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Lake Eva Cutthroat Trout Population Status, 1996

by

Artwin E. Schmidt,

Robert P. Marshall,

and

Roger D. Harding

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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

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LAKE EVA CUTTHROAT TROUT POPULATION STATUS, 1996

by

Artwin E. Schmidt
Division Sport Fish, Sitka
and
Robert P. Marshall and Roger D. Harding
Division Sport Fish, Juneau

Alaska Department of Fish and Game
Division of Sport Fish
Anchorage, Alaska

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Address correspondence to:

Artwin E. Schmidt
Alaska Department of Fish and Game, Division of Sport Fish, Region I
304 Lake Street, Room 103, Sitka, AK 99835-7563, USA

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ABSTRACT

Suspected declines in cutthroat trout *Oncorhynchus clarki* abundance in Southeast Alaska and a history of thorough research in the 1960s at the Lake Eva system on Baranof Island prompted a re-examination of the Lake Eva system between 1995 and 1997. Research in 1995 included a weir to count emigrants for comparison to historical data, and a mark recapture experiment in Lake Eva to estimate abundance. An estimated 2,154 (SE = 274) cutthroat trout ≥180 mm fork length (FL) were present in mid-July 1995, after mature sea-run trout had emigrated from the lake.

Lake sampling was extended in 1996 and 1997 to permit use of a Jolly-Seber (JS) model to estimate abundance in 1996. An estimated 1,487 (SE = 464) cutthroat trout ≥180 mm FL were present during mid-July 1996 using the JS model. Catch per unit effort with traps decreased from a high of 1.77 fish per trap in 1995 to 1.27 in 1996, then to a low of 0.47 fish per trap in 1997. The low CPUE in 1997 may indicate significantly lower population size in 1997. The estimate of survival for marked fish between 1995 and 1996 was $\phi = 0.27$. This low estimate likely resulted because Lake Eva serves as a nursery lake for immature anadromous fish, and/or that fish sampled in one year simply emigrated to unsampled stream habitats above and below the lake prior to subsequent samplings.

Approximately one-half of the cutthroat trout ≥180 mm FL present in the lake during mid-July 1995–1997 were larger than 240 mm FL, and one-half were between 180 mm and 239 mm FL. Only 51 of 1,111 (4.6%) cutthroat sampled during the study were larger than the minimum 14-inch size limit (>336 mm FL) established for harvesting by sport fishermen.

Key words: Alaska, Lake Eva, cutthroat trout, abundance, mark-recapture, Jolly-Seber model.

INTRODUCTION

Concern over suspected declining abundance of cutthroat trout in Southeast Alaska (Figure 1) prompted the Alaska Board of Fisheries to adopt more restrictive regulations for cutthroat trout in 1994 (Appendix A1). Historical data exist for few systems in Southeast Alaska, but extensive research was conducted on the anadromous emigrations from the Eva system during the 1960s (Heiser 1966; Armstrong 1971). Thus, we placed a weir across Eva Creek in the summer of 1995 to count emigrant Dolly Varden and cutthroat trout for comparison to historical abundance (Yanusz and Schmidt 1996). A total of 2,562 cutthroat trout and 117,821 Dolly Varden emigrated in 1995, far more than counted in the 1960s. Also, a two-event (closed population) mark-recapture experiment was used to estimate an abundance of 2,154 cutthroat trout ≥180 mm FL (large cutthroat trout, LCT) in the lake following the spring emigration in 1995 (Yanusz and Schmidt 1996).

The mark-recapture experiment at Lake Eva was extended to the summers of 1996 and 1997 to enable an estimate of abundance in 1996 based on an open population model. The added result would, we reasoned, complement the Petersen estimate for Lake Eva in 1995 and provide a robust analysis of the population size. The objectives of the Lake Eva project in 1996 and 1997 were unchanged from 1995: our goals were to estimate abundance and length composition of LCT in Lake Eva during a period when mature sea-run trout were absent from the lake.

STUDY AREA

The Lake Eva drainage is located on northeastern Baranof Island in Southeast Alaska (Figure 2), and drains into Peril Strait at Hanus Bay (57° 2′ 31″ N, 125° 4′ 3″ W). Lake Eva's (anadromous stream catalog number 113-52-10040-0010) surface area is 105 ha and its maximum depth is 22 m (Figure 3). The outlet stream to Lake Eva,

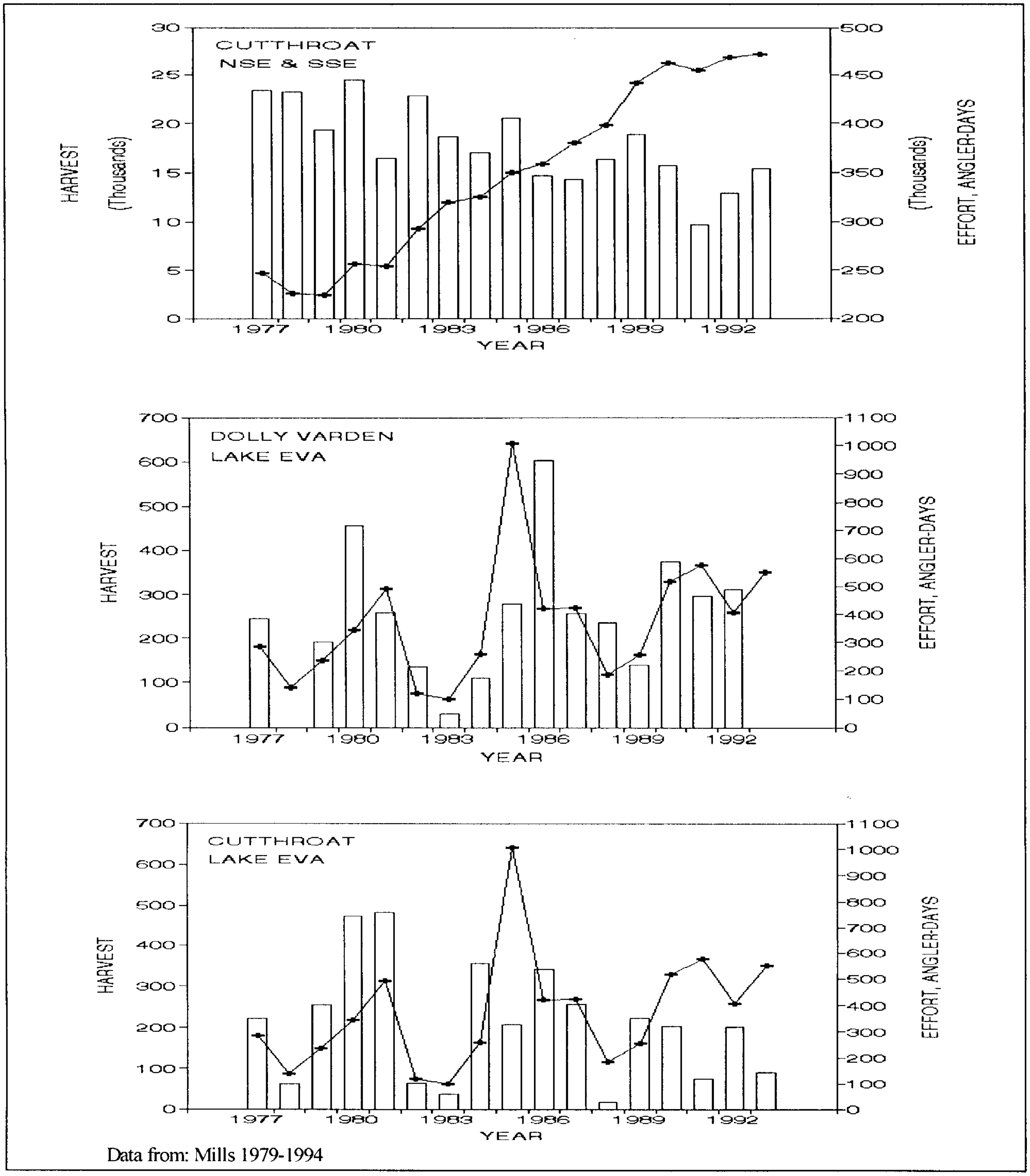

Figure 1.–Harvests of cutthroat trout for all of Southeast Alaska (top), Dolly Varden (middle) and cutthroat trout (bottom) at Lake Eva, and associated effort, 1977–1993. Harvests are represented by bars and effort by lines. From Yanusz and Schmidt (1996).

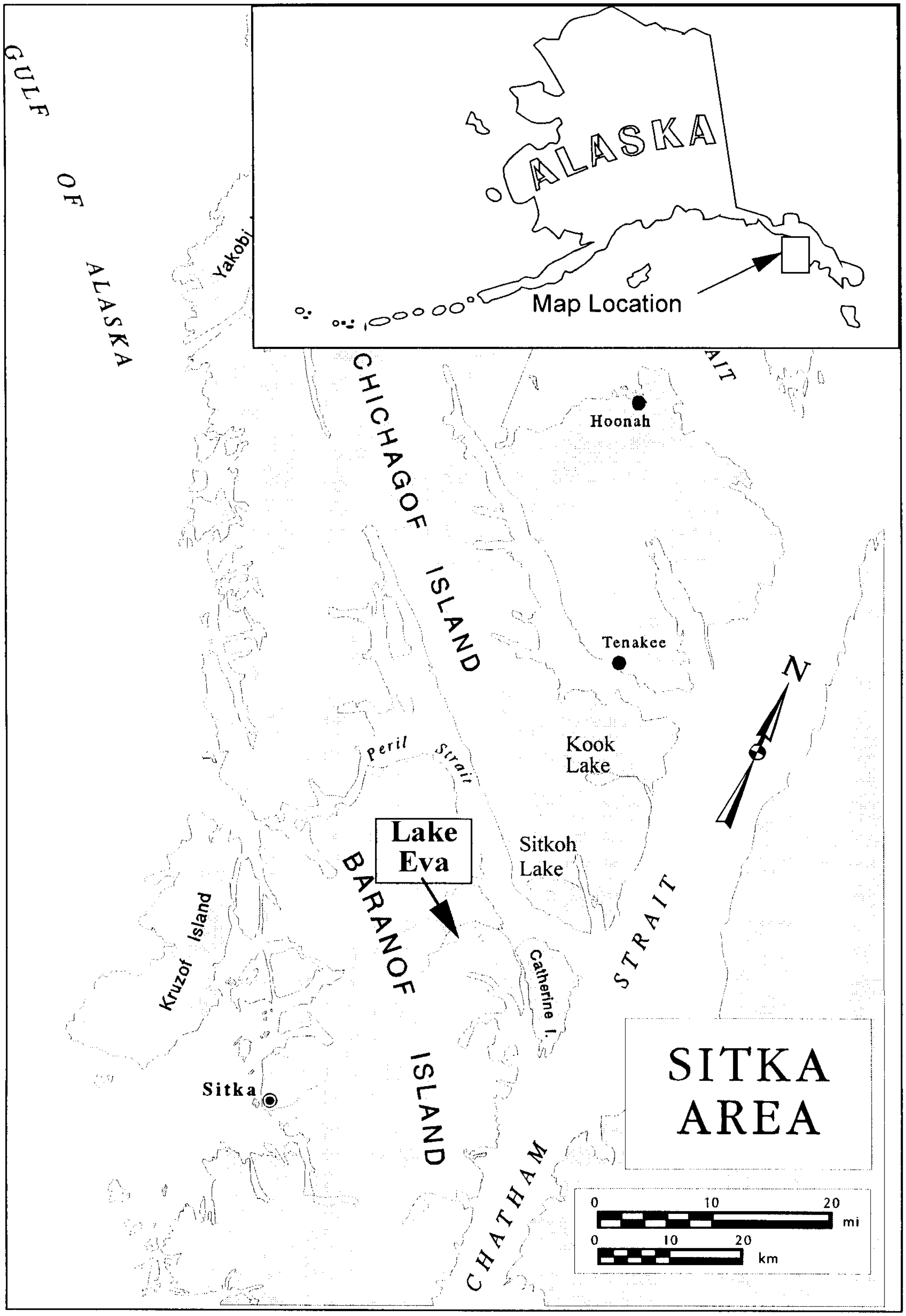

Figure 2.–Location of Lake Eva on northern Baranof Island in northern Southeast Alaska.

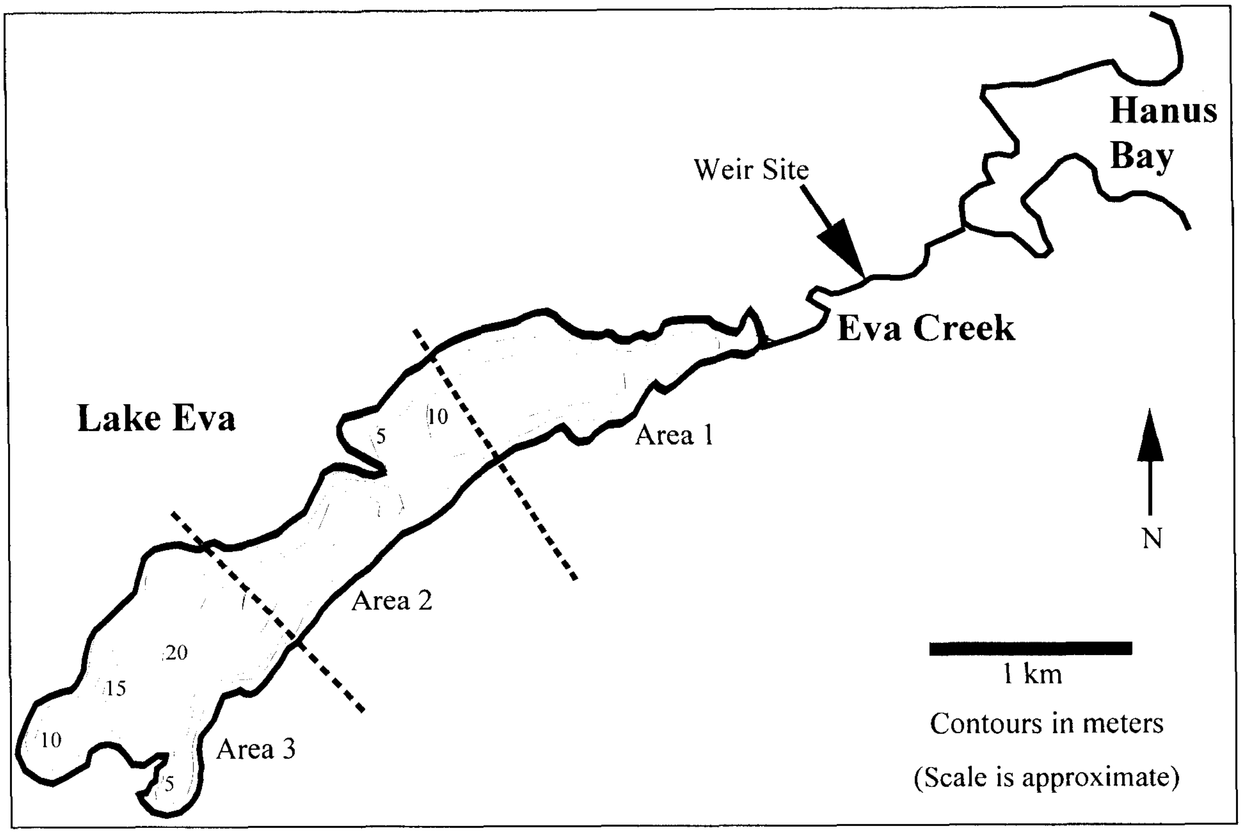

Figure 3.–Lake Eva, Eva Creek and Hanus Bay, showing location of weir site and boundaries of lake sampling areas.

Eva Creek (anadromous stream catalog number 113-52-10040), is approximately 1.5 km long, 20–50 m wide, and 0.3–2 m deep. The main inlet stream to Lake Eva is a low-gradient meandering stream that extends at least 3 miles above the head of the lake. Cutthroat trout spawning is documented in Eva Creek (Armstrong 1971). Substantial spawning (i.e. 1,000 fish on July 21, 1961) of sockeye salmon *Oncorhynchus nerka* is documented in the inlet stream via aerial survey (Parker 1970), but its use for spawning by cutthroat trout is only assumed (Doug Jones, Rich Yanusz, Alaska Department of Fish and Game, Douglas, personal communication). The extent of spawning in the Lake Eva system by anadromous and non-anadromous (potamodromous) life history forms of cutthroat trout is unknown (i.e., Armstrong 1971; Yanusz and Schmidt 1996).

The Lake Eva system is an important overwintering site for sea-run Dolly Varden and anadromous cutthroat trout populations. During 1962–1964 an average of 1,346 cutthroat trout (range 1,210 to 1,594) emigrated from Lake Eva, and during 1962 and 1963 an average of 66,130 Dolly Varden (range 38,957 to 93,303) emigrated (Heiser 1966; Armstrong 1971).

METHODS

A Jolly-Seber (JS) mark-recapture experiment was used to estimate the abundance of cutthroat trout ≥180 mm FL present in Lake Eva during mid-July 1996. Sampling occurred each July from 1995 through 1997 (i.e., in k = 3 years), when emigration of mature, anadromous trout from the lake was completed in 1995, or assumed to be completed in 1996 and 1997. Historical weir counts from Eva Creek from 1962 to 1965 and daily weir counts in 1995 (Figure 4, Yanusz and Schmidt 1996) were used to estimate an

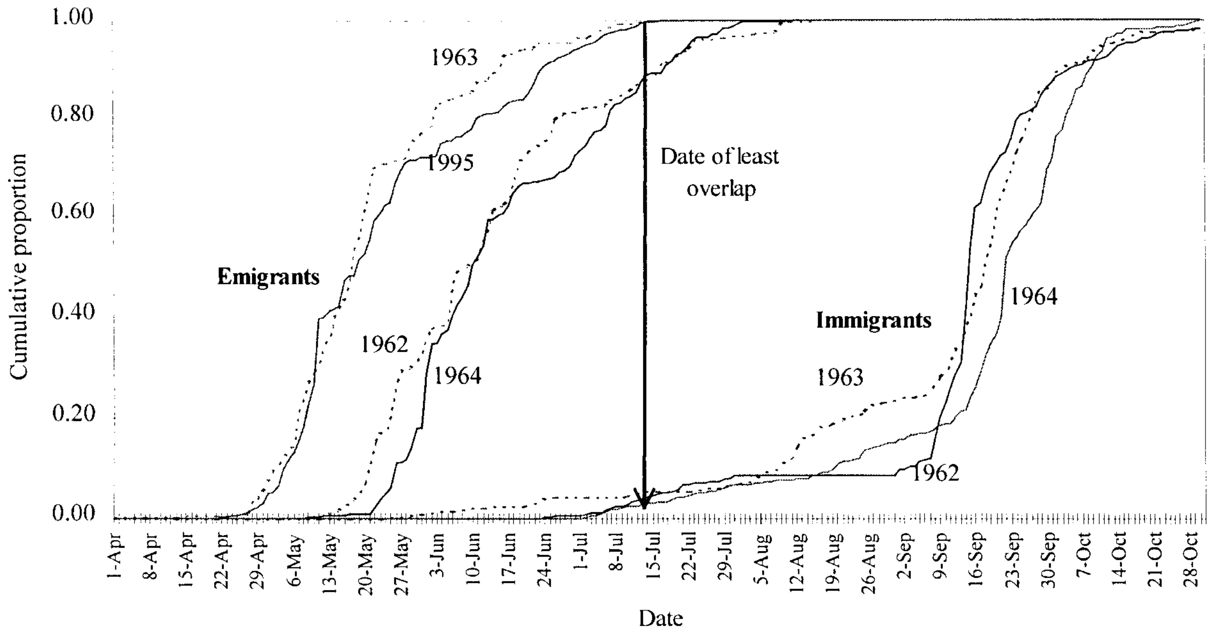

Figure 4.–Timing of immigration and emigration of sea-run cutthroat trout at Lake Eva during 1962–1964 and 1995, showing date of least overlap of the migrations, 14 July. Data from Alaska Department of Administration Archives, Juneau, Alaska.

"optimal" sampling date in 1995 (the time when most anadromous emigrants were absent from the lake). The first sampling event consisted of two 10-day sampling trips (pooled into event 1 for this experiment) between 2 July and 1 August 1995. Sampling events 2 and 3 occurred from 22 to 31 July 1996 and from 9 to 20 July 1997, near the estimated "optimal" sampling date of July 14 (Figure 4).

Fish were captured with baited funnel traps (1 m long and 0.6 m wide) and sport fishing (hook-and-line, H&L) gear. Traps were baited with about 300 ml of whole salmon eggs. All LCT sampled were examined for marks, measured to the nearest 1 mm FL, tagged with a numbered Floy® anchor T-bar tag if unmarked (except for some captured in 1995), given a secondary mark to permit estimation of tag loss, and sampled for scales. Tags were inserted on the left side of the fish immediately below the dorsal fin. Secondary marks were clipped adipose fins in 1995, and Visual Implant (VI) tags (in the anal fin) in 1996. Scales were sampled from the caudal peduncle immediately above the lateral line. Cutthroat trout <180 mm FL were processed as above except no marks were placed. Dolly Varden captured were counted and not otherwise sampled. Sampling was not conducted in inlet streams or in Eva Creek. Mean catch per unit effort (CPUE) by sampling period and gear type was calculated using standard methods.

Sampling methods varied slightly each year, but were always designed so that each fish present in the lake should have a similar probability of being captured each year. During 1995, traps were moved across the lake surface during each 10-day trip, and in 1996 and 1997 traps were redistributed uniformly across the lake surface each day. Traps were set overnight on the lake bottom, and depths were determined with a fathometer. During 1995 and 1997, hook-and-line sampling was distributed uniformly around the lake perimeter, whereas in 1996 it was uniformly distributed, via trolling, across the entire surface of the lake.

The assumptions for accurate estimation under the JS model are as follows (Seber 1982):

1) every fish in the population has the same probability of capture in the ith sample;

2) every marked fish has the same probability of surviving from the ith to the $(i+1)$th sample and being in the population at the time of the $(i+1)$th sample;

3) every fish caught in the ith sample has the same probability of being returned to the population;

4) marked fish do not lose their marks between sampling events and all marks are reported on recovery; and,

5) all samples are instantaneous (i.e., sampling time is negligible).

A goodness-of-fit test (of marked fish seen before versus not seen before *against* seen again versus not seen again) as discussed in Pollock et al. (1990) and implemented in program JOLLY (Brownie et al. 1986) was used to test the assumptions of homogeneous capture and survival probabilities. The test is equivalent to the Robson (1969) test for short-term mortality (Pollock et al. 1990).

The condition that the probability of capture is the same for all fish within a sampling event can be waived in an experiment based on the JS model if marked and unmarked fish mix completely between sampling events (Seber 1982:211). A test for mixing *by mark status* is to compare the recapture/capture (R/C) fractions of fish caught with traps on the lake bottom to those caught near shore with hook-and-line, *using only fish marked with traps in the previous year.* If $(R/C)_{trap} > (R/C)_{H\&L}$, lack of complete mixing is indicated, if $(R/C)_{trap} = (R/C)_{H\&L}$, complete mixing is indicated, and if $(R/C)_{trap} < (R/C)_{H\&L}$, trap shyness is indicated. A chi-square (2×2 contingency table) statistic ($\alpha = 0.10$) was used for the test.

The assumption of equal probabilities of capture is also violated by differential vulnerability to sampling gear (size-selective sampling). A test for size-selective sampling was conducted by comparing an abundance estimate for the entire population of LCT against the sum of estimates obtained by stratifying the experiment into two size classes. If size-selective sampling was not significant, the sum of the stratified estimates should not be significantly different from the estimate for all fish ≥180 mm FL. We stratified the capture data at 280 mm FL in this experiment, a point near the median length of fish recaptured each year in the lake. Adequacy of the stratified data set for large fish was tested using the GOF test noted above. However, the procedure cannot be applied to the smaller size class since marks applied at time i-1 will more likely have grown out of the analysis than fish marked at time i. Also, the annual survival rate estimate for the small size class is meaningless, since small fish can grow into the larger size class between events. In fact, the likely presence of immature anadromous fish in the lake dictates that all survival estimates from the analysis must be carefully considered.

The assumption that all fish have the same chance of surviving from the ith to the $(i+1)$th sampling implies the absence of significant age dependent mortality rates for LCT (Manly 1970). Little evidence of age dependent mortality was found for LCT in Florence Lake (Rosenkranz et al. 1998). A gross indication of size (or age) dependent mortality in this experiment can be obtained by comparing the survival estimate from the largest size class of the length-stratified analysis (described above) to the survival estimate from the unstratified analysis. If the two estimates are similar, the absence of a strong age dependent mortality schedule at Eva Lake would be indicated.

Assumption 3 will be evaluated by direct examination of the capture histories (mortality status by year) from each event. Assumption 4 was addressed by double marking fish with secondary marks. Tag loss was calculated for each sampling date/year. Estimates of loss greater than 10% will necessitate special consideration of bias in the estimates.

Assumption 5 was possible in this experiment: sampling was confined to 21 days in 1995, 9 days in 1996, and 12 days in 1997. Since this is a relatively short time in the context of the experiment, we assume that additions and losses (recruitment and death) to the population during each sampling are insignificant.

Data for the JS analysis were organized and processed using the computer program POPAN-4 (Arnason et al. 1995). Minimum length 95% confidence intervals for an estimate of abundance were also estimated using the nonparametric bootstrap as implemented in the computer program RECAP (Buckland 1980).

Because size-selective sampling was not indicated in this analysis, the length composition of cutthroat trout present in Lake Eva in mid-July, when emigrant fish were absent from the system, was calculated by pooling data from each sampling 1995–1997. The fraction p of fish in length group i (20-mm increments) was calculated:

$$\hat{p}_i = \frac{n_i}{n} \quad (1)$$

$$V[\hat{p}_i] = \frac{\hat{p}_i(1 - \hat{p}_i)}{n - 1} \quad (2)$$

where n_i is the number in group i and n is the total number sampled.

RESULTS

The estimated number of LCT present in Lake Eva during mid-July 1996 was 1,487 (SE = 464). Nonparametric (95%) bootstrap confidence intervals for the estimate were 716 to 2,763 fish; the mean bootstrap estimate of 1,590 fish suggests statistical bias was small (6%). The goodness-of-fit test for homogeneous capture/survival probabilities reveals no significant inadequacy (P = 0.61, Table 1). Also, contingency table tests for mixing by mark status indicate mixing of marks between 1996 and 1997 (P = 0.53, Table 2a), and for (pooled) marks placed in 1995-1996 and captured in 1997 (P = 0.49, Table 2b). Similarly, an estimate of abundance obtained by stratifying the experiment by size groups, $\hat{N}$ = 1,098 (SE = 556), is not significantly different (P = 0.60) from the unstratified estimate of 1,487 (Table 3). Goodness-of-fit tests could not be completed for the stratified data due to the small sample sizes. Very few fish were lost or injured significantly at capture, and loss of numbered primary tags during the 3-year experiment was acceptably small (7%). Survival of marked fish from 1995 to 1996 (Table 3) was 0.27 (SE = 0.07). Statistics and capture histories

Table 1.–Goodness-of-fit test for homogeneous capture/survival probabilities by tag group in 1995 and 1996 (p is the probability of capture for each group of tagged fish).

		First captured in 1995	First captured in 1996
Captured in 1996, released and recaptured		2.0	30.0
Expected value		2.8	29.3
Captured in 1996, released, not recaptured		18.0	183.0
Expected value		17.3	183.8
χ^2 = 0.26, 1 df, P = 0.61	$\hat{p} \rightarrow$	0.10	0.14

Table 2.–Goodness-of-fit tests for complete mixing of fish marked offshore with traps by recovery method/location in 1997 (p is the probability of capture for each group of tagged fish).

PANEL A: MARKED IN 1996		Captured offshore by trap in 1997	Captured onshore by H&L in 1997
Recaptures marked in traps in 1996		9.0	19.0
Expected value		7.6	20.4
Recaptures not marked in traps in 1996		94.0	258.
Expected value		95.4	257.
$\chi^2 = 0.39$, 1 df, $P = 0.53$	$\hat{p} \rightarrow$	0.087	0.069

PANEL B: MARKED IN 1995 AND 1996		Captured offshore by trap in 1997	Captured onshore by H&L in 1997
Recaptures marked in traps in 1995-96		10.0	34.0
Expected value		11.9	32.1
Recaptures not marked in traps in 1995-96		93.0	243.
Expected value		91.1	245.
$\chi^2 = 0.48$, 1 df, $P = 0.49$	$\hat{p} \rightarrow$	0.097	0.12

Table 3.–Jolly-Seber estimates and standard errors.

PANEL A: Cutthroat trout ≥180 mm FL

Year	N	SE(N)	ϕ	SE(ϕ)	p	SE(p)
1995			0.272	0.069		
1996	1487	464			0.150	0.048

PANEL B: Cutthroat trout 180–280 mm FL

Year	N	SE(N)	ϕ	SE(ϕ)	p	SE(p)
1995			0.105	0.048		
1996	592	289			n/a	n/a

PANEL C: Cutthroat trout >280 mm FL

Year	N	SE(N)	ϕ	SE(ϕ)	p	SE(p)
1995			0.261	0.209		
1996	506	475			n/a	n/a

for the JS analysis are summarized in Appendices A2–A4; a key to the data archived from this analysis is Appendix A5.

Catch per unit effort of LCT caught with trap gear (Table 4) decreased from a high of 1.77 fish per trap in 1995 to 1.27 in 1996, then to a low of 0.47 fish per trap in 1997. The annual CPUE should be comparable since in each year the traps were set uniformly across the lake on each day sampled. The low CPUE in 1997 may thus indicate a significantly lower population size in 1997. However, another year of study would have been necessary to obtain a population estimate for 1997. In contrast, we note that the CPUE by H&L is not comparable over time, as methods in 1995 (mostly casting along shore), 1996 (mostly *trolling* offshore), and 1997 (mostly casting along shore, but with bait at times) differed significantly over time.

The distribution of lengths for LCT captured in large traps did not vary significantly from year to year (Figure 5), which suggests that distribution

Table 4.–Effort and catch statistics (top panel) and catch per unit effort (CPUE, lower panel) for cutthroat trout (CT) and Dolly Varden (DV) captured in traps (fish/set) and with hook and line (HL, fish/hr) at Lake Eva 1995–1997.

	Effort		Catch					
			DV		CT <180mm		CT ≥180mm	
Year	No.traps	HL hrs	Trap[a]	HL	Trap[a]	HL	Trap[a]	HL
1995	260	73	3,006	84	101	8	461	228
1996[a]	180	47	4,063	14	71	0	228	16
1997	220	99	1,029	75	52	23	104	279

	CPUE					
	DV		CT <180mm		CT ≥180mm	
Year	Trap[a]	HL	Trap[a]	HL	Trap[a]	HL
1995	11.56	1.15	0.39	0.11	1.77	3.12
1996[a]	22.57	0.30	0.39	0.00	1.27	0.34
1997	4.68	0.75	0.24	0.23	0.47	2.81

[a] Traps were generally fished 18–30 hr/set. HL effort in 1996 was mostly by trolling offshore.

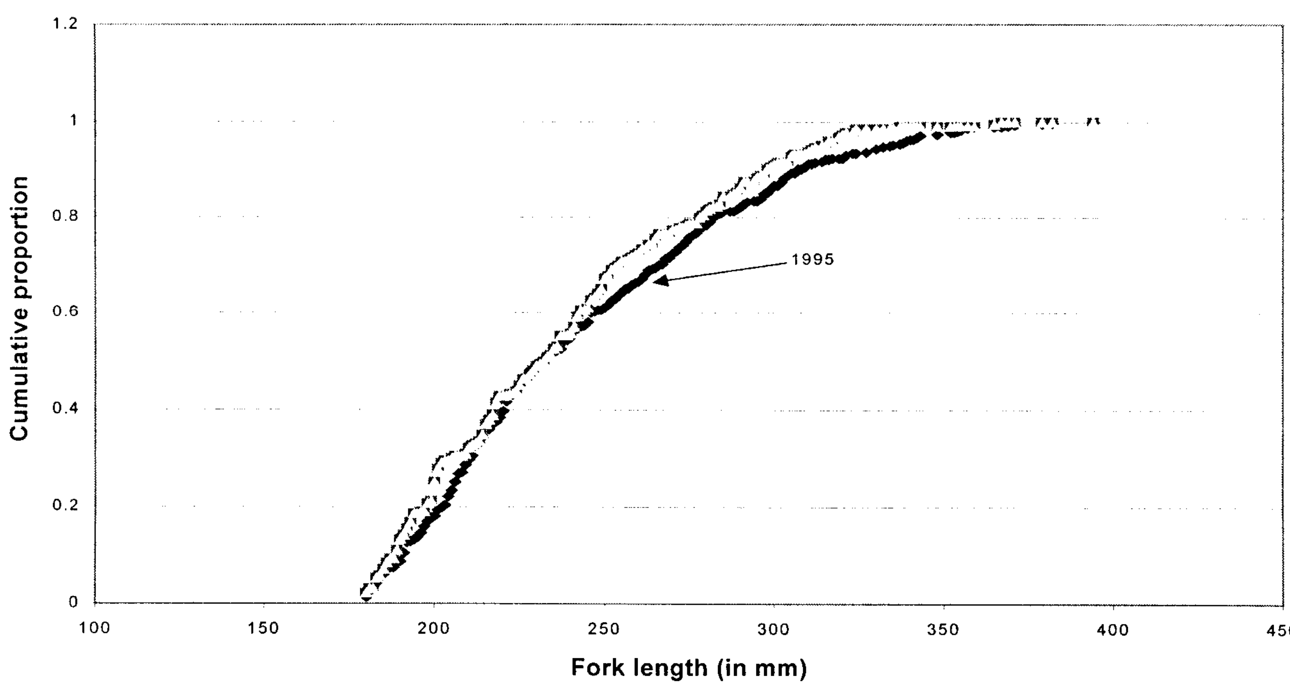

Figure 5.–Cumulative length distribution of cutthroat trout captured in large traps at Lake Eva, 1995, 1996, and 1997.

of fish sizes was stable. In contrast, the distribution of cutthroat lengths did vary annually when H&L catches were included (Figure 6). This occurs because H&L fishing contributed heavily to samples only in 1995 and 1997, and fish landed with H&L were larger than fish landed in traps ($\bar{L}_{H\&L}$ = 267 mm vs. $\bar{L}_{trap}$ = 236 mm in 1997, for example).

Average length composition of the LCT present in Lake Eva during mid-July was estimated by pooling data from all original captures over all years (Figure 7, Table 5). Approximately one-half of the fish captured ≥180-mm FL in this study were > 240 mm FL, and one-half were between 180 mm and 239 mm FL. The largest fish sampled was < 400 mm FL. Only 51 of the 1,111 large cutthroat sampled (4.6%) were larger than the minimum 14-inch size limit (> 336 mm FL) for sport fishermen.

DISCUSSION

The estimated abundance of LCT in Lake Eva during the summer of 1996 (1,487, SE = 464) is slightly lower than the estimate for 1995 (2,154 SE = 274, Yanusz and Schmidt 1996). The two estimates are not strictly comparable, however, because they pertain to different years.

Annual survival estimated from the experiment (ϕ = 0.27, SE = 0.07) is unusually low for a trout population. For example, estimates of annual survival in Florence Lake (0.42–0.54) are significantly higher, even though they are known to be biased low (Rosenkranz et al. 1998). Two probable explanations for the low survival estimate are:

- A significant fraction of the fish present in the lake during mid-July are progeny of anadromous parents, and thus emigrated to sea prior to sampling in 1996 and/or 1997. Immature juveniles which reared in the Lake Eva system since birth seem likely candidates under this scenario, but it may also be possible that immature fish immigrated from other systems the previous fall (seeking better rearing habitat, for example), and that anadromous emigrants elected to remain in freshwater a summer (Doug Jones, Alaska Department of Fish and Game, Douglas, personal communication).
- The Lake Eva system utilized by summer "residents" includes significant stream habitat(s) outside of our sampling frame (the lake). Some fish sampled in one year could simply have migrated into unsampled habitats prior to subsequent samplings (in 1996 and 1997). As noted earlier, significant, presumably suitable stream habitat does exist above and below Lake Eva.

Under either scenario the JS survival estimate is meaningless. If the first explanation is correct, the closed population and JS model estimates (for 1995 and 1996, respectively) both provide accurate estimates of abundance *in the lake*. Under the second, the JS model again accurately estimates abundance in the lake, whereas the closed population estimate is biased high *if* significant mixing between sampled and unsampled areas occurred during the 4-week experiment. Bias in this case is the "recruitment" (of unmarked fish into the lake) divided by the "survival" rate (i.e., the loss of marked fish to the unsampled area). A similar situation, where sampling was limited to littoral areas during two summers, occurred at Florence Lake (Rosenkranz et al. 1998).

Experimental power to support either explanation above is low. We cannot demonstrate spawning by anadromous trout in Lake Eva streams, but would be hard pressed to dismiss this possibility without definitive research. Also, we have no record of a fish being marked during summer (July) in Lake Eva and then recovered in another system. Again, essentially no effort was expended in this regard.

Some evidence for an emigration between Lake Eva and other (stream) areas exists. Yanusz and Schmidt (1996) report:

> "Five {*of 394*} cutthroat tagged at the lake passed downstream through the weir or were captured by hook and line between the lake and weir. This was not a complete survey of emigration possibilities, but shows that emigration to a large alternative habitat (the outlet stream) was low {*during the 1995 experiment*}."

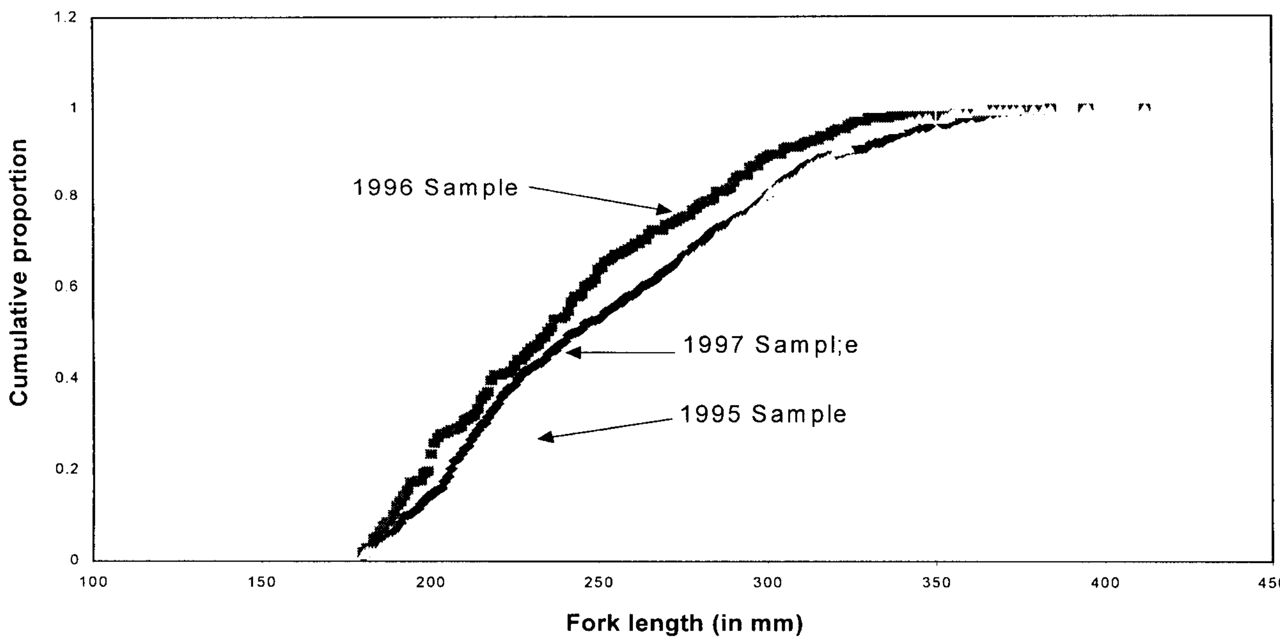

Figure 6.–Cumulative length distribution of cutthroat trout captured with all gear types (large traps and hook and line) at Lake Eva, 1995, 1996, and 1997.

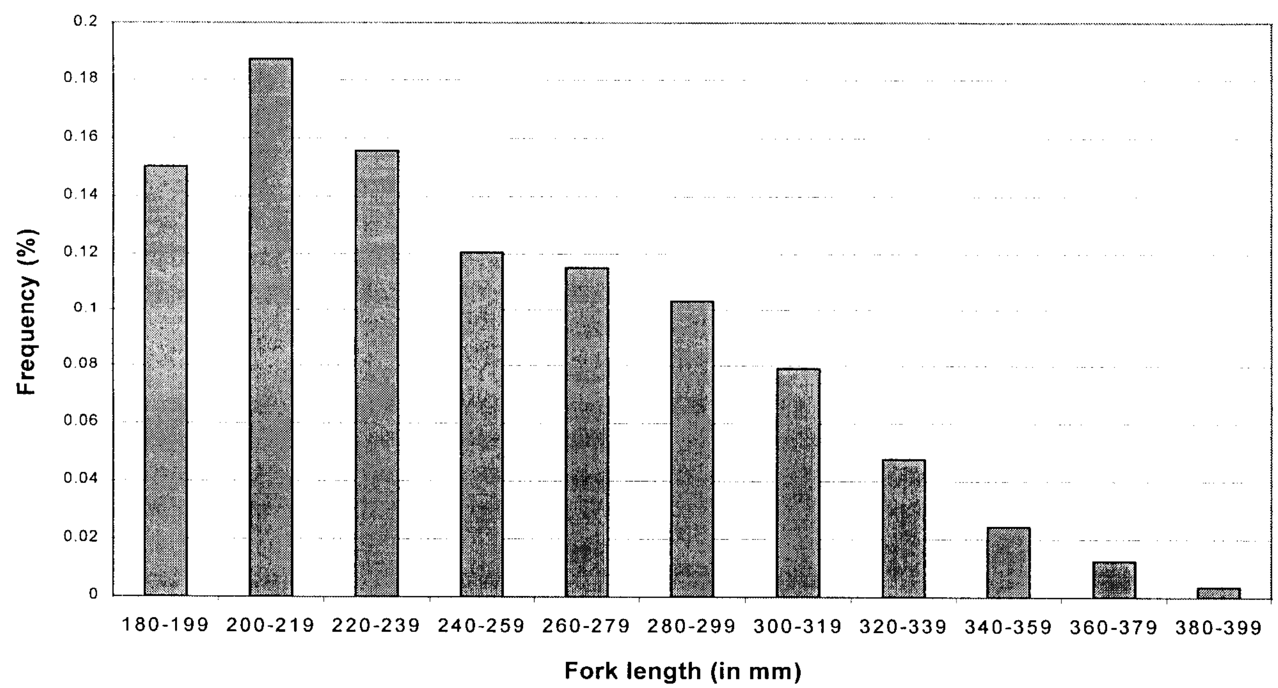

Figure 7.–Length composition of initially captured large cutthroat trout (recaptures excluded) resident in Lake Eva during July sampling, 1995–1997.

Table 5.–Length composition of 1,111 cutthroat trout ≥180 mm FL in Lake Eva in mid-July. Data are from all cutthroat originally caught (no recaptures) with hook and line and traps, 1995–1997.

Fork length	Count (n_i)	Proportion (p_i)	SE (p_i)
180-199	167	0.150	0.011
200-219	208	0.187	0.012
220-239	173	0.156	0.011
240-259	134	0.121	0.010
260-279	128	0.115	0.010
280-299	115	0.104	0.009
300-319	88	0.079	0.008
320-339	53	0.048	0.006
340-359	27	0.024	0.005
360-379	14	0.013	0.003
380-399	4	0.004	0.002

We note that emigration/mixing between the 3 or so miles of stream above the lake was obviously also possible. In the JS experiment, much more time was available for marked fish to mix between the lake and stream habitats. The only data germane to this mixing question are that two emigrant trout tagged at the weir in 1995 were captured in the lake during July 1997 (Yanusz and Schmidt 1996).

In concluding the discussion of these two possibilities, we note the goodness-of-fit employed in the JS analysis (Table 1) is sensitive to age-dependent "emigration" rates, just as it is to heterogeneous capture or "survival" rates. If, for instance, the lake population each July were to consist entirely of immature anadromous fish, one might assume that those marked in year *t* would on average be more likely to "survive" or be present in the lake during July of year $t + 1$ than fish marked in year t-1. Although ("older") fish marked in 1995 were captured at a lower rate than ("younger fish") marked in 1996 ($p = 0.10$ versus $p = 0.14$), the test was not statistically significant ($P = 0.61$, Table 1). Unfortunately, because sample sizes were low, power of the test ($1-\beta$ at $\alpha = 0.1$) to detect a significant difference in the two observed capture rates ($p = 0.1$ and $p = 0.14$) is only about 0.25.

Other difficulties with the mark-recapture experiments are not apparent. Spawning migrations of non-anadromous cutthroat trout in the system were most likely concluded prior to our July samplings (Armstrong 1971; Morrow 1980; Trotter 1987; Behnke 1992; Rosenkranz et al 1998), and sampling uniformly blanketed the entire lake each trip. We implicitly assumed mature, anadromous adults were absent from the lake during each sampling trip. While we observed the emigration in 1995, we could not do so in 1996 and 1997, and movements in 1995 may not accurately indicate the timing in 1996 and 1997. However, because the abundance estimate for 1996 is below the estimate for 1995, it is unlikely that a significant number of mature, anadromous adults remained in the lake during sampling in 1996.

Abundance during the 1995–1996 study period would appear adequate to sustain the relatively low (<250 fish) harvest rates just prior to recent harvest restrictions (Figure 1). However, historical data indicate that harvest approached 500 fish per year in the early 1980s (23–33% of Lake Eva's summer population in 1995 and 1996), which would be cause for concern. Fewer than 5% of the fish in the lake are larger than the current legal size limit (14 inches, or about 336 mm FL) which may help explain the current reduction in harvests. Larger, mature sea-run fish might also be captured early and late in the season, but sport fishing effort at Lake Eva is believed to be small at these times of the year.

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APPENDIX A

Appendix A1.–Harvest regulations at Lake Eva, 1960–1997.

Years	Daily limit	Additional restrictions	Possession limit
1960-1974	15	3 > 20 in	2 daily bag limits
1975-1979	10	2 > 20 in	2 daily bag limits
1980-1982	4	1 > 16 in	1 daily bag limit
1983-1984	4	1 > 16 in	2 daily bag limit
1985-1993	5	1 > 16 in	2 daily bag limit
1994-1997	2	14-22 in only, bait prohibited year-round	1 daily bag limit

Appendix A2.–Summary statistics (above) and capture histories for the unstratified Jolly-Seber model, fish ≥180 mm FL, Lake Eva.

Year	n_i	m_i	R_i	r_i	z_i
1995	491	0	491	36	0
1996	233	20	233	32	16
1997	360	48	360	0	0

Capture history	Frequency
100	425
110	18
101	16
111	2
010	183
011	30
001	312

Appendix A3.–Summary statistics (above) and capture histories for the stratified Jolly-Seber model, fish 180-280 mm FL, Lake Eva.

Year	n_i	m_i	R_i	r_i	z_i
1995	155	0	155	6	0
1996	49	3	49	3	3
1997	116	6	116	0	0

Capture history	Frequency
100	149
110	3
101	3
111	0
010	43
011	3
001	110

Appendix A4.–Summary statistics (above) and capture histories for the stratified Jolly-Seber model, fish >280 mm FL, Lake Eva.

Year	n_i	m_i	R_i	r_i	z_i
1995	336	0	336	13	0
1996	184	10	184	21	3
1997	244	24	244	0	0

Capture history	Frequency
100	323
110	9
101	3
111	1
010	154
011	20
001	220

Appendix A5.–Location of historical data, and contents of report and raw data files used to produce this report.

File name	Software	Contents
Database for 1995.xls	Excel	Trap and sport fishing catches, tag numbers, lengths and sample numbers at Lake Eva
Database for 1996-97.xls	Excel	Trap and sport fishing catches, tag numbers, lengths and sample numbers at Lake Eva
Cumlength.xls	Excel	Data analysis of info from previous two files