Fishery Data Series No. 93-27

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[1] This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-8, Job Number R-3-3(a-1).

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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 1992 to estimate abundance, growth, and survival. Estimated abundance of stocked lake trout > 244 millimeters fork length in Coalmine #5 Lake was 650 fish (SE = 167); > 214 millimeters in Pauls Pond was 316 fish (SE = 30); > 159 millimeters in North Twin Lake was 711 fish (SE = 171); > 184 millimeters in Chet Lake was 427 fish (SE = 25); > 188 millimeters in Nickel Lake was 476 (SE = 53); > 228 millimeters in Ghost Lake was 27 (SE = 5); and > 135 millimeters in Rapids Lake was 50 (SE = 13). Growth was rapid in these small lakes and was equal to or exceeded rates estimated from wild populations. Survival to age-4 for the populations varied from 0.01 to 0.017 with a mean of 0.11 (SE = 0.02). Mean survival to age-3 was estimated at 0.26 (SE = 0.03, 0.03 - 0.62). Survival to age-1 varied from 0.01 to 0.71 with a mean of 0.36 (SE = 0.09).

Stocked lake trout were present in sufficient numbers at Fourmile, Triangle, and Fourteenmile lakes to warrant future stock assessment. Catch rates of stocked lake trout in Summit Lake were too low to encourage future stock studies; no lake trout were caught in West Twin Lake.

Total annual mortality was estimated for eight wild lake trout populations using maximum age analysis. Estimates varied from 0.17 in Twobit Lake to 0.55 in Paxson Lake. The results using this method compared well with results from the Jolly Seber method.

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

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). However, data on the stocked lake trout are very limited. To date, most other studies conducted on lake trout in Alaska have been on wild populations in larger lakes in the Alaska Mountain Range. Lake trout age-4 and less are very poorly represented in samples from these populations. As a result, very little is known about the population dynamics of juvenile lake trout in Alaska.

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-4 and less, scales could be used for age determination (Sharp and Bernard 1988) and age-based analyses could be used. Data collected from these stocked populations provided 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 lakes which were selected for sampling during 1992 were those in which Skaugstad and Clark (1991) found lake trout surviving from previous stockings (1988 or 1989) or were stocked in 1991. The specific project objectives during the 1992 field season were to:

1. estimate abundance of lake trout in Coalmine #5, Old Beaver, North Twin, Chet, Nickel, Rapids, Craig, 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 1991 stocking cohort of lake trout in lakes listed above except for Ghost Lake;

4. determine if lake trout stocked in Fourmile, Fourteenmile, Summit, West Twin, and Triangle lakes are present in sufficient numbers to be captured in sample gear at the rate high enough to facilitate future stock assessment; and,

5. evaluate maximum age analysis as a technique for estimating annual survival (mortality) rate of lake trout from lakes in the Arctic-Yukon-Kuskokwim (AYK) data base.

Old Beaver Lake was not sampled because of winterkill of fish in that lake. In addition to the sampling of stocked lake trout in small lakes, stocked lake trout were also sampled in Harding Lake.

This report is partitioned into three sections. The first section concerns the evaluation of lake trout stocked into small lakes as fingerlings in 1988, 1989 and 1991. The next section is a review of lake trout data from Harding Lake. The third section contains an evaluation of maximum age analysis for estimating annual mortality of lake trout.

Length distributions of lake trout sampled in small lakes during 1992 is 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

A total of 13 lakes which were stocked with age-0 lake trout originating from Paxson Lake were sampled during 1992. The sampling methodology used at the lakes was of one of two types. The first group of lakes were more intensely sampled because the objective was to estimate population abundance, mean length at age, length and age compositions and survival of lake trout. The second set of lakes were more lightly sampled. The objective was to determine whether or not lake trout survived in sufficient numbers to permit future stock assessment.

Abundance Estimates:

Mark recapture experiments were conducted to estimate the abundance of lake trout in eight 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; Rapids Lake at mile 228 of the Richardson Highway; and Craig Lake at mile 1383 of the Alaska Highway (Table 1, Figure 1). The lakes are all small in size ranging from 1.3 to 8.4 ha (3 to 2 ac).

The number 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 mid June and was followed by recapture sampling after a hiatus ranging from 12 to 17 days (Table 2). Fish were marked with a partial lower caudal fin clip. All lake trout captured were measured to the nearest mm 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.

Table 1. Lakes sampled during 1992 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 1989 1991	2,600 2,600 2,600	RT	5.4	8.5	807
Paul's Pond	1988 1989 1991	1,000 1,000 1,000	GR, RT, SSC	2.1	7.0	823
North Twin	1991	1,000	RT, SSC	8.4	6.1	518
Chet	1988 1989 1991	1,600 800 2,000	GR, LNS, RT	2.8	9.1	580
Nickel	1988 1989 1991	1,000 500 1,000	GR, RT	1.3	18.3	580
Ghost	1988 1989	1,000 500	AC, RT	3.7	15.5	580
Rapids	1991	2,839	RT	2.3	9.1	715
Craig	1991	3,500	CB, RT	6.4	24.4	460
Fourmile	1991	20,000	RT, SF	41.0	6.1	600
Fourteenmile	1991	17,960	RT	40.5	15.8	1,080
Summit	1989	2,000	BB, DV, GR HWF, RWF	162.0	9.4	710
West Twin	1989	25,600	BB, HWF, LCI, NP	680.0	33.5	228
Triangle	1988 1989	6,500 10,000	GR, BF	43.0	12.2	160

[a] Fish species present in addition to lake trout: AC - Arctic char *Salvelinus alpinus*, BB - burbot *Lota lota*, BF - Alaska blackfish *Dallia pectoralis*, CB - lake chub *Couesius plumbeus*, DV - Dolly Varden *Salvelinus malma*, GR - grayling *Thymallus arcticus*, HWF - humpback whitefish *Coregonus pidschian*, LCI - least cisco *Coregonus sardinella*, LNS - longnose sucker *Catostomus catostomus*, NP - northern pike *Esox lucius*, RT - rainbow trout *Oncorhynchus mykiss*, RWF - round whitefish *Prosopium cylindraceum*, SSC - slimy sculpin *Cottus cognatus* and SF - sheefish *Stenodus leucichthys*.

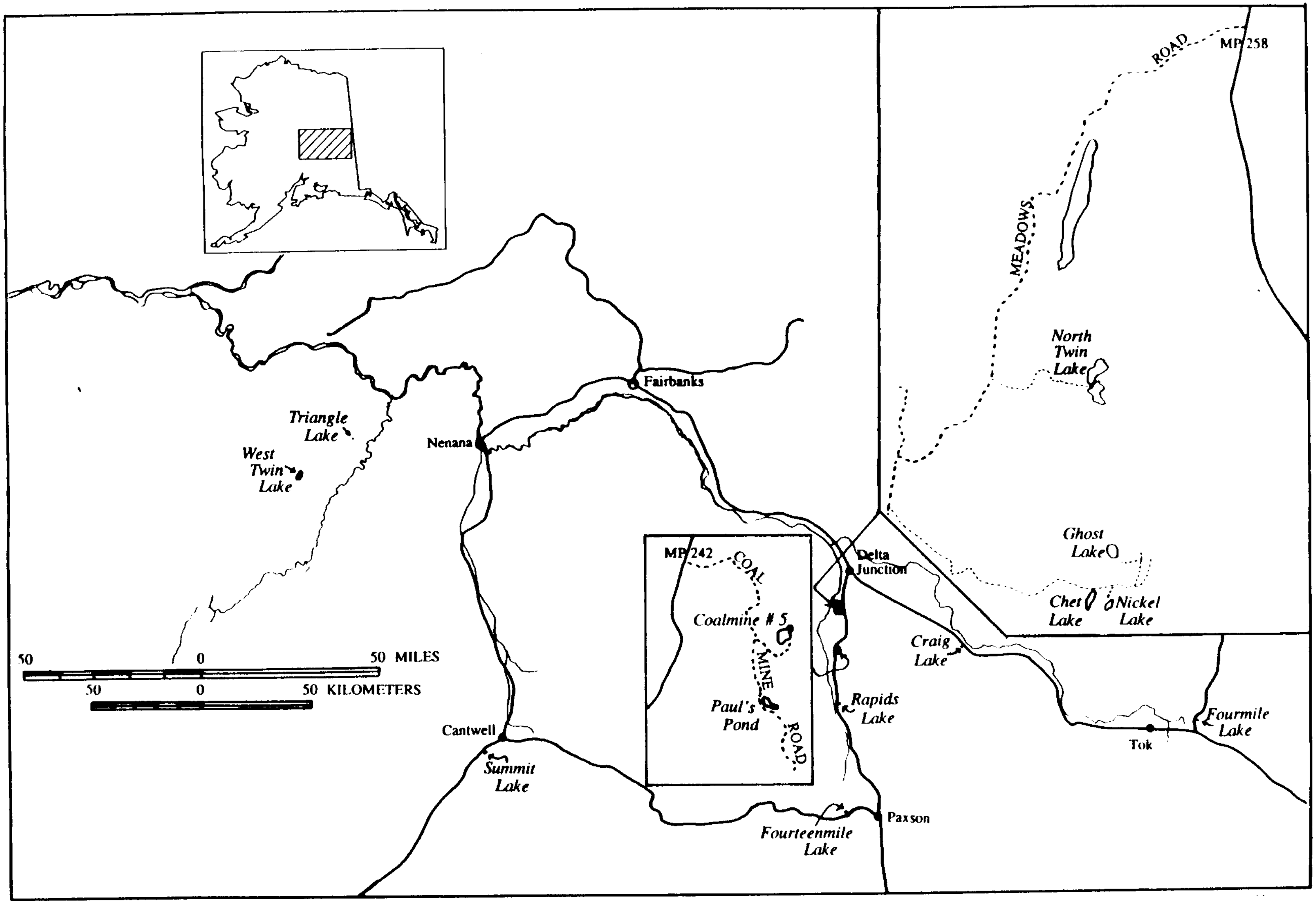

Figure 1. Location of lakes stocked with lake trout and sampled during 1992.

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 23 - 25	Fyke, Hoop Nets
	July 6 - 17	Fyke, Hoop Nets
Paul's Pond	June 23 - 25	Fyke, Hoop Nets
	July 6 - 10	Fyke, Hoop Nets
North Twin Lake	June 16 - 26	Fyke, Hoop Nets
	July 6 - 30	Fyke, Hoop Nets
Chet Lake	June 16 - 18	Fyke Nets
	July 6 - 10	Fyke Nets
Nickel Lake	June 16 - 19	Fyke Nets
	July 6 - 10	Fyke Nets
Ghost Lake	June 17 - 26	Fyke, Hoop Nets
	July 6 - 10	Fyke, Hoop Nets
Rapids Lake	July 6 - 10	Fyke, Hoop Nets
	July 23 - 28	Fyke, Hoop Nets
Craig Lake	July 6 - 9	Fyke, Hoop Nets
	July 13 - 23	Fyke, Hoop Nets

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

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

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

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 fin clips. 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.

The assumption of complete mixing of marked and unmarked fish was not tested; the same fin clip 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 length frequency of tagged fish recaptured versus the length frequency of those not recaptured. The second test compared the length frequency of fish captured during the marking event with the 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. 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. The proportions of each size or age category were estimated with the following formulas (Cochran 1977):

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

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

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.

As outlined by Bernard and Hansen 1992 when the second hypothesis was rejected, (the distribution of lengths during the two sampling events was not the same) samples from only the first or second sampling event were used for estimating the proportion in each size class.

Size and age composition were estimated directly with Eq. 3 when no size bias from sampling gear was detected. If size selectivity was found (hypothesis one was rejected), the estimate of size composition was adjusted for size selectivity of the sampling gear.

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

$$\hat{N}_g = \textstyle\sum_k p_{kg} N_k \tag{5}$$

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

$$\hat{V}[\hat{N}_g] = \sum_k \left[V[p_{kg}]\, N_k^2 + V[N_k]\, p_{kg}^2 - V[p_{kg}]\, V[N_k] \right] \quad (6)$$

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

$$\hat{p}_g = \sum_k \frac{\hat{p}_{kg}\, \hat{N}_k}{\hat{N}} ; \quad (7)$$

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

where:

n_{kg} = the number of lake trout in the sample of group g in 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 1992 from those stocked in each year. Variance of the estimates of survival (V [S]) was estimated by:

$$\hat{S}_{i,92} = \frac{\hat{N}_{i,92}}{N_i} ; \quad \text{and,} \quad (9)$$

$$\hat{V}[\hat{S}_{i,92}] = \hat{V}[\hat{N}_{i,92}] \cdot \left(\frac{1}{N_i} \right)^2 \qquad (10)$$

where:

$\hat{S}_{i,92}$ = the estimated survival rate of lake trout from stocking in year i to 1992;

$\hat{N}_{i,92}$ = the estimated abundance of lake trout in 1992 that were stocked in year i; and,

N_i = the number of lake trout stocked in year i.

Presence of Stocked Lake Trout:

Sampling was conducted at five lakes to determine if stocked lake trout were present in sufficient numbers to facilitate future stock assessment. The lakes sampled were: Fourmile Lake on the Taylor Highway; Fourteenmile Lake on the Denali Highway; Summit Lake near Cantwell; and, West Twin Lake and Triangle Lake located in the Kantishna drainage (Table 1). These lakes were sampled with monofilament experimental gill nets measuring 38 m x 1.8 m with one panel each of mesh measuring 13 mm, 19 mm, 25 mm, 32 mm, and 38 mm and with fyke nets and baited hoop nets (Table 3). Where catch rates were less than 0.1 lake trout per gill net hour, or 0.5 fish per net night for hoop and fyke nets, lake trout density was considered to be too low to permit future stock assessment.

Results

Abundance Estimates:

Coalmine #5 Lake. The estimated abundance of lake trout 245 mm and larger in Coalmine #5 Lake in June of 1992 was 650 (SE = 167) fish.

Between June 23 and June 25, 167 lake trout 112 to 385 mm FL were marked with lower caudal fin clips. Between July 6 and July 17, the population was again sampled and 160 lake trout 116 to 367 mm were captured of which 64 (246 - 367 mm) were marked from the first sampling period. Because no lake trout less than 245 mm were recaptured (Figure 2), the estimated abundance was calculated for fish 245 mm and larger only.

Comparison of lengths of fish (245 mm and larger) marked in the first event to those recaptured in the second event showed differences in the size of fish sampled (KS two sample test; $D = 0.21$, $P < 0.01$). Similarly, lengths of all fish 245 mm and larger captured during the two sampling periods were different (KS two sample test; $D = 0.43$, $P < 0.01$). Hence, size selectivity in the sampling gear was indicated in at least the second sampling period. Because of the size bias, the catch data were stratified and separate abundance estimates were calculated for lake trout 245 to 279 mm and for fish 280 mm and larger.

Table 3. Sampling times, fishing gear, fishing effort and catch from sampling conducted at five lakes to determine the presence or absence of stocked lake trout.

Waterbody	Sample Period	Fishing Gear	Fishing Effort[a]	Catch	Catch Rate
Fourmile Lake	July 7 to July 8	gill nets	13 hr	2	0.15/hr
		hoop nets	3 nn	2	0.7 /night
Fourteenmile Lake	July 26 to July 30	hoop nets	28 nn	14	0.5 /night
		fyke nets	4 nn	93	23.0 /night
Summit Lake	July 14 to July 17	gill nets	52 hr	2	0.04/hr
		hoop nets	16 nn	0	0.0 /night
		fyke nets	6 nn	0	0.0 /night
West Twin Lake	August 17 to August 20	gill nets	128 hr	0	0.0 /hr
		hoop nets	42 nn	0	0.0 /night
Triangle Lake	August 18	gill nets	24 hr	22	0.92/hr

[a] Fishing effort given in units of net hours for gill nets and net nights (nn) for hoop nets and fyke nets.

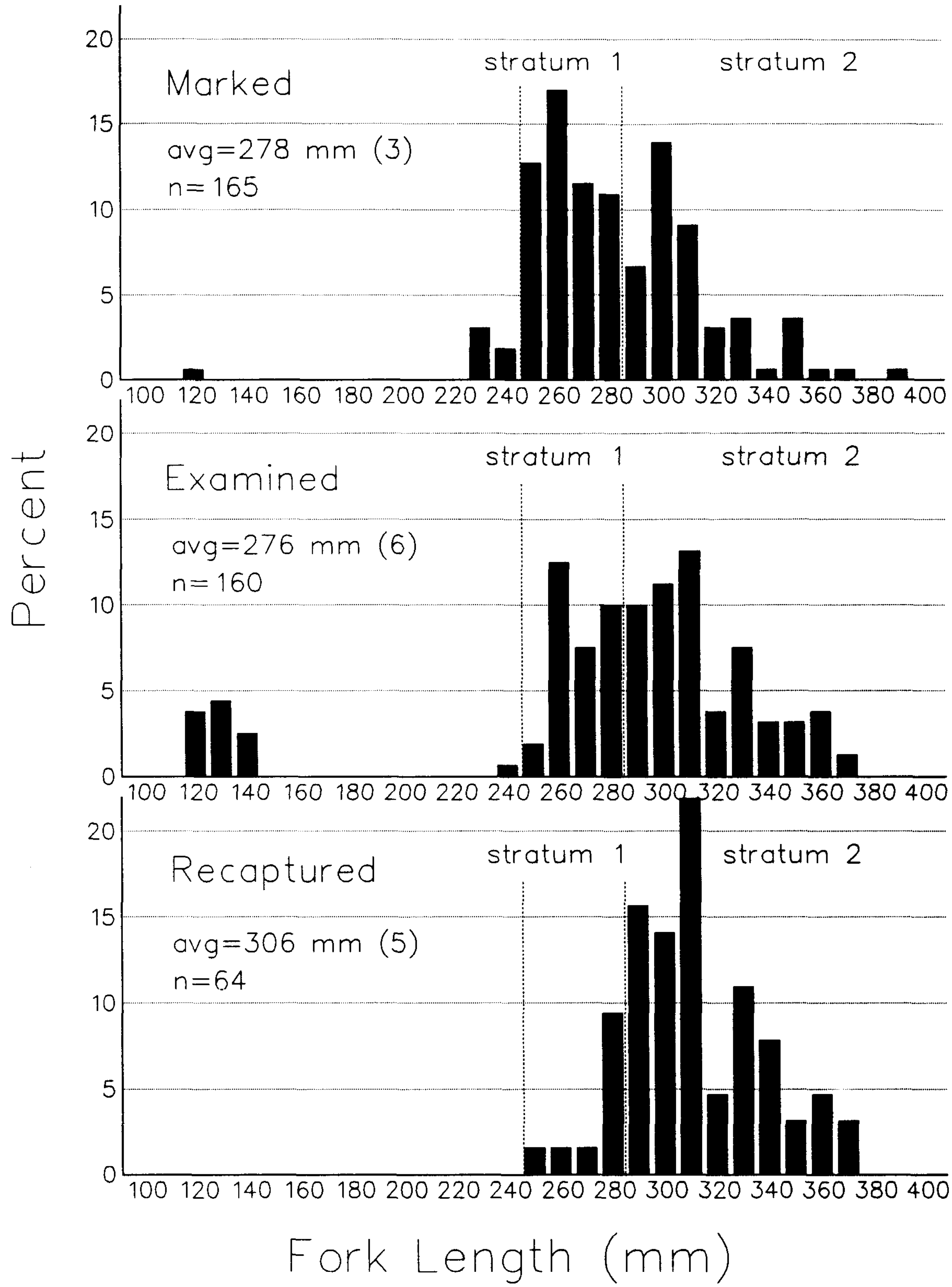

Figure 2. Length distribution of lake trout captured for estimating population abundance in Coalmine #5 Lake. Lower limit of sizes included in the estimate and limits of the two strata are deliniated by verticle dashed lines.

The estimated abundance for lake trout 245 to 279 mm was 534 (SE = 167). Within this stratum, 77 fish were marked during June and 47 fish were examined in July of which six were recaptured from the June sample period (Table 4). For lake trout 280 mm and larger the estimated abundance was 116 (SE = 4) fish. In this size group, 71 lake trout were marked and 95 were examined of which 58 were recaptured (Table 4).

Population abundance for lake trout 245 mm and larger was also calculated without stratification to investigate if the size bias in the samples was significant. A total of 148 fish were marked and 142 were examined of which 64 were recaptured from the marked population (Table 4). The resulting estimated abundance without stratification was 327 (SE = 22) and was substantially less than the stratified estimate. This indicates that the size bias was indeed significant and the presumably more accurate but less precise stratified estimate was selected.

Pauls Pond. Population abundance of lake trout 215 mm FL and larger in 1992 was estimated to be 316 (SE = 30) fish.

Between June 23 and June 25, 178 lake trout 198 to 367 mm FL were marked with lower caudal fin clips. Between July 6 and July 10, the population was again sampled and 84 lake trout 118 to 372 mm were captured of which 39 (215 - 371 mm) were marked from the first sampling period (Figure 3). Because no lake trout less than 215 mm were recaptured, the estimated abundance was calculated for fish 215 mm and larger only. Within this size group, 168 lake trout were marked and 74 were examined of which 39 were recaptured from the marked population (Table 4).

Comparison of lengths of fish (215 mm and larger) marked and recaptured during the two sampling periods showed no differences in the size of fish sampled (KS two sample test; D = 0.23, P = 0.08). Similarly, no difference in the lengths of all fish 215 mm and larger captured during the two sampling periods was detected (KS two sample test; D = 0.16, P = 0.13). Hence, a single non-stratified abundance estimate was calculated for lake trout 215 mm and larger.

North Twin Lake. The abundance of age-1 (>160 mm) lake trout larger than 160 mm FL in North Twin Lake was estimated to be 769 (SE = 185) fish.

Between June 16 and June 26, 140 lake trout 140 to 200 mm FL were captured and fin clipped. Between July 6 and July 30, the population was again sampled and 70 lake trout 150 to 233 mm were captured of which 11 (162 - 201 mm) were marked from the first sampling period (Figure 4). Because no lake trout less than 160 mm were recaptured, the estimated abundance was calculated for fish 160 mm and larger only.

Comparison of lengths of fish (160 mm and larger) marked in the first event and to those recaptured in the second event showed no differences in the size of fish sampled (KS two sample test; D = 0.21, P = 0.78). However, lengths of all fish 160 mm and larger captured during the two sampling periods were different (KS two sample test; D = 0.23, P = 0.02). Hence, size selectivity in the sampling gear was indicated in the first sampling period. Because of

Table 4. Estimated abundance of lake trout in selected stocked waters in the Tanana River drainage, June 1992.

Lake	Size Group (mm FL)	Number of Lake Trout: Marked	Captured	Recaptured	Estimated Abundance	SE
Coalmine #5	245 - 279	77	47	6	534	167
	> 279	71	95	58	116	4
	strata combined				650	167
	all fish > 244	148	142	64	327	22
Pauls Pond	> 214	168	74	39	316	30
North Twin	160 - 174	42	12	4	111	34
	> 174	89	57	7	652	193
	strata combined				763	196
	all fish > 159	131	69	11	769	185
Chet	185 - 200	37	19	4	151	50
	> 200	162	141	80	285	15
	strata combined				436	52
	all fish > 184	199[a]	160	84	414	24
Nickel	> 188	98	182	37	476	53
Ghost	> 228	21	10	6	27	5
Rapids	> 135	10	16	4	50	13

[a] Twenty-six fish without complete measurements.

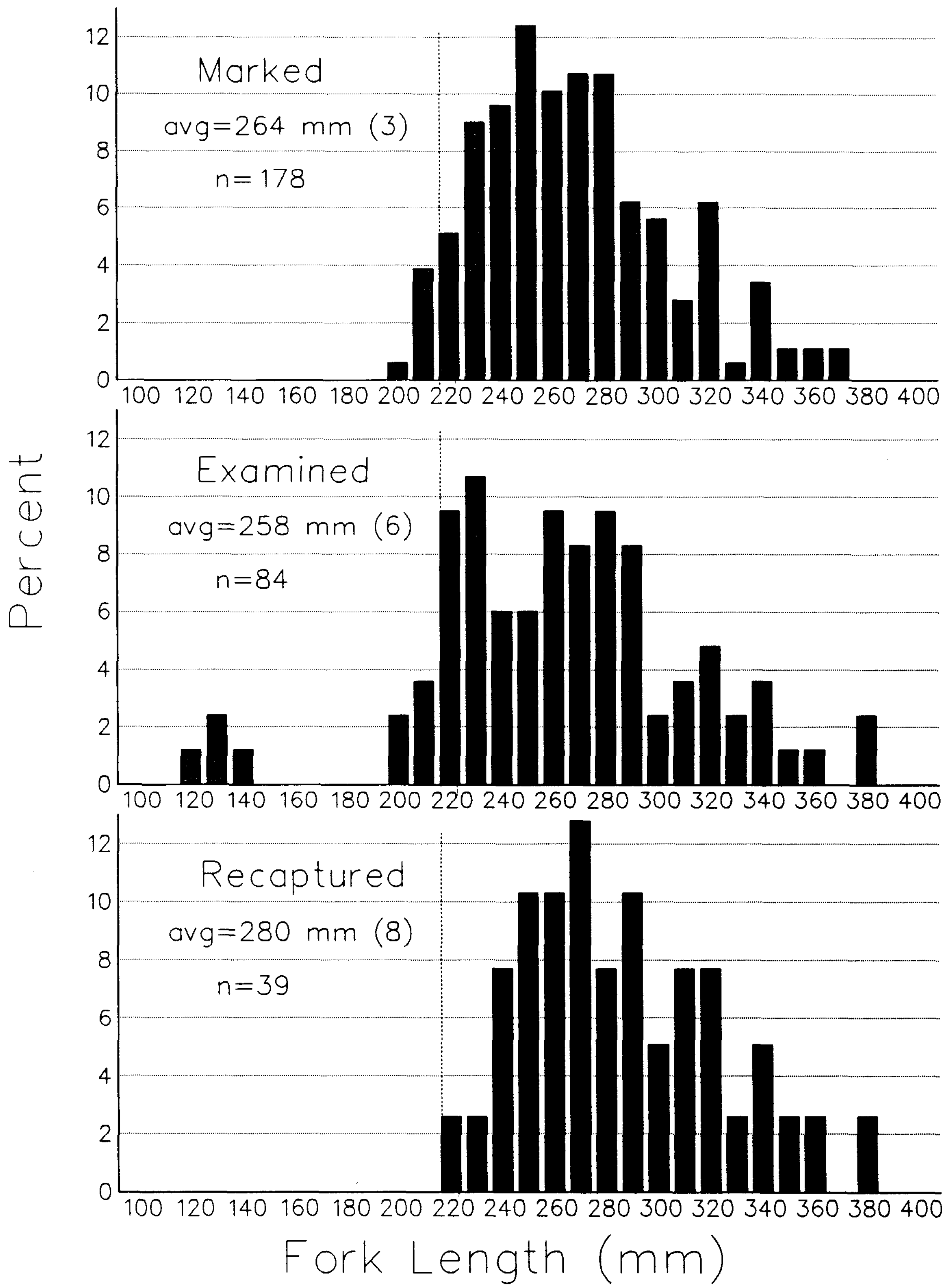

Figure 3. Length distribution of lake trout captured for estimating population abundance in Paul's Pond. Lower limit of sizes included in the estimate is deliniated by verticle dashed line.

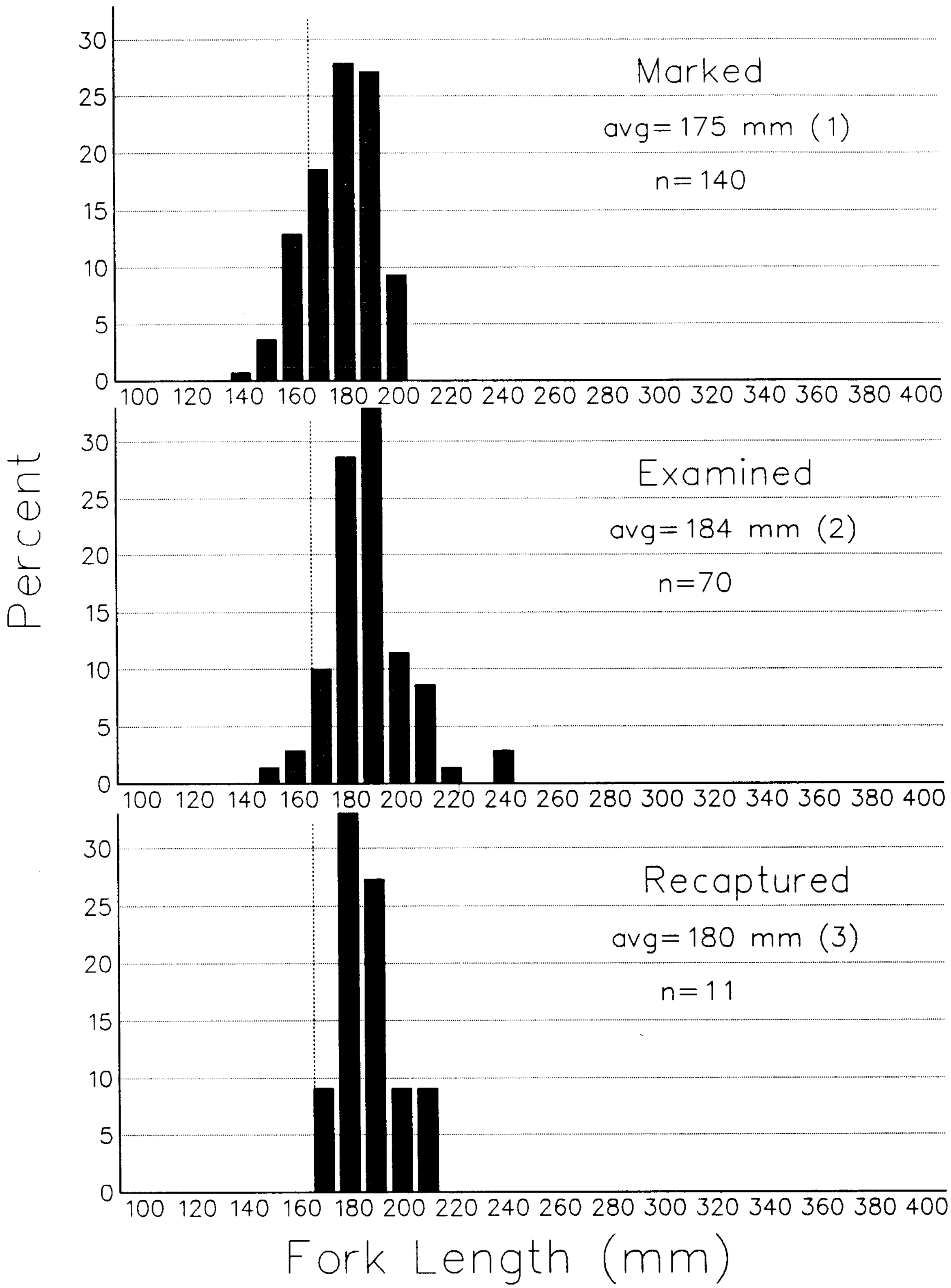

Figure 4. Length distribution of lake trout captured for estimating population abundance in North Twin Lake. Lower limit of sizes included in the estimate is deliniated by verticle dashed line.

the potential size bias, the catch data were stratified and separate abundance estimates were calculated for lake trout 160 to 173 mm and for fish 174 mm and larger.

The estimated abundance for lake trout 160 to 173 mm was 111 (SE = 34). Within this strata, 42 fish were marked during June and 12 fish captured in July of which four were recaptured from the June sample period (Table 4). For lake trout 174 mm and larger the estimated abundance was 652 (SE = 193) fish. In this size group, 89 lake trout were marked and 57 were examined of which seven were recaptured (Table 4). The estimated abundance of lake trout 160 mm and larger from the stratified estimate was 763 (SE = 196).

Population abundance for lake trout 160 mm and larger was also calculated without stratification to investigate if the size bias detected in the samples was significant. A total of 131 fish were marked and 69 were examined of which 11 were recaptured from the marked population (Table 4). The resulting estimated abundance without stratification was 711 (SE = 171) and was not substantially different from the stratified estimate. This indicates that the size bias was not significant. The more precise non stratified estimate was selected.

Chet Lake. Lake trout abundance in June 1992 was estimated to be 414 (SE = 25) fish 185 mm and larger.

Between June 16 and June 18, 218 lake trout varying from 172 to 284 mm FL were captured and fin clipped. Between July 6 and 10, the population was again sampled and 160 lake trout 176 to 330 mm were captured of which 84 (187 - 287 mm) were marked from the first sampling period (Figure 5). Because no lake trout less than 185 mm were recaptured, the estimated abundance was calculated for fish 185 mm and larger only.

Comparison of lengths of fish (185 mm and larger) marked during the first sample period and recaptured during the second sampling period showed differences in the size of fish sampled (KS two sample test; $D = 0.32$, $P < 0.01$). Similarly, lengths of all fish 185 mm and larger captured during the two sampling periods were different (KS two sample test; $D = 0.25$, $P < 0.01$). Hence, size selectivity in the sampling gear was indicated in at least the second sampling period. Because of the size bias, the catch data were stratified and separate abundance estimates were calculated for lake trout 185 to 200 mm and for fish 201 mm and larger.

The estimated abundance for lake trout 185 to 200 mm was 151 (SE = 50). Within this strata, 37 fish were marked during June and 19 fish captured in July of which four were recaptured from the June sample period (Table 4). For lake trout 201 mm and larger the estimated abundance was 285 (SE = 15) fish. In this size group, 162 lake trout were marked and 141 were examined of which 80 were recaptured from the marked population (Table 4). The estimated abundance of lake trout from these strata combined was 436 fish (SE = 52).

Population abundance for lake trout 185 mm and larger was also calculated without stratification to investigate if the size bias detected in the samples was significant. A total of 218 fish were marked and 160 were examined of which 84 were recaptured from the marked population (Table 4). The resulting

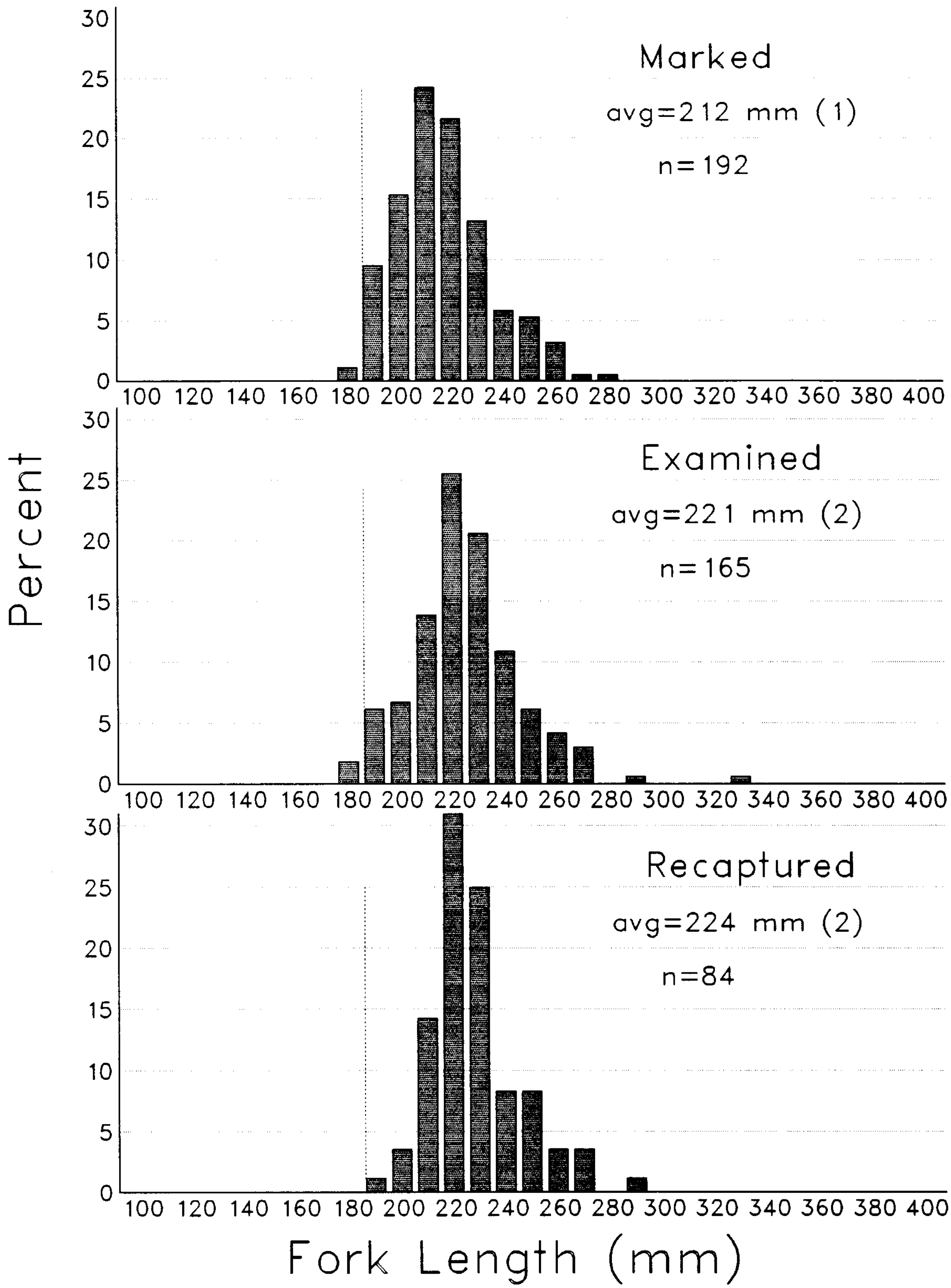

Figure 5. Length distribution of lake trout captured for estimating population abundance in Chet Lake. Lower limit of sizes included in the estimate is delineated by vertical dashed line.

estimated abundance without stratification was 427 (SE = 25) and was not substantially different from the stratified estimate. This indicates that the size bias was not significant. The more precise non stratified estimate was selected.

Nickel Lake. Estimated abundance of lake trout 189 mm and larger in Nickel Lake during June 1992 was 476 (SE = 53) fish.

Between June 16 and June 19, 108 lake trout 101 to 258 mm FL were marked with lower caudal fin clips. Between July 6 and July 10, the population was again sampled and 197 lake trout 109 to 276 mm were captured of which 38 (116 - 276 mm) were marked from the first sampling period. Although one lake trout 116 mm in length was recaptured, the other 37 recaptures varied from 189 to 276 mm in length (Figure 6). To increase precision and accuracy, the estimated abundance was calculated for fish 189 mm and larger only.

Comparison of lengths of fish (189 mm and larger) marked and recaptured during the two sampling periods showed no differences in the size of fish sampled (KS two sample test; D = 0.15, P = 0.48). Similarly, lengths of all fish 189 mm and larger captured during the two sampling periods were not significantly different (KS two sample test; D = 0.11, P = 0.36). Hence, a single, non stratified estimate of abundance was calculated.

Ghost Lake. Lake trout abundance in Ghost Lake in June 1992 was estimated to be 27 (SE 5) fish.

Between June 17 and 26 a total of 21 lake trout varying from 228 to 332 mm were captured and marked with lower caudal fin clips. In July, (6 through 10) 10 lake trout (157 to 312 mm) were captured six of which had clipped fins from the June sample period (Table 4, Figure 7).

Comparison of lengths of all fish marked and recaptured during the two sampling periods showed no differences in the size of fish sampled (KS two sample test; D = 0.43, P = 0.36). Similarly, lengths of all fish captured during the two sampling periods were not significantly different (KS two sample test; D = 0.36, P = 0.34). Because of the small number of fish captured during each sampling period the likelihood of detecting differences in the length distribution of fish examined is small. A single, non stratified estimate of abundance was calculated.

Rapids Lake. The abundance of age-1 lake trout 135 mm FL and larger in Rapids Lake during June 1992 was estimated to be 50 (SE = 13) fish.

A total of ten lake trout ranging from 135 to 156 mm FL were marked during the week of July 7 through 10. Between July 14 and 17, 22 lake trout were captured (105 - 153 mm FL) of which four (139 to 147 mm) were marked during the first sample period. Sample sizes were too small to allow detection and correction for size biased samples. Six of the lake trout caught during

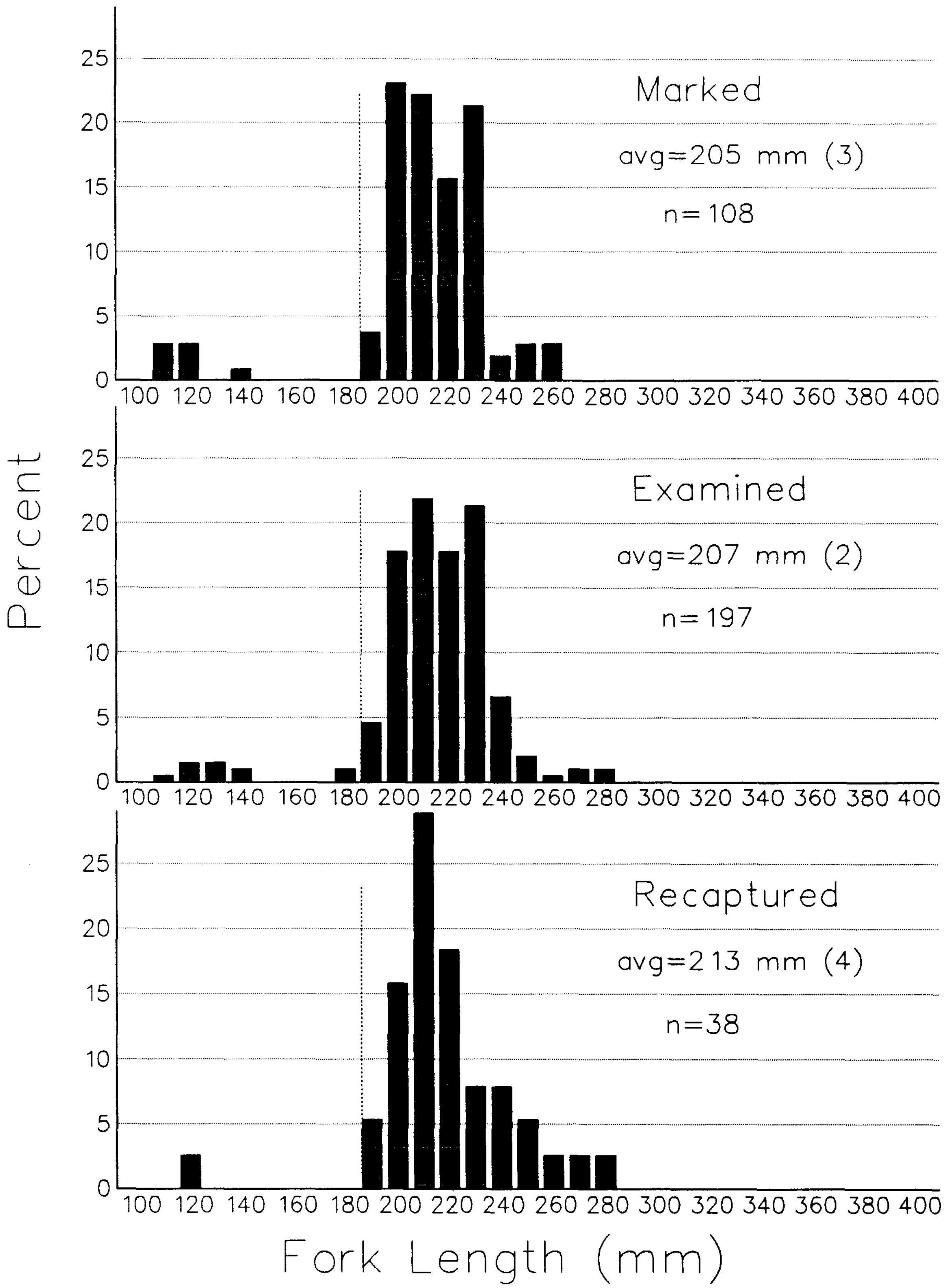

Figure 6. Length distribution of lake trout captured for estimating population abundance in Nickel Lake. Lower limit of sizes included in the estimate is deliniated by verticle dashed line.

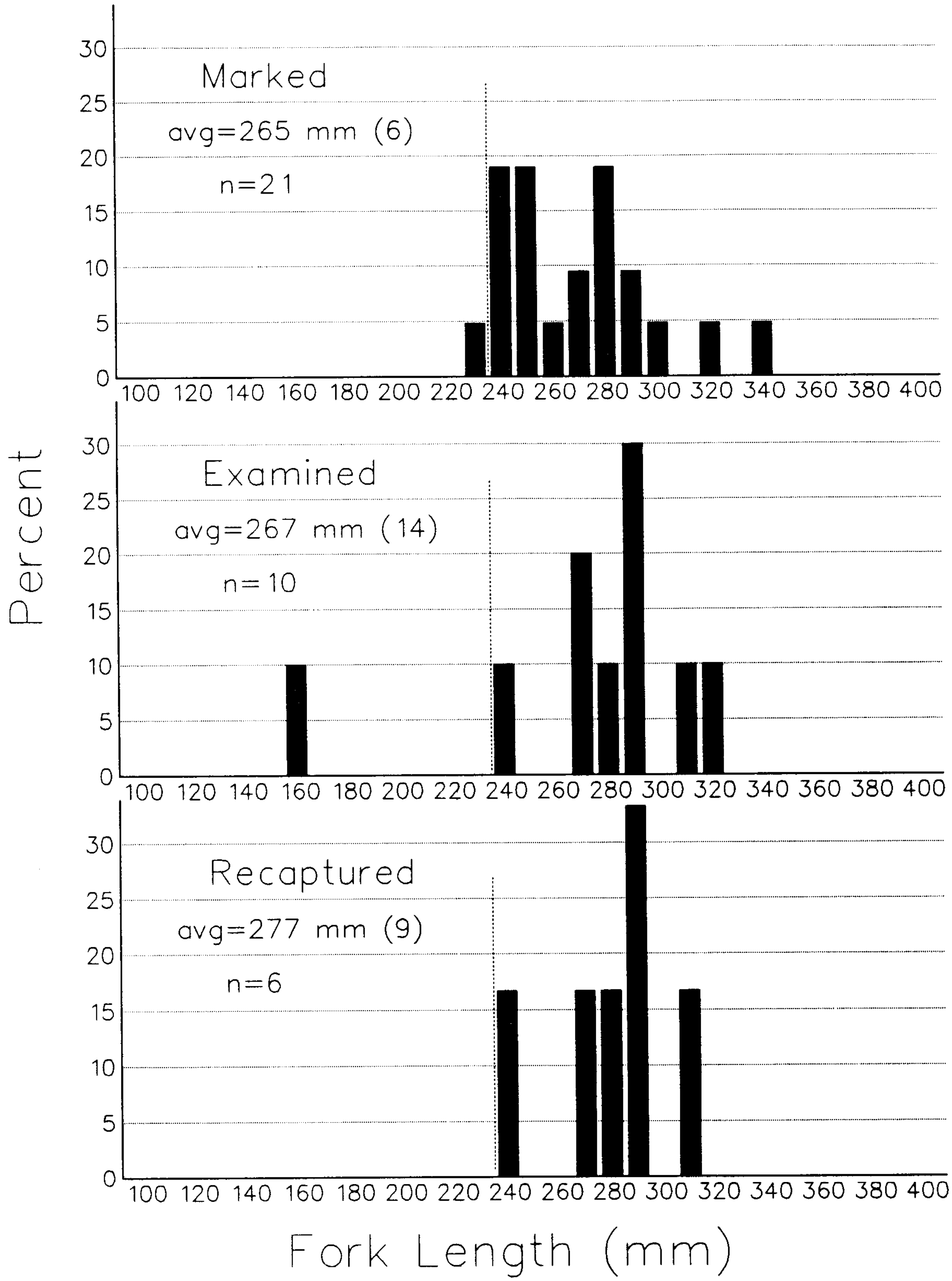

Figure 7. Length distribution of lake trout captured for estimating population abundance in Ghost Lake. Lower limit of sizes included in the estimate is deliniated by verticle dashed line.

the second sample period were smaller than 135 mm. Hence, the number of fish examined was reduced to 16 and a single, non-stratified estimate was calculated (Table 4, Figure 8).

Craig Lake. Too few lake trout were captured during sampling efforts to provide an estimate of abundance. A total of 15 lake trout were captured in baited hoop nets. No lake trout were caught in fyke nets. These age-1 lake trout averaged 146 mm FL and varied from 123 to 177 mm.

Length at Age:

Mean length at age was calculated for all 12 of the stocked lake trout populations sampled. Mean length at age-1 varied from 116 mm for lake trout in Nickel Lake to 193 mm in Fourmile Lake (Table 5, Figure 9). In most of the populations, mean length at age-1 was less than 150 mm. The estimated mean length of fish at age-3 varied from 204 in Chet Lake to 408 mm in Triangle Lake. In most populations, age-3 lake trout were between 200 and 260 mm. Mean length of age-4 lake trout varied from 219 mm in Nickel Lake to 443 mm in Triangle Lake. The large lake trout in Triangle Lake were unique. The estimated mean length of age-4 fish was less than 302 mm for the other populations sampled (Table 5, Figure 9).

Length and Age Compositions:

The proportions of lake trout which 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 for lakes from which population abundance was successfully estimated. Significant size selectivity was detected in the samples only from Coalmine #5 Lake. Because of the size bias in the samples from Coalmine #5 Lake, only lengths and ages from the second sampling period were used to estimate length and age compositions. These proportions were adjusted for the length bias. Age and length compositions of lake trout in Coalmine #5 Lake are given in Table 6 and Figure 10. For the other six populations, the samples from both sampling periods were pooled to estimate age and length composition and the results are reported in Table 6 and Figure 10. 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. Although age-1 fish were caught in all populations except for Ghost Lake (where they were not expected) and for Chet Lake (where they were, Appendix A), the relative abundance of this year class remains unknown in most cases. Population abundance was estimated for age-1 fish in North Twin Lake and in Rapids Lake.

Survival of 1988, 1989, and 1991 Stocking Cohorts:

Survival was estimated for lake trout in lakes where population abundance was estimated. Estimates of abundance were obtained for age-1 fish in two lakes only: North Twin Lake and Rapids Lake. The smaller age-1 fish, particularly in Rapids Lake were not well represented in the samples due to poor catchability of these fish. As a result, estimates of abundance for age-1

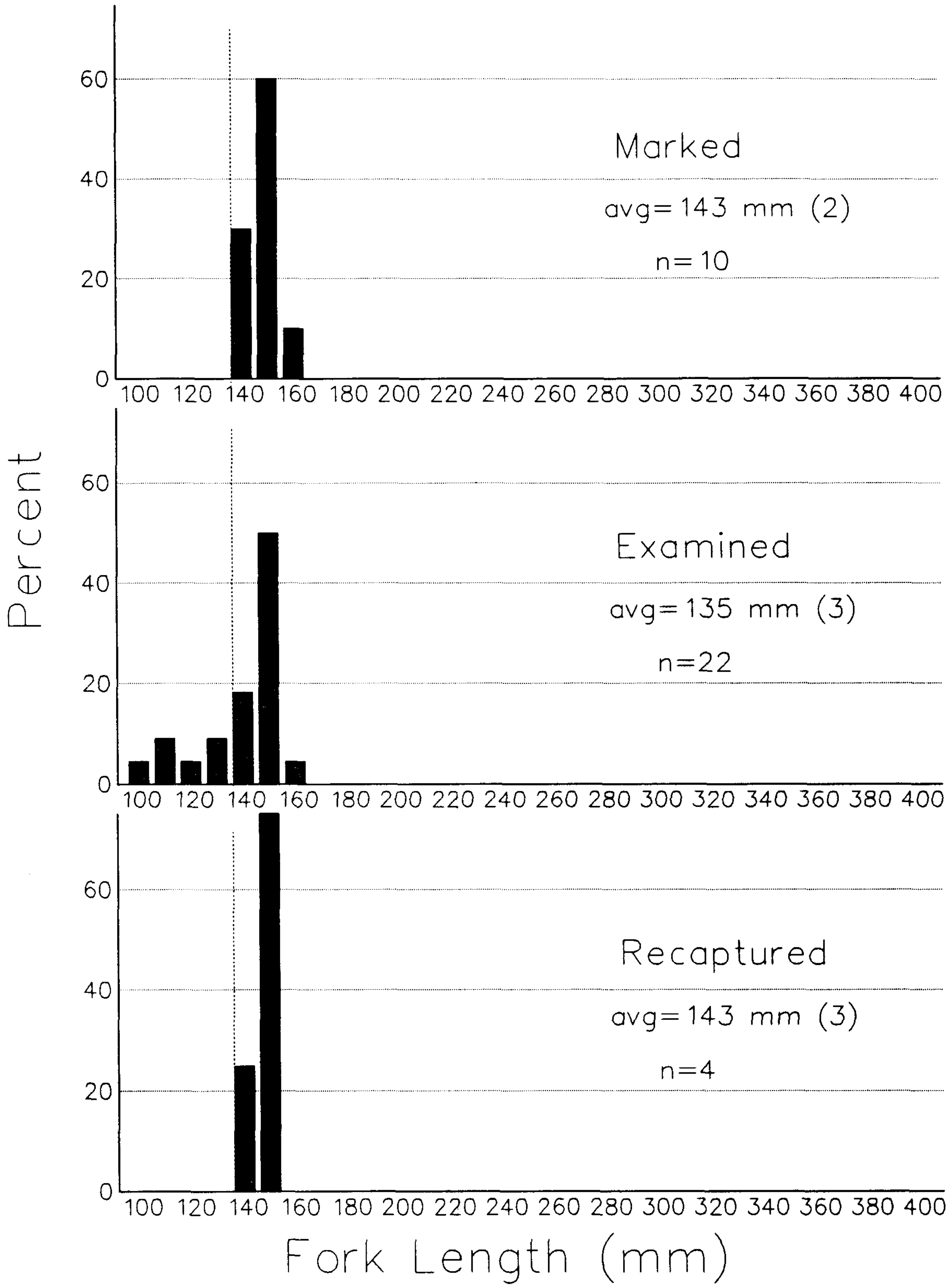

Figure 8. Length distribution of lake trout captured for estimating population abundance in Rapids Lake. Lower limit of sizes included in the estimate is deliniated by verticle dashed line.

Table 5. Estimated mean length (mm FL) at age (from scales or known age) of lake trout from populations stocked in lakes in the Tanana drainage.

Lake	Age	Mean Length	Sample Size	SE
Coalmine #5	1	124	18	2
	2	nd[a]	nd	
	3	259	101	2
	4	301	124	2
	All	276	325	3
Pauls Pond	1	127	4	4
	2	nd	nd	
	3	237	123	2
	4	291	120	3
	All	262	262	3
North Twin	1	177	210	1
Chet	1	nd	nd	
	2	nd	nd	
	3	204	154	1
	4	228	82	2
	All	216	357	1
Nickel	1	116	10	3
	2	nd	nd	
	3	208	163	1
	4	219	82	2
	All	207	305	2
Ghost	3	255	16	5
	4	292	9	8
	All	266	31	6
Rapids	1	138	32	2
Craig	1	146	145	4
Fourmile	1	193	4	4
Fourteenmile	1	117	108	1
Triangle	3	408	6	15
	4	443	16	7
	All	434	22	7
Summit	3	330	2	6

[a] nd = No data.

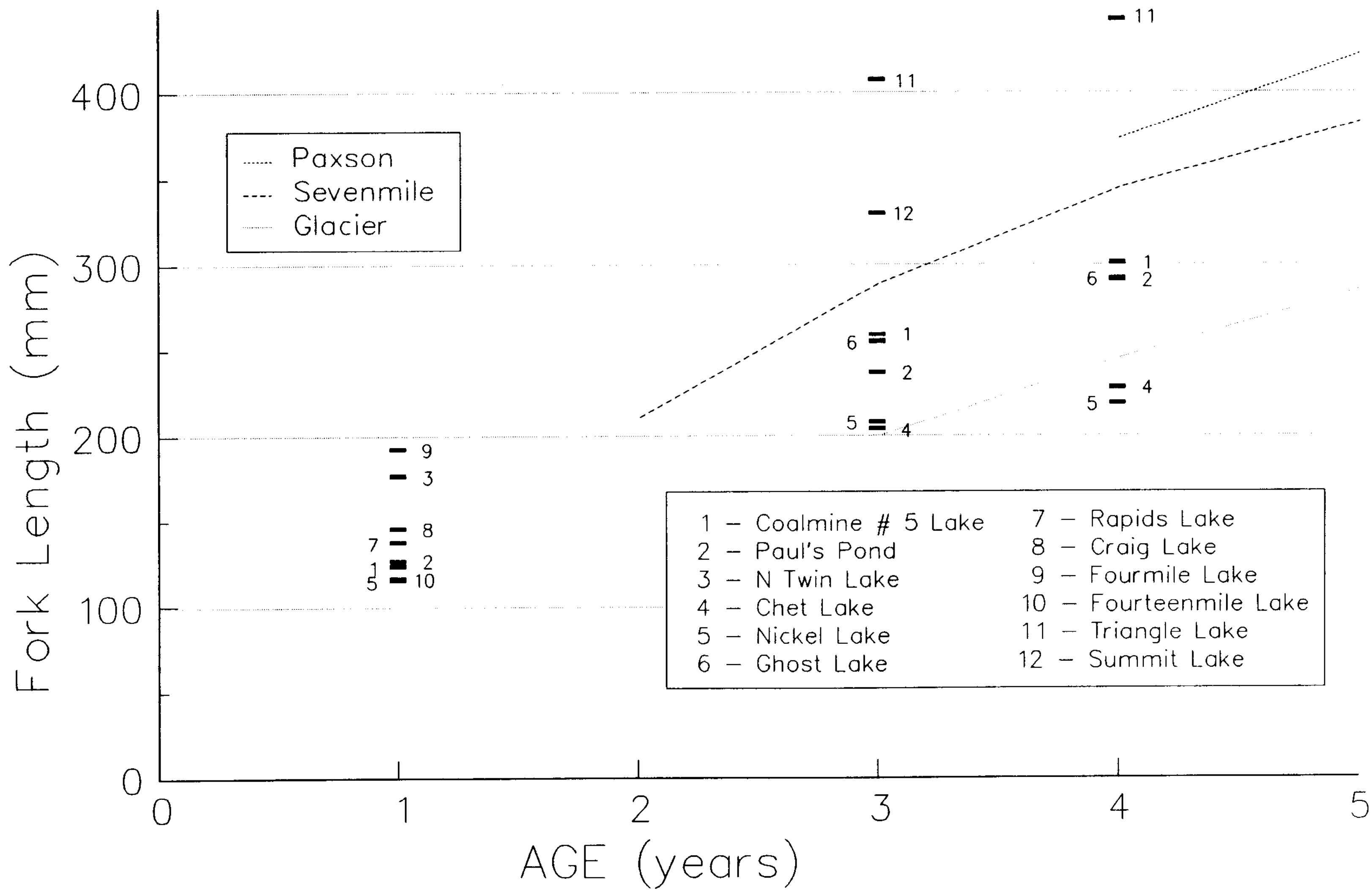

Figure 9. Growth as estimated by mean length at age for lake trout stocked as young of the year in 1988, 1989, and 1991. Growth of wild lake trout stocks in Sevenmile, Paxson (parent stock) and Glacier lakes (Burr 1992) is shown with lines.

Table 6. Population age composition of lake trout larger than the minimum length indicated for seven stocked populations.

Waterbody	Minimum Length Included[b]	Age Group	Group Specific Abundance	SE	Percent	SE
Coalmine #5[a] Lake	245	3	400	258	62	0.37
		4	250	233	38	0.37
Pauls Pond	214	3	149	17	47	0.03
		4	167	19	53	0.03
North Twin Lake	160	1	711		100	
Chet Lake	185	3	279	21	65	0.03
		4	148	16	35	0.03
Nickel Lake	189	3	312	38	66	0.03
		4	164	23	34	0.03
Ghost Lake	228	3	17	4	64	0.10
		4	10	3	36	0.10
Rapids Lake	135	1	36		100	

[a] adjustment made for size selective gear
[b] mm fork length

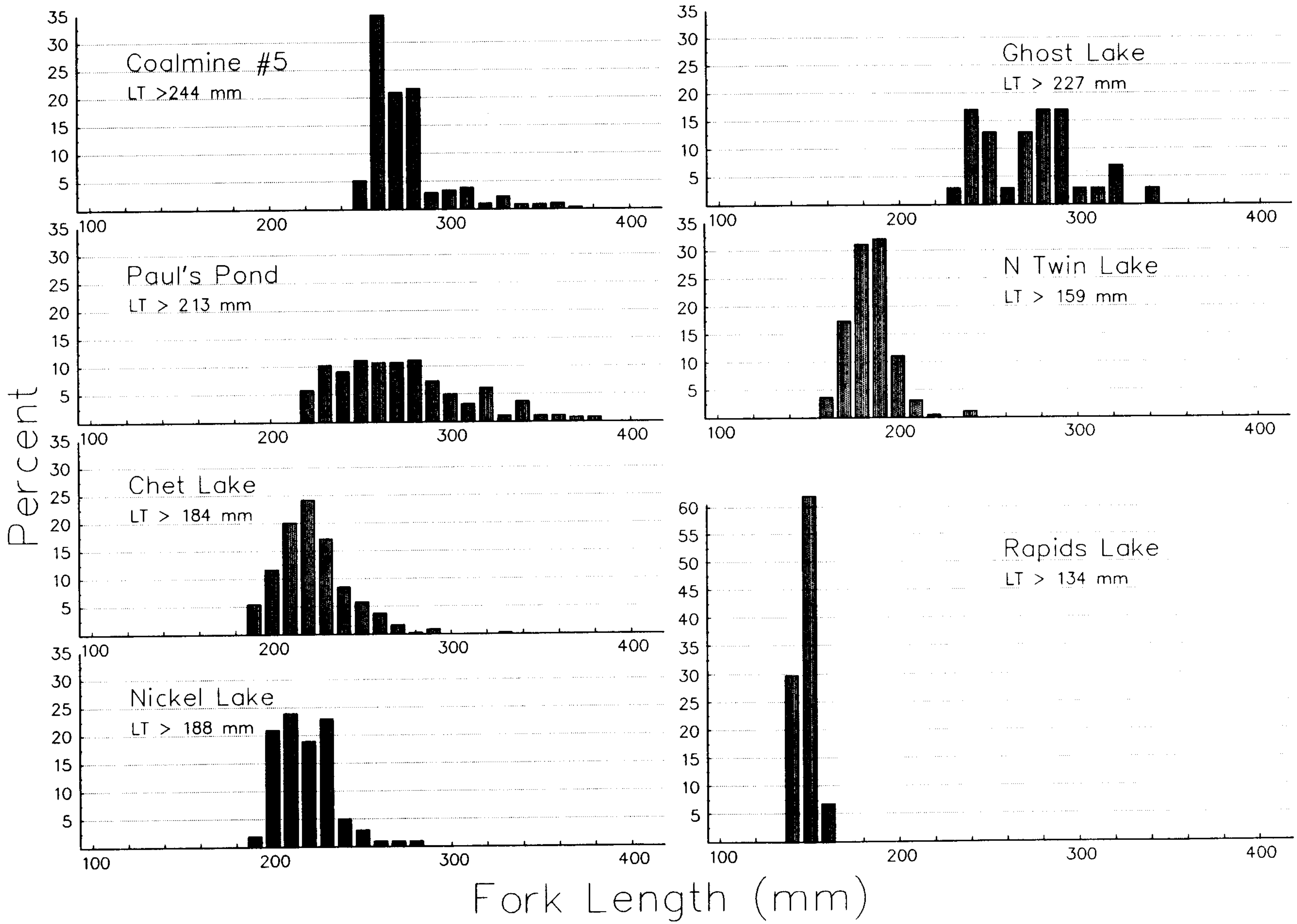

Figure 10. Population, length composition of stocked lake trout for Seven lakes in the Tanana River drainage. Minimum size of fish included in estimates is as noted.

fish are imprecise as are estimates of survival. The survival of age-1 lake trout in North Twin Lake which were larger than 159 mm in 1992 was estimated to be 0.71 (SE = 0.17) (Table 7). In Rapids Lake, estimated survival for lake trout larger than 135 mm was 0.01 (SE = <0.01). Mean survival to age-1 for these two populations was estimated to be 0.36 (SE = 0.09; Table 7).

Survival to age-3 was estimated for five populations. Estimates for these populations were: 0.15 (SE = 0.10) in Coalmine #5 Lake; 0.15 (SE = 0.02) in Pauls Pond; 0.35 (SE = 0.03) in Chet Lake; 0.62 (SE = 0.08) in Nickel Lake; and 0.03 (SE = 0.01) in Ghost Lake (Table 7). Mean survival to age-3 for the five populations was 0.26 (SE = 0.03).

Survival to age-4 was also estimated for these five populations. Estimates for these populations were: 0.10 (0.09) in Coalmine #5 Lake; 0.17 (SE = 0.02) in Pauls Pond; 0.09 (SE = 0.01) in Chet Lake; 0.16 (SE = 0.02) in Nickel Lake; 0.01 (SE = <0.01) in Ghost Lake (Table 7). Mean survival to age-4 for the five populations was 0.11 (SE = 0.02).

Presence/Absence of Stocked Lake Trout:

Sampling conducted to determine the presence or absence of lake trout stocked into Fourmile Lake, Fourteenmile Lake, Summit Lake, West Twin Lake, and Triangle Lake found lake trout in all lakes except for West Twin Lake. Catch rates with gill nets varied from 0.04 to 0.92 lake trout per net hour. Hoop nets caught from 0.5 to 0.7 lake trout per net night. Lake trout were caught in fyke nets in Fourteenmile Lake only; the catch rate was 23 lake trout per net night (Table 3).

Lake trout were considered to be present in sufficient numbers to permit future stock assessment if catch rates were equal to or higher than 0.10 fish per net hour for gill nets or 0.5 fish per net night for hoop nets or fyke nets. Based on these criteria, lake trout were present in sufficient numbers in three of the four lakes in which lake trout were captured. Catch rates of lake trout in Summit Lake were too low to encourage future stock assessment.

<u>Discussion</u>

Catchability of age-1 lake trout in all lakes sampled proved to be poor. In all cases where age-1 lake trout were present with other stocking cohorts (Coalmine #5 Lake, Paul's Pond, Chet Lake, and Nickel Lake), no or very few fish in this age group were recaptured from the marked population (Figures 2-6). Hence the abundance of age-1 lake trout could not be estimated for these populations. Where estimates of abundance for age-1 lake trout were obtained, sample sizes were quite limited and substantial portions of the age group were excluded from the estimates (Figures 4 and 8). In Craig Lake the attempt to estimate abundance failed due to very low catch rates.

Initial evaluation of some of these stocked populations was conducted and reported by Skaugstad and Clark (1991). They found limited and variable catch rates for age-1 lake trout in these waters. One year after the 1988 stocking, no lake trout were captured in Coalmine # 5 Lake, but, the following year 64 were captured from this cohort. Similar results were reported from Ghost Lake. In contrast, high catch rates were reported for age-1 lake trout from Paul's Pond. Only lakes in which survival of stocked lake trout was

Table 7. Survival of age-0 lake trout stocked in lakes in the Tanana drainage in 1988, 1989, and 1991.

Waterbody	Survival to Age-1		Survival to Age-3		Survival to Age-4	
	Estimate	SE	Estimate	SE	Estimate	SE
Coalmine #5	nd		0.15	0.10	0.10	0.09
Paul's Pond	nd		0.15	0.02	0.17	0.02
N Twin	0.71	0.17	nd		nd	
Chet	nd		0.35	0.03	0.09	0.01
Nickel	nd		0.62	0.08	0.16	0.02
Ghost	nd		0.03	0.01	0.01	0.00
Rapids	0.01	0.003	nd		nd	
All	0.36	0.09	0.26	0.03	0.11	0.02

documented by Skaugstad and Clark (1991) or lakes which were stocked with lake trout for the first time in 1991 were included in the present study. It is possible that lake trout have survived in additional lakes which were stocked in 1988 and/or 1989 but were not caught in 1989 or 1990.

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. For age-3 and age-4 fish, growth was slower in most of 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 1992). The cause of the faster growth of lake trout in two of the stocked populations (Triangle and Summit lakes) is unknown. The low stocking densities (Table 1), and abundant food supplies are likely to be at least partially responsible. White fish are exceptionally abundant in Summit Lake, and Alaska blackfish *Dallia pectorais* were found in the stomachs of most of the lake trout killed in Triangle Lake. In the other stocked populations sampled, growth 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. Predation by lake trout stocked in 1988 and 1989 will likely have an increasingly large role in determining 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.

An objective of this project was to estimate the survival of the 1991 stocking cohort. Problems with the catchability of age-1 lake trout precluded estimation of abundance of age-1 lake trout in most populations. In North Twin Lake and in Rapids Lake where abundance was estimated, a substantial proportion of the year class was not included in the estimated abundance due to size selectivity. As a result, the accuracy of the survival estimates is questioned.

Age-3 fish were also not fully recruited to the sampling gear. However, the proportion of age-3 fish which were excluded from each of the estimates of abundance was much less than for the smaller age-1 fish. Hence, the degree of bias introduced by size selectivity is likely to be less. Age-4 fish were fully recruited and no bias from size selectivity in the estimates of survival is anticipated.

The relatively high catch rates of age-1 lake trout in Fourteenmile Lake and to a lesser extent Fourmile Lake are encouraging, particularly in light of the generally low catchability of age-1 fish. Conversely, the very low catch rate observed in Summit Lake indicates low numbers of stocked lake trout in this waterbody. Lake trout in Summit Lake were relatively large for age-3 fish (Figure 9) and should have been more available to the fishing gear if present in substantial numbers. The very high initial catch rate of lake trout in Triangle Lake indicates that estimation of population parameters should be feasible.

LAKE TROUT IN HARDING LAKE

Background

In 1939 and 1940 "about a dozen" lake trout from an unknown source were stocked into Harding Lake by the US Fish and Wildlife Service. These fish apparently reproduced but (as determined by test-netting and angler success) the population remained very small and did not support a sport fishery.

In an effort to establish a sport fishery, Alaska Department Fish and Game transplanted 252 lake trout (FL range 173-813 mm) from Boulder and Twobit lakes to Harding Lake. In 1965, 235 adult lake trout (FL range 254-508 mm, scale ages 8-10 yrs) were transplanted from Monte Lake. In December 1965, 88,000 eyed lake trout eggs were introduced into Harding Lake from Susitna Lake. Despite these efforts, the lake trout population in Harding Lake remains small.

In 1990, 72,000 fingerling lake trout from the Paxson Lake population were transferred to floating net pens in Harding Lake from Clear Hatchery. After rearing for several weeks the fish were released into the lake in August.

Stock Status

Test netting has been conducted at Harding Lake since the 1970's. Catch rates have remained low. Starting in 1987, systematic test netting was initiated. Catch rates during September have varied from 0.01 to 0.03 lake trout per net hour and averaged 0.015 (Table 8). Although the lake trout stocked in 1990 are probably too small to be available to the sampling gear, the population abundance appears to remain low.

Lake trout sampled from Harding Lake indicate that a large number of year classes are present. Ages for adult lake trout can be determined only from fish that have been killed. Hence, the number of age-samples available are limited. Length is used as an approximation of age. Since 1985, lake trout between 110 and 948 mm FL have been caught (Figure 11).

Growth of lake trout in Harding Lake is very good (Figure 12). Estimated mean length at age-5 for both sexes is 569 mm FL (Table 9). In comparison, mean length at age-5 at Paxson Lake is 411 mm and at Fielding Lake 372 mm.

Lake trout in Harding Lake mature at a young age and large size. Most females are mature by age-8 and at 600 mm FL (Figure 13). All males sampled were mature by age-5 and at 600 mm FL. Most of the lake trout sampled since 1979

Table 8. Catch and effort from gill netting in Harding Lake 1987 - 1992.

Year	Month	Effort Net Nights	Catch	CPUE Net Nights	CPUE Net Hours
1987	June	20	4	0.20	0.008
	July	20	5	0.25	0.010
	August	14	9	0.64	0.027
	September	19	6	0.32	0.013
1988	June	4	0	0.00	0.000
	September	20	7	0.35	0.015
1989	July	12	2	0.17	0.007
	August	4	0	0.00	0.000
	September	4	1	0.25	0.010
1990	June	12	0	0.00	0.000
	July	20	1	0.05	0.002
	August	20	6	0.30	0.012
	September	20	4	0.20	0.008
1991	September	32	11	0.34	0.014
1992	September	32	23	0.72	0.030
Averages	September			0.36	0.015
	August			0.31	0.013
	July			0.16	0.006
	June			0.07	0.003

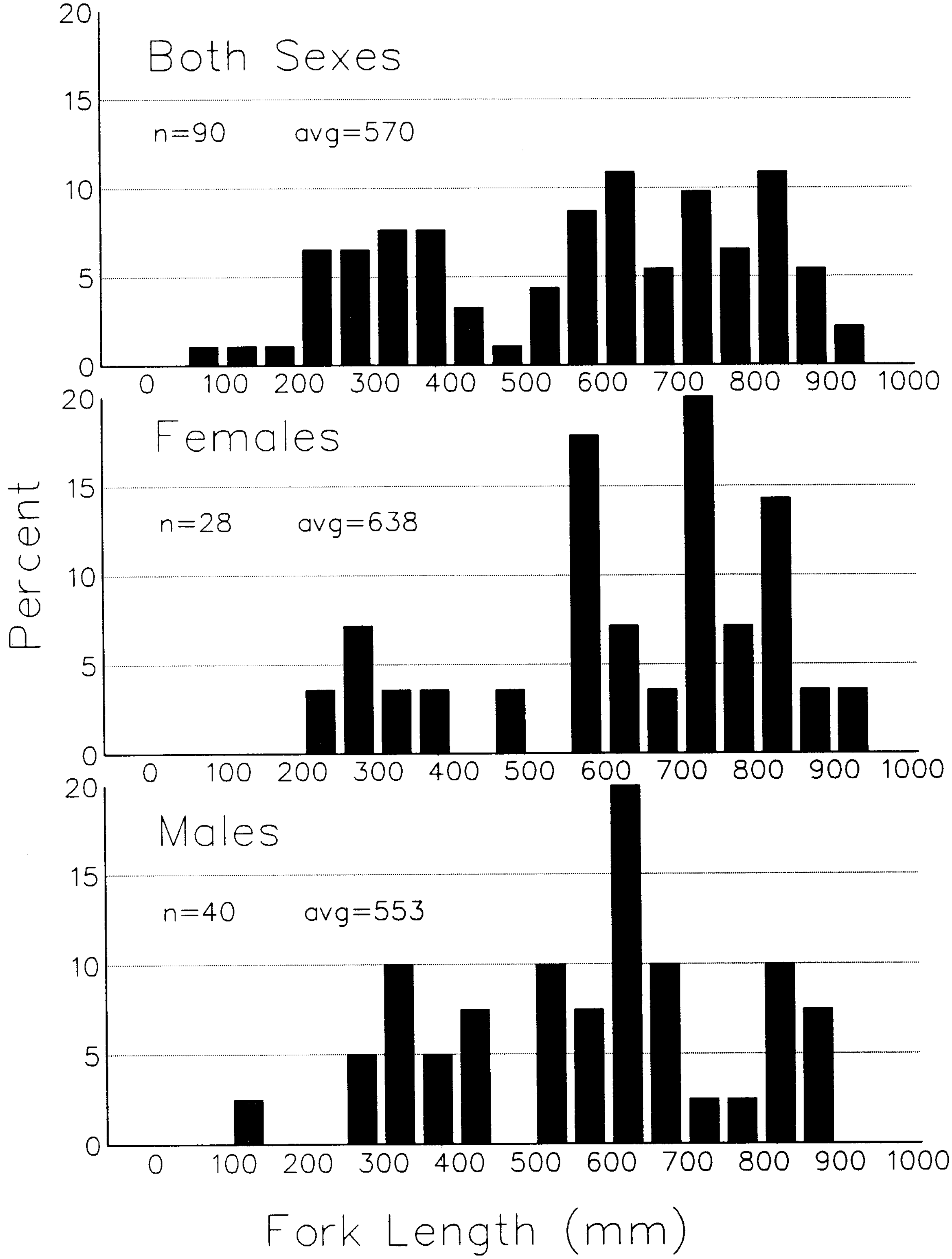

Figure 11. Length distribution of lake trout sampled in Harding Lake since 1985.

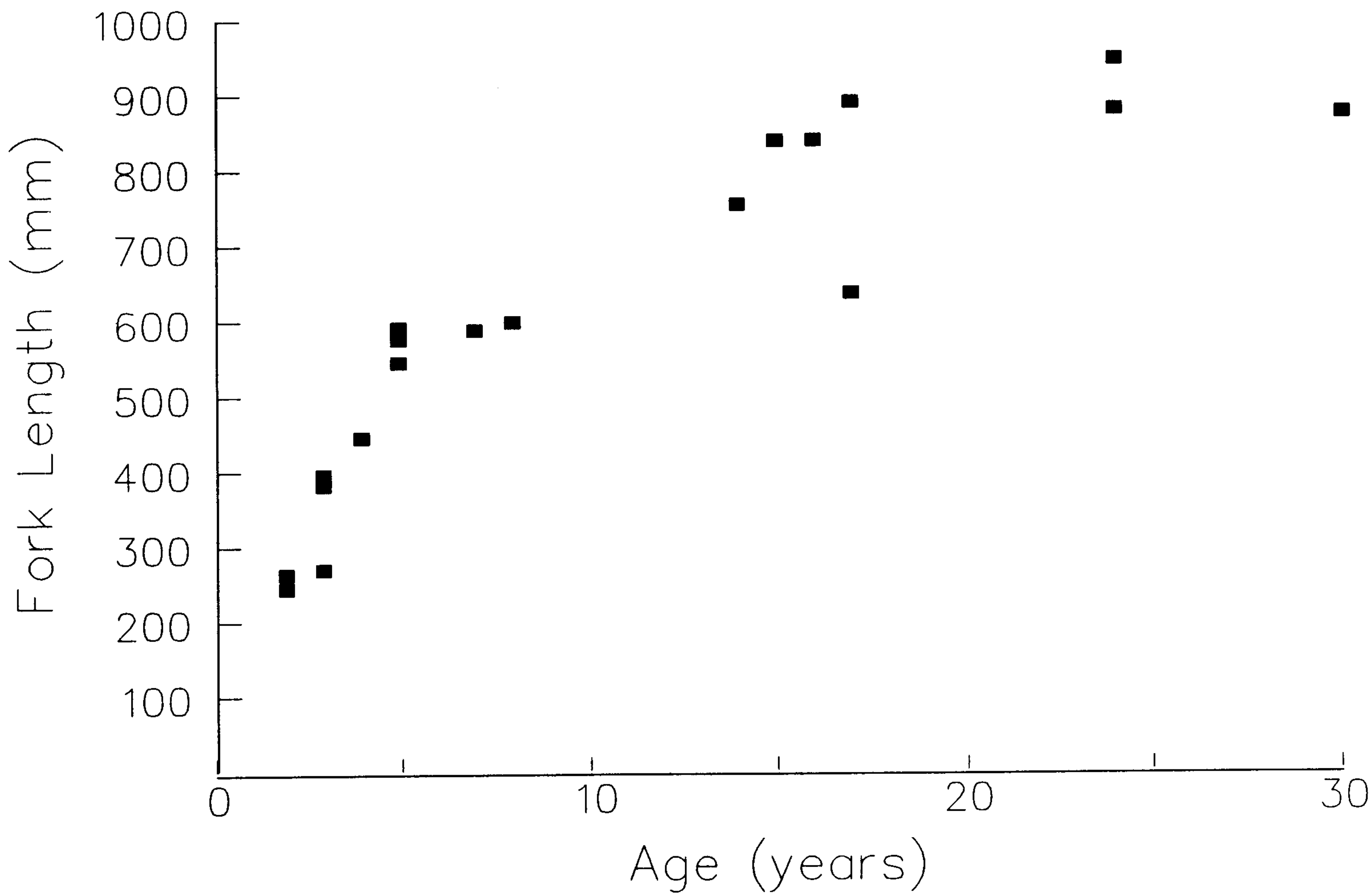

Figure 12. Growth of lake trout in Harding Lake as shown by length at age of lake trout samples.

Table 9. Estimated length (mm FL) at age (from otoliths) of lake trout from Harding Lake, 1985-92.

Age	All Lake Trout			Female Lake Trout			Male Lake Trout		
	Mean Length	Sample Size	SE	Mean Length	Sample Size	SE	Mean Length	Sample Size	SE
0		0			0			0	
1		0			0			0	
2	247	2	10	256	1			0	
3	343	3	41	376	1		326	2	64
4	440	1			0		440	1	
5	569	4	9	581	2	7	558	2	16
6		0			0			0	
7	585	1			0			0	
8	596	1		596	1			0	
9		0			0			0	
10		0			0			0	
11		0			0			0	
12		0			0			0	
13		0			0			0	
14	753	1		753	1			0	
15	838	1		838	1			0	
16	839	1			0		839	1	
17	762	2	128	890	1		634	1	
18		0			0			0	22
19		0			0			0	
20		0			0			0	
21		0			0			0	
22		0			0			0	
23		0			0			0	
24	914	2	34	948	1		880	1	
25		0			0			0	
26		0			0			0	
27		0			0			0	
28		0			0			0	
29		0			0			0	
30	875	1			0		875	1	
ALL	604	20	51	640	10	70	604	9	75

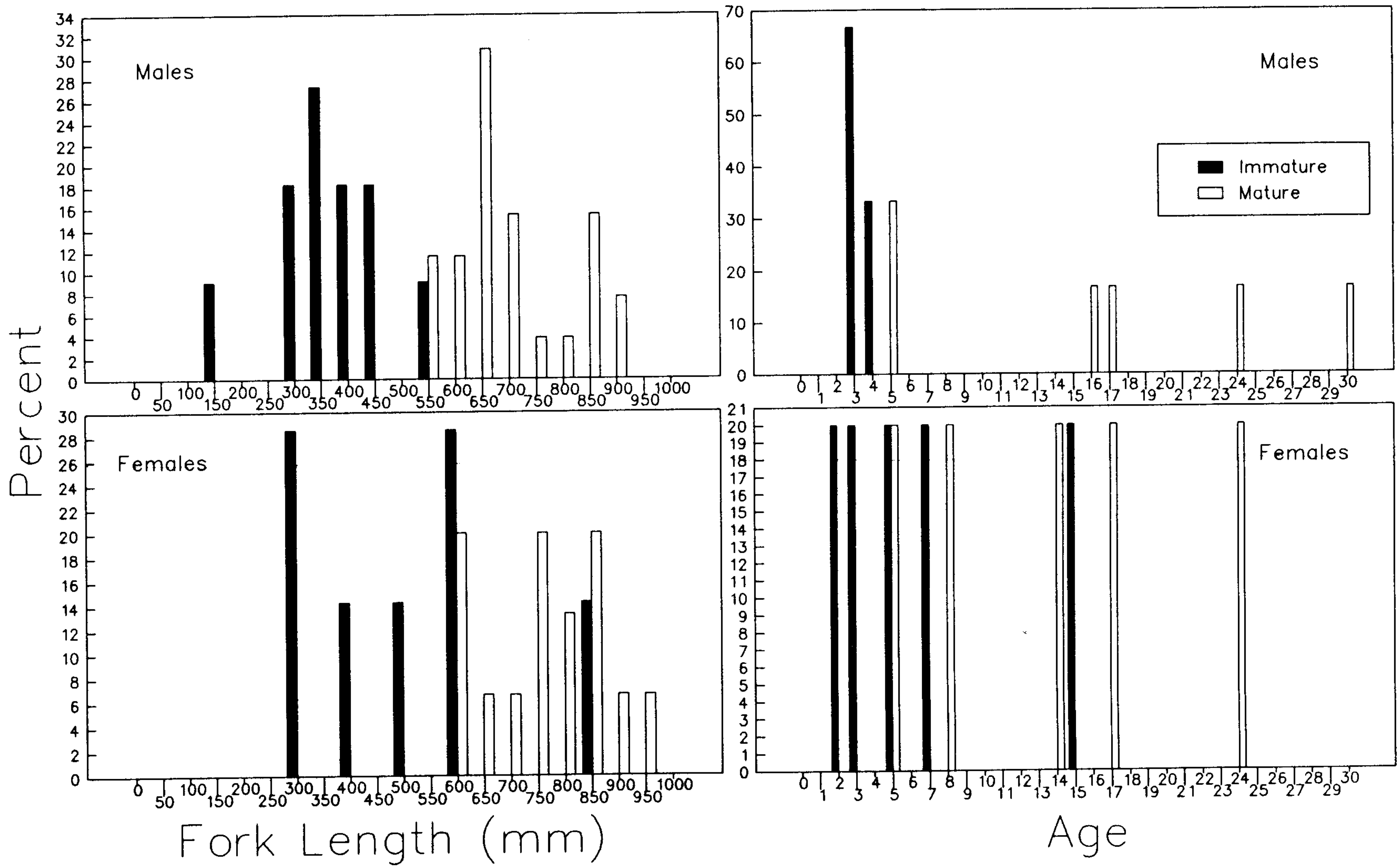

Figure 13. Percent maturity at length and age for lake trout sampled in Harding Lake, 1985 - 1992.

for which age estimates are available appear to have been the product of natural reproduction (Table 10). Until 1990, there were no known stockings since the eyed eggs were introduced in December of 1965. The 1965 cohort would have been age-14 (15 years old) in 1980. Assuming accurate estimation of age for the samples, only one fish since 1980 would have come from the earlier stockings.

Yield

The level of harvest reported by Mills (1987-1992) appears to be within the 0.5 kg/ha/yr guideline suggested by Healey (1978). The greatest estimated harvest reported by Mills was for 1992 and was 133 lake trout. An 18 inch TL minimum size limit is in effect at Harding Lake and all lake trout harvested should be 18 in or larger. The mean weight of 18 in lake trout sampled from the population is approximately 1 kg. Hence, the minimum weight of lake trout that the 133 fish would represent is 133 kg. The mean weight of lake trout larger than 18 in TL which have been sampled during test netting is approximately 4 kg. If the mean size of lake trout harvested was also 4 kg, the 1992 harvest in terms of weight would be 532 kg. The maximum estimated harvest in terms of weight is likely to have been greater than 133 kg and no greater than 532 kg.

Harding Lake is 1,012 ha (2,500 ac) in surface area. The estimated yield for 1992 is thus estimated to be between 0.13 and 0.53 kg/ha/yr. All other estimates of annual harvest are less. At present the incidental mortality associated with sampling for other species is insignificant. In 1992 six lake trout were killed during test fishing for other species at Harding Lake. The most lake trout killed incidental to sampling in any one year was 14.

ESTIMATION OF TOTAL MORTALITY WITH MAXIMUM AGE ANALYSIS

Introduction

Estimates of age composition are not available for any of the wild populations that have been studied since the initiation of the lake trout project in 1986. As a result, standard methods for estimating mortality or survival which are based on population age structure can not be used. Maximum age analysis was used as a technique for estimating annual survival rates of lake trout from lakes in the AYK data base. Eight lakes were selected for which sufficient age samples had been previously collected. The lakes selected were: Glacier, Twobit, Paxson, Sevenmile, Fielding, Upper/Round Tangle, Landlocked Tangle, and Butte.

Methods

The total mortality rate (Z) was estimated for lake trout populations following the procedure of Hoenig and Lawing (1983).

The mortality rate and variance are estimated as:

$$\hat{Z} = \lambda \, \underline{D} \, \underline{X} \qquad (11)$$

Table 10. Age and length samples from gill netting conducted at Harding Lake 1978 through 1992.

Age at Capture	Year and mean Fork Length at Capture																					
	1978		1979		1981		1982		1984		1985		1986		1987		1990		1991		1992	
	FL[a]	n[b]	FL	n	FL	n	FL	n	FL	n	FL	n	FL	n	FL	n	FL	n	FL	n	FL	n
1		0	110	1		0		0		0		0		0		0		0		0		
2		0	262	1		0		0		0		0		0		0		0	256	1	237	1
3		0		0		0	362	1	298	3		0		0		0		0		0	383	2
4		0		0		0		0	316	2		0		0		0		0		0	440	1
5		0		0		0		0		0	454	3	568	3	573	1		0		0		0
6		0	629	1		0		0	487	1	451	1		0		0		0		0		0
7		0	599	3	585	1		0		0		0		0		0		0		0		0
8		0		0		0	596	1	617	3		0		0		0		0		0		0
9		0		0		0		0		0	746	1		0		0		0		0		0
10		0		0		0		0		0		0		0		0		0		0		0
11		0		0		0		0	738	1		0		0		0		0		0		0
12		0		0		0		0		0	770	1		0		0		0		0		0
13		0		0		0		0		0		0		0		0		0		0		0
14		0		0		0		0		0		0		0		0		0	753	1		0
15		0		0		0		0		0		0	838	1		0		0		0		0
16		0		0		0		0		0		0		0		0		0		0	839	1
17		0		0		0		0		0		0	890	1		0		0	634	0		0
18		0		0		0		0		0		0		0		0		0		0		0
19	813	1		0		0		0		0		0		0		0		0		0		0
20-24	823	1		0		0		0		0		0		0		0	880	1	948	1		0
25-29	832	7		0		0		0	730	1		0		0		0		0		0		0
30-34	846	4		0		0		0		0		0		0		0		0		0	875	1
35+	762	1		0		0		0		0		0		0		0		0		0		0

[a] FL = Mean Fork Length.
[b] n = Number in Sample.

$$V(\hat{Z}) \simeq \lambda \hat{Z}^2 \qquad (12)$$

where:

$\lambda = (\underline{D}\ \underline{U})^{-1}$
$\underline{D}$ = a 1Xk vector of the coefficients from Table 12.
$\underline{U}$ = a kX1 unit vector; and,
$\underline{X}$ = a kX1 vector of elements X_i

where:

$$X_i = \frac{1}{(t_{n^*-k+1} - t_c)\ A_{k-1}} \qquad \textit{for } i = 1 \textit{ to } k$$

and:

t_{n^*-k+1} = the age of $(n^*-k+i)^{th}$ fish ranked according to ascending age;
n^* = the number of fully recruited fish sampled;
t_c = the age at which full recruitment occurs;
A = the coefficient from Table 11; and,
k = the number of order statistics to be used in estimating Z.

The five oldest lake trout sampled each year from each population were used for the analysis. The number of fully recruited lake trout with assigned ages in the samples and the ages for each lake are given in Table 3.

Results and Discussion

There was no detectable difference in the estimated total mortality of lake trout by year in Glacier Lake (Table 13). Hence, the estimate of mortality from the pooled data from all years from Glacier Lake is accepted. These results indicate that annual mortality does not change significantly from year to year for the lake trout population and that pooling data across years should not introduce significant bias into the estimates. For Paxson and Twobit lakes, sample sizes were smaller and some of the estimates of annual mortality were different (Table 13). In several lakes (e.g. Sevenmile Lake and Fielding Lake) small sample sizes from any one year precluded estimates of total mortality. However, the pooled data gave estimates that seem reasonable given other characteristics of these populations (Burr 1992).

The technique of Hoenig and Lawing (1983) appears to give estimates of total annual mortality that are within the range of values anticipated. Annual mortality has also been estimated for the Paxson Lake population for the years 1988 through 1990 with the Jolly Seber estimator (Burr 1989, 1990, Szarzi 1992). Estimates from Paxson Lake for 1988, 1989 and 1990 were: S=0.70 (SE = 0.058), Z=0.36; S=0.82 (SE = 0.035) Z=0.20; and S=0.73 (SE = 0.057), Z=0.31. The average estimated annual mortality for these three years is 0.297 compared with 0.25 from the Hoenig and Lawings method. The mean annual mortality from the Jolly Seber estimate is within the 95% confidence interval of the estimate from the maximum age method.

Table 11. Coefficients, Ak-i, for estimating the mortality rate Z.

Sample Size	Coefficient for k-i =					
	5	4	3	2	1	0
20	0.819	0.710	0.610	0.514	0.419	0.312
25	0.692	0.612	0.536	0.460	0.382	0.291
30	0.614	0.550	0.487	0.424	0.357	0.276
35	0.560	0.507	0.453	0.398	0.338	0.264
40	0.521	0.474	0.427	0.377	0.323	0.254
45	0.490	0.449	0.406	0.361	0.310	0.247
50	0.466	0.428	0.389	0.347	0.300	0.240
55	0.446	0.411	0.375	0.336	0.292	0.234
60	0.429	0.397	0.363	0.326	0.284	0.230
65	0.415	0.384	0.352	0.318	0.278	0.225
70	0.402	0.374	0.343	0.310	0.272	0.221
75	0.391	0.364	0.335	0.304	0.267	0.218
80	0.382	0.356	0.328	0.298	0.262	0.215
90	0.365	0.341	0.316	0.287	0.254	0.209
100	0.351	0.329	0.305	0.279	0.247	0.204
110	0.340	0.319	0.297	0.271	0.242	0.200
120	0.330	0.310	0.289	0.265	0.236	0.197
140	0.314	0.296	0.277	0.255	0.228	0.191
160	0.301	0.285	0.267	0.246	0.221	0.186
180	0.291	0.275	0.258	0.239	0.215	0.182
200	0.282	0.267	0.251	0.233	0.210	0.178
250	0.265	0.252	0.238	0.221	0.201	0.171
300	0.253	0.241	0.228	0.213	0.194	0.166
350	0.243	0.232	0.220	0.206	0.188	0.161
400	0.236	0.225	0.214	0.200	0.183	0.158
450	0.229	0.219	0.208	0.196	0.179	0.155
500	0.224	0.214	0.204	0.192	0.176	0.152
600	0.215	0.206	0.197	0.185	0.170	0.148
700	0.208	0.200	0.191	0.180	0.166	0.145
800	0.202	0.195	0.186	0.176	0.162	0.142
900	0.198	0.190	0.182	0.172	0.159	0.140
1000	0.193	0.186	0.178	0.169	0.157	0.137

Table 12. Coefficients of the row vector $\underline{D}$ for estimating the total mortality rate from the last k order statistics. (d1 corresponds to the smallest order statistic used.)

Sample Size	k = 1	k = 2		k = 3		
N	d1	d1	d2	d1	d2	d3
20	0.311	10.731	6.252	10.535	3.170	6.399
25	0.290	12.188	6.423	12.359	3.350	6.558
30	0.274	13.519	6.557	14.032	3.520	6.684
35	0.263	14.726	6.677	15.589	3.656	6.797
40	0.253	15.829	6.789	17.048	3.764	6.904
45	0.245	16.857	6.891	18.387	3.878	7.004
50	0.239	17.820	6.973	19.652	3.932	7.082
55	0.233	18.714	7.058	20.866	4.057	7.165
60	0.228	19.563	7.133	21.981	4.152	7.237
65	0.224	20.370	7.192	23.081	4.220	7.295
70	0.220	21.114	7.271	24.107	4.277	7.371
75	0.217	21.850	7.325	25.093	4.351	7.424
80	0.214	22.531	7.379	26.070	4.385	7.477
90	0.208	23.841	7.484	27.829	4.517	7.579
100	0.204	25.039	7.579	29.488	4.613	7.672
110	0.200	26.139	7.665	31.029	4.693	7.757
120	0.196	27.184	7.740	32.525	4.753	7.830
140	0.190	29.095	7.885	35.195	4.900	7.972
160	0.185	30.804	8.015	37.627	5.011	8.101
180	0.181	32.393	8.103	39.788	5.171	8.136
200	0.178	33.814	8.214	41.883	5.223	8.296
250	0.171	37.002	8.403	46.381	5.472	8.482
300	0.165	39.714	8.584	50.257	5.656	8.660
350	0.161	42.040	8.734	53.668	5.772	8.809
400	0.157	44.205	8.849	56.767	5.924	8.923
450	0.155	46.081	8.965	59.559	6.001	9.037
500	0.152	47.795	9.096	62.119	6.064	9.167
600	0.148	50.965	9.233	66.543	6.353	9.302
700	0.144	53.702	9.374	70.633	6.469	9.441
800	0.142	56.060	9.525	74.168	6.559	9.591
900	0.139	58.221	9.641	77.378	6.661	9.706
1000	0.137	60.230	9.710	80.230	6.868	9.774

-continued-

Table 12. (Page 2 of 4).

Sample Size	k = 4			
N	d1	d2	d3	d4
20	10.078	2.440	3,186	6.513
25	12.115	2.644	3.364	6.660
30	14.036	2.803	3.533	6.778
35	15.827	2.954	3.668	6.887
40	17.519	3.091	3.775	6.990
45	19.132	3.178	3.889	7.086
50	20.625	3.282	3.992	7.162
55	22.057	3.387	4.067	7.242
60	23.455	3.427	4.161	7.313
65	24.741	3.532	4.230	7.369
70	26.011	3.584	4.286	7.444
75	27.188	3.664	4.360	7.496
80	28.329	3.762	4.394	7.548
90	30.513	3.850	4.526	7.648
100	32.552	3.951	4.621	7.739
110	34.462	4.037	4.701	7.823
120	36.275	4.151	4.761	7.895
140	39.608	4.289	4.907	8.035
160	42.614	4.439	5.018	8.162
180	45.446	4.468	5.178	8.246
200	48.007	4.623	5.235	8.354
250	53.627	4.875	5.479	8.538
300	58.550	5.047	5.662	8.715
350	62.995	5.137	5.778	8.862
400	66.913	5.294	5.930	8.975
450	70.517	5.396	6.006	9.088
500	73.655	5.594	6.069	9.217
600	79.748	5.506	6.360	9.351
700	84.606	5.928	6.473	9.489
800	89.445	5.897	6.564	9.638
900	93.398	6.141	6.665	9.752
1000	97.352	6.074	6.872	9.819

-continued-

Table 12. (Page 3 of 4).

Sample Size	k = 5				
N	d1	d2	d3	d4	d5
20	9.475	2.031	2.447	3.200	6.608
25	11.636	2.235	2.651	3.376	6.744
30	13.707	2.411	2.809	3.544	6.855
35	15.687	2.544	2.959	3.678	6.959
40	17.560	2.672	3.096	3.784	7.059
45	19.333	2.808	3.182	3.897	7.152
50	21.064	2.867	3.287	4.001	7.226
55	22.683	2.958	3.391	4.075	7.305
60	24.224	3.080	3.431	4.169	7.374
65	25.745	3.114	3.537	4.237	7.429
70	27.167	3.211	3.588	4.293	7.503
75	28.564	3.239	3.668	4.368	7.553
80	29.870	3.305	3.766	4.401	7.604
90	32.384	3.424	3.854	4.533	7.702
100	34.728	3.540	3.955	4.628	7.793
110	37.005	3.593	4.041	4.707	7.875
120	39.085	3.702	4.155	4.767	7.946
140	42.917	3.901	4.292	4.913	8.085
160	46.578	3.937	4.442	5.024	8.210
180	49.757	4.173	4.471	5.184	8.293
200	52.815	4.252	4.626	5.240	8.401
250	59.713	4.298	4.877	5.483	8.583
300	65.598	4.463	5.050	5.666	8.758
350	70.829	4.684	5.139	5.782	8.904
400	75.353	4.931	5.296	5.934	9.016
450	79.566	5.134	5.398	6.010	9.128
500	83.639	5.016	5.597	6.073	9.256
600	90.622	5.477	5.509	6.364	9.389
700	97.002	5.240	5.930	6.477	9.527
800	102.501	5.651	5.899	6.567	9.675
900	107.736	5.442	6.143	6.669	9.788
1000	112.096	5.867	6.076	6.876	9.855

-continued-

Table 12. (Page 4 of 4).

Sample Size	k = 6					
N	d1	d2	d3	d4	d5	d6
20	8.843	1.716	2.035	2.453	3.212	6.693
25	11.052	1.929	2.238	2.656	3.386	6.817
30	13.232	2.091	2.414	2.814	3.553	6.921
35	15.326	2.247	2.547	2.964	3.686	7.021
40	17.345	2.366	2.675	3.100	3.792	7.117
45	19.290	2.456	2.810	3.186	3.905	7.208
50	21.125	2.600	2.870	3.291	4.008	7.280
55	22.917	2.674	2.960	3.395	4.082	7.357
60	24.608	2.757	3.082	3.435	4.176	7.425
65	26.222	2.886	3.116	3.540	4.244	7.479
70	27.813	2.941	3.213	3.592	4.300	7.552
75	29.322	3.042	3.241	3.671	4.374	7.601
80	30.345	3.047	3.307	3.769	4.407	7.652
90	33.660	3.151	3.426	3.357	4.538	7.748
100	36.279	3.254	3.542	3.958	4.633	7.337
110	38.749	3.419	3.595	4.043	4.722	7.919
120	41.158	3.447	3.704	4.157	4.772	7.989
140	45.661	3.456	3.902	4.295	4.913	8.126
160	49.543	3.801	3.939	4.445	5.023	8.250
180	53.354	3.755	4.175	4.473	5.188	8.333
200	56.790	3.895	4.254	4.628	5.245	8.439
250	64.591	4.193	4.300	4.880	5.488	8.620
300	71.189	4.488	4.464	5.052	5.670	8.794
350	77.300	4.572	4.686	5.141	5.786	8.938
400	82.353	4.431	4.932	5.298	5.937	9.050
450	87.398	4.407	5.136	5.400	6.014	9.162
500	92.287	4.772	5.018	5.599	6.077	9.289
600	100.489	4.859	5.479	5.510	6.367	9.422
700	107.835	5.081	5.241	5.932	6.480	9.558
800	114.013	5.365	5.652	5.901	6.570	9.705
900	120.076	5.535	5.443	6.145	6.672	9.818
1000	125.371	5.454	5.868	6.078	6.878	9.884

Table 13. Total annual mortality estimated from eight lake trout populations in Alaska.

Waterbody	Recruitment Age	Recruitment Year	Sample Size	Ages used	Estimated Total Mortality Z	V [Z]	95% CI
Glacier Lake	6	1986	152	26,26,26,28,29	0.18	0.00051	0.14 to 0.23
		1989	99	24,24,27,32,33	0.18	0.00062	0.14 to 0.23
		1990	90	22,23,23,26,31	0.19	0.00068	0.14 to 0.24
		Pooled	352	28,29,31,32,33	0.20	0.00042	0.16 to 0.24
Twobit Lake	7	1986	74	22,23,23,26,30	0.19	0.00075	0.14 to 0.24
		1987	72	22,23,25,25,28	0.09	0.00017	0.06 to 0.11
		1988	24	19,21,21,24,26	0.16	0.00079	0.10 to 0.21
		Pooled	170	25,26,26,28,30	0.17	0.00065	0.13 to 0.23
Paxson Lake	6	1987	69	28,24,24,22,22	0.18	0.00070	0.13 to 0.23
		1988	58	24,24,26,28,29	0.15	0.00055	0.10 to 0.19
		1989	37	19,19,20,25,29	0.16	0.00079	0.10 to 0.21
		1990	78	22,26,27,27,28	0.18	0.00065	0.13 to 0.26
		1991	88	24,26,27,30,30	0.18	0.00060	0.13 to 0.23
		1992	134	19,20,20,21,27	0.25	0.00099	0.19 to 0.31
		Pooled	472	28,29,29,30,30	0.25	0.00060	0.20 to 0.30
Sevenmile Lake	3	Pooled	94	13,14,14,14,15	0.32	0.00192	0.23 to 0.40
Fielding Lake	4	Pooled	81	12,12,14,15,24	0.33	0.00223	0.24 to 0.42
Upper and Round Tangle	5	Pooled	69	14,14,17,21,23	0.28	0.00175	0.20 to 0.36
Landlocked Tangle	8	1987	119	25,26,26,26,29	0.20	0.00068	0.15 to 0.25
Butte	6	Pooled	105	11,12,13,15,19	0.55	0.00555	0.40 to 0.70

The technique appears to yield reasonable estimates of mortality for these lake trout populations. Annual mortality is unlikely to change significantly (assuming equilibrium) for different age classes of adult lake trout given their life history characteristics. The likelihood of sampling fish in the oldest age classes during a single year is low. Therefore, the estimate derived from samples pooled across years is probably most realistic. For most Alaskan lake trout populations data necessary for conventional methods of estimating annual mortality are not available. This method provides the best estimates of annual mortality and survival presently available.

ACKNOWLEDGEMENTS

The author wishes to thank Mark Zeller who assisted with the field work associated with this study. Thanks also to Sandra Sonnichsen for editorial comments. Appreciation is extended to Margaret Merritt and John H. Clark for editorial comments and support in all aspects of this project. I also thank the U. S. Fish and Wildlife Service for funding support through the Federal Aid in Fish Restoration Act, (16 U.S.C. 777-777K) under Project F-10-8, Job Number R-3-3(a-1).

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APPENDIX A

Appendix A1. Length distribution of all lake trout sampled from stocked lakes during 1992.

Length Category	Age-1			Age-3			Age-4			All Ages		
	#	%	SE	#	%	SE	#	%	SE	#	%	SE
100	1	0.3	0.002	0	0.0	0	0	0.0	0	1	0.1	0.000
110	23	5.9	0.011	0	0.0	0	0	0.0	0	24	1.4	0.002
120	66	16.9	0.018	0	0.0	0	0	0.0	0	71	4.2	0.004
130	36	9.2	0.014	1	0.2	0.001	0	0.0	0	44	2.6	0.003
140	20	5.1	0.011	0	0.0	0	0	0.0	0	24	1.4	0.002
150	29	7.4	0.013	0	0.0	0	0	0.0	0	29	1.7	0.003
160	25	6.4	0.012	0	0.0	0	0	0.0	0	25	1.5	0.002
170	35	9.0	0.014	0	0.0	0	0	0.0	0	35	2.1	0.003
180	61	15.6	0.018	4	0.7	0.003	1	0.2	0.002	68	4.1	0.004
190	63	16.1	0.018	34	6.0	0.010	1	0.2	0.002	104	6.2	0.005
200	22	5.6	0.011	79	14.1	0.014	12	2.8	0.007	125	7.4	0.006
210	7	1.8	0.006	93	16.5	0.015	25	5.8	0.011	153	9.1	0.007
220	1	0.3	0.002	77	13.7	0.014	30	6.9	0.012	153	9.1	0.007
230	0	0.0	0	72	12.8	0.014	49	11.3	0.015	155	9.2	0.007
240	2	0.5	0.003	40	7.1	0.010	19	4.4	0.009	77	4.6	0.005
250	0	0.0	0	50	8.9	0.012	18	4.1	0.009	82	4.9	0.005
260	0	0.0	0	47	8.4	0.011	27	6.2	0.011	92	5.5	0.005
270	0	0.0	0	27	4.8	0.009	32	7.4	0.012	69	4.1	0.004
280	0	0.0	0	16	2.8	0.007	35	8.1	0.013	69	4.1	0.004
290	0	0.0	0	11	2.0	0.005	29	6.7	0.012	53	3.2	0.004
300	0	0.0	0	2	0.4	0.002	39	9.0	0.013	55	3.3	0.004
310	0	0.0	0	2	0.4	0.002	31	7.1	0.012	46	2.7	0.003
320	0	0.0	0	0	0.0	0	21	4.8	0.010	28	1.7	0.003
330	0	0.0	0	1	0.2	0.001	13	3.0	0.008	22	1.3	0.002
340	0	0.0	0	1	0.2	0.001	13	3.0	0.008	17	1.0	0.002
350	0	0.0	0	0	0.0	0	11	2.5	0.007	16	1.0	0.002
360	0	0.0	0	0	0.0	0	5	1.2	0.005	11	0.7	0.001
370	0	0.0	0	0	0.0	0	4	0.9	0.004	5	0.3	0.001
380	0	0.0	0	0	0.0	0	2	0.5	0.003	2	0.1	0.000
390	0	0.0	0	0	0.0	0	1	0.2	0.002	2	0.1	0.000
400	0	0.0	0	0	0.0	0	1	0.2	0.002	2	0.1	0.000
410	0	0.0	0	2	0.4	0.002	1	0.2	0.002	3	0.2	0.001
420	0	0.0	0	0	0.0	0	3	0.7	0.003	3	0.2	0.001
430	0	0.0	0	2	0.4	0.002	1	0.2	0.002	3	0.2	0.001
440	0	0.0	0	0	0.0	0	2	0.5	0.003	2	0.1	0.000
450	0	0.0	0	1	0.2	0.001	1	0.2	0.002	2	0.1	0.000
460	0	0.0	0	0	0.0	0	1	0.2	0.002	1	0.1	0.000
470	0	0.0	0	0	0.0	0	2	0.5	0.003	2	0.1	0.000
480	0	0.0	0	0	0.0	0	2	0.5	0.003	2	0.1	0.000
490	0	0.0	0	0	0.0	0	1	0.2	0.002	1	0.1	0.000
500	0	0.0	0	0	0.0	0	1	0.2	0.002	1	0.1	0.000
Total	391			562			434			1,679		

Appendix A2. Length distribution of all lake trout sampled from Coalmine #5 Lake during 1992.

Length Category	Age-1 #	Age-1 %	Age-1 SE	Age-3 #	Age-3 %	Age-3 SE	Age-4 #	Age-4 %	Age-4 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	7	38.9	0.118	0	0.0	0	0	0.0	0	7	2.2	0.008
130	7	38.9	0.118	0	0.0	0	0	0.0	0	7	2.2	0.008
140	4	22.2	0.100	0	0.0	0	0	0.0	0	4	1.2	0.006
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	0	0.0	0	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	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	0	0.0	0	0	0.0	0	0	0.0	0
230	0	0.0	0	5	5.0	0.021	0	0.0	0	5	1.5	0.006
240	0	0.0	0	3	3.0	0.016	0	0.0	0	4	1.2	0.006
250	0	0.0	0	21	20.8	0.040	2	1.6	0.011	24	7.4	0.014
260	0	0.0	0	34	33.7	0.047	5	4.0	0.017	48	14.8	0.019
270	0	0.0	0	18	17.8	0.038	8	6.5	0.022	31	9.5	0.016
280	0	0.0	0	11	10.9	0.031	14	11.3	0.028	34	10.5	0.017
290	0	0.0	0	6	5.9	0.023	12	9.7	0.026	27	8.3	0.015
300	0	0.0	0	2	2.0	0.013	26	21.0	0.036	41	12.6	0.018
310	0	0.0	0	1	1.0	0.009	23	18.5	0.035	36	11.1	0.017
320	0	0.0	0	0	0.0	0	7	5.6	0.020	11	3.4	0.010
330	0	0.0	0	0	0.0	0	11	8.9	0.025	18	5.5	0.012
340	0	0.0	0	0	0.0	0	3	2.4	0.013	6	1.8	0.007
350	0	0.0	0	0	0.0	0	8	6.5	0.022	11	3.4	0.010
360	0	0.0	0	0	0.0	0	2	1.6	0.011	7	2.2	0.008
370	0	0.0	0	0	0.0	0	2	1.6	0.011	3	0.9	0.005
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	1	0.8	0.008	1	0.3	0.003
400	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
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	18			101			124			325		

Appendix A3. Length distribution of all lake trout sampled from Pauls Pond during 1992.

Length Category	Age-1			Age-3			Age-4			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	1	25.0	0.25	0	0.0	0	0	0.0	0	1	0.4	0.003
130	2	50.0	0.288	0	0.0	0	0	0.0	0	2	0.8	0.005
140	1	25.0	0.25	0	0.0	0	0	0.0	0	1	0.4	0.003
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	0	0.0	0	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	0	0.0	0
200	0	0.0	0	3	2.4	0.013	0	0.0	0	3	1.1	0.006
210	0	0.0	0	10	8.1	0.024	0	0.0	0	10	3.8	0.011
220	0	0.0	0	17	13.8	0.031	0	0.0	0	17	6.5	0.015
230	0	0.0	0	24	19.5	0.035	0	0.0	0	25	9.5	0.018
240	0	0.0	0	20	16.3	0.033	1	0.8	0.008	22	8.4	0.017
250	0	0.0	0	22	17.9	0.034	4	3.3	0.016	27	10.3	0.018
260	0	0.0	0	11	8.9	0.025	12	10.0	0.027	26	9.9	0.018
270	0	0.0	0	7	5.7	0.020	18	15.0	0.032	26	9.9	0.018
280	0	0.0	0	3	2.4	0.013	20	16.7	0.034	27	10.3	0.018
290	0	0.0	0	4	3.3	0.016	13	10.8	0.028	18	6.9	0.015
300	0	0.0	0	0	0.0	0	12	10.0	0.027	12	4.6	0.012
310	0	0.0	0	0	0.0	0	8	6.7	0.022	8	3.1	0.010
320	0	0.0	0	0	0.0	0	12	10.0	0.027	15	5.7	0.014
330	0	0.0	0	1	0.8	0.008	2	1.7	0.011	3	1.1	0.006
340	0	0.0	0	1	0.8	0.008	8	6.7	0.022	9	3.4	0.011
350	0	0.0	0	0	0.0	0	3	2.5	0.014	3	1.1	0.006
360	0	0.0	0	0	0.0	0	3	2.5	0.014	3	1.1	0.006
370	0	0.0	0	0	0.0	0	2	1.7	0.011	2	0.8	0.005
380	0	0.0	0	0	0.0	0	2	1.7	0.011	2	0.8	0.005
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
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	4			123	100		120			262		

Appendix A4. Length distribution of all lake trout sampled from North Twin Lake during 1992.

Length Category	Age-1		
	Number	Percent	SE
100	0	0.0	0
110	0	0.0	0
120	0	0.0	0
130	0	0.0	0
140	1	0.5	0.00
150	6	2.9	0.01
160	20	9.5	0.02
170	33	15.7	0.03
180	59	28.1	0.03
190	61	29.0	0.03
200	21	10.0	0.02
210	6	2.9	0.01
220	1	0.5	0.005
230	0	0.0	0
240	2	1.0	0.01
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
410	0	0.0	0
420	0	0.0	0
430	0	0.0	0
440	0	0.0	0
450	0	0.0	0
460	0	0.0	0
470	0	0.0	0
480	0	0.0	0
490	0	0.0	0
500	0	0.0	0
Total	210		

Appendix A5. Length distribution of all lake trout sampled from Chet Lake during 1992.

Length Category	Age-1			Age-3			Age-4			All Ages		
	#	%	SE	#	%	SE	#	%	SE	#	%	SE
100	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
120	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
140	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
160	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
180	0	0		3	1.9	0.011	0	0.0	0	5	1.4	0.006
190	0	0		23	14.9	0.028	1	1.2	0.012	28	7.8	0.014
200	0	0		33	21.4	0.033	3	3.7	0.020	40	11.2	0.016
210	0	0		44	28.6	0.036	9	11.0	0.034	69	19.3	0.020
220	0	0		31	20.1	0.032	17	20.7	0.045	83	23.2	0.022
230	0	0		12	7.8	0.021	18	22.0	0.045	59	16.5	0.019
240	0	0		7	4.5	0.016	12	14.6	0.039	29	8.1	0.014
250	0	0		1	0.6	0.006	9	11.0	0.034	20	5.6	0.012
260	0	0		0	0.0	0	8	9.8	0.032	13	3.6	0.009
270	0	0		0	0.0	0	3	3.7	0.020	6	1.7	0.006
280	0	0		0	0.0	0	0	0.0	0	1	0.3	0.002
290	0	0		0	0.0	0	2	2.4	0.017	3	0.8	0.004
300	0	0		0	0.0	0	0	0.0	0	0	0.0	0
310	0	0		0	0.0	0	0	0.0	0	0	0.0	0
320	0	0		0	0.0	0	0	0.0	0	0	0.0	0
330	0	0		0	0.0	0	0	0.0	0	1	0.3	0.002
340	0	0		0	0.0	0	0	0.0	0	0	0.0	0
350	0	0		0	0.0	0	0	0.0	0	0	0.0	0
360	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
380	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
400	0	0		0	0.0	0	0	0.0	0	0	0.0	0
410	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
430	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
450	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
470	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
490	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
Total	0			154			82			357		

Appendix A6. Length distribution of all lake trout sampled from Nickel Lake during 1992.

Length Category	Age-1 #	Age-1 %	Age-1 SE	Age-3 #	Age-3 %	Age-3 SE	Age-4 #	Age-4 %	Age-4 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	3	30.0	0.152	0	0.0	0	0	0.0	0	4	1.3	0.006
120	5	50.0	0.166	0	0.0	0	0	0.0	0	6	2.0	0.007
130	0	0.0	0	1	0.6	0.006	0	0.0	0	3	1.0	0.005
140	2	20.0	0.133	0	0.0	0	0	0.0	0	3	1.0	0.005
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	0	0.0	0	1	0.6	0.006	1	1.2	0.012	2	0.7	0.004
190	0	0.0	0	11	6.7	0.019	0	0.0	0	13	4.3	0.011
200	0	0.0	0	43	26.4	0.034	9	11.0	0.034	60	19.7	0.022
210	0	0.0	0	39	23.9	0.033	16	19.5	0.044	67	22.0	0.023
220	0	0.0	0	29	17.8	0.030	13	15.9	0.040	52	17.0	0.021
230	0	0.0	0	30	18.4	0.030	31	37.8	0.053	65	21.3	0.023
240	0	0.0	0	6	3.7	0.014	6	7.3	0.028	15	4.9	0.012
250	0	0.0	0	2	1.2	0.008	3	3.7	0.020	7	2.3	0.008
260	0	0.0	0	1	0.6	0.006	2	2.4	0.017	4	1.3	0.006
270	0	0.0	0	0	0.0	0	1	1.2	0.012	2	0.7	0.004
280	0	0.0	0	0	0.0	0	0	0.0	0	2	0.7	0.004
290	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
300	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
310	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
320	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
330	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
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	0	0.0	0	0	0.0	0
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
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	10			163			82			305		

Appendix A7. Length distribution of all lake trout sampled from Ghost Lake during 1992.

Length Category	Age-1 #	Age-1 %	Age-1 SE	Age-3 #	Age-3 %	Age-3 SE	Age-4 #	Age-4 %	Age-4 SE	All Ages #	All Ages %	All Ages SE
100	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
120	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
140	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
160	0	0		0	0.0	0	0	0.0	0	1	3.2	0.032
170	0	0		0	0.0	0	0	0.0	0	0	0.0	0
180	0	0		0	0.0	0	0	0.0	0	0	0.0	0
190	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
210	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
230	0	0		1	6.3	0.062	0	0.0	0	1	3.2	0.032
240	0	0		4	25.0	0.111	0	0.0	0	5	16.1	0.067
250	0	0		4	25.0	0.111	0	0.0	0	4	12.9	0.061
260	0	0		1	6.3	0.062	0	0.0	0	1	3.2	0.032
270	0	0		2	12.5	0.085	2	22.2	0.146	4	12.9	0.061
280	0	0		2	12.5	0.085	1	11.1	0.111	5	16.1	0.067
290	0	0		1	6.3	0.062	2	22.2	0.146	5	16.1	0.067
300	0	0		0	0.0	0	1	11.1	0.111	1	3.2	0.032
310	0	0		1	6.3	0.062	0	0.0	0	1	3.2	0.032
320	0	0		0	0.0	0	2	22.2	0.146	2	6.5	0.044
330	0	0		0	0.0	0	0	0.0	0	0	0.0	0
340	0	0		0	0.0	0	1	11.1	0.111	1	3.2	0.032
350	0	0		0	0.0	0	0	0.0	0	0	0.0	0
360	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
380	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
400	0	0		0	0.0	0	0	0.0	0	0	0.0	0
410	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
430	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
450	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
470	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
490	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
Total	0			16			9			31		

Appendix A8. Length distribution of all lake trout sampled from Rapids Lake during 1992.

Length Category	Age-1		
	Number	Percent	SE
100	1	3.1	0.03
110	2	6.3	0.04
120	1	3.1	0.03
130	2	6.3	0.04
140	7	21.9	0.07
150	17	53.1	0.09
160	2	6.3	0.04
170	0	0.0	0
180	0	0.0	0
190	0	0.0	0
200	0	0.0	0
210	0	0.0	0
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
410	0	0.0	0
420	0	0.0	0
430	0	0.0	0
440	0	0.0	0
450	0	0.0	0
460	0	0.0	0
470	0	0.0	0
480	0	0.0	0
490	0	0.0	0
500	0	0.0	0
COUNT	32		

Appendix A9. Length distribution of all lake trout sampled from Craig Lake during 1992.

	Age-1		
Length Category	Number	Percent	SE
100	0	0.0	0
110	0	0.0	0.00
120	0	0.0	0
130	3	20.0	0.11
140	2	13.3	0.09
150	4	26.7	0.12
160	2	13.3	0.09
170	2	13.3	0.09
180	2	13.3	0.09
190	0	0.0	0
200	0	0.0	0
210	0	0.0	0
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
410	0	0.0	0
420	0	0.0	0
430	0	0.0	0
440	0	0.0	0
450	0	0.0	0
460	0	0.0	0
470	0	0.0	0
480	0	0.0	0
490	0	0.0	0
500	0	0.0	0
Total	15		

Appendix A10. Length distribution of all lake trout sampled from Fourmile Lake during 1992.

Length Category	Age-1 Number	Age-1 Percent	Age-1 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	0	0.0	0
190	2	50.0	0.29
200	1	25.0	0.25
210	1	25.0	0.25
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
410	0	0.0	0
420	0	0.0	0
430	0	0.0	0
440	0	0.0	0
450	0	0.0	0
460	0	0.0	0
470	0	0.0	0
480	0	0.0	0
490	0	0.0	0
500	0	0.0	0
Total	4		

Appendix A11. Length distribution of all lake trout sampled from Fourteenmile Lake during 1992.

	Age-1		
Length Category	Number	Percent	SE
100	0	0.0	0
110	17	15.7	0.04
120	56	51.9	0.05
130	27	25.0	0.04
140	6	5.6	0.02
150	2	1.9	0.01
160	0	0.0	0
170	0	0.0	0
180	0	0.0	0
190	0	0.0	0
200	0	0.0	0
210	0	0.0	0
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
410	0	0.0	0
420	0	0.0	0
430	0	0.0	0
440	0	0.0	0
450	0	0.0	0
460	0	0.0	0
470	0	0.0	0
480	0	0.0	0
490	0	0.0	0
500	0	0.0	0
Total	108		

Appendix A12. Length distribution of all lake trout sampled from Summit Lake during 1992.

Length Category	Age-1			Age-3			Age-4			All Ages		
	#	%	SE	#	%	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	0	0		0	0.0	0	0	0		0	0.0	0
290	0	0		0	0.0	0	0	0		0	0.0	0
300	0	0		0	0.0	0	0	0		0	0.0	0
310	0	0		1	50.0	0.5	0	0		1	50.0	0.5
320	0	0		0	0.0	0	0	0		0	0.0	0
330	0	0		0	0.0	0	0	0		0	0.0	0
340	0	0		0	0.0	0	0	0		0	0.0	0
350	0	0		0	0.0	0	0	0		0	0.0	0
360	0	0		1	50.0	0.5	0	0		1	50.0	0.5
370	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
390	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
410	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
430	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
450	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
470	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
490	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
Total	0			2			0			2		

Appendix A13. Length distribution of all lake trout sampled from Triangle Lake during 1992.

Length Category	Age-1			Age-3			Age-4			All Ages		
	#	%	SE	#	%	SE	#	%	SE	#	%	SE
100	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
120	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
140	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
160	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
180	0	0		0	0.0	0	0	0.0	0	0	0.0	0
190	0	0		0	0.0	0	0	0.0	0	0	0.0	0
200	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
220	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
240	0	0		0	0.0	0	0	0.0	0	0	0.0	0
250	0	0		0	0.0	0	0	0.0	0	0	0.0	0
260	0	0		0	0.0	0	0	0.0	0	0	0.0	0
270	0	0		0	0.0	0	0	0.0	0	0	0.0	0
280	0	0		0	0.0	0	0	0.0	0	0	0.0	0
290	0	0		0	0.0	0	0	0.0	0	0	0.0	0
300	0	0		0	0.0	0	0	0.0	0	0	0.0	0
310	0	0		0	0.0	0	0	0.0	0	0	0.0	0
320	0	0		0	0.0	0	0	0.0	0	0	0.0	0
330	0	0		0	0.0	0	0	0.0	0	0	0.0	0
340	0	0		1	16.7	0.166	0	0.0	0	1	4.5	0.045
350	0	0		0	0.0	0	0	0.0	0	0	0.0	0
360	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
380	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
400	0	0		0	0.0	0	1	6.3	0.062	1	4.5	0.045
410	0	0		2	33.3	0.210	1	6.3	0.062	3	13.6	0.074
420	0	0		0	0.0	0	3	18.8	0.100	3	13.6	0.074
430	0	0		2	33.3	0.210	1	6.3	0.062	3	13.6	0.074
440	0	0		0	0.0	0	2	12.5	0.085	2	9.1	0.062
450	0	0		1	16.7	0.166	1	6.3	0.062	2	9.1	0.062
460	0	0		0	0.0	0	1	6.3	0.062	1	4.5	0.045
470	0	0		0	0.0	0	2	12.5	0.085	2	9.1	0.062
480	0	0		0	0.0	0	2	12.5	0.085	2	9.1	0.062
490	0	0		0	0.0	0	1	6.3	0.062	1	4.5	0.045
500	0	0		0	0.0	0	1	6.3	0.062	1	4.5	0.045
Total	0			6			16			22		

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
Bullwinkle	1989	None	1
Chet Lake	1991	Adipose	0
Coal Mine #5	1991	Adipose	10
Craig	1991	None	5
Fourmile	1991	None	0
Fourteenmile	1991	None	25
Nickel	1991	Adipose	10
North Twin	1991	None	18
Paul's Pond	1991	Adipose	4
Rapids	1991	None	7
Summit	1989	None	2

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:

-continued-

$$\hat{p} = \frac{a}{n}$$

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

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 experimentwise 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: $\mu_{scales} = \mu_{otoliths} = \mu_{opercular}$
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: $\beta = 0$
H_a: $\beta < 0$.