested. In testing populations statewide, the ADF&G Pathology Lab has found BKD present in almost every trout population tested (Dr. Jim Seeb, Alaska Department of Fish and Game, Anchorage, personal communication). The presence of BKD could limit our options for transferring these fish, however, because of concern for other species in the systems we would like to stock.

The accurate use of Peterson estimators requires that neither immigration (or growth recruitment) or deaths occur during the experiment. We held this assumption to be valid in this experiment. Another assumption is that all fish have the same probability of capture during the first sample or the second sample or that marked and unmarked fish mix completely between the two sampling events. We attempted to satisfy this requirement by sampling uniformly across the lake surface during each sampling period. However, the hypothesis of equal probability of capture by area was soundly rejected (Table 5), so the experiment was stratified to equalize probabilities of capture for fish of different sizes, and a Darroch estimator was used to adjust for partial mixing across geographic areas of the lake.

## ACKNOWLEDGMENTS

We appreciate the efforts of Ken Koolmo and Karen Koolmo for their outstanding work in the field and for their insights into the information we collected. Kurt Kondzela assisted with field and logistical support. We thank the Shee Atika Corporation for allowing us to maintain a field camp on their property while we conducted our field studies on Florence Lake.

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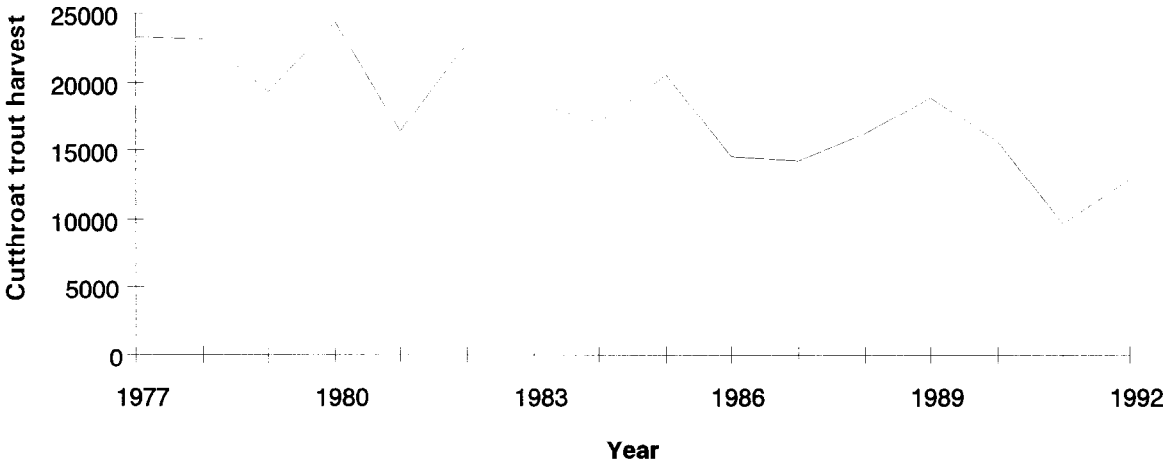
APPENDIX A




Appendix A1. Harvests of cutthroat trout in Southeast Alaska, 1977 through 1992. Bag limits were reduced from ten fish per day to four fish per day in 1980, then increased to five fish per day in 1985.

Appendix A2. History of cutthroat trout tagging and migrations by weirs at Florence Lake, 1993. Weirs operated at Koolmo and Cabin Creeks. All fish were tagged at a weir or a location described in comments.

| Tag Num. | Date Up | Date Down | Length | Sex | Comments[a] |
|---|---|---|---|---|---|
| | | | Koolmo Creek | | |
| 2629 | 16-May | | 304 | F | RIPE FECUNDITY SAMP. FIRST TAGGED 8-7-90 00LT 272mm |
| 5639 | 8-May | | 245 | F | NOT MUCH COLOR FIRST TAGGED 7-28-91 3FN 201mm |
| 5639 | | 29-May | 238 | F | TAIL SCRAGGLY |
| 5939 | 20-May | | 286 | F | ALMOST RIPE FECUNDITY SAMP. FIRST TAGGED 8-21-91 2LT 258mm NSA |
| 6411 | 12-May | | | M | ALMOST RIPE DARK FIRST TAGGED 7-3-91 8LT 228mm NSA |
| 6706 | 6-May | | 261 | F | ALMOST RIPE FIRST TAGGED 7-24-91 1LT 245mm NSA |
| 8148 | 19-May | | 209 | M | FIRST TAGGED 5-14-92 5WR 200mm NSA |
| 8984 | 15-May | | 252 | M | SPAWNING COLORS FIRST TAGGED 7-26-92 6LT 243mm NSA |
| 10112 | 20-May | | 250 | F | SPAWNED OUT FIRST TAGGED 5-10-92 3LT 247mm NSA |
| 10228 | 20-May | | 249 | F | ALMOST RIPE FIRST TAGGED 5-15-92 5LT 229mm NSA |
| 10336 | 14-May | | 250 | F | RIPE FECUNDITY SAMP. FIRST TAGGED 5-19-92 5LT 230mm NSA |
| 10360 | 19-May | | 268 | F | SPAWNED OUT SLACK STOMACH FIRST TAGGED 5-20-92 7LT 265mm NSA |
| 10498 | 24-May | | 217 | F | SPAWNED OUT FIRST TAGGED 6-1-92 2LT 219mm |
| 10498 | | 29-May | 219 | F | |
| 11523 | 20-May | | 191 | M | ALMOST RIPE FIRST TAGGED 7-26-92 5LT 183mm NSA |
| 12001 | 28-Apr | | 245 | | BRIGHT ORANGE FINS ROSY LAT. LINE TAGGED AT WEIR NSA |
| 12002 | 30-Apr | | 252 | F | SPAWNED OUT FLACID STOMACH TAGGED AT WEIR |
| 12002 | | 5-May | 252 | F | SPAWNED OUT |
| 12003 | 3-May | | 239 | M | DRIPPING MILT TAGGED AT WEIR NSA |
| 12004 | 5-May | | 238 | M | RIPE SPAWNING COLORS TAGGED AT WEIR NSA |
| 12005 | 5-May | | 293 | M | GOLDEN COLOR TAGGED AT WEIR NSA |
| 12006 | | 9-May | 317 | F | SPAWNED OUT DARK BRONZE TAGGED AT WEIR |
| 12007 | 9-May | | 228 | F | ALMOST RIPE TAGGED AT WEIR NSA |
| 12008 | 10-May | | 220 | M | ALMOST RIPE SPAWNING COLORS TAGGED AT WEIR NSA |
| 12009 | 12-May | | 254 | M | ALMOST RIPE SPAWNING COLORS TAGGED AT WEIR |
| 12009 | | 1-Jun | 247 | M | SPAWNED OUT |
| 12010 | 14-May | | 218 | M | DRIPPING MILT TAGGED AT WEIR NSA |
| 12011 | 14-May | | 223 | M | RIPE TAGGED AT WEIR NSA |
| 12020 | 16-May | | 225 | F | ALMOST RIPE TAGGED AT WEIR NSA |
| 12022 | 17-May | | 224 | M | DARK FINS YELLOWISH BELLY TAGGED AT WEIR NSA |
| 12023 | 17-May | | 240 | F | FAINT YELLOW ON BELLY TAGGED AT WEIR NSA |
| 12024 | 19-May | | 225 | F | TAGGED AT WEIR NSA |
| 12025 | 19-May | | 251 | F | RIPE FECUNDITY SAMP. TAGGED AT WEIR |
| 12026 | | 20-May | 236 | F | SPAWNED OUT TAGGED AT WEIR NSA |
| 12027 | 20-May | | 242 | M | TAGGED AT WEIR NSA |
| 12028 | 20-May | | 285 | M | TAGGED AT WEIR |
| 12028 | | 1-Jun | 281 | M | SPAWNED OUT |
| 12032 | 21-May | | 293 | F | SPAWNED OUT SLACK STOMACH TAGGED AT WEIR |
| 12032 | | 29-May | 288 | F | TAIL BEAT UP |
| 12140 | | 18-May | 264 | F | SPAWNED OUT FIRST TAGGED 4-25-93 7LT 263mm NSA |
| 14153 | 14-May | | 199 | M | TAGGED AT WEIR |
| 14153 | 20-May | | 199 | M | SECOND TIME UP |
| 14157 | 16-May | | 215 | F | SPAWNED OUT? TAGGED AT WEIR |
| 14157 | | 18-May | 215 | F | SPAWNED OUT |
| 14158 | 16-May | | 182 | M | DRIPPING MILT TAGGED AT WEIR NSA |
| 14159 | 16-May | | 205 | F | RIPE FECUNDITY SAMPLE TAGGED AT WEIR NSA |
| 14160 | 17-May | | 208 | M | LOTS OF ORANGE ON FINS TAGGED AT WEIR NSA |
| 14161 | 19-May | | 203 | M | TAGGED AT WEIR NSA |
| 14162 | 20-May | | 195 | M | DRIPPING MILT TAGGED AT WEIR NSA |
| 14163 | 20-May | | 198 | F | FECUNDITY SAMPLE TAGGED AT WEIR |
| 12316 | 17-May | | 223 | M | FIRST TAGGED 4-29-93 3LT 223mm NSA |
| 14361 | 20-May | | 214 | F | FECUNDITY SAMPLE FIRST TAGGED 4-26-93 3LT 215mm |

-continued-

Appendix A2. (page 2 of 2).

| Tag Num. | Date Up | Date Down | Length | Sex | Comments[a] |
|---|---|---|---|---|---|
| 14373 | 27-Apr | | 199 | | ROSY BODY COLOR FIRST TAGGED 4-26-93 3LT 199mm NSA |
| 15016 | 14-May | | 215 | M | FIRST TAGGED 5-11-93 3LT 218mm |
| | 20-May | | 179 | M | RIPE |
| | 16-May | | 248 | F | FECUNDITY SAMPLE |
| | 30-Apr | | 253 | F | FECUNDITY SAMPLE RIPE |
| | 10-May | | | F | FECUNDITY SAMPLE RIPE |
| | 19-May | | 257 | F | FECUNDITY SAMPLE RIPE |
| | 17-May | | 278 | F | FECUNDITY SAMPLE RIPE |
| | 16-May | | | F | FECUNDITY SAMPLE RIPE |
| | 14-May | | 225 | F | FECUNDITY SAMPLE RIPE |
| | 12-May | | 267 | F | FECUNDITY SAMPLE RIPE |
| | 27-Apr | | 179 | M | ALMOST RIPE ROSY BODY |
| | 5-May | | 226 | F | FECUNDITY SAMPLE ALMOST RIPE |
| | | | Cabin Creek Weir | | |
| 1833 | 16-May | | 247 | F | NOT RIPE FIRST TAGGED 8-8-89 7LT 173mm |
| 1833 | | 18-May | 247 | F | RIPE STILL NEEDS TO SPAWN |
| 5317 | 15-May | | 220 | M | REGEN AD FIRST TAGGED 7-11-91 6FN 192mm NSA |
| 6657 | 17-May | | 393 | F | FECUNDITY SAMPLE FIRST TAGGED 7-17-91 9HN 380mm |
| 6665 | 15-May | | 320 | M | DRIPPING MILT FIRST TAGGED 7-17-93 6LT 303mm NSA |
| 7795 | 16-May | | 198 | | COULDN'T SEX FIRST TAGGED 7-8-92 6LT 182mm NSA |
| 7874 | 17-May | | 208 | M | DRIPPING MILT FIRST TAGGED 7-24-92 6LT 197mm NSA |
| 10542 | 17-May | | 240 | M | RIPE ORANGE FINS FIRST TAGGED 6-3-92 5LT 224mm |
| 10542 | | 4-Jun | 240 | M | SPAWNED OUT |
| 10695 | 16-May | | | F | FECUNDITY SAMPLE FIRST TAGGED 6-9-92 5LT 311mm |
| 12012 | | 15-May | 272 | F | SPAWNED OUT TAGGED AT WEIR NSA |
| 12013 | 15-May | | 263 | | COULDN'T SEX TAGGED AT WEIR |
| 12013 | | 30-May | 262 | F | SPAWNED OUT |
| 12014 | 15-May | | 251 | | COULDN'T SEX NOT MUCH COLOR TAGGED AT WEIR NSA |
| 12015 | 15-May | | 272 | | COULDN'T SEX NOT MUCH COLOR TAGGED AT WEIR NSA |
| 12016 | 15-May | | 279 | | COULDN'T SEX NOT MUCH COLOR TAGGED AT WEIR NSA |
| 12017 | 16-May | | 223 | F | NOT RIPE TAGGED AT WEIR NSA |
| 12018 | 16-May | | 237 | M | DRIPPING MILT TAGGED AT WEIR NSA |
| 12019 | 16-May | | 241 | F | RIPE FECUNDITY SAMPLE TAGGED AT WEIR |
| 12021 | 17-May | | 229 | F | RIPE DARK COLOR TAGGED AT WEIR NSA |
| 12029 | 20-May | | 222 | M | RIPE TAGGED AT WEIR NSA |
| 12030 | 20-May | | 227 | F | ALMOST RIPE FECUNDITY SAMPLE TAGGED AT WEIR |
| 12031 | 20-May | | 296 | F | ALMOST RIPE FECUNDITY SAMPLE TAGGED AT WEIR |
| 12033 | 23-May | | 236 | M | TAGGED AT WEIR NSA |
| 12034 | | 24-May | 244 | M | SPAWNED OUT TAGGED AT WEIR NSA |
| 14151 | 1-May | | 190 | M | RIPE TAGGED AT WEIR NSA |
| 14152 | 13-May | | 218 | M | DARK RIPE TAGGED AT WEIR NSA |
| 14154 | 16-May | | 188 | M | TAGGED AT WEIR NSA |
| 14155 | 16-May | | 208 | M | DRIPPING MILT TAGGED AT WEIR NSA |
| 14156 | 16-May | | 229 | F | ALMOST RIPE TAGGED AT WEIR NSA |
| 14164 | 23-May | | 218 | F | ALMOST RIPE FECUNDITY SAMPLE TAGGED AT WEIR |
| 14165 | 23-May | | 214 | M | TAGGED AT WEIR NSA |
| 14166 | | 25-May | 208 | F | SPAWNED OUT TAGGED AT WEIR NSA |
| 14441 | | 20-May | 215 | F | SPAWNED OUT FIRST TAGGED 4-26-93 8LT 216mm NSA |

NSA = not seen again in 1993; LT = large trap; HN = hoop net; FN = fyke net; HL = hook and line.

[a] Comments may include area originally tagged, length at tagging, date tagged, capture method, and other observations from 1993 (e.g., tag number 5639 was originally placed on 7/28/91 in area 3 where capture was by fyke net; the fish was 258 mm in length at time of capture and was not seen again in 1993).

Appendix A3. Number of eggs, fork length (mm), weight (g), and egg size (mm) from cutthroat trout fecundity samples collected at Florence Lake during 1993.

| Date | Length | Weight | Number of eggs | Recap number | Weight of Eggs | Size of eggs | | | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Average | SE | N | |
| 7-May | 225 | | 44 | | | 5.33 | 0.0423 | 10 | Spawned Out, Did not weigh |
| 7-May | 231 | | 189 | | | 5.08 | 0.0793 | 10 | Full, Good Fecundity Sample |
| 7-May | 261 | | 222 | 6706 | | 5.095 | 0.0790 | 10 | Good Fecundity Sample |
| 7-May | 192 | | 184 | | | | | | Not Quite Ripe |
| 7-May | 235 | | 194 | | | 5.225 | 0.1009 | | Not Quite Ripe |
| 7-May | 263 | | 209 | | | 5.04 | 0.1462 | | Not Quite Ripe |
| 7-May | 205 | | 152 | | | | | | Not Ripe |
| 7-May | 274 | | 373 | | | | | | Not Ripe |
| 7-May | 215 | | 147 | | | | | | Not Ripe |
| 7-May | 240 | | 242 | | | | | | Not Ripe |
| 7-May | 232 | | 178 | | | | | | Not Ripe |
| 7-May | 222 | | 153 | | | | | | Not Ripe |
| 13-May | 268 | 158 | 218 | 12430 | 20.4 | | | | Ripe-Ovarian Fluid not weighed |
| 13-May | 230 | 114 | 198 | 10633 | 15.3 | | | | |
| 13-May | 240 | 123 | 168 | 14838 | 16.0 | | | | |
| 13-May | 345 | 323 | 42 | 12450 | 4.6 | | | | Spawned Out, 4.6 g eggs left |
| 13-May | 265 | 157 | 242 | | 13.6 | | | | Ripe |
| 13-May | 193 | 68 | 136 | 15004 | 7.4 | | | | Ripening |
| 13-May | 274 | 174 | 204 | 12129 | 16.8 | | | | Ripening |
| 13-May | 220 | 94 | 158 | 5379 | 9.2 | | | | Ripe |
| 13-May | 198 | 75 | 212 | 14897 | 12.1 | | | | Ripening |
| 13-May | 283 | 195 | 216 | | 17.8 | | | | Ripe |
| 13-May | 250 | 151 | 176 | 12416 | 15.1 | | | | Ripe |
| 13-May | 192 | 65 | | 5749 | | | | | Immature |
| 13-May | 345 | 339 | | 10696 | | | | | Spawned Out |
| 13-May | 232 | 117 | 149 | 5406 | 10.6 | | | | Ripening |
| 13-May | 221 | 106 | 212 | 4850 | 14.0 | | | | Ripening |
| 13-May | 228 | 113 | 189 | 5255 | 12.9 | | | | Ripe |
| 13-May | 244 | 144 | 181 | 12395 | 12.4 | | | | Ripe |
| 13-May | 205 | 90 | 115 | 8267 | 8.3 | | | | Ripening |
| 13-May | 218 | 96 | 134 | 10442 | 9.9 | | | | Ripening |
| 13-May | 280 | 229 | 252 | 12519 | 25.9 | | | | Ripening |
| 13-May | 198 | 79 | 141 | 14992 | 8.5 | | | | Ripening, 20 eggs not weighed |
| 13-May | 245 | 145 | 204 | 12410 | 17.2 | | | | Ripening, 15 eggs not weighed |
| 13-May | 251 | 127 | 138 | 6213 | 8.2 | | | | Ripe, 13 Eggs not weighed |
| 13-May | 205 | 87 | 175 | 15000 | 9.7 | | | | Ripe, 9 Eggs not weighed |
| 13-May | 186 | 69 | 152 | 11548 | | | | | Ripening, 65 eggs not weighed |
| 13-May | 210 | 98 | 174 | 14906 | | | | | Ripening, 10 eggs not weighed |
| 19-May | 262 | 161 | 250 | | 24.3 | | | | Ripe |
| 19-May | 215 | 85 | | 14849 | | | | | Male, Spawn out |
| 19-May | 237 | 106 | 6 | 3328 | | | | | Spawn out |
| 19-May | 277 | 183 | | | | | | | Spawn out |
| 19-May | 183 | 55 | 10 | 15122 | | | | | Immature |
| 19-May | 202 | 72 | 131 | 14159 | 6.9 | | | | Ripe, 14 eggs not weighed |
| 19-May | 241 | 120 | 184 | 10111 | 12.5 | | | | Ripe, 13 eggs not weighed |
| 19-May | 233 | 124 | 144 | 12019 | 11.3 | | | | Ripe |
| 19-May | 386 | 524 | 493 | 6657 | 59.0 | 5.6 | 0.1247 | 10 | Ripe |
| 19-May | 300 | 252 | 238 | 2629 | 23.6 | | | | Ripe, 7 eggs not weighed |

-continued-

Appendix A3. (page 2 of 2).

| Date | Length | Weight | Number of eggs | Recap number | Weight of Eggs | Size of eggs | | | Comments |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Average | SE | N | |
| 19-May | 315 | 313 | 339 | 10695 | 31.3 | | | | Ripe, 5 eggs not weighed |
| 19-May | 295 | 230 | 238 | | 26.0 | | | | Ripe |
| 19-May | 275 | 181 | 222 | | 17.8 | | | | Ripe |
| 19-May | 245 | 147 | 245 | 10336 | 19.1 | | | | Ripe |
| 27-May | 215 | 81 | 158 | 14361 | 9.1 | | | | Ripe, 10 eggs not weighed |
| 27-May | 216 | 92 | 186 | 14164 | 10.0 | | | | Ripe, 15 eggs not weighed |
| 27-May | 199 | 71 | 167 | 14163 | 8.0 | | | | Ripe, 14 eggs not weighed |
| 27-May | 250 | 141 | 267 | | 18.2 | | | | Ripe, 14 eggs not weighed |
| 27-May | 244 | 126 | 163 | 12025 | 8.3 | | | | Ripe, 49 eggs not weighed |
| 27-May | 223 | 108 | 242 | 12030 | 12.5 | | | | Ripe, 16 eggs not weighed |
| 27-May | 280 | 218 | 280 | 5939 | 28.2 | | | | Ripening, 14 eggs not weighed |
| 27-May | 289 | 205 | 265 | 12031 | 15.4 | | | | Ripe, 67 eggs not weighed |
| 27-May | 198 | 69 | 119 | 8260 | 4.7 | | | | Ripening, 17 eggs not weighed |
| 27-May | 203 | 79 | | 8187 | | | | | Spawn out, Opaque eggs |
| 27-May | 256 | 142 | | 10273 | | | | | Spawn out |
| 27-May | 273 | 196 | 172 | 6539 | 19.9 | | | | Ripening, 30 eggs not weighed |
| 27-May | 250 | 155 | 210 | 5514 | 14.3 | | | | Ripe, 29 eggs not weighed |
| 27-May | 206 | 68 | | | | | | | Spawn out |
| 27-May | 305 | | | | | | | | Spawn out |

Appendix A4. List of Florence Lake 1993 data files[a].

| Data file | Description |
|---|---|
| FLCAB93.DBF | dBase data file of Cabin Creek weir data, including daily and cumulative number of fish passed upstream and downstream, and water temperature and level |
| FLEFRT93.DBF | dBase data file of trap catch effort, including date, time, area, number of fish, gear type, and trap depth |
| FLKOOL93.DBF | dBase data file of Koolmo Creek weir data, including daily and cumulative number of fish passed upstream and downstream, and water temperature and level |
| FLOAWL93.DBF | dBase data file of date, area, species, length, and tag number for cutthroat trout >180 mm tagged or recaptured in Florence Lake in 1993 |

[a] Archived at and available from the Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1599.