Fishery Data Series No. 95-43

Abundance and Length Composition of Cutthroat Trout in Florence, Turner, and Young Lakes, Southeast Alaska, 1994

by

Roger D. Harding

December 1995

Alaska Department of Fish and Game

Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

FISHERY DATA SERIES NO. 95-43

ABUNDANCE AND LENGTH COMPOSITION OF CUTTHROAT TROUT IN FLORENCE, TURNER, AND YOUNG LAKES, SOUTHEAST ALASKA, 1994

by

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December 1995

This investigation was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-9 and F-10-10, Job No. R-1-1.

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This document should be cited as:
Harding, Roger D. 1995. Abundance and Length Composition of Cutthroat Trout in Florence, Turner, and Young Lakes, Southeast Alaska, 1994. Alaska Department of Fish and Game, Fishery Data Series No. 95-43, Anchorage.

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ABSTRACT

Mark-recapture experiments were conducted to estimate abundance of cutthroat trout *Oncorhynchus clarki* in Florence, Turner, and Young lakes in Southeast Alaska in 1994. Baited minnow-type traps and hook and line were used to capture fish during sampling trips, Florence Lake was sampled four times between April 23 and June 12, 1994, and between July 12 and Turner Lake was sampled four times between September 8. Two sampling trips were used to estimate abundance in Young Lake; the first from June 6 through June 9, 1994, the second from September 15 through September 17, 1994. The abundance of cutthroat trout in Florence Lake was an estimated 10,787 (SE = 674) fish ≥180 mm fork length; in Turner Lake abundance was an estimated 2,107 (SE=148) fish ≥180 mm fork length, and abundance in Young Lake an estimated 1,562 (SE=185) fish ≥180 mm fork length.

INTRODUCTION

In 1988, the Division of Sport Fish began a research program on cutthroat trout in Southeast Alaska. This program was initiated because the regionwide harvest of cutthroat trout had dropped by almost 50% in a 14-year period. Through this program, abundance and status has been determined for stocks in several lakes. Based on these research data, data from other studies, and extensive public comment, new fishery regulations were adopted in 1994 that affect all cutthroat trout fisheries in the Southeast Alaska (Appendix A1). Beginning in 1994, the cutthroat trout research project redirected its studies to gather information to verify the efficacy and correctness of the new regulations and to obtain data to estimate sustained yield in major trout fisheries. As part of this program, studies in 1994 focused on Florence , and Turner lakes (Figure 1).

To estimate Maximum Sustainable Yield (MSY), two essential biological parameters are needed: annual survival rate and surplus production. Annual survival rate can estimated using a multiple event Jolly-Seber abundance experiment (Seber 1982) and surplus production can be obtained by estimating the change in biomass (Ricker 1975). While biomass is typically used in MSY models, we can use abundance if we remember that there is about a four-year lag between adult spawning and the contribution of their progeny (recruitment) to production. A multiple year abundance experiment was completed at Florence Lake in 1994 which will provide an estimate of annual survival. An estimate of abundance at Turner Lake in 1994, combined with the 1990 Turner Lake abundance estimate, will provide an estimate of surplus production. The length composition from Florence, Turner, and Young lakes will provide data to estimate the percentage of the cutthroat trout available for legal harvest under the new trout regulations.

A cooperative agreement between Alaska Department of Fish and Game, Sport Fish Division and the US Forest Service, Admiralty Island National Monument, was signed in March, 1995. The main objective of this agreement was to gather baseline cutthroat trout population data from small lakes on Admiralty Island. As part of this agreement, an abundance experiment were conducted at Young Lake (Figure 1) during 1994.

Florence Lake lies approximately 50 km southwest of Juneau, on the west side of Admiralty Island at long. 134°4' W, lat. 58°3' N; the 431-hectare lake is narrow (<1 km wide) and about 7.2 km long, with a maximum depth of approximately 27 m (Figure 2). Florence Lake has been a popular fly-in lake, but active clearcut logging at the lake may reduce angler visits. The lake outlet flows about 1 km into Chatham Strait and passes over a barrier falls about 400 m upstream of tidewater, blocking the lake to anadromous species.

The Division of Sport Fish has studied Florence Lake cutthroat trout from 1989 to 1994, as part of a study to develop gear and methods for estimating annual trout abundance, and to gather data for a multiple year Jolly-Seber abundance experiment.

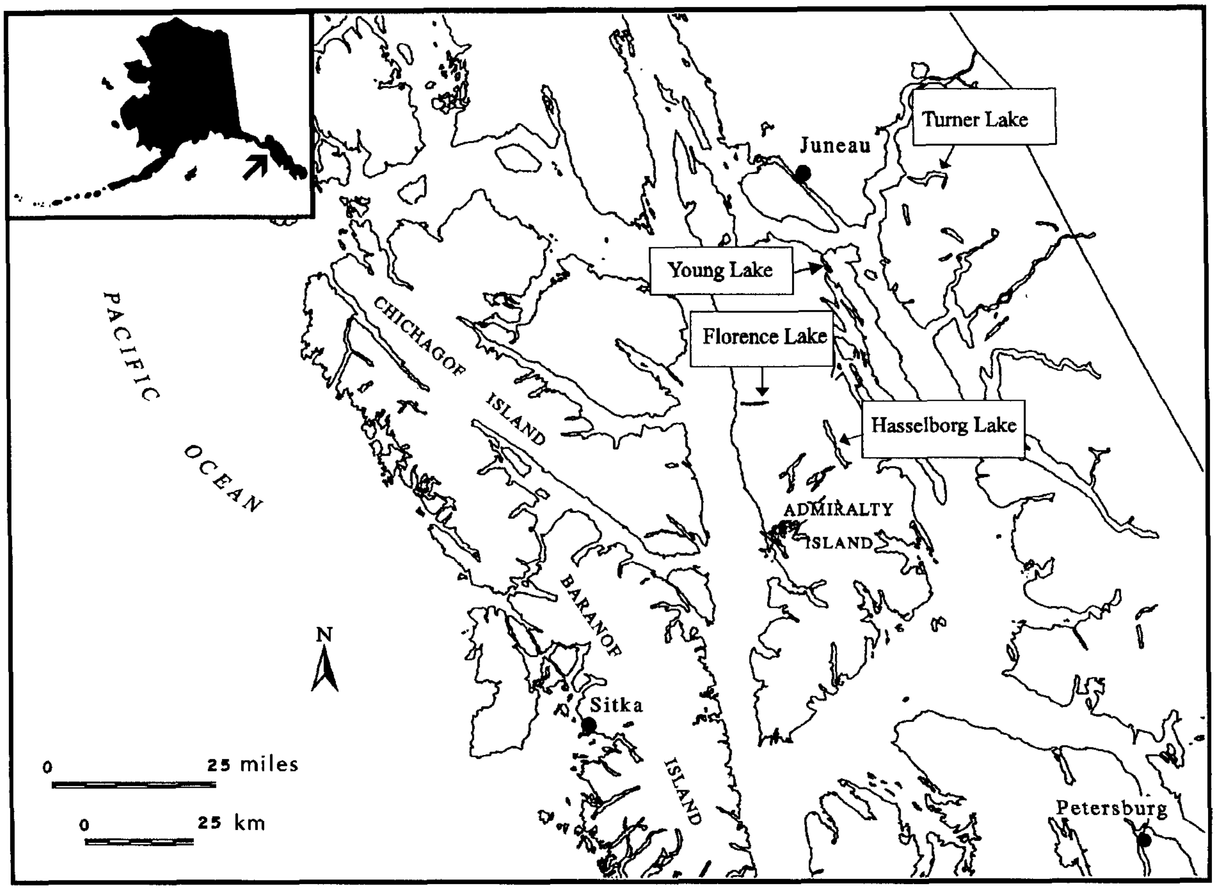


Figure 1.–Location of Turner, Florence, and Young lakes, northern Southeast Alaska.

Turner Lake is located in upper Taku Inlet, 26 km east of Juneau (Figure 3). Turner Lake is 14 km long and has a surface elevation of just over 22 m. The lake is very steep-sided except near inlet streams, covers about 1,270 hectares, and has a maximum depth of 215 m (Schmidt 1979). The lake outlet flows about 1,700 m from the lake to the Taku Inlet and is blocked to upstream fish passage by a barrier falls just below the lake. Turner Lake receives some of the most concentrated angling pressure for cutthroat trout in Southeast Alaska (Jones 1994).

Young Lake is located approximately 5 km from tidewater on the east coast of Admiralty Island and flows into Admiralty Cove. The lake is 2.6 km long and 0.3 km wide, and its deepest point is approximately 30 m deep (Figure 4). Two USFS recreational cabins are on Young Lake, and the lake is a popular destination for hunters and fishermen.

The objectives of the research in 1994 were:

(1) to estimate abundance of cutthroat trout ≥180 mm fork length in Turner, Florence, and Young lakes such that the estimates were within ± 25% of the true value 95% of the time; and

(2) estimate length composition of the cutthroat trout ≥180 mm fork length in Turner, Florence, and Young Lakes such that the estimate is within ± 5% of the true value 95% of the time.

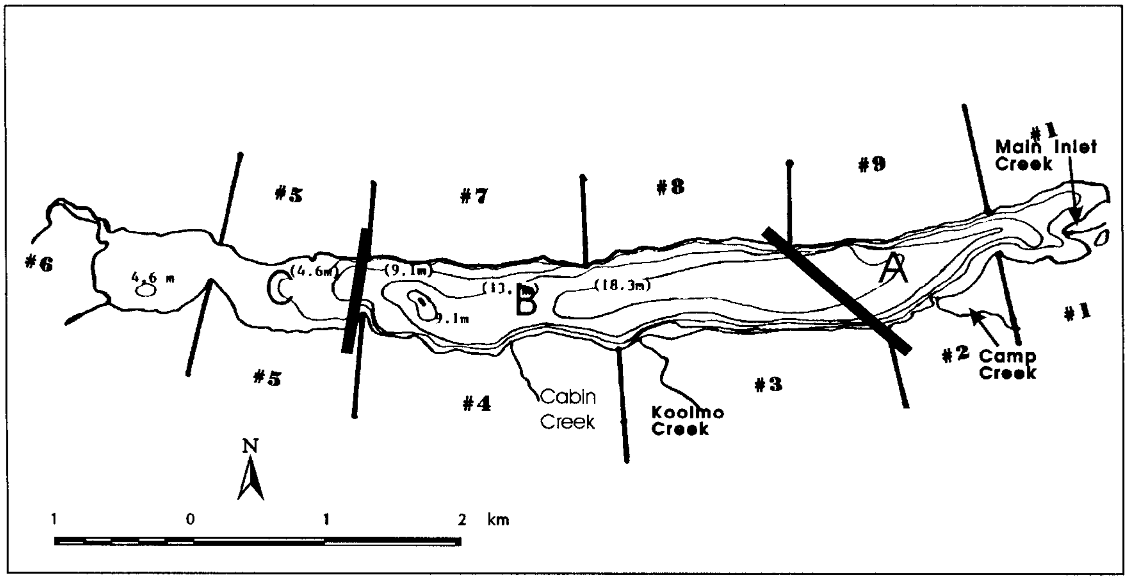


Figure 2.–Bathymetric map of Florence Lake on Admiralty Island, Southeast Alaska, showing location of large sampling areas. Sampling area "A" comprises zones 1,2, and 9; sampling area "B" comprises zones 3, 4, 7, and 8; and sampling area "C" comprises zones 5 and 6.

An additional task in 1994 was the operation of two weirs on small (<1.5 m) Florence Lake inlet streams. These weirs provided a means to capture immigrant spawning cutthroat and select previously tagged ripe females for otolith and fecundity sampling. Otolith samples from fish tagged from 1990 through 1992 were needed to complete an age validation study. Ovarian samples from large (>300 mm FL) cutthroat trout were needed to improve our estimates of fecundity for larger fish. The weirs were also operated to provide information about the number of spawners and migration timing.

Results from the multiple event jolly-Seber abundance experiment at Florence and the estimation of surplus production at Turner Lake will be reported in future reports i.e., only the annual abundance and length compositions are reported here. Estimates of age composition of cutthroat trout at Turner and Florence Lakes will be reported at the conclusion of the age validation study, and fecundity results will also be reported in a future report.

METHODS

FLORENCE AND TURNER LAKES

Abundance

The abundance of cutthroat trout in Florence and Turner Lakes was estimated by using two-event mark-recapture experiments. Sampling took place at Florence Lake between April 23 and May 14 (marking event) and between May 21 and June 12 (recapture event) and at Turner Lake between July 12 and August 4 (marking event) and between August 16 and September 8 (recapture event). Large minnow-type traps (or large traps) baited with Betadine-treated salmon eggs, and hook and line, were used to capture cutthroat trout during each sampling event. Hoop nets were also used at Turner Lake. The large traps were 1.5 m long and 0.6 m in diameter, with a 9-cm opening in each end of the trap and a mesh size of 1 cm. Hoop nets used at Turner Lake were 1.4 m long and consisted of four 0.6-m-diameter hoops with 9-cm-diameter throats attached to the first and third hoops, and a mesh size of 1 cm; hoop nets were held open with two spreader bars, each 2 cm wide by 1.5 m long.

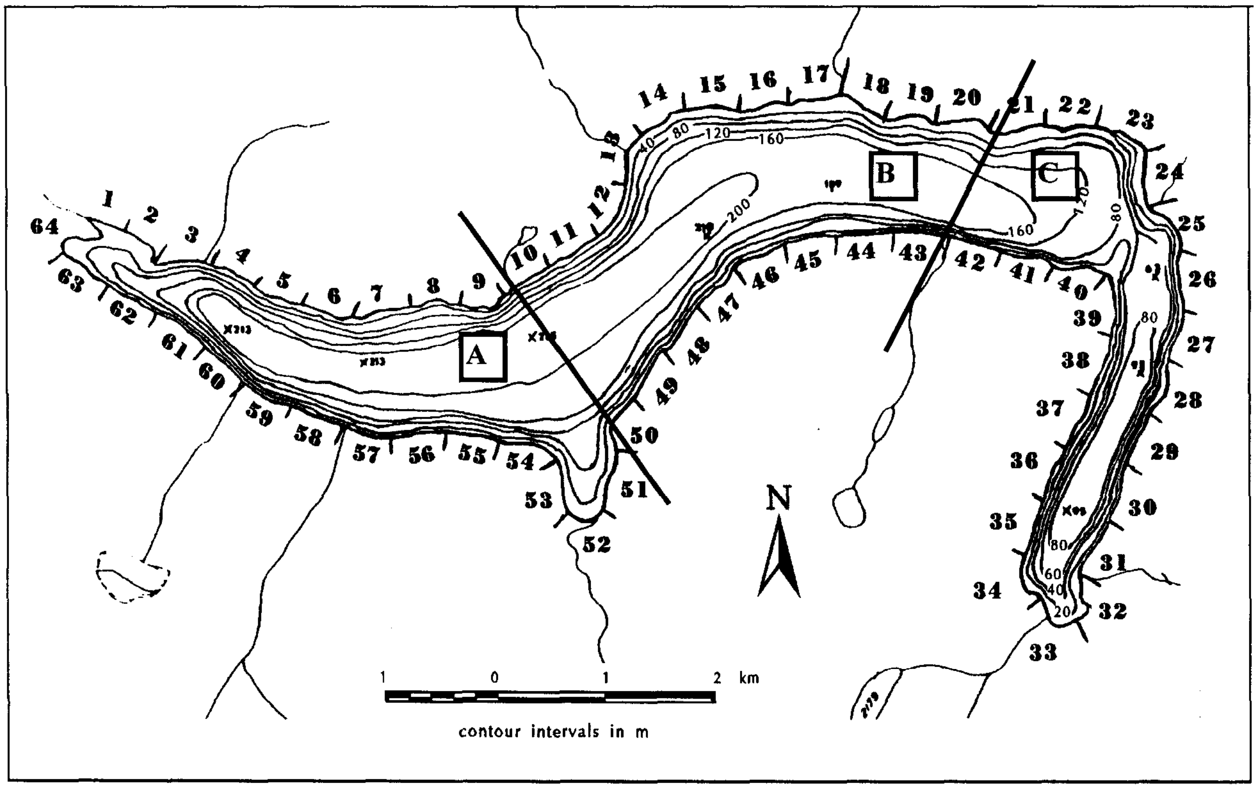


Figure 3. –Bathymetric map of Turner Lake, northern southeast Alaska, showing location of sampling areas. The numbers are the study area locations used during the 1988-1990 study and the three large areas (A, B, and C) were used during 1994.

Captured, untagged cutthroat trout ≥180 mm fork length (FL) in good physical condition were tagged with a uniquely numbered T-bar (Floy) anchor tag, sampled for scales, and measured to the nearest mm FL, then returned to the lake. Recaptured cutthroat trout tagged during 1994 were measured and the tag number recorded; fish recaptured from previous years were measured, scale sampled, and tag number recorded. The ≥180 mm size category was selected to match the size ranges anglers tend to keep; cutthroat trout <180 mm FL were simply counted and returned to the lake.

The large traps were rotated between three study areas, or zones, in Florence Lake (see Figure 2) and three zones in Turner Lake (see Figure 3) during each of four 10-day sampling periods. Periods 1 and 2 were combined to form 'event' 1 (marking); periods 3 and 4 were combined to form event 2 (recapture). The number of traps set in each zone was based on the proportion of total lake surface in each zone (Tables 1 and 2).

In Florence Lake, traps were set in a roughly uniform distribution across each zone without regard to depth; in Turner Lake the gear was uniformly distributed across each zone between the margin of the lake and 30 m in depth. As time permitted, hook and line sampling was done with sport fishing gear, using small lures, flies, or spinners.

The assumptions necessary for accurate estimation of abundance in a closed population are (Seber 1982 pg. 59):

1. the population is closed (i.e., the effects of migration and mortality and recruitment are negligible);

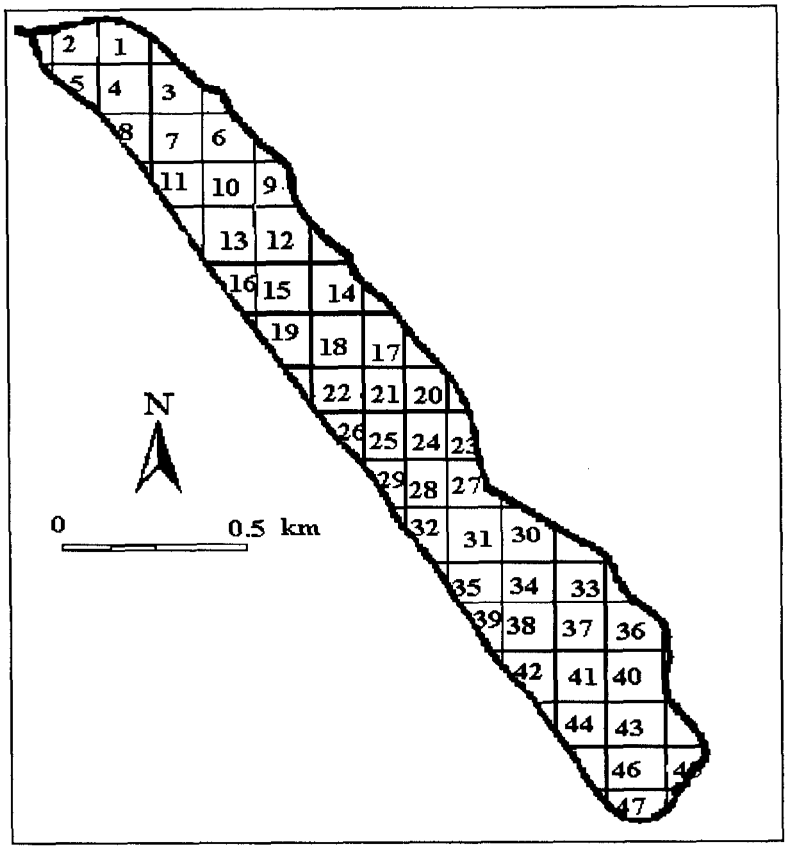


Figure 4.–Map of Young Lake area, northern southeast Alaska, showing location of sampling areas.

2. all cutthroat trout have the same probability of capture in the marking event or in the recapture event, or marked and unmarked cutthroat trout mix completely between the marking and recapture sampling events;
3. marking of cutthroat trout does not affect their probability of capture during the recapture event;
4. cutthroat trout do not loose their mark between sampling events; and,
5. all cutthroat trout are reported when recovered during the recapture event.

Testing of Assumptions

The first assumption could not be tested directly. However, physical migrations from or to Florence and Turner Lakes are not possible due to barrier falls in the outlet stream and deaths and growth recruitment are not expected to be significant due to the short duration between mark and recapture events. However mature adult fish make seasonal spawning migrations out of the study area. These migrations occur in May, when the first sampling occurred at Florence Lake. However, most fish were probably back in the lake for the second event. Assumptions 4 and 5 were assumed to be valid because of double marking and rigorous examination of all cutthroat trout captured.

Assumptions 2 and 3 were tested in two ways. First, the capture probability between different areas of the lakes may be significantly different. To determine if capture probability did differ between areas, each lake was divided into three areas and the fractions of marked fish captured from each area was compared using a chi-square contingency table. If the hypothesis of equal marking ratio was accepted (alpha = 0.05), either every fish has an equal probability of being caught during the first event or marked fish mixed completely between events. Under these circumstances abundance was estimated with the Chapman estimators (Seber 1982):

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

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

where

$\hat{N}$ = abundance of cutthroat trout ≥180 mm FL;

n_1 = number of cutthroat trout ≥180 mm FL marked in event 1;

n_2 = number of cutthroat trout ≥180 mm FL examined in event 2; and

m_2 = number of marked cutthroat trout recaptured in event 2.

If the hypothesis of equal marked fractions were rejected, the data were stratified by area and abundance was estimated using the Darroch estimator (Seber 1982, Darroch 1961):

$$\hat{\underline{U}} = D_u M^{-1} \underline{a} \qquad (3)$$

where

$\underline{U}$ = vector of the estimated number of unmarked fish in each area j during the second sampling event;

D_u = diagonal matrix of the number of unmarked fish captured in each area j during the second sampling event;

M = matrix (m_{ij}) of the number of tagged fish recovered in area (j) which were released in area i; and,

$\underline{a}$ = vector of the number of tagged fish released in area i.

The estimate of abundance is then $\hat{N} = \hat{U} + A$, where U and A are sums of the vector elements in $\hat{\underline{U}}$ and $\underline{a}$, respectively.

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

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

[a] areas of Florence Lake as described in Figure 2.

Table 2.–Estimated surface area (km^2), proportion of surface area in each sampling zone, and number of traps set in each zone in Turner Lake.

Sampling zone [a]	Surface area (km^2) between (0 and 40 m)	Proportion in zone <30m	No. of large traps
1	0.72	0.33	59
2	0.56	0.26	47
3	0.95	0.41	74
Total	2.23	1.00	180

[a] areas of Turner Lake as described in Figure 3.

Statistical bias and variance of the estimate were estimated using the bootstrap technique (Efron 1982, Bernard and Hansen 1992). Tag histories were resampled 2,500 times, abundance was estimated for each sample. The bootstrap estimates of abundance $\bar{N}*$ and its variance were:

$$\bar{N}* = \frac{\sum_{s=1}^{B} N_s *}{B} \qquad (4)$$

$$V[\bar{N}*] = \frac{\sum_{s=1}^{B} (N *_S - \bar{N}*)^2}{B-1} \qquad (5)$$

where B is the number of bootstrap and N^*_s is the estimated abundance from the sth bootstrap sample. Statistics of interest are abundance $\hat{N}$, the variance $V[\bar{N}^*]$, and statistical bias $|\hat{N} - \bar{N}^*|$.

Size selective sampling during either the marking or recapture events may occur. Two Kolmogorov-Smirnov (KS) statistical tests were then used to determine if capture probability differs by size of fish. The first KS test compared the length frequency distribution of recaptured cutthroat trout with those captured during the marking event. The second KS test compared the length frequency distribution of cutthroat trout captured in the marking event with those captured during the recapture event. (Appendix A3; Bernard and Hansen 1992). The first KS test was used to determine if sampling during the recapture event was size selective. If so, sizes for stratifying the experiment were determined with a series if chi-square tests using 20 mm and 30 mm size classes. The size at stratification that produced the largest chi-square value (i.e., the greatest difference in capture probability) was used to stratify the data for separate abundance estimation. The second KS test was used to determine if estimates of age and size data needed to be corrected for changes in capture probability (see Length Composition below).

YOUNG LAKE

Abundance

Abundance in Young Lake was estimated using the procedures described above except as noted below. Sampling took place from June 6 through June 9 (marking event) and from September 14 through September 17 (recapture event).

Young Lake was divided into a grid containing 47 individual sample squares (Figure 4). To ensure equal probability of capture during the marking and recapture events, sample squares were randomly selected each day using a random number table.

During the marking event, six hoop nets and one large trap were used, and during the recapture event, nine hoop nets were used. One trap was set overnight in each of the selected sample squares without regard to depth. As time permitted, sampling with hook and line was done using small lures, flies, or spinners.

Captured, unmarked cutthroat trout ≥180 mm FL in good physical condition were given an adipose clip (marking event), sampled for scales, and measured to the nearest mm FL, then returned to the lake; cutthroat trout <180 mm FL were simply counted and returned to the lake.

During the recapture event, captured, unmarked cutthroat trout ≥180 mm FL in good physical condition were sampled for scales, measured to the nearest mm FL, and given an adipose clip and an upper dorsal clip; recaptured fish from the marking event (i.e. adipose clip) were given upper dorsal and upper caudal clips.

Since fish were not uniquely marked the capture probability between different areas of the lake could not be tested, size selective sampling was tested with a Kolmogorov-Smirnov (K-S) as described above.

FLORENCE LAKE

Spawning Migrations

Small two-way weirs or 'wolf traps,' were built on Cabin and Koolmo Creeks at Florence Lake, each of which was approximately 1.5 m wide (Figure 2), to capture immigrant and emigrant cutthroat trout >100 mm FL. Cabin Creek weir was operated April 21 through June 8, but was not fish-tight from May 21-22 because of high water. Koolmo Creek weir was operated April 22 through June 10. All immigrant and emigrant cutthroat trout captured were counted, tagged with a numbered T-bar anchor tag, sampled as described above, and allowed to continue their migration. Fish tagged at the weir were not used in the abundance experiment.

Otolith and Fecundity Samples

Otolith and fecundity samples were collected from cutthroat collected at Florence Lake using large trap, hook and line, and weirs. Otoliths were collected to complete an age validation study and fecundity samples were collected to improve our estimates of fecundity. Our otolith sample goal was to collect otoliths from 20 fish marked in 1990, 1991, and 1992 (a total of 60 samples).

Few fecundity samples from large cutthroat (>300 mm FL) have ever been collected at Florence Lake. Thus, large ripe females recaptured from 1990 through 1992 were sacrificed for fecundity and otolith samples. Fish selected for sampling were held in large traps until they could be sent to Juneau for sampling. All sacrificed fish were sampled for length, weight, scales, otoliths, and fecundity. Eggs were removed from the body cavity of each fish and counted.

FLORENCE, TURNER, AND YOUNG LAKES

Length Composition

Methods for estimating length composition depends on results from two KS tests. The first KS test (described above) determines if size selectivity occurred in the recovery event and the second is used to determine if selectivity occurred in the first or marking event (Appendix A3; Bernard and Hansen 1992). If there were no size-selectivity during sampling, length composition in 20 mm length classes k was estimated:

$$\hat{p}_k = \frac{n_k}{n} \qquad (6)$$

$$V[\hat{p}_k] = \frac{\hat{p}_k(1 - \hat{p}_k)}{n - 1} \qquad (7)$$

where n is the number of fish sampled to estimate length composition, n_k is the number of fish sampled in length class k, and $\hat{p}_k$ is the estimated proportion of fish in length class k

If size-selective sampling occurred, corrections to reduce bias were required (Appendix A3; Bernard and Hansen 1992).

The estimated abundance of cutthroat trout in length class k was calculated as

$$\hat{\mathbf{N}}_{\mathbf{k}} = \hat{\mathbf{p}}_{\mathbf{k}}\hat{\mathbf{N}} \qquad (8)$$

The variance of $\hat{N}_k$ was estimated using the formula for the exact variance of the product of two independent random variables (Goodman 1960):

$$V[\hat{N}_k] = V[\hat{p}_k]\hat{N}^2 + V[\hat{N}]\hat{p}_k^2 - V[\hat{p}_k]V[\hat{N}] \qquad (9)$$

Mean length and variance of cutthroat trout in the mark-recapture sample were calculated using standard statistical formulae (Cochran 1977).

RESULTS

FLORENCE LAKE

Abundance

A total of 3,165 cutthroat trout ≥180 mm FL was caught with baited large traps and hook and line between April 23 and June 12, 1994 (Table 3, Figure 5). In addition, 170 trout were captured in weirs on inlet streams, but these fish were not included in the abundance estimate because they may not have mixed completely with other fish during the experimental period or may have had a higher mortality rate than trout captured in the lake (Appendix A2). In the first sampling event, 1,610 cutthroat trout between 180 mm and 425 mm FL were newly tagged or recaptured from a previous year (Table 4).

During the second sampling event, 1,278 cutthroat trout between 180 mm FL and 360 mm FL were inspected for marks; 1,275 fish were measured, and of these 190 had been 'marked' (either newly marked or recaptures from previous years) in the first sampling event.

The distribution of lengths of fish recaptured in event 2 was significantly different from the distribution of fish marked in event 1 (d_{max} = 0.11, P = 0.031; Figure 6), suggesting the second sampling event was size selective. Therefore, tests were made to determine optimal length intervals for stratifying the abundance estimate by length. To conduct the tests, data were stratified into 20-mm and 30-mm size intervals. Results (Chi-square) for lengths grouped in 20-mm increments (six classes; X^2 = 8.865; P = 0.181; df = 6) and 30-mm increments (five classes; X^2 = 6.023, P = 0.197; df = 4) were not significantly different, suggesting that the differences in marked fractions were not functionally significant.

Finally, mixing of fish between sampling areas occurred between sampling events (Table 5), and the hypothesis of equal probability of capture by area is accepted (X^2 = 4.258, df = 2, P = 0.119; Table 6), suggesting that the Peterson estimator was appropriate for estimating abundance.

Abundance of cutthroat trout in Florence Lake ≥180 mm FL was estimated at 10,787 (SE = 674) using an unstratified Peterson model. Relative precision for the estimate is ± 12%, for a 95% confidence interval. To test the assumption that size selectivity was not functionally significant, a stratified Peterson model (stratified by length stratum) was also used to estimate the abundance of fish (Table 7). The estimated stratified abundance for trout between 180 and 210 mm FL was 5, 327 (SE = 433) and the abundance of trout between 211 and 410 mm FL was 5,519 (SE = 535).The combined stratified estimate was 10,846 (SE = 688) fish, within 0.5% of the non-stratified Peterson estimate.

To allow comparisons to previous abundance estimates at Florence Lake, the Darroch model was also used to estimate the abundance of trout. The Darroch model estimated the abundance of cutthroat in Florence Lake ≥180 mm FL at 6,029 (SE = 8,413). The Darroch model was unstable and resulted in highly variable abundance estimates for areas B and C; 28,652 (SE = 14,099) and -31,974 (SE =21,534), respectively (Table 5). The bootstrap method estimated abundance of fish 52% above the Darroch estimate, but the bootstrap estimates were unstable. Relative precision for the estimate is ± 19%, for a 95% confidence interval.

Table 3.–Sampling effort (hours), catch, and catch per unit effort (CPUE, fish per hour) by period, gear, and species, Florence Lake, 1994.

			Cutthroat trout ≥180 mm		Cutthroat trout <180 mm		Dolly Varden	
Period	**Gear**	**Effort**	Catch	CPUE	Catch	CPUE	Catch	CPUE
1	Hook and line	6	1	0.18	0	0	0	0
	Large trap	2,176	814	0.37	231	0.11	2,819	1.3
2	Hook and line	14	6	0.43	0	0	3	0.21
	Large trap	2,318	898	0.39	295	0.13	3,659	1.58
3	Hook and line	18	62	3.44	18	1	4	0.22
	Large trap	2,269	697 [a]	0.31	276	0.12	2,443	1.08
4	Hook and line	16	80	5.12	28	1.79	16	1.02
	Large trap	2,290	607 [b]	0.27	267	0.12	1,798	0.79
Total	Hook and line	53	149	2.80	46	0.87	23	0.43
	Large trap	9,053	3,016	0.33	1,069	0.12	10,719	1.18
Grand Total			3,165		1,115		10,742	

[a] One fish escaped before being sampled.

[b] Two fish escaped before being sampled.

Spawning Migrations

One hundred eighty-eight (188) cutthroat trout were captured at Cabin and Koolmo Creek weirs (130 immigrants and 58 emigrants). Trout spent from less than a day to nearly a month in the stream after immigration, with the majority of fish spending three to seven days. Immigration occurred from April 13 through May 31, 1994, dates that are similar to dates of immigration in the same creeks in 1993 and two other inlet streams in 1992 (Figure 7).

Of the 130 immigrants ≥180 mm FL, 115 were classified by sex and were measured for length; 46 were females and averaged 248 mm FL (SE = 4 mm), and 69 were males and averaged 234 mm FL (SE = 5 mm). One male

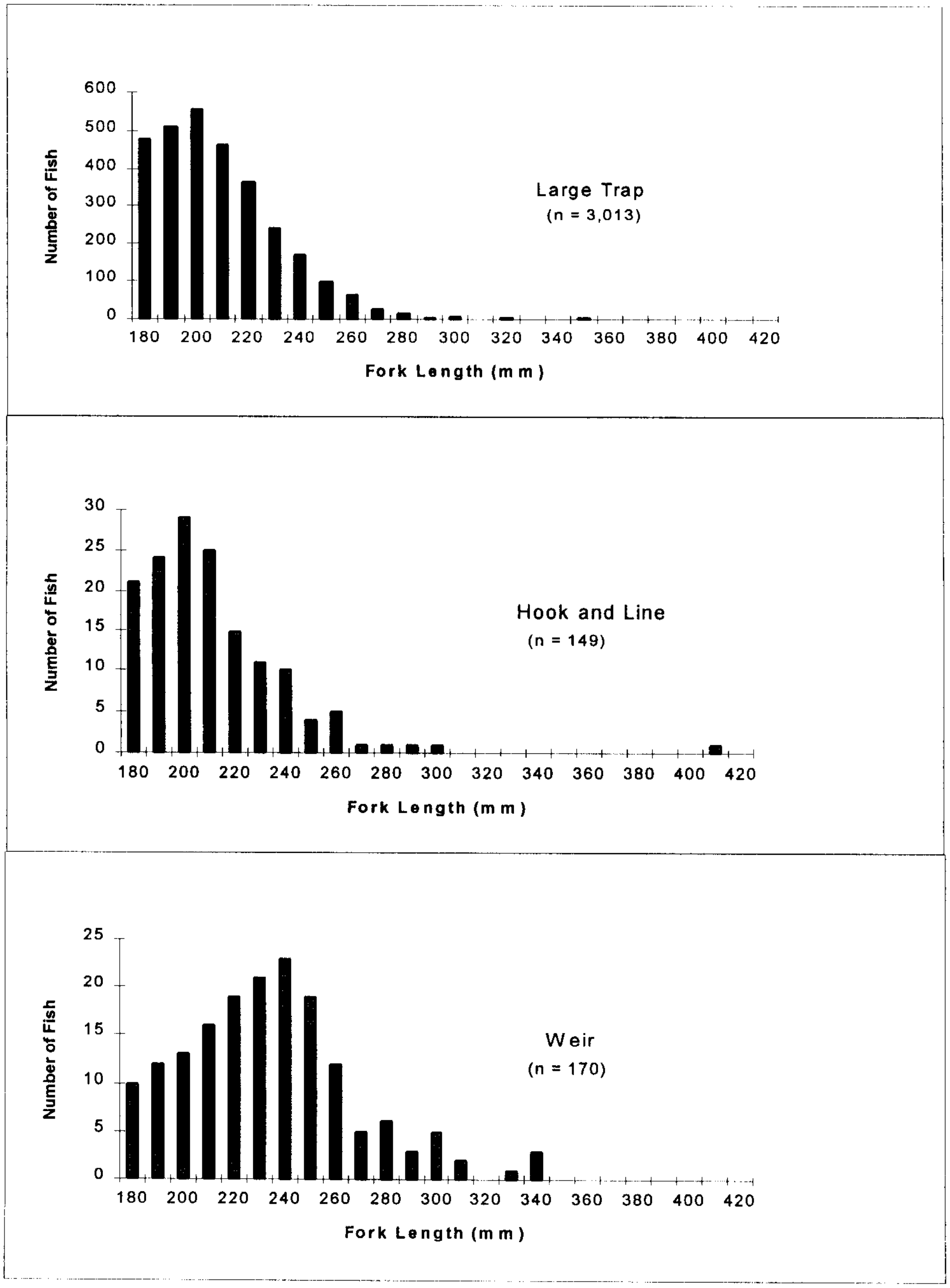


Figure 5.–Length frequency of cutthroat trout captured at Florence Lake, by gear type, 1994.

was not measured, three fish were not sexed, and eleven ripe males <180 mm FL were passed upstream (Appendix A2).

Otolith and Fecundity Samples

Fifty-six (56) cutthroat trout > 180 mm FL were sacrificed for otolith and fecundity samples at Florence Lake during 1994. Matching otoliths and paired scales were also collected from 84 juvenile cutthroat between 25 mm FL and 179 mm FL. Many of the fish sampled for otoliths had already spawned, and only nine fecundity samples were collected; only two fecundity samples collected were from fish which exceeded 300 mm FL.

Length Composition

The length frequency distributions of cutthroat trout captured during the first and second sampling events were significantly different (d_{max} = 0.067, P = 0.029) (Figure 6), suggesting size selectivity during the first event (marking). Therefore length data collected during the second event (recapture) were used to estimate the length composition estimates of cutthroat trout ≥180 mm FL (Table 8; Appendix A3; Bernard and Hansen 1992). Although there are no size regulations regarding minimum sizes for harvests of cutthroat trout at Florence Lake, only about 1.5% of the population would be eligible for harvest under the current Southeast Alaska regionwide minimum size limit of 12 inches (287 mm FL).

Table 4.–Summary of cutthroat trout tagging and recovery data for all fish used in abundance experiment, Florence Lake, 1994. Marking event 1 is periods 1 and 2; recapture event or event 2 is periods 3 and 4.

	1994 Sampling periods			
	Newly Marked		Recaptured	
	Period 1 4/11 - 4/20	Period 2 4/25 - 5/4	Period 3 5/15 - 5/24	Period 4 5/29 - 6/7
Newly tagged fish released alive	677[a]	728	594	380
Recaptured fish tagged during:				
1988				
1989	3		1	
1990	9	1		2
1991	15	1	2	3
1992	26	15	5	3
1993	72	65	14	11
1994 - event 1			101	48
Captured, not tagged			2	
Removed from experiment for fecundity sample	4	23[b]	19	16
Transported to Juneau [c]				77
Redundant catch; within period	9	14	21	23
Redundant catch; within event		57		124
Total catch	815	904	759	687

[a] Includes 2 fish marked and released but killed during Period 2 for Fecundity sample; these two were not used in mark/recap abundance estimate.

[b] Includes 3 mortalities and the two fish marked during Period 1.

[c] Newly captured fish examined for marks and transported to Juneau for stocking into Twin Lakes at conclusion of abundance experiment.

Table 5.–Number of cutthroat trout marked but not recaptured in any area (ai), number of marked fish recaptured by area of recapture (mi,j), and number of unmarked fish caught by area (uj) during the second sampling event at Florence Lake, 1994.

Area fish was marked	Total fish marked	Marked but not recaptured (a_i),	Number of marked fish recaptured by area of recapture (m_{ij})		
			A[a]	B[b]	C[c]
A	497	454	27	13	3
B	1,147	1,004	16	108	19
C	152	148	0	4	0
Total marked fish recaptured			43	125	22
Unmarked fish caught (u_j)			302	629	157

[a] Study zones 1,2, and 9; $\hat{N}_A$ = 6,336 ±5,414 at time of sampling (bootstrap SE = 10,279).

[b] Study zones 3, 4, 7, and 8; $\hat{N}_B$ = 28,652 ±14,099 at time of sampling (bootstrap SE = 19,755).

[c] Study zones 5 and 6; $\hat{N}_C$=-31,974 ±21,534 at time of sampling (bootstrap SE = 37,065).

Table 6.–Numbers of marked and unmarked cutthroat trout captured in sampling event 2, by recovery area, Florence Lake, 1994.

	Recovery area			
	A[a]	B[b]	C[c]	
Marked fish	43	125	22	190
Unmarked fish	302	629	157	1,088
	345	754	179	1,278

X^2 = 4.258, df = 2, P = 0.119

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

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

[c] Study zones 5 and 6.

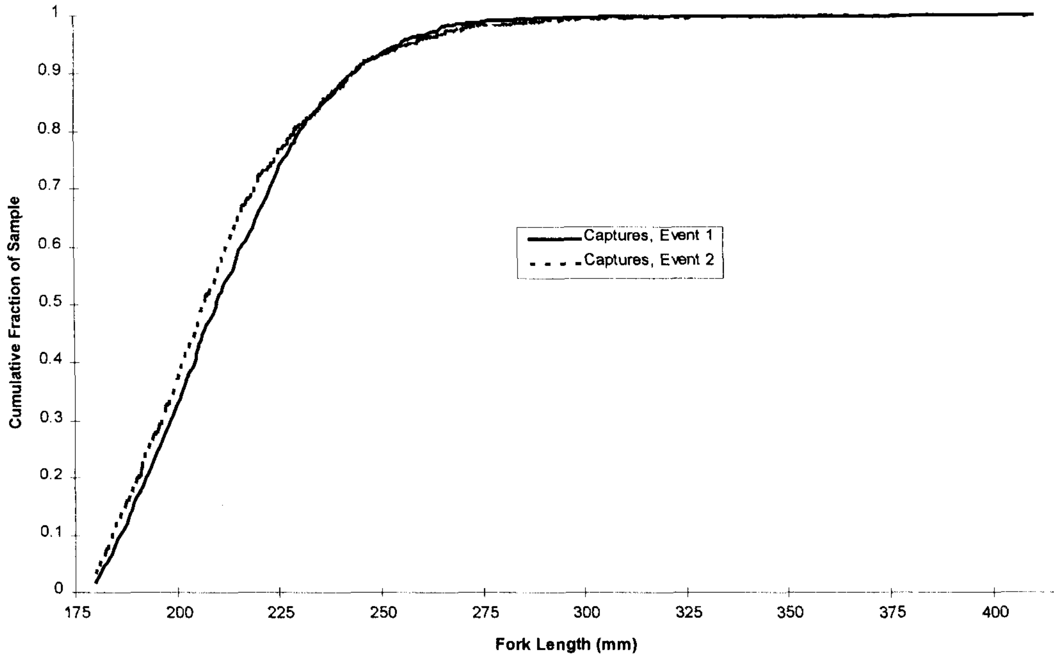
TURNER LAKE

Abundance

A total of 1,141 cutthroat trout ≥180 mm FL was caught with large traps, hoop nets, and hook and line at Turner Lake between July 12 and September 8, 1994 (Table 9, Figure 8). In the first sampling event, 605 cutthroat trout between 180 mm and 601 mm FL were newly tagged or recaptured from a previous year (Table 10). During the second sampling event, 536 cutthroat trout between 180 mm FL and 561 mm FL were inspected for marks; 170 of these fish had been 'marked' (either newly marked or recaptures from previous years) in the first sampling event.

There was no significant difference (d_{max} = 0.124, P = 0.078) (Figure 9) between the distribution of lengths of fish recaptured in event 2 and the distribution of lengths of fish marked in event 1. Thus the second sampling event was not size selective, and abundance was estimated without stratifying by length.

Though some mixing of fish between sampling areas did occur between sampling events (Table 11) the hypothesis of equal probability of capture by area is rejected (X^2 = 9.76, df = 2, P = 0.008; Table 12), suggesting that Darroch's estimator should be used to estimate abundance. Estimated abundance for trout ≥180 mm Fl was 2,107 (SE=148). The bootstrap suggested bias in the estimate and variance was small, 1.5% and 1.7% respectively. Bootstrap estimates were stable; i.e., no unrealistic capture probabilities were included in the simulation. Relative precision for the estimate was ± 14%, for a 95% confidence interval.



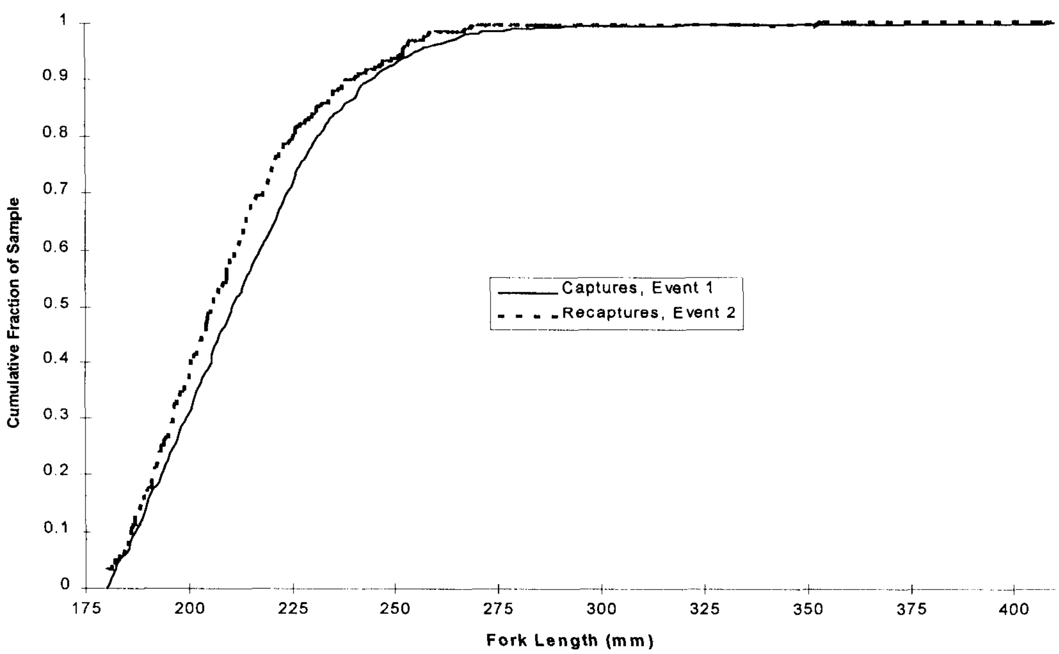


Figure 6.–Cumulative histogram of lengths of cutthroat trout marked versus lengths of cutthroat trout examined for marks (upper panel) and versus lengths of cutthroat trout recaptured (lower panel), Florence Lake, 1994.

Table 7.–Peterson abundance estimates of cutthroat trout ≥180 mm FL (unstratified), and for fish 180–210 mm FL and 211–410 mm FL (stratified) at Florence Lake during 1994.

	Unstratified estimates	Stratified estimates [a]		
	≥180 mm FL	180–210 mm	211–410 mm	180–410 mm
n1 =	1,610	821	789	1,610
n2 =	1,278	712	565	1,277
m2 =	190	109	80	189 0
$\hat{N}$ =	10,787	5,327	5,519	10,846 0
V[$\hat{N}$] =	45,4481	187,349	285,790	473,139
SE =	674	433	535	688

[a] One fish was not measured during recapture event and was not included in this estimate; i.e., n2 = 1,278 in unstratified and n2 = 1,277 in stratified estimates.

Length Composition

The length distributions of cutthroat trout recaptured during the second event were not significantly different (d_{max} = 0.124, P = 0.078; Figure 9) from the length of fish marked during event 1. There was also no significant difference between the distribution of lengths of fish captured in event 1 and the distribution of lengths of all fish captured in event 2 (d_{max} = 0.063, P = 0.233; Figure 9), further suggesting that there was no size selectivity during either sampling event. Consequently, length data from both events were pooled to estimate length composition of cutthroat trout ≥180 mm FL. Harvest of cutthroat trout in Turner Lake is currently prohibited; however, no fish in Turner Lake were caught during our sampling that were larger than the regional size limit for trophy lakes of 25 inches (602 mm FL) (Table 13). Thirty-one percent (31%) of the cutthroat in Turner Lake are estimated to exceed the 12-inch regional size limit.

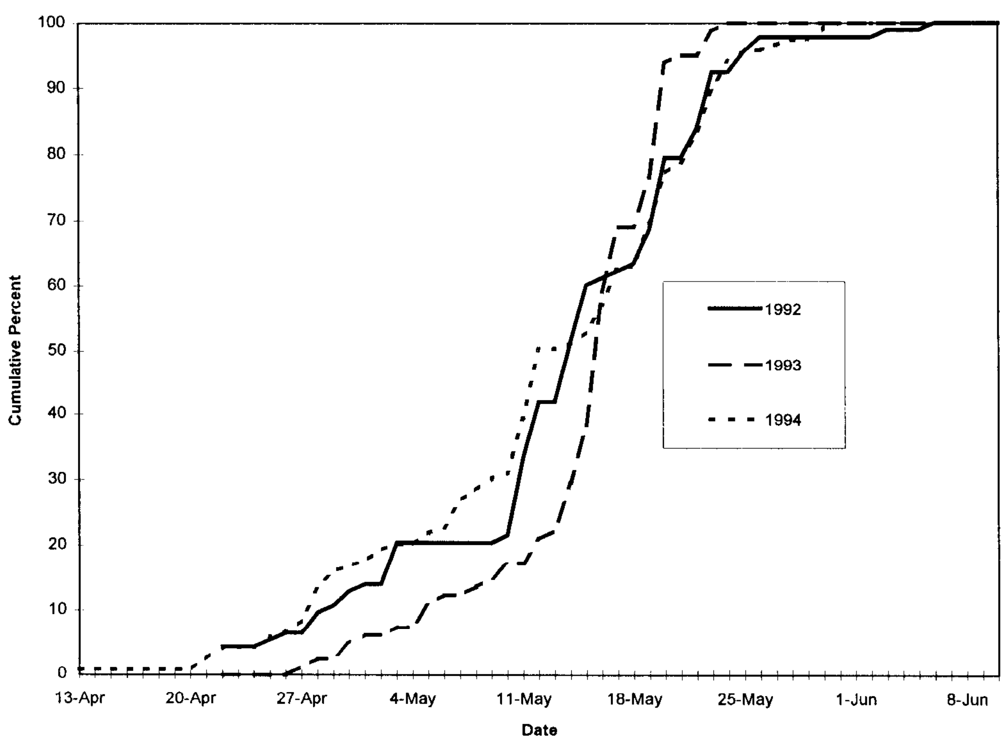


Figure 7.–Cumulative percent of cutthroat trout immigrating through the Cabin and Koolmo Creek weirs in 1993 and 1994, and through Camp, Main Inlet and Koolmo Creeks in 1992, at Florence Lake. All immigrant data from both weirs are combined for each year.

Table 8.–Length composition and estimated abundance at length for cutthroat trout ≥180 mm FL, Florence Lake, 1994. The proportion (pk), abundance (Nk), standard error (SE), and coefficient of variation (CV) for each 20 mm length class are shown.

Length k, mm FL	n_k	p_k	SE[p_k]	CV[p_k]	N_k	SE[N_k]	CV[N_k]
180 - 200	475	0.372	0.014	0.036	4,012	290	0.072
201 - 220	436	0.341	0.013	0.039	3,683	271	0.074
221 - 240	206	0.161	0.010	0.064	1,740	155	0.089
241 - 260	109	0.085	0.008	0.092	921	102	0.111
261 - 280	32	0.025	0.004	0.175	270	50	0.185
281 - 300	10	0.008	0.002	0.315	84	27	0.321
301 - 320	4	0.003	0.002	0.499	34	17	0.502
321 - 340	3	0.002	0.001	0.577	25	15	0.579
341 - 360	2	0.002	0.001	0.707	17	12	0.708
n	1,277				10,787		

Table 9.–Sampling effort (hours), catch, and catch per unit effort (CPUE, fish per hour) by period, gear, and species, Turner Lake, 1994.

			Cutthroat ≥180 mm		**Cutthroat <180 mm**		**Dolly Varden**	
Period [a]	**Gear**	**Effort**	Catch	CPUE	Catch	CPUE	Catch	CPUE
1	Hook and line	27.8	91	3.28	6	0.22	2	0.07
	Hoop net	1536.4	51	0.03	11	0.01	379	0.25
	Large trap	2505.8	155	0.06	49	0.02	786	0.31
2	Hook and line	29.5	106	3.59	2	0.07	0	0.00
	Hoop net	1686.8	42	0.02	29	0.02	127	0.08
	Large trap	2104.9	160	0.08	80	0.04	482	0.23
3	Hook and line	56.0	128	2.28	23	0.41	4	0.07
	Hoop net	1711.2	49	0.03	26	0.02	201	0.12
	Large trap	2064.8	105	0.05	83	0.04	458	0.22
4	Hook and line	73.5	143	1.95	3	0.04	1	0.01
	Hoop net	1742.6	36	0.02	35	0.02	107	0.06
	Large trap	2182.3	75	0.03	60	0.03	261	0.12
Total	Hook and line	186.8	468	2.51	34	0.18	7	0.04
	Hoop net	6676.9	178	0.03	101	0.02	814	0.12
	Large trap	8857.8	495	0.06	272	0.03	1,987	0.22
Sum			1,141		407		2,808	

[a] Periods: 1 = July 12 through July 21; 2 = July 26 through August 4; 3 = August 16 through August 25; 4 = August 30 through September 8.

Table 10.–Summary of cutthroat trout tagging and recovery data for all fish, Turner Lake, 1994. Marking event 1 is periods 1 and 2; recapture event or event 2 is periods 3 and 4.

	1994 Sampling periods			
	Newly Marked		**Recaptured**	
	Period 1 7/12 - 7/21	Period 2 7/26 - 8/4	Period 3 8/16 - 8/25	Period 4 8/30 - 9/8
Newly tagged fish released alive	284	249	202	156
Recaptured fish tagged during:				
1988	0	0	0	0
1989	2	0	0	0
1990	4	8	2	1
1994 - event 1			65	52
Captured, not tagged; Mortalities	2	2	9	4
Redundant catch; within period	5	6	4	9
Redundant catch; within event		43		32
Total catch	297	308	282	254

Table 11.–Number of cutthroat trout marked but not recaptured in any area (ai), number of marked fish recaptured by area of recapture (mi,j), and number of unmarked fish caught by area (uj) during the second sampling event at Turner Lake, 1994.

Area fish was marked	Total fish marked	Marked but not recaptured (a_i),	Number of marked fish recaptured by area of recapture (m_{ij}) A[a]	B[b]	C[c]
A	203	169	29	4	1
B	221	179	5	35	2
C	249	199	4	5	41
Total marked fish recaptured			38	44	44
Unmarked fish caught (u_j)			87	94	188

[a] Study zones A; $\hat{N}_A$ = 640 ±103 at time of sampling (bootstrap SE = 100.

[b] Study zones B, $\hat{N}_B$ = 574 ±90 at time of sampling (bootstrap SE = 88).

[c] Study zones C; $\hat{N}_C$ = 892 ± 133 at time of sampling (bootstrap SE = 133).

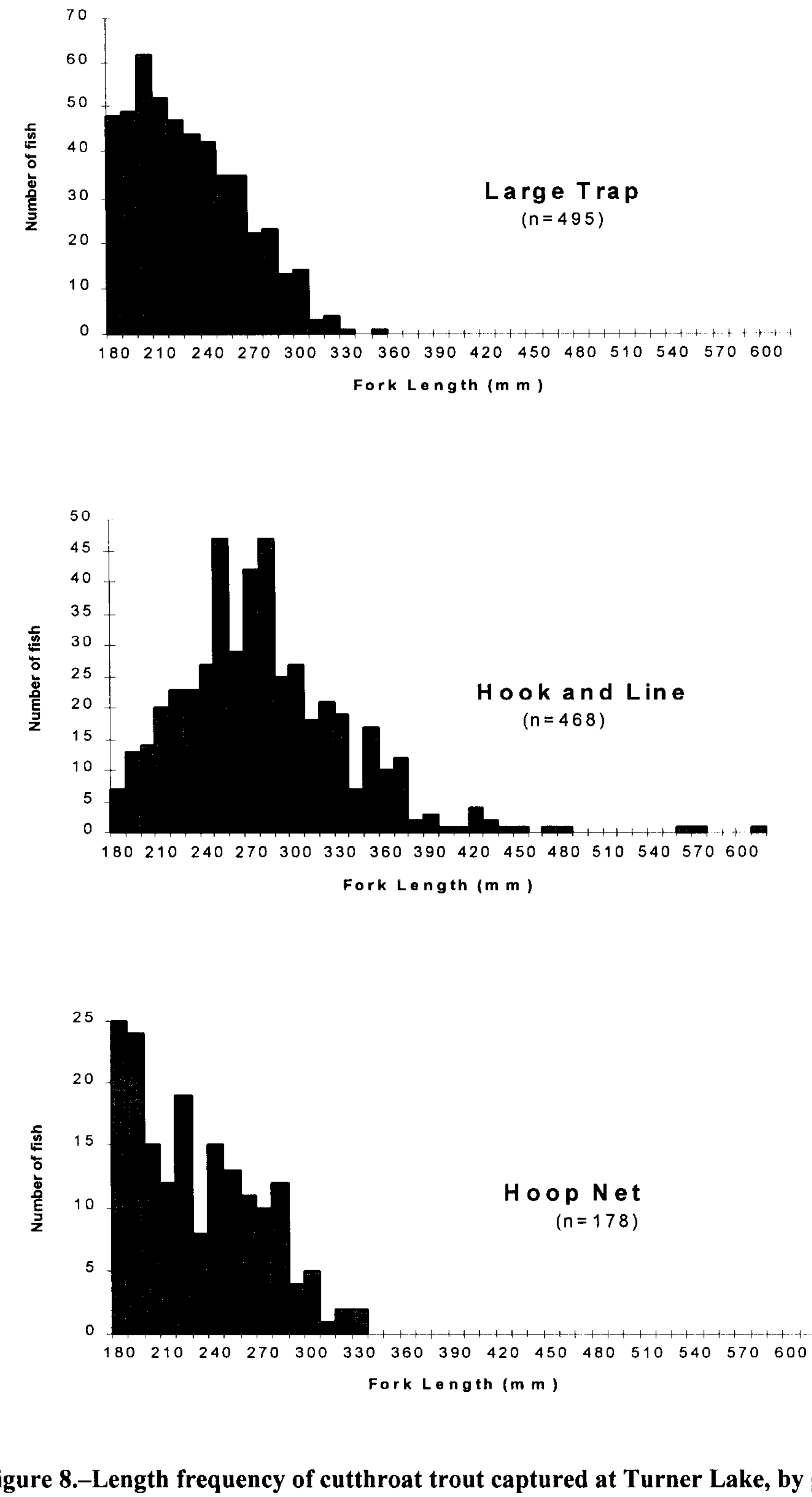


Figure 8.–Length frequency of cutthroat trout captured at Turner Lake, by gear type, 1994.

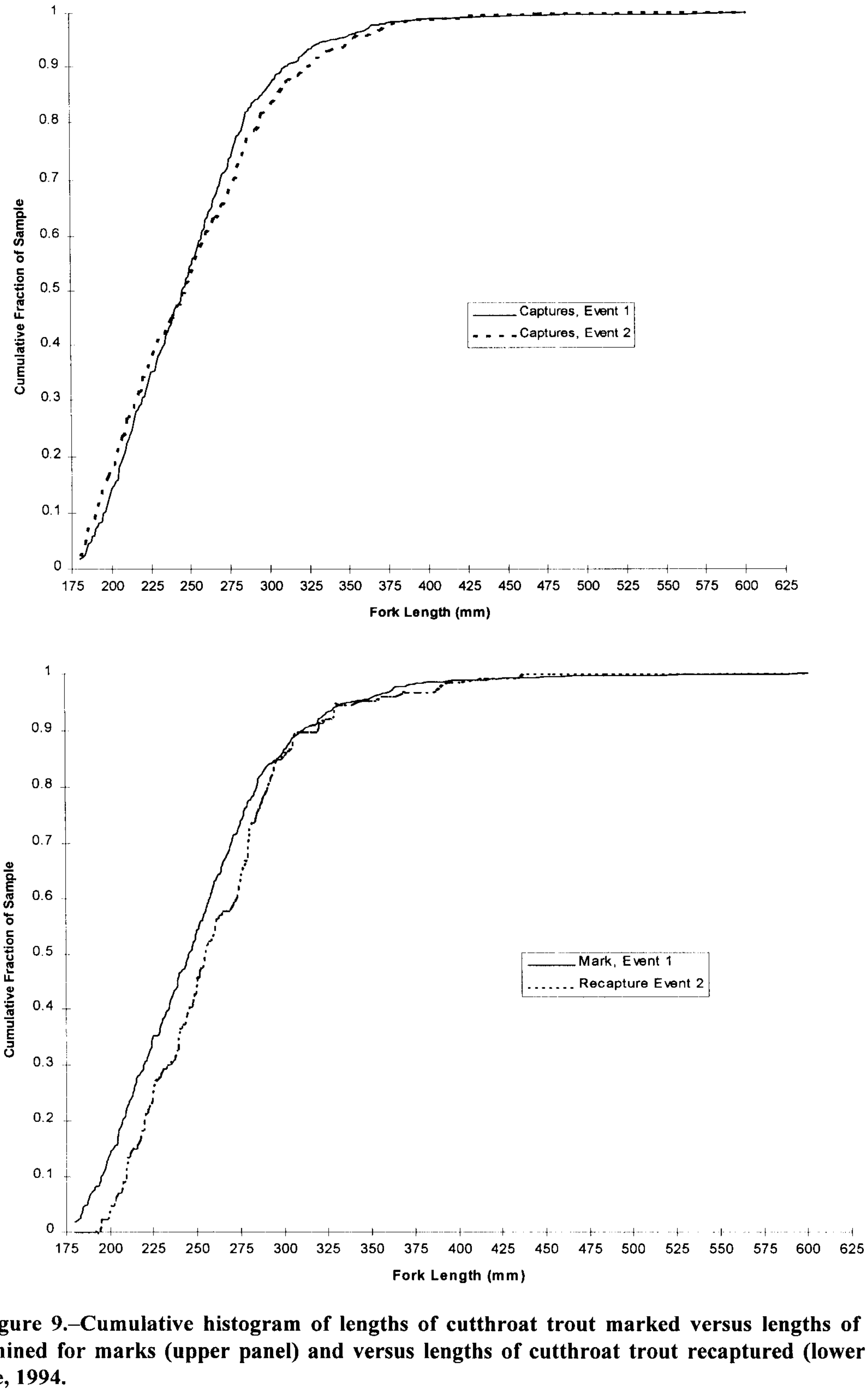


Figure 9.–Cumulative histogram of lengths of cutthroat trout marked versus lengths of cutthroat trout examined for marks (upper panel) and versus lengths of cutthroat trout recaptured (lower panel), Turner Lake, 1994.

YOUNG LAKE

Abundance

A total of 215 cutthroat trout between 180 and 477 mm FL was caught, marked, and released during the first sample event conducted between June 6 through June 9, 1994. During the second event, September 15 through September 17, 1994, 347 cutthroat trout (between 180 mm FL and 370 mm FL) were caught and inspected for marks. Of the fish inspected during the second event, 46 had been marked in the first sample event. (Table 14, Figure 10).

There was no significant difference in the distribution of lengths of fish recaptured in event 2 and the distribution of lengths marked in event 1, suggesting the second sampling event was not size selective (d_{max} = 0.181, P = 0.144) (Figure 11). Therefore, the abundance estimate was not stratified by length. Additionally, there was no significant difference between the distribution of lengths of fish captured in event 1 and the distribution of lengths of all fish captured in event 2 (d_{max} = 0.076, P = 0.386) (Figure 11), suggesting that there was no size selectivity during either sampling event; consequently, length data for both events could be pooled to estimate length composition.

Since captured fish were not uniquely marked, the hypothesis of equal probability of capture could not be tested; random selection of sample grids was used to ensure equal probability of capture. An unstratified Peterson estimator was used to estimate the abundance of cutthroat trout in Young Lake at 1, 562 (SE = 185) ≥180 mm FL. Relative precision for the estimate is ± 23%, for a 95% confidence interval.

Length Composition

We found no significant difference between the length distributions of cutthroat trout captured during the first and second events (d_{max} = 0.076, P = 0.386) (Figure 11); therefore, length data collected during both events were used to estimate

Table 12.–Numbers of marked and unmarked cutthroat trout captured in sampling event 2, by recovery area, Turner Lake, 1994.

	Recovery area			
	A[a]	B[b]	C[c]	
Marked fish	38	44	44	126
Unmarked fish	87	94	188	369
	125	138	232	495

X^2 = 9.76, df = 2, P = 0.008

Table 13.–Length composition statistics for cutthroat trout ≥180 mm FL, Turner Lake, 1994. The proportion (pk), abundance (Nk), standard error (SE), and coefficient of variation (CV) for each 20-mm length class are shown.

Length k, mm FL	n_k	p_k	$SE[p_k]$	$CV[p_k]$	N_k	$SE[N_k]$	$CV[N_k]$
180 - 200	169	0.162	0.011	0.070	342	34	0.099
201 - 220	167	0.160	0.011	0.071	338	34	0.100
221 - 240	150	0.144	0.011	0.076	303	31	0.103
241 - 260	159	0.153	0.011	0.073	322	33	0.101
261 - 280	136	0.131	0.010	0.080	275	29	0.106
281 - 300	102	0.098	0.009	0.094	206	24	0.117
301 - 320	58	0.056	0.007	0.128	117	17	0.146
321 - 340	40	0.038	0.006	0.155	81	14	0.170
341 - 360	21	0.020	0.004	0.216	42	10	0.227
361 - 380	21	0.020	0.004	0.216	42	10	0.227
381 - 400	5	0.005	0.002	0.446	10	5	0.452
401 - 420	3	0.003	0.002	0.577	6	4	0.581
421 - 440	5	0.005	0.002	0.446	10	5	0.452
441 - 460	1	0.001	0.001	1.000	2	2	1.002
461 - 480	1	0.001	0.001	1.000	2	2	1.002
481 - 500	1	0.001	0.001	1.000	2	2	1.002
>500	3	0.003	0.002	0.577	6	4	0.581
n	1042				2107		

Table 14.–Number of cutthroat trout captured by day and gear type in the Young Lake abundance experiment, 1994.

	Gear			Total	Total	Total
Date	Hoop Net	Hook & Line	Large Trap[a]	**Marked**	**Recaptured [c]**	**Captured**
USFS Sampling						
6/6/94	0	11	0	11	0	11
6/7/94	56	15	7	78	0	78
6/8/94	28	21	0	49	0	49
6/9/94	34	40	3	77	3	80
Totals	118	87	10	215	3	218
ADF&G Sampling						
9/15/94	151	0	0	151	23	174
9/16/94	83	2	0	85	18	103
9/17/94	57	0	0	57	13	70
Totals	291	2	0	293	54 [b]	347

[a] Large trap not used by ADF&G.

[b] Five fish captured more than once by ADF&G.

[c] All recaptures in hoop net.

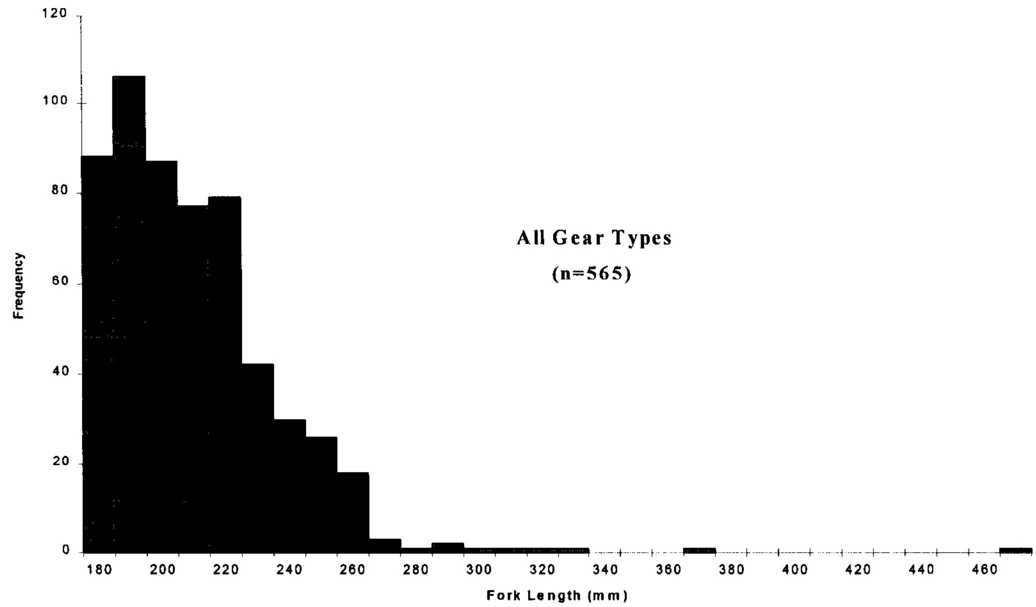


Figure 10.–Length frequency of cutthroat trout captured at Young Lake, all gear types, 1994.

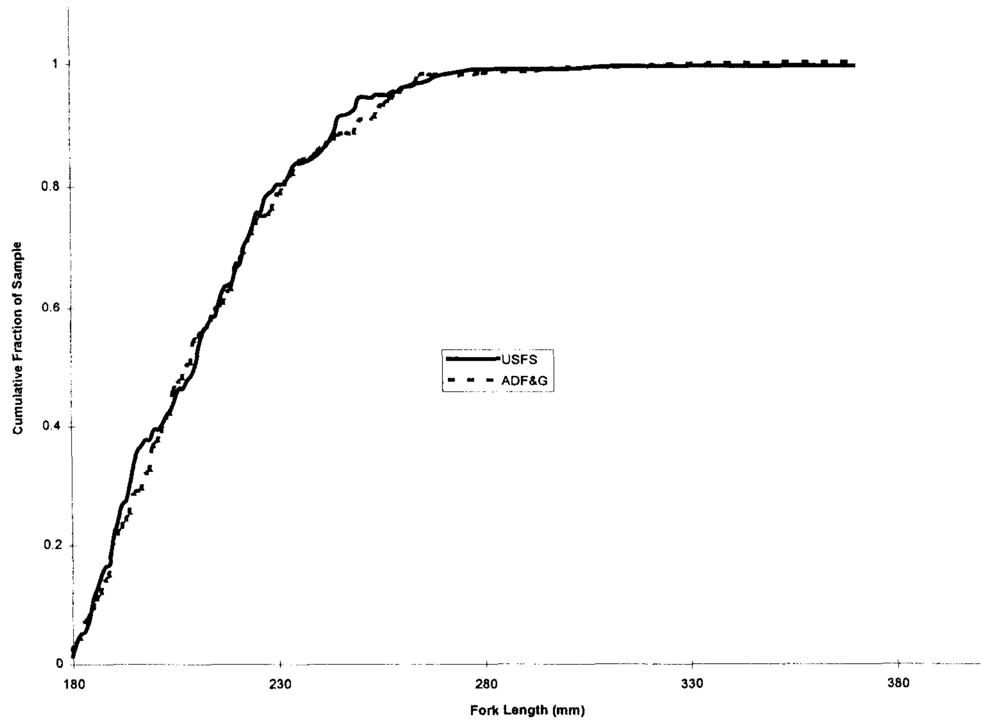
the length composition of cutthroat trout ≥180 mm FL. Harvest of cutthroat trout in Young Lake is restricted to fish >335 mm FL (14 total inches) and <529 mm FL (22 inches total). Only 0.06% of the cutthroat in Young Lake are estimated to exceed the 14-inch 'high-use cutthroat trout lakes' minimum size limit; no fish are estimated to exceed the 22- inch maximum size limit (Table 15).

DISCUSSION

To estimate the percentage of cutthroat trout available for harvest under the new Southeast trout regulations, the regulation's minimum length was applied to length compositions in Young, Turner and Florence lakes. Under the 14-inch 'high-use cutthroat trout lakes' minimum size limit (currently in effect at Young Lake), fewer than 0.06% of the fish in Young Lake are available for legal harvest. While no harvest of cutthroat is currently allowed in Turner Lake, and no minimum size limit is in effect at Florence Lake, if the regional regulations were in effect in these lakes, few fish could be legally harvested. Based on the 1994 length composition of cutthroat trout in Florence Lake, fewer than 1.5% of the population would be available for harvest under the regionwide minimum size limit of 12 inches (287 mm FL), and fewer than 0.5% could be legally harvested under the high-use cutthroat trout lakes size limit. Cutthroat trout harvest at Turner Lake has been prohibited since 1991, but we caught no fish in our hook and line samples that exceeded the 25-inch (602 mm FL) minimum size limit of the 'trophy lake' regulation category; approximately 10% and 25% exceeded the 14-inch and 12-inch size limits, respectively.

At Florence Lake, four (2 males and 2 females) of the 130 immigrant trout counted at weirs on Cabin and Koolmo Creek had been tagged at the same weir in 1993. The migratory timing of these four fish was very similar to that observed in 1993. Furthermore, all four returned to the same creek to spawn, suggesting fidelity to the same spawning stream.

At the conclusion of the 1994 Florence Lake abundance experiment, 524 cutthroat trout were captured and transported to Twin Lakes. The Division of Sport Fish wanted to provide Juneau area anglers an opportunity to harvest cutthroat trout. All fish transplanted to Twin Lakes were unmarked, Seventy-seven of the fish were



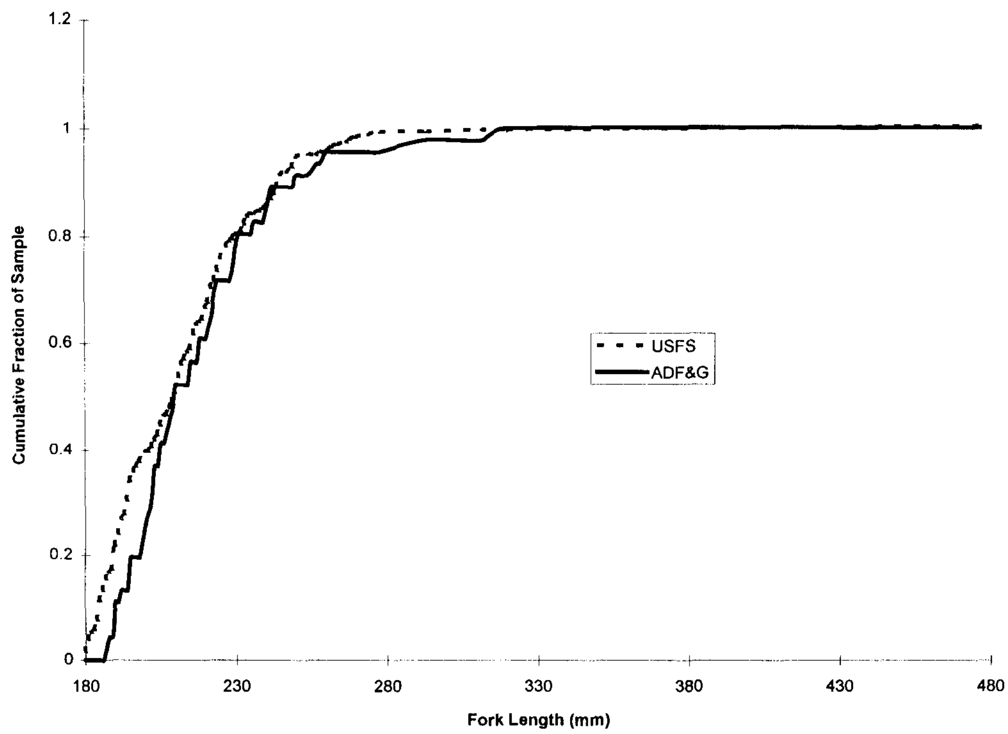


Figure 11.–Cumulative histogram of lengths of cutthroat trout marked versus lengths of cutthroat trout examined for marks (upper panel) and versus lengths of cutthroat trout recaptured (lower panel), Young Lake, 1994.

Table 15.–Length composition statistics for cutthroat trout ≥180 mm FL, Young Lake, 1994. The proportion (pk), abundance (Nk), standard error (SE), and coefficient of variation (CV) for each 20-mm length class are shown.

Length k, mm FL	nk	pk	SE[pk]	CV[pk]	Nk	SE[Nk]	CV[Nk]
180 - 200	212	0.375	0.020	0.054	586	76.341	0.130
201 - 220	164	0.290	0.019	0.066	453	61.382	0.135
221 - 240	107	0.189	0.016	0.087	296	43.410	0.147
241 - 260	55	0.097	0.012	0.128	152	26.449	0.174
261 - 280	19	0.034	0.008	0.226	53	13.316	0.254
281 - 300	3	0.005	0.003	0.576	8	4.846	0.584
301 - 320	2	0.004	0.003	0.706	6	3.933	0.711
321 - 340	1	0.002	0.002	1.000	3	2.764	1.000
341 - 360	0	0.000	0.000	0.000	0	0.000	0.000
361 - 380	1	0.002	0.002	1.000	3	2.764	1.000
> 380	1	0.002	0.002	0.000	3	2.764	0.000
n	565				1562		

captured on the last day of the abundance experiment and were used in the abundance experiment. They are reported as "examined for marks" in Table 4. The transplanted cutthroat trout ranged in size from 170 to 360 mm FL.

Sampling gear was not uniformly set between the mark and recapture events during the Young Lake abundance experiment (Table 14). During the second or recapture event at Young Lake, poor weather conditions restricted the sampling gear to hoop nets only, because the lake was too rough for hook and line sampling. Large traps were not used during the recapture event, since only 10 fish were captured in large traps during the capture event. To compensate for the reduced hook and line effort and to replace the large trap, three additional hoop nets were used during the recapture event (i.e., nine hoop nets used during recapture vs. six hoop nets and one large trap during marking event).

Annual abundance experiments have been conducted at Florence Lake since 1990. The 1994 abundance of cutthroat trout in Florence ≥180 mm FL was estimated at 10,787 (SE = 674) using an unstratified Peterson model. The 1994 abundance experiment was patterned after the 1993 experiment which was conducted early in spring to capture and mark fish before they mixed and to thereby improve mixing. However, the 1994 experiment was the first time that the hypotheses of equal probability of capture was not rejected, and thus, the first time that the Peterson estimator was used.

Past abundance experiments, using the Darroch estimator, estimated the abundances of cutthroat trout ≥180 mm FL at 8,382 (SE = 818), 10,586 (SE = 1,536), 8,924 (SE = 1,052), and 6,787 (SE = 1,171), respectively, for 1993, 1992, 1991, and 1990. The 1994 abundance experiment falls outside the 95% CI for 1993 and 1990 but within the 95% CI for 1992 and 1991.

Harvest of cutthroat trout has been prohibited in Turner Lake since 1991, and the 1994 abundance experiment provided us with our first estimate of abundance since 1990. The 1994 abundance estimate for cutthroat trout ≥180 mm Fl was 2,107 (SE = 148), and the 1990 abundance estimate was 1,242 (SE = 157) for cutthroat trout between 161 mm FL and 280 mm FL. Since they are for different size categories of fish, the two estimates are not directly comparable. However, the abundance of fish estimated between 180 mm FL and 280 mm FL during 1994 exceeds the 1990 abundance estimate of fish between 161 and 280 mm FL by 338 fish, a 23% increase. Offspring of fish which spawned during 1990 were four years old during the 1994 abundance experiment. Since cutthroat are fully recruited to our capture gear at four years of age (Jones and Harding 1991), we had hoped to see an increase in abundance at this size range. This year's abundance estimate suggests that the cutthroat trout population in Turner Lake may be rebounding.

ACKNOWLEDGMENTS

I thank Ken Koolmo and Karen Koolmo for their outstanding work at Florence Lake and Brad Gruening, Robert Harley, and Carol Coyle, who conducted the field work at Turner and Young Lake. Kurt Kondzela assisted with field and logistical support for all projects. We thank the Shee Atika Corporation for allowing us to maintain a field camp on their property while we conducted our field studies on Florence Lake. The work at Young Lake was conducted through a cooperative research agreement between ADF&G and the US Forest Service. We acknowledge and appreciate the efforts of the US Forest Service, Admiralty National Monument fisheries crew (lead by Mark Laker), who conducted the marking event at Young Lake and provided logistical support during the recapture event.

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APPENDIX A

Appendix A1. History of general regulations affecting trout fisheries in Southeast Alaska.

Years	Daily limit	Additional restrictions	Possession limit
1940s–1959	20	3 over 20 in.	2 daily bag limits
1960–1974	15	3 over 20 in.	2 daily bag limits
1975–1979	10	2 over 20 in.	2 daily bag limits
1980–1982	4	1 over 16 in.	1 daily bag limit
1983–1984	4	1 over 16 in.	2 daily bag limits
1985–1993	5	1 over 16 in.	2 daily bag limits
1994–present [a]	2	12 in. minimum 22 in. maximum bait prohibited except Sep 15–Nov 15	1 daily bag limit

[a] Regulations for High Use Lakes (Young and 22 other lakes) differ as follows: additional restrictions are instead a 14 in. minimum size limit, and bait is prohibited year-around. Regulations for "Trophy Lakes" differ as follows: one cutthroat per day and in possession, 25 inches or more, and bait prohibited year-round. Turner Lake is catch-and-release only for cutthroat trout.

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

Tag no.	Date up	Date down	Length	Sex	Comments
			KOOLMO CREEK WEIR		
2638	12-May		305	M	OTOLITH SAMP. TAGGED 8-7-90 LT MIDLAKE 237mm
5501	17-May		246	F	DRIPPING EGGS FIRST TAGGED 7-18-91 2HN 207mm
5501		22-May	244	F	SPAWN OUT
5639	20-May		NONE	M	MILT FIRST TAGGED 7-28-91 3FN 201mm
5940	23-May		238	F	FIRST TAGGED 8-12-91 2LT 206mm
5940		30-May	235	F	SPAWN OUT
6158	17-May		306	F	FIRST TAGGED 6-27-91 5LT 242mm
6158		25-May	306	F	OTOLITH SAMPLE
6732	11-May		275	F	FULL BELLY FIRST TAGGED 7-25-91 3LT 249mm
6889	11-May		316	M	MILT FIRST TAGGED 7-30-91 4LT 295mm
10169	11-May		306	F	FIRST TAGGED 5-12-92 5LT 269mm
10694		30-May	244	F	SPAWN OUT FIRST TAGGED 6-8-92 3HL 238mm
11523	11-May		199	M	FIRST TAGGED 7-26-92 5LT 183mm
12002	21-Apr		255	F	SPAWNING COLORS TAGGED 4-30-93 UP 3WR 252mm
12011	3-May		218	M	SPAWNING COLORS TAGGED 5-14-93 UP 3WR 223mm
12026	19-May		255	F	FIRST TAGGED 5-20-93 DN 3WR 236mm
12026		22-May	254	F	SPAWN OUT
12152	15-May		348	M	MILT FIRST TAGGED 4-26-93 3LT 318mm
13327	12-May		285	M	FIRST TAGGED 5-1-94 3LT 287mm
13327		1-Jun	280	M	SPAWN OUT
13396	23-May		242	F	FIRST TAGGED 5-16-94 4LT 240mm
13396		2-Jun	241	F	SPAWN OUT
13952	22-Apr		282	F	DRIPPING EGGS TAGGED AT WEIR
13952		20-May	278	F	SPAWN OUT RAGGED TAIL RUBBED NOSE
13954	25-Apr		243	M	SPAWNING COLORS TAGGED AT WEIR
13954		20-May	241	M	SPAWN OUT DRAWN UP BELLY
13955	25-Apr		193	M	MILT TAGGED AT WEIR
13955		28-May	186	M	SPAWN OUT
13956	26-Apr		220	M	DARK COLOR TAGGED AT WEIR NSA
13958	28-Apr		210	M	DARK COLOR TAGGED AT WEIR NSA
13961	29-Apr		234	M	SPAWN COLORS TAGGED AT WEIR NSA
13964	1-May		218	M	SPAWNING COLORS TAGGED AT WEIR
13964		30-May	217	M	MILT BEAT UP TAIL
13965	2-May		188	M	TAGGED AT WEIR NSA
13966	2-May		219	M	TAGGED AT WEIR NSA
13967	5-May		333	M	MILT DARK FINS TAGGED AT WEIR NSA
13968	5-May		266	F	DRIPPING EGGS TAGGED AT WEIR NSA
13969		5-May	253	F	SPAWN OUT TAGGED AT WEIR NSA
13970	7-May		217	M	ESCAPED DOWN STRM TAGGED AT WEIR NSA
13971		7-May	267	F	SPAWN OUT TAGGED AT WEIR NSA
13973	8-May		211	F	NOT MUCH COLOR TAGGED AT WEIR NSA
13977	11-May		244	F	TAGGED AT WEIR

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Tag no.	Date up	Date down	Length	Sex	Comments
13977		14-May	243	F	SPAWN OUT
13978	11-May		242	F	TAGGED AT WEIR
13978		16-May	240	F	SPAWN OUT
13979	11-May		231	F	DRIPPING EGGS TAGGED AT WEIR NSA
13980	11-May		215	M	TAGGED AT WEIR NSA
13981	11-May		203	M	MILT TAGGED AT WEIR
13981		24-May	178	M	LENGTH LOOKS WRONG
13982	11-May		212		TAGGED AT WEIR NSA
13984	12-May		251	F	SOFT BELLY TAGGED AT WEIR
13984		17-May	248	F	SPAWN OUT
13985	12-May		263	F	SOFT BELLY TAGGED AT WEIR NSA
13986	12-May		259	F	SOFT BELLY TAGGED AT WEIR NSA
13987	12-May		255	M	MILT TAGGED AT WEIR
13987		2-Jun	250	M	SOME MILT RAGGED TAIL
13988	12-May		234	F	TAGGED AT WEIR
13988		20-May	231	F	SPAWN OUT
13989	12-May		243	M	SPAWNING COLORS TAGGED AT WEIR
13989		27-May	235	M	SPAWN OUT
13990	12-May		221	M	MILT TAGGED AT WEIR
13990		3-Jun	218	M	SPAWN OUT
13991	12-May		198	F	TAGGED AT WEIR
13991		20-May	195	F	SPAWN OUT SLACK BELLY
13992	14-May		181	M	LOTS OF COLOR TAGGED AT WEIR
13992		24-May	177	M	
13995	16-May		226	M	MILT TAGGED AT WEIR
13995		28-May	226	M	SOME MILT
13996	16-May		246	M	DARK COLORED TAGGED AT WEIR
13996		3-Jun	245	M	HAD LITTLE CUTTHROAT IN MOUTH
13997	16-May		265	F	TAGGED AT WEIR
13997		24-May	263	F	SPAWN OUT BATTERED TAIL
13999	17-May		225	F	TAGGED AT WEIR
13999		21-May	224	F	SPAWN OUT SKINNY BELLY
14279	31-May		223	M	MILT FIRST TAGGED 4-25-93 4LT 198mm
14279		3-Jun	222	M	SPAWN OUT
14371	23-May		231	M	FIRST TAGGED 4-26-93 3LT 208mm NST
14725	12-May		235	F	VERY RIPE FIRST TAGGED 4-30-93 8LT 211mm NSA
15420	17-May		227	M	MILT FIRST TAGGED 5-27-93 3LT 207mm
15420		31-May	223	M	SPAWN OUT
15481	22-May		206	F	FIRST TAGGED 5-30-93 2LT 196mm
15481		31-May	206	F	SPAWN OUT
15970	10-May		189	M	SPAWNING COLORS FIRST TAGGED 4-17-94 3LT 187mm
15970	28-May		187	M	MILT
15970		29-May	186	M	SPAWN OUT
16423	16-May		207	F	FIRST TAGGED 5-1-94 3LT 205mm
16423		23-May	203	F	SPAWN OUT

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Tag no.	Date up	Date down	Length	Sex	Comments
16952	19-May		255	M	NOT MUCH COLOR TAGGED AT WEIR NSA
16953	19-May		228	F	TAGGED AT WEIR
16953		28-May	226	F	SPAWN OUT
16957	20-May		238	F	VERY RIPE TAGGED AT WEIR
16957		24-May	235	F	SPAWN OUT
16958	20-May		226	F	VERY RIPE TAGGED AT WEIR
16958		26-May	225	F	SPAWN OUT
16959	20-May		226	M	TAGGED AT WEIR NSA
16961	20-May		254	M	TAGGED AT WEIR
16961		27-May	253	M	MILT
16962	22-May		232	M	MILT TAGGED AT WEIR NSA
16963	22-May		233	F	TAGGED AT WEIR NSA
16964	22-May		285	M	MILT TAGGED AT WEIR NSA
16965	23-May		344	M	MILT TAGGED AT WEIR
16965		30-May	342	M	SPAWN OUT
16966	23-May		249	M	TAGGED AT WEIR NSA
16967	23-May		222	M	TAGGED AT WEIR NSA
16968	24-May		235	M	TAGGED AT WEIR NSA
16969	30-May		255	M	MILT TAGGED AT WEIR NSA
18285		31-May	214	F	SPAWN OUT FIRST TAGGED 5-21-94 3LT 216mm
18990	25-May		195	M	MILT TAGGED AT WEIR NSA
18991	24-May		208	M	MILT LOTS OF COLOR TAGGED AT WEIR NSA
18993	23-May		190	M	TAGGED AT WEIR
18993		24-May	189	M	
18994	23-May		200	M	TAGGED AT WEIR NSA
18995	22-May		204	M	TAGGED AT WEIR NSA
18996	21-May		208	M	MILT TAGGED AT WEIR NSA
			CABIN CREEK WEIR		
5208	28-Apr		237	M	SPAWNING COLORS FIRST TAGGED 6-30-91 7HL 186mm
5317	30-Apr		225	M	SPAWNING COLORS FIRST TAGGED 7-11-91 6FN 192mm
5831	17-May		262	F	FIRST TAGGED 8-9-91 8HN 245mm
5831		28-May	260	F	SPAWN OUT
6145	7-May		315	F	FIRST TAGGED 6-27-91 5LT 286mm
7000	20-May		295	M	MILT FIRST TAGGED 8-9-91 5LT 265mm
8969	20-May		235	M	OTOLITH SAMPLE FIRST TAGGED 7-23-92 4LT 224mm
13951	13-Apr		264	M	DARK TAGGED AT WEIR NSA
10169	27-Apr		307	F	FIRST TAGGED 5-12-92 5LT 269mm
10542	12-May		251		FIRST TAGGED 6-3-92 5LT 224mm
10623	28-Apr		276	M	SPAWNING COLORS FIRST TAGGED 6-6-92 5LT 252mm
12018	25-May		249	M	MILT FIRST TAGGED 5-16-93 4WR 237mm
12066	7-May		259	F	FIRST TAGGED 4-23-93 6LT 234mm
12066		15-May	258	F	SPAWN OUT RAGGED TAIL
12069	6-May		264		FIRST TAGGED 4-23-93 6LT 248mm

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Tag no.	Date up	Date down	Length	Sex	Comments
12342	21-Apr		278	M	SPAWNING COLORS FIRST TAGGED 5-1-93 6LT 227mm
12377	27-May		288	M	NOT RIPE FIRST TAGGED 5-7-93 6HL 281mm
12960	28-Apr		241	M	SPAWNING COLORS FIRST TAGGED 4-12-94 4LT 241mm
12960	7-May		241	M	SPAWNING COLORS
13953	22-Apr		262	M	SPAWNING COLORS TAGGED AT WEIR NSA
13957	27-Apr		188	M	SPAWNING COLORS TAGGED AT WEIR
13957		23-May	187	M	LOOKS SKINNY
13959	28-Apr		212	M	SPAWNING COLORS TAGGED AT WEIR NSA
13960	28-Apr		195	M	SPAWNING COLORS TAGGED AT WEIR NSA
13962	29-Apr		204	M	TAGGED AT WEIR
13962		30-Apr	204	M	LOOKS HEALTHY
13963	29-Apr		262	F	SOFT BELLY TAGGED AT WEIR NSA
13972	7-May		298	F	TAGGED AT WEIR
13972		10-May	295	F	SPAWN OUT
13974	8-May		285	M	SPAWNING COLORS TAGGED AT WEIR NSA
13975	9-May		198	M	TAGGED AT WEIR NSA
13976	9-May		253	F	TAGGED AT WEIR NSA
13983	12-May		194	F	TAGGED AT WEIR
13983		28-May	193	F	DROPPED A FEW EGGS
13993	15-May		239	F	VERY RIPE TAGGED AT WEIR
13993		20-May	239	F	SPAWN OUT
13998	16-May		270	F	SOFT FULL BELLY TAGGED AT WEIR
13998		25-May	268	F	
14000	17-May		243	F	TAGGED AT WEIR
14000		28-May	243	F	LOOKED SPAWNED OUT BUT DROPPED 15 EGGS
14200	24-May		184	M	MILT FIRST TAGGED 4-12-94 4LT 184mm NSA
15831		25-May	193	M	MILT FIRST TAGGED 4-15-94 2LT 192mm NSA
16065	24-May		206	F	NOT VERY RIPE FIRST TAGGED 4-26-94 4LT 205mm NSA
16951	17-May		245	F	TAGGED AT WEIR
16951		24-May	243	F	SPAWN OUT
16954	19-May		250	F	TAGGED AT WEIR NSA
16955	19-May		254	F	TAGGED AT WEIR
16955		24-May	252	F	SPAWN OUT
16956	19-May		226	F	TAGGED AT WEIR
16956		27-May	223	F	SPAWN OUT FOUND DEAD
16960	20-May		233	M	TAGGED AT WEIR
16960		20-May	233	M	UP THIS MORNING DOWN THIS AFTERNOON
16970	30-May		235	F	FULL BELLY TAGGED AT WEIR NSA
18992	24-May		216	M	MILT TAGGED AT WEIR NSA
18997	21-May		194	M	MILT TAGGED AT WEIR NSA
18998	20-May		200	M	TAGGED AT WEIR NSA
18999	19-May		217	M	TAGGED AT WEIR
18999		29-May	218	M	MILT
19000	19-May		213	F	DRIPPING EGGS TAGGED AT WEIR NSA

Appendix A3. Detection of size-selective sampling. From Bernard and Hansen (1992).

Result of hypothesis test on lengths of fish CAPTURED during the first event and RECAPTURED during the second event	**Result** of hypothesis test on lengths of fish CAPTURED during the first event and CAPTURED during the second event

Case I: **Accept H_0** — **Accept H_0**

There is no size-selectivity during either sampling event.

Case II: **Accept H_0** — **Reject H_0**

There is no size-selectivity during the second sampling event but there is during the first.

Case III: **Reject H_0** — **Accept H_0**

There is size-selectivity during both sampling events.

Case IV: **Reject H_0** — **Reject H_0**

There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.

Case I: Calculate one unstratified abundance estimate, and pool lengths, sexes, and ages from both sampling events to improve precision of proportions in estimates of composition.

Case II: Calculate one unstratified abundance estimate, and only use lengths, sexes, and ages from the second sampling event to estimate proportions in compositions.

Case III: Completely stratify both sampling events, and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Pool lengths, ages, and sexes from both sampling events to improve precision of proportions in estimates of composition, and apply formulae to correct for size bias to the pooled data.

Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata to get a single estimate for the population. Use lengths, ages, and sexes from only the second sampling event to estimate proportions in compositions, and apply formulae to correct for size bias to the data from the second event.

Whenever the results of the hypothesis tests indicate that there has been size-selective sampling (Case III or IV), there is still a chance that the bias in estimates of abundance from this phenomenon is negligible. Produce a second estimate of abundance by not stratifying the data as recommended above. If the two estimates (stratified and unbiased vs. biased and unstratified) are dissimilar, the bias is meaningful, the stratified estimate should be used, and data on compositions should be analyzed as described above for Cases III or IV. However, if the two estimates of abundance are similar, the bias is negligible in the UNSTRATIFIED estimate, and analysis can proceed as if there were no size-selective sampling during the second event (Cases I or II).

Appendix A4. List of 1994 data files used in the abundance experiments at Florence, Turner, and Young lakes.

Data file	Description
Florence Lake	
FLCABN94.DBF	dBase data file of Cabin Creek weir data, including daily and cumulative number of fish passed upstream and downstream, and water temperature and level
FLEFRT94.DBF	dBase data file of trap catch effort, including date, time, area, number of fish, gear type, and trap depth
FLKOOL94.DBF	dBase data file of Koolmo Creek weir data, including daily and cumulative number of fish passed upstream and downstream, and water temperature and level
FLOR_94.XLS	Excel file of abundance estimation and analysis
FLOAWL94.DBF	dBase data file of date, area, species, length, and tag number for cutthroat trout >180 mm tagged or recaptured in Florence Lake in 1994; includes weir caught fish.
Turner Lake	
TLEFRT94.DBF	dBase data file of trap catch effort, including date, time, area, number of fish, gear type, and trap depth
TURN_94.XLS	Excel file of abundance estimation and analysis
TLAWL94.DBF	dBase data file of date, area, species, length, and tag number for cutthroat trout >180 mm tagged or recaptured in Turner Lake in 1994
Young Lake	
YOUNG.XLS	Excel file of combined USFS/ADFG data and abundance analysis
ADFGRECP.XLS	Excel file of ADFG recapture event and length analysis

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