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ABSTRACT

Lake trout stocked as yearlings (age-0) into small lakes in the Tanana drainage in 1988, 1989, and 1991 were sampled during 1993 to estimate abundance, growth, and survival. Estimated abundance of stocked lake trout >150 millimeters fork length in Coalmine #5 Lake was 211 fish (SE = 11); >175 millimeters in Paul's Pond was 154 fish (SE = 9); in North Twin Lake was 217 fish (SE = 54); >210 millimeters in Chet Lake was 180 fish (SE = 10); >150 millimeters in Nickel Lake was 265 (SE = 38); and >160 millimeters in Rapids Lake was 213 (SE = 34). Growth was rapid in these small lakes and was similar to rates estimated from most wild populations. Survival to age-5 for the populations varied from 0.01 to 0.17 with a mean of 0.11 (SE = 0.02). Mean survival to age-4 was estimated at 0.26 (SE = 0.03, range 0.03 - 0.62). Survival to age-2 varied from 0.01 to 0.22 with a mean of 0.09 (SE = 0.02).

In 1991, estimated abundance of lake trout 250 millimeters and larger in Sevenmile Lake was 1,426 (SE = 57). Abundance of adult lake trout (>375 millimeters FL) of both sexes was estimated to be 931 (SE = 57) in 1991 and 1,139 (SE = 152) in 1993. A total of 107,500 eggs were live stripped from 90 females. This number of eggs represents a minimum of 20 percent of the annual egg production of the population.

KEY WORDS: Lake trout, *Salvelinus namaycush*, population abundance, age, growth, survival, stocking, introductions.

INTRODUCTION

Lake trout *Salvelinus namaycush* from Paxson Lake were stocked as yearlings (age-0) in a number of small lakes in interior Alaska in 1988, 1989 and 1991 (no stocking of lake trout occurred in small lakes in 1990). The purpose of these stockings was to diversify the fish species available to sport anglers and to establish self-sustaining populations. Initial evaluation of some of these stockings was conducted and reported by Skaugstad and Clark (1991). Burr (1993) continued evaluation of these stocked waters but found that fish stocked in 1991 (age-1 in 1992) were not well represented in samples. The stocked lakes which were selected for sampling during 1993 were a subset of the lakes sampled in 1992 by Burr (1993). Other studies conducted on lake trout in Alaska have been on wild populations in larger lakes. Lake trout age-4 and less are very poorly represented in samples from these populations. This is due to the very low catchability of juvenile lake trout in these larger waterbodies. Hence information concerning the population dynamics of juvenile lake trout in Alaska is limited.

The lake trout stocked into these smaller lakes provided an excellent opportunity to gain further knowledge on the biology of the species in Alaska. Because all stocked lake trout were age-5 and less in 1993, scales could be used for age determination (Sharp and Bernard 1988) and age-based analyses could be used. Data collected from these stocked populations provide estimates of annual growth and survival. The lake trout of known age also provided an excellent opportunity to validate ages as determined from scales, otoliths and opercular bones. Otoliths are generally used for age determination because they are believed to be more reliable for lake trout older than age-5. Opercular bones have been proposed as a structure for age determination in lake trout (Sharp and Bernard 1988). Scales have also been used for age determination and are believed to be accurate for fish up to age-5. However, ages determined from these structures have not yet been validated for Alaskan populations.

The lake trout stocking program is still considered experimental but at this time appears to be successful. The small stocked lakes on the Meadows and Coalmine roads provided 17% of the annual harvest of lake trout in the Tanana area in 1992 (Mills 1993). Initial growth and survival have been good. Using lake trout for put-grow-and-take fisheries appears feasible in these small waters and may relieve a portion of the effort directed at stressed wild stocks. No lake trout have been stocked since 1991 and lake trout egg takes were not conducted in 1991 or 1992.

A new brood source for the AYK stocking program was selected to replace the Paxson Lake population which is outside of the watershed. Sevenmile Lake was selected as a brood source because it: (1) is located in the Tanana drainage which is important for disease and genetic considerations, (2) has good road access providing transport of live eggs in all weather, and (3) contains a dense population of small but fast growing and early maturing lake trout. Sevenmile Lake is small (33 ha) and there is concern about the impact that the loss of a substantial number of eggs might have on the population. The abundance of adult lake trout was estimated along with the potential population fecundity to assess the probable impact of the egg take.

The specific project objectives during the 1993 field season were to:

1. estimate abundance of lake trout in seven lakes: Coalmine #5, North Twin, Chet, Nickel, Rapids, and Ghost lakes and Paul's Pond;

2. estimate the mean length at age, the length composition, and the age composition of lake trout in the lakes listed above;

3. estimate survival of the 1988, 1989, and 1991 stocking cohorts of lake trout in the lakes listed above;

4. estimate the 1991 abundance of lake trout 250 mm FL and larger in Sevenmile Lake; and,

5. estimate the 1993 abundance of lake trout 380 mm FL and larger in Sevenmile Lake.

In addition, project tasks were to:

1. validate that ages of lake trout stocked in 1991 as determined from otoliths, opercular bones and scales are true ages; and,

2. collect up to 75,000 fertilized lake trout eggs from Sevenmile Lake for use in the Tanana drainage stocking program.

This report is partitioned into two sections. The first section concerns the evaluation of lake trout stocked into small lakes as fingerlings in 1988, 1989 and 1991. The second section contains estimates of abundance of lake trout in Sevenmile Lake.

Length distributions of lake trout sampled in small lakes during 1993 are in Appendix A. A study designed to validate ages of lake trout as determined from otoliths, scales and opercular bones in being conducted. Information concerning this ongoing study is provided in Appendix B.

EVALUATION OF STOCKED LAKE TROUT

Methods

Seven lakes which were stocked with age-0 lake trout originating from Paxson Lake were sampled during 1993. The sampling methodology used at all lakes was similar.

Abundance Estimates:

Mark recapture experiments were conducted to estimate the abundance of lake trout in seven lakes: Coal Mine #5 Lake, and Paul's Pond on the Coal Mine

Road; North Twin, Chet, Nickel, and Ghost lakes on the Meadows Road on Fort Greely; and Rapids Lake at mile 228 of the Richardson Highway (Table 1). The lakes are all small in size ranging from 1.3 to 8.4 ha (3 to 2 ac).

The abundance of lake trout in each population was estimated using a modification of the Petersen mark-recapture estimator (Chapman 1951). Lake trout were captured using fyke nets and hoop traps. Sampling to mark lake trout for these experiments began in early June and was followed by recapture sampling in July following a hiatus ranging from 12 to 20 days (Table 2). Fish were marked with a upper caudal fin punch. All lake trout captured were measured to the nearest millimeter of fork length and scale samples for age determination were collected from the left side below the anterior edge of the dorsal fin. Sampling periods and fishing gear used at each water body are listed in Table 2.

For each population, the abundance and the variance of the estimate was calculated with the following formulas (Seber 1982):

$$\hat{N} = \frac{(C + 1)(M + 1)}{(R + 1)} - 1; \qquad (1)$$

$$V[\hat{N}] = \frac{(M + 1)(C + 1)(M - R)(C - R)}{(R + 1)^2(R + 2)}; \qquad (2)$$

where:

M = the number marked during the first period;

C = the number captured during the second period; and,

R = the number captured during the second period with marks from the first period.

Assumptions for the accurate use of the estimator are: a closed population, complete mixing of tagged and untagged fish (or equal probability of capture of all fish), no loss of mark, all marked fish are reported when recovered in the recapture sample, and equal mortality between marked and unmarked fish.

The lake trout populations in the study lakes are considered closed since all existing outlet streams are too small to provide a route for immigration or emigration. The Petersen estimator remains valid if either mortality or recruitment (but not both) occurs between sampling events. Recruitment is unlikely as no lake trout were stocked during 1992 and the lake trout present were all juveniles. All fish captured during recapture sampling were carefully examined for finclips. The length of time between marking and recapture (two weeks minimum) should have been sufficient to allow for complete mixing of marked and unmarked fish. To minimize differential mortality between marked and unmarked fish, only lake trout which appeared to be in good condition were released. The estimated abundance is germane to the time of marking.

Table 1. Lakes sampled during 1993 which were stocked with age-0 lake trout from Paxson Lake in 1988, 1989, and/or 1991.

Waterbody	Stocking		Other Species Present[a]	Surface Area (ha)	Maximum Depth (m)	Elevation (m)
	Date	Number				
Coalmine # 5	1988	2,600	RT	5.4	8.5	807
	1989	2,600				
	1991	2,600				
Paul's Pond	1988	1,000	GR, RT,	2.1	7.0	823
	1989	1,000	SSC			
	1991	1,000				
North Twin	1991	1,000	RT, SSC	8.4	6.1	518
Chet	1988	1,600	GR, LNS,	2.8	9.1	580
	1989	800	RT			
	1991	2,000				
Nickel	1988	1,000	GR, RT	2.3	18.3	580
	1989	500				
	1991	1,000				
Ghost	1988	1,000	AC, RT	1.7	15.5	580
	1989	500				
Rapids	1991	2,839	RT	2.3	9.1	715

[a] Fish species present in addition to lake trout: AC - Arctic char *Salvelinus alpinus*, GR -grayling *Thymallus arcticus*, LNS - longnose sucker *Catostomus catostomus*, RT - rainbow trout *Oncorhynchus mykiss*, and SSC - slimy sculpin *Cottus cognatus*.

Table 2. Sampling periods and fishing gear used in lakes where experiments were conducted to estimate population abundance.

Waterbody	Sampling Period	Fishing Gear
Coal Mine # 5 Lake	June 18 - 29	Fyke, Hoop Nets
	July 13 - 16	Fyke, Hoop Nets
Paul's Pond	June 18 - 26	Fyke Nets
	July 13 - 16	Fyke Nets
North Twin Lake	June 3 - 29	Fyke, Hoop Nets
	July 7 - 30	Fyke, Hoop Nets
Chet Lake	June 3 - 18	Fyke, Hoop Nets
	July 7 - 9	Fyke, Hoop Nets
Nickel Lake	June 3 - 18	Fyke, Hoop Nets
	July 8 - 16	Fyke, Hoop Nets
Ghost Lake	June 3 - 16	Fyke, Hoop Nets
	July 8 - 30	Fyke, Hoop Nets
Rapids Lake	July 18 - 26	Hoop Nets
	July 13 - 30	Hoop Nets

The assumption of complete mixing of marked and unmarked fish was not tested; the same finclip was used throughout each lake. However, it is likely that mixing did occur prior to recapture sampling because several days were allowed for mixing and the lakes are very small (1 to 8 ha). The hypothesis of equal probability of capture for fish of all sizes during the two sampling events was tested using two sample Kolmogorov-Smirnov (KS) tests. The first test compared the cumulative length frequency of marked fish versus the cumulative length frequency of those recaptured. The second test compared the cumulative length frequency of fish captured during the marking event with the cumulative length frequency of fish captured during the recapture event (Seber 1982). The procedure followed given each possible outcome of these tests is given on pages 17 and 18 in Bernard and Hansen 1992. If the first hypothesis was rejected (the gear was size selective), the abundance of each significant size class was estimated separately as suggested in Ricker (1975) and then summed to obtain an abundance estimate. The variance of the population estimate in this case was the sum of variances for each size class.

Length at Age, and Length and Age Compositions:

Estimates of mean length at age were generated with standard normal procedures. Data for these estimates were collected during the population abundance sampling. Scales were used for age determination and for estimating mean length at age.

Age and size compositions were estimated as multinomial proportions from sampling to estimate population abundance. Age composition was estimated as the proportion of fish in existing age groups. Size composition was estimated as the proportion of fish in 10 mm length categories.

Hypothesis testing conducted to test assumptions necessary for accurate abundance estimation were used to detect biases in age and size composition samples. If no differences were detected between fish marked in event 1 and recaptured in event 2 (test 1) or between fish sampled in each event (test 2), no adjustments to age and size data were required and data from both events were pooled. If differences were detected in test 2, size selectivity was indicated in event 1 and only data from event 2 were used to estimate age and size composition. In these cases, the proportions of each size or age category were estimated with the following formulas (Cochran 1977):

$$\hat{p}_g = \frac{n_g}{n}\text{; and,} \tag{3}$$

$$V[\hat{p}_g] = \frac{\hat{p}_g(1 - \hat{p}_g)}{n - 1}[1 - n / \hat{N}]; \tag{4}$$

where:

n_g = the number in the sample from group g;

n = the number of fish in the sample; and,

$\hat{p}_g$ = the estimated fraction of the population that is made up of group g.

$\hat{N}$ = the estimated population abundance.

If a difference was detected in test 1 but not test 2, size selectivity was indicated in both sampling events and data from both events were pooled to estimate age and size composition but the data were adjusted to correct for bias due to size selectivity. When differences were found by both hypothesis tests, only data from sampling event 2 were used and the data were corrected for size bias. In both of these cases the data were divided into significant size groups (stratum) using contingency table analysis.

The estimated abundance of age group g in the population (N_g) is:

$$\hat{N}_g = \Sigma_k \; p_{kg} \; N_k \tag{5}$$

The variance for $\hat{N}_g$ is a sum of the exact variance of a product from Goodman (1960):

$$V[\hat{N}_g] = \Sigma_k \left[V[p_{kg}] N_k^2 + V[N_k] p_{kg}^2 - V[p_{kg}] V[N_k] \right] \tag{6}$$

Length composition was estimated in a similar manner, replacing age class with 10 mm length intervals.

The proportion of the populations corresponding to each size category (stratus) was estimated with equation (7) and the approximate variance was calculated with equation (8) (from the Delta method, Seber 1982):

$$\hat{p}_g = \sum_k \frac{\hat{p}_{kg} \hat{N}_k}{\hat{N}} ; \tag{7}$$

$$V[\hat{p}_g] \approx \frac{\sum_k V[\hat{p}_{kg}] \left[\frac{\hat{N}_k}{\hat{N}} \right]^2 + \sum_k V[\hat{N}_k] (\hat{p}_{kg} - \hat{p}_g)^2}{\hat{N}^2} \tag{8}$$

where:

n_{kg} = the number of lake trout in the sample of group g in length stratum k; and,

n_k = the number of lake trout in the sample in size stratum k;

$\hat{p}_g$ = the estimated fraction of the population that is of group g;

$\hat{p}_{kg}$ = the estimated fraction of the population that is of group g in size stratum k($= n_{kg}/n_k$);

$\hat{N}_g$ = the estimated abundance of lake trout in age group g;
$\hat{N}_k$ = the estimated abundance of lake trout of size stratum k; and,
$\hat{N}$ = the estimated abundance of lake trout of all size strata.

Survival of 1988, 1989, and 1991 Stocking Cohorts:

The survival rate (S) of lake trout stocked in 1988, 1989, and 1991 was estimated as the proportion of fish surviving to 1993 from those stocked in each year. The estimate of the variance of the estimates of survival (V [S]) was estimated by:

$$\hat{S}_{i,93} = \frac{\hat{N}_{i,93}}{N_i}\text{; and,} \tag{9}$$

$$\hat{V}[\hat{S}_{i,93}] = \hat{V}[\hat{N}_{i,93}]\cdot\left[\frac{1}{N_i}\right]^2 \tag{10}$$

where:

$\hat{S}_{i,93}$ = the estimated survival rate of lake trout from stocking in year i to 1993;
$\hat{N}_{i,93}$ = the estimated abundance of lake trout in 1993 that were stocked in year i; and,
N_i = the number of lake trout stocked in year i.

Age specific annual survival for lake trout from June 1992 to June 1993 for each of the stocked cohorts was estimated from the estimated abundance in each year by:

$$\hat{S} = \frac{\hat{N}_{92}}{\hat{N}_{93}} \tag{11}$$

$$V[\hat{S}] = V[\hat{N}_{93}]\left(\frac{1}{\hat{N}_{92}}\right)^2 + \hat{N}_{93}^2\,\frac{1}{\hat{N}_{92}^4}\,V[\hat{N}_{92}] - V[\hat{N}_{93}]\,\frac{1}{\hat{N}_{92}^4}\,V[\hat{N}_{92}] \tag{12}$$

where:

$\hat{S}$ = the estimated survival for a cohort from 1992 to 1993;
$\hat{N}_{92}$ = the estimated abundance of a cohort in 1992; and,
$\hat{N}_{93}$ = the estimated abundance of a cohort in 1993

Results

Abundance Estimates:

Coalmine #5 Lake. The estimated abundance of lake trout 150 mm and larger in Coalmine #5 Lake in June of 1993 was 211 (SE = 11) fish.

Between June 18 and June 29, 176 lake trout ranging in size from 150 to 391 mm FL were marked with an upper caudal fin punch. Between July 13 and July 16, the population was again sampled and 45 (153 - 367 mm) lake trout were captured (Table 3). Thirty-one (153 - 367 mm) of the 45 fish captured in July were marked from the June sampling period.

Comparison of lengths of all lake trout marked in June with those recaptured in July indicated that they were not significantly different (KS two sample test; D = 0.13, P = 0.76). However, lengths of all fish captured during the two sampling periods were different (KS two sample test; D = 0.34, P < 0.001). The age-2 cohort was distinct in size from the larger age-4 and age-5 fish (Appendix A1). Comparison of lengths of age-2 fish marked and recaptured (D = 0.33, P = 0.77) and captured during the two sample periods (D = 0.41, P = 0.16) failed to detected significant differences. Similar results were obtained when only lengths of fish from the older cohorts were compared (mark verses recapture, D = 0.20, P = 0.33; captured June verses captured July, D = 0.17, P = 0.48). These results indicate that the smaller age-2 fish were not captured at the same rate as the older larger cohorts (Figure 1). Hence, the catch data were stratified and separate abundance estimates were calculated for lake trout 150 to 200 mm and for fish 248 mm and larger.

The estimated abundance for lake trout 150 to 197 mm was 34 (SE = 7). Within this stratum, 12 fish were marked during June and 18 fish were examined in July of which six were recaptured from the June sample period (Table 3). For lake trout 248 mm and larger, the estimated abundance was 177 fish (SE = 8). In this size group, 164 lake trout were marked and 27 were examined of which 25 were recaptured (Table 3).

Population abundance for lake trout 150 mm and larger was also calculated without stratification to investigate if the size bias in the samples was significant. A total of 176 fish were marked and 45 were examined of which 31 were recaptured from the marked population (Table 3). The resulting estimated abundance without stratification was 253 (SE = 22) and was greater and less precise than the stratified estimate. This indicates that the size bias was significant and the presumably more accurate and more precise stratified estimate was selected.

Paul's Pond. Population abundance of lake trout 175 mm FL and larger in June 1993 was estimated to be 154 (SE = 9) fish.

Between June 18 and June 26, 120 lake trout 175 to 384 mm FL were marked with upper caudal fin punches. Between July 13 and July 16, the population was

Table 3. Estimated abundance of lake trout in selected stocked waters in the Tanana River drainage, June 1993.

Lake	Size Group (mm FL)	Number of Lake Trout Marked	Captured	Recaptured	Estimated Abundance[a]	SE
Coalmine #5	150 - 197	12	18	6	34	7
	248 - 391	164	27	25	177	8
	strata combined				211*	11
	all fish > 150	176	45	31	253	9
Paul's Pond	> 175	120	49	38	154	9
North Twin	> 176	33	55	8	217	54
Chet	211 - 260	76	29	21	104	10
	> 260	47	49	32	72	4
	strata combined				176	10
	all fish > 210	123	78	53	180*	10
Nickel	> 210	133	73	51	190	11
Ghost					nd[b]	
Rapids	160 - 180	82	10	6	129	27
	> 180	30	18	6	83	21
	strata combined				213*	34
	> 160	112	28	12	251	47

[a] Starred * estimate of abundance selected, see text.
[b] nd = no data, catch rates too low to provide meaningful estimate of abundance.

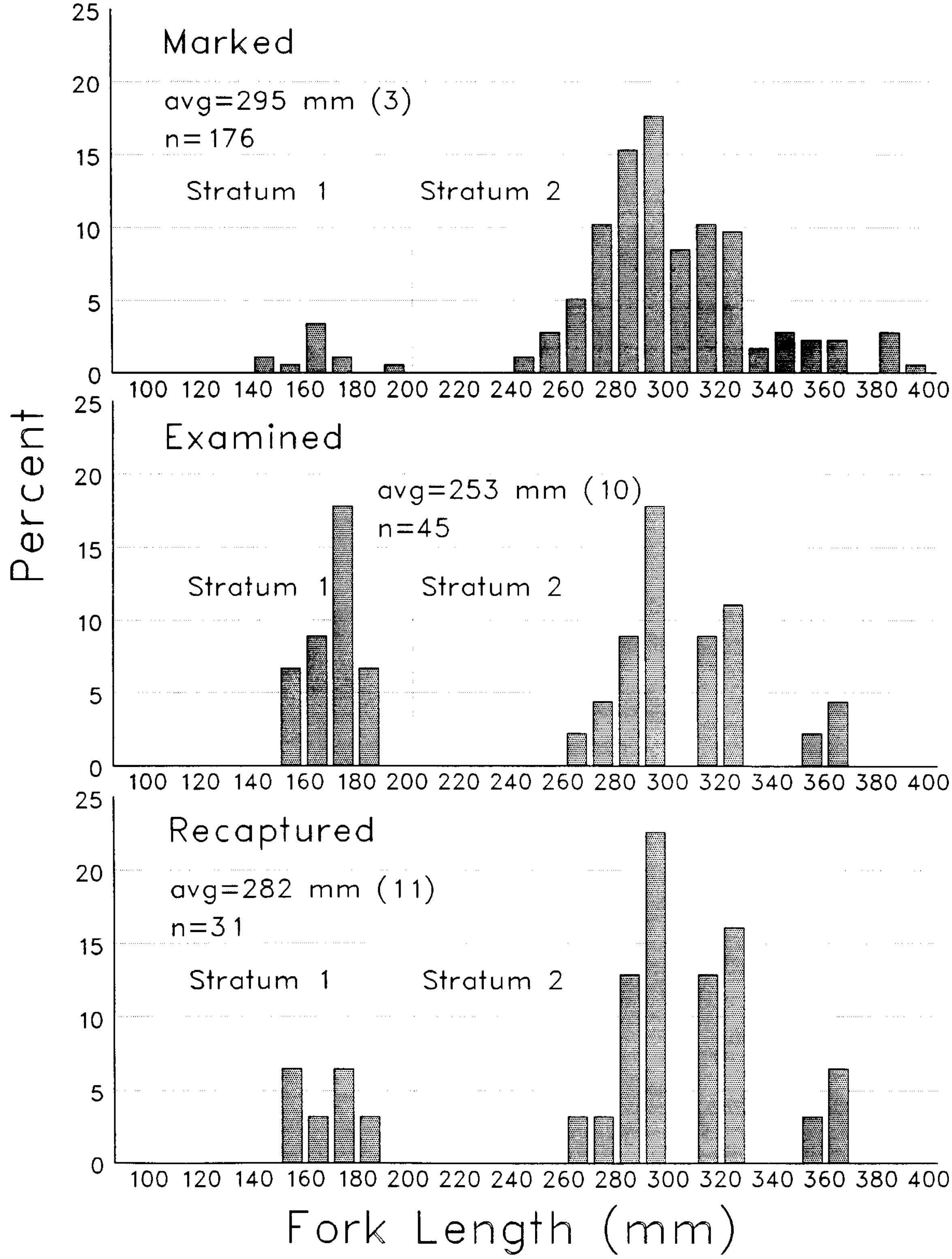

Figure 1. Length distribution of lake trout captured for estimating population abundance in Coalmine #5 Lake, 1993. Two strata are delineated by vertical dashed lines.

again sampled and 49 lake trout 179 to 325 mm were captured of which 38 (179 - 325 mm) were marked from the first sampling period (Figure 2, Table 3).

Comparison of lengths of fish marked and recaptured during the two sampling periods showed no differences in the size of fish sampled (KS two sample test; D = 0.24, P = 0.07). Similarly, no difference in the lengths of all fish captured during the two sampling periods was detected (KS two sample test; D = 0.23, P = 0.06). Hence, a single non-stratified abundance estimate was calculated.

<u>North Twin Lake</u>. The abundance of age-2 lake trout in North Twin Lake was estimated to be 217 (SE = 54) fish.

Between June 6 and June 29, 34 lake trout 176 to 300 mm FL were captured and 33 were marked and released. Between July 7 and July 30, the population was again sampled and 55 lake trout 176 to 285 mm were captured of which eight (176 - 282 mm) were recaptured from the first sampling period (Figure 3, Table 3).

Comparison of lengths of fish marked in the first event with those recaptured in the second event showed no differences in the size of fish sampled (KS two sample test; D = 0.18, P = 0.99). Similarly, lengths of all fish captured during the two sampling periods were not different (KS two sample test; D = 0.19, P = 0.46). A single non-stratified abundance estimate was calculated for age-2 fish.

<u>Chet Lake</u>. Lake trout abundance in June 1993 was estimated to be 180 (SE = 10) fish larger than 210 mm FL.

Between June 3 and June 18, 127 lake trout varying from 168 to 341 mm FL were captured and marked. Between July 8 and 9, the population was again sampled and 78 lake trout 213 to 320 mm were captured of which 53 (213 - 318 mm) were marked from the first sampling period (Figure 4). Because no lake trout less than 210 mm were captured during the second sampling event, the estimated abundance was calculated for fish 210 mm and larger only.

Comparison of lengths of fish (210 mm and larger) marked during the first sample period and recaptured during the second sampling period indicated differences in the size of fish sampled (KS two sample test; D = 0.28, P = 0.004). Similarly, lengths of all fish 210 mm and larger captured during the two sampling periods were different (KS two sample test; D = 0.29, P < 0.001). However, examination of the plotted lengths indicated that the differences detected may have been due to growth of individual fish between sample periods (Figure 5). Nevertheless, the catch data were stratified and separate abundance estimates were calculated for lake trout 211 to 260 mm and for fish 261 mm and larger.

The estimated abundance for lake trout 211 to 260 mm was 104 (SE = 10). Within this strata, 76 fish were marked during June and 29 fish captured in July of which 21 were recaptured from the June sample period (Table 3). For

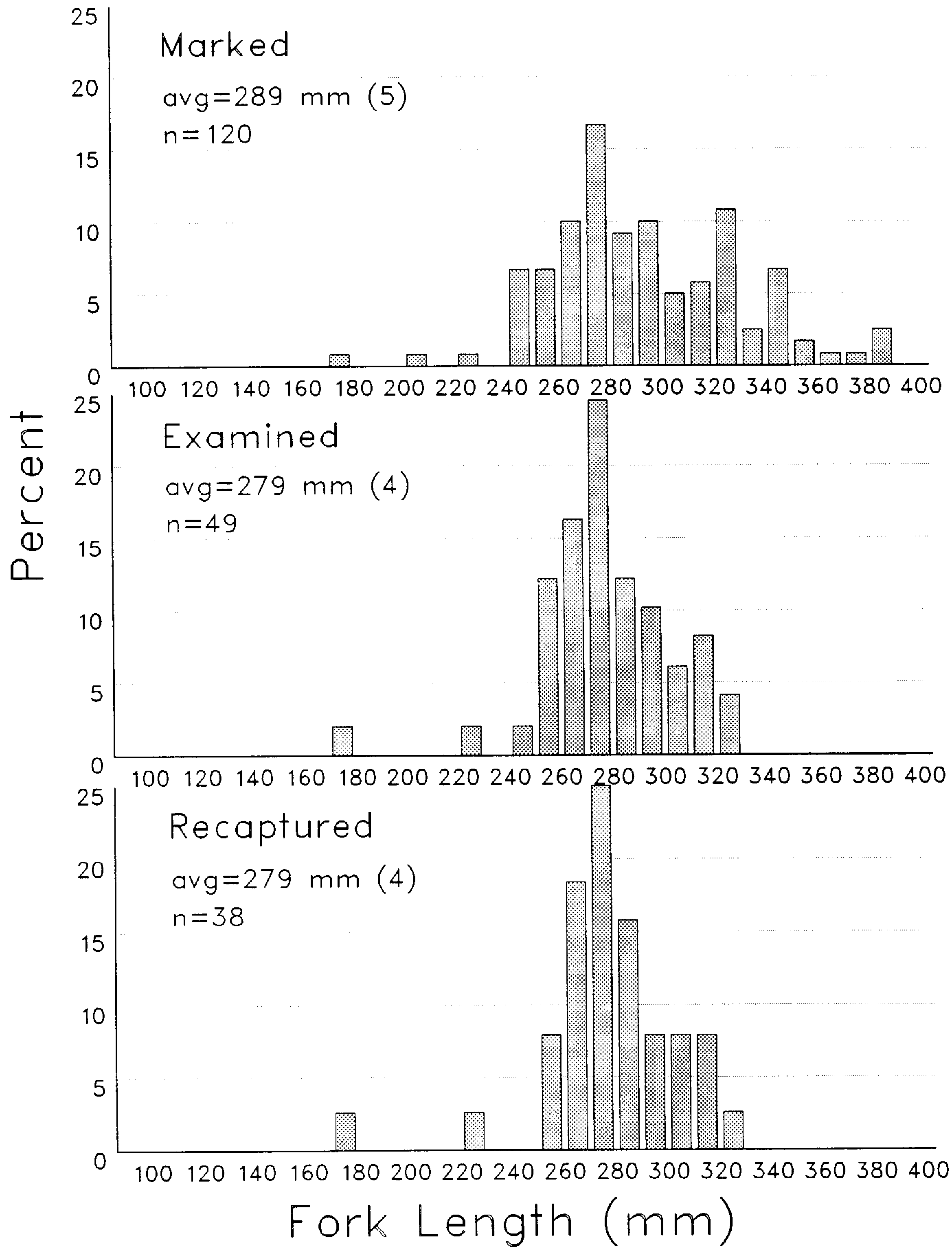

Figure 2. Length distribution of lake trout captured for estimating population abundance in Paul's Pond, 1993.

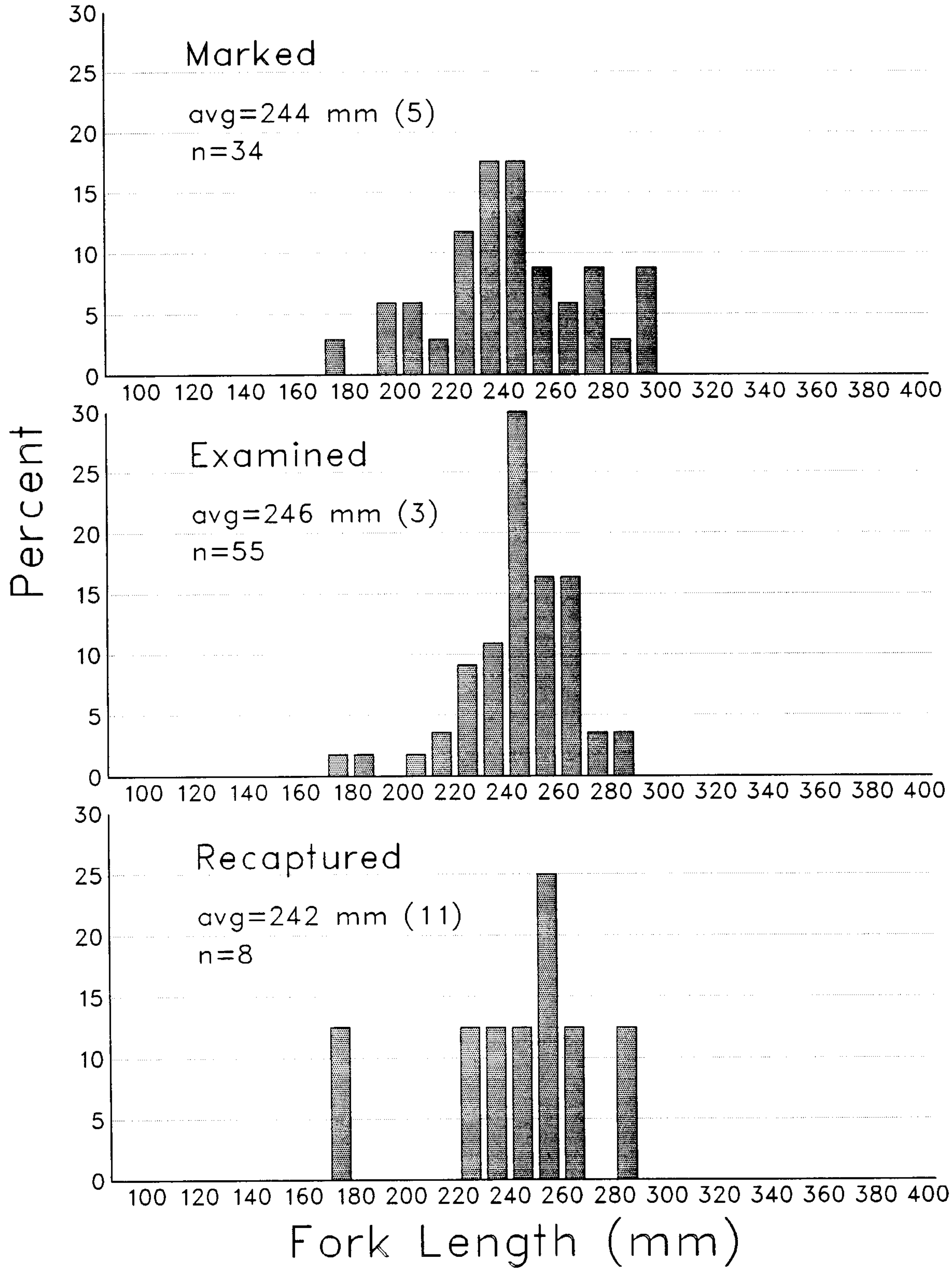

Figure 3. Length distribution of lake trout captured for estimating population abundance in North Twin Lake, 1993.

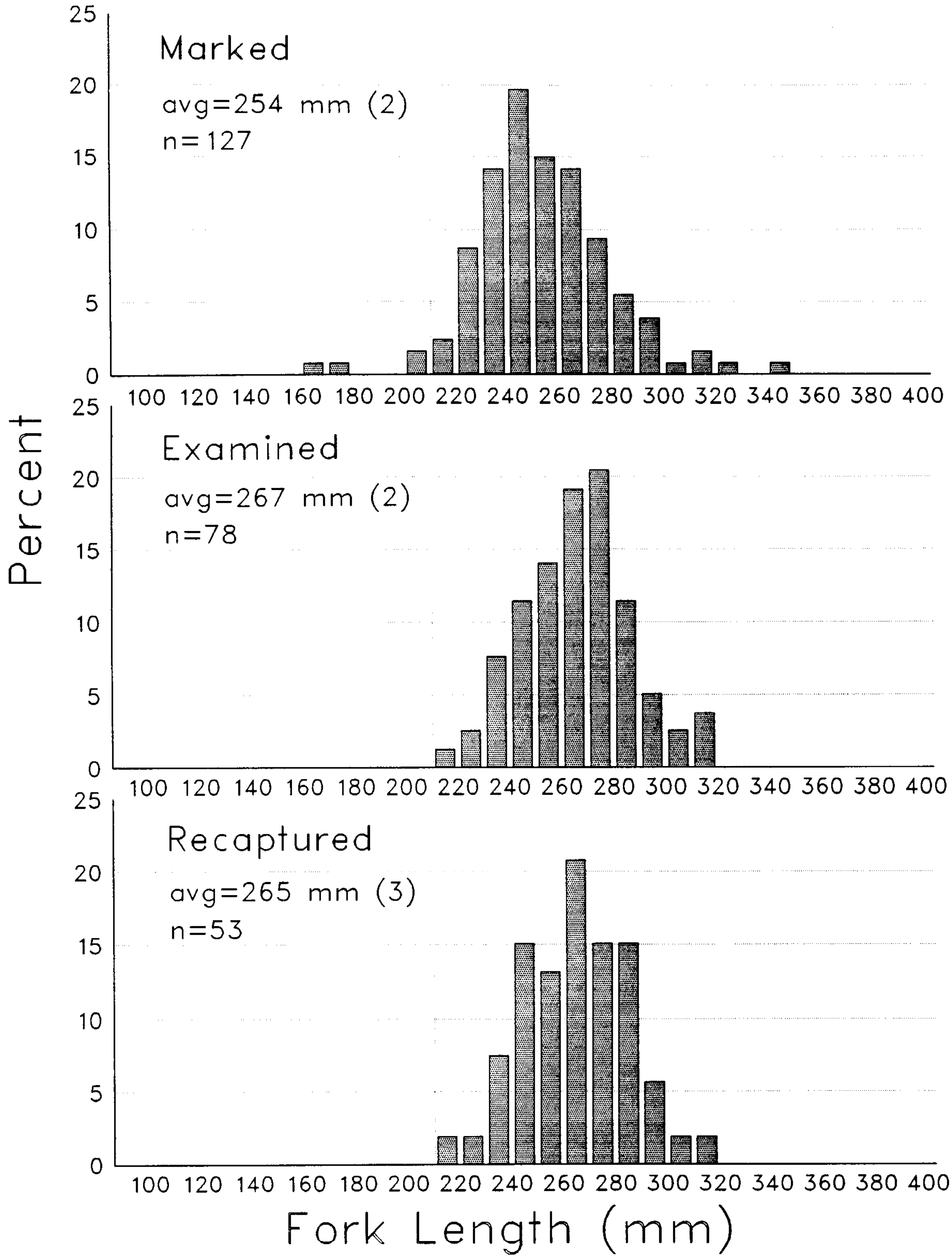

Figure 4. Length distribution of lake trout captured for estimating population abundance in Chet Lake, 1993. Lower limit of sizes included in the estimate is delineated by vertical dashed line.

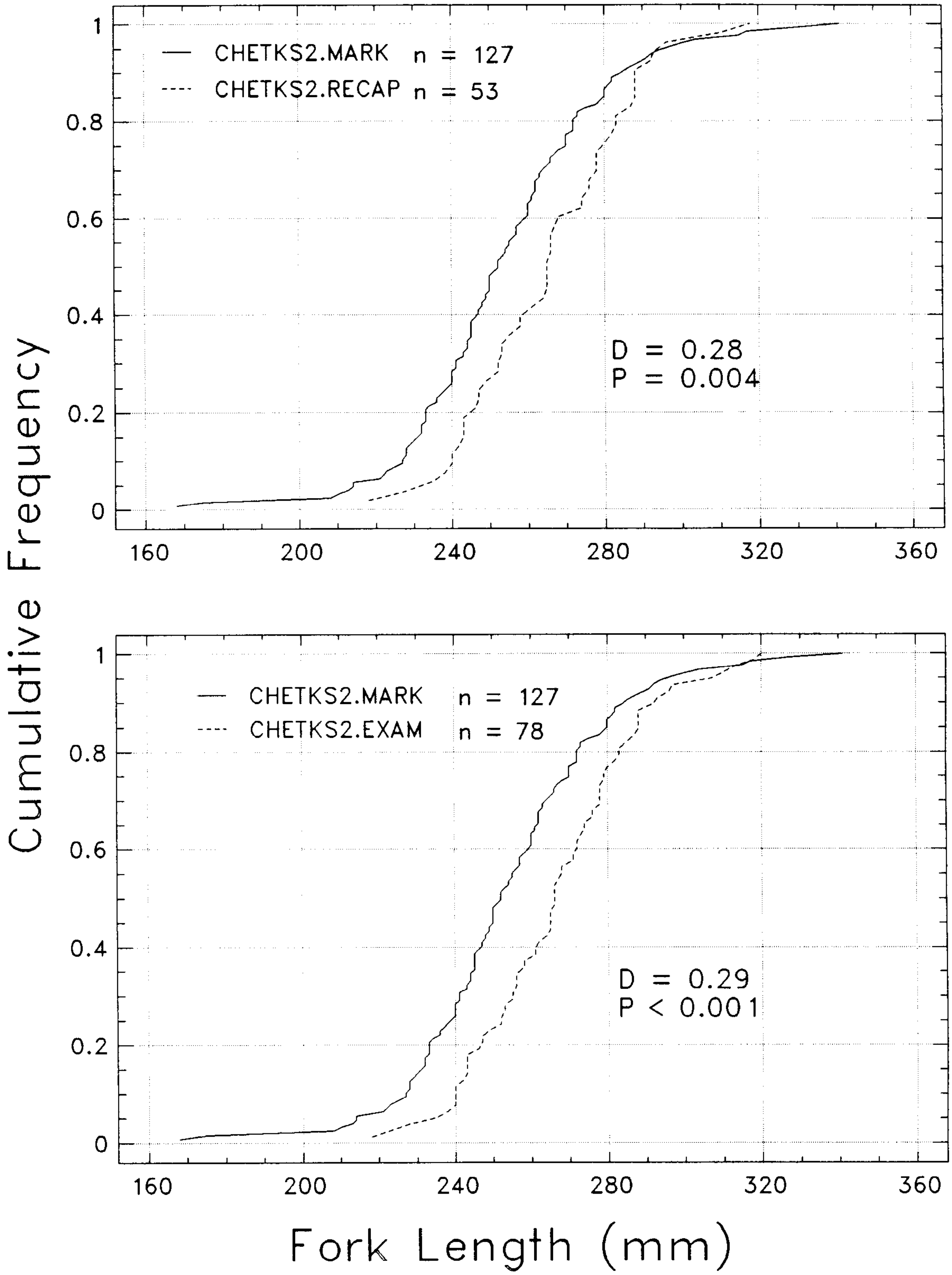

Figure 5. Cumulative distribution of lengths of lake trout marked and recaptured and captured during each sample period in Chet Lake, 1993.

lake trout 261 mm and larger the estimated abundance was 72 (SE = 4) fish. In this size group, 47 lake trout were marked and 49 were examined of which 32 were recaptured from the marked population (Table 3). The estimated abundance of lake trout from these strata combined was 176 fish (SE = 10).

Population abundance for lake trout 211 mm and larger was also calculated without stratification to investigate if the size bias detected in the samples was significant. A total of 123 fish were marked and 78 were examined of which 53 were recaptured from the marked population (Table 3). The resulting estimated abundance without stratification was 180 (SE = 10) and was not substantially different from the stratified estimate. This indicates that any size bias was not significant. The non stratified estimate was selected.

<u>Nickel Lake</u>. Estimated abundance of lake trout 210 mm and larger in Nickel Lake during June 1993 was 190 (SE = 11) fish.

Between June 3 and June 18, 151 lake trout 151 to 310 mm FL were marked with an upper caudal fin punch. Between July 8 and July 16, the population was again sampled and 80 lake trout 159 to 336 mm were captured of which 52 (159 - 312 mm) were marked from the first sampling period. Only one lake trout of the 18 that were marked between 151 and 210 mm in length was recaptured. This length range corresponds closely with the length range of the age-2 cohort (Figure 6, Appendix A5). The abundance of fish 150 to 200 mm was not calculated because of statistical bias resulting from the very low number of recaptures. For lake trout 211 mm and larger, 133 lake trout were marked and 73 were examined of which 51 were recaptured from the marked population (Table 3).

Comparison of lengths of lake trout larger than 210 mm marked and recaptured during the two sampling periods showed no differences in the size of fish sampled (KS two sample test; D = 0.21, P = 0.06). Similarly, lengths of all fish larger than 210 mm captured during the two sampling periods were not different (KS two sample test; D = 0.15, P = 0.23).

<u>Ghost Lake</u>. A meaningful estimate of abundance of lake trout in Ghost Lake could not be captured because of very low catches. Between June 3 and 16 a total of 16 lake trout varying from 272 to 387 mm were captured and marked with upper caudal fin punches. In July, (8 through 30) 9 lake trout (290 to 368 mm) were captured only two of which (334 and 343 mm) had marked fins from the June sample period (Table 3, Figure 7).

No fish were recaptured which were less than 330 mm in length. Length at age data from 1993 indicate that no age-4 fish were larger than 320 mm and that most age-5 fish were 330 mm or larger (Appendix A6).

<u>Rapids Lake</u>. The abundance of age-2 lake trout in Rapids Lake during June 1993 was estimated to be 213 (SE = 34) fish.

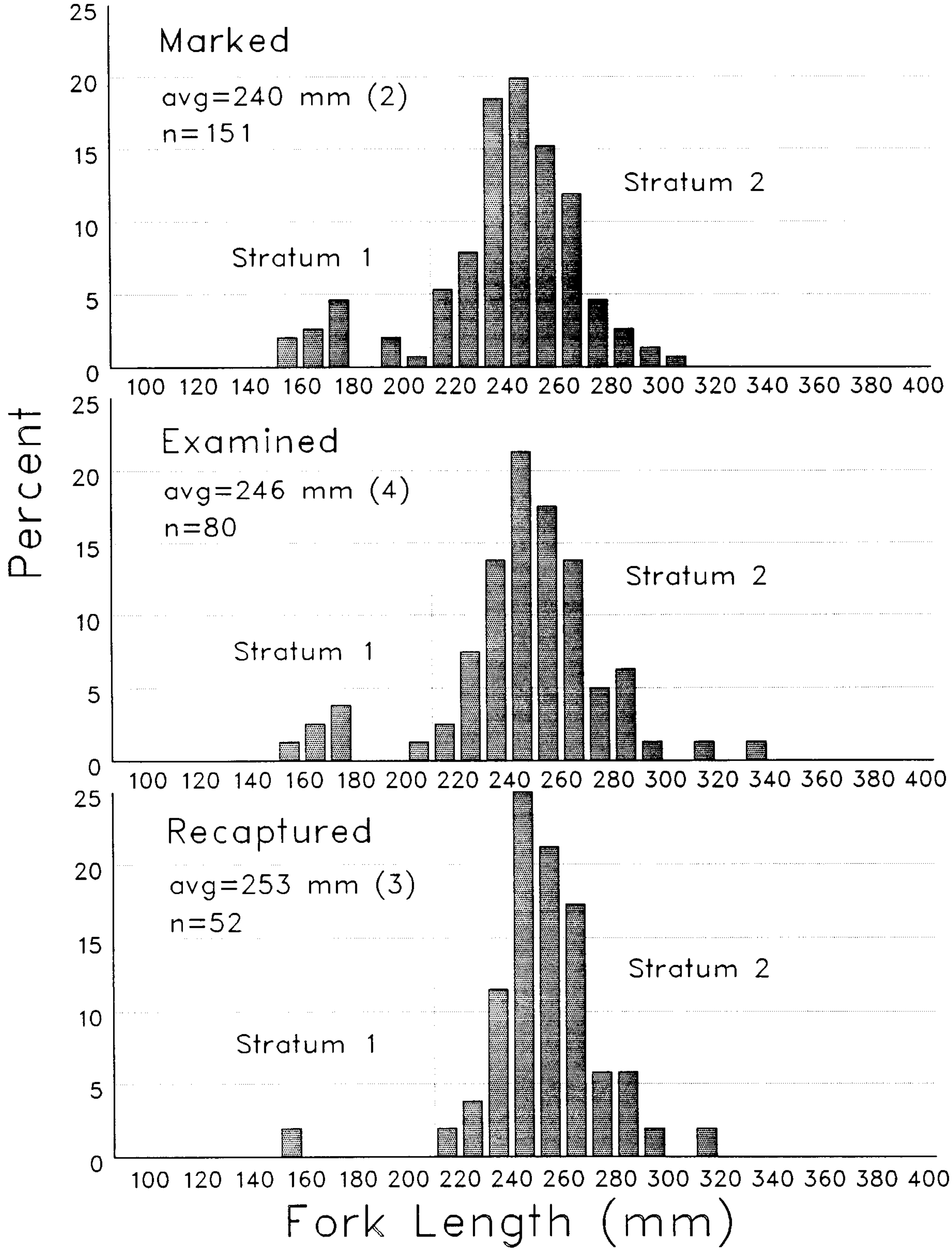

Figure 6. Length distribution of lake trout captured for estimating population abundance in Nickel Lake, 1993. Lower limit of sizes included in the estimate is delineated by vertical dashed line.

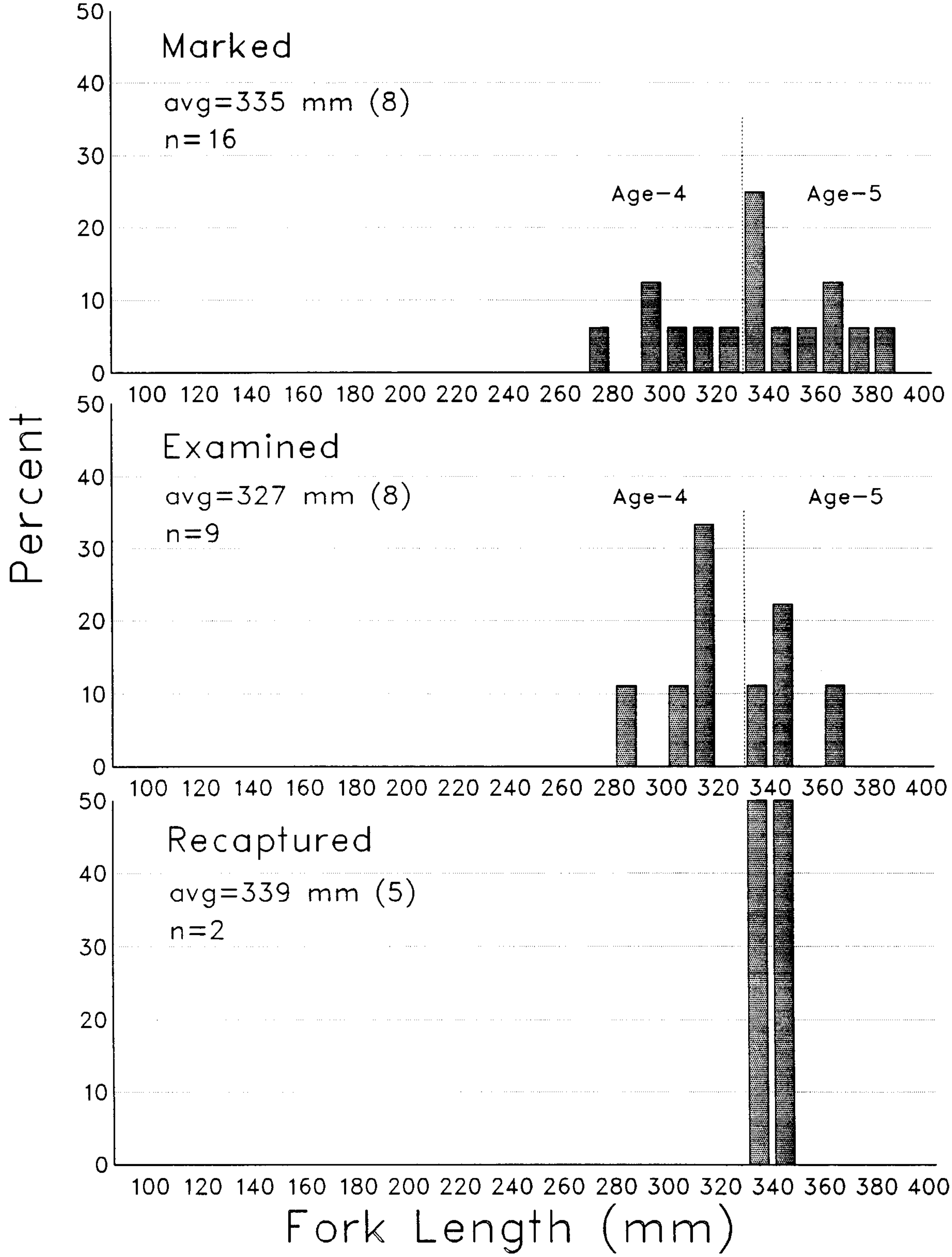

Figure 7. Length distribution of lake trout captured for estimating population abundance in Ghost Lake, 1993. No abundance estimate was obtained due to low number of recaptures.

Between June 18 and 29, 120 lake trout ranging from 161 to 196 mm FL were captured; 112 (161 to 196 mm) were marked and released, eight were killed by the sampling gear. Between July 13 and 30, 28 lake trout were captured (165 - 207 mm FL) of which 12 (165 to 195 mm) were marked during the first sample period. Comparison of lengths of fish marked during the first sample period and recaptured during the second sampling period indicated differences in the size of fish sampled (KS two sample test; $D = 0.44$, $P = 0.03$). Similarly, lengths of all fish captured during the two sampling periods were different (KS two sample test; $D = 0.48$, $P < 0.001$). The catch data were stratified and separate abundance estimates were calculated for lake trout 161 to 180 mm and for fish 181 mm and larger (Figure 8).

The estimated abundance for lake trout 161 to 180 mm was 129 (SE = 27). Within this strata, 82 fish were marked during June and 10 fish captured in July of which six were recaptured from the June sample period (Table 3). For lake trout 181 mm and larger the estimated abundance was 83 (SE = 21) fish. In this size group, 30 lake trout were marked and 18 were examined of which six were recaptured from the marked population (Table 3). The estimated abundance of lake trout from these strata combined was 213 fish (SE = 34).

Population abundance for age-2 lake trout was also calculated without stratification to investigate if the size bias detected in the samples was significant. The resulting estimated abundance without stratification was 251 (SE = 47, Table 3). Although these two estimates of total abundance are statistically different, the stratified estimate was selected because it is likely to be more accurate and is more precise (Figure 8).

Length at Age:

Mean length at age was calculated for each of populations of stocked lake trout sampled. Mean length at age-2 varied from 179 mm for lake trout in Nickel Lake to 246 mm in North Twin Lake (Table 4, Figure 9). Estimates of mean length at age-2 were 200 mm or less for all lakes other than North Twin. The estimated mean length of fish at age-4 varied from 242 in Nickel Lake to 304 mm in Ghost Lake. Mean length of age-5 lake trout varied from 267 mm in Nickel Lake to 350 mm in Ghost Lake (Table 4, Figure 9).

Length and Age Compositions:

The proportions of lake trout that were sampled in 10 mm length categories and in age groups were calculated from all sampled populations and are provided for reference in Appendix A. Population length and age compositions were estimated from the population abundance estimates and are given in Table 5 and Figure 10. Significant size selectivity was detected in the samples only from Coalmine #5 Lake, Nickel Lake, and Rapids Lake. However, in Coalmine #5 and Nickel lakes, different catch rates were observed for age-2 fish compared with the larger age-4 and age-5 fish. In Rapids Lake only one age group is present. Thus, no adjustment of the age composition was necessary due to size selectivity and age data from both sampling periods were pooled.

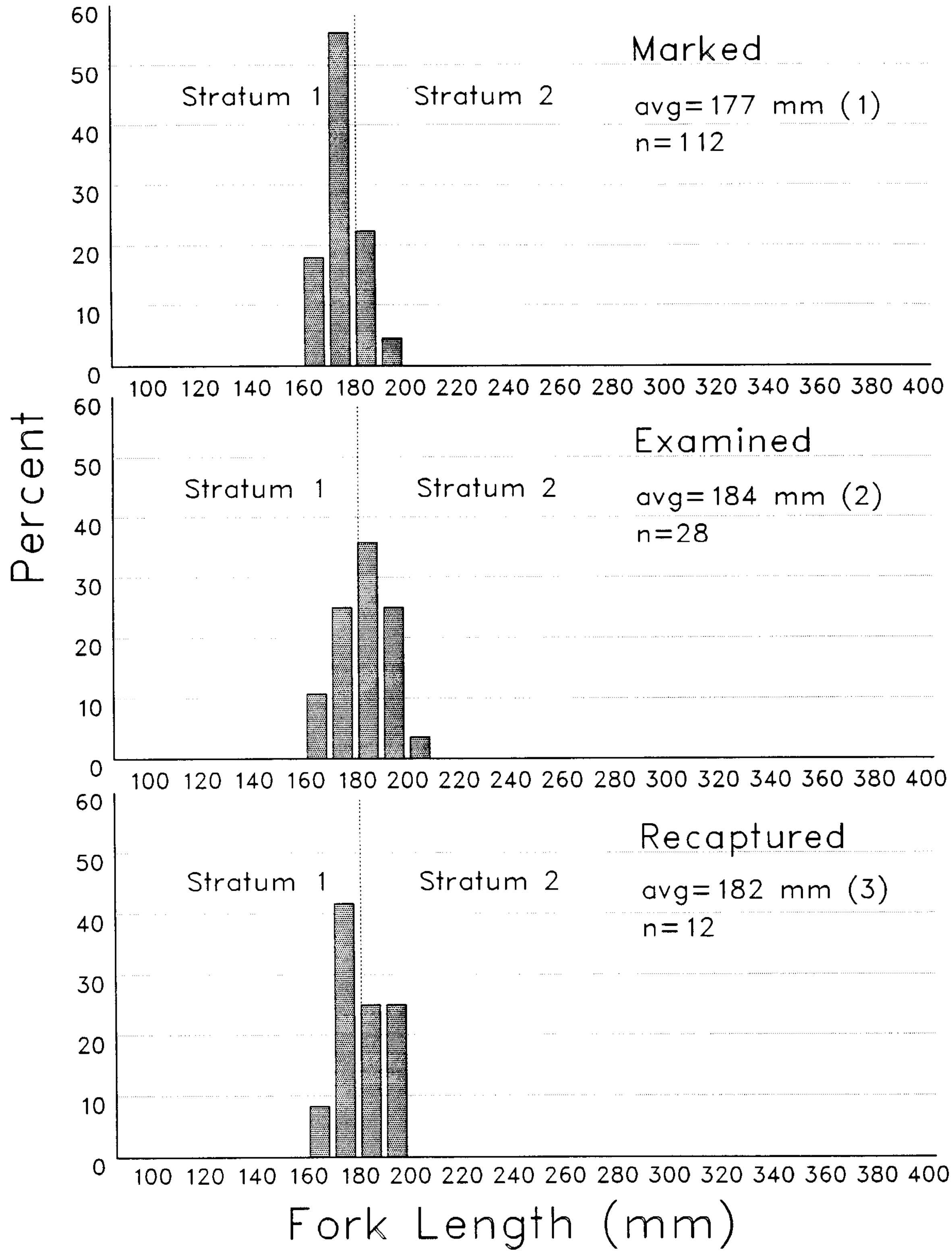

Figure 8. Length distribution of lake trout captured for estimating population abundance in Rapids Lake, 1993. The two strata are delineated by vertical dashed line.

Table 4. Estimated mean length (mm FL) at age (from scales or known age) of lake trout stocked in lakes in the Tanana drainage.

Lake	Age	1992[a] Mean Length	1992[a] Sample Size	1992[a] SE	1993 Mean Length	1993 Sample Size	1993 SE
Coalmine #5	1	124	18	2	nd[a]		
	2	nd			170	30	2
	3	259	101	2	nd		
	4	301	124	2	288	107	2
	5				331	58	4
	All	276	325	3	283	195	4
Paul's Pond	1	127	4	4	nd		
	2	nd			201	3	14
	3	237	123	2	nd		
	4	291	120	3	272	74	6
	5				329	38	5
	All	262	262	3	287	131	4
North Twin	1	177	210	1			
	2				246	81	3
Chet	1	nd			nd		
	2	nd			197	4	15
	3	204	154	1	nd		
	4	228	82	2	245	77	2
	5	nd			275	58	3
	All	216	357	1	256	139	2
Nickel	1	116	10	3	nd		
	2	nd	163	1	179	22	5
	3	208	82	2	nd		
	4	219			242	111	2
	5				267	38	3
	All	207	305	2	240	171	2
Ghost	3	255	16	5	nd		
	4	292	9	8	304	9	5
	5				350	12	7
	All	266	31	6	330	21	7
Rapids	1	138	32	2	nd		
	2				178	136	1

[a] From Burr 1993.
[b] nd = No data, lake trout stocked in 1988, 1989, and 1991 only.

Figure 9. Growth as estimated by mean length at age for lake trout stocked in Tanana River drainage lakes as young of the year in 1988, 1989, and 1991. Lake reference numbers left of symbols indicate estimates from 1992, numbers right of symbols are for estimates for 1993. Growth of wild lake trout stocks in Sevenmile, Paxson (parent stock) and Glacier lakes (Burr 1992) is shown with lines.

Table 5. Population age composition of lake trout larger than the minimum length indicated for seven stocked populations.

Waterbody	Minimum Length Included	Age Group	Group Specific Abundance	SE	Proportion	SE
Coalmine #5 Lake	151	2	34	7[a]	0.16	0.025
		4	115	9[b]	0.55	0.034
		5	62	7[b]	0.29	0.031
Paul's Pond	176	2	4	2[b]	0.03	0.013
		4	99	9[b]	0.64	0.039
		5	51	8[b]	0.33	0.038
North Twin Lake	175	2	217	54[a]	1.00	
Chet Lake	211	2	3	2[b]	0.02	0.010
		4	101	11[b]	0.56	0.037
		5	76	9[b]	0.42	0.037
Nickel Lake	151	2	75	36[a]	0.28	0.037
		4	142	11[b]	0.53	0.037
		5	49	7[b]	0.18	0.024
Rapids Lake	160	2	213	34[a]	1.00	

[a] SE from formula 2 (Seber 1982)
[b] SE from formula 6 (Goodman 1960)

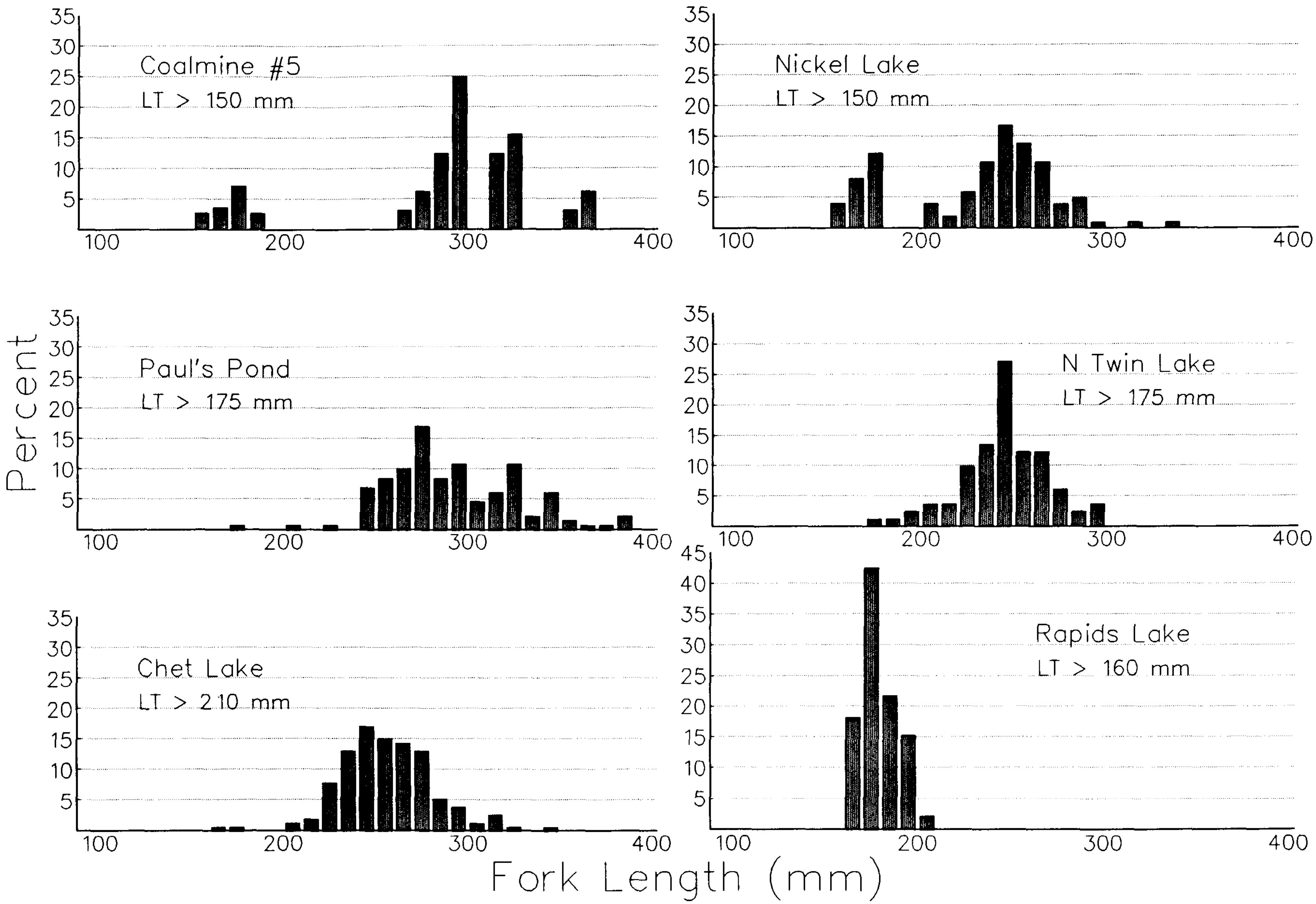

Figure 10. Population length composition of stocked lake trout for six lakes in the Tanana River drainage, 1993. Minimum size of fish included in estimates is as noted.

The proportion of fish in length categories were adjusted for length bias in these three populations and only lengths from the second sampling period were used. For the other three populations, the samples from both sampling periods were pooled to estimate length composition. The minimum length for which population abundance was estimated for each population varied. The proportion of fish in length and age categories that were smaller than the lower limit of length for which abundance was estimated is unknown.

Survival of 1988, 1989, and 1991 Stocking Cohorts:

Survival was estimated for lake trout for each of the three cohorts present in the lakes from the abundance estimates. Estimates of abundance for age-2 fish from the six lakes in which they were present were much less precise than were estimates for the larger and older age groups (Table 6). In Chet Lake, approximately one half of the size range of age-2 fish sampled were included in the abundance estimate. The age-2 fish were not well represented in the samples, presumably due to poor catchability of these smaller fish. If lower catchability of the smaller age-2 fish is the cause for few in the sample from each lake, the relatively imprecise estimates of survival derived from the abundance estimates must be considered minimum estimates. The estimated abundance of age-2 lake trout in Paul's Pond, Chet Lake, and Nickel Lake could not be reliably calculated due to low catches; age-2 survival was not calculated for these populations. Estimated survival from stocking to age-2 in the other three lakes ranged from 0.01 to 0.22 (Table 6). Mean survival to age-2 for these four populations was estimated to be 0.09 (SE = 0.02).

Survival to age-4 was estimated for four populations. Estimates for these populations were: 0.04 (SE = 0.003) in Coalmine #5 Lake; 0.01 (SE = 0.009) in Paul's Pond; 0.13 (SE = 0.012) in Chet Lake; and 0.28 (SE = 0.02) in Nickel Lake (Table 6). Mean survival to age-4 for the four populations was 0.11 (SE = 0.01).

Survival to age-5 was estimated for four populations. Estimates for these populations were: 0.02 (0.003) in Coalmine #5 Lake; 0.05 (SE = 0.008) in Paul's Pond; 0.05 (SE = 0.006) in Chet Lake; 0.05 (SE = 0.007) in Nickel Lake; (Table 6). Mean survival to age-5 for the four populations was 0.041 (SE < 0.01).

Annual survival from age-1 to age-2 was calculated to be 0.30 (SE = 0.10) in North Twin Lake and 5.9 (SE = 1.8) in Rapids Lake (Table 7). The estimate from Rapids Lake is clearly inaccurate and reflects the poor estimate of abundance obtained for the population in 1992. Survival from age-3 to age-4 for four lakes ranged from 0.29 to 0.67 and averaged 0.44 (SE = 0.06). Survival from age-4 to age-5 for four of the lakes ranged from 0.25 to 0.52 and averaged 0.34 (SE = 0.06).

Table 6. Survival of age-0 lake trout stocked in lakes in the Tanana drainage in 1988, 1989, and 1991.

Waterbody	Survival to Age-2		Survival to Age-4		Survival to Age-5	
	Estimate	SE	Estimate	SE	Estimate	SE
Coalmine #5	0.01	0.003	0.04	0.003	0.02	0.003
Paul's Pond	nd		0.01	0.009	0.05	0.008
N Twin	0.22	0.054	nd		nd	
Chet	nd		0.13	0.012	0.05	0.006
Nickel	nd		0.28	0.022	0.05	0.007
Ghost	nd		nd		nd	
Rapids	0.07	0.012	nd		nd	
All	0.10	0.019	0.11	0.005	0.04	0.003

nd = no data

Table 7. Annual survival of lake trout stocked in lakes in the Tanana drainage in 1988, 1989, and 1991.

Waterbody	Survival Age-1 to Age-2		Survival Age-3 to Age-4		Survival Age-4 to Age-5	
	Estimate	SE	Estimate	SE	Estimate	SE
Coalmine #5	nd		0.29	0.19	0.25	0.23
Paul's Pond	nd		0.67	0.10	0.30	0.06
N Twin	0.30	0.10	nd		nd	
Chet	nd		0.37	0.04	0.52	0.08
Nickel	nd		0.45	0.06	0.30	0.06
Ghost	nd		nd		1.00	0.71
Rapids	5.92	1.80	nd		nd	
All	0.30[a]	0.80	0.44	0.06	0.34[b]	0.06

[a] Estimate from Rapids Lake excluded.
[b] Estimate from Ghost Lake excluded.

Discussion

In lakes where multiple age groups were present, catch rates for lake trout stocked in 1991 continued to be low. Burr (1993) reported very low catch rates for this stocking cohort in 1992 and suggested that the poor catchability was the result of size selective gear which was unable to capture the small age-1 fish. These lakes were sampled in 1993 under the premise that the 1991 cohort would have grown enough to be more fully recruited to the capture gear. But in Paul's Pond, Chet Lake, and Nickel Lake no or very few fish in this age group were recaptured from the marked populations (Figures 3, 4, and 6). In Coalmine #5 and Rapids lakes the age-2 fish were similar in length to the other three populations (150 - 200 mm) but were more prevalent in the samples (Figures 1 and 8). Thus, lake trout 150 to 200 mm are at times available to the capture gear used, and the low number of these fish in samples from the various lakes may reflect the actual relative abundance of the age group. It should be noted that the catch rates were much lower for all populations during the July sample period than in June.

All lake trout stocked into the various lakes sampled originated from fertilized eggs from Paxson Lake. The growth of lake trout in these stocked lakes was quite variable but no more so than the variation in growth observed in natural populations (Figure 9 and Burr 1991). Growth of age-1 and age-2 lake trout reported by Skaugstad and Clark (1991) were similar to the results reported here. They reported that mean length at age for age-1 lake trout varied from 130 to 162 mm, and from 178 to 248 mm for age-2 fish. In Alaska, few estimates of growth for wild lake trout in young age groups are available.

Growth of the stocked populations is compared with three wild populations (Paxson Lake, Sevenmile Lake and Glacier Lake) in Figure 9. Age-2 fish in North Twin Lake showed faster growth than that seen in wild Alaskan stocks. For age-4 and age-5 fish, growth was slower in the stocked lake trout populations than in Paxson and Sevenmile lakes. Lake trout in Paxson and Sevenmile lakes show faster growth than other wild Alaskan lake trout populations studied (Burr 1992a). Growth in these stocked populations was similar to or faster than growth in Glacier Lake. Glacier Lake's population is more typical of wild lake trout populations inhabiting lakes in the Tanana drainage.

The rapid growth observed in these small lakes may not be sustained in subsequent stockings. The limited resources available in these small lakes will be partitioned between the established resident population and newly introduced cohorts. Stocking density plays an important role in growth and survival. Rapids Lake was stocked at high density (1,230 fish/ha) compared with North Twin Lake (120 fish/ha, Table 1). Growth was much slower at Rapids Lake than at North Twin Lake (178 mm verses 246 mm at age-2) as was survival to age-2 (Table 6). Predation by lake trout stocked in 1988 and 1989 will likely have an increasingly large role in determining the growth and survival of future stockings of lake trout and other species in these lakes. If annual stockings of lake trout and other species continues, newly stocked fish may come to represent a major annual energy input into these lake trout populations.

The survival of the 1991 cohort to age-2 appears to be low in lakes where lake trout were previously stocked (< 0.10, Table 6) but, the impact of size selectivity is not fully known. Annual survival of the 1991 cohort from 1992 to 1993 was variable and reflects the imprecision in the estimates of abundance. The change in abundance at North Twin Lake from 769 (SE = 185) in 1992 to 217 (SE = 54) in 1993 was likely caused by sport harvest during the winter. Local anglers "discovered" this population and harvested substantial numbers (Fronty Parker pers. comm[1]). Few problems with size selectivity were encountered with the larger age-4 and age-5 fish which appear to be fully recruited to the sampling gear. However, low abundance and changing catch rates throughout the season precluded obtaining precise estimates from some of the populations, most notably from Ghost Lake.

Burr (1993) reported survival to age-4 for the 1988 cohort to be: 0.10 (SE = 0.09) for Coalmine #5, 0.17 (SE = 0.02) for Paul's Pond, 0.09 (SE = 0.01) for Chet Lake, and 0.16 (SE = 0.02) for Nickel Lake. The estimate for the 1989 cohort in Coalmine #5 was not significantly different from 1988 cohort (Table 6). Estimated survival to age-4 was less for the 1989 cohort in Paul's Pond but greater in Chet and Nickel lakes. It is interesting that where stocking densities did not change (Table 1), survival to age-4 was unchanged or less (Coalmine #5 and Paul's Pond). Where stocking density was reduced (Chet and Nickel lakes), survival to age-4 increased.

Estimates of mean annual survival for all populations for each of the three age groups were similar (0.3 to 0.4, Table 7). Survival from age-1 to age-2 is unlikely to be representative of other populations. Rapids Lake was excluded because population abundance in 1992 was not accurately estimated and the North Twin population was subjected to heavy fishing mortality during the winter of 1992-93. Survival rates of 40 to 30% for age-3 and age-4 fish seem realistic for exploited populations in small lakes. Such high mortality rates would be totally unacceptable in self sustaining populations but are desirable in put-grow-and-take fisheries.

SEVENMILE LAKE

Methods

Two estimates of abundance were made for lake trout in Sevenmile Lake; one for lake trout 250 mm and larger during 1991 and a second estimate for adult lake trout (>375 mm) in September 1993. In both experiments, abundance was estimated using a modification of the Petersen mark/recapture population estimator (Chapman 1951) described in equations 1 and 2.

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[1] Parker, Fronty. 1993. Personal Communication. ADF&G, P.O. Box 605, Delta Jct., AK 99737.

The 1991 abundance of lake trout (> 249 mm FL) in Sevenmile Lake was estimated with a Petersen mark-recapture experiment performed over two seasons (Seber 1982). Lake trout were captured and marked in Sevenmile Lake annually between 1987 and 1991. Few fish less than 250 mm FL were captured and marked in this lake, thus, the abundance estimate was for fish greater than 249 mm. For this experiment, fish released with tags and left pectoral finclips in 1991 comprised the marked population and the recapture sampling occurred in September 1993. Lake trout were captured using gill nets, hoop traps, and fyke nets between September 8 and 24, 1993. The estimated abundance is germane to the time of marking (1991).

It is probable that growth recruitment and mortality occurred between the 1991 and 1993 sampling events. The Petersen estimator allows for recruitment or mortality between sampling events but not both. To evaluate recruitment through growth between the marking period and the recapture period, a nonparametric method of testing and culling recruitment was used (Robson and Flick 1965). The length beyond which no significant growth recruitment is detectable (L_r) was determined and separate estimates of abundance for each portion of the population were made. The abundance of fish larger than L_r was calculated with the Petersen estimator. The abundance of fish below L_r was calculated with the model from Robson and Flick (1965):

$$\hat{N} = (m + 1)(\overline{u}_r) - 1; \text{ and,} \tag{13}$$

$$V[\hat{N}] = (m + 1)^2 V[\overline{u}_r]; \tag{14}$$

where:

$\hat{N}$ = estimated abundance of fish smaller than the upper extent of growth recruitment (L_r);

m = number of marked fish from the marking period that are smaller than the upper extent of growth recruitment (L_r); and,

$\overline{u}_r$ = frequency of unmarked fish averaged over the cells formed by the fish recaptured in the recapture period beyond the upper extent of growth recruitment (L_r).

The variance of $\overline{u}_r$ was calculated using standard normal procedures to find the variance of a mean over the u_i where i is from r to M.

Unbiased estimates are produced from the procedures of Robson and Flick (1965) when sampling during the first event is not size selective. Hypothesis tests to detect size-selectivity may not be effective when there is a long hiatus between sampling events. Hence, examination of length distributions of fish captured in 1991 (marking event) with fish captured in 1993 (recapture event) may not provide needed information on gear selectivity. It was assumed that size selectivity would not introduce significant bias to the estimated abundance of lake trout in Sevenmile Lake. This assumption is supported by previous sampling which occurred at Sevenmile Lake. During August 1990 and in August and September 1991 lake trout were sampled using the same mix of gear types that was used in 1993 (Burr 1992). No gear selectivity was detected for fish 370 mm and larger when comparing the samples from 1990 with samples from August and/or September of 1991. Also, gear size selectivity was not detected during a mark-recapture experiment conducted in 1987 for fish 250 mm and larger (Burr 1988).

The 1993 abundance of adult lake trout (>375 mm FL) in Sevenmile Lake was estimated with a Petersen mark-recapture experiment performed during September 1993. Lake trout were captured, marked with floy tags and an upper caudal fin punch, and held in net pens from September 7 to 11. Adult fish were live spawned and released on September 12. Sampling resumed September 14-24 to examine fish for marks. The experiment estimated abundance during the marking sampling period (September 1993).

The procedures described on pages 6 and 7 designed to ensure that the assumptions for the accurate use of the Petersen estimator were met were followed in estimating abundance in Sevenmile Lake in 1991 and 1993. Because tags were used in the experiments at Sevenmile Lake, and because of the larger lake size, the following additional steps were taken. Tag loss between annual sampling events can be significant (Burr 1992). To measure tag loss, all tagged fish were given a left pectoral finclip in 1991 and an upper caudal finclip in 1993 for future evaluation. For the 1993 abundance estimate, the time between marking and recapture was only a few days hence there was concern whether complete mixing of marked and unmarked fish occurred. To promote mixing, fish were released throughout this 32 ha lake. In addition, the location of capture and recapture was noted and contingency analysis was used to evaluate mixing.

To facilitate comparison of densities of adult lake trout in 1991 and 1993, the 1991 abundance estimate was reduced by the proportion of fish in the 1991 sample which were less than 375 mm FL. The proportion of adult fish was estimated with equation (3) and the variance of the proportion with equation (4). Abundance of adult fish (and the corresponding variance) was calculated as follows (Goodman 1960):

$$\hat{N}_m = \hat{p}\hat{N}; \text{ and,} \qquad (15)$$

$$V[\hat{N}_m] = \hat{P}^2V[\hat{N}] + V[\hat{p}]\hat{N}^2 - V[\hat{p}]V[\hat{N}]; \qquad (16)$$

where:

$\hat{N}$ = estimate of abundance of lake trout

$\hat{N}_m$ = estimate of lake trout of adult size; and,

$\hat{p}$ = estimate of the proportion of adult fish.

Results

Sevenmile Lake Abundance Estimate 1991:

The estimated abundance of lake trout larger than 250 mm FL in Sevenmile Lake at the end of sampling in 1991 was estimated to be 1,426 (SE = 68; Table 8). Estimated density was 43.2 fish per ha (17.5 LT/ac). Abundance of mature lake trout (>375 mm) in Sevenmile lake in 1991 was estimated to be 931 (SE = 57) and density of mature lake trout was estimated to be 28.2 fish per ha (11.4 LT/ac; Table 8).

During sampling in 1991, 357 lake trout 250 mm and larger were captured of which 312 were marked and released (Figure 11). During sampling in September 1993, 535 lake trout were captured of which 109 were recaptured from the 1991 population of marked fish.

Comparison of lengths of fish 250 mm and larger captured in 1991 and in 1993 indicated that the distribution of lengths was not the same (KS two sample test; $D = 0.22$, $P < 0.01$). No lake trout measuring less than 396 mm in September 1993 were recaptured from 1991. Not surprisingly, lengths of fish 250 mm and larger marked in 1991 and recapture in 1993 were different (KS two sample test; $D = 0.39$, $P < 0.01$). However when lengths of fish 400 mm and larger were compared no differences were detected (captured 1991 verses captured 1993, $D = 0.11$, $P = 0.12$; marked 1991 verses recaptured 1993, $D = 0.12$, $P = 0.10$). These results show that probability of capture for small and large fish was not the same during each sampling period (year).

Recruitment through growth is very likely because lake trout were marked in 1991 and recaptured in 1993. Growth recruitment was indicated by comparison of lengths of fish recaptured from 1991 with fish captured without tags in 1993 (KS two sample test; $D = 0.31$, $P = 0.03$) and by examination of plots of these data (Figure 12). The technique of Robson and Flick (1965) indicated that the upper extant of growth recruitment was 400 mm. Burr (1991) reported that the upper extant of growth recruitment after one year for this population was 399 mm. This was calculated from annual growth of tagged fish across multiple years. The upper extant of growth recruitment for the two year hiatus is thus estimated to be 400 mm FL.

Since no size selectivity of the sampling gear was detected for fish larger than 400 mm, the data were divided into two strata, fish 250 mm to 399 mm and fish 400 mm and larger. With the assumption that growth recruitment for lake trout 400 mm and larger is negligible, an unbiased estimate of abundance for fish larger than 399 mm was obtained with the modified Petersen estimator (Table 8). The estimate of abundance of lake trout 250 to 399 was made with the procedure of Robson and Flick (1965) after growth recruitment was removed.

Table 8. Estimated abundance of lake trout larger than 250 mm FL and larger than 375 mm FL in Sevenmile Lake in 1991.

Strata	Number of lake trout			$\bar{u}_r$[a]	Abundance Estimate	SE	Lake Trout per Hectare
	Marked	Recaptured	Examined				
250 - 400 mm	121	2	146	5.0	733	57	22.2
> 401 mm	81	107	389		692	37	21.0
Total	312	109	535		1,426	68	43.2
> 375 mm					931	57	28.2

[a] Average number of unmarked to marked lake trout 400 mm FL and larger in 1989.

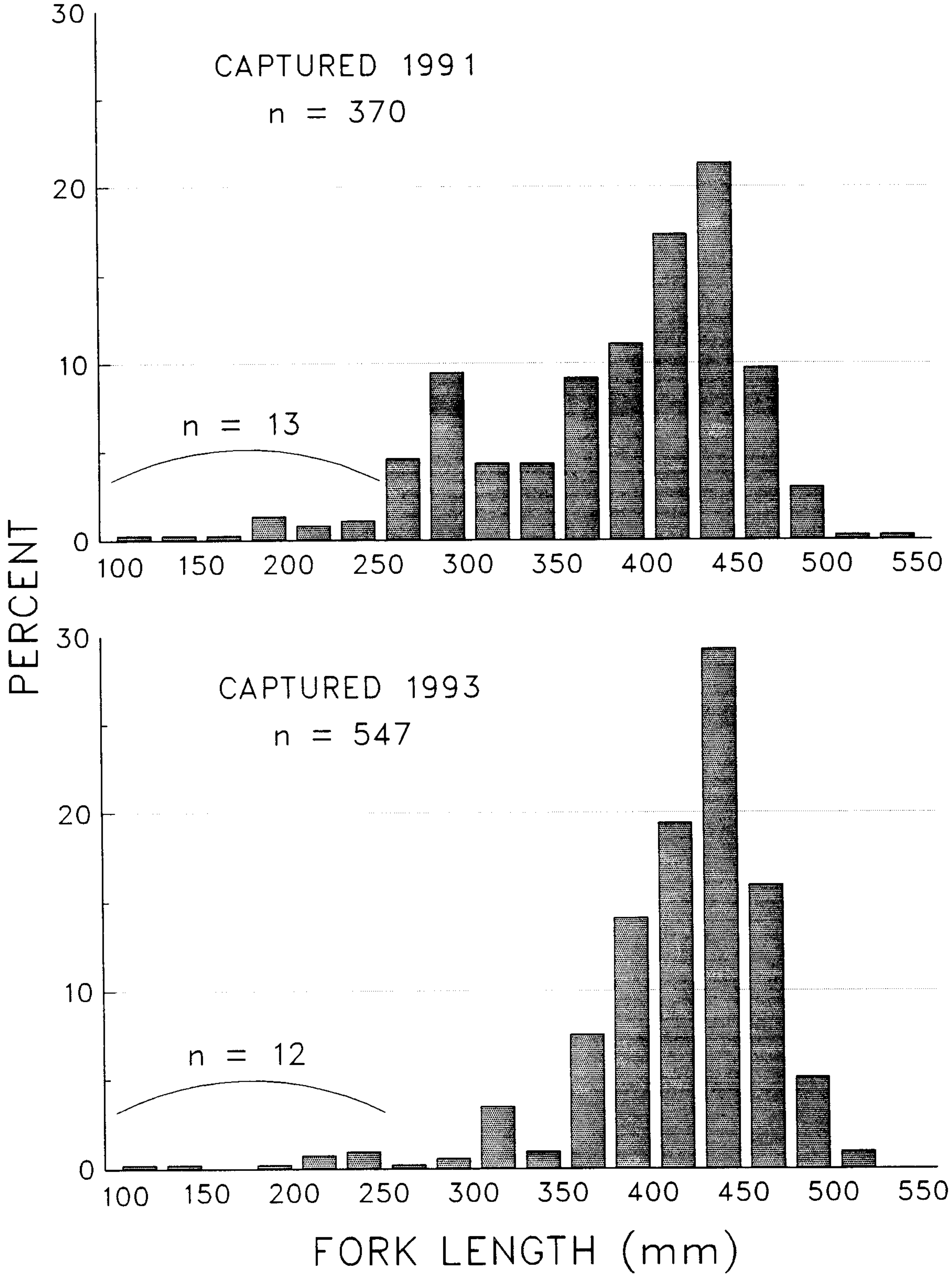

Figure 11. Distribution of lengths of lake trout captured during 1991 and during 1993 in Sevenmile Lake.

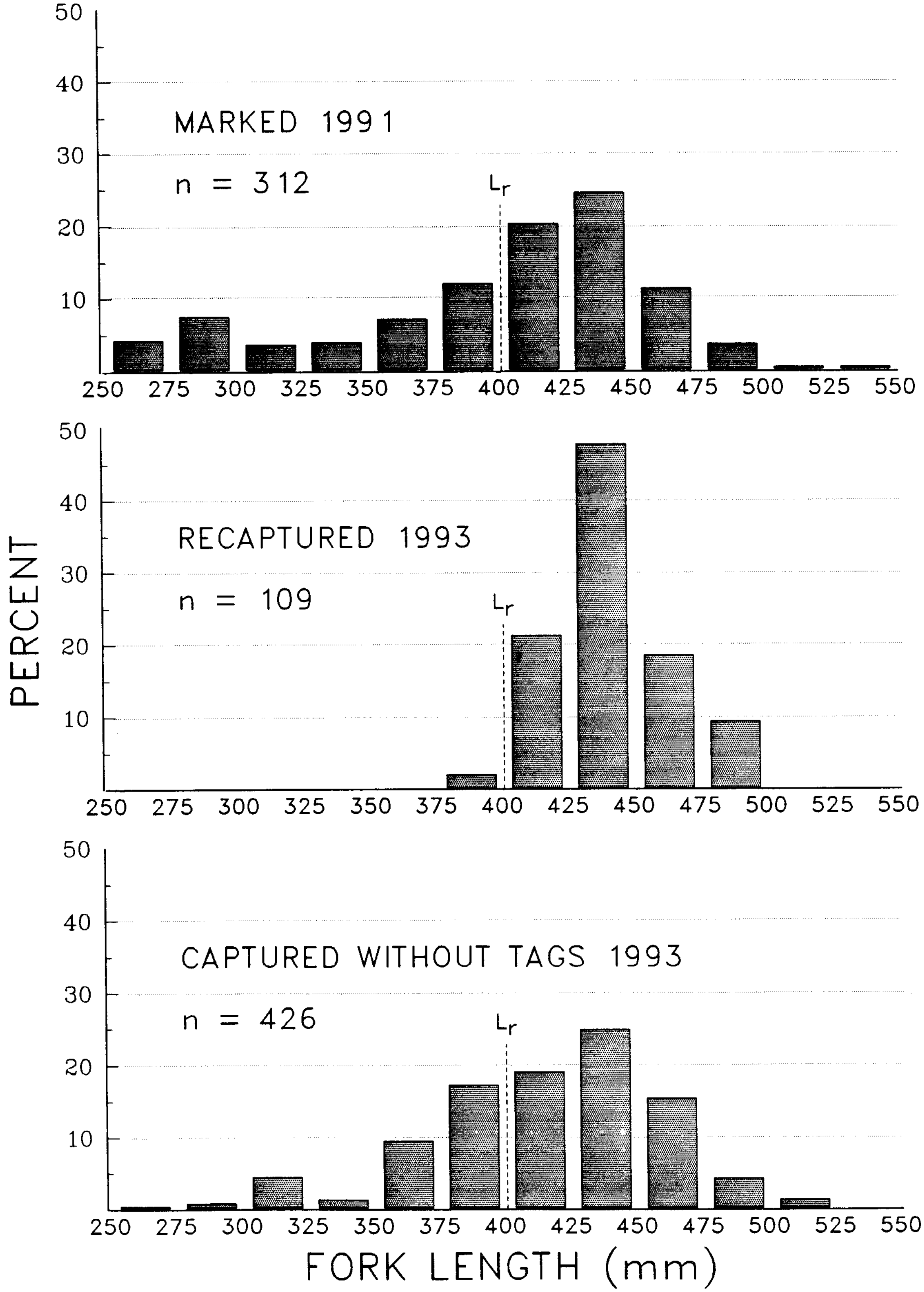

Figure 12. Distribution of lengths of lake trout marked with tags in 1991, recaptured in 1993, and captured without tags in 1993. Lr indicates upper extant of growth recruitment.

Sevenmile Lake Abundance Estimate 1993:

The estimated abundance of lake trout larger than 375 mm FL in Sevenmile Lake in September 1993 was estimated to be 1,139 (SE = 152). Estimated density was 34.5 fish per ha (14.0 LT/ac; Table 9).

During sampling between September 8 and 11 1993, 358 lake trout 375 mm and larger were captured, marked and released (Figure 13). From September 14 to 24, 107 lake trout were captured of which 33 were recaptured from the fish marked earlier in September 1993.

Comparison of lengths of fish 375 mm and larger captured in the first sampling period with lengths of fish captured during the second, failed to detect a difference (KS two sample test; D = 0.12, P = 0.20; Figure 13). Comparison of lengths of fish marked in the first period with fish recaptured from the marked fish in the second period also failed to detect a difference (KS two sample test; D = 0.16, P = 0.45). Thus, no size selectivity in either sampling period was indicated.

To test the hypothesis that the probability of capture was the same for fish in the east and west halves of the lake, the proportion of fish captured in the second sampling period with and without marks from the first were compared (Appendix C1). A significant difference was not found ($X^2 = 3.70$, df = 1, $0.05 < P < 0.10$) indicating that marked fish mixed with unmarked fish between sampling periods.

Between September 8 and September 11, lake trout were concentrated on spawning beds primarily located in the north east end of the lake. When sampling resumed on September 14, very few lake trout were found on the spawning beds. It appears that the spawning season was completed by mid September and the fish had dispersed. Because the fish had apparently dispersed, the catch rates were much lower after September 14.

Discussion

The primary goal of the stock assessment at Sevenmile Lake was to estimate the abundance of mature lake trout in the population. The estimates pertaining to 1991 (931 [SE = 57] fish) and 1993 (1,139 [SE = 152] fish) were not significantly different (P = 0.10). These estimates compare well with most previous estimates (Table 10). Estimates from 1988 through 1990 were not significantly different from each other or the 1991 and 1993 abundance estimated in the present study (P > 0.05). The estimates from 1987 and the earlier estimate from 1991 (Burr 1992) were both approximately 500 fish and were significantly different from the other five estimates (P < 0.01). It appears that the abundance of adult lake trout has not changed in the last six years and that approximately 1,000 adults reside in the lake.

It is estimated that there are approximately 500 adult female lake trout in the Sevenmile Lake population. The ratio males to females in other lake trout

Table 9. Estimated abundance of lake trout larger than 375 mm FL in Sevenmile Lake in September, 1993.

Size	Number of lake trout			Abundance Estimate	SE	Lake Trout per Hectare
	Marked	Recaptured	Examined			
> 375 mm	358	33	107	1,139	152	34.5

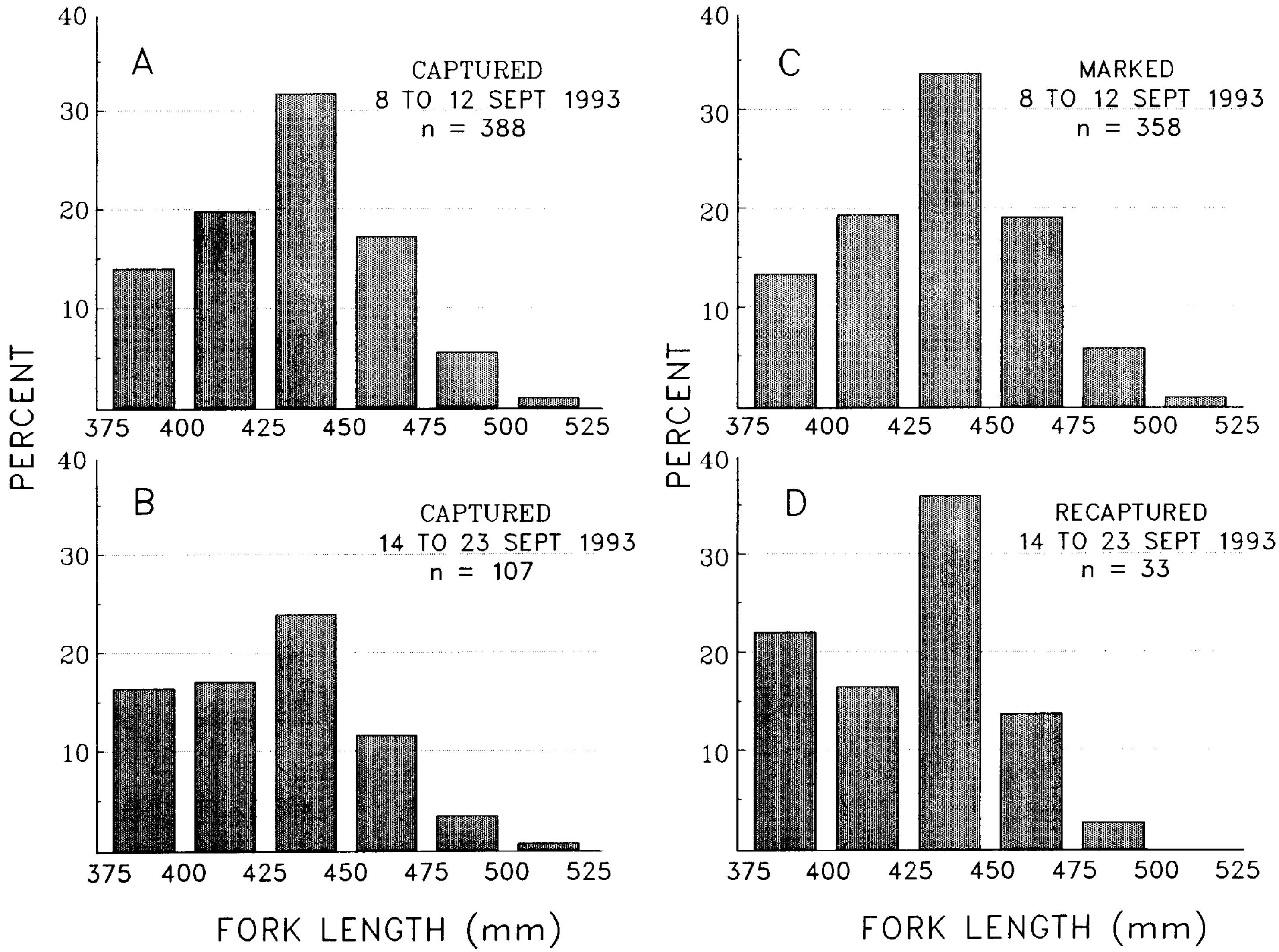

Figure 13. Distribution of lengths of lake trout captured in early September (Panel A), captured in late September (Panel B), marked in early September (Panel C), and recaptured in late September (Panel D) in Sevenmile Lake, 1993.

Table 10. Estimated abundance and density of lake trout of mature size in Sevenmile Lake, 1987 to 1991.

Year Estimated	Estimated Abundance (SE)	Density fish/ha	Source
1987	459 (85)	13.9	Burr 1988
1988	791 (158)	23.9	Burr 1989
1989	1,054 (138)	31.9	Burr 1990
1990	1,084 (175)	33.9	Burr 1992b
1991	505 (73)	15.9	Burr 1992b
	931 (57)	29.1	This Study
1993	1,139 (152)	35.6	This Study

populations that have been studied has not differed significantly from 1:1 (Martin and Olver 1980). In September of 1993, 90 females were live spawned which yielded a total of 107,500 eggs (1,194 eggs per female). Most of the female lake trout captured from the spawning areas were larger than 425 mm (Figure 14). Female lake trout in this population larger than 425 mm are mostly age-7 and older (Burr 1991).

If all adult female lake trout spawn annually in Sevenmile Lake, the 107,500 eggs taken in 1993 represent approximately 20% of the potential annual production. If some portion of the females do not spawn every year, the proportion of the annual production lost would be greater. Survival from egg to age-1 in the wild is estimated to be no more than 0.004 from Ontario (Evans et al. 1991). The 107,500 eggs would therefore represent a maximum recruitment of approximately 430 age-1 fish. The lost recruitment could thus be replaced by stocking 1,000 yearlings back into Sevenmile Lake. This figure assumes that the probability of survival of the hatchery fish is one half that of the wild fish.

However, it is not clear that stocking yearlings would be beneficial to the wild population. It is possible that the reduced number of eggs deposited on the spawning grounds in 1993 will result in better survival and growth of these wild yearlings such that the number of age-1 fish recruiting to the population would not be significantly different. Predation on juvenile lake trout by both adult lake trout and by burbot has been observed in this population. The introduction of a large number of inexperienced hatchery yearlings could result in increased predation on the wild juveniles.

To more fully assess the effect of live spawning 90 females in the population, information concerning the frequency at which females spawn is needed to determine the proportion of spawners present in a given year. To assess the potential impact of replacing the lost recruitment to age-1 with hatchery fish, the growth to age-1 for fish in the population prior to 1993 should be compared with growth of the 1993 age group. If it is found that the 1993 fish grew faster, growth compensation and presumably increased survival occurred. If there is not a change in growth rates for yearling fish, no compensatory growth and or survival is indicated and modest supplemental stocking may be recommended.

At the present time, supplemental stocking of lake trout in Sevenmile Lake to replace the fertilized eggs lost to the hatchery is not recommended. Alternate year egg takes will reduce the impact on recruitment without creating the potential problems of supplemental stocking. The next scheduled egg take from Sevenmile Lake is to occur in September 1995.

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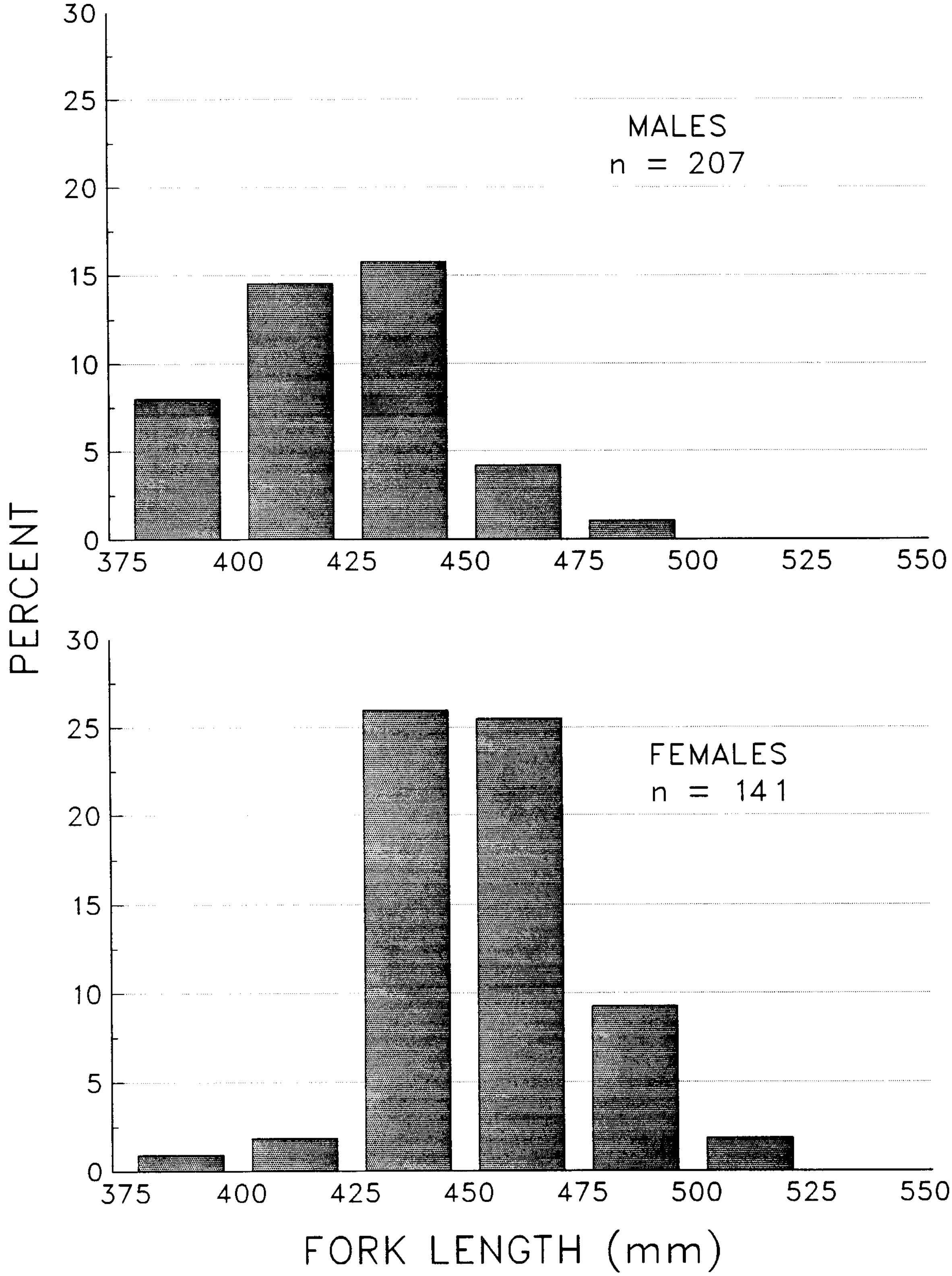

Figure 14. Length distribution of male and female lake trout captured from spawning areas in Sevenmile Lake, September, 1993.

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APPENDIX A

Appendix A1. Length distribution of all lake trout sampled from Coalmine #5 Lake during 1993.

Length Category	Age-2 #	Age-2 %	Age-2 SE	Age-4 #	Age-4 %	Age-4 SE	Age-5 #	Age-5 %	Age-5 SE	All Ages #	All Ages %	All Ages SE
100	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
110	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
120	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
130	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
140	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
150	2	6.7	0.04	0	0.0	0	0	0.0	0	2	0.9	0.00
160	4	13.3	0.06	0	0.0	0	0	0.0	0	4	1.8	0.00
170	10	33.3	0.08	0	0.0	0	0	0.0	0	10	4.5	0.01
180	10	33.3	0.08	0	0.0	0	0	0.0	0	10	4.5	0.01
190	3	10.0	0.05	0	0.0	0	0	0.0	0	3	1.4	0.00
200	1	3.3	0.03	0	0.0	0	0	0.0	0	1	0.5	0.00
210	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
220	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
230	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
240	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
250	0	0.0	0	2	1.9	0.01	0	0.0	0	2	0.9	0.00
260	0	0.0	0	5	4.7	0.02	0	0.0	0	5	2.3	0.00
270	0	0.0	0	9	8.4	0.02	0	0.0	0	10	4.5	0.01
280	0	0.0	0	19	17.8	0.03	0	0.0	0	21	9.5	0.01
290	0	0.0	0	27	25.2	0.04	0	0.0	0	31	14.0	0.02
300	0	0.0	0	23	21.5	0.03	8	13.8	0.04	39	17.6	0.02
310	0	0.0	0	11	10.3	0.02	4	6.9	0.03	15	6.8	0.01
320	0	0.0	0	8	7.5	0.02	10	17.2	0.05	22	9.9	0.02
330	0	0.0	0	3	2.8	0.01	14	24.1	0.05	22	9.9	0.02
340	0	0.0	0	0	0.0	0	3	5.2	0.02	3	1.4	0.00
350	0	0.0	0	0	0.0	0	5	8.6	0.03	5	2.3	0.00
360	0	0.0	0	0	0.0	0	4	6.9	0.03	5	2.3	0.00
370	0	0.0	0	0	0.0	0	4	6.9	0.03	6	2.7	0.01
380	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
390	0	0.0	0	0	0.0	0	5	8.6	0.03	5	2.3	0.00
400	0	0.0	0	0	0.0	0	1	1.7	0.01	1	0.5	0.00
410	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
420	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
430	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
440	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
450	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
460	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
470	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
480	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
490	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
500	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
Total	30			107			58			222		

Appendix A2. Length distribution of all lake trout sampled from Paul's Pond during 1993.

Length Category	Age-2			Age-4			Age-5			All Ages		
	#	%	SE	#	%	SE	#	%	SE	#	%	SE
100	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
110	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
120	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
130	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
140	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
150	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
160	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
170	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
180	1	33.3	0.33	0	0.0	0	0	0.0	0	1	0.8	0.00
190	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
200	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
210	1	33.3	0.33	0	0.0	0	0	0.0	0	1	0.8	0.00
220	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
230	1	33.3	0.33	0	0.0	0	0	0.0	0	1	0.8	0.00
240	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
250	0	0.0	0	7	9.7	0.03	0	0.0	0	9	7.0	0.02
260	0	0.0	0	7	9.7	0.03	0	0.0	0	11	8.5	0.02
270	0	0.0	0	10	13.9	0.04	2	5.3	0.03	13	10.1	0.02
280	0	0.0	0	17	23.6	0.05	1	2.6	0.02	22	17.1	0.03
290	0	0.0	0	11	15.3	0.04	0	0.0	0	11	8.5	0.02
300	0	0.0	0	8	11.1	0.03	4	10.5	0.05	14	10.9	0.02
310	0	0.0	0	4	5.6	0.02	1	2.6	0.02	6	4.7	0.01
320	0	0.0	0	4	5.6	0.02	3	7.9	0.04	8	6.2	0.02
330	0	0.0	0	3	4.2	0.02	10	26.3	0.07	14	10.9	0.02
340	0	0.0	0	0	0.0	0	3	7.9	0.04	3	2.3	0.01
350	0	0.0	0	1	1.4	0.01	7	18.4	0.06	8	6.2	0.02
360	0	0.0	0	0	0.0	0	2	5.3	0.03	2	1.6	0.01
370	0	0.0	0	0	0.0	0	1	2.6	0.02	1	0.8	0.00
380	0	0.0	0	0	0.0	0	1	2.6	0.02	1	0.8	0.00
390	0	0.0	0	0	0.0	0	3	7.9	0.04	3	2.3	0.01
400	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
Total	3			72			38			129		

Appendix A3. Length distribution of all lake trout sampled from North Twin Lake during 1993.

Length Category	Age-2 Number	Age-2 Percent	Age-2 SE
100	0	0.0	0
110	0	0.0	0
120	0	0.0	0
130	0	0.0	0
140	0	0.0	0
150	0	0.0	0
160	0	0.0	0
170	0	0.0	0
180	1	1.2	0.01
190	1	1.2	0.01
200	2	2.5	0.01
210	3	3.7	0.02
220	3	3.7	0.02
230	8	9.9	0.03
240	11	13.6	0.03
250	22	27.2	0.04
260	10	12.3	0.03
270	10	12.3	0.03
280	5	6.2	0.02
290	2	2.5	0.01
300	3	3.7	0.02
310	0	0.0	0
320	0	0.0	0
330	0	0.0	0
340	0	0.0	0
350	0	0.0	0
360	0	0.0	0
370	0	0.0	0
380	0	0.0	0
390	0	0.0	0
400	0	0.0	0
Total	81		

Appendix A4. Length distribution of all lake trout sampled from Chet Lake during 1993.

Length Category	Age-2			Age-4			Age-5			All Ages		
	#	%	SE	#	%	SE	#	%	SE	#	%	SE
100	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
110	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
120	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
130	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
140	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
150	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
160	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
170	1	25.0	0.25	0	0.0	0	0	0.0	0	1	0.7	0.00
180	1	25.0	0.25	0	0.0	0	0	0.0	0	1	0.7	0.00
190	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
200	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
210	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
220	0	0.0	0	5	6.5	0.02	0	0.0	0	5	3.6	0.01
230	2	50.0	0.28	9	11.7	0.03	1	1.7	0.01	12	8.6	0.02
240	0	0.0	0	16	20.8	0.04	2	3.4	0.02	18	12.9	0.02
250	0	0.0	0	19	24.7	0.04	4	6.9	0.03	23	16.5	0.03
260	0	0.0	0	13	16.9	0.04	8	13.8	0.04	21	15.1	0.03
270	0	0.0	0	9	11.7	0.03	12	20.7	0.05	21	15.1	0.03
280	0	0.0	0	4	5.2	0.02	12	20.7	0.05	16	11.5	0.02
290	0	0.0	0	1	1.3	0.01	7	12.1	0.04	8	5.8	0.01
300	0	0.0	0	1	1.3	0.01	4	6.9	0.03	5	3.6	0.01
310	0	0.0	0	0	0.0	0	2	3.4	0.02	2	1.4	0.01
320	0	0.0	0	0	0.0	0	4	6.9	0.03	4	2.9	0.01
330	0	0.0	0	0	0.0	0	1	1.7	0.01	1	0.7	0.00
340	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
350	0	0.0	0	0	0.0	0	1	1.7	0.01	1	0.7	0.00
360	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
370	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
380	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
390	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
400	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
Total	4			77			58			139		

Appendix A5. Length distribution of all lake trout sampled from Nickel Lake during 1993.

Length Category	Age-2			Age-4			Age-5			All Ages		
	#	%	SE	#	%	SE	#	%	SE	#	%	SE
100	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
110	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
120	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
130	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
140	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
150	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
160	3	13.6	0.075	0	0.0	0.000	0	0.0	0.000	3	1.8	0.010
170	6	27.3	0.097	0	0.0	0.000	0	0.0	0.000	6	3.5	0.014
180	8	36.4	0.105	0	0.0	0.000	0	0.0	0.000	8	4.7	0.016
190	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
200	2	9.1	0.063	0	0.0	0.000	0	0.0	0.000	2	1.2	0.008
210	0	0.0	0.000	1	0.9	0.009	0	0.0	0.000	1	0.6	0.006
220	1	4.5	0.045	8	7.2	0.025	0	0.0	0.000	9	5.3	0.017
230	2	9.1	0.063	14	12.6	0.032	0	0.0	0.000	16	9.4	0.022
240	0	0.0	0.000	30	27.0	0.042	2	5.3	0.037	32	18.7	0.030
250	0	0.0	0.000	26	23.4	0.040	6	15.8	0.060	32	18.7	0.030
260	0	0.0	0.000	19	17.1	0.036	6	15.8	0.060	25	14.6	0.027
270	0	0.0	0.000	8	7.2	0.025	12	31.6	0.076	20	11.7	0.025
280	0	0.0	0.000	4	3.6	0.018	4	10.5	0.050	8	4.7	0.016
290	0	0.0	0.000	1	0.9	0.009	4	10.5	0.050	5	2.9	0.013
300	0	0.0	0.000	0	0.0	0.000	2	5.3	0.037	2	1.2	0.008
310	0	0.0	0.000	0	0.0	0.000	1	2.6	0.026	1	0.6	0.006
320	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
330	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
340	0	0.0	0.000	0	0.0	0.000	1	2.6	0.026	1	0.6	0.006
350	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
360	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
370	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
380	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
390	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
400	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
Total	22			111			38			171		

Appendix A6. Length distribution of all lake trout sampled from Ghost Lake during 1993.

Length Category	Age-4			Age-5			All Ages		
	#	%	SE	#	%	SE	#	%	SE
100	0	0.0	0	0	0.0	0	0	0.0	0
110	0	0.0	0	0	0.0	0	0	0.0	0
120	0	0.0	0	0	0.0	0	0	0.0	0
130	0	0.0	0	0	0.0	0	0	0.0	0
140	0	0.0	0	0	0.0	0	0	0.0	0
150	0	0.0	0	0	0.0	0	0	0.0	0
160	0	0.0	0	0	0.0	0	0	0.0	0
170	0	0.0	0	0	0.0	0	0	0.0	0
180	0	0.0	0	0	0.0	0	0	0.0	0
190	0	0.0	0	0	0.0	0	0	0.0	0
200	0	0.0	0	0	0.0	0	0	0.0	0
210	0	0.0	0	0	0.0	0	0	0.0	0
220	0	0.0	0	0	0.0	0	0	0.0	0
230	0	0.0	0	0	0.0	0	0	0.0	0
240	0	0.0	0	0	0.0	0	0	0.0	0
250	0	0.0	0	0	0.0	0	0	0.0	0
260	0	0.0	0	0	0.0	0	0	0.0	0
270	0	0.0	0	0	0.0	0	0	0.0	0
280	1	11.1	0.11	0	0.0	0	1	4.8	0.04
290	1	11.1	0.11	0	0.0	0	1	4.8	0.04
300	1	11.1	0.11	1	8.3	0.08	2	9.5	0.06
310	2	22.2	0.14	0	0.0	0	2	9.5	0.06
320	4	44.4	0.17	0	0.0	0	4	19.0	0.08
330	0	0.0	0	1	8.3	0.08	1	4.8	0.04
340	0	0.0	0	3	25.0	0.13	3	14.3	0.07
350	0	0.0	0	1	8.3	0.08	1	4.8	0.04
360	0	0.0	0	1	8.3	0.08	1	4.8	0.04
370	0	0.0	0	3	25.0	0.13	3	14.3	0.07
380	0	0.0	0	1	8.3	0.08	1	4.8	0.04
390	0	0.0	0	1	8.3	0.08	1	4.8	0.04
400	0	0.0	0	0	0.0	0	0	0.0	0
Total	9			12			21		

Appendix A7. Length distribution of all lake trout sampled from Rapids Lake during 1993.

	Age-2		
Length Category	Number	Percent	SE
100	0	0.0	0
110	0	0.0	0
120	0	0.0	0
130	0	0.0	0
140	0	0.0	0
150	0	0.0	0
160	0	0.0	0
170	26	19.1	0.03
180	66	48.5	0.04
190	33	24.3	0.03
200	10	7.4	0.02
210	1	0.7	0.00
220	0	0.0	0
230	0	0.0	0
240	0	0.0	0
250	0	0.0	0
260	0	0.0	0
270	0	0.0	0
280	0	0.0	0
290	0	0.0	0
300	0	0.0	0
310	0	0.0	0
320	0	0.0	0
330	0	0.0	0
340	0	0.0	0
350	0	0.0	0
360	0	0.0	0
370	0	0.0	0
380	0	0.0	0
390	0	0.0	0
400	0	0.0	0
Total	136		

APPENDIX B

APPENDIX B

LAKE TROUT AGE VALIDATION STUDY

Stocked lake trout have provided fish of known age from which validation of age determination will be investigated. Lakes which contain lake trout of known age are listed in the following table. The age of these fish is known because either the water body was stocked only once or fin clips were used to differentiate between stocking cohorts. Lake trout stocked into these water bodies in the future will be marked with fin clips or other permanent marks to differentiate cohorts. Starting in 1992, lake trout were sampled and the age structures archived from the 1991 stocking cohort. It is estimated that approximately 100 samples will be required annually from this cohort. These data will be collected for five consecutive year after which analysis and evaluation of these data will be conducted.

Lake	Date Stocked	Fin Clip	Number Sampled	
			1992	1993
Bullwinkle	1989	None	1	0
Chet Lake	1991	Adipose	0	0
Coal Mine #5	1991	Adipose	10	0
Craig	1991	None	5	0
Fourmile	1991	None	0	0
Fourteenmile	1991	None	25	14
Nickel	1991	Adipose	10	1
North Twin	1991	None	18	6
Paul's Pond	1991	Adipose	4	0
Rapids	1991	None	7	16
Summit	1989	None	2	0

-continued-

PLANNED ANALYSIS

To determine if the ages obtained from otoliths, opercular bones, and scales are true ages, the proportion (and variance) of lake trout whose estimated age reflects the true age will be calculated for each structure as:

$$\hat{p} = \frac{a}{n} \qquad (B.1)$$

$$V[\hat{p}] = \frac{\hat{p}\,(1-\hat{p})}{n - 1} \qquad (B.2)$$

where:

a = the number of fish whose assigned ages agree with the true age; and,
n = total number of known age structures in the sample.

A one-tailed Z test (Zar 1984) will be performed to determine if the accuracy rate for any one structure is significantly less than 0.90.

H_o: $P = 0.90$
H_a: $P < 0.90$

The test will have the ability to detect a 10% difference with the probabilities of an experiment-wise type I error being 0.05 and the probability of a type II error being 0.20.

Contingency table analysis will be used to determine if all structures are equally accurate by testing the hypothesis:

H_o: accuracy is independent of structure
H_a: accuracy is dependent on structure.

To determine if the estimated ages for any of the structures is different, the mean ages determined for each structure will be compared using analysis of variance with structures as fixed effects. Multiple comparisons will be made using Fisher's Least Significant Difference test. The hypothesis that will be tested is:

H_o: $l_{scales} = l_{otoliths} = l_{opercular}$
H_a: at least one is not equal.

Logistic regression will be used to determine if the accuracy in determining the age of lake trout decreases as the true age increases:

H_o: $b = 0$
H_a: $b < 0$.

APPENDIX C

Appendix C1. Number of marked and unmarked lake trout captured by area in Sevenmile Lake, September 14 - 24, 1993.

Area	Number of lake trout captured		p
	With Marks	Without Marks	
West	23	59	0.28
East	13	14	0.48
	$X^2 = 3.70$[1]	df = 1	$0.05 < P < 0.10$

[1] The X^2 value is the test statistic for the hypothesis of equal probability of capturing marked fish in either half of Sevenmile Lake (Seber 1982).