Fishery Data Series No. 05-73

Stock Assessment of the Rainbow Trout in the Tazimina River

Final Project Report No. FIS 04-415
USFWS Office of Subsistence Management
Fishery Information Services Division

by

Craig J. Schwanke

and

David G. Evans

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

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
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 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. 05-73

STOCK ASSESSMENT OF THE RAINBOW TROUT IN THE TAZIMINA RIVER

by
Craig J. Schwanke
Division of Sport Fish, Dillingham

and

David G. Evans
Division of Sport Fish, Research and Technical Services, Anchorage

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska 99518-1599

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Craig J. Schwanke
Alaska Department of Fish and Game, Division of Sport Fish
PO Box 230, Dillingham, AK 99576-0230, USA
and
David G. Evans,
Alaska Department of Fish and Game, Division of Sport Fish
333 Raspberry Rd, Anchorage, AK 99518-1599, USA

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FINAL REPORT SUMMARY PAGE

Title: Stock Assessment of the Rainbow Trout in the Tazimina River.

Study Number: FIS 04-415

Investigator(s)/Affiliation(s): Craig J. Schwanke, Jason Dye, and Craig Collins, Alaska Department of Fish and Game, Division of Sport Fish, PO Box 230, Dillingham, AK 99576-0230, USA; David G Evans, Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services, 333 Raspberry Road, Anchorage, AK, 99518-1565, USA.

Management Region: Bristol Bay/Alaska Peninsula/Kodiak/Aleutians

Information Type: Stock Status and Trends

Issue Addressed: Abundance of the Tazimina rainbow trout population was unknown and there are concerns that a recently adopted regulation that allows the rod and reel subsistence harvest of these fish may result in overharvest of this stock of rainbow trout.

Study Cost: $111,000

Study Duration: February 1, 2004–June 30, 2005

Key Words: Tazimina River, rainbow trout, *Oncorhynchus mykiss*, subsistence, mark-recapture, estimation of abundance, sexual maturity composition, length composition, catch per unit effort, Arctic grayling, *Thymallus arcticus*.

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ABSTRACT

A stock assessment of rainbow trout *Oncorhynchus mykiss* was conducted during spring and fall 2004 on the Tazimina River in response to reports by user groups of decreased abundance and reduced fish size. From 22 April to 28 May 2004 a mark-recapture experiment to estimate abundance resulted in an estimate of 950 (SE = 213) rainbow trout in river of which 16% (SE = 2.3%) were sexually mature. Sampled fish ranged from 161 to 612 mm FL with a mean length of 307 mm (SE = 4.10).

Between 19 and 27 August 2004 CPUE and length distribution were estimated for comparison with past research conducted during the same time frame. Four hundred fourteen (414) rainbow trout were captured with a CPUE of 3.23 rainbow trout per hour. Length distribution ranged from 82 to 518 mm with a mean of 285 mm (SE = 4.15). CPUE during 2004 was higher than previous years; however, the proportion of fish over 500 mm FL was lower.

Key words: Tazimina River, rainbow trout, *Oncorhynchus mykiss*, subsistence, mark-recapture, estimation of abundance, sexual maturity composition, length composition, catch per unit effort, Arctic grayling, *Thymallus arcticus*.

INTRODUCTION

The Tazimina River located within Lake Clark National Park and Preserve in the Bristol Bay region of Alaska supports a subsistence and recreational fishery in the lower 14 km (Figure 1). The river flows southwesterly entering Six Mile Lake in the Newhalen River drainage opposite the village of Nondalton. The river is approximately 80 km long including the lengths of two large lakes. An impassable series of falls prevents fish migration up river and confines the majority of subsistence and recreational sport fishing to the lower 14 km of river.

The Tazimina River supports populations of sockeye salmon *Oncorhynchus nerka*, rainbow trout *O. mykiss*, Arctic grayling *Thymallus arcticus* and Dolly Varden *Salvelinus malma*. A cooperative study between the Alaska Department of Fish and Game (ADF&G) and the National Park Service (NPS) conducted in 1987 and 1988 documented substantial recreational angling effort and a high catch of rainbow trout, sockeye salmon and Arctic grayling (Brookover 1989). The rainbow trout population appeared abundant and was considered healthy at that time. The popularity of the rainbow trout fishery led to the designation of the Tazimina River as a catch-and-release special management area for rainbow trout. Additional studies included an environmental assessment on the Tazimina River drainage for the 1998 installation of a run-of-the-river hydroelectric power generator at the falls (HDR Alaska, Inc. 1998). Radiotelemetry was conducted in 1989 on the rainbow trout population by the NPS and ADF&G. A formal report was not written for the study and poor survival limited results; however, some fish tagged in the Tazimina River moved into Six Mile Lake and the Newhalen River during the fall for the winter.

In recent years, the sustainability of the Tazimina River rainbow trout stock has been an issue of concern for local residents, along with subsistence and sport anglers. User groups are concerned that rainbow trout abundance and size composition has decreased in recent years. Catch-and-release sport fishing regulations on the Tazimina River, established in 1990, are conservative and include a spawning season closure for rainbow trout. Federal subsistence regulations that allow for the daily harvest of two rod-and-reel captured rainbow trout may exacerbate a decline in abundance and size composition or the population's ability to recover.

The Statewide Harvest Survey (SWHS), conducted annually by ADF&G, Division of Sport Fish (DSF), provides evidence of a decline in the catch of rainbow trout in the Tazimina River through estimates of angler catch and effort. For the Tazimina River from 1992-2000, reported

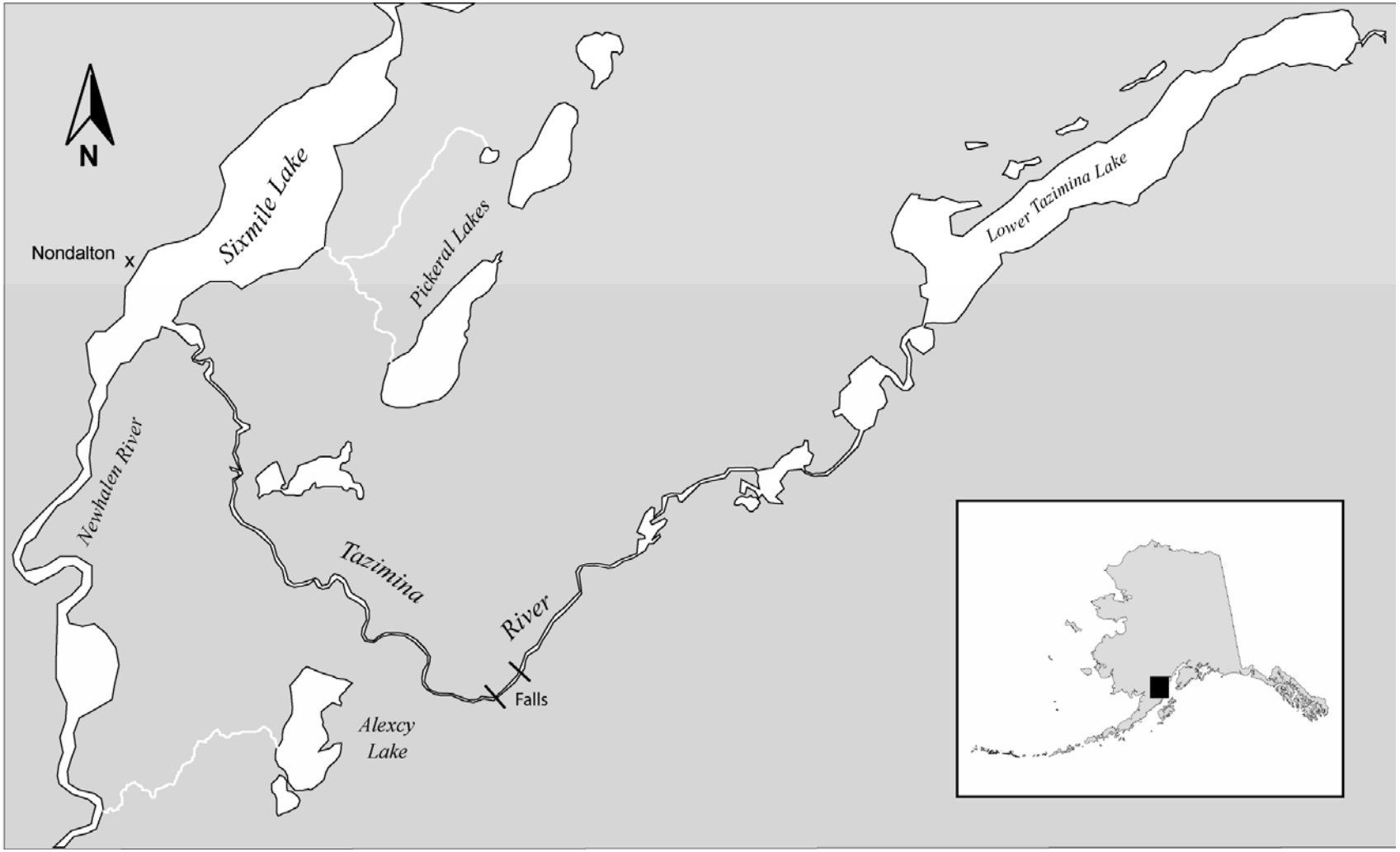

Figure 1.-The lower 40 km of the Tazimina River, located within Lake Clark National Park and Preserve in the Bristol Bay region of Alaska. The study area extends from the confluence of the Tazimina River and Six Mile Lake to the series of falls (approximately 14 km).

average sport catch was 1,121 rainbow trout and effort (all species) was 462 angler days (Howe et al. 1995, 1996, 2001 a-d; Mills 1993, 1994; Walker et al. 2003). Sport catch and effort have declined significantly since then, with an average sport catch of 99 rainbow trout and sport effort of 35 angler days in 2001-2003 (Jennings et al. 2004, *In prep* a, b). Information from commercial sport fish guides suggests that the decrease in effort is due to lower than historical abundance and size of rainbow trout.

The harvest of resident fish for subsistence use is an important component of the mixed subsistence-cash economy throughout Bristol Bay. The community of Nondalton is in close proximity to the Tazimina River and their annual subsistence harvest of rainbow trout was most recently documented in 1983 at 3,613 (Fall et al. 1996). The majority of this harvest took place during the winter with hook-and-line gear through the ice in Six Mile Lake and incidentally in nets during open water periods (Fall et al. 1996). This documented harvest in addition to the more recent federal subsistence regulation allowing year round rod and reel harvest has caused concern among managers regarding the health of the Tazimina River rainbow trout population and resulted in the funding of this research through the Fisheries Research Monitoring Project.

The goal of this study was to conduct a stock assessment of rainbow trout in the Tazimina River during the spring and fall of 2004. Abundance, size composition, sexual maturity composition, spawning locations and distribution in the drainage were of interest. This information will help managers set appropriate regulations for the population and document potential changes in stock abundance.

OBJECTIVES

Research objectives for the study were to:

1. Estimate the abundance of the rainbow trout population $\geq$ 200 mm FL in the Tazimina River between the mouth of Six Mile Lake and the series of falls (rkm 14) during 12 April through 14 May 2004.
2. Estimate length and sexual maturity composition of the rainbow trout population $\geq$ 200 mm FL in the Tazimina River between the mouth of Six Mile Lake and the series of falls (rkm 14) during 12 April through 14 May 2004.
3. Estimate CPUE (number of rainbow trout captured per hour) by 1.6 rkm (1 mile) sections in the Tazimina River rainbow trout fishery between the confluence of the Tazimina River and Six Mile Lake to the series of falls (rkm 14) from 18 to 28 August 2004.
4. Document distribution and estimate size composition of rainbow trout in the Tazimina River between the confluence of the Tazimina River and Six Mile Lake to the series of falls (rkm 14) from 18 to 28 August 2004.

TASKS

1. Collect a fin clip from rainbow trout $\geq$ 200 mm FL for genetic analysis.
2. Record the number of guided and unguided anglers observed on the Tazimina River each day and their type of boat transportation.
3. Record movement of finclipped fish between two sections of the Tazimina River during the spring, 2004.

METHODS

STUDY AREA

The study area encompassed an area from the mouth of Six Mile Lake to a series of falls located at approximately rkm 14. The study area was divided into two subareas for the spring research; the lower 7 and the upper 7 km of the Tazimina River and divided into 1.6 km (1 mile) sections for the fall research.

DATA COLLECTION

Spring 2004

Sampling of the Tazimina River occurred at least 4 days each of 4 weeks. Ice conditions dictated that the earliest sampling could commence was 22 April, and sampling continued until 28 May. Attempts at capturing fish were made with entanglement netting (16 and 32 m long with 5.1 and 7.6 cm stretch mesh), hook-and-line, and beach seining (46 m long with 5.1 cm stretch mesh).

After repeated failure to capture rainbow trout or observe fish in the upper section of the river, sampling effort focused on the lower section of the river. Therefore, the following describes treatment of fish caught in the lower 7 km section during spring sampling.

Captured rainbow trout were measured to the nearest millimeter FL. Gear and river section of capture were recorded for each fish. Maturity and sex of captured fish were also recorded. Each fish was categorized as sexually immature, sexually mature or postspawn. Sexually mature rainbow trout were those fish capable of spawning during the spring of the survey. Visually examining and rating rainbow trout for the following characteristics determined sexual maturity: color, presence of reproductive products, ovipositor extension, kype development, abdomen development, and abdomen hardness. Sexual dimorphism allowed for the determination of sex among sexually mature fish. Males were dark, had a developed kype, and often expelled milt. Females were silver, had extended abdomens, an ovipositor extended from the vent, and lacked a kype. Postspawn fish appeared similar to sexually mature fish but males did not expel milt and females were thin bodied with flaccid abdomens indicating that eggs were no longer present.

Captured fish were examined for tags, fin clips, and fin punches. Tag number and type of fin clip were recorded for marked fish while unmarked rainbow trout were marked with a uniquely numbered Floy^{TM} T-Bar Anchor Tag placed on the left side near the posterior base of the dorsal fin. A different fin clip was given depending on the week of capture (right pectoral = week 1, left pectoral = week 2, right pelvic = week 3). To assess tag loss and the movement of fish between the upper and lower 7 km sections (Task 3) two different marks were used. A right pectoral hole punch was used for fish caught in the lower section while a right pelvic hole punch was used in the upper section.

Sampling with hook-and-line and beach seines also occurred once a week in the Newhalen River from the outlet of the Tazimina River to Alexcy Creek (Figure 1) to detect fish movement out of the study area. These fish were measured for FL and site of capture (Newhalen River or Alexcy Creek) was recorded. These fish were not tagged.

Tissue from the fin clipping was collected from each rainbow trout $\geq$200 mm FL captured in the Tazimina and Newhalen rivers. Tissue samples were preserved in vials of ethanol, and labeled with the date and location of sample. Samples were sent to the ADF&G genetics lab and cataloged for future analysis.

All other species captured were measured for FL and the location of capture and gear type was recorded.

Fall 2004

Sampling of the Tazimina River occurred every day from 19 to 27 August 2004. Sampling was conducted up to rkm 13; however, the majority of sampling occurred below rkm 12 due to low water. The river was divided into 1.6 km (1 mile) sections beginning at the confluence with Six Mile Lake for the estimation of CPUE by section. Up to 10 rkm were fished by at least two Department technicians using hook-and-line each day. Effort within each 1.6 rkm was focused on the most likely sections thought to yield fish. The ultimate comparison to be made was that with CPUE of sport fishers in 1987-1988 (Brookover 1989). Past effort was assumed to occur in the same locations.

Terminal gear consisted of beads used to imitate salmon eggs, spinners and streamer flies. Each technician recorded the number of hours fished each day and the number of fish caught in each 1.6 rkm for the calculation of CPUE (Objective 3).

All resident species captured were measured for FL to the nearest millimeter. Rainbow trout were also weighed to the nearest 10 grams and examined for the presence of tags and fin clips. The terminal gear and rkm of capture were recorded for each fish.

DATA ANALYSIS

Spring Mark-Recapture Abundance Estimate

Abundance of rainbow trout ≥ 200 mm in the Tazimina River in spring of 2004 was estimated from mark-recapture techniques in the lower 7 km section of the river, with the assumption that the population in the upper section was minimal. Closed mark-recapture models (Ricker 1975; Otis et al. 1978; Seber 1982) were evaluated using MARK (White and Burnham 1999). The models included: M_o, where probability of capture was assumed constant over sampling events, M_t where probability of capture may differ over events, M_h where probability of capture may differ between animals, M_b where probability of capture may differ depending on whether an animal has been previously captured, and models representing combinations of these factors. Model choice was driven by respective Akaike Information Criteria (AIC) values provided by MARK. An abundance estimate from a (two event) Chapman modified Lincoln-Petersen estimator model was compared to that generated from multi-event analysis:

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

where:

M = number of fish marked and released in the first event,
R = number of marked fish recaptured in the second event, and
C = number of fish examined for marks in the second event,

with variance estimated by:

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

The three temporal strata for the multi-event mark recapture model were defined as: 4 May-12 May, 13 May-20 May and 21 May-28 May. The two temporal strata used in the Petersen-style estimator were defined by 4 May-14 May and 15 May-28 May, each representing approximately half the total number of captured fish.

Assumptions necessary to estimate abundance with a closed multi-event population model are (Seber 1982):

1. The population is closed with no additions or losses between sampling events (through recruitment, mortality, immigration, or emigration).
2. All fish have an equal capture probability in each sampling event.
3. Marking does not affect capture probability in subsequent capture events.
4. Marks (tags) are not lost between events.
5. All marked fish recaptured during subsequent capture events are correctly identified and recorded.

Assessment of Assumptions for Abundance Estimate

Closed Population

Field work dates were chosen to coincide with the probable spawning period of rainbow trout in the Tazimina River. Rainbow trout tend to aggregate and remain aggregated in certain areas during spawning, resulting in closure of the spawning population. The original survey area encompassed all possible spawning areas of the Tazimina River, but the actual area sampled was mainly the lower 7 km. The validity of the estimate of abundance with respect to closure of the population therefore depends on the closure of the lower 7 km of the river. Some sampling was conducted in the Newhalen River and in the upper 7 km and this provided insight with respect to emigration during the study from the area of inference.

It was also possible that mortality and immigration or emigration occurred. If significant immigration or emigration from the upper 7 km of the Tazimina River or from the Newhalen River occurred during the experiment, a constant or a declining marked to unmarked ratio would be expected over the course of the study. Careful handling of all captured fish minimized sampling mortality. Spawning mortality was assumed equal between marked and unmarked fish.

The tests for closure developed by Pollock (1974) were used if either Model M_o or M_h (Otis et al. 1978) was appropriate. If model M_t was chosen, the test of closure developed by Stanley and Burnham (1999) (CLOSETEST) was used.

Capture Probability and Marking Effects on Capture Probability

On each sampling day within the lower 7 km, effort was distributed evenly, improving the chance of equal probability of capture within the section for each event.

The Anderson-Darling tests (Scholz and Stephans 1987) could not be used to assess differences in rainbow trout length distributions among all three capture events due to a lack of captured fish during the first event. Therefore, a two-sample Kolmogorov-Smirnov (KS) test was used to assess differences in size groups between data aggregated into two time strata beginning with the date that a fish was first captured: 4-14 May and 15-28 May. A significant test ($\alpha = 0.05$) would indicate that different size groups were caught between the two aggregated data strata and that stratification by size would be indicated.

Although the third assumption that marking does not affect capture probability during subsequent capture events could not be directly tested, careful and rapid processing when capturing and handling fish minimized stress and violation of this assumption. In addition, fish with excessive bleeding or in poor condition at capture were not tagged.

Mark Loss and Data Collection

Use of fin clips as secondary marks allowed testing of the assumption of no tag loss, while allowing for the determination of the week a fish was originally tagged, and resurrection of capture histories if required.

Careful examination of all fish captured and proper recording of data minimized problems of marked fish not being properly detected and recorded.

Spring Length and Maturity Composition

The proportion of rainbow trout of length class, or sexual maturity class (mature or immature) *j* was estimated as a binomial proportion (Cochran 1977) by:

$$\hat{p}_j = \frac{n_j}{n}, \tag{3}$$

with variance estimated as:

$$\hat{Var}(\hat{p}_j) = \frac{\hat{p}_j(1-\hat{p}_j)}{n-1}, \tag{4}$$

where:

n_j = the number of rainbow trout of length (or maturity) class *j*, and,

n = the total number of rainbow trout measured for length (or maturity).

The abundance of sexually mature rainbow trout (maturity class *j*) was estimated as a product of two random variables by:

$$\hat{N}_j = \hat{N}\,\hat{p}_{j,}, \tag{5}$$

and its variance estimated by (Goodman 1960):

$$\hat{Var}(\hat{N}_j) = \hat{N}^2\hat{Var}(\hat{p}_j) + \hat{p}_j^2\hat{Var}(\hat{N}) - \hat{Var}(\hat{p}_j)\hat{Var}(\hat{N}),$$

where:

N = the estimated abundance of sexually mature rainbow trout. (6)

Fall CPUE Estimate of Relative Density and Distribution

CPUE was used as a measure of relative fish density by 1.6 km sections to document inriver distribution of rainbow trout (Objective 4). CPUEs were pooled over eight 1.6 km sections. Differences between CPUE during this study and 1987-1988 (Brookover 1989) were interpreted as a relative change in population abundance between 1987-1988 and 2004.

CPUE was estimated for each 1.6 km section sampled as:

$$CPUE = {c_i}/{e_i}, \tag{7}$$

where:

c = total number of rainbow trout captured by all technicians angling in a 1.6 km section;

i = the section sampled; and

e = total number of hours angled by all technicians in the section.

CPUE was plotted by 1.6 km sections to provide an impression of relative fish density in the Tazimina River.

Average CPUE was also calculated for the entire river as a ratio (Thompson 2002):

$$\overline{CPUE} = \sum_{i=1}^{n} c_i \Big/ \sum_{i=1}^{n} e_i \,, \tag{8}$$

where n was the number of 1.6 km sections sampled in the river. $\overline{\text{CPUE}}$ was compared to that in Table 4 of Brookover (1989) for the "River Mouth" location.

Fall Length-Weight Composition

The proportion and variance of rainbow trout of length or weight class j was estimated as in Equations 3 and 4.

Approximately equal sampling effort was applied to each 1.6 km of the river, so a representative length and weight sample of the resident population was obtained. Pooling of the length/weight data afforded a pseudo-random sample of the whole population. A KS test was used to test the null hypotheses that the length distributions of sampled rainbow trout in 2004 are the same as those sampled by Brookover (1989) in 1987-1988. The KS test was also used to test the hypothesis that the distributions did not differ between the two sublocations defined as the upper and lower 6 km of the river.

To aid in the comparison of the length distribution among years, data for hook-and-line sampled rainbow trout from 14 to 31 August were used to compute incremental relative stock density values (RSD) for each year rainbow trout samples were collected from the Tazimina River. These values are percentages of fish in the following proposed quality length classes: $\leq$250, 251 to 400, 401 to 500, 501 to 650 and >650 mm FL (Anderson and Neumann 1996).

Angler Observations

The number of guided and unguided anglers observed on the Tazimina River and the type of boat transportation (i.e. raft, propeller or jet driven boat) was recorded for each day.

Final data are archived with ADF&G (Appendix A1).

RESULTS

SPRING MARK RECAPTURE ESTIMATE OF ABUNDANCE

Sampling commenced on 22 April 2004 when the lower Tazimina River became ice free, but rainbow trout were not observed or captured until 4 May. Rainbow trout were captured daily in the lower river section after 4 May until the project ended 28 May.

All rainbow trout sampled from the Tazimina River were captured with hook-and-line. Several attempts were made at capturing fish with entanglement nets and a beach seine, however these were unsuccessful due to the presence of woody debris and the location of fish in deep pools.

A total of 248 rainbow trout were captured, of which 220 were measured and 204 were given unique tags (Table 1). Sixteen fish were captured in a different sampling event than initial tagging and were included in the estimation of abundance (Table 1). Examination of all captured rainbow trout indicated that no tag loss occurred. Mortalities resulting from sampling totaled 24 rainbow trout. The first recapture on the Tazimina River occurred 7 May and the remainder of recaptures occurred after 17 May. Tagging and recovery data used in the mark-recapture estimate are summarized in Table 1. Seventeen rainbow trout were captured from the Newhalen River with hook-and-line, 10 of which were captured in upper Alexcy Creek. An additional 36 rainbow trout were captured with a beach seine in the Newhalen River.

Table 1.-Numbers of rainbow trout marked and recaptured and the percent recaptured from a previous week in the Tazimina River during the spring, 2004.

Week	Dates	Captured	Tagged	Recaptured	Tagged Percentage
1	4 May-12 May	82	82	0	0%
2	13 May-20 May	49	47	2	4%
3	21 May-28 May	89	75	14	16%
	Total	220	204	16	

Several results support the use of a closed unstratified abundance estimator. The marked to unmarked ratio increased over the course of sampling, and during the last two of the three events the proportion of marked fish in the sample increased from 0.04 to 0.16, indicating that significant immigration or emigration did not occur (Table 1). In addition, no fish tagged in the Tazimina River were captured in the Newhalen River. There was also no significant difference ($D = 0.069$; $P = 0.92$) in the length distribution of fish sampled during the capture events of 4 to 14 May or 15 to 28 May (Figure 2) and in the length distribution of marked to recaptured fish ($D = 0.267$; $P = 0.32$) over these two periods (Figure 3). Based on these results, abundance estimates were calculated for the entire sampled population, rainbow trout >200 mm FL, without the need to stratify estimates by size class.

AIC values provided by MARK for the models described earlier suggest that model M_t was the most appropriate; this model allows capture probabilities to vary over time. The M_t estimate was 950 rainbow trout $\geq$200 mm FL (SE = 213). The CLOSETEST test of the null hypothesis of closure, appropriate when model M_t is the right model, was insignificant ($p = 0.35$). In addition, the results indicated that a two-event Petersen model would provide an unbiased estimate of abundance. This model estimated a similar abundance (950 with SE = 210).

SPRING LENGTH AND MATURITY COMPOSITION

From 4 to 28 May, lengths were recorded for 246 of the 248 rainbow trout sampled, ranging from 161 to 612 mm FL with a mean of 307 mm (SE = 4.10). Most (94%) immature fish were in the 201-350 mm categories, while most (85%) mature fish were in the 351-500 mm categories (Figure 4). Most (208 of 246) Tazimina rainbow trout sampled were immature (Figure 4).

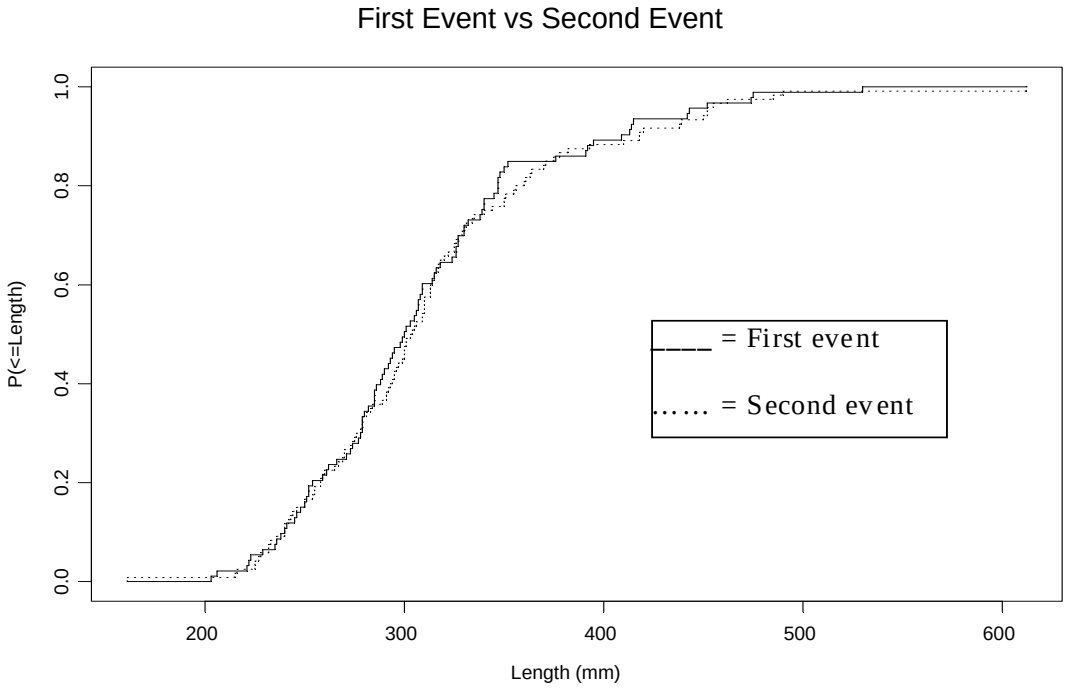

Figure 2.-Cumulative length distribution of rainbow trout from the Tazimina River captured during the first (4-14 May) and second (15-28 May) sampling events, 2004.

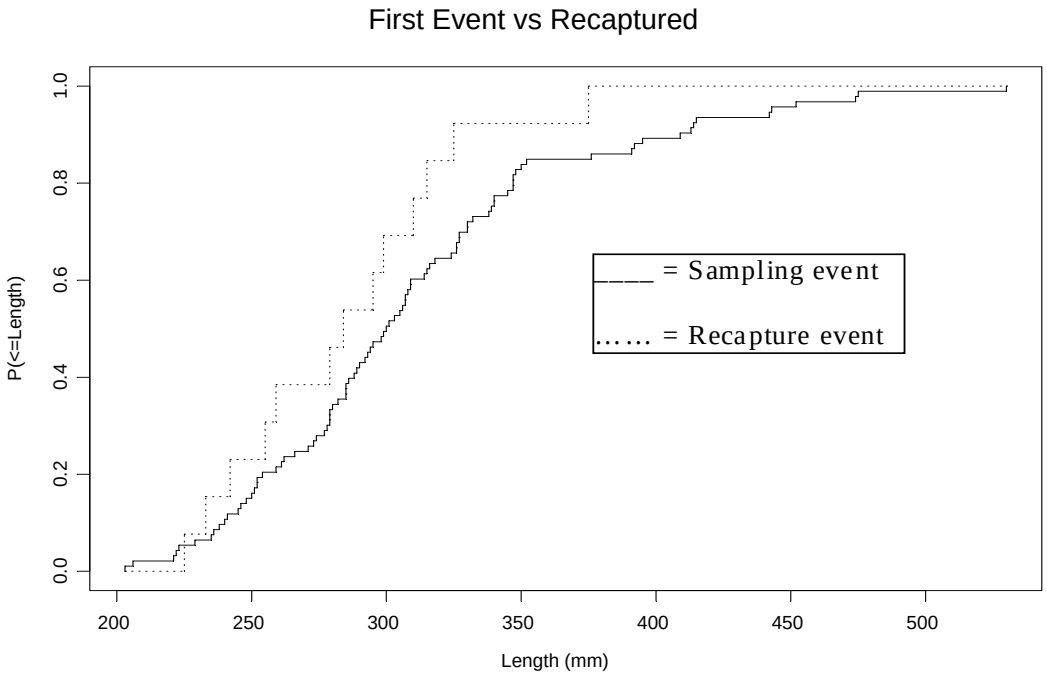

Figure 3.-Cumulative length distribution of rainbow trout from the Tazimina River captured in the first sampling event (4-14 May) and those recaptured from 4 to 28 May 2004.

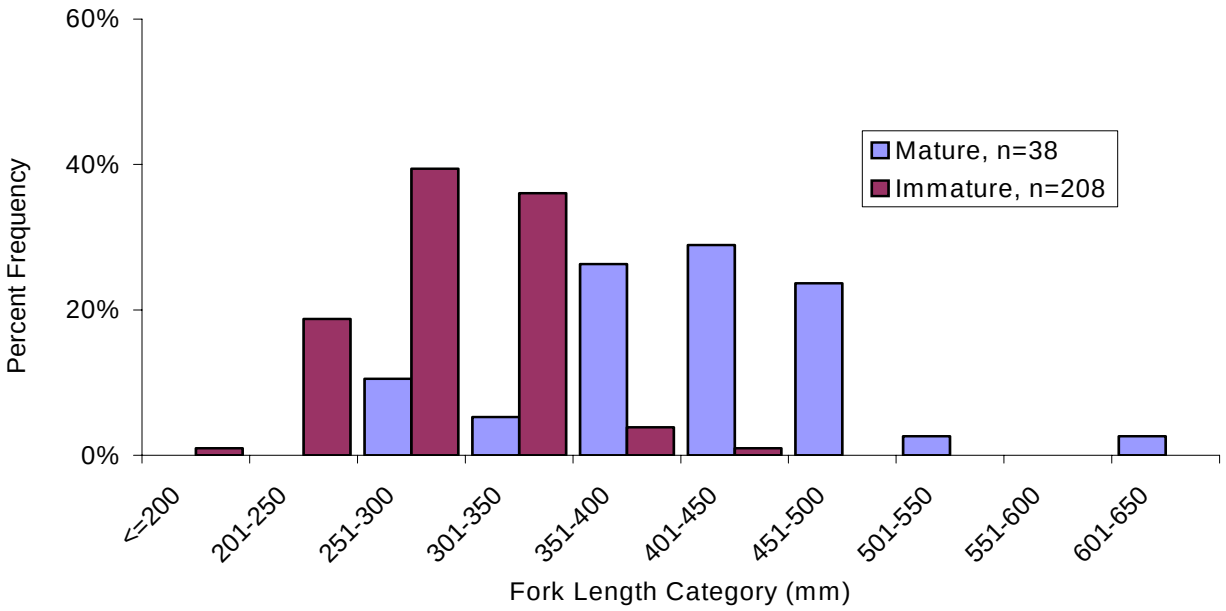

Figure 4.-Length frequency distributions of sexually immature and mature rainbow trout captured from 4 May to 28 May in the Tazimina River, 2004.

Sexually mature rainbow trout comprised only 16% (SE = 2.3%) of the sample, and the sex ratio of these was about 50:50 (18 females and 20 males).

The lengths of sexually mature fish ranged from 276 to 612 mm. Most were in the 301-400 mm or 401-500 mm length categories (Figure 5). The mean lengths of sexually mature males (409 mm, SE = 17.13) and females (411 mm, SE = 14.91) were similar. Based on the estimated abundance and proportion of sexually mature fish sampled it was estimated that there were about 150 (SE = 40) sexually mature rainbow trout in the lower 7 km of the Tazimina River.

Arctic grayling was the only other species captured in the Tazimina River during the spring. The first Arctic grayling was captured in the lower river on 23 April. After 4 May Arctic grayling were captured on a daily basis in the lower river. Only five Arctic grayling were captured in the upper river at the end of May.

FALL CPUE ESTIMATE OF RELATIVE DENSITY AND DISTRIBUTION

From 19 to 27 August, a total of 128.08 man-hours were expended using hook-and-line. The mean number of hours fished per 1.6 rkm (sections 1-8) was 16.01 with a low of 3.00 hours for section 8 and a high of 23.75 hours for section 3 (Table 2). Excluding section 8 the lowest number of hours expended was 15.25 for section 5.

A total of 414 rainbow trout was captured in the Tazimina River during the fall. CPUE over the entire river for the 9 days of sampling was 3.23 rainbow trout per hour. CPUE of anglers in 1987 and 1988 was 0.22 and 0.28. CPUE by section varied from 1.67 for section 8 to 5.16 for section 6 (Table 2, Figure 6). The CPUE for fish ≥250 mm ranged from a low of 1.00 in section 1 to 2.43 for section 5. CPUE for fish <250 mm ranged from 0.00 in section 8 to 2.77 in section 6 (Table 2). CPUE was also calculated by 1.6 km sections for captured Arctic grayling and Dolly Varden (Table 2).

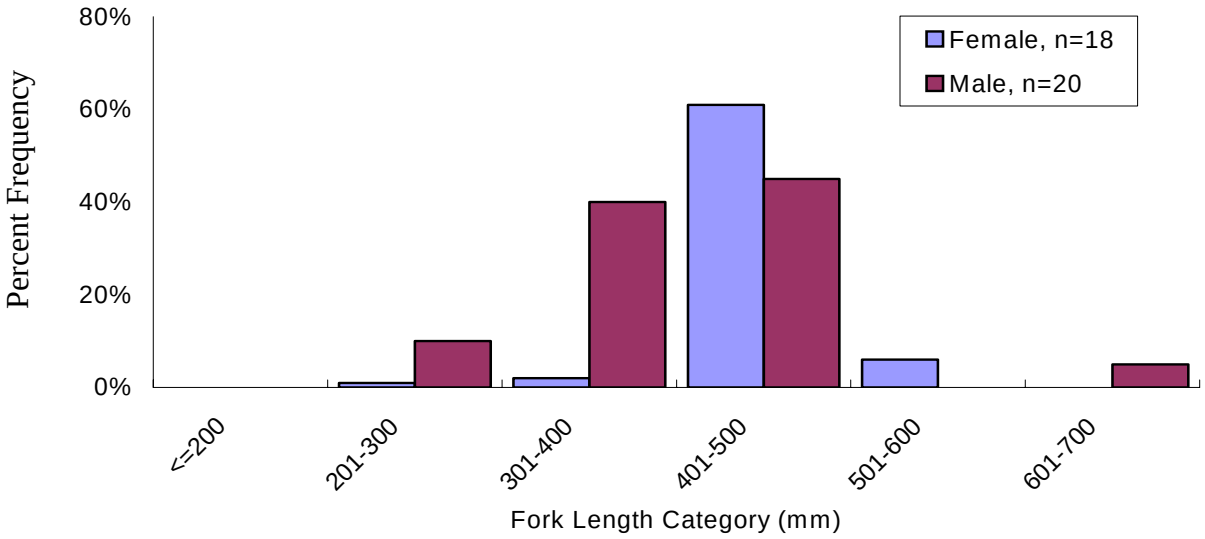

Figure 5.-Length frequency distributions, by sex, of sexually mature rainbow trout captured from 4 May to 28 May in the Tazimina River, 2004.

Table 2.-Summary of fish species catch, effort, and CPUE in the Tazimina River by 1.6 kilometer sections during the fall of 2004.

River	Total	Rainbow Trout						Arctic Grayling		Dolly Varden	
section	hours	>250 mm	CPUE	<250mm	CPUE	Total	CPUE	Sampled	CPUE	Sampled	CPUE
1	17.00	17	1.00	16	0.94	33	1.94	10	0.59	0	0.00
2	15.83	27	1.71	14	0.88	41	2.59	9	0.57	0	0.00
3	23.75	49	2.06	27	1.14	76	3.20	25	1.05	0	0.00
4	21.25	43	2.02	39	1.84	82	3.86	58	2.73	3	0.14
5	15.25	37	2.43	25	1.64	62	4.07	43	2.82	2	0.13
6	15.50	37	2.39	43	2.77	80	5.16	28	1.81	5	0.32
7	16.50	32	1.94	3	0.18	35	2.12	16	0.97	2	0.12
8	3.00	5	1.67	0	0.00	5	1.67	9	3.00	0	0.00
Total	128.08	247	1.93	167	1.30	414	3.23	198	1.55	12	0.09

Rainbow trout distribution based on CPUE by river mile indicated the highest concentrations of rainbow trout occurred in the middle to upper section of the river, which encompassed sections 3 through 6 (Figure 6).

FALL LENGTH-WEIGHT COMPOSITION

The lengths of 392 rainbow trout sampled from 19 to 27 August ranged from 82 to 518 mm FL and the mean length was 285 mm FL (SE = 4.15) (Table 3). The length distribution indicated a high frequency of fish in the 201 to 450 mm FL range (Figure 7). The mean length of all fish sampled by 1.6 km sections varied from an average of 261 mm (SE = 9.04) for section 6 to 346 mm (SE = 10.46) for section 7 (Table 3). However, there was no significant difference (D = 0.305, P = 0.256) in the cumulative length frequency distribution of fish in the lower 6 rkm compared to fish in the upper 6 rkm (Figure 8). There was a significant difference (D =2 2.14,

P < 0.001) between the cumulative length distribution of rainbow trout captured during the last 2 weeks of August in 1988 and 2004 (Figure 9). In previous years RSD values for rainbow trout over 500 mm FL ranged from 7 to 54, while in 2004 the value was 0 (Table 4).

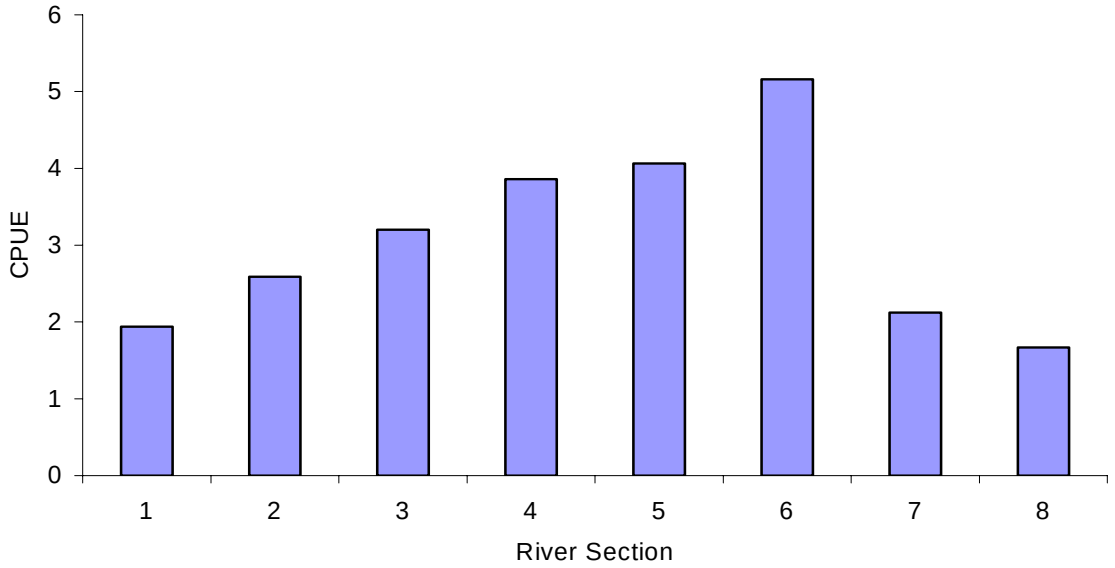

Figure 6.-Catch per unit effort (CPUE) of rainbow trout in the Tazimina River by 1.6 rkm section from 19 to 27 August 2004.

Table 3.-Mean length (millimeters) and weight (grams) of rainbow trout by sex sampled by 1.6 kilometer sections from the Tazimina River, 19 through 27 August 2004.

	River Section								
	1	2	3	4	5	6	7	8	All sections
All fish									
Mean length	273	294	285	272	301	261	346	334	285
Standard error	15	10	10	9	14	9	10	21	4
Sample size	31	35	87	85	38	76	35	5	392
Fish > 250 mm									
Mean length	338	317	335	330	341	332	355	334	336
Standard error	9	8	7	8	12	7	9	21	3
Sample size	17	28	60	48	27	37	33	5	255
Mean weight	367	309	374	392	410	380	429	319	380
Standard error	35	24	24	28	52	26	33	53	12
Sample size	16	28	60	45	28	34	32	5	248

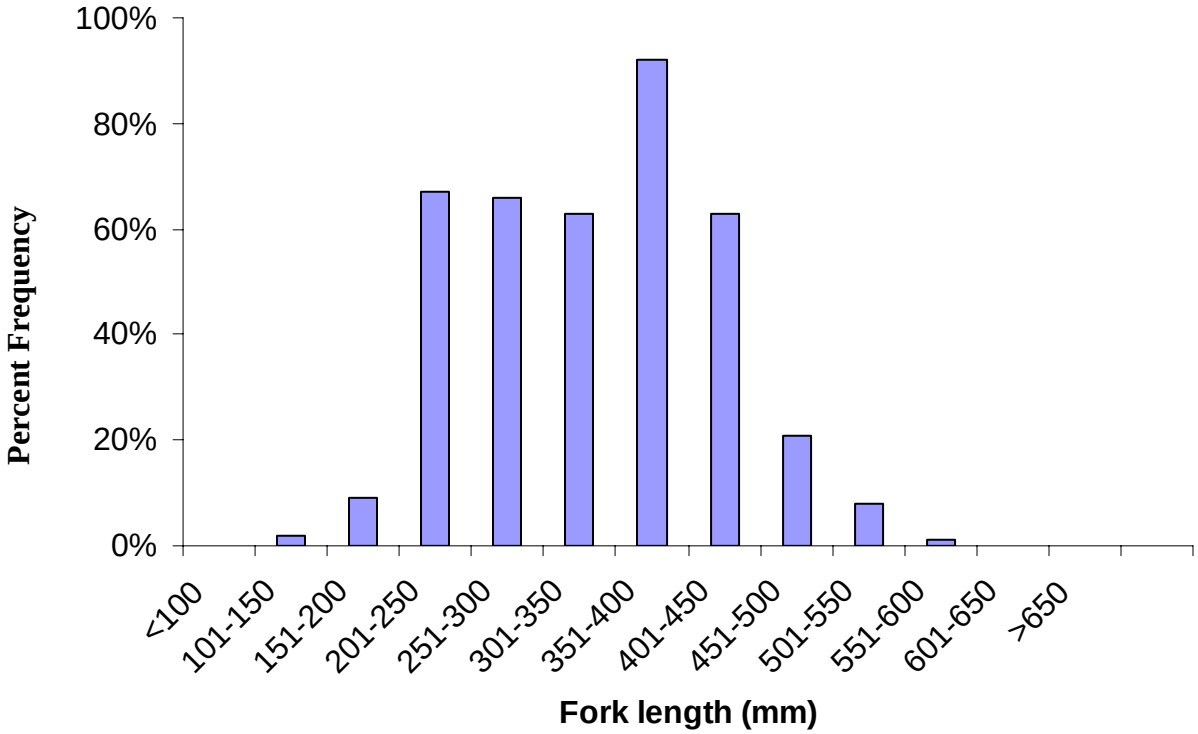

Figure 7.-Length frequency distributions of rainbow trout captured with hook and line from 19 to 27 August in the Tazimina River, 2004.

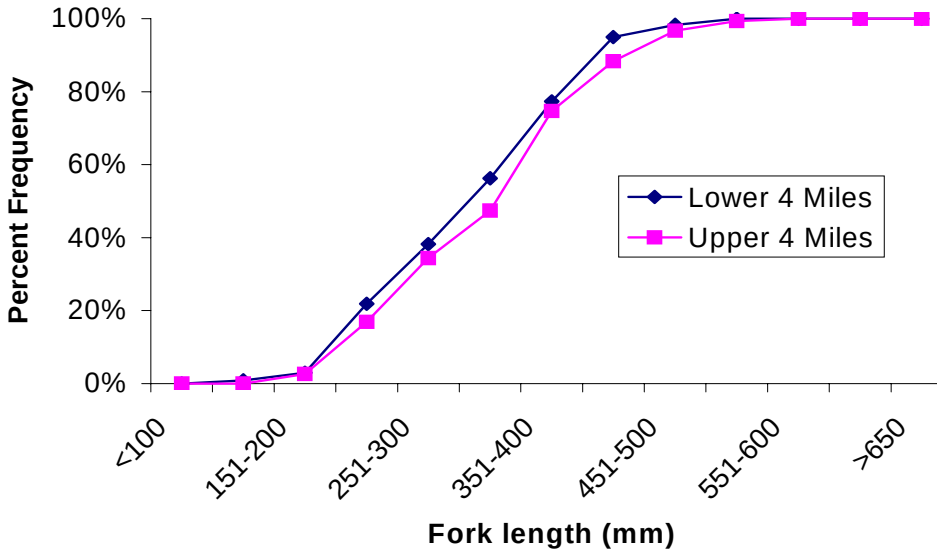

Figure 8.-Cumulative relative length frequency distributions of rainbow trout captured with hook and line in the lower and upper 6 km of the Tazimina River from 19 to 27 August 2004.

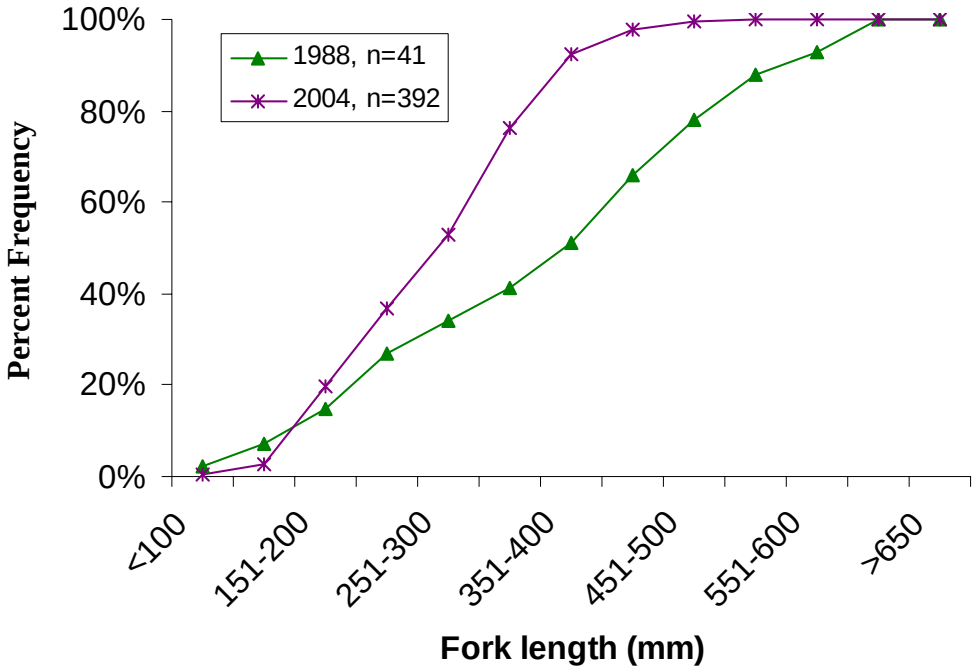

Figure 9.-Cumulative relative length frequency distributions of rainbow trout captured with hook and line in the Tazimina River between 14 and 27 August, 1988 and 2004.

Table 4.-Relative stock density (RSD) of rainbow trout sampled with hook and line between 14 and 31 August from the Tazimina River, 2004.

Length Category	Year				
	1979	1987	1988	1989	2004
<250	14	0	27	0	37
251-400	64	0	24	21	56
401-500	15	60	27	21	7
501-650	7	40	22	54	0
>650	0	0	0	4	0

Source: Brookover 1989; Minard and Dunaway 1991.

Two hundred forty eight rainbow trout over 250 mm were weighed to the nearest gram. The mean length and weight of rainbow trout ≥250 mm was 336 mm (SE = 3.3) and 380 g (SE = 11.94). Average length by river section ranged from 317 mm (SE = 8) for section 2 to 355 mm (SE = 9) for section 7, and average weight by river section ranged from 309 g (SE = 24) for section 2 to 429 g (SE = 33) for section 7 (Table 3).

A total of 540 Arctic grayling and 12 Dolly Varden were sampled for length during the fall.

ANGLER OBSERVATIONS

Fourteen boats transporting 36 anglers were observed on the Tazimina River from 19 to 27 August (Table 5). Twelve of the boats were outboard jet driven and two were rafts. All of the anglers observed during the survey were guided.

MOVEMENT

Five fish were recaptured during the fall that had previously been captured in the fall of 2004, as indicated by fin clips. Two of these fish were initially captured and recaptured below section 5. Three fish were recaptured above section 5 that were initially captured below section 5. Additionally, 13 fish with tags from the spring were recaptured in the fall (Table 6). All of these fish were tagged below section 5 in the spring. Eight of these fish were recaptured below section 5 and the remaining five were recaptured above section 5 in the fall.

DISCUSSION

Rainbow trout and Arctic grayling begin to enter the Tazimina River shortly after the river is ice-free in the spring. Although rainbow trout were not observed spawning in the Tazimina River, it is likely they do spawn there since sexually mature males and females, that freely expelled milt and eggs, were captured there during sampling, and one captured female that was sexually mature at initial capture was postspawn when recaptured 2 weeks later. However, the abundance of sexually mature fish appeared low given the length of the river and the availability of shallow gravel riffles for spawning.

Although some spawning does occur, the Tazimina River does not currently appear to be a major spawning drainage for rainbow trout and it is unclear if it was in the past. Rather, our data indicate that the majority of rainbow trout are entering the Tazimina River in the spring to spend the summer and feed. A sport fishing guide who commonly worked the Tazimina River reported catching multiple tagged fish daily over the course of the summer. In addition, 13 rainbow trout tagged in the spring were sampled in the fall. The movement of three finclipped fish from the lower river to upper river during fall sampling may indicate a general upstream movement, likely in response to increased sockeye salmon spawning activity during the last few days of fall sampling.

Other tributaries of Six Mile Lake and the Newhalen River were examined for spawning rainbow trout. Alexcy Creek, a small tributary of the Newhalen River approximately 5 mi downstream from the Tazimina River was sampled several times during the course of the spring research and spawning rainbow trout were observed and sampled. The creek consists of shallow riffles and small pools and 10 rainbow trout in spawning condition were sampled with 50 additional spawning fish observed. No rainbow trout were captured in Pickerel Creek, which flows into Six Mile Lake approximately 2.4 km from the Tazimina River.

Table 5.-Daily boat traffic and number of anglers on the Tazimina River from 19 to 27 August for 1987, 1988 and 2004.

	1987 [a]			1988 [b]			2004		
Date	Boat	Raft	Anglers	Boat	Raft	Anglers	Boat	Raft	Anglers
19-Aug	ND	ND	ND	3	0	5	2	0	5
20-Aug	ND	ND	ND	7	0	19	1	0	2
21-Aug	ND	ND	ND	4	2	11	0	0	0
22-Aug	ND	ND	ND	1	3	7	2	0	4
23-Aug	ND	ND	ND	4	0	6	2	0	5
24-Aug	ND	ND	ND	4	0	9	3	0	8
25-Aug	1	2	24	5	2	13	0	1	4
26-Aug	1	0	5	1	4	7	1	1	5
27-Aug	1	2	ND	2	0	8	1	0	3
Total	3	4	29	31	11	85	12	2	36

[a] Data compiled from appendix tables 1, 3, 5 and 6, Brookover 1989. ND indicates that no data were available for that date.

[b] Data compiled from appendix tables 2, 7, 9 and 10, Brookover 1989.

Table 6.-Summary of tagged rainbow trout from spring sampling that were recaptured during fall sampling, 2004.

	Spring Capture[a]	Fall Recapture	
Tag Number	Date	Date	River section
00112	5/17/2004	8/22/2004	1
00153	5/26/2004	8/20/2004	2
00164	5/25/2004	8/21/2004	2
00070	5/11/2004	8/27/2004	3
00041	5/6/2004	8/20/2004	4
00056	5/9/2004	8/20/2004	4
00201	5/27/2004	8/23/2004	4
00104	5/17/2004	8/26/2004	4
00170	5/25/2004	8/19/2004	6
00081	5/25/2004	8/22/2004	6
00174	5/25/2004	8/22/2004	6
00126	5/24/2004	8/27/2004	6
00044	5/6/2004	8/20/2004	8

[a] All rainbow trout recaptured were tagged in the lower 7 km of the river.

Sampling during the spring provided valuable information as to rainbow trout movement into the river, abundance, size and spawning composition. However, there were no previous studies for comparisons of abundance or size composition in the spring. Sampling during the fall did provide a comparison of angler CPUE as an index of rainbow trout abundance and length distribution to a past study conducted in 1987 and 1988 (Brookover 1989).

Brookover (1989) collected CPUE data from anglers at exit locations and the only past data comparable to 2004 was from anglers exiting the river at the mouth of the Tazimina River. Anglers exiting at the mouth by boat had access to the majority of the river and likely fished locations similar to 2004 staff, providing a comparison. The CPUE of rainbow trout by the 2004 sampling crew was considerably higher than the CPUE estimated for anglers exiting the Tazimina River fishery in 1987 and 1988. Some caveats must be considered when comparing these CPUEs. The angler hours for 1987 and 1988 were estimated from a direct expansion creel survey sampling design. In 2004, the hours were closely recorded during sampling by Department and NPS staff with the objective of documenting CPUE. It is likely that the estimated hours from the previous creel survey are not as accurate as those recorded in 2004 and do not precisely reflect time actually spent angling. Some anglers interviewed in the previous study may not have been targeting rainbow trout. Creel survey data indicate that sockeye salmon and grayling were commonly caught by anglers. If species other than rainbow trout were targeted by some anglers, the catch of rainbow trout would be reduced.

Another consideration in comparing the changes in CPUE between the study of Brookover (1989) and this study is that heavier fishing effort in 1987 and 1988 may have depressed the CPUE of anglers compared to that observed in 2004. In 1988 there was an average of nine anglers on the river each day from 19 to 27 August, compared to an average of four in 2004 (Table 4). Technicians sampling in 2004 reported reduced CPUE when fishing the same stretch of river as fished the previous day or fishing a section of river that guided anglers had already fished that day providing evidence that increased angling effort may reduce CPUE. In addition, the accessible water of the lower Tazimina River consists of a relatively small stretch of river (up to 14 km depending on water levels) further confining anglers to fishable locations. A similar phenomenon of low rainbow trout catches was observed on the upper Alagnak River for staff test fishers after an area had been fished by sport anglers (Jaenicke 1998).

There are inherent pitfalls when comparing rainbow trout length compositions among years including the repeatability of study designs and spatial and temporal heterogeneity in fish size due to fluctuations in habitat parameters or food abundance in a river from among years (Schwanke et al. *In prep*). However large deviations in fish size can indicate changes in a population. Since more rainbow trout were sampled during corresponding time periods in fall of 2004 than in past years, the lack of large fish in 2004 is difficult to dispute. The smaller average size in 2004 was also due to the occurrence of more small fish, particularly those smaller than 250 mm FL, as well as the occurrence of few fish larger than 500 mm FL.

CONCLUSIONS

Local residents and recreational anglers reported a decline in the number and size of rainbow trout in the Tazimina River in the 1990s. Results of this 2004 study suggest that the rainbow trout population may be rebounding from these depressed levels. CPUE data provide some

evidence that more rainbow trout were in the Tazimina River during late August in 2004 than either in 1987 and 1988. Also, while the proportion and number of fish in the population larger than 500 mm FL was less in 2004 than past years, there appeared to be an increase in the total number of fish, particularly those smaller than 250 mm FL. The population is relatively protected from harvest while spawning and feeding in the Tazimina River since sport fishing is strictly catch-and-release and subsistence users can only use rod-and-reel. If the rainbow trout in the Tazimina River continue to grow and survive to recruit into the larger, mature size classes, then the length composition of the population should become more similar to that observed in the past. Another study, similar to the one conducted in 2004, should be conducted in about 3 years to continue to monitor the status of this population.

Studies conducted in 2004 and past years have also provided limited information on the life history of rainbow trout in the Tazimina River. However, many questions remain concerning the stock structure and interactions of rainbow trout in the Tazimina River with those in the Newhalen River drainage. A radiotelemetry study of Tazimina River rainbow trout would provide important information on seasonal movements as well as spawning, feeding, and wintering areas. Also, collection and analysis of additional genetic samples from spawning populations and summer feeding aggregations could provide information on stock structure and mixing. An examination of the rainbow trout harvest in the Six Mile Lake rod-and-reel ice fishery in conjunction with life history studies could provide valuable information on a possible source of exploitation on the Tazimina River rainbow trout stock. This information would allow fishery managers to better understand this resource and ensure it is sustained.

ACKNOWLEDGEMENTS

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APPENDIX A

Appendix A1.–Archived biological data files collected during this research project.

Data Files	Description
Spring Data	
Rainbow Trout:	
S-000901B032004	Tazimina River rainbow trout hook-and-line AWL samples
S-000703B052004	Newhalen River rainbow trout hook-and-line AWL samples
S-000703B042004	Newhalen River rainbow trout beach seine AWL samples
S-013801B012004	Alexcy Creek rainbow trout hook-and-line AWL samples
Arctic Grayling:	
S-000901B012004	Tazimina River Arctic grayling hook-and-line AWL samples
S-000902B012004	Tazimina River Arctic grayling hook-and-line AWL samples
S-000901B022004	Tazimina River Arctic grayling gill net AWL samples
S-000703B032004	Newhalen River Arctic grayling beach seine AWL samples
S-000703B062004	Newhalen River Arctic grayling hook-and-line AWL samples
S-013300B012004	Pickerel Creek Arctic grayling hook-and-line AWL samples
Lake Trout:	
S-000900B032004	Lake Clark lake trout hook-and-line AWL samples
Northern Pike:	
S-000900B022004	Pickerel Lake northern pike hook-and-line AWL samples
S-000703B022004	Newhalen River northern pike beach seine samples
Whitefish:	
S-000703B012004	Newhalen River white fish beach seine AWL samples
Fall Data	
Rainbow Trout:	
S-000900D022004	Tazimina River rainbow trout hook-and-line AWL samples
Arctic Grayling:	
S-000900D012004	Tazimina River Arctic grayling hook-and-line AWL samples
Dolly Varden:	
S-000900D032004	Tazimina River Dolly Varden hook-and-line AWL samples