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Cutthroat Trout Studies at Florence and Hasselborg Lakes, Southeast Alaska, 1991

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ABSTRACT

We conducted mark-recapture experiments to estimate abundance of cutthroat trout *Oncorhynchus clarki* in lakes on Admiralty Island, near Juneau, in 1991. The studies included Florence Lake, on the west side of Admiralty Island, and Hasselborg Lake, located in the Admiralty Island Wilderness Area. Cutthroat trout were captured by using baited fyke nets, hoop traps, hook and line, and funnel traps. Four sampling trips to Florence Lake between June 25 and August 14, and two trips to the north basin of Hasselborg Lake between August 21 and September 11 were used to mark and recapture fish. The estimate of cutthroat trout abundance in Florence Lake was 8,924 trout (SE = 1,052) for fish between 180 and 350 millimeters in length. The estimate for cutthroat trout abundance in the north basin of Hasselborg Lake is 4,824 (SE = 594) for fish between 180 and 350 millimeters in length. The abundance estimate for Hasselborg was obtained in a pilot survey having small samples.

A postal survey of registered users of U.S. Forest Service cabins at Florence, Hasselborg, and Turner lakes was conducted to estimate minimum angler effort, catch, and harvests in 1991. At Florence Lake, a minimum of 731 hours of angler effort was expended to catch at least 1,883 cutthroat trout, 116 kokanee *Oncorhynchus nerka*, and 143 Dolly Varden *Salvelinus malma*. At Hasselborg Lake, a minimum 1,679 hours of angler effort was expended to catch 3,738 cutthroat trout, 365 kokanee, and 227 Dolly Varden. In Turner Lake we estimated a minimum 1,379 hours of angler effort was spent to catch 720 cutthroat trout, 325 kokanee, and 551 Dolly Varden.

Cutthroat trout harvest in Florence Lake in 1991 was estimated to be 464 fish or about 5% of the estimated cutthroat trout abundance. Harvest in Hasselborg Lake (both basins) in 1991 was estimated to be 878 cutthroat trout. The exploitation rate for cutthroat trout in Hasselborg lake (both basins) is unknown, but it was potentially higher than in Florence Lake.

KEY WORDS: Cutthroat trout, *Oncorhynchus clarki*, Florence Lake, Hasselborg Lake, Turner 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 have declined from about 23,000 fish in 1977 to about 15,000 fish in 1990 (Figure 1), or about one-third in the past 13 years (Mills 1991). The decline is more apparent in data for Ketchikan, Prince of Wales Island, Kake, Petersburg, Wrangell, and Stikine in southern Southeast Alaska than for Sitka and Juneau in northern Southeast Alaska (Mills 1991). This regional harvest data is for both anadromous and resident (potamodromous) forms of cutthroat trout (Trotter 1989).

Management of cutthroat trout in Southeast Alaska prior to 1982 was summarized by Jones (1982), who thought that abundance of anadromous cutthroat trout had declined, while, with local exceptions, populations of resident cutthroat trout remained fairly stable. A daily bag limit of 20 cutthroat trout per day was first established in the 1940's and has changed several times since as listed below:

Years	Daily limit	Additional restrictions	Possession limit
1940's - 1959	20	3 over 20"	2 daily bag limits
1960 - 1970	15	3 over 20"	2 daily bag limits
1971 - 1974	15	3 over 20"	2 daily bag limits
1975 - 1979	10	2 over 20"	2 daily bag limits
1980 - 1982	4	1 over 16"	1 daily bag limit
1983 - 1984	4	1 over 16"	2 daily bag limits
1985 - present	5	1 over 16"	2 daily bag limits

Large, popular lakes (Turner, Florence, Hasselborg, etc.) probably receive the most concentrated angling pressure (for cutthroat trout) in Southeast Alaska. Selection of Turner Lake for a sockeye salmon (*O. nerka*) enhancement project provided an impetus to develop techniques for estimating trout abundance, age, and harvests in large, remote lakes in Southeast Alaska (Jones et al. 1989, Jones et al. 1990). The enhancement project at Turner Lake was canceled in May 1990, due to the potential for introducing Infectious Hematopoietic Necrosis Virus (IHNV). Exploitation rates in Turner Lake were high (Jones and Harding 1991) and a catch-and-release-only regulation was imposed in 1992. Practical research to refine sampling methodologies for estimating abundance, age, and other parameters to calculate sustainable harvests is currently conducted at Florence and Hasselborg Lakes. A postal survey is also being conducted on each lake to estimate cutthroat trout effort, catch and harvest.

Florence Lake and Hasselborg Lake (Figure 2) are two of the most popular lakes in Southeast Alaska for fly-in fishing for cutthroat trout. Access to both lakes is mostly by small plane from Juneau or Sitka. Florence and Hasselborg lakes are designated "High Quality" or "Important" watersheds by both the Alaska Department of Fish and Game (ADF&G) and United States Forest Service (USFS) (TLMP 1979). The number of reported visitor days to these lakes has nearly doubled in the past 15 years (Laura Calhoon, USFS, Sitka, Alaska, personal communication) to over 4,000 at Florence Lake and 3,000 at Hasselborg Lake during 1991 (USFS, Juneau, Alaska, personal communication).

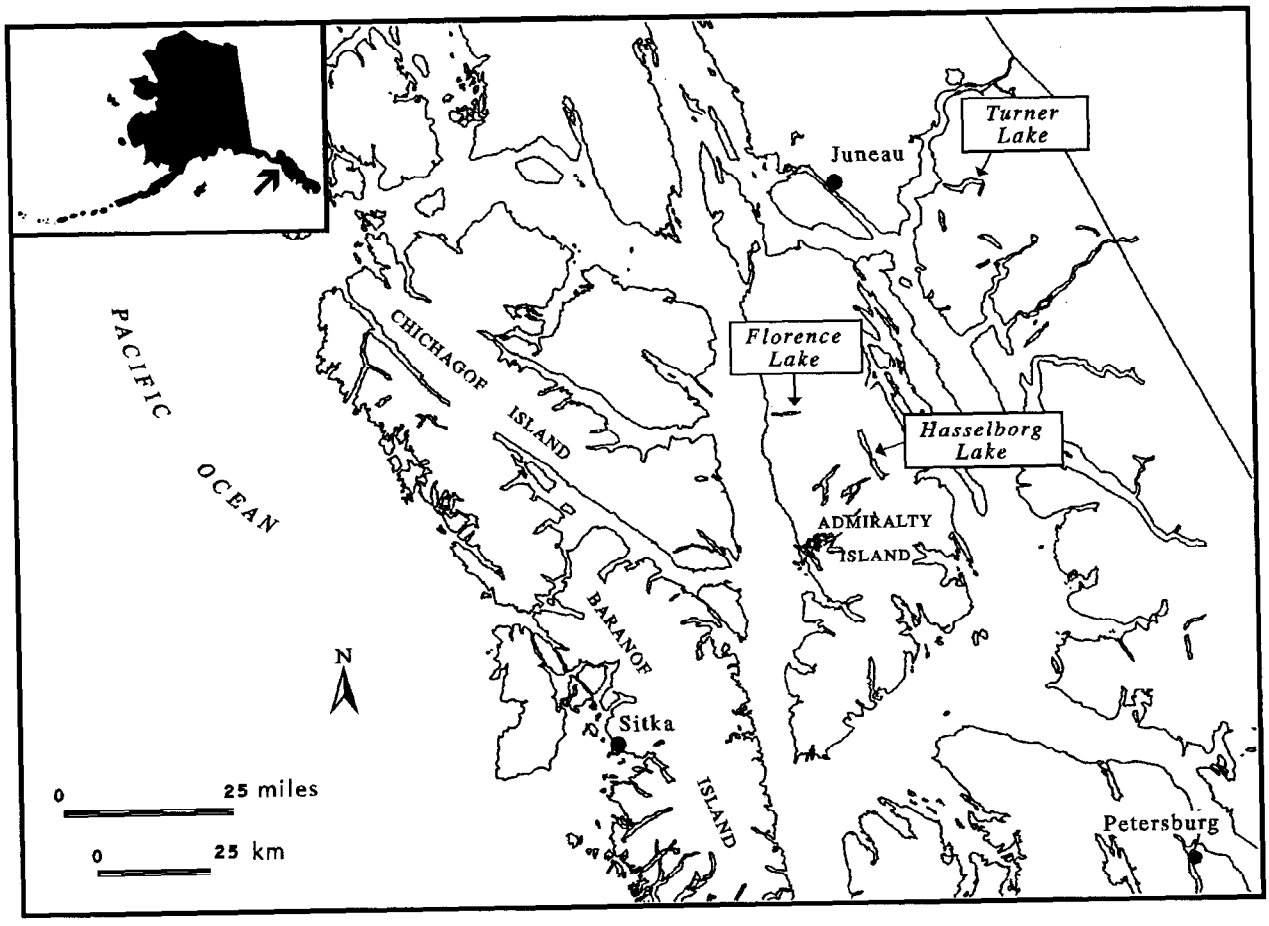

Figure 2. Juneau area and location of Florence, Hasselborg, and Turner lakes, northern Southeast Alaska.

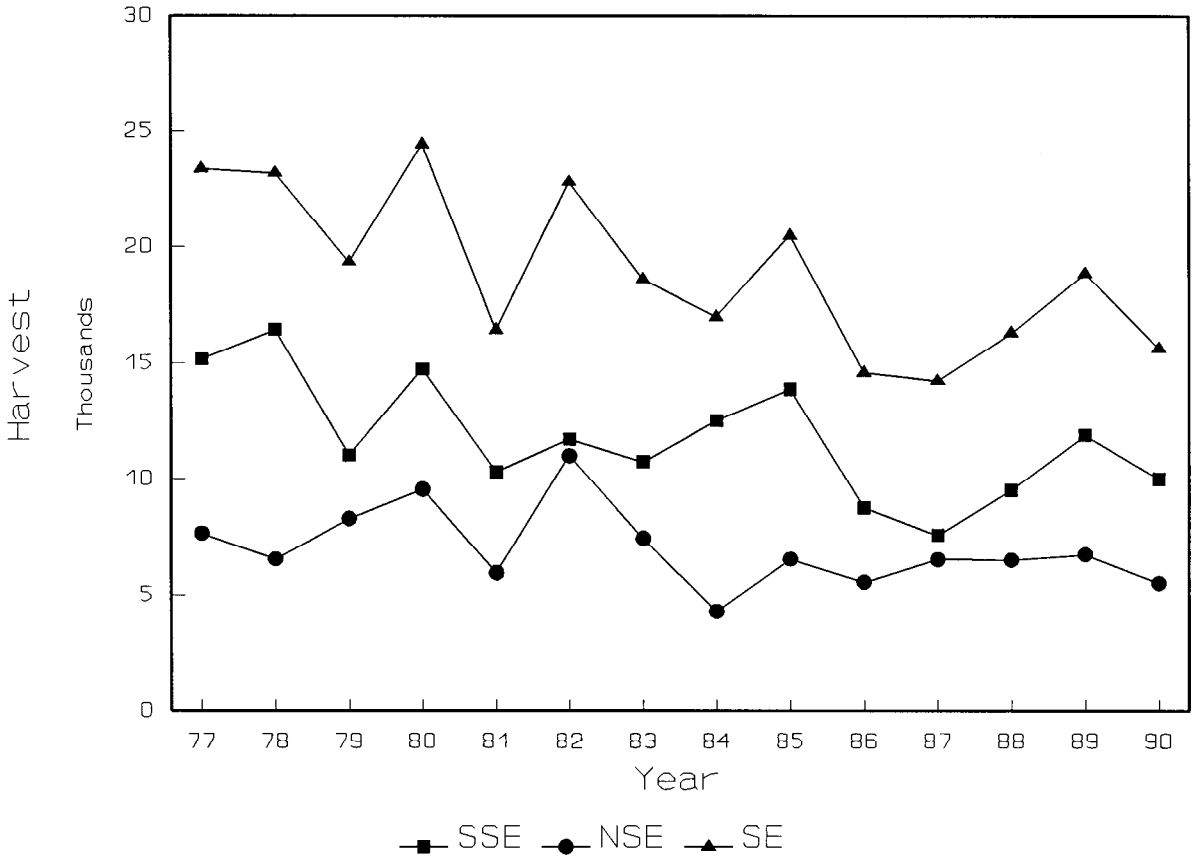

Figure 1. Harvests of cutthroat trout in southern Southeast Alaska (SSE), northern Southeast Alaska (NSE), and all of Southeast (SE) Alaska, 1977 through 1990. Bag limits were reduced from 10 fish/day to 4 fish/day in 1980, then increased to 5 fish/ day in 1985.

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.

The Florence Lake watershed is scheduled for extensive clear-cut logging in the next 2 years (James Senna, Shee Atika Corporation, Sitka, Alaska, personal communication). The logging started during late 1991 and is expected to strip the perimeter of the lake of all marketable timber. The effects of the logging and associated road building on the lake habitat and its fishery resources are not known. An early study at Florence Lake (Jones 1981) focused on mapping stream habitat for cutthroat trout.

Hasselborg Lake, at longitude 134°3′ W, latitude 57°7′ W, about 64 km south of Juneau in the interior of Admiralty Island (in the Admiralty Island National Monument), is almost 14 km long, with a maximum depth of just over 89 m (Figure 4). Hasselborg Lake is divided into two basins by a narrow, 7-m-deep isthmus. The outlet of Hasselborg Lake is blocked by barrier falls, so all cutthroat trout in this system are potamodromous.

Hasselborg Lake is one of three lakes (Turner, Wilson, and Hasselborg) in Southeast Alaska known to produce significant numbers of trophy-class (≥3 pound) cutthroat trout. Hasselborg Lake has produced over 21% of the trophy cutthroat trout in the ADF&G Trophy Sport Fish Program. No trophy cutthroat trout have been reported, however, since 1982. Hasselborg Lake was cited for priority study in the ADF&G Strategic Plan for Juneau (Schwan 1990). An earlier study at Hasselborg Lake (Jones 1980) was oriented to mapping stream habitats.

Our research objectives in 1991 were to:

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

2. estimate the age composition of cutthroat trout ≥180 mm FL in Florence Lake and the north basin of Hasselborg Lake;

3. estimate mean length at age for cutthroat trout ≥180 mm FL in Florence and Hasselborg lakes; and

4. census minimum angler effort, catch, and harvests by users of USFS cabins at Florence, Hasselborg, and Turner lakes in 1991.

We continued the postal survey for Turner Lake, even though we were not conducting field studies there, to continue monitoring angler effort, catch and harvests in this system.

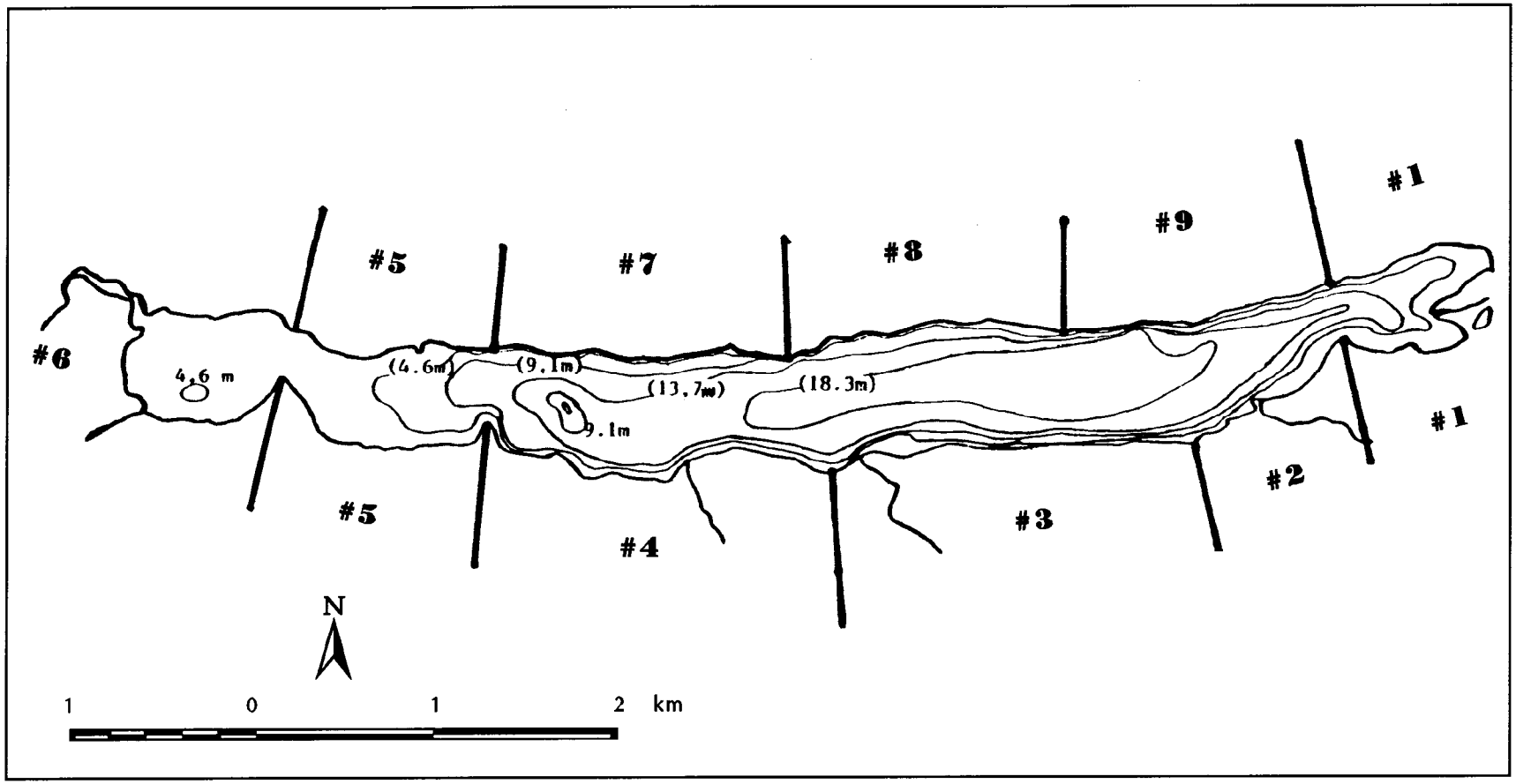

Figure 3. Bathymetric map of Florence Lake, Admiralty Island, Southeast Alaska, showing location of study areas. Sampling area "A" is study areas 1, 2, and 9, area "B" is study areas 3, 4, 7, and 8, and sampling area "C" is study areas 5, and 6.

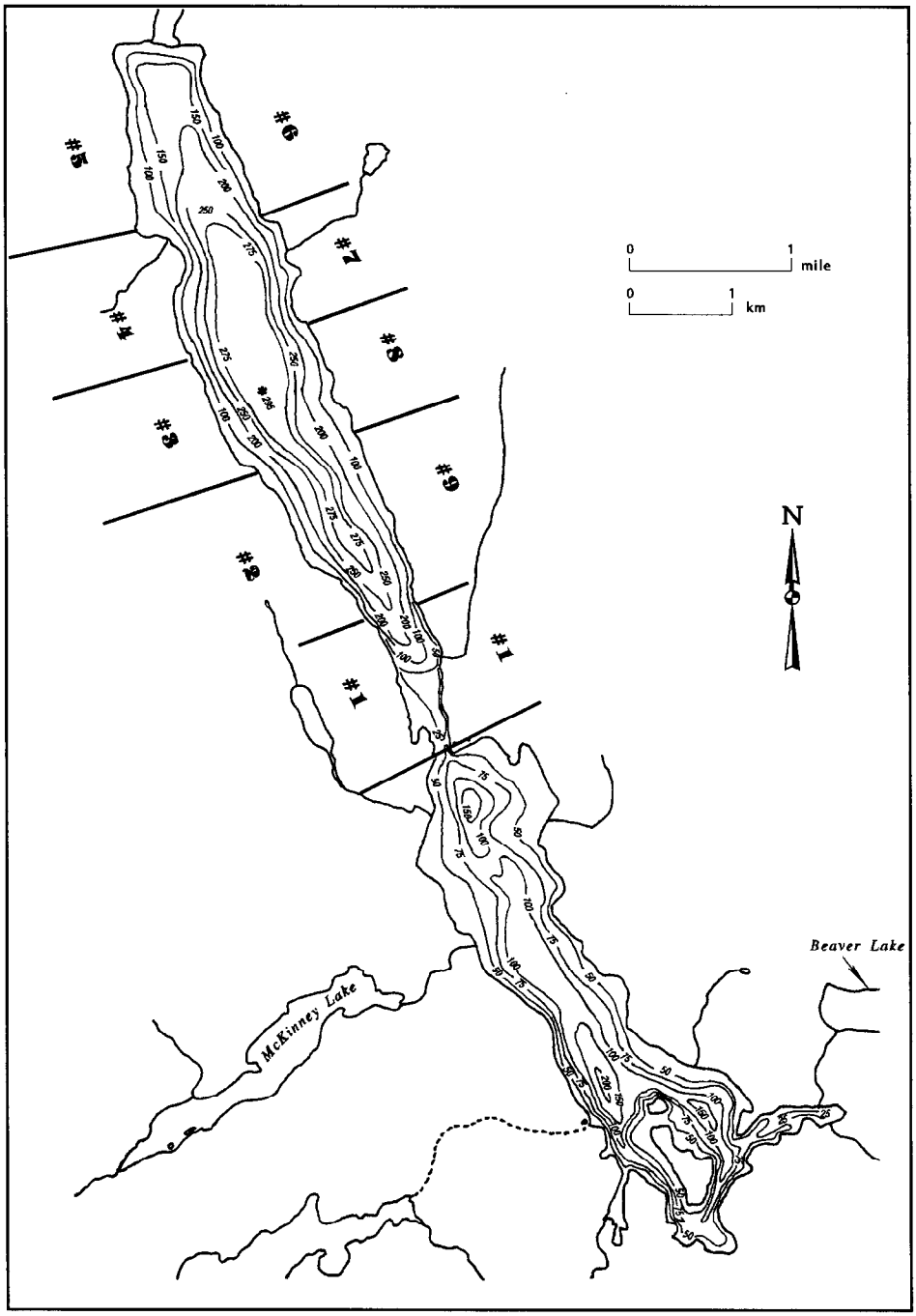

Figure 4. Bathymetric map of Hasselborg Lake, Admiralty Island, Southeast Alaska, showing location of study areas. Sampling area "A" is study areas 1-3, area "B" is study areas 4-6, and sampling area "C" is study areas 7-9.

METHODS

Abundance

The abundance of cutthroat trout in Florence and Hasselborg lakes was estimated using two-event mark-recapture experiments. Four sampling trips were made to Florence Lake in 1991, and two trips were made to Hasselborg Lake. In Florence Lake, the first trip was considered the first sampling event, and the following three trips were combined as the second sampling event. The first trip to Florence Lake was June 25 to July 3; the second event was July 10 through July 18. The third trip was from July 24 through August 1, and the fourth and final trip was from August 6 through August 14. The first trip to Hasselborg Lake was August 21 through August 29, and the second event was September 5 through September 11.

During both sampling events at each lake, 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.

Each sampling trip was 10 days long. Consequently, the lake was divided into nine zones, and sampling gear was moved among zones in a day-by-day schedule. Each gear type was fished for a similar amount of time in each zone. A minimum of 1 hour hook-and-line fishing, and overnight sets of 12 large minnow traps, 1 fyke net, and 4 hoop traps were fished in each area during each trip. Betadine-treated salmon eggs were used as bait in each gear type.

Passive gear types (traps and lake fyke nets) were not fished in adjacent areas at the same time. The progression of sampling passive gear types around the lake was thus staggered; e.g., zones 1, 3, 5, 7, 9, 2, 4, 6, 8 for traps, and zones 4, 6, 8, 1, 3, 5, 7, 9, 2 for fyke nets during each trip.

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. Hoop traps were also fished in three depth zones (see above). The fyke net was set near-shore.

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. Hoop traps were 1.4 m in length and consisted of four 0.6-m diameter hoops with throats attached to the first and third hoops. Fyke traps had 13-cm stretch mesh with a 0.9-m by 1.8-m opening, two 6.1-m by 1-m wings off each side, a 15.2-m by 1-m center lead, and two funnel entrances leading to the cod end. A small lure or spinner was used for bait with sport fishing gear.

The probability that fish of different sizes were captured with equal probability during the second sampling event was estimated with a Kolmogorov-Smirnov (K-S) 2-sample test. If size selectivity was suggested by the K-S test, the mark-recapture 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 areas (ends and middle) of each lake. If this was not so, a Darroch estimator (Seber 1982, Darroch 1961) was used to estimate

$$\underline{U} = \mathbf{D}_u \mathbf{M}^{-1} \underline{a} \tag{1}$$

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 $\underline{\hat{N}} = \underline{U} + \underline{a}$. The variance-covariance matrix (Seber 1982) was estimated

$$E[(\underline{\hat{U}} - \underline{U})(\underline{\hat{U}} - \underline{U})^T] \approx \mathbf{D}_U \Theta^{-1} \mathbf{D}_\mu \mathbf{D}_\alpha^{-1} \Theta^{T^{-1}} \mathbf{D}_U + \mathbf{D}_U (\mathbf{D}_\rho - \mathbf{I}) \tag{2}$$

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:

$$\hat{N} = \frac{(n_1+1)(n_2+1)}{(m_2+1)} - 1 \tag{3}$$

$$V[\hat{N}] = \frac{(n_1+1)(n_2+1)(n_1-m_2)(n_2-m_2)}{(m_2+1)^2(m_2+2)} \tag{4}$$

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 were applied to trout tagged in event 1 to provide means for estimating tag loss. Adipose fins clips, and holes punched in caudal fins, respectively, were used for this purpose in Hasselborg and Florence Lakes.

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.

Age and Length

Scales were selected from an area just over the lateral line, forward of a line between the posterior insertion of the dorsal fin and the anterior insertion of the anal fin. We separated the scales and stored them in acetate envelopes prior to reading. Age was determined by viewing the scales under a Micron 780 microfiche projector.

Age composition of the sampled population (p_a) was estimated

$$\hat{p}_a = \frac{\sum_i \hat{p}_{a,i}\hat{N}_i}{\sum_i \hat{N}_i} \tag{5}$$

$$V[\hat{p}_a] = \sum_i V[\hat{p}_{a,i}]\left[\frac{\hat{N}_i}{\hat{N}}\right]^2 + \frac{\sum_i V[\hat{N}_i](\hat{p}_{a,i} - \hat{p}_a)^2}{\hat{N}^2} \tag{6}$$

where

$$\hat{p}_{a,i} = \frac{n_{a,i}}{n_i} \tag{7}$$

$$V[\hat{p}_{a,i}] = \frac{\hat{p}_{a,i}(1 - \hat{p}_{a,i})}{n_i - 1} \tag{8}$$

and $p_{a,i}$ = proportion in length group i with estimated age a,

$n_{a,i}$ = number in length group i with estimated age a,

n_i = number successfully aged in length group i,

N_i = abundance estimate for length group i, and

N = estimated abundance for all length groups ($\sum N_i$).

Variance formula (6) is an approximation from the delta method (Seber 1982).

Mean length at age was estimated using standard procedures and was graphically summarized with notched box plots[1].

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[1] The median length at each age is represented by a horizontal line within the box, and the top and bottom of the box represent the upper and lower quartiles of the data for that age. Vertical lines from each box extend to the upper and lower adjacent values (upper and lower quartiles ± 1.5 x IQR, where IQR is the interquartile range); values outside the upper and lower adjacent values are plotted as asterisks. The tops and bottoms of the notches are at $\sqrt{n}$, where M is the median and n is the number of observations, and estimate the 95% confidence intervals assuming a normal distribution of values about the median.

Creel Survey

Two USFS cabins at both Florence and Turner Lakes, and three USFS cabins at Hasselborg Lake are available for recreational use for a $20 per day fee. We believe most angling at these lake systems results 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 August 31, and the second covered trips from September 1 to December 31, 1991.

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.

Three separate mailings were conducted for each of two mailout surveys. The first mailing was sent to every party leader on a USFS reservation list. 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:

$$H_r = \sum_{m=1}^{3} H_{r,m} \tag{9}$$

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. If response to each mailing was similar, total harvest H at the cabin was calculated

$$H = \left(\frac{N}{N_r}\right) H_r \tag{10}$$

where N_r = number of responding parties 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.

If trends in harvest per responding party by mailing were apparent, response could be modeled to estimate total harvest (see, for example, Mills 1990).

Expansions for effort and harvest by species were calculated by substituting the appropriate variable for C. 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.

RESULTS

Abundance

Florence Lake:

Three thousand, nine hundred fifty-one (3,951) cutthroat trout were captured in 1991, mostly with the large funnel traps (Table 1, Figures 5 and 6).

Eight hundred fifty-one (851) cutthroat trout between 180 mm and 455 mm FL were newly tagged or recaptured from a previous year in sampling event 1. One thousand, seven hundred thirty-nine (1,739) cutthroat trout between 180 mm FL and 398 mm FL were inspected for marks during the second sampling event; 253 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, 848 cutthroat trout between 180 mm and 350 mm Fl were "marked" (newly tagged or recaptured from a previous year) in event one. One thousand, seven hundred twenty-three (1,723) fish between 180 mm and 350 mm FL were subsequently inspected for marks; 243 of these fish were recaptures (newly tagged or recaptured from a previous year) from event 1 (Table 2).

The distribution of lengths of fish recaptured in event 2 was different from the distribution of lengths marked in event 1 (Figure 7), suggesting the second sampling event was size selective (Kolmogorov-Smirnov [K-S] test, $d_{max} = 0.12$, $P = 0.007$). Based on the tagging data, little growth had occurred between sampling event 1 and sampling event 2 (average growth was 2 mm FL, range -9 mm to 13 mm FL). Re-analysis of the length data found two size ranges that had equal probabilities of capture: "small" (180-213 mm FL) and "large" (214-350 mm FL) (Table 3).

Some mixing of fish between sampling areas does 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 ($P \leq 0.001$, Tables 6 and 7), suggesting that Darroch's estimators should be used to estimate abundance.

The abundance of cutthroat trout between 180 mm FL and 213 mm FL is $\hat{N} = 4,264$, $SE[\hat{N}] = 847$. The bootstrap method estimated an abundance 8% above the Darroch estimate with SE = 1,322, but these estimates were unstable. Similarly, the abundance estimate for fish between 214 mm FL and 350 mm FL was $\hat{N} = 4,660$, $SE[\hat{N}] = 622$. The bootstrap method estimated an abundance 3% above the Darroch estimate, with SE = 723. Abundance of cutthroat trout between 180 mm FL and 350 mm FL is then $\hat{N} = 8,924$, $SE[\hat{N}] = 1,051$. Relative precision for the estimate is thus ±23% for a 95% confidence interval.

Hasselborg Lake:

One thousand, six hundred forty-four (1,644) cutthroat trout were captured in 1991, mostly with hoop nets (Table 8, Figures 5 and 6). Two cutthroat trout caught in sampling event 1 were >350 mm FL (one 353 mm and one 357 mm FL); otherwise the longest fish captured was 335 mm FL. Abundance was estimated for fish ≥180 mm and ≤350 mm FL (Table 9).

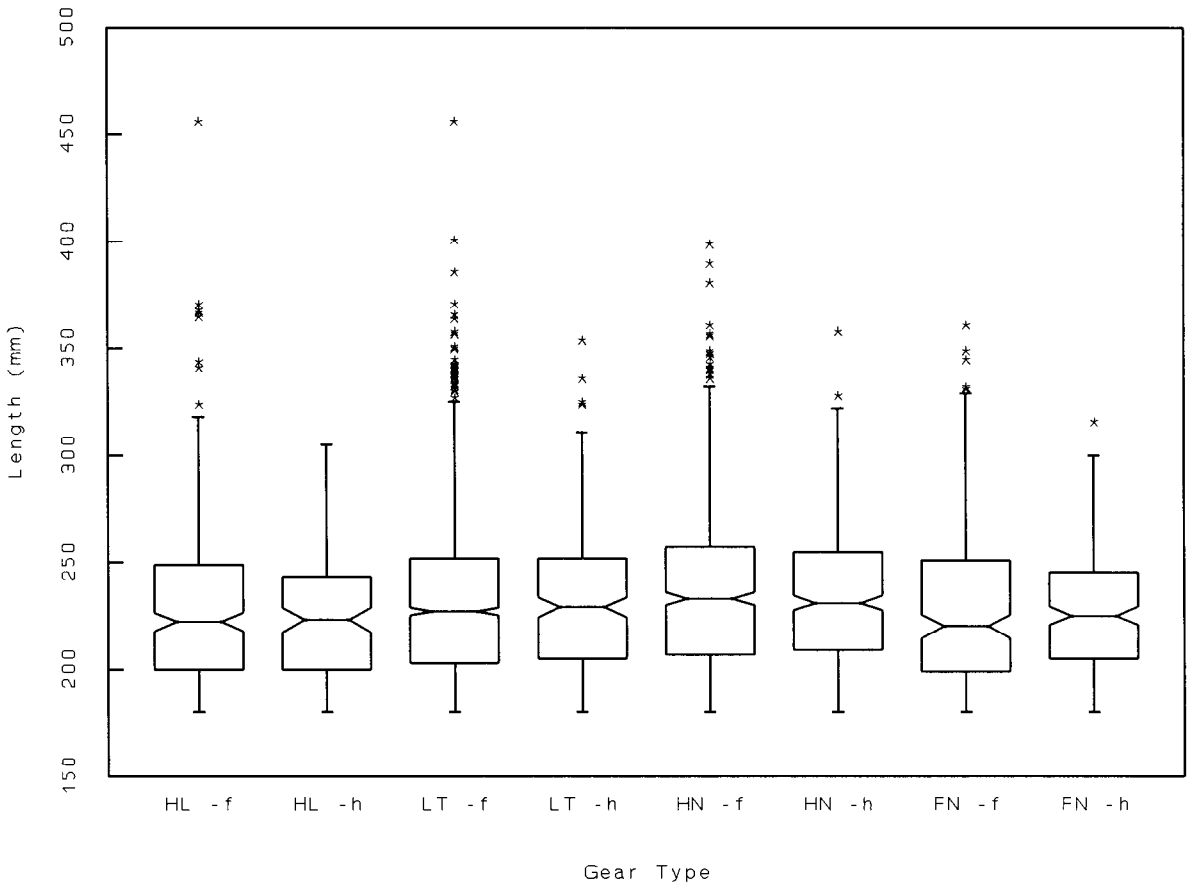

Figure 5. Box plots showing size distribution of total catch of cutthroat trout at Florence (-f) and Hasselborg (-h) lakes in 1991 by gear type (HL = hook & line, LT = funnel trap, HN = hoop net, and FN = fyke net).

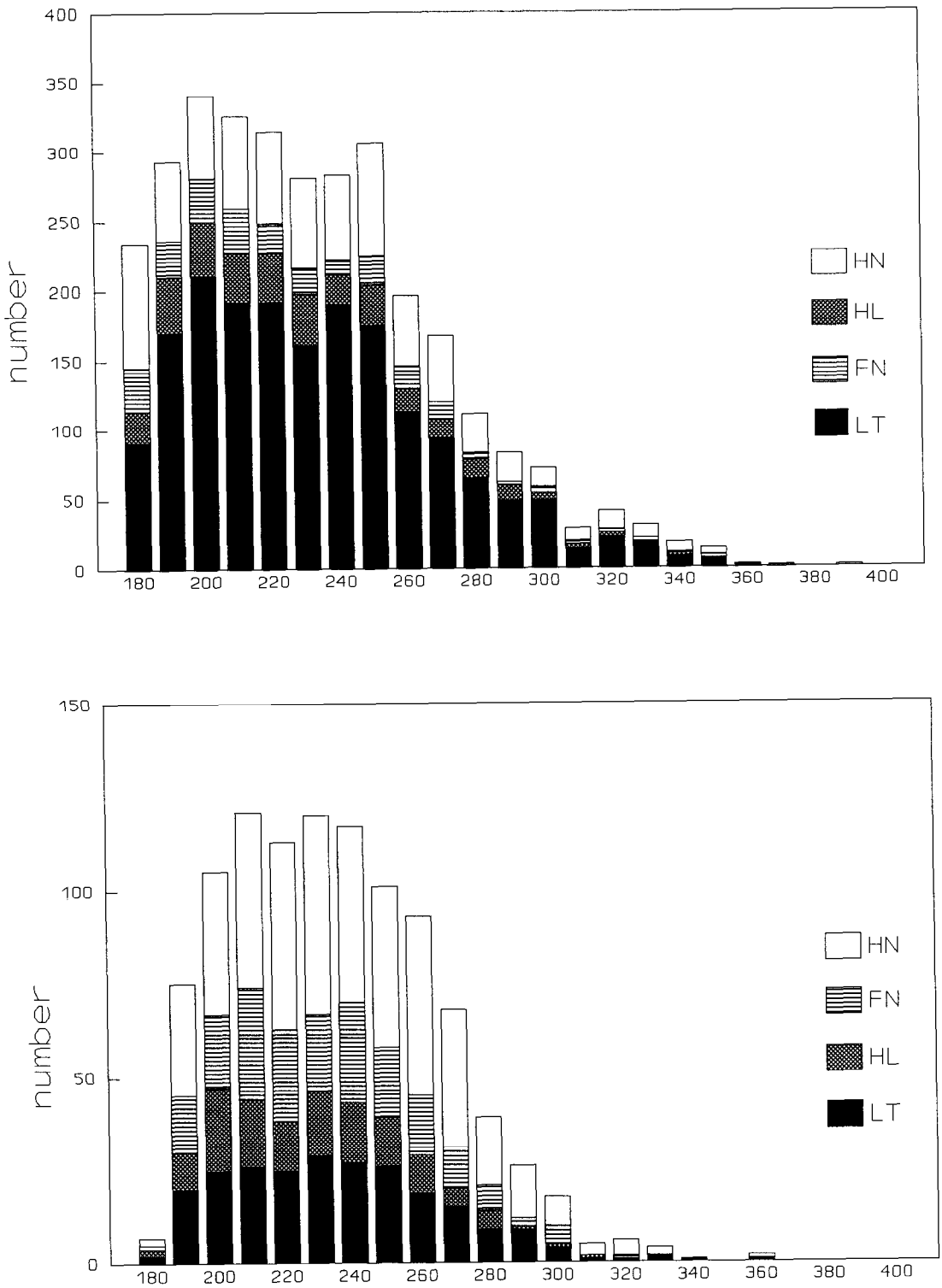

Figure 6. Length frequency of total cutthroat trout catch at Florence Lake (above) and Hasselborg Lake (below) in 1991, by gear type (LT = funnel trap, FN = fyke net, HL = hook and line, HN = hoop net).

Table 1. Sampling effort (hours), catch, and catch-per-unit-effort (CPUE, fish per hour) by period, gear and species, Florence Lake, 1991.

Period[b]	Gear	Effort	Cutthroat trout[a]		Dolly Varden		Kokanee	
			Catch	CPUE	Catch	CPUE	Catch	CPUE
1	Fyke Net	199	44	0.22	34	0.17	3	0.02
	Hook & Line	38	153	4.01	16	0.42	0	0.00
	Hoop Net	40	27	0.67	0	0.00	0	0.00
	Large Trap	2,139	955	0.45	1,045	0.49	0	0.00
2	Fyke Net	191	96	0.50	71	0.37	0	0.00
	Hook & Line	23	109	4.72	13	0.56	0	0.00
	Hoop Net	984	259	0.26	490	0.50	12	0.01
	Large Trap	2,326	461	0.20	670	0.29	1	0.00
3	Fyke Net	174	172	0.99	180	1.03	2	0.01
	Hook & Line	22	74	3.44	3	0.14	0	0.00
	Hoop Net	1,012	288	0.28	520	0.51	2	0.00
	Large Trap	2,317	514	0.22	915	0.39	0	0.00
4	Fyke Net	196	70	0.36	63	0.32	5	0.03
	Hook & Line	20	82	4.08	1	0.05	1	0.05
	Hoop Net	903	260	0.29	537	0.59	0	0.00
	Large Trap	2,113	387	0.18	1,388	0.66	3	0.00
Total	Fyke Net	760	382	0.50	348	0.46	10	0.01
	Hook & Line	103	418	4.06	33	0.32	1	0.01
	Hoop Net	2,939	834	0.28	1,547	0.53	14	0.00
	Large Trap	8,896	2,317	0.26	4,018	0.45	4	0.00

[a] Cutthroat trout ≥180 mm FL.
[b] Period 1 = 25 June to 3 July; 2 = 10 July to 18 July; 3 = 24 July to 1 August; 4 = 6 August to 14 August.

Table 2. Summary of cutthroat trout tagging and recovery data for fish 180-350 mm FL, Florence Lake, 1991[a]. Period 1 is event 1 and periods 2 through 4 are event 2.

	1991 sampling period			
	Period 1 25 June- 3 July	Period 2 10 July- 18 July	Period 3 24 July- 1 Aug.	Period 4 8 Aug.- 14 Aug.
Newly tagged fish released alive	740[b]	508[b]	466[c]	321[d]
Recaptured fish tagged in:				
1988	0	0	1	0
1989	27[e]	29[g]	19[j]	7[m]
1990	81[f]	79[h]	44[k]	39[n]
1991 - Period 1		99[i]	67[l]	36[o]
Captured, not tagged	14	4	2	2
Total catch	862	719	599	405

[a] Also captured were: 16 fish >350 mm FL, 269 fish <180 mm FL, and 355 fish captured more than once during a single sampling event.
[b] Fish 180-350 mm FL.
[c] Fish 180-343 mm FL.
[d] Fish 180-348 mm FL.
[e] Fish 195-350 mm FL.
[f] Fish 180-305 mm FL.
[g] Fish 180-320 mm FL.
[h] Fish 181-317 mm FL.
[i] Fish 183-337 mm FL.
[j] Fish 199-294 mm FL.
[k] Fish 184-311 mm FL.
[l] Fish 182-342 mm FL.
[m] Fish 212-349 mm FL.
[n] Fish 180-290 mm FL.
[o] Fish 185-301 mm FL.

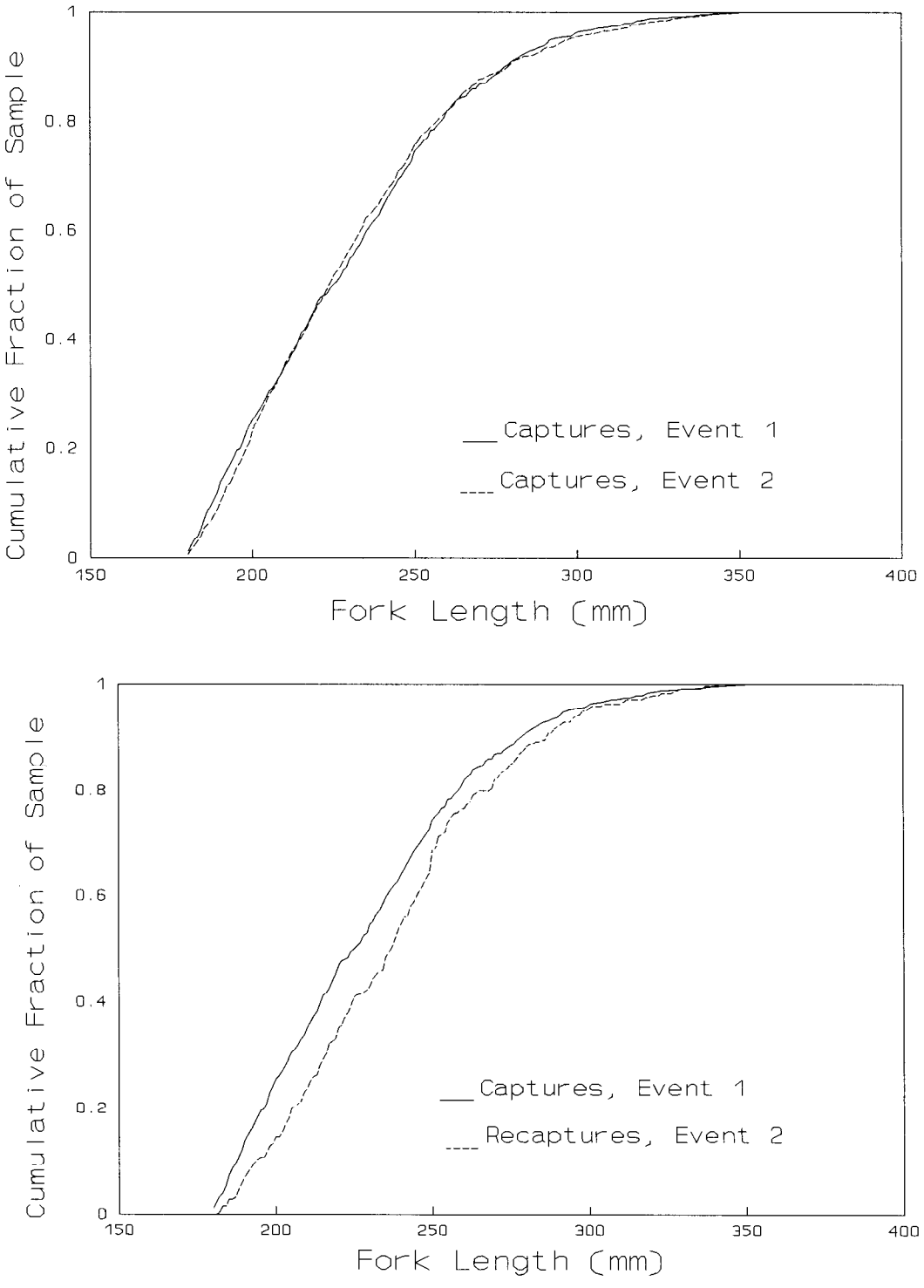

Figure 7. Cumulative histogram of lengths of cutthroat trout marked versus lengths of cutthroat trout examined for marks (above) and versus lengths of cutthroat trout recaptured (below), Florence Lake, 1991.

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	180-213	68	253	0.21
II	214-247	88	186	0.32
III	248-281	57	118	0.33
IV	282-315	20	32	0.38
V	316-350	6	12	0.33

Hypothesis A:

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

Result: $\chi^2=14.4$, $df=4$, $p < 0.006$; reject H_0.

Hypothesis B:

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

Result: $\chi^2=0.81$, $df=3$, $p = 0.85$; accept H_0.

Hypothesis C:

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

Result: $\chi^2=13.5$, $df=1$, $p < 0.001$; reject H_0.

CONCLUSION: Stratify experiment by two size classes: $P_{(I)}$=180-213 mm, and $P_{(II+III+IV)}$=214-350 mm FL.

Table 4. Numbers of cutthroat trout 180-213 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, 1991.

	Recovery area			
Tagging area	A[a]	B[b]	C[c]	a_i
A	12	3	2	81
B	9	33	0	151
C	0	1	8	89
u_j	176	180	243	

[a] Study areas 1, 2, and 9. $\hat{N}_A$=808 ±332 at time of tagging (bootstrap SE=481).
[b] Study areas 3,4,7, and 8. $\hat{N}_B$=750 ±152 at time of tagging (bootstrap SE=203).
[c] Study areas 5 and 6. $\hat{N}_C$=2,705 ±888 at time of tagging (bootstrap SE=1,396).

Table 5. Numbers of cutthroat trout 214-350 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, 1991.

	Recovery area			
Tagging area	A[a]	B[b]	C[c]	a_i
A	35	3	1	115
B	9	89	3	207
C	1	13	21	202
u_j	232	295	351	

[a] Study areas 1, 2, and 9. $\hat{N}_A$=802 ±114 at time of tagging (bootstrap SE=124).
[b] Study areas 3, 4, 7, and 8. $\hat{N}_B$=700 ±70 at time of tagging (bootstrap SE=82).
[c] Study areas 5 and 6. $\hat{N}_C$=3,158 ±641 at time of tagging (bootstrap SE=755).

Table 6. Numbers of marked and unmarked cutthroat trout 180-213 mm FL captured in sampling event 2, by recovery area, Florence Lake, 1991.

	Recovery area			
	A[a]	B[b]	C[c]	
Marked fish	21	37	10	68
Unmarked fish	176	180	243	599
	197	217	253	667

$\chi^2 = 22.0$, df = 2, $P \leq 0.001$

[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 214-350 mm FL captured in sampling event 2, by recovery area, Florence Lake, 1991.

	Recovery area			
	A[a]	B[b]	C[c]	
Marked fish	45	105	25	175
Unmarked fish	232	295	351	878
	277	400	376	1053

$\chi^2 = 53.8$, df=2, $P \leq 0.001$

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

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

[c] Study areas 5 and 6.

Table 8. Sampling effort (hours), catch, and catch-per-unit-effort (CPUE, fish per hour) by period, gear, and species, Hasselborg Lake, 1991.

Period[b]	Gear	Effort	Cutthroat trout[a]		Dolly Varden		Kokanee	
			Catch	CPUE	Catch	CPUE	Catch	CPUE
1	Fyke Net	213	141	0.66	15	0.07	6	0.03
	Hook & Line	23	113	4.91	1	0.04	0	0.00
	Hoop Net	1,008	364	0.36	339	0.34	3	0.00
	Large Trap	2,392	320	0.13	261	0.11	1	0.00
2	Fyke Net	147	143	0.98	52	0.35	41	0.28
	Hook & Line	25	99	3.93	0	0.00	0	0.00
	Hoop Net	765	294	0.38	335	0.44	0	0.00
	Large Trap	1,888	170	0.09	406	0.22	0	0.00
Total	Fyke Net	360	284	0.79	67	0.19	47	0.13
	Hook & Line	48	212	4.40	1	0.02	0	0.00
	Hoop Net	1,773	658	0.37	674	0.38	3	0.00
	Large Trap	4,280	490	0.11	667	0.16	1	0.00

[a] Cutthroat trout ≥180 mm FL.
[b] Period 1 = 21 August to 29 August; period 2 = 5 September to 11 September.

Table 9. Summary of cutthroat trout tagging and recovery data for fish 180-350 mm FL, Hasselborg Lake, 1991.

	Period 1 21 Aug- 29 Aug	Period 2 5 Sept- 11 Sept
Newly tagged fish Released alive	525[a]	425
Recaptured fish		51[b]
Total Catch	525	476[c]

[a] Fish 180-327 mm FL.

[b] Fish 190-323 mm FL.

[c] Fish 180-335 mm FL.

Five hundred twenty-five (525) cutthroat trout ≥180 mm and ≤350 mm FL were tagged in event 1; 425 trout were inspected for marks during sampling event 2, and 51 of these fish were marked in event 1 (Table 9).

The distribution of lengths of fish recaptured in event 2 looked different from the distribution of lengths of fish marked in event 1 (Figure 8), although a K-S test ($d_{max} = 0.16$, $P = 0.199$) suggested that the difference was not statistically significant. However, sample sizes for the K-S test were small and the cumulative distributions were similar to Florence Lake (Figure 7).

Some mixing of fish between sampling areas did occur between sampling events (Table 10). The hypothesis of equal probability of capture by area was accepted ($P = 0.29$, Table 11), so a simple Peterson model was used to estimate abundance.

The abundance estimate for fish between 180 mm FL and 350 mm FL is $\hat{N} = 4,824$ $SE[\hat{N}] = 594$, using Chapman's model. These pilot-survey estimates should be used with caution, since assumptions for the Peterson model were not met.

Age and Length

Florence Lake:

Ages were estimated for 2,329 cutthroat trout sampled in 1991. Fish aged 4 and 5 years dominated the sample (Table 12). The oldest fish sampled were aged 12 years and averaged 455 mm FL.

The length frequency distribution of captured cutthroat trout between 180 mm and 350 mm FL (Figure 7) was not significantly different between sampling events (K-S test, $d_{max} = 0.035$, $P = 0.48$), so data from all trips were combined to estimate age composition (Table 13). Fish aged 4 and 5 years appeared to be the dominant ages in the population between 180 mm and 350 mm FL, in 1991. Mean length at age shows a linear, or increasing, trend with age (Figure 9).

Comparison of the age composition and mean length at age data with estimates for 1990 (Jones and Harding 1991) suggests that sampled fish were both older and shorter in length in 1991, or that ages were estimated differently in each year. As discussed below, problems in aging cutthroat trout are probably responsible for some of the differences between years. Thus, the estimates in Tables 12 and 13 should be considered preliminary, and to be updated in a future report.

Hasselborg Lake:

Ages were estimated for 937 cutthroat trout sampled in 1991. Fish aged 4 and 5 years dominate the sample (Table 12). The oldest fish sampled were aged at 7 years old and averaged 280 mm FL.

The length frequency distribution of captured cutthroat trout over 180 mm FL (Figure 8) was not significantly different between sampling events (K-S test, $d_{max} = 0.060$, $P = 0.33$), so data from both trips were combined to estimate age composition (Table 13, Figure 9). Fish aged 4 years appeared the dominant age in the population between 180 mm and 350 mm FL in 1991. The age composition for fish 4, 5, and 6 years old was roughly similar to that estimated for Florence Lake.

Although we have no age data for Hasselborg Lake in 1990 to compare to these results, the aging results for Hasselborg Lake from 1991 could be biased, as the

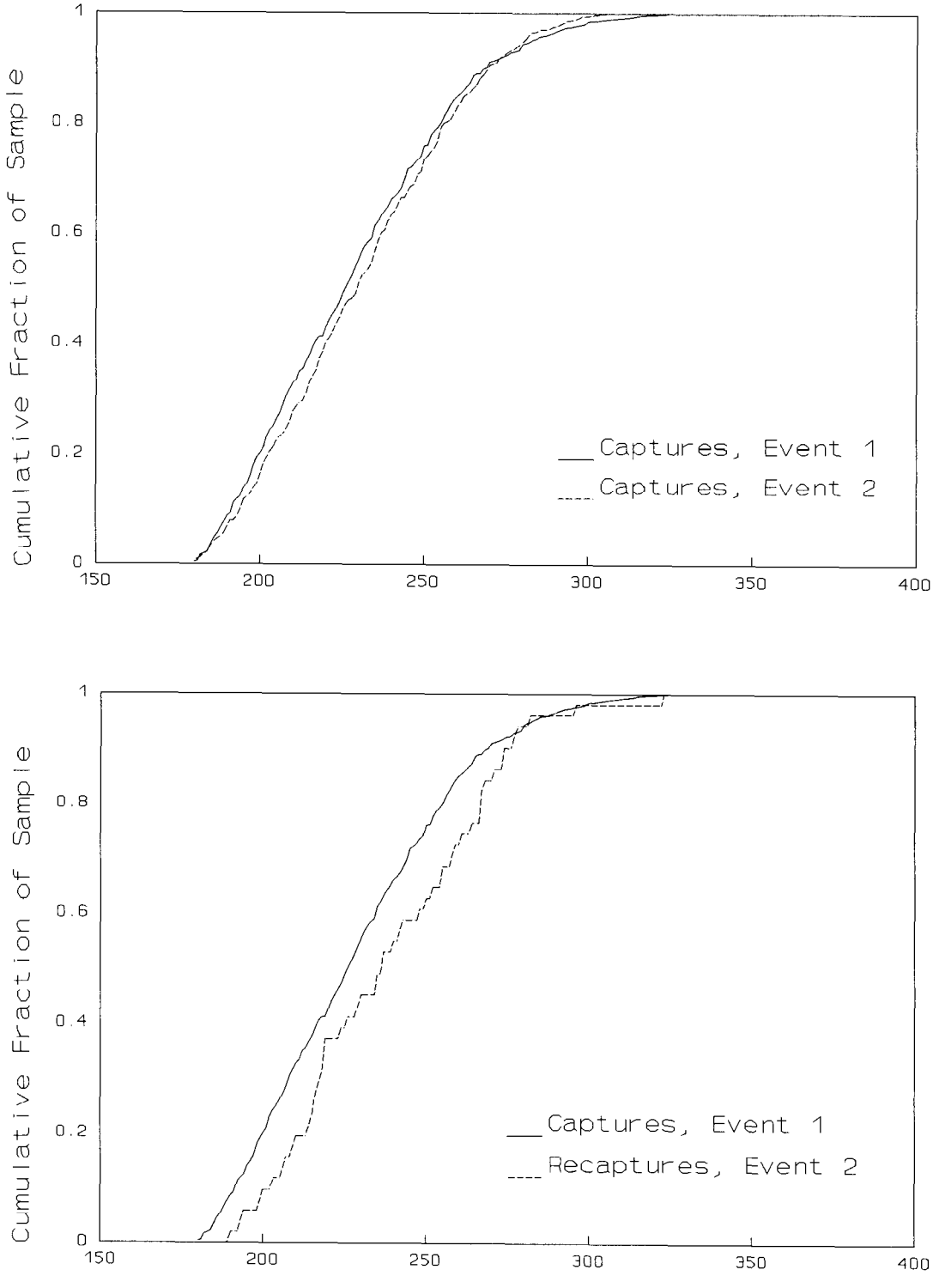

Figure 8. Cumulative histogram of lengths of cutthroat trout marked versus lengths of cutthroat trout examined for marks (above) and versus lengths of cutthroat trout recaptured (below), Hasselborg Lake, 1991.

Table 10. Numbers of trout 180-350 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, Hasselborg Lake, 1991.

	Recovery area			
Tagging area	A[a]	B[b]	C[c]	a_i
A	14			178
B	3	7		146
C	1		26	201
u_j	126	99	200	

[a] Study areas 1,2, and 3.

[b] Study areas 4,5, and 6.

[c] Study areas 7,8, and 9.

Table 11. Contingency table comparing the number of marked and unmarked cutthroat trout 180-350 mm FL captured in sampling event 2, by recovery area, Hasselborg Lake, 1991.

	Recovery area			
	A[a]	B[b]	C[c]	
Marked fish	18	7	26	51
Unmarked fish	126	99	200	425
	144	106	226	476

$\chi^2 = 2.50$, df=2, P = 0.29

[a] Study areas 1,2, and 3.

[b] Study areas 4,5, and 6.

[c] Study areas 7,8, and 9.

Table 12. Preliminary estimates of length at age for cutthroat trout sampled in Florence and Hasselborg lakes, 1991.

	Age	Number sampled	Minimum length	Maximum length	Mean length	Standard error
Hasselborg	2	4	106	186	165	19.6
	3	116	180	222	195	1.0
	4	333	180	300	213	0.9
	5	320	181	315	242	1.2
	6	136	202	335	263	2.1
	7	28	236	357	280	5.5
Florence	2	3	112	153	128	12.5
	3	91	158	224	183	1.1
	4	662	160	250	199	0.5
	5	884	178	290	224	0.6
	6	453	199	330	255	0.9
	7	172	244	343	290	1.8
	8	47	281	370	321	3.4
	9	12	306	398	352	7.8
	10	3	330	400	340	23.0
	12	2	455	455	455	

Table 13. Preliminary estimated age composition of cutthroat trout between 180 mm FL and 350 mm FL sampled in Florence and Hasselborg lakes, 1991.

	Florence Lake		Hasselborg Lake	
Age	P_a	$SE(p_a)$	P_a	$SE(p_a)$
2			0.004	0.002
3	0.040	0.007	0.143	0.019
4	0.331	0.033	0.408	0.040
5	0.373	0.013	0.310	0.028
6	0.172	0.020	0.114	0.024
7	0.065	0.009	0.021	0.007
8	0.016	0.003		
9	0.002	0.001		
10	0.001	0.001		

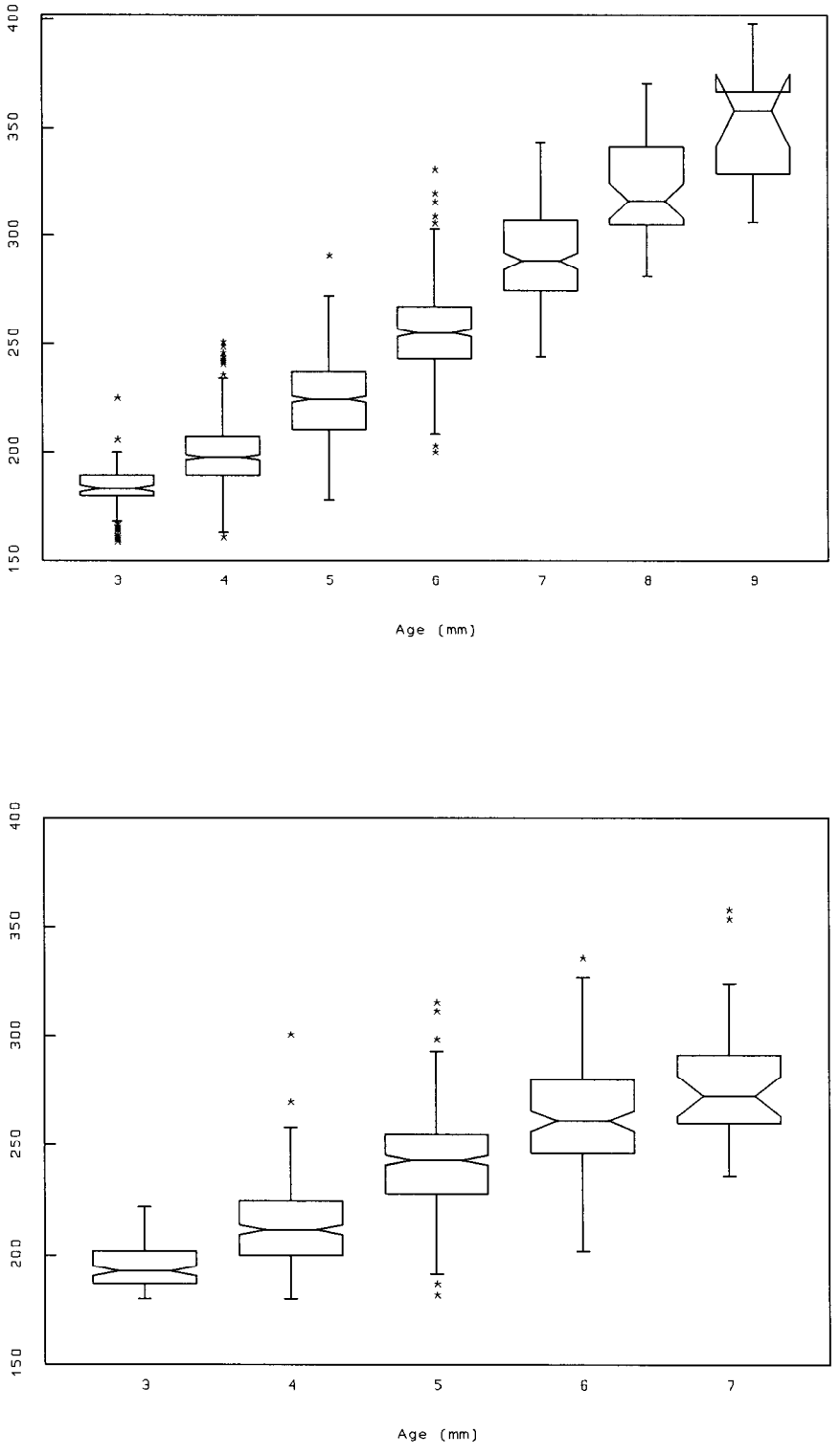

Figure 9. Notched box plot of length at age (estimated from scales) for cutthroat trout at Florence (upper panel) and Hasselborg (lower panel) lakes in 1991.

results for Florence Lake may be biased for 1991. Thus, the aging results for Hasselborg Lake in Tables 12 and 13 should also be considered preliminary, and to be updated in a future report.

Creel Survey

Florence Lake:

Thirty-three of 36 parties (91.7%) with registrations for use of USFS cabins at Florence Lake in 1991 responded to our survey, and only one survey was returned undeliverable. Of parties that responded, 27 (75%) used their cabin reservation (Appendix A1) and 21 (77.8%) using the reservation fished during their visit. Fifteen (71.4%) of the respondents who fished considered the fishing at Florence Lake to be "good to excellent." The average size of a party using a reservation was 2.8 people.

We detected no apparent trends in the catch rate (catch/party) for parties responding to the three mailings in our survey. The mean catch for parties responding to the first mailing was 42.9 cutthroat trout, for the second mailing the mean catch was 123.5, and the mean catch for parties responding to the third and final mailing was 97.8.

Anglers at Florence Lake spent an estimated total of 731 hours to harvest 464 cutthroat trout, and catch 1,883 cutthroat trout, 116 kokanee, and 143 Dolly Varden in 1991 (Table 14). An estimated 1,419 cutthroat trout were released in Florence Lake for an overall release rate of 75.4%.

Hasselborg Lake:

Fifty-five of 64 parties (86.1%) with registrations for use of the cabins at Hasselborg Lake in 1991 responded to our survey, and two were returned undeliverable. Of parties that responded, 44 (69.2%) used their cabin reservation (Appendix A1) and 40 (90.9%) using the reservation fished during their stay. Twenty-eight (73.7%) of the respondents who fished considered the fishing at Hasselborg Lake to be "good to excellent." The average size of a party using a reservation was 3.9 people, the largest party size of the three lakes studied.

We detected no apparent trends in the catch rate (catch/party) for parties responding to the three mailings in our survey. The mean catch for parties responding to the first mailing was 78.4 cutthroat trout, for the second mailing the mean catch was 79.2, and the mean catch for parties responding to the third and final mailing was 24.3.

Anglers at Hasselborg Lake spent an estimated total of 1,679 hours to harvest 878 cutthroat trout and catch 3,738 cutthroat trout, 365 kokanee, and 227 Dolly Varden in 1991 (Table 14). An estimated 2,860 cutthroat trout were released in Hasselborg Lake for an overall release rate of 76.5%.

Turner Lake:

Fifty-seven of 60 parties (95.0%) with registrations for use of USFS cabins at Turner Lake in 1991 responded to our survey, and no surveys were returned undeliverable. Of parties that responded, 50 (83.3%) used their cabin reservation (Appendix A1) and 46 (92.0%) using the reservation fished during

Table 14. Observed and estimated total effort and harvest for Florence, Hasselborg, and Turner lakes from the postal survey in 1991.

		Observed	Expanded
Florence	Hours fished	671	731
	Small cutthroat harvested[a]	397	433
	Large cutthroat harvested[b]	28	31
	Cutthroat released	1,301	1,419
	Kokanee harvested	12	13
	Kokanee released	94	103
	Dolly Varden harvested	8	9
	Dolly Varden released	123	134
Hasselborg	Hours fished	1,447	1,679
	Small cutthroat harvested	647	751
	Large cutthroat harvested	109	127
	Cutthroat released	2,464	2,860
	Kokanee harvested	123	143
	Kokanee released	191	222
	Dolly Varden harvested	9	10
	Dolly Varden released	187	217
Turner	Hours fished	1,311	1,379
	Small cutthroat harvested	238	251
	Large cutthroat harvested	21	22
	Cutthroat released	425	447
	Kokanee harvested	76	80
	Kokanee released	233	245
	Dolly Varden harvested	200	211
	Dolly Varden released	323	340

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

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

their visit. Only 21 (47.8%) of the respondents who fished considered the fishing at Turner Lake to be "good to excellent." The average size of a party using a reservation was 3.5 people.

We detected no apparent trends in the catch rate (catch/party) for parties responding to the three mailings in our survey. The mean catch for parties responding to the first mailing was 13.2 cutthroat trout, for the second mailing the mean catch was 25.7, and the mean catch for parties responding to the third and final mailing was 23.8.

Anglers at Turner Lake spent an estimated total of 1,379 hours to harvest 273 cutthroat trout, and catch 720 cutthroat trout, 325 kokanee, and 551 Dolly Varden in 1991 (Table 14). An estimated 447 cutthroat trout were released in Turner Lake for an overall release rate of 62.1%.

DISCUSSION

Estimated harvest in Florence Lake in 1991 (464 cutthroat trout) represents about 5% of the population of 8,924 fish over 180 mm FL. This is the lowest harvest rate of any of the three lakes we have studied.

Of the three lakes studied in 1991, Hasselborg Lake had by far the highest catch (3,738) and harvest (878) of cutthroat trout. Catch per unit effort (CPUE) for cutthroat trout in Hasselborg Lake (2.2 trout/hour) was similar to CPUE in Florence Lake (2.6 trout/hour). Thus, total angler effort in Hasselborg Lake (1,679 hours) and catches of other species were roughly twice that of Florence Lake. Hasselborg Lake also had more visitors than either of the other two lakes studied in 1991. Estimated cutthroat trout harvest in Hasselborg Lake in 1991 (878 cutthroat trout) represents an unknown fraction of the number of large fish in both basins of the lake.

Anglers reported that about 76% of the cutthroat they caught in Florence and Hasselborg lakes were released, compared to 62% in Turner Lake. Since the catch rate for cutthroat trout in Florence and Hasselborg lakes is four to five times higher than in Turner Lake (0.5 trout/hour), anglers may be more inclined to keep the cutthroat trout they catch in Turner Lake.

In 1990, the exploitation rate for cutthroat trout in Turner Lake was about 25% of abundance for fish between 161 mm and 280 mm FL (Jones and Harding 1991). This year we estimate a 36% increase in angler effort and a 8% decrease in catch in Turner Lake. The estimated harvest of "large" or trophy-size cutthroat also dropped, from 44 in 1990 to 22 fish in 1991. Based on these findings and anecdotal information from anglers, a catch-and-release-only fishing regulation was imposed at Turner Lake in 1992.

The accurate use of Peterson estimators requires the following assumptions: that there immigration, growth recruitment, or deaths occurred in the size ranges of interest during the experiment. Since the time between our sampling events was short (1-2 weeks), we assumed these assumptions were valid in these experiments. 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. The experiment at Hasselborg Lake was a pilot study to estimate parameters for future studies, and sample sizes there were relatively low. Thus, we could not detect size-selective sampling or incomplete mixing across areas of this lake in 1991, although these events may have been important.

Cutthroat trout sampled at Florence Lake showed a steady increase in length with increasing age (Figure 9), which causes us again to question the accuracy of ages determined from reading cutthroat trout scales (Jones and Harding 1991). Also, in 1991, most fish sampled in Florence Lake appeared to be 4 and 5 years of age, rather than 3 and 4 years of age as found in 1990 (Jones and Harding 1991). Since estimates for 1990 pertain to fish ≥141 mm FL, not ≥180 mm FL as in 1991, results for 1990 were reworked for comparison to 1991 findings (Appendix A2). Age composition of comparably sized fish in 1991 (Table 13) and 1990 (Appendix A2) is strikingly different, with many fewer fish aged 3 years in 1990. However, mean fork length for fish aged 3 (183±10 mm in 1991, 196±24 mm in 1989, 196±19 mm in 1990) and fish aged 4 (199±14 mm in 1991, 229±22 mm in 1989, 228±20 mm in 1990) also decreased sharply in 1991, suggesting the possibility that errors in age determination, rather than numbers at age, may be responsible for the differences between years. This possibility was investigated by taking a randomized sample of the scales aged in 1989, 1990, and 1991 for reanalysis.

Most fish sampled in Florence Lake in 1991 were aged 4 and 5 years of age, rather than 3 and 4 years of age as in 1990 (Jones and Harding 1991). However, age composition in 1991 was estimated for fish ≥180 mm FL, and age composition in 1990 was estimated for fish ≥141 mm FL. Age composition of comparably sized fish in 1991 (Table 13) and 1990 (Appendix A2) was still quite different, with many fewer fish aged 3 in the sample from 1991. Also, mean fork lengths for fish aged 3 (196±24 mm in 1989, 196±19 mm in 1990, and 183±10 mm in 1991) and fish aged 4 (229±22 mm in 1989, 228±20 mm in 1990, and 199±14 mm in 1991) decreased sharply in 1991. Thus, variability in the method to estimate age may be partly responsible for the discrepancy in age compositions estimated for 1990 and 1991.

Variation in estimating ages of cutthroat trout sampled at Florence Lake in 1990 and 1991 was investigated using two tests. First, a random sample of scales aged 3, 4, and 5 years in 1990 and a random sample of scales aged 3, 4, and 5 years in 1991 were re-aged in 1992. The reader, who had aged all samples in 1990 and 1991, was given no information with the scales to be re-aged, except that they were from Florence Lake. The difference between the two age determinations was significant (Table 15), with scales from 1990 appearing older during the second reading, and scales from 1991 appearing younger during the second reading. Second, ages previously estimated from scales sampled in 1990 (and aged in 1990) and then recaptured in 1991 (and aged in 1991) were compared. If a bias was not present in estimating ages, the mean difference between the estimates should be 0 and the distribution of differences should be roughly symmetrical, after adjusting for 1 year of real growth. The difference between the estimates was highly skewed, with nearly as many differences being greater than 0 years (the true value) as were 0 years (Figure 10). Thus, age was probably estimated differently in 1990 and in 1991.

Because ages estimated in 1992 tended to be older than ages estimated in 1990, and younger than ages estimated in 1991, the age compositions for 1990 and 1991 are more similar than the results in this and previous studies (Jones and Harding 1991) suggest. If a weak age class was present in the lake (age 2 in 1990 and age 3 in 1991) this fact will be visible in samples collected in 1992 (age 4 in 1992). Research to detail factors that lead to variability in aging our

Table 15. Comparison of the frequency of Florence Lake cutthroat trout scales aged 3, 4, and 5 years in 1990, 1991, and then in 1992.

1990 Scales

	Estimated Age			
	3	4	5	6
1st Reading (1990)	34	35	34	0
2nd Reading (1992)	13	52	38	8

$\chi^2 = 12.9$, df=2, P = 0.002 (data for ages 5 and 6 pooled)

1991 Scales

	Estimated Age			
	3	4	5	6
1st Reading (1991)	32	46	31	0
2nd Reading (1992)	33	64	12	0

$\chi^2 = 11.4$, df=2, P = 0.003 (data for ages 5 and 6 pooled)

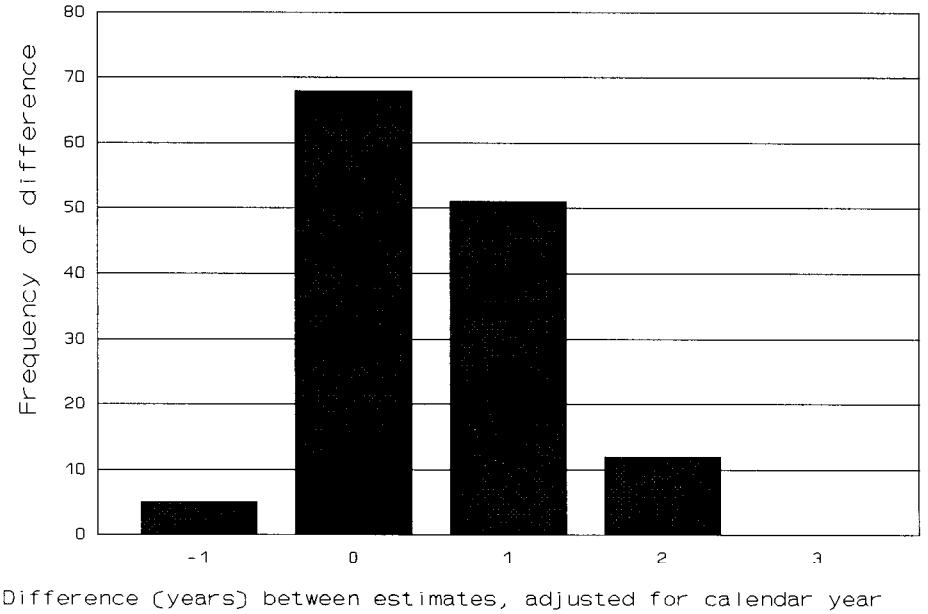

Figure 10. Comparison of age estimates for fish aged in 1990, then recaptured and aged in 1991. Difference in age (years) equals age estimated in 1991, minus age estimated in 1990, minus 1.

cutthroat trout scales will be pursued in 1992. Robust criteria for aging scales must then be developed and tested, and applied to prior data collections, so that the dynamics the populations being studied can be described.

ACKNOWLEDGMENTS

We appreciate the efforts of Kurt Kondzela and Brad Gruening for their outstanding work in the field and for their insights into the information we collected. Kurt also was invaluable in getting the scales from both lake systems aged. 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. In 1991, we had Dan Peroni, a volunteer from South Carolina, assisted with field work in 1991. His energy and intelligence were a valuable addition to the project.

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APPENDIX A

Appendix A1. Responses to the mail-out survey.

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

	Turner Lake	Florence Lake	Hasselborg Lake
Yes	50 (83.3%)	27 (75.0%)	44 (69.2%)
No	7 (11.7%)	6 (16.7%)	11 (16.9%)
No Response	3 (5.0%)	3 (8.3%)	9 (13.9%)

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

	Turner Lake	Florence Lake	Hasselborg Lake
Yes	46 (92.0%)	21 (77.8%)	40 (90.9%)
No	4 (8.0%)	6 (22.2%)	4 (9.1%)

3. How many people were in your group?

Turner Lake	Florence Lake	Hasselborg Lake
3.5 (Average, SE=0.3)	2.8 (Average, SE=0.3)	3.9 (Average, SE=0.3)

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

	Turner Lake	Florence Lake	Hasselborg Lake
Yes	33 (55.0%)	18 (50.0%)	32 (58.2%)
No	19 (31.7%)	9 (25.0%)	10 (18.2%)
No Response	8 (13.3%)	9 (25.0%)	23 (41.8%)

5. Overall, how would you rate the fishing here?

	Turner Lake	Florence Lake	Hasselborg Lake
Poor	10 (22.7%)	3 (14.3%)	1 (2.6%)
Fair	13 (29.5%)	3 (14.3%)	9 (23.7%)
Good	16 (36.4%)	7 (33.3%)	13 (34.2%)
Excellent	5 (11.4%)	8 (38.1%)	15 (39.5%)

Table I (below) is similar to Table 7 (Jones and Harding 1991), except the minimum fish size of interest has been raised to 180 mm FL. As previously concluded (Jones and Harding 1991), marked fish of different sizes were recaptured with similar probablities (Figure I and Table II). Partial mixing of tagged and untagged fish does occur across areas (Table III), but mark to unmarked ratios are *not* similar across areas (Table IV), so Darroch's equations are appropriate for estimating abundance. However, very imprecise and unstable estimates result if this estimator is used, probably because the recapture data-matrix is scarce. A simple Peterson estimate of abundance for trout between 180 mm and 300 mm FL is $\hat{N} = 6,787$ $SE[\hat{N}] = 1,171$; the estimate should be used with caution since assumptions of the estimator are not met. Age composition of all fish sampled between 180 mm and 350 mm FL is shown in Table V.

Table I. Summary of cutthroat trout tagging and recovery data for fish 180-300 mm FL, Florence Lake, 1990.

	Sampling Period, 1990		
	Period 1 1 Aug- 9 Aug	Period 2 14 Aug- 23 Aug	Period 3 28 Aug- 6 Sept
Newly tagged fish released alive	281[a]	289[b]	286[a]
Recaptured fish tagged in:			
1988	0	0	0
1989	12	16	5[e]
1990 Period 1	1	16[c]	11[d,e,f]
1990 Period 2		3	17
1990 Period 3			4
Captured, not tagged	12	8	17
Total catch	306[a]	332[b]	343[a]

[a] Fish 180-295 mm.
[b] Fish 180-299 mm.
[c] Fish 187-294 mm.
[d] Fish 182-277 mm.
[e] Not including 1 fish recaptured twice in period.
[f] Not including 1 fish previously recaptured in Period 2.

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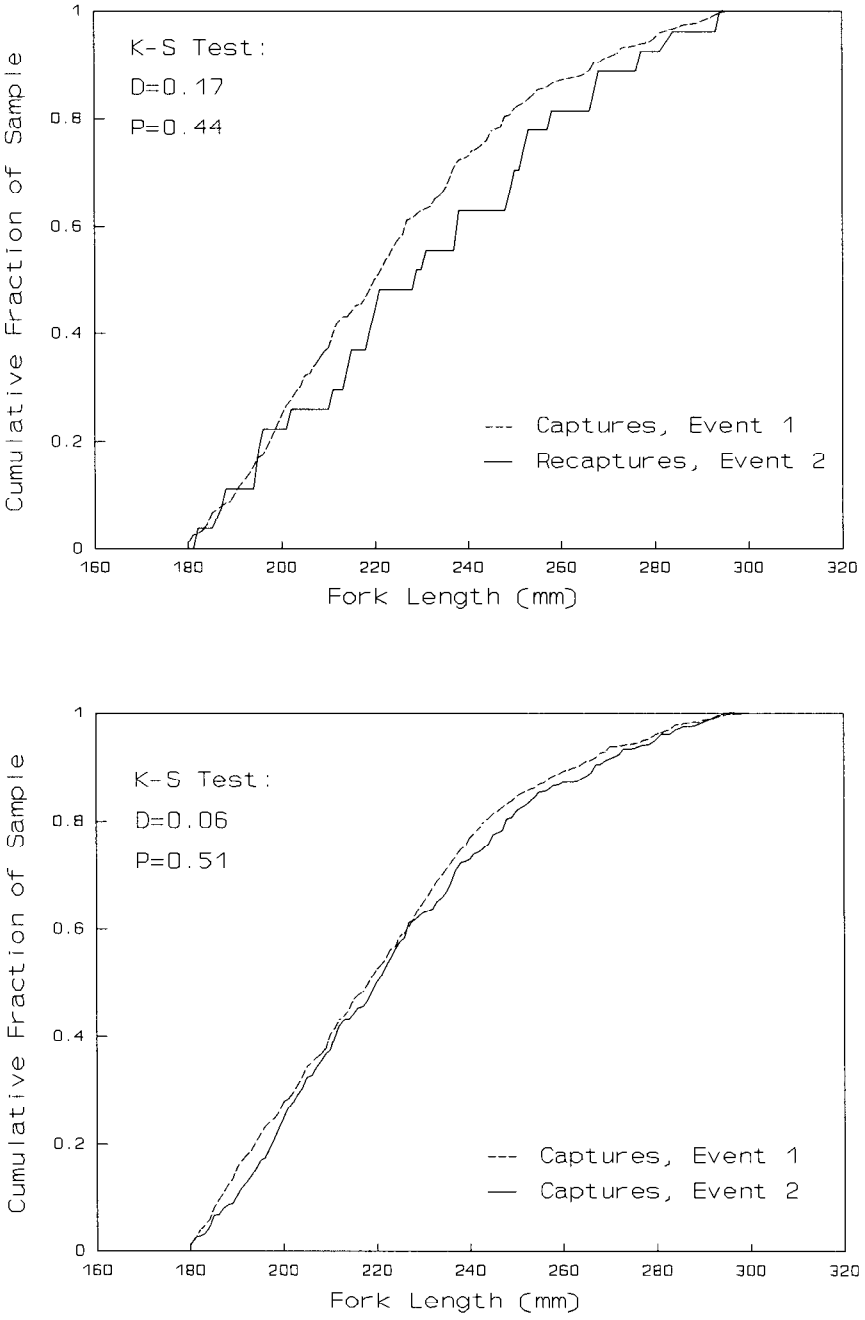

Figure I. Cumulative histogram of lengths of cutthroat trout marked versus lengths of cutthroat trout examined for marks (above) and versus lengths of cutthroat trout recaptured (below), fish between 180 mm and 300 mm FL, Florence Lake, 1990.

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Table II. Contingency table comparing the number of marked cutthroat trout 180-300 mm FL recaptured in event 2 to the number not recaptured by length category, Florence Lake, 1990.

	Length category		
	180-213 mm FL	214-300 mm FL	
Recaptured fish	10	17	27
Not recaptured fish	112	143	255
	122	160	282

$\chi^2 = 0.47$, df=1, P = 0.49

Table III. Numbers of trout 180-300 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, 1990.

	Recovery area			
Tagging area	A[a]	B[b]	C[c]	a_i
A	1	0	0	71
B	0	12	0	97
C	1	1	12	113
u_j	216	233	197	

[a] Study areas 6-8.
[b] Study areas 4-5, 9-10.
[c] Study areas 1-3, 11.

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Table IV. Contingency table comparing the number of marked and unmarked cutthroat trout 180-300 mm FL captured in sampling event 2, by recovery area, Florence Lake, 1990.

	Recovery area			
	A[a]	B[b]	C[c]	
Marked fish	2	13	12	27
Unmarked fish	216	233	197	646
	218	246	209	673

$\chi^2 = 8.1$, df=2, P = 0.018

[a] Study areas 6-8.
[b] Study areas 4-5, 9-10.
[c] Study areas 1-3, 11.

Table V. Estimated age composition of cutthroat trout between 180 mm FL and 350 mm FL sampled in Florence Lake, 1990.

Age	P_a	$SE(p_a)$
2	0.032	0.007
3	0.377	0.019
4	0.392	0.019
5	0.149	0.014
6	0.038	0.008
7	0.011	0.004
8	0.002	0.002