Fishery Data Series No. 99-24

Evaluation of Short-Term Handling and Tagging Mortality of Cutthroat Trout at Florence Lake, Southeast Alaska, 1998

by

Roger D. Harding

October 1999

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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EVALUATION OF SHORT-TERM HANDLING AND TAGGING MORTALITY OF CUTTHROAT TROUT AT FLORENCE LAKE, SOUTHEAST ALASKA, 1998

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October 1999

Development of this manuscript was partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Projects F-10-13, and F-10-14, Job No. R-1-7.

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This document should be cited as:
Harding, R. D. 1999. Evaluation of short-term handling and tagging mortality of cutthroat trout at Florence Lake, Southeast Alaska, 1998. Alaska Department of Fish and Game, Fisheries Data Series No. 99-24, Anchorage.

TABLE OF CONTENTS

Page

LIST OF TABLES ii

LIST OF FIGURES ii

LIST OF APPENDICES ii

ABSTRACT 1

INTRODUCTION 1

STUDY AREA 2

METHODS 2

RESULTS AND DISCUSSION 5

RECOMMENDATIONS 8

ACKNOWLEDGMENTS 9

LITERATURE CITED 9

APPENDIX A 11

LIST OF TABLES

Table **Page**

1. Frequency and percent mortality by treatment (type of tag and finclip) for fish marked and held overnight for observation, Turner Lake, 1998 2
2. Treatment, sample size, percent mortality, and related statistics for cutthroat trout captured, tagged, sampled, and held overnight at Florence Lake, 1998, by treatment group 4
3. Mortality rate, incidence of fish sampled <200 mm FL, and relative order of sampling in treatment group 2 as a function of time out of water, Florence Lake, 1998 8

LIST OF FIGURES

Figure **Page**

1. Map showing location of Turner and Florence lakes, Southeast Alaska 3
2. Temperature and depth profile at Florence and Turner lakes, 1998 5
3. Percent mortality and temperature by holding depth for cutthroat trout held approximately 24 h during the short-term mortality experiment at Florence Lake, 1998 6
4. Survival status by fork length for cutthroat trout held approximately 24 h during the short-term mortality experiment at Florence Lake, 1998 7
5. Cumulative distributions of lengths of cutthroat trout which died during 24-h holding period versus lengths of cutthroat trout which survived, Florence Lake, 1998 7

LIST OF APPENDICES

Appendix **Page**

A1. Name and type data summaries and raw data files used to produce this report 12

ABSTRACT

In response to observed mortality of cutthroat trout *Oncorhynchus clarki* during a mark-recapture experiment at Turner Lake, a study was initiated to estimate, identify and reduce short-term handling and tagging induced mortality. The study was conducted at Florence Lake between August 25 and 28, 1998. Cutthroat trout were tagged using techniques and tag types that have been employed over the last several years in Southeast Alaska. Impacts of various combinations of passive integrated transponder (PIT), visual implant (VI), and anchor T-bar tags with adipose and left axillary finclips on short-term mortality were tested. Analysis suggests that fish size and the order in which the fish were sampled (sequence order) were the most important variables affecting mortality probability. High water temperatures and extensive handling of fish at Turner Lake may also have contributed to the observed mortality at that site.

Key words: Alaska, Florence Lake, Turner Lake, cutthroat trout, mortality, PIT tags, anchor T-bar tags, visual implant (VI) tags, water temperature, handling.

INTRODUCTION

During July 1998, I observed mortality among cutthroat trout *Oncorhynchus clarki* that were captured and affixed with sonic tags for a telemetry study at Turner Lake. Initially, 2 fish were captured, injected with passive integrated transponder (PIT) and visual implant (VI) tags, given adipose and left axillary finclips, measured for length, and implanted with a sonic tag (23 mm by 9 mm) in the esophagus. These fish were subsequently held overnight at a depth of about 3 m to watch for short-term regurgitation of the transmitter. Both cutthroat died while being held, and necropsies provided no insight about the cause(s) of death. Following these mortalities, unsampled or “control” fish were added to holding pens, and additional tagged fish were held for observation. Two of 6 tagged fish similarly handled and marked and 0 of 4 control fish died overnight, yielding an overall mortality rate of 50% for the 8 fish exposed to this experimental treatment. These observations led to further evaluation of techniques that might be causing the mortalities.

Twenty-six (26) additional fish at Turner Lake were captured, PIT and/or VI tagged, given 1 to 3 secondary finclips (adipose, left axillary appendage, upper caudal) and held overnight at depths between 3 and 16 m (Table 1). None of these fish were given sonic transmitters, so handling and tagging procedures were more similar to those used during recent mark-recapture experiments at Turner Lake (Harding 1995). No more than 6 fish were held overnight in one trap. Also, 16 fish which had not been sampled in any way were held overnight as “controls.” Some auxiliary sampling and handling procedures varied during this “experiment,” with the thought that survival rates might obviously be improved. For example, water in the onboard holding tanks was sometimes cooled with ice, holding traps were sometimes moved to deeper/cooler water, and fish were sometimes not scale-sampled or measured for length. However, none of these auxiliary changes obviously improved survival; mortality appeared to be a function of the overall stress of handling and tagging, as none of 16 control fish died but mortality of marked fish was 42% (Table 1). During both “experiments” I observed that surface water temperatures at Turner Lake were warmer than usual and captured fish sometimes appeared weak and lost scales more readily than during previous sampling.

These observations led to formulation of a more controlled experiment to better determine causes and short-term mortality rates related to typical handling and tagging procedures used during mark-recapture studies of cutthroat trout (e.g., Harding 1995). The experiment was conducted at Florence Lake because fish are much more

Table 1.–Frequency and percent mortality by treatment (type of tag and finclip) for fish marked and held overnight for observation, Turner Lake, 1998. Not included are 16 fish given no tags or finclips and held overnight, none of which died.

	Tags[a]		Finclips[b]			No. of	
Frequency	PIT	VI	AD	LX	UC	mortalities	% mortality
14	x	x	x	x	x	7	50
2	x		x	x	x	2	100
2	x		x	x		0	0
3	x		x			1	33
1	x					0	0
4				x		1	25
Total = 26						11	42

[a] Passive integrated transponder (PIT) and visual implant (VI) tags.

[b] Adipose (AD), left axillary appendage (LX), and partial upper caudal (UC) finclips.

abundant there, and I desired to contrast results with those from Turner Lake. The research objective was:

to estimate short-term (24 hr) mortality rate of cutthroat trout captured at Florence Lake during late August, 1998 and marked with a) anchor T-bar tags and adipose finclips, b) PIT tags and adipose finclips, c) PIT tags, VI tags and adipose finclips, and d) not marked at all.

STUDY AREA

Florence Lake lies approximately 50 km southwest of Juneau, on the west side of Admiralty Island at long. 134º4' W, lat. 58º3' N (Figure 1). The 431-ha lake is narrow (<1 km wide) and about 7.2 km long, with a maximum depth of approximately 27 m. Florence Lake has been a popular fly-in lake, but recent clearcut logging at the lake has reduced angler visits. The lake outlet flows about 1 km into Chatham Strait and passes over a falls about 400 m upstream of tidewater, which blocks the lake to anadromous species. The Division of Sport Fish conducted cutthroat trout abundance experiments at Florence Lake between 1989 and 1994 (Rosenkranz et al. 1999).

Turner Lake is located in upper Taku Inlet, 26 km east of Juneau (Figure 1), 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 ha, and has a maximum depth of 215 m (Schmidt 1979). The lake outlet flows about 1,700 m from the lake to Taku Inlet and is blocked to upstream fish passage by a barrier falls just below the lake.

METHODS

Cutthroat trout were captured with baited hoop traps (BHT) set at random locations across Florence Lake from August 25 to 28. BHT 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. Bait for these traps was whole/crushed salmon eggs which had been disinfected in betadine solution.

Captured cutthroat trout were tagged with either anchor T-bar tags, PIT and VI tags, or PIT tags (labeled groups 1, 2, and 3, respectively). Anchor T-bar tags were included in the experiment because they have been widely used in past mark-recapture studies (e.g., Harding 1995, Rosenkranz et al. 1999). Adipose finclips were given to all fish, since this is a typical secondary mark. Fish in all treatment groups were measured for length and groups 1 and 2 were sampled for scales. My sampler had considerable tagging experience but had not VI tagged cutthroat trout in approximately

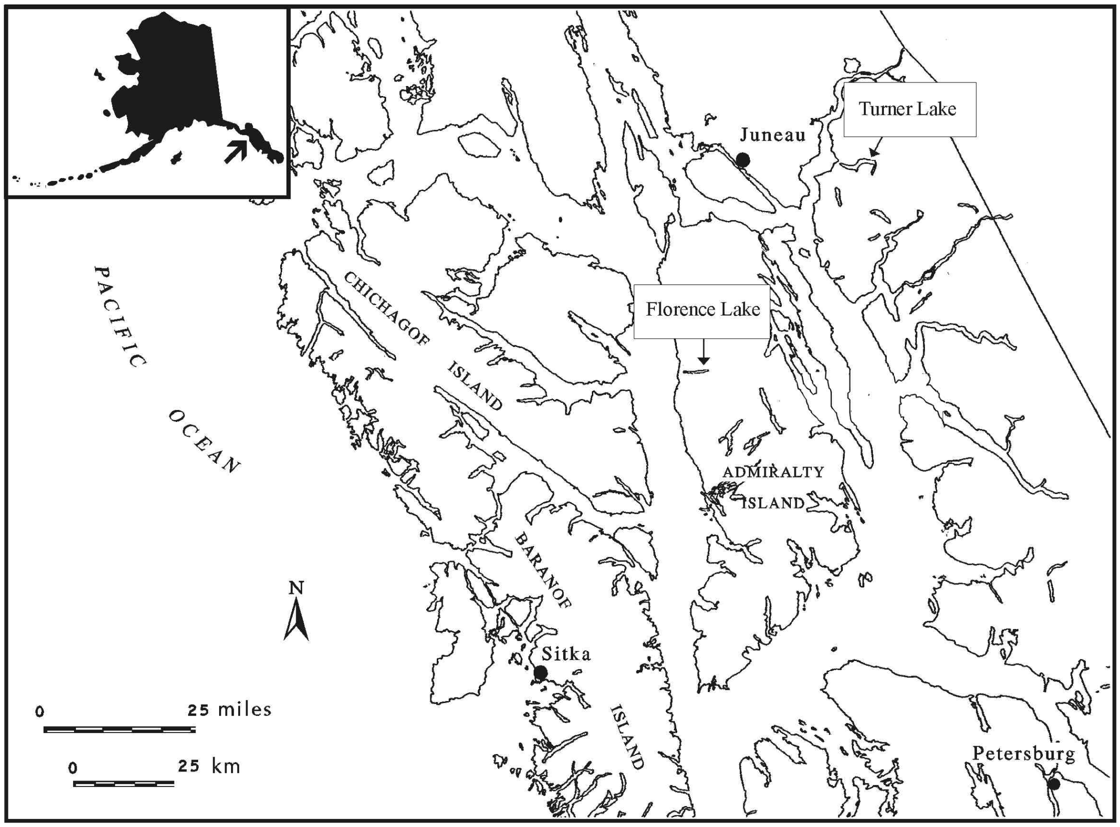

Figure 1.–Location of Turner and Florence lakes, Southeast Alaska.

2 years. Tagging and sampling procedures were applied to one treatment group at a time.

None of the fish selected for this experiment had been marked during previous studies at Florence Lake (e.g., Harding 1995). Treatments were applied to fish in sequential time-order (i.e., group 1, then group 2, etc.), and the controls were dispersed across the entire experiment as treatments occurred. After sampling, treatment and "control" fish were placed in closed hoop traps for observation overnight. No more than 5 fish (4 sampled and 1 control) were held in a single trap.

Physical handling of the fish varied by treatment. Fish marked with PIT and VI tags were removed from the onboard holding tank and held with the fish's head facing the tagger. A PIT tag was then injected into muscle tissue just below the dorsal fin, then the fish was repositioned perpendicular, with the back of the fish facing the tagger. A VI tag was next injected into the clear adipose tissue just posterior to the left eye of the fish. An additional change in position was then needed to permit scale sampling. The sampled fish was then returned to an onboard holding tank until four fish had been sampled. These four fish were then transferred along with a control fish to a closed hoop trap, and lowered to the lake bottom. The next day the fish were examined and mortalities recorded by treatment group. Live fish were released immediately back into the lake.

Samples sizes for the experiment were estimated according to a standard formula for estimating binomial proportions (Cochran 1977). I assumed *a priori* 24-hour mortality rates similar to those observed at Turner Lake, and planned to estimate the proportion for each group within ±10 percentage points of the true value for a 95% confidence interval.

Four treatment groups were added during the last day of the experiment (Table 2). Group 4 (10 fish) was similar to group 3 (PIT tags and adipose

Table 2.–Treatment, sample size, percent mortality, and related statistics for cutthroat trout captured, tagged, sampled, and held overnight at Florence Lake, 1998, by treatment group.

							Mean for sampled individuals						
Treatment	Group # time-order	Scale sample	Length sample	Sample size	Number dead	Percent dead	Time out[a]	Fork length (mm)	Capture depth (m)	Capture temp (°C)	Depth held (m)	Temp held (°C)	Time held[b]
Anchor T-bar tag + adipose finclip	1	Y	Y	49	6	12	36	226.4	5.1	13.9	9.4	13.2	19.5
PIT & VI tags + adipose finclip	2	Y	Y	74	16	22	64	216.1	7.8	13.0	10.0	11.8	20.4
PIT tag + adipose finclip	3	N	Y	60	1	2	27	226.3	5.3	13.9	11.4	12.0	21.0
PIT tag + adipose finclip	4	Y	Y	10	0	0	39	210.0	2.0	14.0	4.0	14.0	15.4
PIT tag + left axillary & adipose finclips	5	Y	Y	10	0	0	49	220.8	2.0	14.0	10.0	13.0	14.7
Held in dip net for 90 seconds	6	N	N	9	0	0	90	N/A	2.0	14.0	8.0	13.5	19.0
Restrained out of water for 60 seconds	7	Y	Y	10	0	0	60	208.0	8.0	13.5	2.0	14.0	16.5
Control	[c]	N	N	56	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A

[a] Average time each fish was out of water during sampling, in seconds.

[b] Time fish were held in trap after sampling, in hours.

[c] Control group was not processed in sequential time order like other groups, but dispersed among the other treatments.

finclips) but scale sampling was added. Group 5 (10 fish) was also similar to group 4, but a clip of the left axillary appendage was added. The other two treatment groups comprised fish that were simply held in a dip net (out of water) for 90 seconds (group 6), or held out of water for 60 seconds while being sampled for scales and length (group 7).

RESULTS AND DISCUSSION

Fish tagged with anchor T-bar tags (group 1) and both PIT and VI tags (group 2) suffered substantial (12–22%) short-term mortality (Table 2). As all other fish sampled (groups 3–7, and control) suffered no, or almost no, short-term mortality, a substantial "treatment" effect is evident in the data. However, some uncontrolled variables (water temperature, fish length, sampling order, and time out of water) were likely to have been important in the experiment. I discuss each of the variables in the paragraphs below.

Several studies have identified temperature as a key factor in trout mortality in catch-and-release experiments. Titus and Vanicek (1988) reported >20% mortality of hook-and-line caught cutthroat and rainbow *O. mykiss* trout in water temperatures above 17ºC. Schisler and Bergersen (1996) also reported a positive correlation between water temperature and hooking mortality of rainbow trout.

All fish were held at depths between 2 and 12 m after tagging and handling at Florence Lake. Since temperature at Florence Lake was fairly constant over this range (Figure 2), it is not surprising that no relationship between mortality and holding depth was observed, especially given the low sample sizes (Figure 3). However, water temperatures at Florence Lake were up to 3ºC cooler than at Turner Lake (Figure 2). The higher mortality rates at Turner Lake may be due in part to the high water temperatures (15–17ºC), as well as the more "severe" treatments—i.e., amount of handling and clips (Tables 1 and 2).

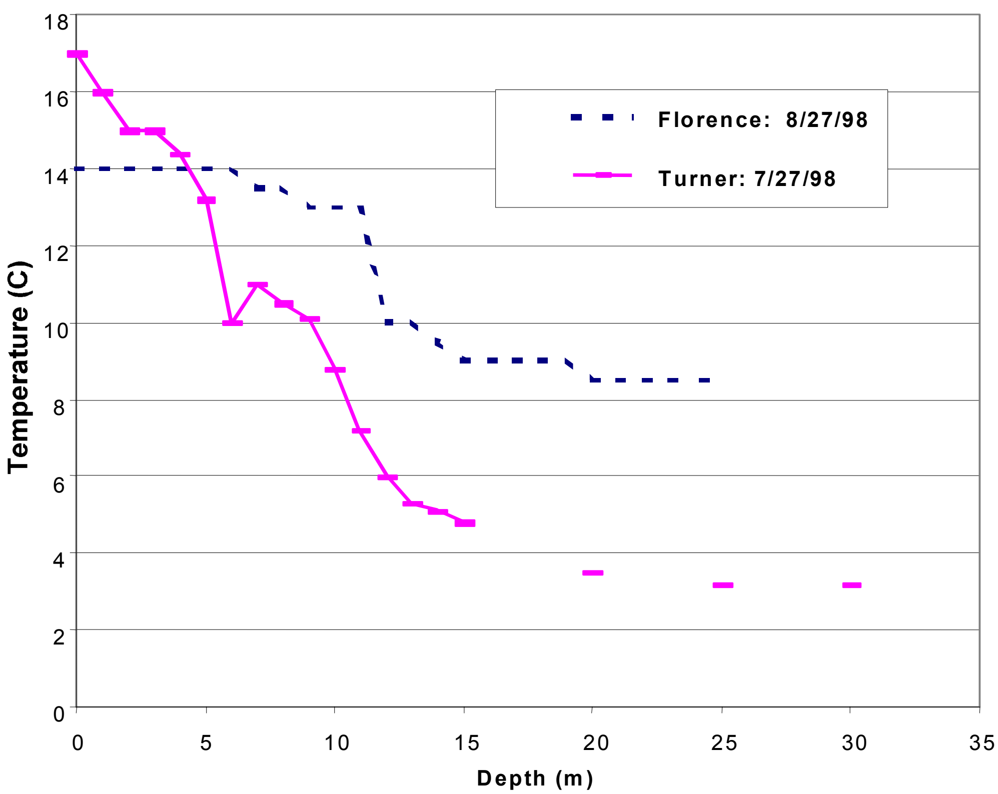

Figure 2.–Temperature and depth profile at Florence and Turner lakes, 1998.

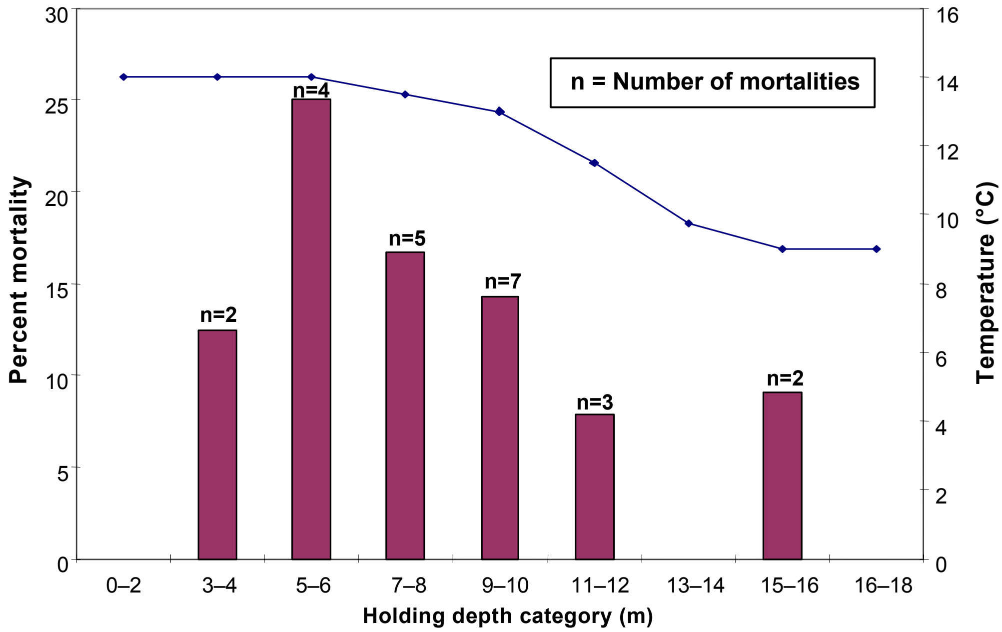

Figure 3.–Percent mortality (bars) and temperature (line) by holding depth for cutthroat trout held approximately 24 h during the short-term mortality experiment at Florence Lake, 1998.

Mortality rates may also be a function of fish size in this experiment, as smaller fish appeared to suffer higher mortality rates (Figure 4). The mean length of cutthroat trout which died during the 24-h holding period was 206 mm FL (SD = 25), compared to 223 mm FL (SD = 29) for cutthroat which survived. The length distribution of cutthroat trout that died was significantly different from those that survived (Kolmogorov-Smirnov test, D_{max} = 0.3771, P = 0.0039; Figure 5).

Tagging stress may be related to time of exposure to air as well as the number of tag/clips administered. Among the two treatment groups yielding significant mortality, time out of water averaged 64 seconds for the 2-tag (PIT, VI) treatment group (2), compared to 36 seconds for the single tag (anchor T-bar) treatment group (group 1). However, there were no mortalities among fish not tagged but held out of water for 60 and 90 seconds (groups 6 and 7; Table 2). This suggests that tagging stress is more important than just time out of water.

The relationships between time out of water and other variables in treatment group 2 were investigated by stratifying the data by time out of water (Table 3). Mortality increased as time out of water increased, but higher proportions of the sampled fish held out of water for long periods were also small (≤200 mm, which suffered greater mortality) and sampled early (the first half) in the sample. Thus, mortality may have been related to learning to efficiently administer the complex treatment for group 2 (see methods). For example, if the first 21 fish sampled in treatment group 2 are removed from the data, the 24-h mortality rate drops from 22% to 9%. Unfortunately, this is likely an oversimplification of the problem since time out of water, fish size, and sampling order are confounded variables.

A logistic-regression analysis (e.g., Schisler and Bergersen 1996) was conducted to better identify which variables had the greatest influence on short-term mortality of cutthroat trout in this study. Variables (in addition to a constant) were added using a typical forward stepwise selection procedure. The analysis was performed with data collected for treatment groups 1 and 2 separately, and groups 1 and 2 combined (Table 2). Results from the logistic-regression analysis suggest fork

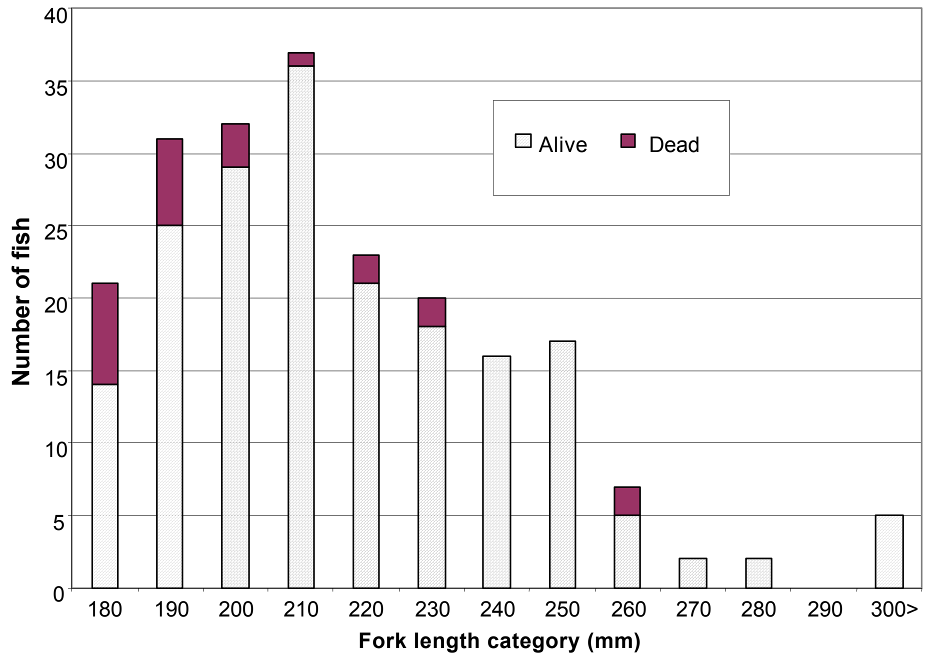

Figure 4.–Survival status by fork length for cutthroat trout held approximately 24 h during the short-term mortality experiment at Florence Lake, 1998.

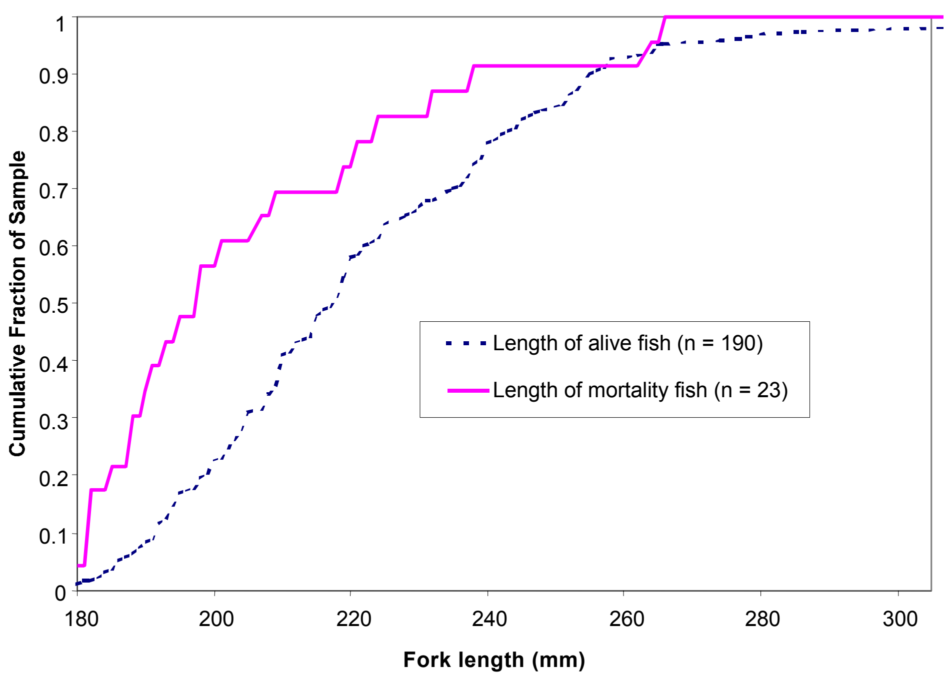

Figure 5.–Cumulative distributions of lengths of cutthroat trout which died during 24-h holding period versus lengths of cutthroat trout which survived, Florence Lake, 1998.

Table 3.–Mortality rate, incidence of fish sampled <200 mm FL, and relative order of sampling in treatment group 2 as a function of time out of water, Florence Lake, 1998. As the time to apply the treatment to individual fish increased, mortality rate increased but the number of small fish treated decreased. Also, time out of water is correlated with the order fish were sampled.

Time out (sec)	Sample size	Mortalities		No. samples ≤ 200 mm	Percent samples ≤ 200 mm	No. samples in 1st 50% (34) samples	Percent samples in 1st 50% (34) samples
		Number	Percent				
38-60	25	3	12	6	24	4	16
61-70	29	9	31	12	41	16	55
71-89	15	4	27	6	40	12	80
	69	16					

length of fish contributed significantly (P = 0.075) to increased mortality in treatment group 1. For treatment group 2, sequence number (i.e., order sampled, P = 0.001) and fork length (P = 0.015) contributed significantly to the mortality. Time out of water was not a significant factor in either analysis after fork length and sequence order entered the model. Analysis of the combined data (groups 1 and 2) suggested that length (P = 0.007) was the most important variable in mortality probability and that sequence number might also be important (P = 0.15).

Other factors probably influenced the mortality of cutthroat trout sampled during my experiments, such as stage of maturity (Marnell and Hunsaker 1970) and handling "irregularities." For example, 25% (3 of 12) of the trout accidentally dropped onto the deck of the boat during sampling in this study died. Overall, fish length and handling efficiency appeared to be most important factors in the Florence Lake study, and high water temperature probably exacerbated mortality rates at Turner Lake.

RECOMMENDATIONS

This study led to the recommendations given below. Items 1, 2, and 3 follow directly from the study, whereas items 4–8 are interim recommendations based on my experience. I recommend each item below be routinely implemented in cutthroat trout mark/recapture abundance experiments.

1) Methods to estimate short-term mortality should be developed and implemented in future mark-recapture experiments. Sampling should be designed to minimize effects of poor initial handling procedures that might lead to increased mortality rates at the beginning of mark-recapture experiments. For example, groups of fish sampled during the first and last stages (at least) of mark-recapture experiments should be held at least 1 day to quantify short-term mortality. If mortality is significant, environmental variables and handling/marking techniques should be reviewed to determine if the causes can be eliminated.
2) Tagging crews should review the manufacturer's training tapes and literature on tag placement and practice procedures immediately prior to conducting abundance experiments. Training on abundant/resilient species like Dolly Varden *Salvelinus malma* may be useful.
3) Future mortality experiments should be designed to account for sequential sampling effects (learning) and fish size and to assess mortality rates over a longer term. I suggest that such studies last at least a week, since Schisler and Bergersen (1996) report that 67–83% of rainbow trout (hooking) mortalities occur within a week.
4) Use innocuous, shallow finclips as marks whenever possible. Excessive combinations of

tags (i.e., PIT and VI) and finclips, scale and length sampling, and other operations that are performed during sampling should be avoided.

5) Minimize handling time when applying tags or marking.

6) Avoid holding fish for extended periods of time prior to processing. If possible, fish should be processed as they are captured; i.e., do not wait until there is an "adequate number" of fish to justify the time required to setup and sample.

7) When possible, avoid sampling cutthroat trout when surface water temperatures are high. Temperatures above 14°C would appear to be cause for special concern and temperatures above 16°C should be avoided.

8) Ambient temperatures and oxygen levels should be maintained in holding and recovery tanks. Temperature should be measured, and frequent water changes, auxiliary oxygen, and/or water pumps used to maintain oxygen and temperature levels.

ACKNOWLEDGMENTS

The author thanks Ken and Karen Koolmo, Dan Peroni, Kurt Kondzela, and Matt Foster, for their conscientious, hard work in the field. Bob Marshall provided significant insight with the data analysis and reviewed the first draft. Doug Jones also reviewed an early draft of this report and provided insightful comments and was instrumental in the design and implementation of this project. Alma Seward performed final copy edit, layout and typesetting.

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APPENDIX A

Appendix A1.–Name and type data summaries and raw data files used to produce this report.

FILE NAME	SOFTWARE	CONTENTS
mort98_v97final.doc	MS Word	This FDS report file.
98_data.xls	MS Excel	Raw data, summaries, analysis, and graphs.
efrt.xls	MS Excel	Trap catch data and mortality data by group.
reg_data.xls	MS Excel	Mortality and group treatment regression data.