Fishery Data Series No. 09-06

Abundance and Length Composition of Cutthroat Trout in Florence Lake, Southeast Alaska, 2003

by

Peter D. Bangs

March 2009

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

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

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

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

General

Alaska Department of Fish and Game	ADF&G
Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
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
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
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	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
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.
minute (angular)	'
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
variance	
population	Var
sample	var

FISHERY DATA SERIES NO. 09–06

ABUNDANCE AND LENGTH COMPOSITION OF CUTTHROAT TROUT IN FLORENCE LAKE, SOUTHEAST ALASKA, 2003

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ABSTRACT

A two-event mark–recapture study was conducted at Florence Lake in 2003 to estimate the abundance and length composition of cutthroat trout *Oncorhynchus clarkii*. Fish were captured with hook-and-line gear and hoop traps, marked with t-bar anchor tags and given a dye mark as a secondary mark. The estimated abundance of cutthroat trout ≥180 mm FL in 2003 was 12,011 fish (SE = 674; 90% CI = 10,969–13,212). Most of the cutthroat trout ≥180 mm FL in Florence Lake were estimated to be ≤299 mm FL ($\hat{p}_{180-299}$ = 0.97, SE = 0.004), while only a small proportion of the population was estimated to be ≥300 mm FL ($\hat{p}_{300+}$ = 0.03, SE = 0.004). The abundance and length composition estimates are similar to estimates from 1994, which suggests that the sportfishing regulation changes adopted by the Alaska Board of Fisheries in 1994 have not been detrimental to the population.

Key words: Florence Lake, cutthroat trout, *Oncorhynchus clarkii*, mark–recapture, length, abundance.

INTRODUCTON

Florence Lake, located on the west side of Admiralty Island, supports one of the largest known populations of cutthroat trout *Oncorhynchus clarkii* in Southeast Alaska (Bangs and Harding 2008). Prior to extensive clearcut logging in the Florence Lake watershed in the early 1990s, the lake was one of the most popular cutthroat trout fisheries in Southeast Alaska (Jones et al. 1992). Angler effort has since declined substantially (Appendix A1). Based upon the declining angler effort at Florence Lake in the early 1990s, as well as the high density of cutthroat trout, the Alaska Board of Fisheries (BOF) adopted less restrictive sportfishing regulations for the lake in 1994 (Harding and Jones 2004). At the time, the BOF had reduced daily harvest limits for many cutthroat trout populations in Southeast Alaska and Florence Lake was identified as one of the populations where additional harvest opportunities could be maintained. In fact, the revised regulations are the least restrictive cutthroat trout regulations in Southeast Alaska (5 fish daily bag limit, 10 fish possession limit, no minimum size limit for fish, bait is allowed year round).

The Division of Sport Fish conducted annual mark–recapture experiments in Florence Lake between 1991 and 1994 to estimate the abundance and length composition of cutthroat trout. Results from these studies resulted in several insights and recommendations about sampling cutthroat trout at Florence and other resident lakes in Southeast Alaska (Rosenkranz et al. 1999). The objectives of this study were to estimate the abundance and length composition of cutthroat trout in Florence Lake in 2003. Additional sampling was conducted in 2002 and will be reported separately.

OBJECTIVES

The study objectives in 2003 were to:

1. Estimate the abundance of cutthroat trout ≥180 mm FL; and,
2. Estimate the length composition of cutthroat trout ≥180 mm FL.

METHODS

STUDY AREA

Florence Lake lies approximately 50 km southwest of Juneau, on the west side of Admiralty Island (Figure 1) at longitude 134°4' W, latitude 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. 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 upstream fish passage. A U.S. Forest Service recreational cabin is located at the east end of the lake, and the primary mode of transportation to the cabin is by float plane. Cutthroat trout and Dolly Varden *Salvelinus malma* are the primary species of fish available to anglers.

SAMPLING DESIGN AND FISH CAPTURE

This study was designed to estimate the abundance and length composition of cutthroat trout in Florence Lake by using mark–recapture

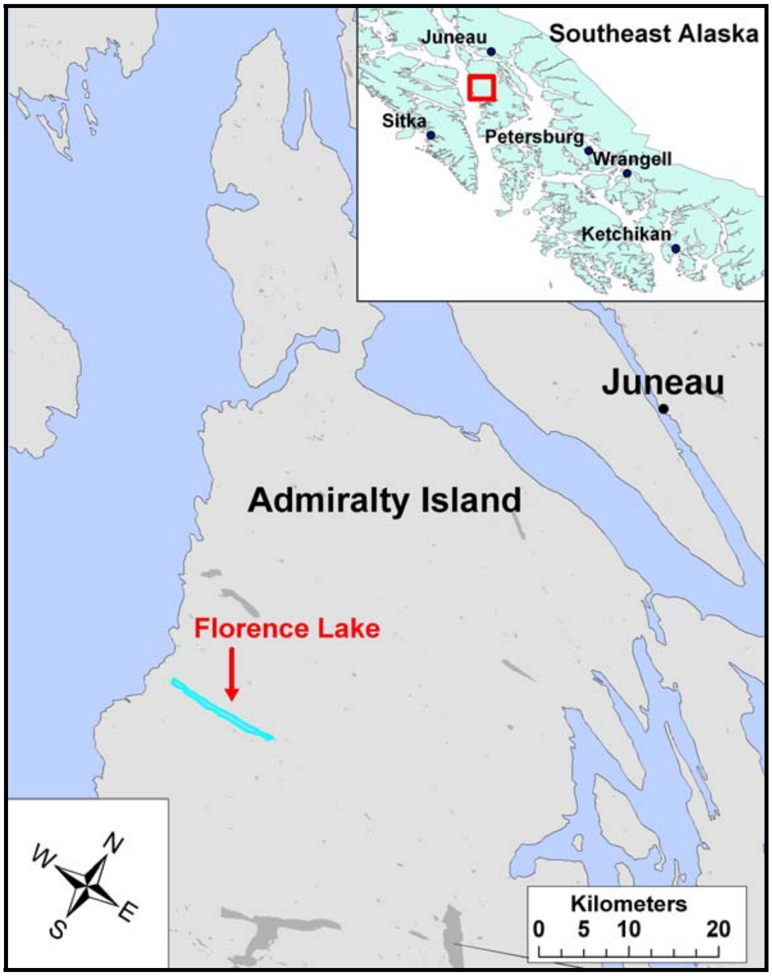

Figure 1.–Location of Florence Lake, near Juneau.

methodology. The first event (i.e., the marking event) occurred between April 22 and April 30, 2003. The second event (i.e., the recapture event) occurred between June 2 and June 11, 2003. The timing of these events was intended to avoid the majority of spawning activity (see Rosenkranz et al. 1999), which presumably occurred in May. Avoiding the spawning period is important because some fish will temporarily emigrate to inlet or outlet streams for spawning and will be unavailable for capture in the lake. Cutthroat trout were captured by employing hoop traps ([HT], Figure 2 in Rosenkranz et al. 1999) baited with salmon eggs that had been disinfected in a povidone-iodine solution. The lake was divided into three areas to facilitate consistent recording of trap locations and to aid in evaluation of assumptions during data analysis (Figure 2). During each sampling event, a total of 108 overnight trap sets were made across the lake (26 overnight sets in Area A, 56 overnight sets in Area B, and 26 overnight sets in Area C). Traps were set on the lake bottom and depths were measured with a fathometer or metered buoy line. Hook-and-line sampling gear was also employed during the second event. This entailed casting small spinners in a manner such that all shoreline areas at depths ≤6 m were fished with similar effort. A total of 29.2 hours of hook-and-line sampling effort was expended (7.2 hours in Area A, 14.9 hours in Area B, and 7.1 hours in Area C).

All cutthroat trout <180 mm FL were counted and released (i.e., not sampled). This minimum size threshold for sampling was selected to be consistent with previous cutthroat trout studies in Southeast Alaska (e.g., Rosenkranz et al. 1999). All cutthroat trout that were ≥180 mm FL were given a red anal fin dye mark, measured from the tip of the snout to the fork of the tail (to the

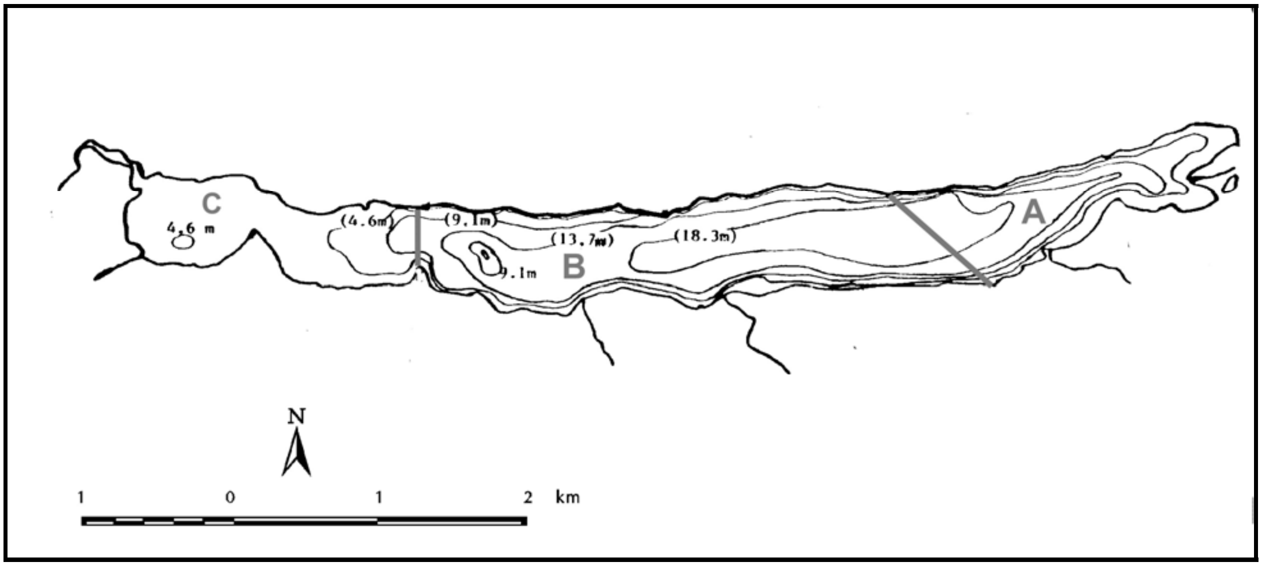

Figure 2.–Location of sampling areas in Florence Lake. The three large lake areas (A, B, C) were used to evaluate study assumptions.

nearest mm FL), and were given a uniquely numbered t-bar anchor tag (Hallprint Pty Ltd., Victor Harbor, South Australia). Previously captured fish (as indicated by the presence of a t-bar tag or dye mark) were measured for length and the t-bar anchor tag number was recorded. For each fish captured, the date, time, gear type, lake area (A, B, C), and depth (for HT) were recorded.

DATA ANALYSIS

The assumptions of the experiment were that:

1) the population was closed (cutthroat trout do not enter the population, via growth or immigration, or leave the population via death or emigration during the experiment);

2) all cutthroat trout had a similar probability of capture in the first or second event, or marked and unmarked cutthroat trout mixed completely between events;

3) marking of cutthroat trout in the first event did not affect the probability of capture in the second event;

4) cutthroat trout did not lose (or gain) marks between events, and marks were recognized and reported during the second event.

Fulfillment of the closure assumption (assumption 1) relied on the relatively short time (33 days) between the two sampling events. To evaluate the possibility of handling or tagging mortality (pertinent to assumptions 1, 2, 3), the first 10 fish sampled in each event were held overnight in a HT for observation. The status of these fish (e.g., whether they were alive, apparent condition) was evaluated to determine if handling procedures were detrimental.

The second assumption was evaluated with tests of consistency for the Petersen estimator (Appendix A2) and with Kolmogorov-Smirnov (K-S) tests for size-selective sampling (Appendix A3). Consistency tests were used to compare capture and recapture rates in each area of the lake. When all three of the null hypotheses outlined in Appendix A2 are rejected ($\alpha = 0.05$), a stratified Peterson estimator (Darroch 1961; and Seber 1982, Chapter 11) is appropriate. Otherwise, when any of the three null hypotheses are accepted, a pooled Peterson estimator can be used. The protocol specified in Appendix A3 provided guidance for conducting K-S tests to evaluate the potential for size-selective sampling as well as the effects of marking on catchability (assumption 3). Assumption 4 was robust in this experiment because all fish had a secondary mark (red anal fin dye mark) and technicians were instructed to thoroughly examine all captured fish for marks.

The abundance of cutthroat trout was estimated by using the Chapman modification of the Petersen estimator (Seber 1982):

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

where $\hat{N}$ is the estimated abundance of cutthroat trout ≥180 mm FL, n_1 is the number of cutthroat trout ≥180 mm FL marked in the first event, n_2 is the number of cutthroat trout ≥180 mm FL examined in the second event, and m_2 is the number of marked cutthroat trout recaptured in the second event.

The standard error along with a 90% confidence interval about $\hat{N}$ were estimated by using a parametric bootstrap routine in Excel®, whereby random variates (m_2) were generated from a hypergeometric distribution based upon fixed values of n_1, n_2, and $\hat{N}$. For each of the generated m_2 values (B = 5,000 iterations), equation (1) was used to generate a potential abundance estimate ($\hat{N}_k$). A 90% confidence interval about the mean was calculated using the 5th and 95th percentiles of the bootstrap distribution (Efron and Tibshirani 1993). The variance of $\hat{N}$ was calculated by:

$$\text{var}[\hat{N}] = \sum_{k=1}^{B} (\hat{N}_k - \overline{N})^2 / (B - 1) \qquad (2)$$

LENGTH COMPOSITION

Size selectivity in sampling was investigated according to the protocols in Appendix A3. The estimated fraction $\hat{p}_a$ of the fish in length group a (20 mm increments) was calculated as:

$$\hat{p}_a = \frac{n_a}{n} \qquad (3)$$

where n is the number of fish measured for length and n_a is the number of fish in length group a. The estimated variance for $\hat{p}_a$ is

$$\hat{\text{var}}[\hat{p}_a] = \frac{\hat{p}_a(1 - \hat{p}_a)}{n - 1} \qquad (4)$$

The abundance of length group a in the population ($\hat{N}_a$) was estimated by

$$\hat{N}_a = \hat{p}_a \hat{N} \qquad (5)$$

where $\hat{N}$ is the estimated abundance of the mark-recapture experiment. From Goodman (1960), the variance of $\hat{N}_a$ is:

$$\hat{\text{var}}[\hat{N}_a] = \hat{\text{var}}(\hat{p}_a)\hat{N}^2 + \hat{\text{var}}(\hat{N})\hat{p}_a^2 - \hat{\text{var}}(\hat{p}_a)\hat{\text{var}}(\hat{N}) \qquad (6)$$

RESULTS

CATCH SUMMARY

Abundance in 2003 was estimated at 12,011 cutthroat trout ≥180 mm FL (SE = 674; 90% CI = 10,969–13,212; n_1 = 1,695, n_2 = 1,713, m_2 = 241). A total of 3,167 unique cutthroat trout ≥180 mm were captured in this experiment; no tag loss was observed. All fish held overnight to evaluate potential handling effects appeared healthy and were released. A length measurement was either not taken or not recorded from one cutthroat trout in the second event. This fish was included in the spatial heterogeneity tests and the abundance estimation procedures, but was excluded from the length composition analysis and K-S tests as it could not be assigned to a length group.

KOLMOGOROV-SMIRNOV TESTS

Stratification by length was deemed unnecessary as the K-S tests did not indicate any significant differences in length composition between fish marked in the first event and fish recaptured in the second event (D = 0.08, P = 0.10, Figure 3). An additional K-S test compared the length composition of fish captured in the second event to those recaptured in the second event (Figure 4). This test offered some evidence of size selectivity in the first event (D = 0.093, P = 0.05), therefore only data from the second sampling event was used to estimate length composition.

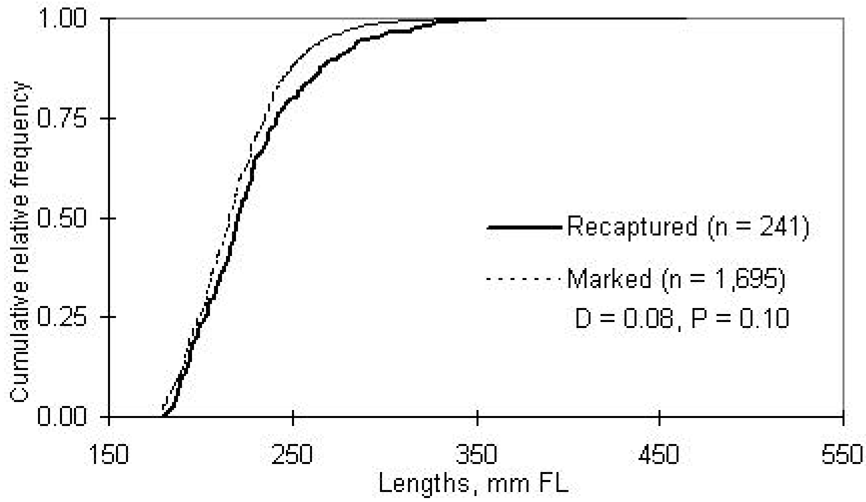

Figure 3.–Cumulative relative frequency of cutthroat trout ≥180 mm FL marked in the first event and recaptured in the second event in 2003.

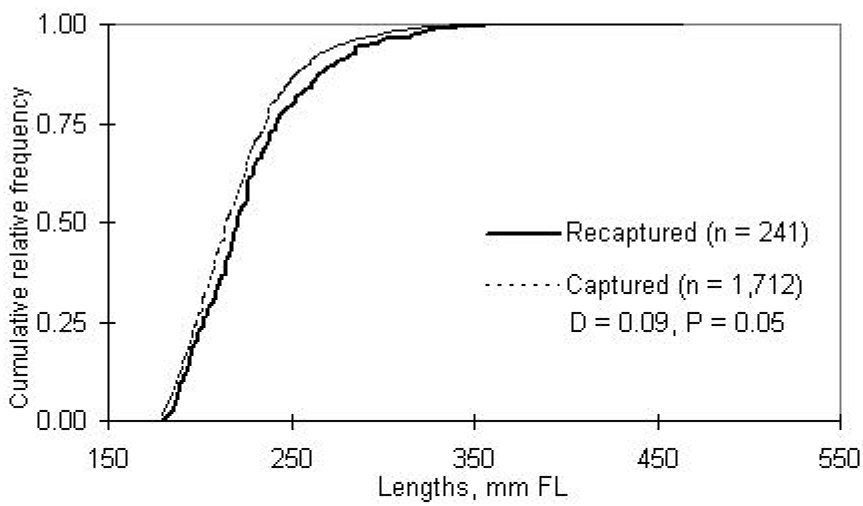

Figure 4.–Cumulative relative frequency of cutthroat trout ≥180 mm FL captured in the second event versus those recaptured in the second event in 2003.

SPATIAL HETEROGENEITY TESTS

Heterogeneity in capture probabilities due to spatial factors (Table 1) was not an apparent source of bias in the abundance estimate as no difference was detected in the marked fractions among the recovery areas ($\chi^2 = 1.62$, df = 2, P = 0.45; the "equal proportions test" in Appendix A2). Although mixing was incomplete ($\chi^2 = 99.58$, df = 6, P < 0.001) and evidence of unequal probabilities of capture in the second event was found ($\chi^2 = 24.03$, df = 2, P < 0.001; the pooled version of the "complete mixing test" in Appendix A2), acceptance of the null hypothesis for only one consistency test was needed to employ the Petersen estimator.

LENGTH COMPOSITION

Fork lengths of measured cutthroat trout captured in 2003 ranged from 180 to 464 mm (Table 2). Most of the cutthroat trout ≥180 mm FL in the population were estimated to be ≤299 mm FL ($\hat{p}_{180-299} = 0.97$, SE = 0.004). A much smaller proportion were 300–379 mm FL ($\hat{p}_{300-379}$ = 0.03, SE = 0.004), and very few fish were ≥380 mm FL ($\hat{p}_{380+}$ = 0.002, SE = 0.001).

Table 1.–Summary of cutthroat trout ≥180 mm FL catches in each of the three sampling areas (A, B, C) at Florence Lake, 2003. Summary statistics include the number of fish marked in each area (n_i) in the first event and the number of unmarked fish captured in each area (u_j) in the second event.

		Recovery area		
Marking area	n_i	A	B	C
A	650	28	19	12
B	738	12	65	56
C	307	0	7	42
	u_j	286	523	663

DISCUSSION

ABUNDANCE

The 2003 abundance estimate of 12,011 cutthroat trout (90% CI = 10,969–13,212) ≥180mm FL is consistent with the preceding closed population estimate from 1994, which was 10,948 fish (standard error not reported, Rosenkranz et al. 1999). Rosenkranz et al. (1999) also provides abundance estimates for 1991 though 1993, however differences in sampling make direct comparisons to this study less straightforward. For example, sampling in 1991 and 1992 was restricted to littoral areas ≤14 m in depth whereas sampling was expanded to deeper depths in subsequent years. Readers should refer to Rosenkranz et al. (1999) for a more elaborate discussion of the 1991–1994 studies as well as other general recommendations for conducting mark–recapture studies for lacustrine populations of cutthroat trout.

LENGTH COMPOSITION

Length composition estimates from this study (Table 2) are similar to the estimates from 1994, where Harding (1995) reported that a very high proportion ($\hat{p}_{180-300}$ = 0.99) of the cutthroat trout were between 180 and 300 mm FL. Length composition estimates for 1991 through 1993 were not reported by Rosenkranz et al. (1999) or others.

MANAGEMENT

Although the BOF modified the sport fishing regulations in 1994 such that Florence Lake has the least restrictive sport fishing regulations of any cutthroat trout populations in Southeast Alaska (5 fish daily bag limit, 10 fish possession limit, no minimum size limit for fish, bait is allowed year round), the abundance and length composition estimates from this study are similar to estimates from the early 1990s. This suggests that the current regulations do not appear to be detrimental based on recent levels of sport fishing harvest (Appendix A1).

Table 2.–Length composition and estimated abundance at length for cutthroat trout ≥180 mm FL in Florence Lake in 2003. Number sampled (n_a ; second event only), proportion ($\hat{p}_a$), abundance ($\hat{N}_a$), and standard error (SE) are shown for each 20-mm length class.

Length a, mm FL	n_a	$\hat{p}_a$	SE($\hat{p}_a$)	$\hat{N}_a$	SE($\hat{N}_a$)
180–199	446	0.261	0.011	3,129	217
200–219	505	0.295	0.011	3,543	239
220–239	405	0.237	0.010	2,841	202
240–259	177	0.103	0.007	1,242	112
260–279	88	0.051	0.005	617	73
280–299	40	0.023	0.004	281	47
300–319	25	0.015	0.003	175	36
320–339	15	0.009	0.002	105	28
340–359	5	0.003	0.001	35	16
360–379	2	0.001	0.001	14	10
≥380	4	0.002	0.001	28	14
Total	1,712[a]		$\hat{N}$ =	12,011	

[a] 1,713 (n_2) - 1 fish with no length recorded = 1,712.

POPULATION MONITORING

Although a monitoring program for cutthroat trout populations in Southeast Alaska does not currently exist, Florence Lake would be a likely candidate for future studies because it is one of the few cutthroat trout populations in Alaska with multiple years of abundance estimates (e.g., Rosenkranz et al. 1999). However, prior to the initiation of future mark–recapture studies on cutthroat trout populations, careful consideration should be given to regionwide monitoring goals and objectives. Gibbs (2000) and Steidl (2001) provide helpful recommendations for designing monitoring programs. While the overall goal may be to preserve wild cutthroat trout populations and their habitat, more specific monitoring goals may be to evaluate the effectiveness of regionwide regulations. In this case, Florence Lake may be a poor choice due to the unique sport fishing regulations and the low harvest levels (Appendix A1). However, periodic stock assessment studies may be warranted due to the unknown long-term effects of habitat alterations (i.e., timber harvest) in the Florence Lake watershed. Researchers should conduct additional stock assessment studies in intervals of 10 years or less.

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APPENDIX A

Appendix A1.–Estimates of sportfishing effort, harvest, and catch of cutthroat trout at Florence Lake, 1992 to 2002. Fishery statistics are from Alaska Department of Fish and Game postal surveys of U. S. Forest Service (USFS) recreational cabins users (Jones 1993-1995; Jones and Kondzela 2001; Harding et al. 2005).

Fishery Statistic	1992	1993	1994	1999	2002
Hours fished	332	423	803	101	126
Days fished	59	94	232	75	54
Harvest	175	197	326	88	77
Released	844	1,990	1,082	317	405
Catch (harvest + release)	1,019	2,187	2,187	405	482

Appendix A2.–Tests of consistency for the Petersen estimator (from Seber 1982, page 438).

Of the following conditions, at least one must be fulfilled to meet assumptions of a Petersen estimator:

- Marked fish mix completely with unmarked fish between events;
- Every fish has an equal probability of being captured and marked during the first event;

or,

- Every fish has an equal probability of being captured and examined during the second event.

To evaluate these three assumptions, the chi-square statistic can be used to examine the following contingency tables as recommended by Seber (1982). At least one null hypothesis needs to be accepted for assumptions of the Petersen model (Bailey 1951-1952; Chapman 1951) to be valid. If all three tests are rejected, a temporally or geographically stratified estimator (Darroch 1961) should be used to estimate abundance.

I.-"Complete mixing test"[a]

	Time/Area Where Recaptured				Not Recaptured
Area/Time Where Marked	1	2	…	t	(n_1-m_2)
1					
2					
…					
s					

II.-"Equal Proportions test"[b]

	Area/Time Where Examined			
	1	2	…	t
Marked (m_2)				
Unmarked (n_2-m_2)				

III.-Pooled version of "Complete mixing test"[c]

	Area/Time Where Marked			
	1	2	…	s
Recaptured (m_2)				
Not Recaptured (n_1-m_2)				

[a] This tests the hypothesis that movement probabilities (θ) from time or area *i* (*i* = 1, 2, ...s) to section *j* (*j* = 1, 2, t) are the same among sections: H_0: $\theta_{ij} = \theta_j$ (test for homogeneity of the rows of the s by (t+1) table.

[b] This tests the hypothesis of homogeneity on the columns of the 2-by-t contingency table with respect to the marked to unmarked ratio among time or area designations: H_0: $\Sigma_i a_i\theta_{ij} = kU_j$, where k = total marks released/total unmarked in the population, U_j = total unmarked fish in stratum *j* at the time of sampling, and a_i = number of marked fish released in stratum I. Accepting H_0: is consistent with an equal probability of capture during the first event.

[c] This tests the hypothesis of homogeneity on the columns of this 2-by-s contingency table with respect to recapture probabilities among time or area designations: H_0: $\Sigma_j\theta_{ij}p_j = d$, where p_j is the probability of capturing a fish in section *j* during the second event, and d is a constant.

Appendix A3.–Detection of size- and/or sex-selective sampling during a two-sample mark–recapture experiment and its effects on estimation of population size and population composition.

Size selective sampling: The Kolmogorov-Smirnov two sample test (Conover 1980) is used to detect significant evidence that size selective sampling occurred during the first and/or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (M) with that of marked fish recaptured during the second event (R) by using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (C) with that of R. A third test that compares M and C is then conducted and used to evaluate the results of the first two tests when sample sizes are small. Guidelines for small sample sizes are <30 for R and <100 for M or C.

Sex selective sampling: Contingency table analysis (Chi^2-test) is generally used to detect significant evidence that sex selective sampling occurred during the first and/or second sampling events. The counts of observed males to females are compared between M&R, C&R, and M&C using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. If the proportions by gender are estimated for a sample (usually C), rather an observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are then compared between samples using a two sample test (e.g. Student's t-test).

M vs. R	**C vs. R**	**M vs. C**
Case I:		
Fail to reject H_o	Fail to reject H_o	Fail to reject H_o
There is no size/sex selectivity detected during either sampling event.		
Case II:		
Reject H_o	Fail to reject H_o	Reject H_o
There is no size/sex selectivity detected during the first event but there is during the second event sampling.		
Case III:		
Fail to reject H_o	Reject H_o	Reject H_o
There is no size/sex selectivity detected during the second event but there is during the first event sampling.		
Case IV:		
Reject H_o	Reject H_o	Either result possible
There is size/sex selectivity detected during both the first and second sampling events.		
Evaluation Required:		
Fail to reject H_o	Fail to reject H_o	Reject H_o

Sample sizes and powers of tests must be considered:

A. If sample sizes for M vs. R and C vs. R tests are not small and sample sizes for M vs. C test are very large, the M vs. C test is likely detecting small differences which have little potential to result in bias during estimation. *Case I* is appropriate.

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B. If a) sample sizes for M vs. R are small, b) the M vs. R p-value is not large (~0.20 or less), and c) the C vs. R sample sizes are not small and/or the C vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the second event which the M vs. R test was not powerful enough to detect. *Case I* may be considered but *Case II* is the recommended, conservative interpretation.

C. If a) sample sizes for C vs. R are small, b) the C vs. R p-value is not large (~0.20 or less), and c) the M vs. R sample sizes are not small and/or the M vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the first event which the C vs. R test was not powerful enough to detect. *Case I* may be considered but *Case III* is the recommended, conservative interpretation.

D. If a) sample sizes for C vs. R and M vs. R are both small, and b) both the C vs. R and M vs. R p-values are not large (~0.20 or less), the rejection of the null in the M vs. C test may be the result of size/sex selectivity during both events which the C vs. R and M vs. R tests were not powerful enough to detect. *Cases I, II, or III* may be considered but *Case IV* is the recommended, conservative interpretation.

Case I. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

Case II. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the M vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case III. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the C vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case IV. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

If stratification by sex or length is necessary prior to estimating composition parameters, then overall composition parameters (p_k) are estimated by combining within stratum composition estimates using:

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$$\hat{p}_k = \sum_{i=1}^{j} \frac{\hat{N}_i}{\hat{N}_\Sigma} \hat{p}_{ik} \qquad (1)$$

and,

$$\hat{V}[\hat{p}_k] \approx \frac{1}{\hat{N}_\Sigma^2} \left(\sum_{i=1}^{j} \hat{N}_i^2 \hat{V}[\hat{p}_{ik}] + (\hat{p}_{ik} - \hat{p}_k)^2 \hat{V}[\hat{N}_i] \right) \qquad (2)$$

where:
- j = the number of sex/size strata;
- $\hat{p}_{ik}$ = the estimated proportion of fish that were age or size *k* among fish in stratum *i*;
- $\hat{N}_i$ = the estimated abundance in stratum *i*; and,
- $\hat{N}_\Sigma$ = sum of the $\hat{N}_i$ across strata.

Appendix A4.–Computer files used to estimate the abundance and length composition of cutthroat trout ≥180 mm FL in Florence Lake in 2003.

File Name	Description
FLOR03ABUN.XLS	EXCEL spreadsheet with abundance estimates and chi-squared tests for heterogeneity in capture probabilities related to spatial heterogeneity
FLOR03KS.XLS	EXCEL spreadsheet with Kolmogorov-Smirnov size selectivity tests
FLOR2003_LENGTH.XLS	EXCEL spreadsheet with length composition analysis
FLOR2003_DATA.XLS	EXCEL spreadsheet with Florence Lake 2003 raw data, including fish lengths, tag numbers, depths, gear type, and comments