Fishery Data Series No. 99-21

Evaluation of Stocked Game Fish in the Tanana Valley, 1998

by
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and
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September 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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ABSTRACT

We estimated the population abundance of rainbow trout *Oncorhynchus mykiss* in three lakes managed to provide trophy-size rainbow trout. The estimated abundance of rainbow trout in Little Harding Lake was 1,220 (SE = 56) of which 72 (SE = 10) were estimated $\geq$ 350 mm tip-of-snout to fork-of-tail (FL). The abundance estimate for rainbow trout in Craig Lake was 191 (SE = 4) of which 4 (SE = 2) were estimated $\geq$ 350 mm. The abundance estimate for rainbow trout in Coal Mine #5 Lake was 959 (SE = 226) of which 36 (SE = 12) were estimated $\geq$ 350 mm. We attempted to estimate the number of rainbow trout that emigrate from Piledriver Slough within one week of stocking. Of 1,000 fish stocked we captured only 25 unique fish. Twenty-three were captured within 24-h of stocking. We consider this loss to the fishery insignificant. Temperature was recorded in three lakes from June to September. None of the temperatures exceeded the upper maximum temperature for rainbow trout (25ºC). However, the upper optimum temperature for rainbow trout (18^{o}C) was exceeded in the entire water column in one lake for 30 days. The other two lakes had areas of refuge where the temperature did not exceed 18^{o}C. Other stocked species such as Arctic char *Salvelinus alpinus* probably would not survive in these and similar lakes if suitable refuge was not present during summer. By altering our stocking methods we can stock catchable (>100 g) Arctic char in late summer after temperatures have fallen. These fish would be available from mid-August through mid-June. This is an acceptable stocking method for put and take fisheries that exist in our popular small lakes.

Key words: Piledriver Slough, small lakes, stocking evaluation, Arctic char, *Salvelinus alpinus*, rainbow trout, *Oncorhynchus mykiss*, Arctic grayling, *Thymallus arcticus*, lake trout, *Salvelinus namaycush*, coho salmon, *Oncorhynchus kisutch*, temperature profile, maximum and optimum temperature, temperature profile, refuge, emigration, trophy, stocking method.

INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) stocks game fish in numerous lakes and one stream in the Tanana River Valley within Alaska's interior (Figure 1). Our goal is to provide more angling opportunities near population centers and offer alternatives to the harvest of wild stocks. The stocking program began in the early 1950's, when lakes along the road system were stocked with rainbow trout *Oncorhynchus mykiss*, or coho salmon *O. kisutch*. Today, the stocking program provides diverse year-round sport fishing for rainbow trout, coho salmon, chinook salmon *O. tshawytscha*, Arctic grayling *Thymallus arcticus*, Arctic char *Salvelinus alpinus*, and lake trout *S. namaycush*.

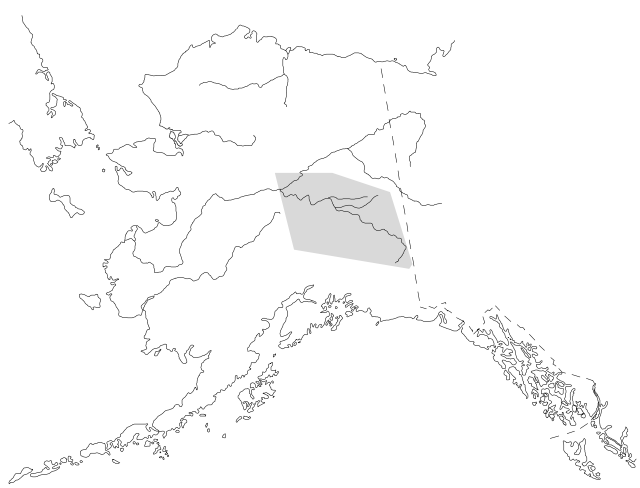

Figure 1.-The Tanana Valley (shaded area).

The stocking program supports consumptive fisheries along the road system where fishing effort and harvests are highest and serves to divert harvest away from wild populations as a conservation measure. In 1996, an estimated 38,786 anglers fished in the Tanana Valley and they generated an estimated 203,962 angler-days of effort[1] (Howe et al. 1997), second only to the Kenai Peninsula for number of angler-days. An estimated 78,196 angler-days of effort were directed toward stocked fish. The estimated harvests of stocked and wild fish in the Tanana Valley in 1996 were 66,729 and 26,044, respectively. Since 1990 stocked fish represent 51 to 72% of the estimated harvest of game fish in the Tanana Valley and about 34 to 38% of the total estimated fishing effort. During 1996, about 67% of the total harvest of wild and stocked fish in the Tanana Valley was attributed to just two stocked species: rainbow trout and landlocked coho salmon (Howe et al. 1997).

The following objective addressed in this report is for Project F-10-13, Job E-3-1(a):

Objective 1: Estimate the abundance of rainbow trout emigrating from Piledriver Slough such that $\Pr\left(\left|\frac{\hat{N}-N}{N}\right| \geq 0.25\right) = 0.10$.

Following are the objectives and a task addressed in this report for Project F-10-14, Job E-3-1(a):

Objective 1: Estimate the abundance of rainbow trout in Craig, Coal Mine #5, and Little Harding lakes such that $\Pr\left(\left|\frac{\hat{N}-N}{N}\right| \geq 0.25\right) = 0.05$.

Objective 2: Estimate the age and size compositions of rainbow trout in these three lakes such that $\Pr(|p - P| \geq 0.05) = 0.05$. Age categories are: age 1 and older than age 1. Size categories are: <350 mm and ≥350 mm tip-of-snout to fork-of-tail (FL).

Task: Obtain lake temperature profiles in selected stocked waters.

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[1] Fishing effort (angler-days) for a location is defined as the estimated number of days fished by all anglers for that location (Mills 1980-1995; Howe et al. 1996 and 1997). Any part day fished by an angler is considered one whole day or one angler-day.

EMIGRATION OF STOCKED RAINBOW TROUT FROM PILEDRIVER SLOUGH

Piledriver Slough is a clear water stream near Fairbanks. Until the upstream portion of the slough was blocked in 1976 to control flooding, a portion of the Tanana River flowed through the slough. We have been stocking catchable rainbow trout into Piledriver Slough since 1987. Fish are released at several locations along the slough from Eielson Farm Road at the downstream end to Stringer Road near the upper end (Figure 2). More than 5,000 rainbow trout

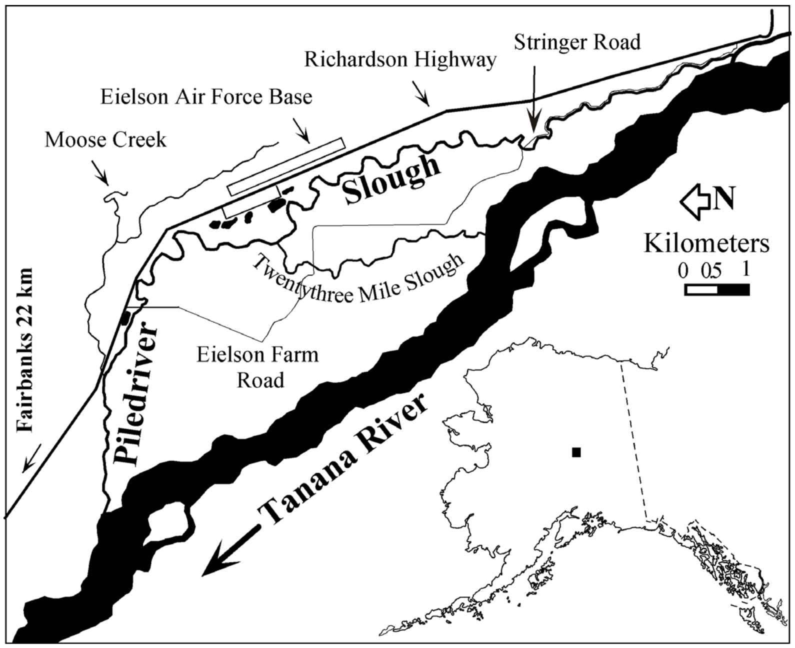

Figure 2.-Piledriver Slough study area.

are released at the Eielson Farm Road from May through July and we suspect that a portion of these fish quickly move downstream into the Tanana River and out of the fishery. Preliminary investigations in 1996 indicated that our suspicions were correct. Fifteen rainbow trout were captured during one 24-hr sampling period with one fyke net and one gill net. The nets were set below the confluence of Piledriver Slough with Moose Creek the day following stocking. Based on these findings we reduced the number of rainbow trout released at Eielson Farm Road from about 2,000 to 500 per stocking event. Usually there are three stocking events each year.

If, during this study, we had found that more than 50 % of the rainbow trout released at Eielson Farm Road emigrate from Piledriver Slough within a week of stocking then we would consider adjusting how we stock rainbow trout into Piledriver Slough. Some alternatives are to stock a greater proportion of the fish further upstream or to stock them in lakes near Fairbanks, North Pole, and Delta Junction. If fish quickly leave Piledriver Slough and do not contribute to the effort or value of the fishery then we can make better use of this resource by stocking the fish in high use urban areas.

METHODS

On 13 July we stocked 1,000 marked rainbow trout (adipose fin clip) where the Eielson Farm Road crosses Piledriver Slough. These fish were marked to distinguish them from any rainbow trout that might be present from earlier stockings. The fish were marked at Ft. Richardson Hatchery two weeks prior to stocking. The Eielson Farm Road crossing is about 4 km upstream of the study area. We used a capture-recapture experiment to estimate the abundance of stocked rainbow trout that left the Piledriver Slough fishery. Any rainbow trout that was captured in the study area (1 km upstream of the confluence with the Tanana River) within five days of stocking was considered to have left the fishery.

The capture-recapture experiment occurred during 13 –17 July. On the day of stocking we set six fyke nets in the study area. The nets were set for five consecutive days but were checked once each day. The fyke nets were set in pairs such that each net of a pair provides coverage from one bank to mid stream. About 100 m separated each pair. To hold the fyke nets in place we slid metal stakes through the metal tubing that comprised the vertical component of the frame and drove the stakes into the slough bottom. When we examined the fyke nets for fish we started with the downstream pair and worked our way upstream.

The fyke nets that we used have an opening 1.2 m sq., mesh size is 9 mm sq., and wings are 7.5 m long. Piledriver Slough at the sampling area is about 1.8 m deep and 10 m wide. During the sampling period the water level, flow and the debris load were normal and the nets were fishing efficiently.

All captured rainbow trout having a clipped adipose fin were marked with a uniquely numbered Floy anchor tag. A small portion of the upper lobe of the caudal fin was also removed to serve as an indicator of Floy tag loss. Each day we examined all fish for clipped fins and Floy tags. After examination and marking, we released the rainbow trout about 30 m downstream of the fyke net in which they were captured.

The following week on 22 July we used a boat equipped with electrofishing gear to search for rainbow trout about 1 km above and below the study site and within 1 km downstream of the confluence of Piledriver Slough with Moose Creek.

RESULTS AND DISCUSSION

We captured 54 rainbow trout in the fyke nets. Of these, 26 did not have an adipose fin clip and were from previous stockings. Twenty-eight rainbow trout had an adipose fin clip and three of these fish were later recaptured in the fyke nets (Table 1). Twenty-three of the marked fish were captured within 24-h (period 1) of release. Catches declined rapidly for the subsequent 24-h capture periods (periods 2-4).

Table 1.-Capture history for adipose clipped rainbow trout captured during the emigration study at Piledriver Slough, 1998.

Net	Period 1 (July 14)		Period 2 (July 15)		Period 3 (July 16)		Period 4 (July 17)	
Site	New Fish	Recap	New Fish	Recaps	New Fish	Recap	New Fish	Recaps
Lower	5	0	0	1	0	0	0	0
Middle	5	0	1	1	0	0	0	0
Upper	13	0	0	1	4	0	0	0

With the electrofishing boat we captured three rainbow trout at the confluence with Moose Creek, upstream of the study site. One of these fish had been captured the previous week in the fyke nets. The other two rainbow trout were not marked. When we were using the electrofishing boat we saw no rainbow trout in the lower portion of Piledriver Slough near the study site.

Because we caught so few rainbow trout we could not estimate the abundance of emigrates. We were surprised that we captured only 25 marked fish during the four 24-h capture periods. The low number of captured fish suggests that only a small portion of the stocked fish actually emigrate from Piledriver Slough. Most emigrating fish leave immediately (within 24-h) while others that initially move downstream from the release site may eventually move back upstream. Our study suggests that only a small portion of the stocked fish leave Piledriver Slough and a few may remain in the lower portion of Piledriver Slough near the confluence with Moose Creek. We would consider a loss of fewer than 50 fish (about $60) from a stocking of 1,000 fish acceptable for such a popular fishery.

Stocking a larger proportion of the rainbow trout further upstream in Piledriver Slough may further reduce emigration. It is unknown if emigration of stocked rainbow trout is influenced by distance, numbers of fish stocked, or some combination of both. The proportion of stocked fish that leave may decrease with increasing distance of the release site from the mouth of Piledriver Slough. The Eielson Farm Road is about 6 km upstream from the mouth of Piledriver Slough. Other release sites are about 12 and 18 km upstream from the mouth of Piledriver Slough. Fish released at a greater distance from the mouth of Piledriver Slough are in the fishery longer and are probably more likely to contribute to the fishery in some way through harvest or catch and release. As the number of fish released at a location increases, the proportion of stocked fish that leave the fishery may increase due to crowding and lack of available habitat and food. We do not have the resources to address these factors (distance and number stocked) at this time, but, if warranted, they will be evaluated later.

ABUNDANCE AND COMPOSITION OF RAINBOW TROUT IN LAKES MANAGED FOR TROPHY SIZE FISH

In 1994 Region III initiated a program to create fisheries for trophy size rainbow trout in Little Harding Lake (22 ha), Craig Lake (7 ha) and Coal Mine #5 Lake (5 ha) (Figure 3). We consider trophy size to be 18 in (460 mm) or larger. We selected this criteria because fish larger than 460 mm (trophy size) will be harvested and not available for evaluation. Special regulations were adopted for these lakes to increase the likelihood of creating successful fisheries. These lakes are open to fishing from 15 May through 30 September. Only unbaited, single-hook, artificial lures and flies may be used. The daily bag and possession limit for rainbow trout is one fish which must be 18 in, 460 mm total length (TL) or larger.

Success in establishing fisheries for trophy rainbow trout in Little Harding Lake, Craig Lake, and Coal Mine #5 Lake have criteria based on size. For these fisheries to be considered successes, at least half of an age cohort must exceed 14 in (350 mm FL) by age 4. When stocked these fish are age 1 and average 42 to 70 g. These three lakes were stocked previously with rainbow trout and other species (Appendix A). Prior to 1994 landlocked coho salmon were present in Little Harding Lake. Lake trout and slimy sculpins *Cottus cognatus* are in Coal Mine #5 Lake and lake chubs *Couesius plumbeus* are present in Craig Lake and Little Harding Lake.

The purposes of this study were to estimate the abundance and composition of the rainbow trout populations in these three lakes. This information will be used to evaluate progress towards achieving size criteria.

METHODS

In 1996 and 1995 we marked all rainbow trout that were stocked in Little Harding Lake, Coal Mine #5 Lake, and Craig Lake. Rainbow trout stocked in 1996 were marked by completely excising the right ventral fin and those stocked in 1995 had the adipose fin excised. Rainbow trout stocked in 1997 and those stocked before 1995 were not marked.

Capture

To estimate the abundance of rainbow trout we conducted a two-sample mark-recapture experiment in each lake. For Little Harding Lake and Craig Lake the experiments occurred in May and June before the 1998 fish stocking occurred. For Coal Mine #5 Lake the experiment was conducted in September after the 1998 fish stocking occurred[2].

Fish were captured with fyke nets. The openings of the fyke nets were either 1.2 or 0.9 m sq., hoop size was 0.9 m diameter, mesh size was 9 mm sq., wings were 7.5 m long by 1.2 m deep, and center leads were 30 m long by 1.2 m deep. The center lead, when used, was attached to the center vertical post on the first square frame. We distributed the fyke nets roughly equidistant to

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[2] While it was originally planned to sample prior to stocking to avoid handling new releases, field sampling was delayed due to scheduling conflicts.

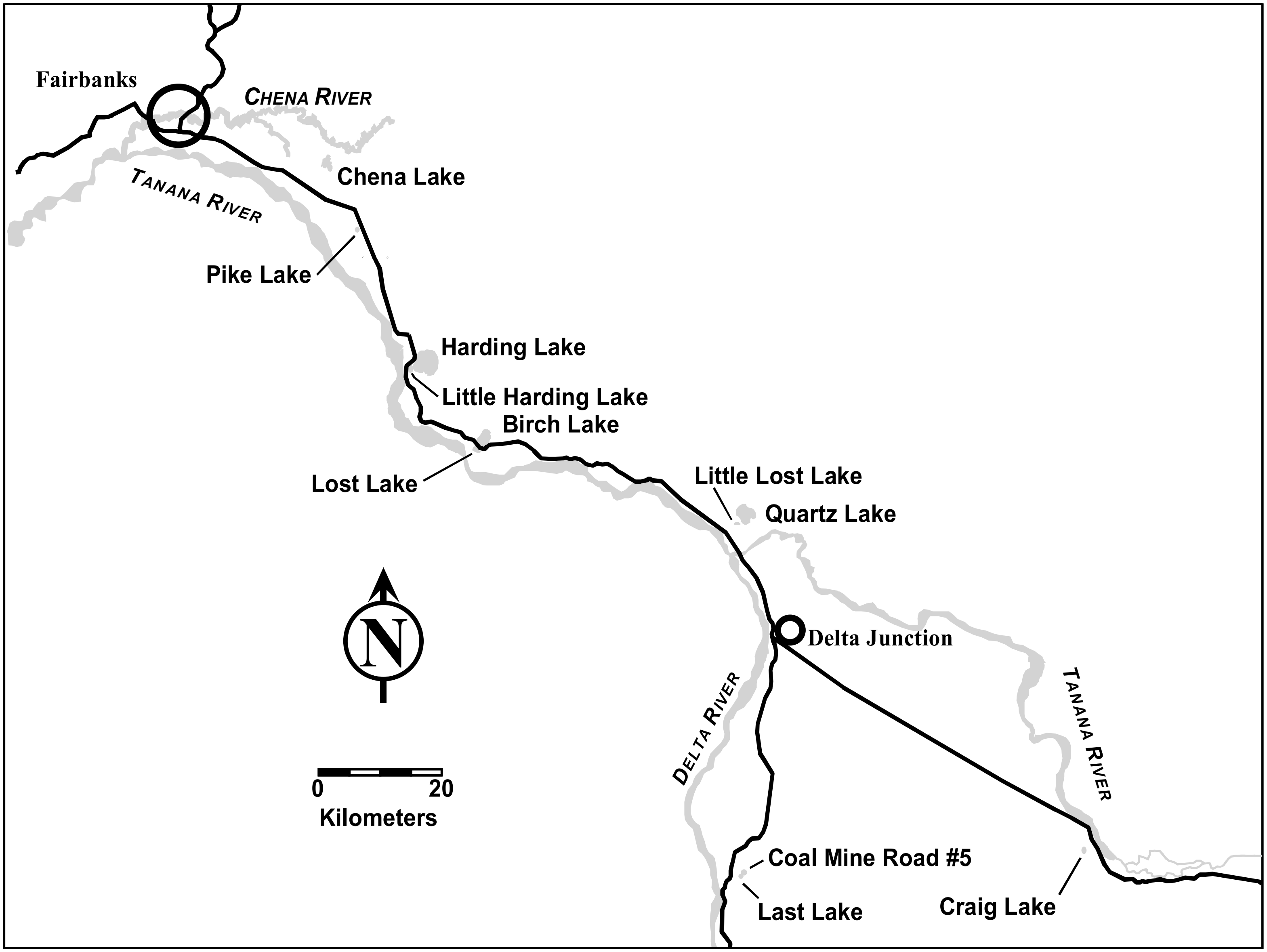

Figure 3.-Lake locations in the Tanana Valley.

each other around the lake perimeters. We used three methods to set the fyke nets. The first method did not use the center lead. We positioned the body of the net parallel to shore with the wings forming a "V". One wing was anchored to shore and a weight was attached to the other wing and positioned offshore. Each fyke net was pulled taut from the cod end which was weighted. The fyke nets rested on the lake bottom. Water depth at these sites varied from 1 to 1.8 m. With the second method, center leads were attached to one or two fyke nets in each lake. The unattached end of the center lead was anchored to shore. The fyke nets were set with the center lead perpendicular to shore and wings parallel to shore. The fyke nets rested on the lake bottom in 1 to 2 m of water. In Craig Lake and Little Harding Lake we also set one fyke net in the middle of each lake. Metal tubing was used to stretch the fyke net and maintain proper shape. Floats were attached around the fyke net to keep it from sinking. With this arrangement we used a center lead but did not use the fyke net wings. All fyke nets were baited with unsalted salmon roe.

Each captured fish was marked to identify the event in which it was captured. For marking we used a paper punch (which produces a 7 mm diameter circular hole) to remove a half disk of tissue from the tip of the caudal fin from each captured fish. During the marking event (first event) fish were marked in the lower lobe of the caudal fin. All fish captured in the recapture event (second event) were marked in the upper lobe. Any fish captured in the second event without a mark in the lower lobe was classified as unmarked (captured for the first time). Any fish captured more than once during either the marking or recapture events was counted only once per event. We measured all captured fish to the nearest mm FL. All length measurements are FL unless noted otherwise.

Data Analysis

The assumptions necessary for accurate estimation of abundance in a closed population and the test of these assumptions are described in Appendices B and C. If significant size bias was detected, separate population estimates were calculated for each size category. The resulting independent estimates were then summed to produce an estimate of abundance. The abundance was then apportioned by size/age group and adjusted for size bias using methods described in Appendix C.

Bailey's modification of the Petersen estimate (Bailey 1951, 1952; Seber 1982, p.61) was used to estimate the abundance of the entire population or a size category of the rainbow trout population in each of the three lakes:

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

where: $\hat{N}$ = the abundance of rainbow trout in a lake; n_1 = the number of rainbow trout marked and released during the first event; n_2 = the number of rainbow trout examined for marks during the second event; and, m_2 = the number of rainbow trout recaptured in the second event.

Variance of this estimator was calculated by (Bailey 1951, 1952):

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

We separated fish into age/size groups by visual inspection of a length frequency distribution of fish captured only once in both events. Generally, these distributions have only two nodes. An arbitrary point was chosen between the nodes that represent the small (usually age 2) and large fish (usually age 3 and older) which gave the lowest number of misclassified individuals.

When the data were adequate, the population abundance was apportioned into age and size categories. Categories were age 2, age 3 and older, <350 mm, and ≥350 mm. The estimated proportion of fish by size category was calculated as:

$$\hat{p}_i = \frac{y_i}{n} \qquad (3)$$

where: $\hat{p}$ = the proportion of rainbow trout by size category *i*; y = the number of rainbow trout sampled that were in size category *i*; and, n = the total number of rainbow trout sampled.

The unbiased variance of this proportion was estimated as:

$$\hat{V}[\hat{p}_i] = \frac{\hat{p}_i(1-\hat{p}_i)}{n-1} \qquad (4)$$

The abundance of size *i* rainbow trout in the population for size *i* was then:

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

The variance for $\hat{N}_i$ in this case was estimated by (Goodman 1960):

$$\hat{V}[\hat{N}_i] = [\hat{p}_i]\hat{N}_i^2 + V[\hat{N}_i]\hat{p}_i^{\,2} - \hat{V}[\hat{p}_i]V[\hat{N}_i] \qquad (6)$$

Similar methods were used to estimate the number of fish in the population by age.

RESULTS

Little Harding Lake

During the mark-recapture experiment, 730 rainbow trout were captured and marked in Event 1 (12 – 15 May) and 108 unmarked and 163 marked rainbow trout were captured in Event 2 (2 – 10 June). Lake chub also were present in the catch, but they were not enumerated.

We could not distinguish age cohorts by visual inspection of length frequency distributions (Figure 4). Tests for size bias inferred there was size-selectivity during the marking event and during the recapture event (Table 2). Visual inspection of the empirical cumulative frequency distributions indicated the greatest difference occurred at about 250 mm (Figures 5 and 6). We stratified the sample into small (<250 mm) and large (≥250 mm) fish and made separate estimates of abundance for each strata. We pooled data from both capture events and then apportioned the total abundance by size category (<350 mm and ≥350 mm). We estimated 1,220 rainbow trout in the population of which 73 rainbow trout were 350 mm or larger (Table 3). The unstratified estimate of abundance was 1,211 of which 72 fish were 350 mm or larger.

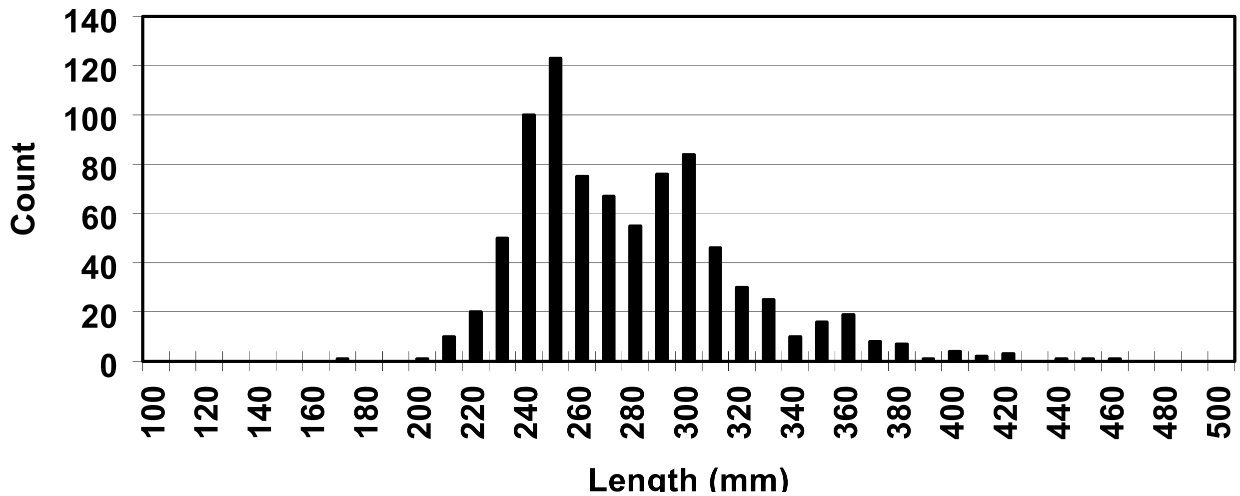

Figure 4.-Length frequency histogram for unique rainbow trout captured during the mark-recapture experiment at Little Harding Lake, 1998.

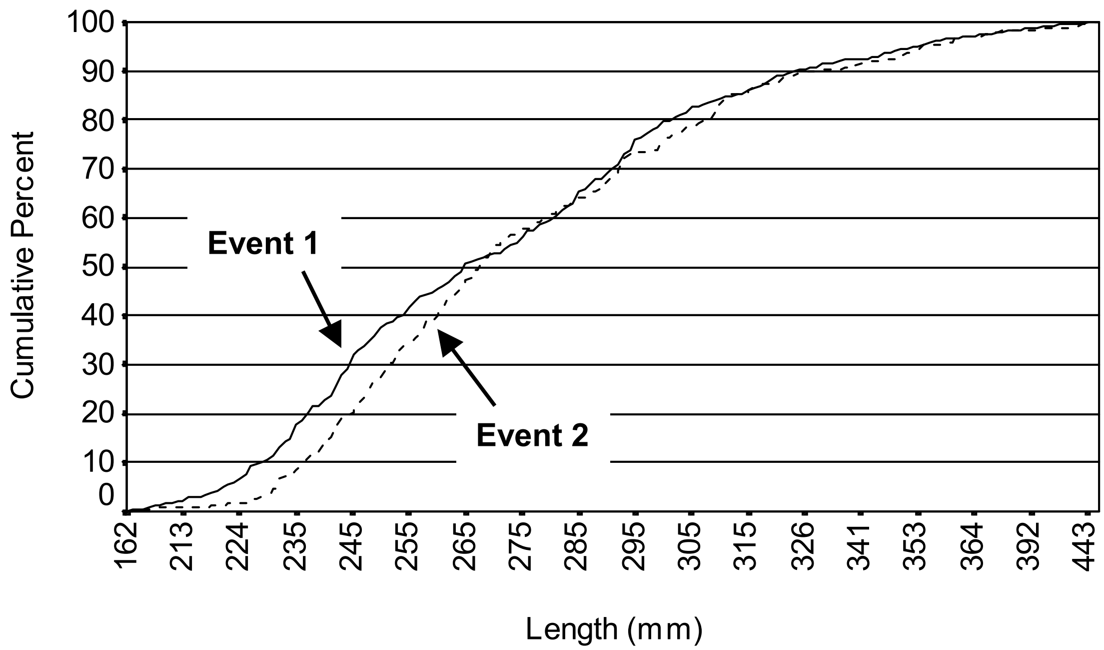

Figure 5.-Cumulative percent length frequency distribution for rainbow trout captured during Event 1 and Event 2 of the mark-recapture experiment at Little Harding Lake, 1998.

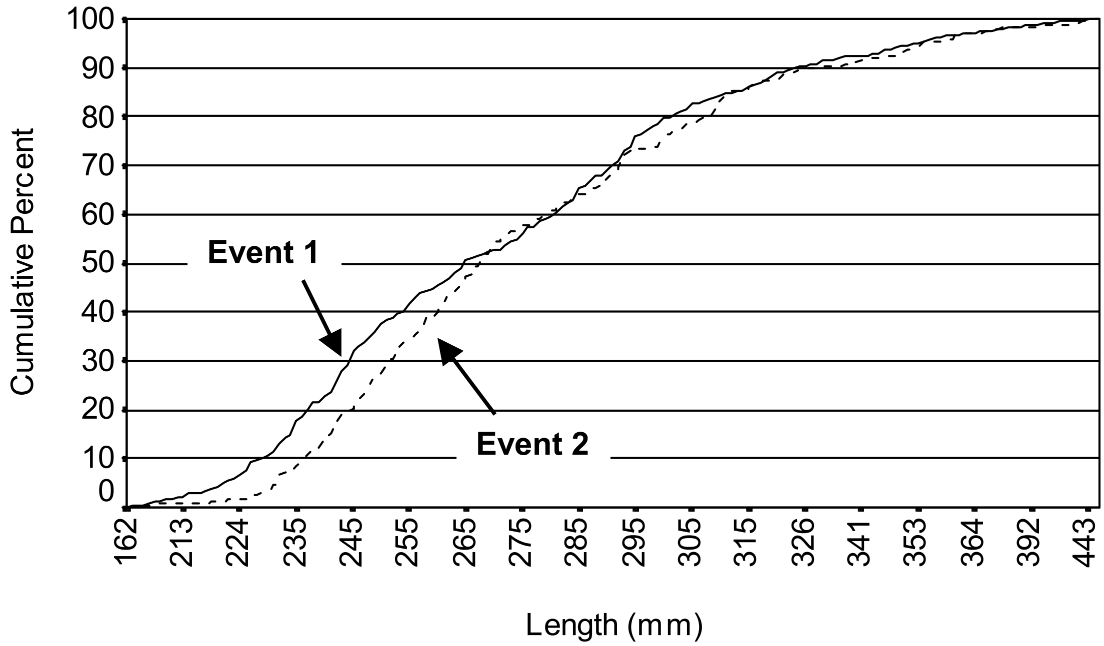

Figure 6.-Cumulative percent length frequency distribution for rainbow trout captured during Event 1 and recaptured during Event 2 of the mark-recapture experiment at Little Harding Lake, 1998.

Table 2.-Evaluation of size bias during the mark-recapture experiment at Little Harding Lake, 1998.

Test 1 (Figure 5)		Test 2 (Figure 6)	
Test Statistic	P-value	Test Statistic	P-value
0.13	0.004	0.14	0.010

Tests for size bias were conducted using the Kolmogorov-Smirnov (K-S) test for two independent samples. The K-S test determines if the length distributions are different for: **Test 1**) all fish captured in the first event and all fish captured in the second event. This test is sensitive to any type of difference in the two distributions – location, dispersion, skewness, etc. The test is based on the largest difference between the two cumulative distributions; and, **Test 2**) all fish captured in the first event versus all marked fish captured in the second event.

Table 3.-Abundance estimates of rainbow trout in Little Harding Lake, 1998.

			95% Confidence Limits	
	Abundance	SE	Lower	Upper
Entire Population				
Unstratified	1,211	52	1,109	1,314
Stratified	1,220	56	1,111	1,330
Fish ≥ 350 mm	73	10	53	92

Craig Lake

During the mark-recapture experiment, 142 rainbow trout were captured and marked in Event 1 (12 – 15 May) and 38 unmarked and 110 marked rainbow trout were captured in Event 2 (19 – 22 May). Length frequency distributions did not show any clear separation between age 2 and age 3 cohorts for unique fish (Figure 7). Because we could not distinguish age cohorts we used a two-sample Kolmogorov-Smirnov test to evaluate size bias. We found no indication of size bias during the experiment (Table 4; Figures 8 and 9). We pooled data from both capture events and then apportioned the total abundance by size category (<350 mm and ≥350 mm). We estimated 191 rainbow trout in the population of which 4 rainbow trout were 350 mm or larger (Table 5).

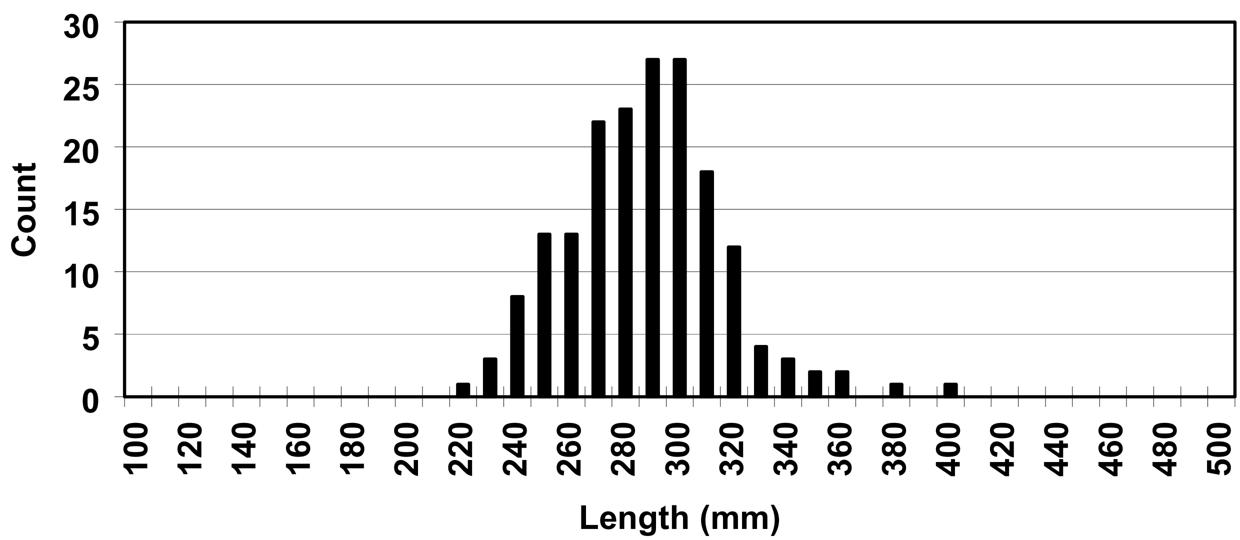

Figure 7.-Length frequency histogram for unique rainbow trout captured during the mark-recapture experiment at Craig Lake, 1998.

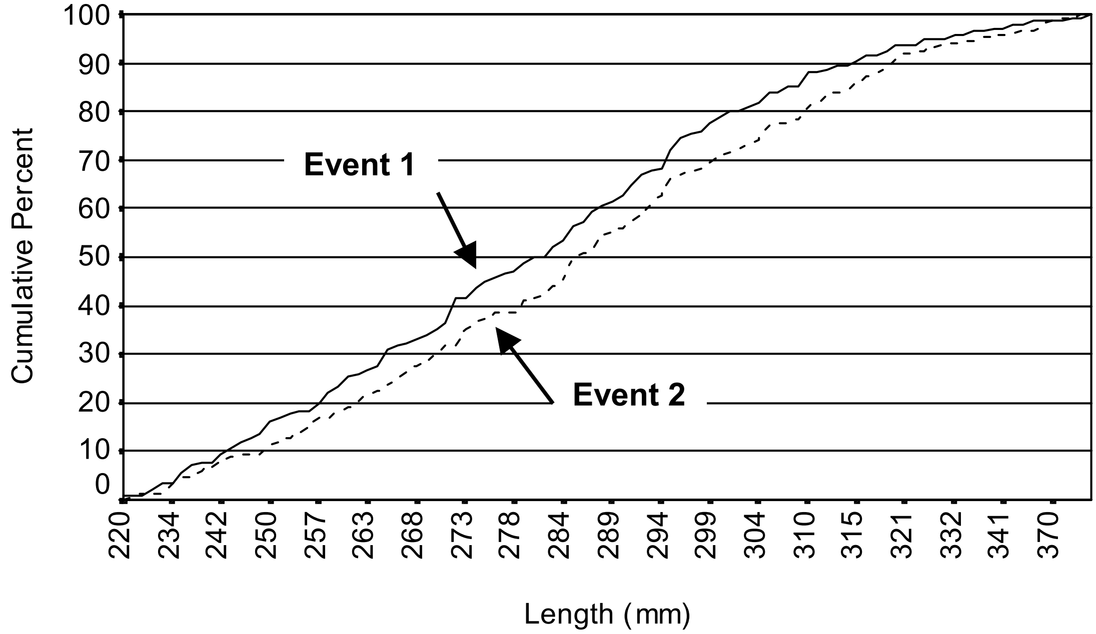

Figure 8.-Cumulative percent length frequency distribution for rainbow trout captured during Event 1 and Event 2 of the mark-recapture experiment at Craig Lake, 1998.

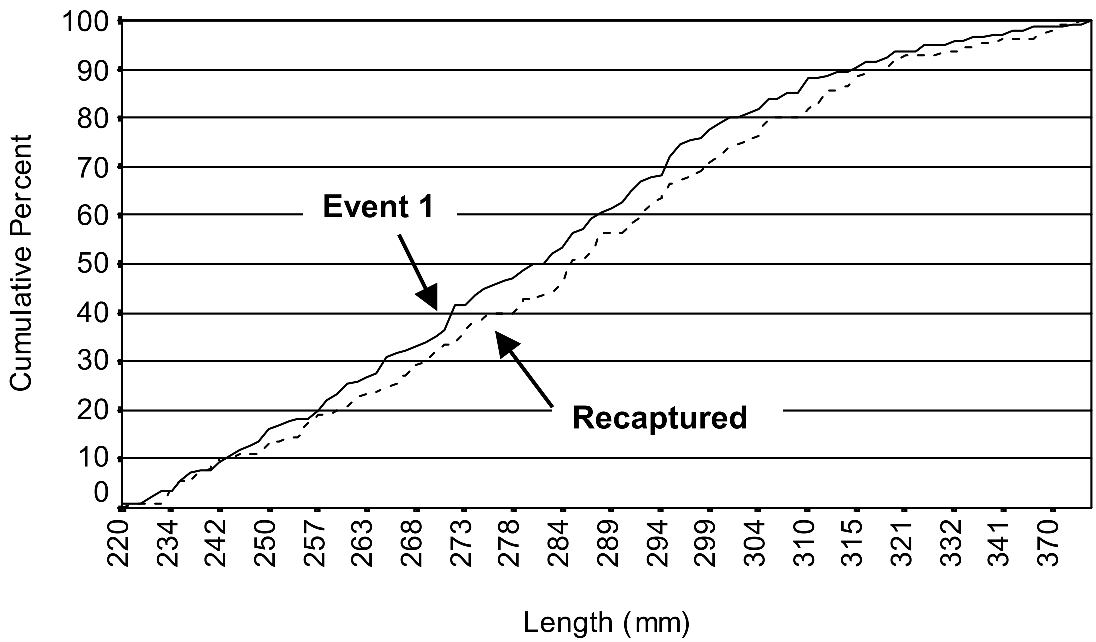

Figure 9.-Cumulative percent length frequency distribution for rainbow trout captured during Event 1 and recaptured during Event 2 of the mark-recapture experiment at Craig Lake, 1998.

Table 4.-Evaluation of size bias during the mark-recapture experiment at Craig Lake, 1998.

Test 1 (Figure 8)		Test 2 (Figure 9)	
Test Statistic	P-value	Test Statistic	P-value
0.83	0.49	0.62	0.83

Table 5.-Abundance estimates of rainbow trout in Craig Lake, 1998.

			95% Confidence Limits	
	Abundance	SE	Lower	Upper
Unstratified	191	4	182	199
Fish ≥ 350 mm	4	2	4	8

Coal Mine #5 Lake

During the mark-recapture experiment 125 rainbow trout were captured and marked in Event 1 (24 - 28 August) and 86 unmarked and 12 marked rainbow trout were captured in Event 2 (8 – 11 September. Length frequency distributions for unique fish showed a clear separation between age 1 and age 2 cohorts (Figure 10). Because we could distinguish age cohorts we used contingency tables to evaluate size bias and found no indication of size bias during the experiment (Table 6). We also captured four lake trout that ranged in length from 457 to 492 mm (FL).

We pooled data from both capture events and then apportioned the total abundance by age/size category (Table 7). We estimated 958 rainbow trout in the population of which 672 were age 1, 286 were age 2+. Thirty six of the total estimated population were 350 mm or larger (Table 8).

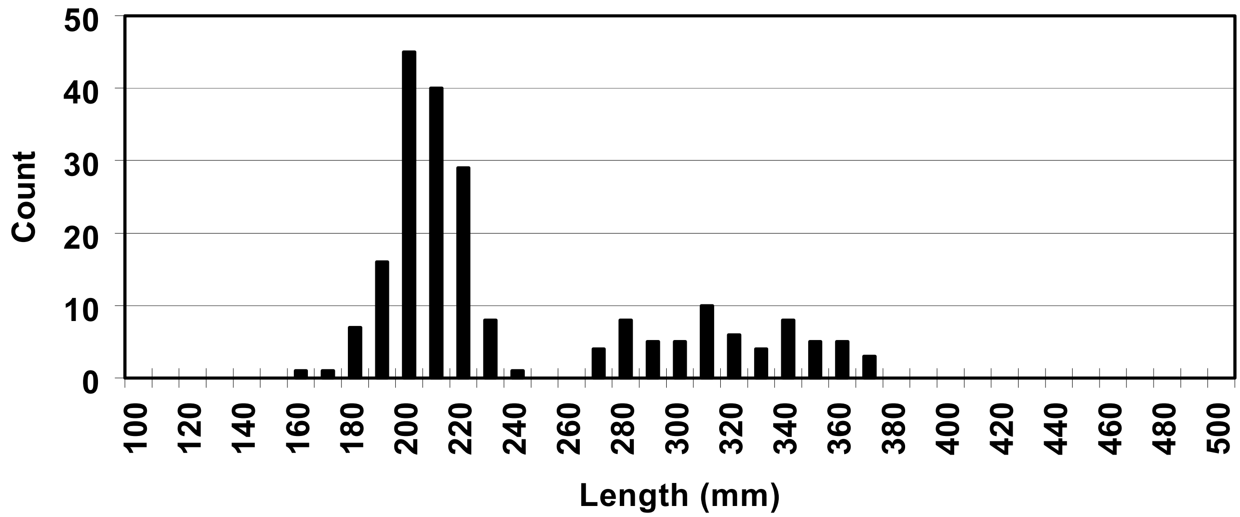

Figure 10.-Length frequency histogram for unique rainbow trout captured during the mark-recapture experiment at Coal Mine #5 Lake, 1998.

Table 6.-Evaluation of size bias during the mark-recapture experiment at Coal Mine #5 Lake, 1998.

	Test 1		Test 2	
	Recaptured	Not Recaptured	Marked	Not Marked
Age/Size Category:				
Age 1 (<250 mm)	6	86	6	56
Age 2+ ($\geq$250 mm)	6	27	6	30
Total Results:	12	113	12	86
χ^2	3.8		1.0	
p-value	0.11		0.49	

Table 7.-Unique rainbow trout captured in Event 1 and Event 2 by age and size category at Coal Mine #5 Lake, 1998.

Age/Size Category	n	p	SE
Age 1 (<250 mm)	148	0.70	0.032
Age 2+ (≥250 mm)	63	0.30	0.030
Total	211		
>350 mm[a]	8	0.04	0.013

[a] Of 211 fish captured, 8 were ≥ 350 mm.

Table 8.-Abundance estimates of rainbow trout in Coal Mine #5 Lake, 1998.

			95% Confidence Limits	
	Abundance	SE	Lower	Upper
Unstratified	958	226	515	1,402
Apportioned:				
Age 1 (<250 mm)	672	29	615	730
Age 2+ (≥250 mm)	286	30	227	344
Total	958			
≥350 mm[a]	36	12	12	60

[a] Of 958 fish captured, 36 were ≥ 350 mm.

RESULTS AND DISCUSSION

Since 1995 we have evaluated the rainbow trout populations in Craig Lake, Coal Mine #5 Lake, and Little Harding Lake every year to evaluate our progress toward providing trophy fisheries. Although the rainbow trout population in Little Harding Lake has not yet achieved our original criteria for success, the number and size of the fish is generally acceptable for most anglers. However, in Craig Lake and Coal Mine #5 Lake there are fewer and smaller fish than we expected. We tried stocking larger fish in these two lakes but we continued to have poor results. Comparison with length frequency histograms from past years (Skaugstad 1997 and 1998) show fish larger than 360 mm disappear from the populations in Craig Lake and Coal Mine #5 Lake. Because these lakes do not produce large fish, we suggest that Craig Lake and Coal Mine #5 Lake be dropped from the trophy rainbow trout program.

Little Harding Lake is now providing a limited number of large (305 to 460 mm) and trophy (460 mm and larger) fish. Anglers have expressed a desire for more large fish in the fishery. To accomplish this objective we will now decrease the number of fish that we stock which is intended to provide fewer but more large fish in the population.

LAKE TEMPERATURE PROFILES

State operated fish hatcheries have recently expanded their capacity for producing catchable rainbow trout (about 100 g or 200 mm). This has provided us with an opportunity to experiment with stocking catchable rainbow trout in lakes that don't usually support fish through winter. Some of these lakes are shallow (< 2 m deep) and freeze to the bottom. Other lakes are deeper and don't freeze to the bottom but when ice-covered they often have dissolved oxygen levels too low (< 1 ppm) to sustain overwintering fish. We considered lakes with such characteristics to be "marginal" because they don't support fish year round. In the past we did not stock these lakes with fingerling or subcatchable size fish because these fish usually did not survive to catchable size. Yet, by stocking marginal lakes with catchable size fish we have created popular summer fisheries along the road system in urban and rural areas. The fishing season for these lakes generally runs from the first part of May when the lakes become ice-free to mid-October when the lakes become ice-covered.

We also have expanded our program to include other marginal lakes that during summer may approach or exceed the upper temperature limits for survival of rainbow trout and other stocked species. For rainbow trout the upper temperature limit (or maximum survivable temperature) is around 25ºC (Hokanson et al. 1977; Bidgood and Berst 1969) while the upper optimum temperature limit is around 18ºC (Raleigh et al. 1984). Higher than optimum temperatures usually have an adverse impact on fish health. These temperatures, however, are not absolute. There are anecdotal reports of rainbow trout surviving up to 28ºC with mechanical aeration. Rainbow trout have also been reared in stagnant ponds where temperatures exceed 26ºC and dissolved oxygen was around 4.5 ppm (Chandrasekaran and Subba Rao 1979). Upper maximum and optimum temperatures probably vary due to local adaptations. If we know that a lake is likely to exceed the maximum temperature or exceed the upper optimum temperature for a significant time then we can alter our stocking method so most fish are stocked and harvested before lethal or optimum temperatures are exceeded. We then restock after the temperatures fall below lethal levels. Generally, lake temperatures in the Tanana Valley are highest from mid June through July. Catchable fish represent a significant investment (about $1.75 per fish) and we want to insure that anglers get the full benefit of this resource.

Some of our popular fisheries are in small (2 to 20 ha) artificial lakes along highways. Most of these lakes were created when gravel was excavated for road or airport construction. Due to their small size and increasing angler use these lakes are quickly fished out. We may need to stock these lakes with catchable size fish two or more times during the summer to meet demand. Information gathered from this study will help us decide which species can be stocked in these small lakes and when stockings can occur.

METHODS

This study is continued from last year. This year we selected three lakes that are typical of several artificial lakes that we stock in the Fairbanks area (Table 9). About 85% of the water volume in each lake is less than 2 m but there is an area that is about 3 m deep in Steese Highway Pond 29.5 and about 4 m deep in Hidden Lake and Steese Pond 34.5 (Table 9).

Table 9.-Characteristics of three lakes sampled in the Tanana River drainage, 1998.

Lake	Surface Area (ha)	Depth (m)	Elevation (m)
Hidden Lake	7.3	4.1	167
Steese Highway Pond 29.5	3.7	3.0	183
Steese Highway Pond 34.5	2.5	4.2	183

Water temperature recordings were made using Hobo and Optic Stowaway temperature data loggers (manufactured by Onset Computer Corporation[3]). A set of data loggers was placed in each lake at the deepest known area. All loggers in a set were attached to a single line. A weight and float were attached to opposite ends of the line. We placed data loggers near the bottom (within 1 m) of all three lakes to determine if a refuge from lethal temperatures existed. Other data loggers were placed at equal distance intervals between the surface and bottom to determine the presence and depth of lethal temperatures (Table 10). Water temperature was recorded every 30 min. Figures 11-13 were generated by plotting the daily maximum temperature.

We used Surfer[4], a computer program, to calculate lake volume above and below specific depths for each lake. Data used for these calculations were obtained during surveys of lake morphology.

RESULTS AND DISCUSSION

No temperature measurements made in the three lakes exceeded the upper maximum temperature for rainbow trout (25ºC; Figures 11-13). However, in Hidden Lake the upper optimal temperature (18ºC) was exceeded in the entire water column for at least 30 consecutive days (Table 11; Figure 11). Based on temperature profiles for the other two lakes, the water temperature for Hidden Lake probably exceed 18ºC for one week prior to placing the data loggers. In Steese Highway Pond 29.5 the upper optimal temperature was exceeded only near the surface (Table 11; Figure 12). Fourteen days was the longest duration above 18ºC. Temperatures for Steese Highway Pond 34.5 did not exceed 17ºC during this study (Table 11; Figure 13). Mid-depth and near-bottom temperatures for both Steese Highway ponds did not exceed 12ºC except on one occasion.

When temperatures were at their highest no portion of Hidden Lake was below the upper optimal temperature for rainbow trout. About 60% of the water volume of Steese Highway Pond 29.5 and all of the water volume of Steese Highway Pond 34.5 did not exceed the upper optimal temperature.

Our data suggest that high summer temperature should not limit rainbow trout survival in our three study lakes. However, rainbow trout will probably be stressed in Hidden Lake because temperatures will be above the optimal limit. Other investigators found that higher than optimal

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[3] Onset Computer Corporation, 536 MacArthur Boulevard. P.O. Box 3450, Pocasset, MA 02559-3450.

[4] Published by Golden Software, Inc.,809 14th Street, Golden Colorado 80401-1866.

temperatures may cause adverse impacts to catch rates and fish health. When temperatures exceed the upper optimal temperature rainbow trout become stressed and catch rates tend to decline with increasing temperature (McMichael and Kaya 1991). Temperature induced stress may also cause increased susceptibility to disease (Roberts 1975).

During summer when water temperature is high, anglers have reported dead fish near favorite fishing locations and fish dying after being released. We have made similar observations when we have used a boat to survey some of the more popular small lakes. Almost all of the dead fish are found only near the more popular fishing sites. These mortalities may be the result of a combination of high water temperature and physical stress caused by catch and release.

Although rainbow trout will tolerate the highest summer temperatures that we measured other species such as Arctic char and lake trout may not survive summer temperatures in Hidden Lake. The upper maximum temperature for two European strains of Arctic char was 24ºC (McCauley 1958). Ultimate upper maximum temperature for lake trout determined experimentally was 23.5ºC (Gibson and Fry 1954). We have stocked Arctic char fingerlings (4 - 8 g) and subcatchables (20 – 60 g) in Hidden Lake in the past but had poor survival. This may be the result of too high water temperatures, competition from other species or predation. We have created successful fisheries in some lakes by stocking catchable Arctic char in May. According to anglers most Arctic char are caught before mid-summer. Only a few are caught the rest of the year. If we are losing fish to high temperatures then we can alter our stocking methods and stock catchable char after mid-August when temperatures are more tolerable. This method may make more Arctic char available from mid-August through mid-June.

Arctic grayling can probably survive the maximum temperatures that we observed in all three lakes. Upper maximum temperature for Arctic grayling, determined experimentally, ranged from 20 to 25ºC (LaPerriere and Carlson 1973). Coho salmon can probably survive in the Steese Highway ponds but not during the summer in Hidden Lake. Upper maximum temperature for coho salmon fry, also determined experimentally, is 25ºC (Brett 1952), similar to that for rainbow trout. However, their optimal temperature is 12 to 14ºC, lower than that for rainbow trout. These fish likely will be extremely stressed during summer and not survive. We stock only fingerling and sub-catchable coho salmon which require 1 to 2 years to grow to catchable size. Therefore, I recommend that coho salmon not be stocked in lakes that have a thermal regime similar to that for Hidden Lake.

The marginal lakes that we stock have potential to provide excellent summer fisheries because they are close to population centers and popular recreation areas. However, because of high summer temperatures we need to consider the biological limits of the candidate species, the lake thermal characteristics, and the extent of possible refuge. With planning we can use marginal lakes to provide additional recreational activity for anglers.

Table 10.-Dates of operation for temperature data loggers at three lakes, 1998.

Lake	Maximum Depth (m)	Date Installed	Date Removed	Depth (m) of Data Logger (from surface)
Hidden Lake	4.1	9 Jul 98	17 Sep 98	1.1
				2.1
				3.4
				4.1
Steese Highway Pond 29.5	3.0	18 Jun 98	17 Sep 98	0.9
				1.8
				2.6
				3.0
Steese Highway Pond 34.5	4.2	18 Jun 98	17 Sep 98	0.8
				2.1
				3.8
				4.2

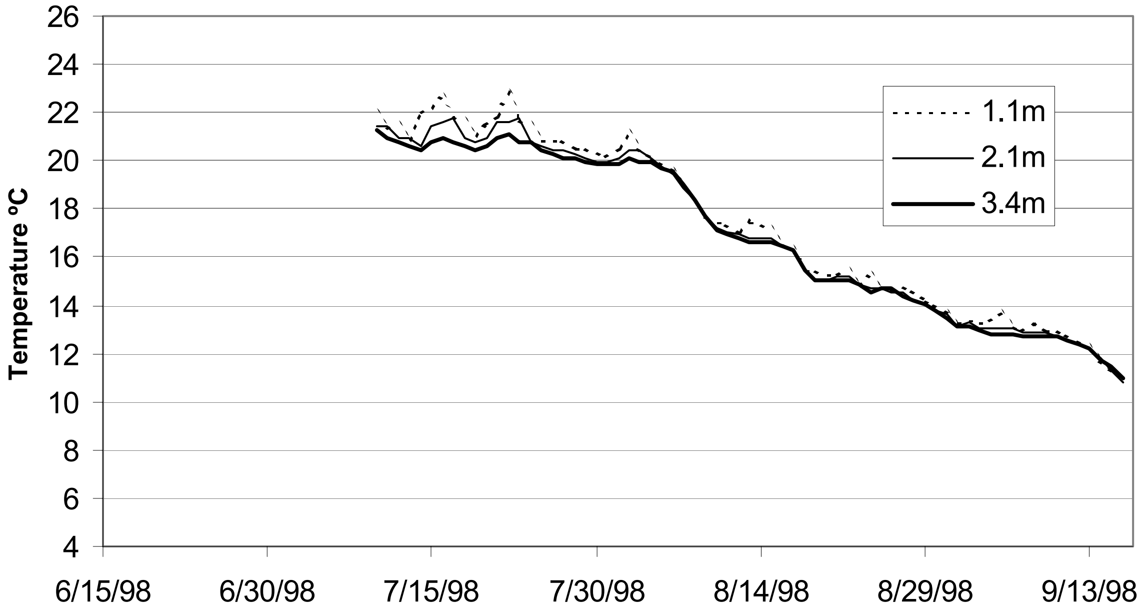

Figure 11.-Temperatures recorded for Hidden Lake, 1998.

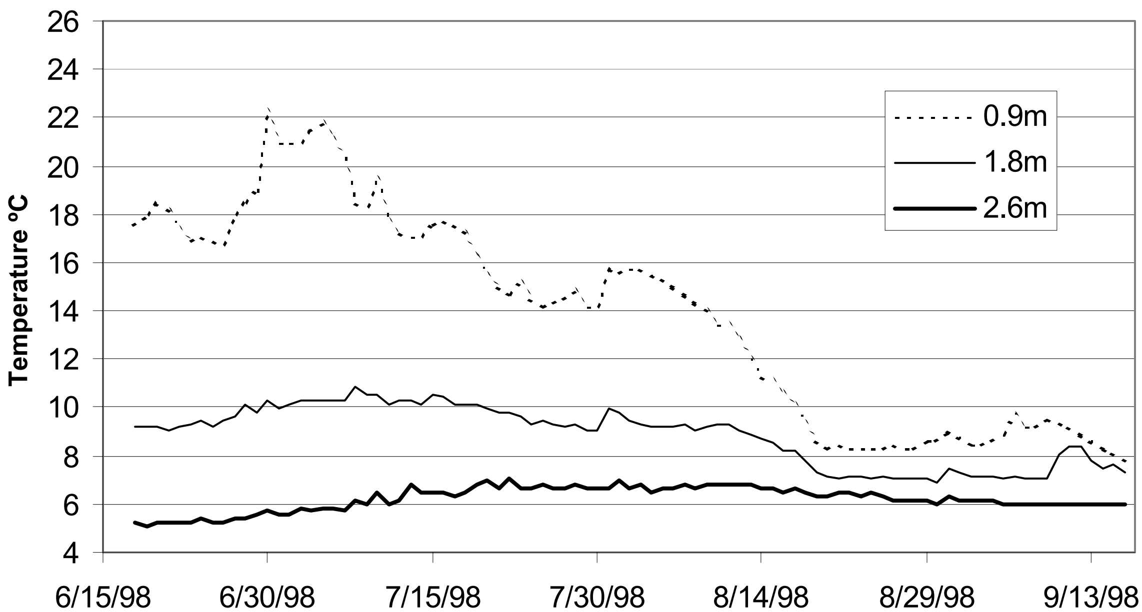

Figure 12.-Temperatures recorded for Steese Highway Pond 29.5, 1998.

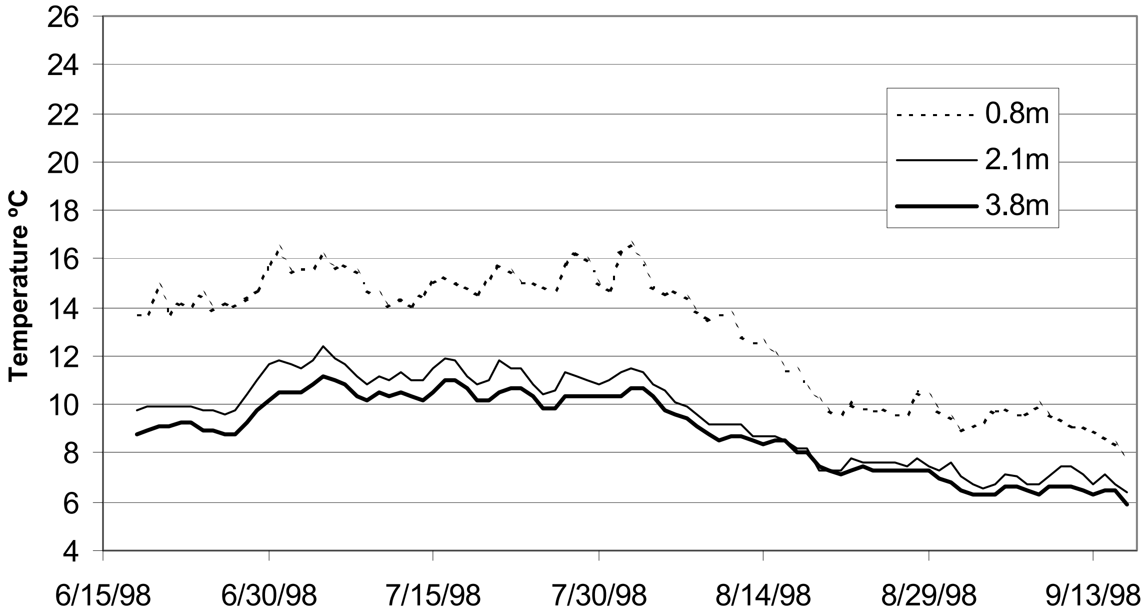

Figure 13.-Temperatures recorded for Steese Highway Pond 34.5, 1998.

Table 11.-Number of days at which water temperature was above "optimum" (18ºC) at three lakes, by depth, 1998.

Lake	Depth (m)	Days
Hidden Lake	1.1	30
	2.1	30
	3.4	30
Steese Highway Pond 29.5	0.9	17
	1.8	0
	2.6	0
Steese Highway Pond 34.5	0.8	0
	2.1	0
	3.8	0

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APPENDIX A

Appendix A.-Stocking history for the Trophy Lakes, 1990-1997.

Location	Species	Stocking Date	Number Stocked	Life Stage[a]	Sex[b]	Weight (g)	Brood Year	Mark[c]
Craig Lake	LT	31-May-91	3,500	F		3.9	90	
Craig Lake	RT	6-Aug-91	4,086	F		2.0	91	
Craig Lake	RT	20-Jul-93	3,500	F		1.6	93	
Craig Lake	RT	14-Jun-94	850	C	AF	70.0	94	
Craig Lake	RT	21-Jun-95	949	S	MF	54.0	94	AD
Craig Lake	RT	10-Jul-96	550	S	MF	66.1	95	RV
Craig Lake	RT	12-Jun 97	390	C	MF	158.5	96	
Craig Lake	RT	12-Jun 97	246	C	AF	87.4	96	
Craig Lake	RT	8-Jul-98	982	C	MF	81.5	97	LV
Coal Mine #5 Lake	LT	29-May-91	2,600	F		3.6	90	
Coal Mine #5 Lake	RT	16-Jul-92	2,600	F		1.6	92	
Coal Mine #5 Lake	AC	1-Jul-93	2,600	F		12.0	92	
Coal Mine #5 Lake	RT	14-Jun-94	750	C	AF	70.0	94	
Coal Mine #5 Lake	RT	21-Jun-95	450	S	MF	54.0	94	AD
Coal Mine #5 Lake	RT	10-Jul-96	450	S	MF	77.1	95	RV
Coal Mine #5 Lake	RT	12-Jun-97	471	C	MF	158.5	96	
Coal Mine #5 Lake	RT	8-Jul-98	546	C	MF	81.5	97	LV
Coal Mine #5 Lake	RT	22-Jul-98	217	C	AF	80.7	97	LV
L Harding Lake	SS	16-Jul-90	3,600	F		2.7	89	
L Harding Lake	RT	24-Jul-90	1,000	F		1.6	90	
L Harding Lake	RT	24-Jul-91	3,600	F		1.8	91	
L Harding Lake	RT	22-Jul-92	11,000	F		1.1	92	
L Harding Lake	SS	21-Jun-93	7,700	F		0.9	92	
L Harding Lake	SS	24-Jun-93	14,300	F		0.8	92	
L Harding Lake	RT	18-May-94	2,838	S		42.0	94	
L Harding Lake	RT	21-Jun-95	1,300	S	MF	54.0	94	AD
L Harding Lake	RT	11-Jul-96	100	B	MF	800.0	93	
L Harding Lake	RT	18-Jul-96	1,750	S	MF	67.0	95	RV
L Harding Lake	RT	8-Jul-97	1,400	S	MF	65.0	96	
L Harding Lake	RT	8-Jul-97	74	B	MF	800.0	94	
L Harding Lake	RT	13-Jul-97	1,497	S	MF	37.2	97	LV

[a] B = broodstock; C = catchable; F = fingerling; S = subcatchable.

[b] AF = All female; MF = male and female.

[c] AD = adipose clip; RV = right ventral clip; and, LV = left ventral clip.

APPENDIX B

Appendix B.-Assumptions necessary for accurate estimation of abundance in a closed population.

The assumptions necessary for accurate estimation of abundance in a closed population are as follows (taken from Seber 1982):

1. the population is closed (no change in the number of rainbow trout in the population during the estimation experiment; i.e. there is no immigration, emigration, births or deaths);
2. all rainbow trout have the same probability of capture in the marking sample or in the recapture sample, or marked and unmarked rainbow trout mix completely between marking and recapture events;
3. marking of rainbow trout does not affect their probability of capture in the recapture sample;
4. rainbow trout do not lose their mark between the marking and recapture events; and,
5. all marked rainbow trout are reported when recovered in the recapture sample.

For assumption 1 no immigration or emigration is assured because the lakes do not have inlets or outlets. The second half of assumption 1 is also assured because rainbow trout do not reproduce in these lakes. If during the study the probability of death is equal for each fish then the abundance estimate is germane to the first event. To minimize the likelihood of higher mortality rates for marked fish, all captured fish were handled carefully and any fish that showed signs of severe stress was marked by excising a small portion of the upper caudal lobe prior to release. Any fish given such a mark was not considered part of the mark-recapture experiment. A hiatus of two weeks was sufficiently long to minimize the effect of previous capture on capture probability as related to assumption 2. Validity of assumptions 2 and 3, relative to sampling induced selectivity of fish, was tested with either Kolmogorov-Smirnov (K-S) or Chi-squared tests generated from length data collected during the marking and recapture events (Appendix C). A length frequency histogram was used to distinguish size classes. The first hypothesis tested was that all marked rainbow trout have the same probability of capture in the recapture sample. Probability of capture usually differs by the size of rainbow trout, especially when a size selective gear is used. Fyke nets should not be size selective, however, they are typically placed near shore in shallow water where part of the population may not frequent. Given this situation the probability of capture will not be the same for all fish. If this test was significant, the recapture sample was biased and the data were partitioned into size classes. Population estimates were generated for each size class and these independent estimates were summed to estimate the abundance of the entire population. If the test does not detect a significant difference, the data were not partitioned and a single population estimate sufficed.

The second hypothesis tested was that rainbow trout captured during the first event had the same length frequency distribution as fish captured in the second event. There were four possible outcomes of these two tests; either one or both of the samples were biased or neither were biased. Possible actions for data analysis are outlined in Appendix C.

-continued-

Assumption 4 was assured because there is not sufficient time for excised tissue to grow back.

Assumption 5 was assured because of rigorous examination of all fish for fin clips.

Complete mixing of marked and unmarked rainbow trout between the first and second events was assumed to be occurring during the experiment. To promote mixing and give each fish an equal chance of being captured there was a two week hiatus between the first and second events (except for Craig Lake) and fish captured in the first event were released towards the middle of the lake.

APPENDIX C

Appendix C.-Methodologies for alleviating bias due to gear selectivity by means of statistical inference.

	Result of first K-S (or χ^2) test[a]	Result of second K-S (or χ^2) test[b]
Case I[c]		
	Fail to reject H_o	Fail to reject H_o
	Inferred cause: There is no size-selectivity during either sampling event.	
Case II[d]		
	Fail to reject H_o	Reject H_o
	Inferred cause: There is no size-selectivity during the second sampling event, but there is during the first sampling event.	
Case III[e]		
	Reject H_o	Fail to reject H_o
	Inferred cause: There is size-selectivity during both sampling events.	
Case IV[f]		
	Reject H_o	Reject H_o
	Inferred cause: There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.	

[a] The first χ^2 test is based on a contingency table to examine the effect of variable catchability of marked fish captured during the second event for various size/age categories. The contingency table is made up of marked fish that are captured and not captured in the second event. H_o for this test is: The probability of capture in the second event for marked fish is constant across the various categories.

or

The first K-S (Kolmogorov-Smirnov) test is on the lengths of fish marked during the first event versus the lengths of fish recaptured during the second event. H_o for this test is: The distribution of lengths of fish sampled during the first event is the same as the distribution of lengths of fish recaptured during the second event.

[b] The second χ^2 test is based on a contingency table to examine the effect of variable catchability in the first event for given size/age categories. The contingency table is made up of marked and unmarked fish captured in the second event. H_o for this test is: The probability of capture in the first event is constant across the various categories.

or

The second K-S test is on the lengths of fish marked during the first event versus the lengths of fish captured during the second event. H_o for this test is: The distribution of lengths of fish sampled during the first event is the same as the distribution of lengths of fish sampled during the second event.

[c] Case I: Calculate one unstratified abundance estimate, and pool lengths and ages from both sampling events for size and age composition estimates.

[d] Case II: Calculate one unstratified abundance estimate, and only use lengths and ages from the second sampling event to estimate size and age composition.

[e] Case III: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Pool lengths and ages from both sampling events and adjust composition estimates for differential capture probabilities.

[f] Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Also calculate a single abundance estimate without stratification.

If stratified and unstratified estimates are dissimilar, discard unstratified estimate and use lengths and ages from second event and adjust these estimates for differential capture probabilities.

If stratified and unstratified estimates are similar, discard estimate with largest variance. Use lengths and ages from first sampling event to directly estimate size and age compositions.

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Testing of assumptions necessary for accurate abundance estimation may also reveal biases in age and size composition samples. Because age and length information are collected during mark-recapture sampling, bias in mark-recapture samples also indicates bias in age and size data that are collected. Age and size composition are used to apportion the population estimate into age classes or size categories, so that age and length information collected during either the marking sample, the recapture sample, or both samples may be used to calculate age and size composition.

If case I is indicated by tests (Appendix B), no adjustments to age and size data are necessary and data from both events may be pooled. If case II occurs, age and size data from the second event must be used to estimate compositions. If the population is closed between sampling events the abundance estimate is germane to both sampling events. For these two scenarios the proportion of fish at age is calculated as:

$$\hat{p}_i = \frac{y_i}{n} \qquad (3)$$

where: $\hat{p}_i$ = the proportion of rainbow trout that are age *i*; y_i = the number of rainbow trout sampled that are age *i*; and, n = the total number of rainbow trout sampled.

The unbiased variance of this proportion is estimated as:

$$\hat{V}[\hat{p}_i] = \frac{\hat{p}_i(1-\hat{p}_i)}{n-1} \qquad (4)$$

Size composition is estimated in a similar manner, replacing age class with the two size categories (less than 355 mm and 355 mm or larger).

If case III or case IV from inference testing occurs, either the first and second events are biased or the second event is unbiased and the status of the first event is unknown. If case III occurs, age and size data from both events can be pooled and adjustments made to these data. If case IV occurs and the partitioned and unpartitioned abundance estimates are dissimilar, age and size data from the second event must be used to estimate compositions. These data must also be adjusted for bias due to size-selectivity. To adjust age and size data, the proportion of fish at age is calculated by summing independent abundances for each age or size class and then dividing by the summed abundances for all age or size classes. First the conditional proportions from the sample are calculated:

$$\hat{p}_{ji} = {n_{ji}}/{n_j} \qquad (5)$$

where: n_j = the number sampled from size class *j* in the mark-recapture experiment; n_{ji} = the number sampled from size class *j* that are age *i*; and, $\hat{p}_{ji}$ = the estimated proportion of age *i* fish in size class *j*. The variance calculation for $\hat{p}_{ji}$ is identical to equation 6 (with appropriate substitutions).

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The estimated abundance of age *i* fish in the population is then:

$$\hat{N}_i = \sum_{j=1}^{s} \hat{p}_{ji} \hat{N}_j \qquad (6)$$

where: N_i = the estimated abundance in size class *j* and s = the number of size classes.

The variance for $\hat{N}_i$ in this case is approximated by the delta method (Seber 1982):

$$\hat{V}\left[\hat{N}_i\right] = \sum_{j=1}^{s} \left(\hat{V}\left[\hat{p}_{ji}\right] \hat{N}_j^2 + V\left[\hat{N}_j\right] \hat{p}_{ji}^2 \right) \qquad (7)$$

The estimated proportion of the population that are age i $(\hat{p}_i)$ is then:

$$\hat{p}_i = \hat{N}_i / \hat{N} \qquad (8)$$

where: $\hat{N} = \sum_{j=1}^{s} \hat{N}_j$

Variance of the estimated proportion can be approximated with the delta method (Seber 1982):

$$\hat{V}\left[\hat{p}_i\right] \approx \sum_{j=1}^{s} \left\{ \left(\frac{\hat{N}_j}{\hat{N}} \right)^2 \hat{V}\left[\hat{p}_i\right] \right\} + \frac{\sum_{j=1}^{s} \left\{ V\left[\hat{N}_j\right] \left(\hat{p}_{ji} - \hat{p}_i\right)^2 \right\}}{\hat{N}^2} \qquad (9)$$

APPENDIX D

Appendix D.-Archive files for data collected during studies covered in this report.

File Name	Description
TROPHY98.XLS	Data sets for fish captured during study of rainbow trout in lakes managed for trophy size fish. Capture locations are Coal Mine #5 Lake, Craig Lake and Little Harding Lake. 1998.
THERMOGRAPHS98.XLS	Data sets collected during study of lake temperature profiles. Lakes in the study are Hidden Lake, Steese Highway Pond 29.5, and Steese Highway Pond 34.5.
U-031900L011998	Data sets for fish sampled during study of rainbow trout emigration from Piledriver Slough, 1998.

Data files are available from the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska, 99518-1599.