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Cutthroat Trout Studies at Florence Lake, Southeast Alaska, 1992

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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 1992. Cutthroat trout were captured using baited funnel traps and hook and line. Five sampling trips to Florence Lake between April 19 and July 30, 1992 were conducted to mark and recapture cutthroat trout. The estimate of cutthroat trout abundance in Florence Lake was 10,586 (standard error = 1,536) for fish between 180 and 350 millimeters fork length.

Three weirs on Florence Lake inlet streams were operated between April 18 and June 10, 1992. These weirs were designed to capture mature cutthroat trout during their spawning migration into the inlet streams. A total of 127 cutthroat were captured; 93 migrating upstream and 34 migrating downstream.

A postal survey of registered users of U.S. Forest Service cabins at Florence Lake was conducted to estimate angler effort, catch, and harvests in 1992. At Florence Lake, an estimated 350 hours of angler effort was expended to catch an estimated 1,057 cutthroat trout, 1 kokanee *Oncorhynchus nerka*, and 362 Dolly Varden *Salvelinus malma*. Cutthroat trout harvest in Florence Lake in 1992 was estimated to be 182 fish or about 1.7 percent of the population over 180 millimeters fork length.

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

Harvests of cutthroat trout *Oncorhynchus clarki* in Southeast Alaska continued to decline from about 23,000 fish in 1977 to about 9,700 fish in 1991 (Figure 1). This is a decline by over one-half in the past 14 years (Mills 1992). This regional harvest data is for both anadromous and resident (potamodromous) forms of cutthroat trout (Trotter 1989). Turner and Hasselborg lakes probably receive the most concentrated angling pressure for cutthroat trout in Southeast Alaska (Figure 2). Florence Lake was extremely popular until 1991 when extensive clear cut logging began at the lake. Since then angling interest in Florence Lake has almost dropped to zero.

Research to refine sampling methodologies for estimating abundance, age, and other parameters to calculate sustainable harvests is being conducted at Florence and Hasselborg Lakes. In 1992, a cooperative agreement between the United States Forest Service (USFS) (Admiralty Island National Monument) and Alaska Department of Fish and Game (ADF&G) (Division of Sport Fish) led to a cutthroat trout study at Hasselborg Lake. A separate Hasselborg Lake report will be issued by the USFS in 1994.

Florence Lake, at longitude 134°4′ W, latitude 58°3′ N, about 50 km southwest of Juneau on the west side of Admiralty Island (Figure 2), is a narrow lake approximately 7.2 km long, with a maximum depth of just over 27 m (Figure 3). The lake outlet flows about 1 km into Chatham Strait. There is a barrier falls about 400 m upstream of Chatham Strait, so the population is entirely resident and lake-dwelling.

In previous studies few large fish (>350 mm FL) were captured, limiting abundance estimates to fish between 180 to 350 mm FL. It is believed that if larger mature fish could be captured in sufficient numbers then an estimate of their abundance could be made. During the spring of 1992, weirs were constructed on inlet streams in an attempt to capture mature fish. Cutthroat were captured as they moved upstream and downstream during their spawning migrations.

Our research objectives in 1992 were to:

1. estimate the abundance of cutthroat trout ≥180 mm FL in Florence Lake;

2. describe the timing of cutthroat spawning immigrations to selected inlet streams in Florence Lake;

3. estimate angler effort, catch, and harvest of cutthroat trout by users of the recreational USFS cabins at Florence Lake during the open-water season in 1992.

METHODS

Abundance

The abundance of cutthroat trout in Florence Lake was estimated using two-event mark-recapture experiments. Sampling took place between April 19 and June 11

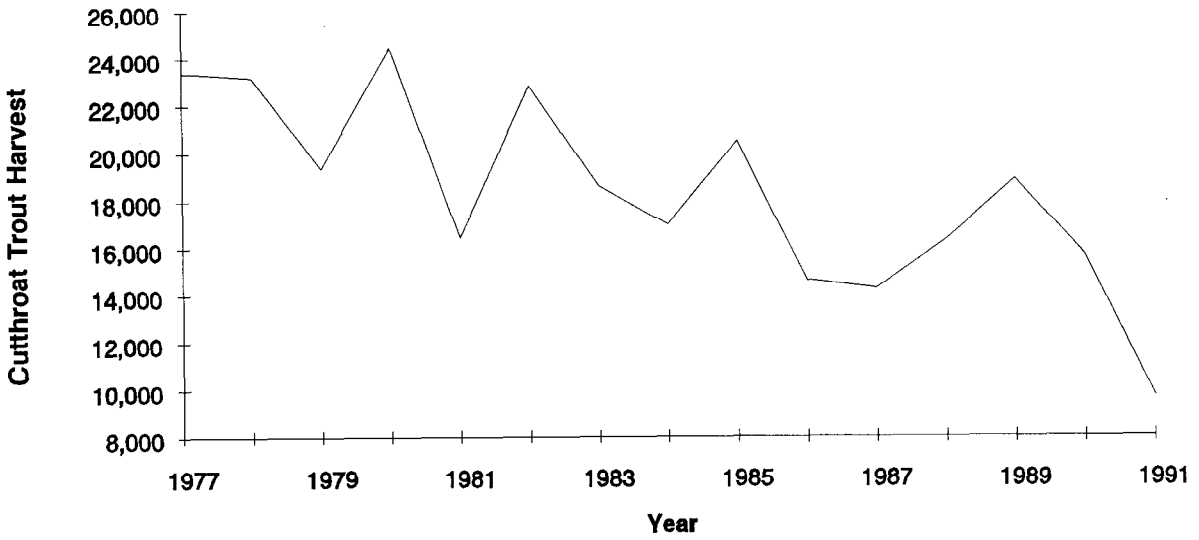


Figure 1. Harvests of cutthroat trout in Southeast Alaska from 1977 through 1991. Bag limits were reduced from 10 fish/day to 4 fish/day in 1980, then increased to 5 fish/day in 1985.

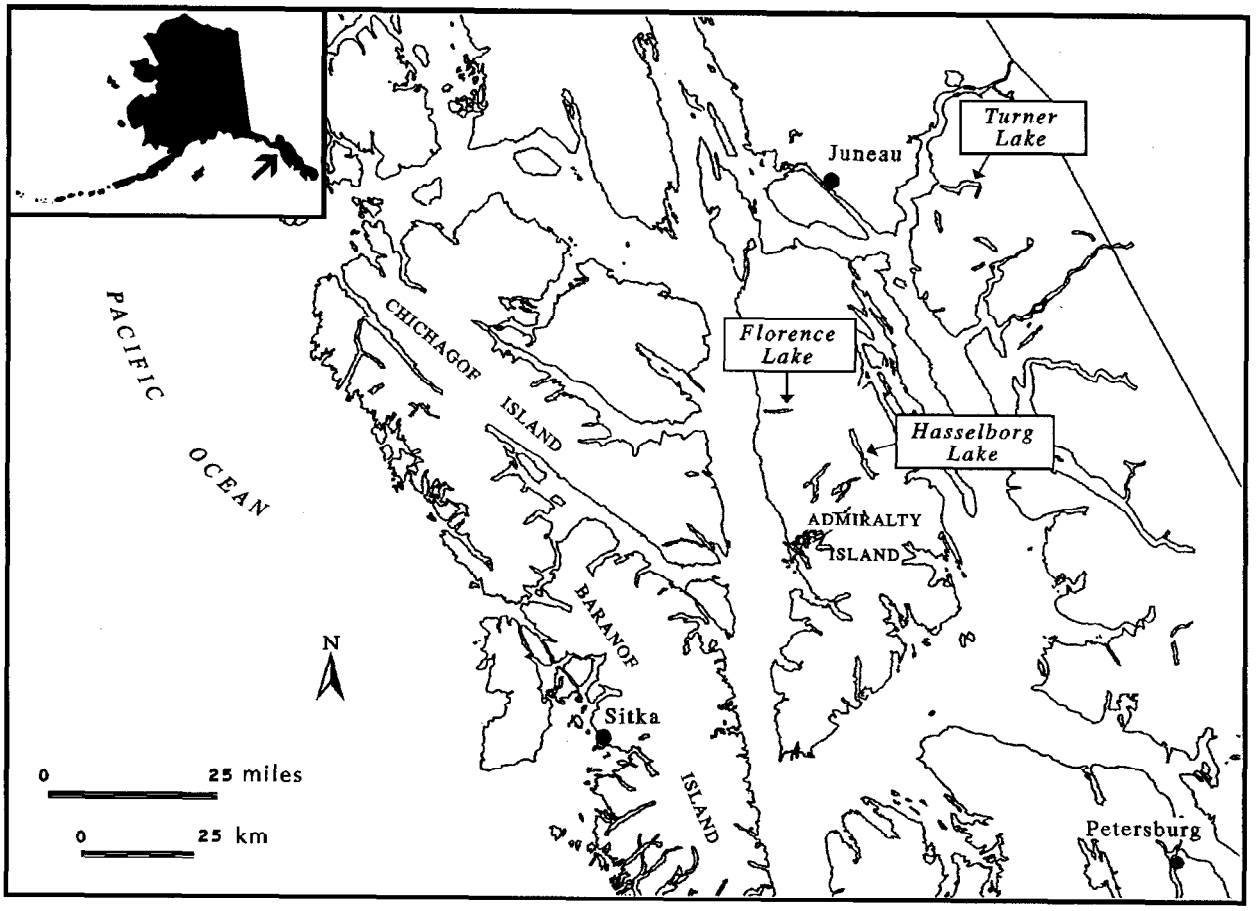


Figure 2. Juneau area and location of Florence lake, northern Southeast Alaska.

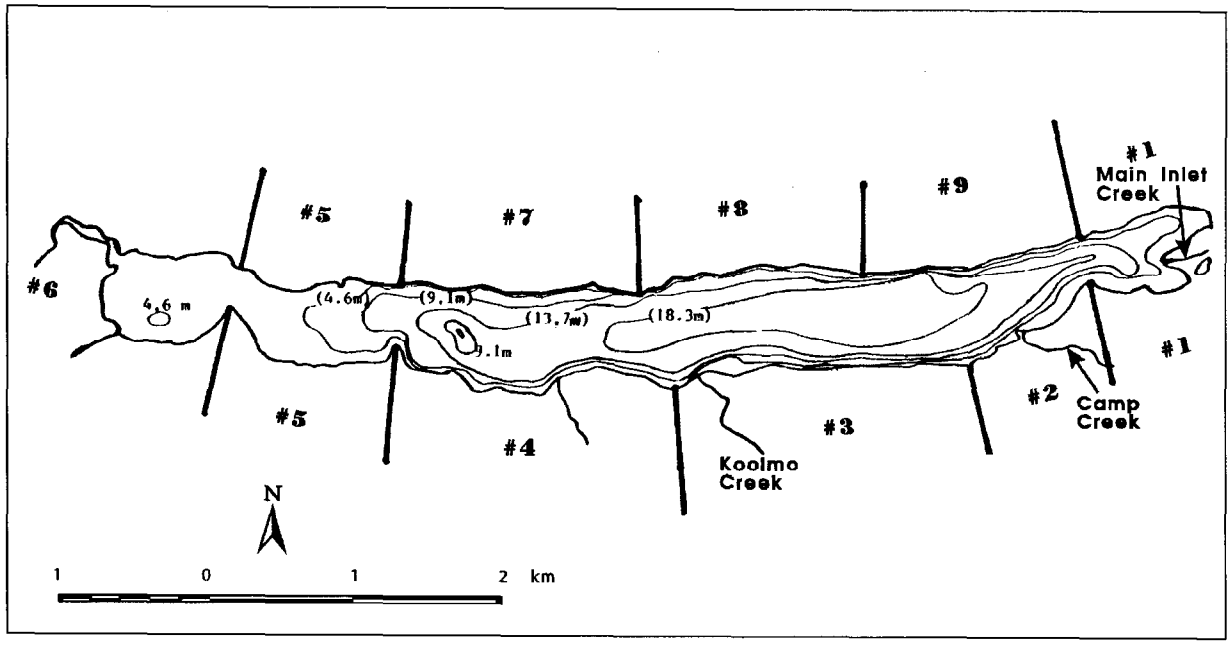


Figure 3. Bathymetric map of Florence Lake, Admiralty Island, Southeast Alaska, showing location of study areas. Sampling area "A" is study areas 1, 2, and 9, sampling area "B" is study areas 3, 4, 7, and 8, and sampling area "C" is study areas 5, and 6.

(marking event) and between July 7 and July 30, (recapture event). Picket weirs were operated at Camp, Koolmo, and Main Inlet Creeks (Figure 3) between April 19 and May 24 (inoperable May 3 through May 9), May 11 and June 11 (inoperable May 26 and June 1), and April 18 and May 3, respectively. The weirs were designed to capture upstream and downstream migrating cutthroat trout. The first sampling event (marking event) included weir operations (April 18 - June 10) and two 10-day sampling trips (May 12 - May 23, and May 29 - June 10). Two sampling trips (July 7 - July 16, and July 21 - July 30) were combined into the second sampling event (recapture event).

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

During sampling periods 2, 3, 4, and 5, large minnow traps or funnel traps were set rotating between nine areas (zones) in the lake (Figure 3). Funnel traps were fished for a similar amount of time in each of the nine zones. Betadine-treated salmon eggs were used as bait in each trap. Funnel traps were not fished in adjacent zones at the same time and the progression of sampling gear around the lake was thus staggered; e.g., zones 1, 3, 5, 7, 9, 2, 4, 6, 8. As time permitted, hook and line sampling was done with sport fishing gear using small lures, flies, or spinners. Only the weirs were operated during sample period 1.

Funnel traps were set in strings of three, perpendicular to shore. The first trap was set in the 0 to 5-m depth range, the second in a 6- to 9-m depth range, and the third in a 10- to 14-m depth range. An echo sounder was used to indicate appropriate depths. In shallow areas of the lake (the lake outlet) an attempt was made to set the traps uniformly across the area. Funnel traps were 1.5 m in length and 0.6 m in diameter, with a 9-cm opening in each end of the trap, and a mesh size of 1 cm.

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) 2-sample test (α=0.05) that compared lengths of fish marked in event 1 against the 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 three large areas (ends and middle) 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 $E[(\hat{\underline{U}} - \underline{U})(\hat{\underline{U}} - \underline{U})^T]$ as explained by Seber (1982) on page 433.

Statistical bias and variance of the estimate were estimated using the bootstrap technique (Efron 1982). Tag histories were resampled 1,000 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 1st sampling event,

n_2 = number of fish inspected for marks in the 2nd sampling event, and

m_2 = number of marked fish recaptured in the 2nd sampling event.

Secondary marks (adipose fin clips) were applied to trout tagged in event 1 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 each lake, by area and gear type.

Postal Survey

Two USFS recreational cabins at Florence Lake are available for use at $20 per day. We believe most angling effort at Florence Lake is from fisherman who fly in and stay at the USFS cabins. Minimum estimates of angler effort, catch, and harvest for the lake were thus obtained using a postal survey of parties making reservations for use of the cabins.

Two separate surveys were conducted to minimize the time between an angling trip and receipt of a survey questionnaire. The first covered all reservations up to June 30, and the second covered trips from June 30 to the end of the year.

The survey questionnaire was sent to all party leaders who had reserved cabins. The questionnaire asked if the reservation was used, the party size, the number of individuals in the party who fished, the number of hours and days fished by each party member, and the numbers of fish caught and kept and caught and released by species. We also requested the number of cutthroat trout harvested in trophy (≥18 inches) and non-trophy (<18 inches) size categories, and how party leaders rated the fishing at the lake.

Three separate mailings were conducted for each of two mailout surveys. The first mailing was sent to every party leader on USFS reservation lists. A second mailing was sent to each non-respondent after three weeks. A third and final questionnaire was sent to remaining non-respondents after another three weeks. The last mailing was sent by registered mail.

Total reported harvest H_r at each cabin is the sum over mailings m=1..3:

$$H_r = \sum_{m=1}^{3} H_{r,m} \tag{4}$$

Because response was not 100%, histograms and mean harvest per responding party for each mailing were used to decide if response to each mailing was similar. Because mean harvest per responding party was similar by mailing, total harvest H at the cabin was calculated:

$$H = \left(\frac{N}{N_r}\right) H_r \tag{5}$$

where N_r = number of responding parties (including those that did not fish), and

N = number of parties on the USFS reservation list.

Calculation of total effort E and total catch C at each cabin by species was as above after substituting the appropriate variable for H.

Expansions for effort and catch by species were calculated by substituting the appropriate variable for H. Occasionally, items are missing in a response from a party head. A party head might, for example, list catch but not effort, or effort but not catch. When this occurred, a value for the missing data was selected from the "deck" of responses received from parties reporting characteristics (effort, catch, party size) similar to those of the party not responding to a particular item. The "hot deck" data imputation procedure thus attempts to reduce bias created by item non-response (Kalton 1983).

Weir Study

Wooden tripod and picket weirs were constructed on the two major inlet streams, "Main Inlet Creek" and "Camp Creek", on April 18 and 19, respectively (Figure 3). The weirs were designed to catch immigrants and emigrants >100 mm FL. The Main Inlet Creek weir was operational between April 18 through May 3 when high water damaged the weir beyond repair. Camp Creek was operational between April 19 and May 24, except between May 3 and May 9 when the weir was inoperable (i.e. not fish-tight) due to high water. A third weir/trap was then installed on a small (1.5 m wide) inlet stream (Koolmo Creek, Figure 3) on May 11. Koolmo Creek was operated between May 11 and June 11; the weir was inoperable on May 16 and June 1. All fish captured were sampled as described above.

RESULTS

Abundance

Five thousand and sixty-five (5,065) cutthroat trout >180 mm FL were captured during sample period 2, 3, 4, and 5, with large traps and hook and line (Table 1, Figure 4). Cutthroat trout captured with weirs or with traps in the inlet streams may not have returned to the lake after spawning or had a higher mortaility than cutthroat captured in the lake. Therefore data from cutthroat trout captured during sample period 1 or captured with a weir (all sample periods) were not used in the abundance estimates. Two hundred and eight cutthroat trout were captured during sample period 1 (primarily in inlet streams) and 142 cutthroat were captured in the three weirs during sample periods 1, 2, and 3 (April 22 through June 10, 1992)(Appendix A1).

One thousand eight hundred and one (1,801) cutthroat trout between 180 mm and 460 mm FL (and 8 fish not measured) were newly tagged (or recaptured from a previous year) in sampling event 1. Eight hundred and thirty three (833) cutthroat trout between 180 mm FL and 389 mm FL were inspected for marks during the second sampling event; 147 of these fish had been "marked" in the first sampling event, but only one was larger than 350 mm FL. The sampling data was then culled of fish longer than 350 mm FL to calculate abundance.

After culling the sampling data (Table 2), 1,786 cutthroat trout between 180 mm and 350 mm FL were "marked" (newly tagged or recaptured from a previous year) in event one. Seven hundred and ninety three (793) fish between 180 mm and 350 mm FL were subsequently inspected for marks; 146 of these fish were recaptures (newly tagged or recaptured from a previous year) from event 1.

The distribution of lengths of fish recaptured in event 2 was different from the distribution of lengths marked in event 1 (Figure 5), suggesting the second sampling event was size selective ($d_{max} = 0.15$, $P = 0.003$). Based on the tagging data, little growth had occurred between sampling event 1 and sampling event 2 (average growth was 5.5 mm FL, range -8 mm to 23 mm FL). Contingency table analysis (Table 3) was used to determine two size ranges with similar probabilities of capture: 180-210 mm FL ("small") and 211-350 mm FL ("large").

Table 1. Sampling effort (hours), catch, and catch-per-unit-effort (CPUE, fish per hour) by period, gear and species, Florence Lake, 1992. Only data used in abundance computation is included (i.e. not sample period 1).

			Cutthroat Trout[a]		Dolly Varden		Kokanee	
Period[b]	Gear	Effort	Catch	CPUE	Catch	CPUE	Catch	CPUE
2	Hook & Line	2	11	5.24	0	0.00	0	0.00
	Large Trap	3,090	1,907	0.62	5,098	1.65	0	0.00
3	Hook & Line	31	125	4.04	25	0.81	1	0.03
	Large Trap	3,150	1,277	0.41	3,408	1.08	3	0.00
4	Large Trap	3,059	1,106	0.36	1,814	0.59	0	0.00
5	Large Trap	3,035	639	0.21	1,212	0.40	3	0.00
Total	Hook & Line	33	136	4.11	25	0.76	1	0.03
	Large Trap	123,358	4,929	0.40	11,532	0.93	6	0.00

[a] Cutthroat trout ≥180 mm FL.
[b] Period 2: 11 May-23 May; Period 3: 28 May-6 June; Period 4: 7 July-16 July; Period 5: 21 July-30 July.

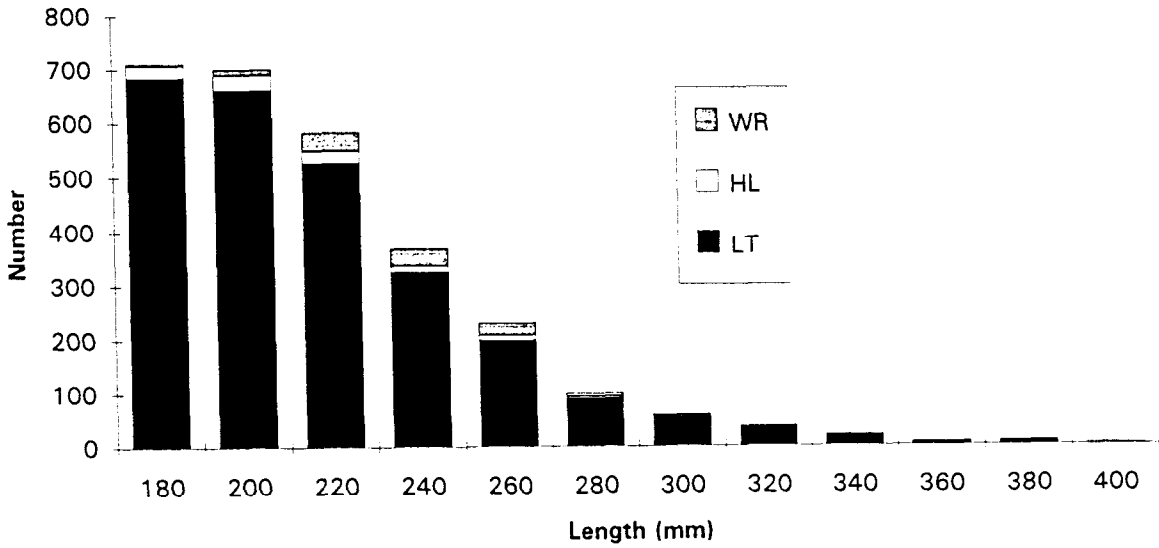
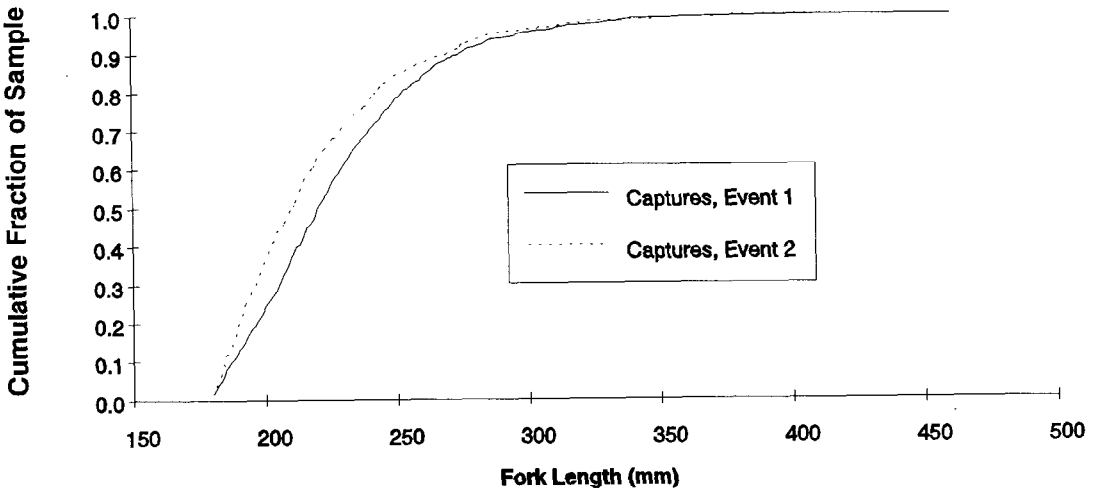


Figure 4. Length frequency of total cutthroat trout catch at Florence Lake in 1992, by gear type (LT = large trap, HL = hook and line, and WR = weir).

Table 2. Summary of cutthroat trout tagging and recovery data for fish 180-350 mm FL, Florence Lake, 1992[a]. Event 1 is periods 1 through 3 and event 2 is periods 4 and 5.

	1992 sampling period				
	Period 1 4/19 - 5/10	Period 2 5/11 - 5/23	Period 3 5/28 - 6/10	Period 4 7/7 - 7/15	Period 5 7/21 - 7/30
Newly tagged fish released alive	143	634	462	369	177
Recaptured fish tagged in:					
1988	0	0	1	0	0
1989	4	14	11	6	2
1990	28	64	43	27	5
1991	57	204	121	89	29
1992 - Event 1		1	0	64	22
Captured, not tagged	3[b]	3[c]	2[d]	2	1[e]
Total catch	235	920	489	557	236

[a] Also captured were: 20 fish >350 mm FL, 2,493 fish <180 mm FL, and 257 fish captured more than once in a sampling event (221 in Event 1, 36 in event 2).
[b] 1 Mort, 1 Tag Number Changed (replaced old tag), and 1 not tagged.
[c] 1 Mort, 1 Tag Number Changed (replaced old tag), and 1 not tagged.
[d] 1 Mort and 1 escaped before tagging.
[e] 1 Mort.



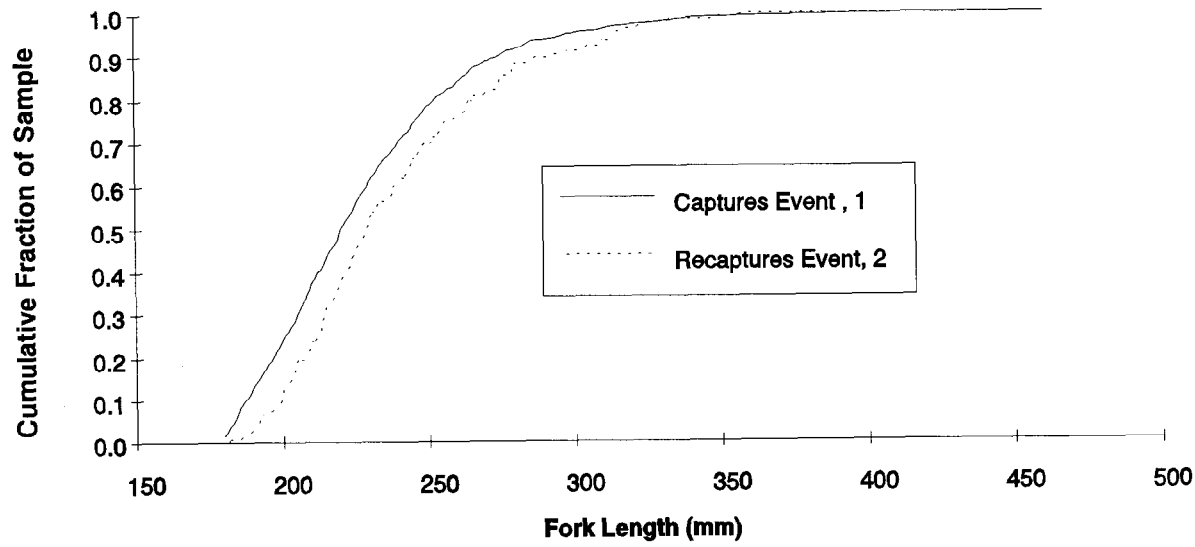


Figure 5. Cumulative histogram of lengths of cutthroat trout marked versus lengths of cutthroat trout examined for marks (above) and versus lengths of cutthroat trout recaptured (below), Florence Lake, 1992.

Table 3. Results of chi-square tests to determine size categories for stratifying the mark-recapture experiment.

Length category	Length mm (FL)	Number recaptured	Number not recaptured	Proportion recovered
I	180-210	42	630	0.06
II	211-240	51	547	0.09
III	241-270	29	303	0.09
IV	271-300	14	104	0.12
V	301-350	10	57	0.15

Hypothesis A:

$H_0 = P_I=P_{II}=P_{III}=P_{IV}=P_V$

Result: $\chi^2=9.77$ *df=4*, $p = 0.045$; reject H_0.

Hypothesis B:

$H_0 = P_{II}=P_{III}=P_{IV}=P_V$.

Result: $\chi^2=3.97$, *df=3*, $p = 0.265$; accept H_0.

Hypothesis C:

$H_0 = P_I=(P_{II}+P_{III}+P_{IV}+P_V)$.

Result: $\chi^2=5.29$, *df=1*, $p < 0.021$; reject H_0.
(12)

CONCLUSION: Stratify experiment by two size classes: $P_{(I)}$=180-210 mm, and $P_{(II+III+IV)}$=211-350 mm FL.

Some mixing of fish between sampling areas did occur between sampling events (Tables 4 and 5). However, the hypothesis of equal probability of capture by area is soundly rejected for both large and small fish (Tables 6 and 7), suggesting that Darroch's estimators should be used to estimate abundance.

Daroch's model estimated abundance for trout between 180 mm FL and 210 mm FL at $\hat{N}$ = 6,627 SE[$\hat{N}$] = 1,482. The bootstrap method estimated abundance of small fish at 3% below the Darroch estimate with SE = 1,570, but the bootstrap estimates were unstable. Similarly, the abundance estimate for fish between 211 mm FL and 350 mm FL was $\hat{N}$ = 3,959, SE[$\hat{N}$] = 404. The bootstrap method estimated abundance of large fish at 2.5% below the Darroch estimate with SE = 440. Abundance of cutthroat trout between 180 mm FL and 350 mm FL is $\hat{N}$ = 10,586, SE[$\hat{N}$] = 1,536. Relative precision for the estimate is ±28%, for a 95% confidence interval.

Postal Survey

Nine of 12 parties (75%) who had registered to use the USFS cabins at Florence Lake in 1992 responded to our survey, and no surveys were returned undeliverable. Eight responding parties (66.7%) used their reservation (Appendix A2) and 7 (77.8%) of these parties fished during their visit. The average size of a party using a reservation was 3.1 people.

We could see no obvious trend in the catch rate (catch/party) for parties responding to the three mailings in our survey. The mean CPUE (catch per party) for parties responding to the first mailing was 0.9, for the second mailing the mean CPUE was 7.5, and the mean CPUE for parties responding to the third and final mailing was 1.3.

Anglers at Florence Lake spent an estimated total of 350 hours to harvest 181 cutthroat trout, and catch 1,043 cutthroat trout, 1 kokanee, and 362 Dolly Varden in 1992 (Table 8). An estimated 862 cutthroat trout were released in Florence Lake for an overall release rate of 83%.

Weir Study

A total of 127 fish were captured in the three weirs; ninety three were immigrants and 34 were emigrants. The timing of the immigrants ranged from April 22 through June 6, 1992 with the midpoint occurring on May 14 (Figure 6). Twenty three (23) of the immigrants were classified as ripe females and averaged 241 mm FL (SE=19 mm); only 1 emigrant was classified as ripe female. Nine immigrants were classified as ripe males (mean length of 230 mm FL, SE=27 mm), and three emigrants were classified as ripe males. The remaining 91 fish (72%) were not extruding gametes and were not sexed. The emigration occurred between April 30 through June 9 with the midpoint occurring on May 16.

Table 4. Numbers of cutthroat trout 180-210 mm FL 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, 1992.

	Recovery area			
Tagging area	A[a]	B[b]	C[c]	a_i
A	7	3	3	215
B	1	11	6	215
C	3	0	8	200
u_j	75	64	227	

[a] Study areas 1,2, and 9. $\hat{N}_A$=1,692 ±774 at time of tagging (bootstrap SE=981).

[b] Study areas 3, 4, 7, and 8. $\hat{N}_B$=635 ±405 at time of tagging (bootstrap SE=405).

[c] Study areas 5 and 6. $\hat{N}_C$=4,300 ±2,009 at time of tagging (bootstrap SE=1,866).

Table 5. Numbers of cutthroat trout 211-350 mm FL 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, 1992.

	Recovery area			
Tagging area	A[a]	B[b]	C[c]	a_i
A	18	10	7	390
B	3	29	5	268
C	0	5	27	353
u_j	37	73	168	

[a] Study areas 1, 2, and 9. $\hat{N}_A$=801 ±169 at time of tagging (bootstrap SE=197).

[b] Study areas 3, 4, 7, and 8. $\hat{N}_B$=672 ±685 at time of tagging (bootstrap SE=151).

[c] Study areas 5 and 6. $\hat{N}_C$=2,486 ±420 at time of tagging (bootstrap SE=404).

Table 6. Numbers of marked and unmarked cutthroat trout 180-210 mm FL captured in sampling event 2, by recovery area, Florence Lake, 1992.

	Recovery area			
	A[a]	B[b]	C[c]	
Marked fish	11	14	17	42
Unmarked fish	75	64	227	366
	86	78	244	408

$\chi^2 = 8.45$, df = 2, P = 0.015

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

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

[c] Study areas 5 and 6.

Table 7. Numbers of marked and unmarked cutthroat trout 211-350 mm FL captured in sampling event 2, by recovery area, Florence Lake, 1992.

	Recovery area			
	A[a]	B[b]	C[c]	
Marked fish	21	44	39	104
Unmarked fish	37	73	168	278
	58	118	207	382

$\chi^2 = 16.25$ df=2, P < 0.001

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

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

[c] Study areas 5 and 6.

Table 8. Observed and estimated total effort and harvest for Florence Lake from the postal survey in 1992.

Lake	Statistic	Observed	Expanded
Florence	Hours fished	296	350
	Small cutthroat harvested[a]	153	181
	Large cutthroat harvested[b]	1	1
	Cutthroat released	740	875
	Kokanee harvested	1	1
	Kokanee released	0	0
	Dolly Varden harvested	3	4
	Dolly Varden released	303	358

[a] Small cutthroat fish <18 inches (angler estimate).

[b] Large cutthroat fish ≥18 inches (angler estimate).

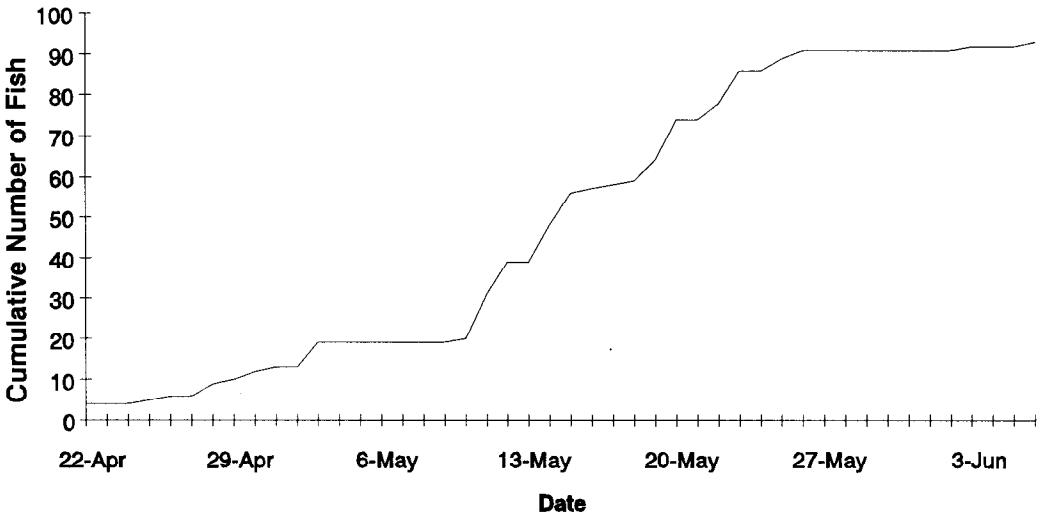


Figure 6. Cumulative number of cutthroat trout immigrating through the Main Inlet, Koolmo, and Camp Creeks, Florence Lake, 1992. Immigrant data from the three inlet streams are combined.

DISCUSSION

The 1992 Florence Lake abundance estimate (10,586, SE=1,536) for cutthroat trout 180 to 350 mm FL was 1,662 higher than the 1991 estimate (8,924, SE=1,052) but within the 95% CI for the 1991 estimate. Angler effort in 1992 was down 52% from 1991, probably due to the increased logging activity at Florence Lake.

Weirs were operated on three inlet streams to Florence Lake to evaluate whether weirs could be used to capture sufficient numbers of large (mature) cutthroat trout for a mark/recapture experiment, and to investigate the location and time period cutthroat trout spawn. High water during the first week of May caused damage to the Main Creek weir rendering it inoperable. High water forced closure of Camp Creek weir between May 3 and May 9, and closure of Koolmo Creek weir on May 11 and June 1. Fish could avoid the weir traps during periods of closure (i.e. go around the weir), and could thus freely pass upstream and downstream. We failed to capture and mark significant numbers of large cutthroat trout with the weirs as only 127 were captured using the three weirs. Cutthroat captured at the weir tended to be larger (Kruskal-Wallis test, X^2=59, P>0.0001) than fish caught with either large traps or with hook and line, during event 1 (April 20 - June 10, Figure 7).

The first mature fish was captured at the Camp Creek weir on April 22, 1992, only three days after the weir was operational. The last mature fish was passed upstream on June 6, 1992. It appears that the peak of spawning activity occurred between May 10 through May 25 (Figure 6).

Cutthroat trout may spawn more than once or experience protracted spawning at Florence Lake. Six fish were passed upstream through the weir twice, usually within 1 to 4 days of each other (tag numbers 6507, 10351, 3124, and 10378), while two fish (at least) passed upstream twice several weeks apart (tag 10004 passed 31 days later and tag 10010 passed 23 days later). Duration above the weir typically ranged from 1 to 4 days but lengths of 10, 17 and 28 days were observed. Since the weir was inoperable during brief periods, fish may have passed downstream and then back up. One cutthroat (tag number 6507) was passed upstream two consecutive days in a row, and thus avoided capture while migrating downstream. The inference that cutthroat trout may make brief spawning runs (or upstream migrations), drop back into the lake and then make another upstream migrations is similar to that described by Jones (1976).

Cutthroat trout captured with large traps during sampling period 2 (May 11 - May 23) tended to be larger (Kruskal-Wallis test, X^2=79, P>0.0001) than cutthroat caught with large traps during periods 3, 4, or 5 (Figure 8). Thus, during period 2, more cutthroat were caught, catch rates were highest, and fish tended to be bigger (Table 1 and Figure 8). This suggests that future studies should be conducted during a similar, early time period.

Koolmo Creek, which is only 1 - 2 m wide, was identified as a relatively important spawning area. Forty two cutthroat (36 upstream and 6 downstream) were passed through Koolmo Creek weir between May 11 and June 8, 1992. Small

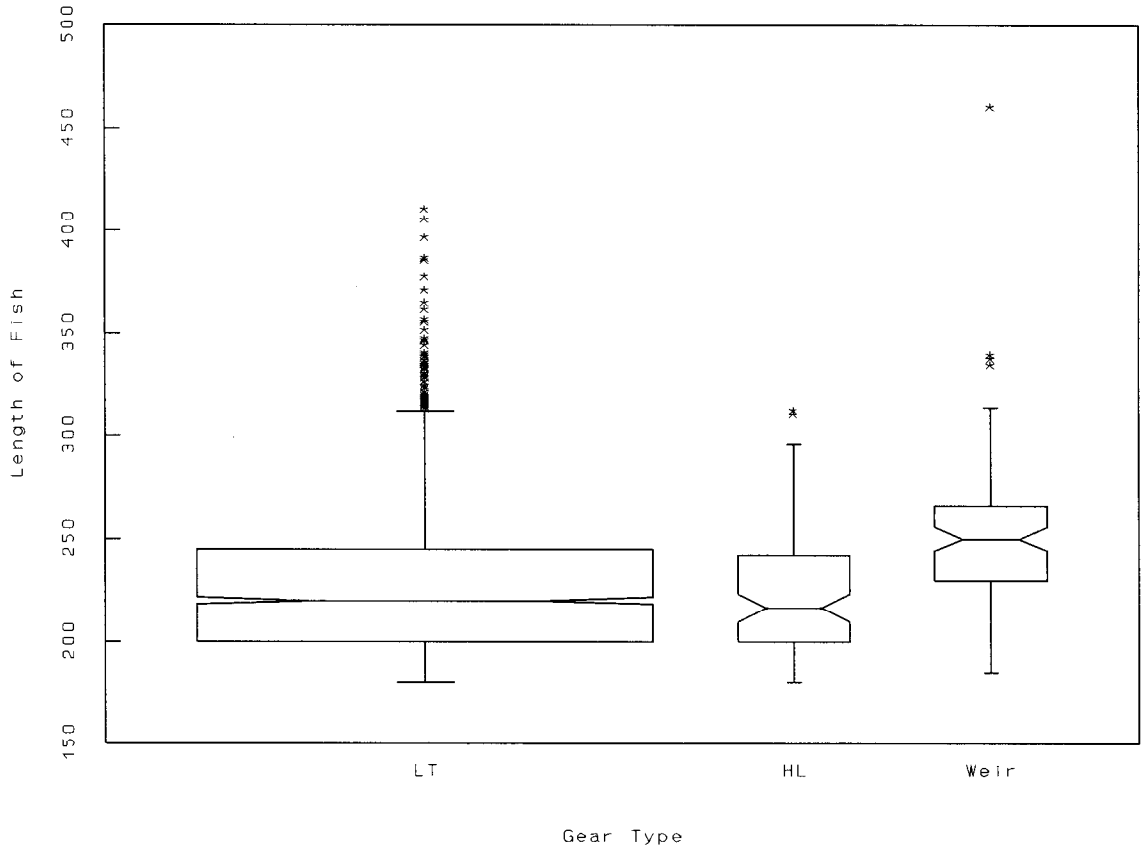


Figure 7. Boxplot of lengths of cutthroat trout caught with large traps (LT), hook and line (HL), and weirs at Florence Lake, event 1 (April 20 - June 10), 1992. The top and bottom of the box rectangles are the upper and lower quartiles of the data, respectively; the median is portrayed by the horizontal line segment within the rectangles; the lengths of the vertical lines relative to the the box show the tails of the distribution; and the notches provide an approximate 95% test of the null hypothesis that the true medians are equal (Chambers et al. 1983).

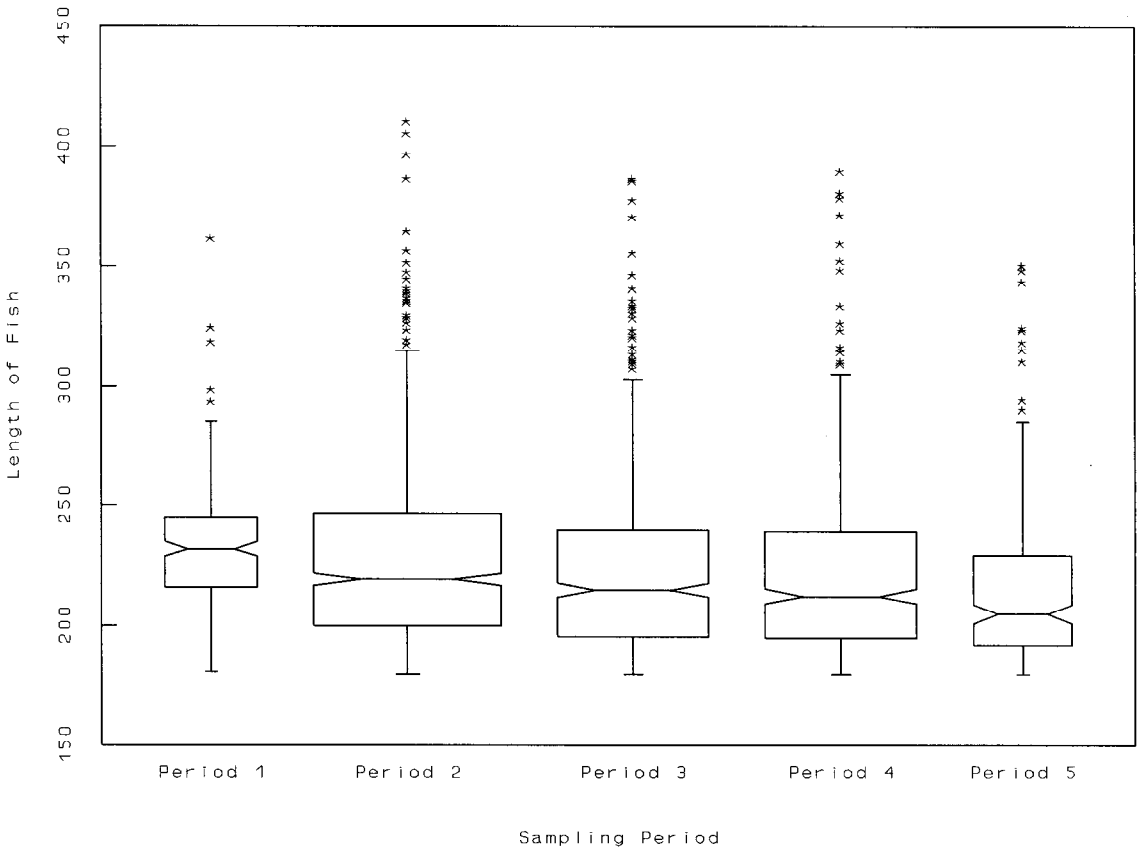


Figure 8. Boxplot of lengths of cutthroat trout caught with large traps in sampling periods 1 through 5, Florence Lake, 1992. Sample period 1 is primarily fish caught in creeks and is not included in abundance computation. The top and bottom of the box rectangles are the upper and lower quartiles of the data, respectively; the median is portrayed by the horizontal line segment within the rectangles; the lengths of the vertical lines relative to the the box show the tails of the distribution; and the notches provide an approximate 95% test of the null hypothesis that the true medians are equal (Chambers et al. 1983).

(1 - 2 m) inlet streams could thus be important spawning areas at Florence Lake. Results from the USFS at Hasselborg Lake also indicate that spawning cutthroat utilize small inlet streams, possibly as much or more than the major inlet streams (Mark Laker, US Forest Service, Admiralty National Monument, Juneau Alaska, personal communication).

The accurate use of Peterson estimators requires that immigration (or growth recruitment) and deaths do not both occur during the experiment. We assumed this assumption was valid in this experiment. Another assumption is that all fish have the same probability of capture during the first sample or in the second sample or that marked and unmarked fish mix completely between the two sampling events. In Florence Lake, the experiment was stratified to equalize probabilities of capture for fish of different size, and a Darroch estimator was used to adjust for partial mixing across geographic areas of the lake.

With the onset of clear-cut logging, interest in fishing Florence Lake appears to have declined dramatically. Effort dropped from 1,035 angler hours in 1990 to 731 hours in 1991 and again to 350 hours in 1992; a decline of 66% in three years (Jones and Harding 1991, and Jones et al. 1992, Jones). Also, catches of cutthroat trout during this period went from 2,332, to 1,883 to 1,057, a drop of over 54%.

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We appreciate the efforts of Ken Koolmo, Karen Koolmo, Brad Gruening, Kurt Kondzela, and Robert Harley for their outstanding work in the field and for their insights into the information we collected. 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. History of cutthroat trout tagging and migrations by weirs at Florence Lake, 1992. Weirs operated at Camp, Koolmo, and Main Inlet Creeks. All fish were tagged at a weir or a location described in comments. Comments may include: area originally tagged, length at tagging, date tagged, capture method, and other observations from 1992 (for example: tag number 6681 was originally placed on 7/18/91 in area 2 where capture was by hoop net; the fish was 270 mm in length at the time of capture).

Tag Num.	Date Up	Date Down	Length	Sex	Comments
Camp Creek Weir					
10004	22-Apr		224	F	Ripe dripping eggs Tagged at weir
10004	23-May		227	F	Dark Body
10005	22-Apr		270	F	Soft belly. Tagged at weir NSA
6681	22-Apr		278	F	Ripe. Tagged 7/18/91 2HN 270mm
6848	22-Apr		230	F	Dripping eggs. Tagged 7/28/91 9LT 225mm
10006	28-Apr		284		Bright, no color on fins. Tagged at weir NSA
10008	28-Apr		220	M	Ripe, dripping milt, Tagged at weir NSA
10009	29-Apr		274		Bit of orange coloration Tagged at weir
10009		16-May			17 days above weir
10010	30-Apr		223		Lean body, colored fins Tagged at weir
10010	23-May		220		Dark body
10012	1-May		226	M	Dark orange fins Tagged at weir NSA
6740	10-May		243		Fins orange. Tagged 7/25/91 3LT 240mm
6903	11-May		272		Tagged 7/31/91 6LT 265mm
8029	11-May		195	M	Tagged 5/10/92 1LT 211mm dripping milt
6802		11-May	249		Tagged 7/26/91 8HN 249mm
10116	11-May		262		Orange fins Tagged at weir
10116		12-May			Dark orange fins, 1 day above weir
5273	11-May		210		Orange fins First tagged 7/3/91 8LT 215mm
5273		14-May	217		Skinny, dark 3 days above weir
10114	11-May		241		Orange fins. Tagged at weir NSA
10115	11-May		277		Orange fins. Tagged at weir NSA
10117	11-May		288		Orange fins. Tagged at weir NSA
10118	11-May		253		Orange fins. Tagged at weir NSA
10119		11-May	281		Tagged at weir NSA
10120		11-May	256		Bright. Tagged at weir NSA
10196		13-May	339		Tagged at weir NSA
10197		13-May	252		Tagged at weir NSA
10198		14-May	294		Tagged at weir NSA
8124		14-May	234		Tagged at weir. Recovered 5/17 2LT 232mm
10218	14-May		250		Tagged at weir
10218		16-May			2 days above weir
2814	15-May		270		First tagged 8/22/90 5LT 248mm
5502	15-May		272		First tagged 7/18/91 2HN 219mm
6141	15-May		216		First tagged 6/27/91 5LT 307mm
2549		15-May	278		First tagged 8/3/90 4GN 260mm
6692	15-May		238		Soft full belly. Tagged 7/18/91 8LT 239mm
10219	15-May		243		Soft full belly, Tagged at weir NSA

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Tag Num.	Date Up	Date Down	Length	Sex	Comments
10220	15-May		297		Tagged at weir NSA
8150	15-May		215	F	Dripping eggs, Tagged at weir NSA
10222		15-May	337		Scale loss over body, Tagged at weir NSA
10223		15-May	334		Tagged at weir NSA
10221	15-May		216		Tagged at weir
10221	16-May				One day above weir
10253		16-May	253	M	Dripping milt. Tagged at weir NSA
2776		16-May	312		First tagged 8/19/90 5LT 296mm
6743	17-May		230		First tagged 7/25/91 3LT 233mm
2772		17-May	314		Dark body. First tagged 8/19/90 5HL 284mm
10323		18-May	272		Tagged at weir NSA
2795	18-May		245		First tagged 8/20/90 8LT 239mm
2795		22-May			Spawned out, 4 days above weir
10034	20-May				Bright, First tagged 5/4/92 2LT 223mm
10283	20-May				Bright, First tagged 5/17/92 2LT 240mm
10347	20-May		253	F	Dripping eggs, tagged at weir NSA
10348	20-May		227		Lean, orange fins, tagged at weir NSA
10349	20-May		222	F	Dripping eggs, tagged at weir NSA
6709	20-May		250		Soft belly, First tagged 7/24/91 4FN 245mm
2739	20-May		233		Soft belly. First tagged 8/17/90 4LT 220mm
2747	20-May		249		Soft, fat, dark, First tagged 8/17/90 00GN 242mm
6679		21-May	230		Rosey First tagged 7/18/91 2HN 232mm
10029		21-May	253		First tagged 5/4/92 2LT 252mm bright
10107		21-May	234		First tagged 5/7/92 3LT 236mm
4058	22-May		230		Fat, dark, First tagged 8/7/90 mid-lake 215mm
6235	23-May				Dark, First tagged 6/28/91 8HL 220mm
6470	23-May		252	F	Dripping eggs, First tagged 7/12/91 8HL 250mm
6310		23-May	284		Fat, First tagged 6/30/91 2LT 278mm
10402	23-May		221		Almost bright, tagged at weir NSA
10403	23-May		245		Dark, fat, tagged at weir NSA
6799	23-May		260		Dark, First tagged 7/26/91 8FN 253mm
6954	23-May		252		First tagged 8/1/91 2HN 250mm
10413		24-May	259		Spawned out, tattered fins, tagged at weir
2543		25-May	460		First tagged 8/2/90 1HL 415mm released in 2
10100		13-May			First tagged 5/7/92 2LT 226mm Ripe soft belly
Koolmo Creek Weir					
6507	11-May		261		Bright, First tagged 7/13/91 1FN 260mm
6507	12-May		264		Color on fins
6507		22-May	261		Dark orange fins, 10 days above weir
3124	11-May		245	F	Soft belly, First tagged 8/8/89 3FN 162mm
3124	14-May		243	F	Ripe dripping eggs
10113	11-May		250	F	Dripping eggs, Tagged at weir NSA
10121	12-May		232	F	Dripping eggs, Tagged at weir NSA
10122	12-May		264		Dark, Tagged at weir NSA
10123	12-May		222		Orange tipped fins, Tagged at weir
10124	12-May		233	F	Dripping eggs Tagged at weir
10125	12-May		256	F	Dripping eggs, Tagged at weir NSA

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Appendix A1. (Page 3 of 3).

Tag Num.	Date Up	Date Down	Length	Sex	Comments
10126	12-May		240	M	Color on fins, Tagged at weir
10126		9-Jun	238	M	Spawned out dark, very skinny
8030	12-May		218		Tagged at weir, NSA
10216	14-May		250	F	Dripping eggs, Tagged at weir NSA
10217	14-May		277	F	Dripping eggs, Tagged at weir, NSA
8148	14-May		200		Dark Tagged at weir, NSA
8149	14-May		209	F	Dripping eggs, Tagged at weir, NSA
10215	14-May		230		Fat belly, Tagged at weir
10215	26-May				Looked like lake fish
4147	14-May		219		Lean body, First tagged 8/15/90 5LT 175mm
5891	14-May		239		First tagged 8/11/91 3FN 229mm
8224		18-May	199		Tagged at weir
8224	19-May				Dark, gill plate colored
6328	19-May		251	F	Big soft belly, First tagged 7/1/91 4LT 250mm
10324	19-May		261		Dark, gill plate colored, Tagged at weir
10324		20-May		M	Dripping milt, 1 day above weir
2706	19-May		233		Dark, First tagged 8/15/90 5LT 210mm
5531	19-May		231	F	Ripe, First tagged 7/18/91 8LT 233mm
10350	20-May		254		Fat belly, Tagged at weir, NSA
10351	20-May		255		Looked like lake cut, Tagged at weir
10351	22-May				Belly dark grayish
10379	22-May		250		Fat belly, Tagged at weir, NSA
10378	22-May		279		Fins darker than lake cut, Tagged at weir
10378	26-May				Dark body and head
8376	25-May		185	M	Dripping milt, Tagged at weir, NSA
3142	25-May		242	F	Dripping eggs, First tagged 8/8/89 7LT 215mm
6057	25-May				Bright, First tagged 6/26/91 3LT 239mm
4751		25-May	258		First tagged 9/2/90 7HL 253mm
2637	3-Jun		225	F	Fat belly, First tagged 8/7/90 mid-lake LT 224m
5522	6-Jun		222	F	Soft belly, First tagged 7/18/91 8LT 219mm
5522		8-Jun	223	F	Spawned out, skinny, mushy
Main Inlet Weir					
10002	25-Apr		270		Colored fins, Tagged at weir NSA
10003	26-Apr		250		Bright, Tagged at weir NSA
10007	28-Apr		223		Bright, Tagged at weir NSA
4043	30-Apr		214		Bright, First tagged 8/5/90 1LT mm
10011		30-Apr	237		Bright, Tagged at weir, NSA
10016		2-May	242		Colored fins, Tagged at weir, NSA
10017	3-May		260	M	Dripping milt, Tagged at weir, NSA
10018	3-May		246	M	Dripping milt, Tagged at weir, NSA
10019	3-May		262	M	Dripping milt, Tagged at weir, NSA
10020	3-May		226		Bright, Tagged at weir, NSA
10021	3-May		266		Bright Tagged at weir, NSA
10022	3-May		236	M	Dripping milt, Tagged at weir, NSA

Code Key:

NSA=Not seen again in 1992
LT=Large trap HN=Hoop net
FN=Fyke net HL=Hook and line

Appendix A2. Frequency of responses to the postal creel survey by question, Florence Lake, 1992.

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1. Did you or a member of your party use your U.S. Forest Service cabin reservation?

Yes	8 (67.7%)
No	1 (8.3%)
No Response	3 (25.0%)

2. If you or a member of your party did use the cabin, did you fish while you were there?

Yes	7 (77.8%)
No	2 (22.2%)

3. How many people were in your group? 3.1 Average

4. Would you like to see a copy of our summary report when it is available?

Yes	7 (77.8%)
No	1 (11.1%)
No Response	1 (11.1%)

5. Overall, how would you rate the fishing at Florence Lake?

Poor	2 (28.6%)
Fair	1 (14.3%)
Good	2 (28.6%)
Excellent	1 (14.3%)
No Response	1 (14.3%)

Appendix A3. List of Florence Lake 1992 data[a] files.

Data file	Description
FLCAMP92.DBF	dBase data file of Camp Creek weir data, including daily and cumulative number of fish passed upstream and downstream, and water temperature and level.
FLEFRT92.DBF	dBase data file of trap catch effort, including date, time, area, number of fish, gear type, and trap depth.
FLKOOL92.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.
FLMAIN92.DBF	dBase data file of Main Inlet Creek weir data, including daily and cumulative number of fish passed upstream and downstream, and water temperature and level.
FLOAWL92.DBF	dBase data file of date, area, species, length, and tag number for cutthroat trout >180 mm tagged or recaptured in Florence Lake in 1992.

[a] Data files are 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.