

Fishery Data Series No. 92-51

**Estimation of Abundance, Seasonal Distribution, and
Size and Age Composition of Rainbow Trout in the
Kvichak River, Alaska, 1986 to 1991**

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TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES.....	ii
LIST OF FIGURES.....	iii
ABSTRACT.....	1
INTRODUCTION.....	2
METHODS.....	2
Study Site.....	2
Capture Techniques.....	5
Biological Sampling Procedures.....	6
Data Collection.....	6
Copper River.....	6
Kvichak River.....	9
Lower Talarik Creek.....	10
Tazimina River.....	10
Data Analysis.....	11
Spring Abundance in the Kvichak River.....	11
Testing Assumptions.....	12
Distribution of Tags in Lake Iliamna.....	12
Age and Mean Length.....	13
RESULTS.....	14
Spring Samples from the Kvichak River.....	14
Age and Size Composition.....	14
Tag Loss.....	17
Estimation of Abundance, Survival, and Recruitment.....	17
Fall Sampling.....	24
Age and Size Composition.....	24
Seasonal Distribution.....	24
DISCUSSION.....	30
ACKNOWLEDGEMENTS.....	34
LITERATURE CITED.....	34

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1. Sample sizes, mean lengths (mm), and standard errors for rainbow trout sampled in the Lake Iliamna drainage, 1986-1991.....	7
2. Recaptures of tagged rainbow trout released in the Lake Iliamna drainage, 1987-1991.....	15
3. Mean lengths (mm) of rainbow trout, by age group, from beach seine samples collected during the spring from the Kvichak River, 1989-1991.....	16
4. Number of rainbow trout sampled and tagged fish recaptured in the Kvichak River by release, recapture location, and week, spring 1991.....	18
5. Tests for random mixing among sublocations between release and recapture events.....	19
6. Releases and recaptures of rainbow trout in the Kvichak River, 1987-1991.....	20
7. Consecutive recaptures of rainbow trout released in 1988 and 1989.....	22
8. Estimates of abundance for rainbow trout over 250 mm in the Kvichak River, during the spring, 1988-1991.....	25
9. Mean lengths (mm) and weights (g) of rainbow trout, by age group, from samples collected by hook and line from the Copper River, Kvichak River, and Lower Talarik Creek, fall 1990.....	26
10. Mean lengths (mm) and weights (g) of rainbow trout, by age group, from samples collected by hook and line from the Kvichak River and Lower Talarik Creek, fall 1991.....	27
11. Recoveries of tagged rainbow trout caught by recreational anglers in the stream-based fall fisheries of Lake Iliamna, 1987-1990.....	28
12. Recoveries in fall fishery areas in 1990 of rainbow trout released in the Kvichak River in the spring of 1990.....	31
13. Recaptures of rainbow trout tagged in the fall of 1990.....	32

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1. Map of Lake Iliamna.....	3
2. Map of sampling area at Igiugig.....	4
3. Cumulative length distribution at release of rainbow trout recaptured 1 and 2 years after release for fish released in 1988 and 1989.....	21
4. Length frequencies of rainbow trout sampled by location at Igiugig, spring 1990.....	23
5. Map of Lake Iliamna with recaptures of rainbow trout tagged and released at Igiugig in the spring, 1987-1990.....	33

ABSTRACT

A total of 8,317 rainbow trout was captured and sampled at four locations in the Iliamna drainage from 1986 to 1991. Abundance estimates of spawning trout found in the Kvichak River, at the outlet of Lake Iliamna near the village of Igiugig, were derived using the Jolly-Seber estimator and ranged from 2,038 to 4,460 rainbow trout. Estimates of survival ranged from 28% to 30%. Spawning rainbow trout tagged in the Kvichak River were primarily found at the lake outlet during the fall and to a lesser extent, at Lower Talarik Creek. Ages of spawning rainbow trout in the Kvichak River were primarily 5 (19%), 6 (21%), and 7 (20%).

KEY WORDS: Rainbow trout, *Oncorhynchus mykiss*, population abundance, age, length, migration, Lake Iliamna, Kvichak River, Lower Talarik Creek, Tazimina River

INTRODUCTION

The Kvichak River drains an extensive portion of the eastern Bristol Bay watershed including Lake Iliamna, the largest freshwater lake in Alaska, and Lake Clark, found in the northern portion of the drainage (Figure 1). Throughout the Kvichak watershed, with the exception of Lake Clark and its tributaries, rainbow trout *Oncorhynchus mykiss* are found in abundance and significant sport fisheries for them occur in the waters of Lower Talarik, Dream, and Belinda creeks, the Newhalen, Copper, Gibraltar, Iliamna, Tazimina, and Kokhonak rivers, and the Kvichak River at the outlet of Lake Iliamna (Figure 1).

Biological information concerning abundance, age, size, and migration patterns of rainbow trout stocks throughout Bristol Bay is limited to life history and migration studies conducted in the Iliamna (Russell 1977), Naknek (Burger & Gwartney 1986, Gwartney 1985) and Tazimina (Brookover 1990) drainages. A general overview of the status of southwestern Alaska rainbow trout stocks was presented to the Alaska Board of Fisheries in February of 1990 (Minard 1990) and included catch and harvest statistics as well as size and age information. A comprehensive summary of age and size statistics for rainbow trout in Southwest Alaska was recently published (Minard and Dunaway 1991).

In the Kvichak River at the outlet to Lake Iliamna (hereafter referred to simply as the Kvichak River), rainbow trout gather in large numbers each spring during the months of April and May. The spring concentration of fish includes both spawners and nonspawners. By mid-June, they disperse into Lake Iliamna where they spend the summer months before making a fall migration to streams flowing into Lake Iliamna, as well as the Kvichak River. In 1987, staff from the Alaska Department of Fish and Game (ADF&G), Division of Sport Fish, began experimenting with beach seines to determine the feasibility of using that gear type for obtaining samples. Initial results were encouraging: large sample sizes were efficiently obtained using standard seining techniques.

The ability to capture and sample large numbers of fish in the spring presented us with an opportunity to monitor the status of this important population. For the past several years, the primary thrust of our research has been to develop a model which describes the stock structure of this population. Specific project objectives were to estimate the following parameters in the spring concentration of rainbow trout in the Kvichak River: (1) abundance survival and recruitment, (2) age and length composition, and (3) the relative contribution of these fish to the stream-based sport fisheries that occur during the fall (August and September).

METHODS

Study Site

Spring sampling was confined to the Kvichak River from the outlet of Lake Iliamna downstream approximately 8 km (Figure 2). In this section of the Kvichak River the river channel is braided, the bottom is composed of pea gravel, and riparian vegetation consists of low alder and willows. The waters of the Kvichak River in the spring are clear with temperatures ranging from

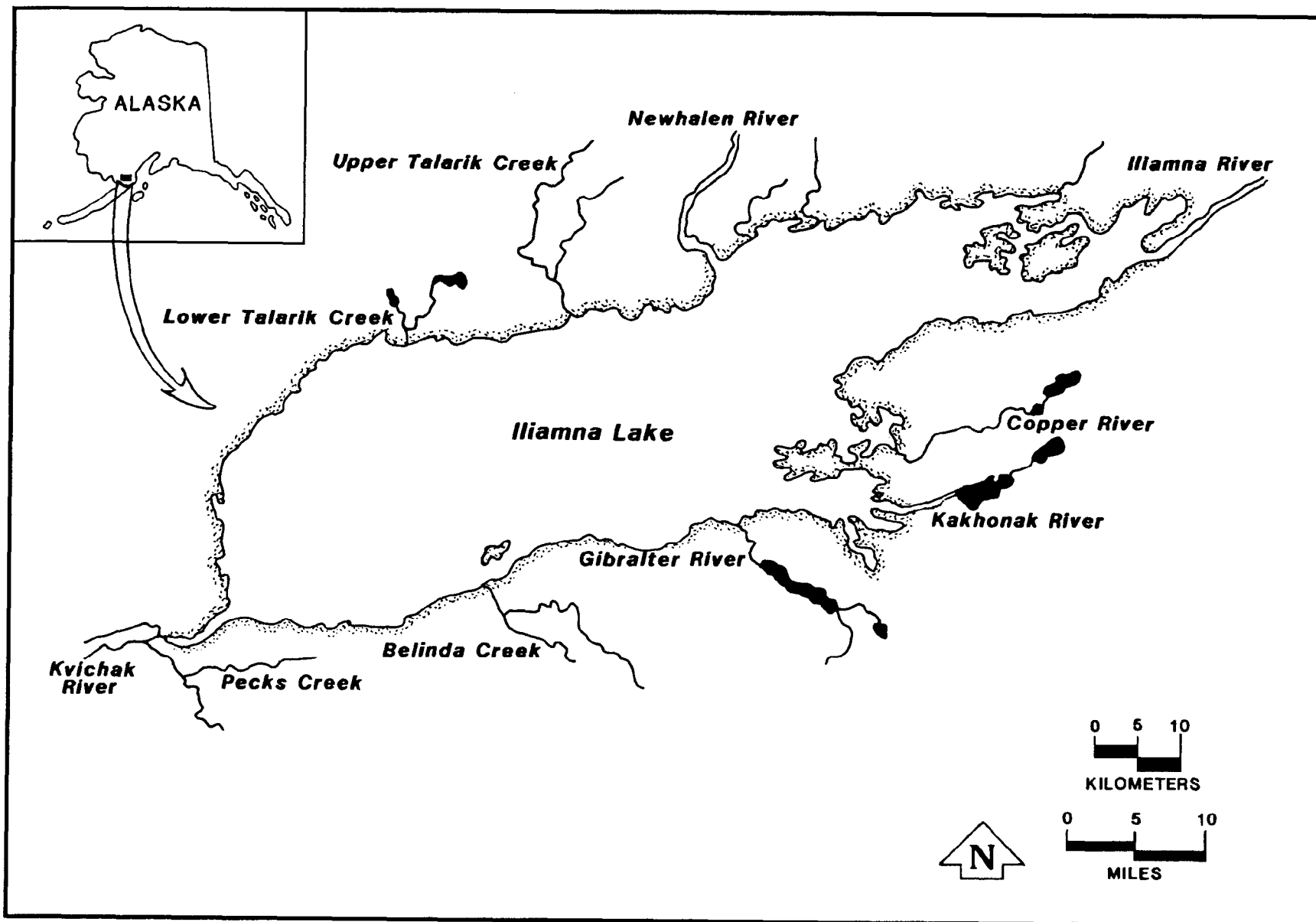


Figure 1. Map of Lake Iliamna.

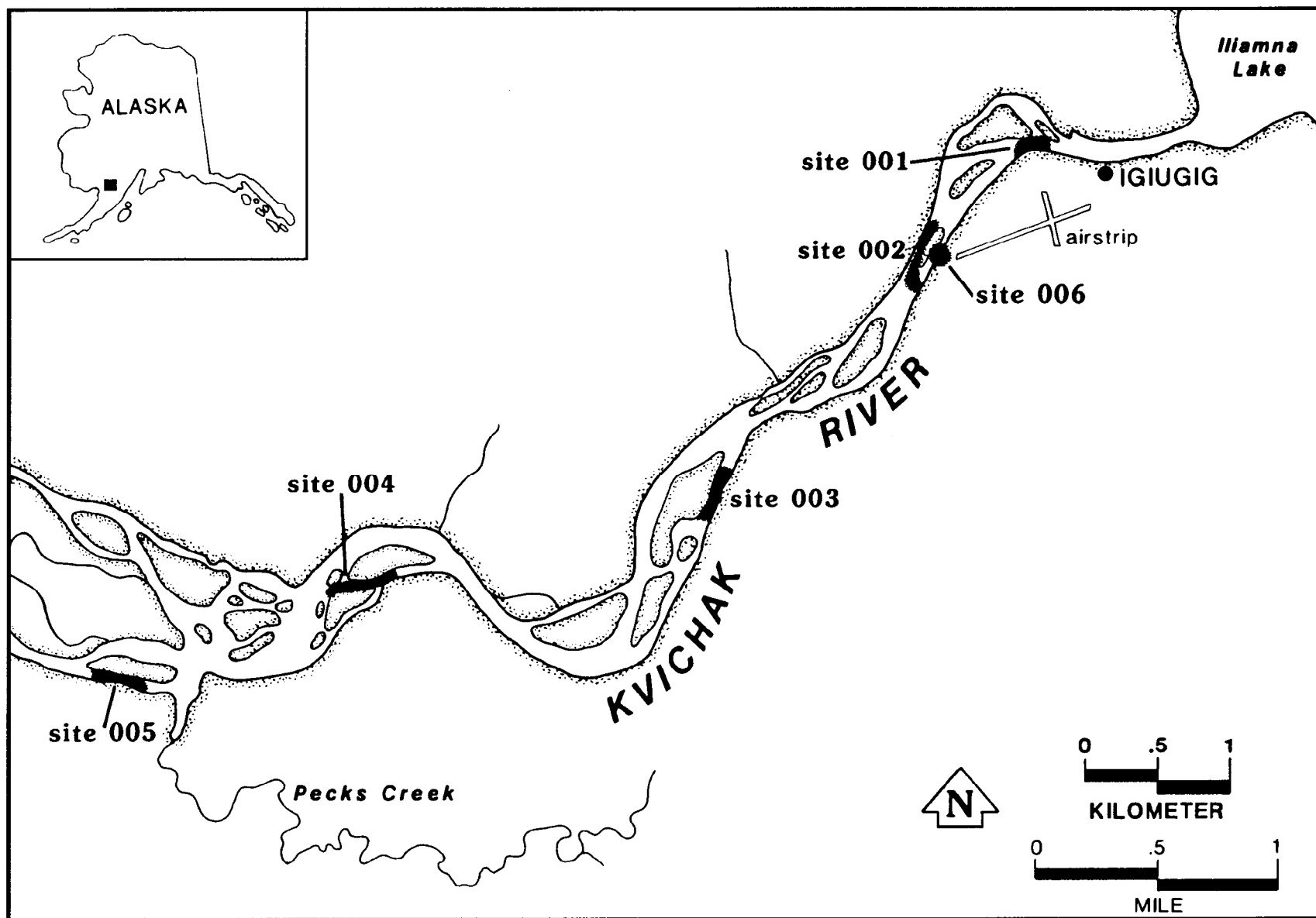


Figure 2. Map of sampling area at Igiugig.

4 to 8 °C. Extensive and repeated aerial surveys indicated that rainbow trout in this section of the Kvichak River concentrated in very specific locations. The study reach was divided into five sublocations for sampling, each of which contained significant numbers of rainbow trout (Figure 2). The five sublocations identified are believed to contain all of the rainbow trout in this river section with the exception of a sixth location that was determined to hold primarily subadult fish. Since the abundance estimate was confined to fish 250 mm in length or greater, the sixth site was abandoned and not sampled consistently.

Fall sampling took place in the same 8 km section of the Kvichak River that was sampled in the spring, however, since fish were more evenly distributed, no sublocations were identified. Additionally, rainbow trout were sampled in Lower Talarik Creek and the Copper River during the fall (Figure 1). Sampling at lower Talarik Creek was confined to the lower 4 km, and in the Copper River took place from the mouth to the falls located approximately 11 km upstream. As part of a previous study, rainbow trout were also sampled in the Tazimina River in 1988 and 1989 (Brookover 1990).

Capture Techniques

Rainbow trout have been sampled for age and size information in the Iliamna drainage since at least 1956 and samples have been collected sporadically since that time (Minard and Dunaway 1991). Samples of rainbow trout collected from the Kvichak River were first obtained in 1964 and were then collected annually until 1971. With the exception of 119 fish measured in 1975, samples were not collected again until 1987. Rainbow trout collected in the 1960s and 1970s were primarily captured using hook and line during the summer months (Minard and Dunaway 1991).

Since 1986, sampling in the Iliamna drainage has been confined to the Kvichak River, Lower Talarik Creek, Copper River, and Tazimina River. Samples were taken during the spring (15 April to 7 June) spawning season and the fall (August and September). Intensity of sampling and gear types employed varied with the season and location.

Since 1986, the most frequently used capture method was sport fishing with hook and line. Department personnel have used hook and line where other techniques such as seining, trapping, and electrofishing have proven unfeasible. A useful spin-off of hook and line sampling is that it allows an estimate of the age and size structure of that segment of the population available for capture by the sport fishery. This attribute makes hook and line sampling useful in describing shifts in size and age distributions of the catch.

Beach seines were used to collect most fish in the spring and a few fish in the fall (Lower Talarik Creek) during this study. The seine consisted of a small mesh (25.4 mm bar) net approximately 45.7 meters long and 0.7 meters deep with no bag. Sets were made in a horseshoe fashion along a suitable section of beach and the net drawn in by hand. Fish encircled in the net were drawn into shallow water near shore. The fish were removed from the net by hand or with the aid of a dip net and placed in a live box for holding before being sampled. Beach seining covers a relatively large area, and substantial catches were made where fish were concentrated in seinable waters (not too swift nor too deep).

Other capture methods including baited hoop traps, dip nets, and minnow traps were tested, but were found to be inefficient and were subsequently abandoned. Because of the physical damage to captured rainbow trout reported by Holmes et al. (1990), electrofishing was not employed.

Biological Sampling Procedures

Sampling of rainbow trout was conducted in a similar fashion between locations and years. All data were recorded on Division of Sport Fish mark-sense forms and/or scale envelopes. Forms were later optically scanned, a procedure that transfers the data from the forms to an electronic data file. In some instances data were entered directly into computer data files from data recorded on scale envelopes, skipping the steps of filling out mark-sense forms and optical scanning.

All captured fish were measured for fork length (from tip of snout to the fork of the tail) which was recorded to the nearest millimeter. Fish that were weighed were placed in a dip net and suspended from a spring scale and the weight recorded to the nearest 10 grams. Each fish was examined for the presence of a tag and the mouth area was examined for hook scars. Sex, if recorded, was determined externally based on head shape, girth-to-length ratio, and presence of ovipositor, eggs, or milt.

Scale smears were collected from nearly all fish sampled, regardless of size, from the left side, halfway between the lateral line and the posterior insertion of the dorsal fin. Four scales per fish were selected from the smear and mounted on gummed cards which were later used to make permanent acetate impressions. The acetate impressions of the scales were enlarged using a microfiche reader and age determined by counting annuli.

All rainbow trout greater than 250 mm fork length were tagged with an individually numbered Floy T-anchor tag. Tags were inserted on the left side near the posterior base of the dorsal fin. Care was exercised to ensure that tags were applied securely. Adipose or left ventral fins of tagged fish were removed as a secondary mark to aid in assessment of tag loss.

Data Collection

Rainbow trout were sampled at the Copper River, the Kvichak River, Lower Talarik Creek, and the Tazimina River (Table 1). The following is a description of those efforts.

Copper River:

Rainbow trout were extensively sampled in the Copper River in the 1970s (Minard and Dunaway 1991), however, little information was collected during the decade preceding this study. During this study, three separate sampling events took place on the Copper River starting in the spring of 1989 when department staff conducted a 2-day float trip to sample spawning rainbow trout and to gain onsite familiarity with the river. In 1989 and 1990, samples were collected from the recreational fishery which occurred in September and October. Only in 1990 were captured rainbow trout tagged.

Table 1. Sample sizes, mean lengths (mm), and standard errors for rainbow trout sampled in the Lake Iliamna drainage, 1986 to 1991.

				All Rainbow Trout			Tagged ^a			Untagged		
				Sample Size ^b	Mean Length	SE	Sample Size ^b	Mean Length	SE	Sample Size ^b	Mean Length	SE
Copper River	89 Spring	(5/19-5/20)	Hook & Line	12	443	15.4	0			12	443	15.4
	89 Fall	(7/13-8/03)	Hook & Line	99	388	7.4	0			99	388	7.4
	90 Fall	(8/24-10/4)	Hook & Line	273	417	6.9	235	436	6.7	38	297	18.0
				384			235			149		
Igiugig	87 Spring	(4/26-4/26)	Beach Seine	102	477	6.8	99	477	7.0	3	481	13.1
	88 Spring	(5/02-5/03)	Beach Seine	542	515	2.7	540	515	2.7	2	396	8.5
	89 Spring	(4/25-5/01)	Beach Seine	662	558	3.1	662	558	3.1	0		
	90 Spring	(4/23-5/03)	Beach Seine	1,287	469	3.7	1,177	491	3.4	110	235	3.2
	90 Fall	(8/16-9/21)	Hook & Line	411	414	5.9	374	425	5.9	37	301	20.6
	91 Spring	(4/22-5/02)	Beach Seine	1,134	494	3.2	1,133	494	3.2	1	515	
	91 Fall	(8/20-10/1)	Hook & Line	530	437	5.2	512	438	5.3	18	384	36.3
			4,668			4,497			170			
Lower Talarik Creek	86 Spring	(4/30-6/15)	Hook & Line	176	440	11.1	0			176	440	11.1
	86 Fall	(8/16-10/08)	Hook & Line	371	373	7.0	0			371	373	7.0
	87 Spring	(4/30-6/07)	Beach Seine	279	448	4.4	23	404	15.2	256	452	4.5
	87 Spring	(4/30-6/07)	Dip Net	51	82	4.1	0			51	82	4.1
	87 Spring	(4/30-6/07)	Hook & Line	178	416	8.3	79	435	10.1	99	401	12.4
	87 Spring	(4/30-6/07)	Found Dead	1	143		0			1	143	
	87 Fall	(6/08-10/09)	Beach Seine	112	424	15.4	88	469	16.3	24	261	12.3
	87 Fall	(6/08-10/09)	Minnow Trap	23	66	2.1	0			23	66	2.1
	87 Fall	(6/08-10/12)	Hook & Line	195	377	10.0	106	441	14.2	89	303	9.1
	87 Fall	(6/08-10/09)	Found Dead	1	298		0			1	298	
	88 Spring	(5/18-5/19)	Beach Seine	248	529	4.7	244	528	4.8	4	569	32.1
	88 Spring	(5/18-5/19)	Hook & Line	10	569	15.0	10	569	15.0	0		
	90 Fall	(9/01-9/20)	Beach Seine	29	436	30.5	21	492	32.1	8	266	6.9
90 Fall	(9/01-9/20)	Hook & Line	316	482	9.5	280	508	9.4	36	270	9.9	
91 Fall	(8/29-9/26)	Hook & Line	500	458	6.3	486	459	6.4	14	398	45.2	
			2,490			1,337			1,153			

-continued-

Table 1. (Page 2 of 2).

				All Rainbow Trout			Tagged ^a			Untagged		
				Sample Size ^b	Mean Length	SE	Sample Size ^b	Mean Length	SE	Sample Size ^b	Mean Length	SE
Tazimina	87 Fall	(7/27-10/4)	Hook & Line	114	464	12.5	84	490	12.3	30	390	29.1
River	87 Fall	(7/27-10/4)	Found Dead	4	634	16.0	0			4	634	16.0
	88 Fall	(6/09-10/03)	Beach Seine	18	329	11.4	17	334	11.2	1	255	
	88 Fall	(6/09-10/03)	Minnow Trap	372	92	1.9	0			372	92	1.9
	88 Fall	(6/09-10/03)	Hook & Line	220	396	8.8	167	437	7.9	53	267	16.9
	88 Fall	(10/03)	Hoop Trap	2	233	12.5	0			2	234	12.5
	89 Fall	(8/21-9/25)	Hook & Line	45	529	13.3	33	569	8.3	12	422	26.2
				775			301			474		
Total				8,317			6,370			1,946		

^a All fish released with tags, including recaptures.

^b Includes a small number of fish that were not measured.

Kvichak River:

In the spring of 1987, department staff first experimented with a beach seine to capture rainbow trout in the mainstem of the Kvichak River at the outlet of Lake Iliamna near Igiugig during a 1-day (26 April) sampling trip. The purpose of the sampling was to test the feasibility of using a beach seine to capture rainbow trout and to collect standard age and size information from the captured fish. Standard beach seining techniques were employed, using a boat and outboard motor with which to set the net, and shorebased personnel to draw it in. All captured trout were sampled, tagged, adipose finclipped and then returned to the water. Results from this initial work were encouraging and in subsequent years the sampling effort was expanded.

In 1988, 2 days (2 May and 3 May) were spent seining and sampling in the same locations sampled the previous year. Sampling objectives were: (1) continued testing of the seining technique, (2) collection of biological information from captured fish, and (3) a reconnaissance to locate all areas where rainbow trout concentrated and were vulnerable to the capture gear. Fixed-wing aircraft were used to spot concentrations of rainbow trout. Multiple seine sets were made at several different locations, and all captured rainbow trout were sampled, tagged, adipose finclipped, and released.

In 1989, sampling was conducted during 5 days, 25-28 April and 1 May. Aerial reconnaissance was conducted on 24 May, and concentrations of rainbow trout marked on a map. Sampling sites located the previous year were seined as were the new areas found by aerial survey. Captured rainbow trout were measured for length, scale samples were collected, and fish ≥ 250 mm were tagged. All tagged fish were given an adipose finclip. Although fish were released at the site of capture, no effort was made to record releases or recaptures by sublocation.

In the spring of 1990 and 1991, sampling efforts were substantially increased to two 5-day sampling trips over a 12-day period (23 April to 4 May). The primary objective was to estimate abundance of rainbow trout at the outlet using standard mark-recapture techniques. At the start of each sampling trip, an aerial survey was flown to determine the number and location of schools of rainbow trout in the Kvichak River. Rainbow trout were then captured using a beach seine as previously described. Sampling occurred in a systematic fashion starting at the downstream end of the study area and working upstream. At least four passes through the study area were made during each sampling trip in an attempt to release tagged fish in an even distribution. Biological data from the catch were recorded as previously described. Fish were released at the site of capture, and the sublocation (Figure 2) of captures and recaptures was recorded.

In addition to sampling in the spring, rainbow trout were captured and tagged in the Kvichak River during the fall (August and September) in 1990 and 1991. The purpose of the fall sampling was to estimate the contribution to the fall fishery of rainbow trout sampled from the Kvichak River during the spring. Ratios of tagged-to-untagged fish were estimated and movements of tagged fish from other locations were recorded to delineate migratory patterns. Hook and line sampling was conducted by department staff using standard sport fishing gear and fishing the same locations and in the same fashion as recreational anglers. Rainbow trout were captured with both hook and line and beach

seines. All captured rainbow trout were sampled for basic biological information as previously described. Weight (to the nearest 10 grams) was measured and all rainbow trout were examined for the presence of a tag and/or adipose finclip. In cases where a tag had been lost as evidenced by an adipose clip but no tag, the condition was noted and the fish again tagged and the new number recorded. Rainbow trout without a tag or finclip were tagged as described above. The number of trout caught each day and the number of recaptures were recorded.

Lower Talarik Creek:

Extensive sampling of rainbow trout was conducted at Lower Talarik Creek from 1964 to 1975 (Minard and Dunaway 1991). However, from 1976 to 1985 little sampling was conducted. In response to concern from sport anglers regarding decreased abundance and size of fish, the department resumed sampling rainbow trout at Lower Talarik Creek in 1986. Activities during 1986 consisted of spring (30 April to 15 June) and fall (16 August to 8 October) samples collected using hook and line. All rainbow trout caught were sampled for age and size information as previously described, but no tags were deployed.

During the spring (30 April to 7 June) and fall (8 June to 9 October) of 1987, sampling continued with a variety of capture gear including hook and line, beach seining, dip nets, and minnow traps. Hook and line and beach seining proved to be the most effective methods of capture. All captured rainbow trout were sampled as previously described and those ≥ 250 mm in length were tagged with numbered Floy T-anchor tags.

In 1988, sampling was confined to a 2-day (18 May to 19 May) sampling trip in the spring. The purpose of the sampling was again to collect age and size information concerning this stock. Beach seines and hook and line were the primary capture gear. All fish ≥ 250 mm were tagged and all fish were sampled for standard age and size information.

No sampling occurred again until the fall of 1990. From 1 September to 20 September, rainbow trout were captured for sampling and tagging using hook and line and a beach seine. The purpose of the fall sampling program was to estimate the number of spring spawners from the Kvichak River that later appear in the fall sport fisheries around the lake, and to define migratory patterns between sampled locations. A target sample size of 300 rainbow trout was established and all captured rainbow trout were sampled for biological information as previously described. All rainbow trout were examined for the presence of tags and finclips. In the case where the tag had been lost as evidenced by a finclip but no tag, the condition was noted and a new tag attached to the fish and the new number recorded. The number of rainbow trout caught each day and the number of recaptures were recorded.

Tazimina River:

From 1987 to 1989, ADF&G Division of Sport Fish was involved in a cooperative study with the National Park Service (NPS) concerning rainbow trout and the recreational fishery in the Tazimina River (Brookover 1990). A variety of capture methods was used but hook and line once again proved the most effective. All rainbow trout ≥ 250 mm in length were tagged and finclipped to prevent double sampling and to help assess tag loss. The purpose of the study

was to estimate the current age and size structure of rainbow trout in the Tazimina River, and to assess their seasonal movements and distribution. Additionally, 40 rainbow trout were surgically implanted with transmitters in the fall of 1989. These fish were tracked by NPS personnel throughout the winter, and overwintering areas were identified (H. Twitchell, National Park Service, personal communication).

Data Analysis

Spring Abundance in the Kvichak River:

Abundance of rainbow trout in the spring concentration in the Kvichak River was estimated using the Jolly-Seber estimator (Seber 1982, Buckland 1980) where each year represents one sample in the analysis. Abundance, N , in the i th sample was estimated by:

$$\hat{N}_i = \left[\frac{n_i M_i}{m_i} \right]; \quad (1)$$

where:

$$\hat{M}_i = \frac{R_i z_i}{r_i} + m_i; \quad (2)$$

and:

- n_i = total number of fish captured in sample i ,
- R_i = number of tags (new and old) released in sample i ,
- r_i = total recoveries from release i in all future samples,
- z_i = recoveries of fish seen before sample i , not seen in sample i , but seen after sample i , and
- m_i = total number of tags from all releases recovered in sample i .

Survival, ϕ , from time i to time $i+1$ was:

$$\hat{\phi}_i = \frac{\hat{M}_{i+1}}{M_i - m_i + R_i}. \quad (3)$$

The recruitment, B_i , from time i to time $i+1$, was estimated by:

$$\hat{B}_i = N_{i+1} - \hat{\phi}_i \{N_i - n_i + R_i\}. \quad (4)$$

The variances were estimated using methods described by Seber (1982, pages 202-204).

Assumptions of the Jolly-Seber estimator are:

1. every animal in the population has the same probability of being caught in the i th sample, given that it is alive and in the population at time i , or complete mixing occurs between events;
2. every animal has the same probability, S_i , of surviving from the i th to the $(i+1)$ th sample and of being in the population at time $i+1$ given that it is alive at time i ;
3. every animal caught in the i th sample has the same probability of being returned to the population;
4. there is no tag loss, and all tags recovered are reported.

Testing Assumptions:

The concentration of rainbow trout in the Kvichak River was assumed to be of spawning fish that would return annually. If all members of the population were not equally available to the sampling gear (assumption number 1), the Jolly-Seber estimator would still be valid as long as marked fish mixed randomly between years (Seber 1982). The rainbow trout at Igiugig were found to migrate among sample areas, immigration and emigration were occurring during the period of sampling, and many areas could not be sampled. However, with the assumption that trout with tags mix completely with untagged trout over the next year, the second part of assumption 1 is met.

The null hypothesis that recaptures from 1988-1990 releases in subsequent years were independent of date or location of release was tested using chi-square statistics.

Distribution of Tags in Lake Iliamna:

Three fall fishery areas were sampled for tags: (1) Kvichak River, (2) Lower Talarik Creek, and (3) Copper River. The proportion (p_k) of trout tagged in the spring in the Kvichak River that was present in each fall fishery area and, conversely, the proportion tagged in each fall fishery that was recaptured in the spring in the Kvichak River were estimated by:

$$p_{k,i} = \frac{m_{k,i}}{n_i}, \quad (5)$$

where:

- $p_{k,i}$ = the proportion tagged at location k that are recaptured at location i ,
- $m_{k,i}$ = the number of fish tagged in location k that were recaptured in location i , and
- n_i = the number of fish sampled in location i .

A chi-square test of independence was used to test the hypothesis that there was no significant difference between the proportion of tags recovered in the fall fisheries.

The odds of a sampled trout being a tagged fish from spring sampling at Igiugig in any recovery location was the ratio of tagged to untagged fish in the sample (Agresti 1990):

$$O_k = \frac{R_k}{U_k} , \quad (6)$$

where:

R_k = number of tagged fish at area k,

U_k = number of untagged fish at area k = $N_k - R_k$,

and the ratio of these odds for two fishery areas (the odds ratio) was:

$$\theta_{I,K} = \frac{O_I}{O_k} , \quad (7)$$

where:

O_I = odds of a tag recovery during sampling in the Kvichak River during the fall fishery, and

O_k = odds of a tag recovery during sampling at Lower Talarik Creek or Copper River.

This odds ratio, $\theta_{I,K}$, is an estimate of how much more likely one was to find a tagged fish in the Kvichak River in the fall than at another fishery. If the odds ratio was equal to one, then the chances of encountering a tagged fish from the Kvichak River spring sampling were equal in both areas and fish tagged in the Kvichak River in the spring distributed evenly over the summer and fall. If the odds ratio was larger than one, then the chances were higher of finding a tagged fish in the Kvichak River and the trout were not distributed evenly.

The variance of the exponential log of $\theta_{I,K}$ was estimated by (Agresti 1990);

$$\sigma^2[\log(\theta_{I,K})] = (1/R_I + 1/U_I + 1/R_k + 1/U_k) , \quad (8)$$

and the 95% confidence interval of $\theta_{I,K}$ was estimated by:

$$e^{[\log(\theta_{I,K})]} \pm e^{[z\alpha/2 \sigma \log(\theta_{I,K})]} . \quad (9)$$

Age and Mean Length:

Mean length and mean length-at-age and their variances were estimated for each sampling event using normal procedures. The proportion for each age class (p_i) was estimated as a binomial proportion:

$$p_i = \frac{n_i}{n_t}, \quad (10)$$

where:

n_i = number of trout at age i ,

n_t = total number of trout sampled,

and its variance by:

$$\text{Var}(p_i) = \frac{p_i(1-p_i)}{n_t-1}. \quad (11)$$

RESULTS

A total of 8,317 rainbow trout were captured in 6 years of sampling (1986-1991) at four locations in the Iliamna drainage (Table 1). Over this period a total of 6,371 fish were released with tags. Most of the samples (4,668) were collected from the Kvichak River. An additional 2,490 samples were collected from Lower Talarik Creek, 775 collected from the Tazimina River, and 384 from the Copper River (Table 1).

During the 4-year period 1988-1991, a total of 666 tagged trout were recaptured during ADF&G sampling events (Table 2). A total of 587 tagged fish was recaptured during spring sampling in the Kvichak River, and 68 rainbow trout were recaptured during sampling in fall fishery areas. In addition, a total of 186 tags have been returned by the public.

Age and size summaries for rainbow trout sampled during the period 1986 to 1989 have already been reported by Minard and Dunaway (1991). Presentation of results in this report focuses on estimation of size and age composition since 1989, and estimation of abundance, and seasonal distribution of the spring concentration of rainbow trout in the Kvichak River.

Spring Samples from the Kvichak River

Age and Size Composition:

In the spring of 1989, a total of 658 rainbow trout was captured and sampled for length from the Kvichak River of which 444 were aged using scales (Table 3). The estimated mean length was 558 millimeters (SE = 3.13). Ages, based on numbers of scale annuli, ranged from 4 to 14 with the predominant age groups being age 6 (11.9%), age 7 (25.0%), age 8 (26.8%) and age 9 (19.6%).

In 1990, 1,291 rainbow trout were sampled for length. Estimated mean length was 470 millimeters (SE = 3.72) (Table 3). Age composition differed from samples taken in 1989, with more small, young fish present in the 1990 samples. Ages, again based on the number of scale annuli, ranged from 2 to 10 with the predominant ages being age 4 (15.6%), age 5 (25.0%), age 6 (21.7%), and age 7 (17.5%) (Table 3).

Table 2. Recaptures^a of tagged rainbow trout released in the Lake Iliamna drainage, 1987-1991.

Location			Recapture Site											Total
			(Number ≥ 250 mm Examined)											
			Copper River		Igiugig					Lower Talarik			Tazimina	
Number Released with Tags		Fall 1990 (249)	Spring 1987 (102)	Spring 1988 (542)	Spring 1989 (662)	Spring 1990 (1,178)	Fall 1990 (399)	Spring 1991 (1,134)	Fall 1991 (529)	Spring 1988 (258)	Fall 1990 (335)	Fall 1991 (502)	Fall 1988 (203)	
Copper River	235	Fall 1990	2					0	0	0	0	0	0	2
Igiugig	99	Spring 1987	0	0	7	2	0	0	0	0	0	0	0	9
	540	Spring 1988	0		2	33	11	1	2	0	0	1	0	50
	662	Spring 1989	0			78	58	3	11	0	0	0	0	150
	1,177	Spring 1990	0				151	0	61	1	4	1		218
	374	Fall 1990	0					3	7	6	0	1		17
	1,133	Spring 1991							149	6		5		160
	512	Fall 1991								1		0		1
Lower Talarik	102	Spring 1987	0		0	0	0	0	0	0	4	0	0	4
Creek	194	Fall 1987	0		0	0	0	0	0	0	1	1	0	2
	254	Spring 1988	0			2	0	0	0	0	2	1	0	5
	301	Fall 1990	0					0	2	0	10	4		16
	486	Fall 1991								0		5		5
Tazimina	84	Fall 1987	0		0	0	0	0	0	0	0	0	10	10
River	184	Fall 1988	0			0	0	0	0	0	0	0	17	17
	33	Fall 1989	0				0	0	0	0	0	0		0
Total	6,370		2	0	9	115	220	7	232	14	5	18	17	666

^a Does not include multiple recaptures of tagged fish within same sampling period and location.

Table 3. Mean lengths (mm) of rainbow trout, by age group, from beach seine samples collected during the spring from the Kvichak River, 1989-1991.

	Age Group													
	Unknown	2	3	4	5	6	7	8	9	10	11	12	14	Total
1989														
n (Known Age)				1	13	53	111	119	87	38	18	3	1	444
Percent				0.2	2.9	11.9	25.0	26.8	19.6	8.6	4.1	0.7	0.2	100.0
SE				0.00	0.01	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.00	
Mean Length	545			271	437	498	549	581	595	597	622	673	735	558
SE	6.04				15.19	7.01	5.21	5.76	6.87	12.85	16.92	8.72		3.13
Sample Size	218			1	13	53	110	117	86	38	18	3	1	658
1990														
n (Known Age)		6	83	164	263	228	184	88	29	5				1,050
Percent		0.6	7.9	15.6	25.0	21.7	17.5	8.4	2.8	0.5				100.0
SE		0.23	0.83	1.12	1.34	1.27	1.17	0.86	0.51	0.21				
Mean Length	414	246	290	377	446	516	592	621	627	681				470
SE	10.39	15.05	6.59	5.67	4.14	5.25	5.37	6.35	11.93	27.46				3.72
Sample Size	244	6	83	163	262	228	184	87	29	5				1291
1991														
n (Known Age)				11	91	128	93	42	34	20	8	1		428
Percent				2.6	21.3	29.9	21.7	9.8	7.9	4.7	1.9	0.2		100.0
SE				0.77	1.98	2.22	2.00	1.44	1.31	1.02	0.66	0.23		
Mean Length	494			380	413	448	487	566	631	669	671	677		492
SE	3.68			12.75	6.10	5.90	7.22	11.96	12.20	16.16	37.68			2.98
Sample Size	848			11	91	128	90	42	34	20	8	1		1,273

In 1991, 1,273 rainbow trout were measured for length and the mean length was estimated at 492 mm (SE = 2.98); ages ranged from 4 to 12, with age 5 (21.3%), age 6 (29.9%), and age 7 (21.7%) being dominant (Table 3).

Tag Loss:

Since all rainbow trout tagged in the Kvichak River received a finclip as a secondary mark, the number of recaptured fish which had lost tags was observed. Tag loss over all years ranged from a low of 0.0% in 1986 and 1987 to a high of 0.0012% in 1990. At this level tag loss was considered negligible and therefore, adjustment to the abundance estimation procedure was not considered necessary.

Estimation of Abundance, Survival, and Recruitment:

To determine if the Jolly-Seber model was a valid estimator, we tested the assumption that fish mixed randomly between years. In the spring of 1991, a total of 1,283 individual rainbow trout was captured from the Kvichak River over a period of 2 weeks in four locations. Most recaptures of tagged rainbow trout released in 1991 were from the location of initial release (Table 4). However, there was movement within the sampling area as releases from all sublocations were recovered in at least one other sublocation (Table 4). The assumption of random mixing of fish in all recapture areas between years was tested by comparing the distribution of recaptured rainbow trout among sublocations in 1991 using a chi-square test. The null hypothesis that there was no difference in recapture rates between areas was not rejected for rainbow trout released in 1989 or in 1990 (Table 5).

We also examined whether fish annually returned to the Kvichak River to spawn. Since 1987, the rate of tag recovery has consistently been much higher in the year following release compared to later years (Table 6). In 1987, 99 rainbow trout were tagged and released in the Kvichak River during the spring sampling event. Seven of these fish were recaptured in 1988 and 2 in 1989 (Table 6). In 1988, 540 rainbow trout were tagged and released, 33 of these were recaptured in 1989, 11 in 1990, and 2 in 1991. In 1989, 662 rainbow trout were released; of these 58 were recaptured in 1990, and 11 in 1991. In 1990, 1,011 rainbow trout were tagged and released in sublocations 1-5; of these, 54 were recaptured in 1991. There was no significant difference in size at release of fish released in 1988 ($D = 0.14$, $p = 0.96$) or 1989 ($D = 0.26$, $p = 0.14$) that were recovered 1 or 2 years later (Figure 3). Nine rainbow trout have been recaptured multiple times, i.e. recaptured in 3 consecutive years (Table 7). In 1988, 540 tagged fish were released and 33 (6.1%) were recaptured in 1989; of these 33 trout, 4 (12.1%) were recaptured in 1990. Similarly, in 1989, 662 tagged fish were released and 58 (8.8%) recaptured in 1990, and of these, 5 (8.6%) were taken again in 1991. These patterns of recovery indicate that at least a portion of the population consistently returned to the spawning grounds in consecutive years during the study period.

Rainbow trout sampled in location 6 in 1990 were smaller than those sampled at other locations in 1990 and in other years (Figure 4). These fish were probably immature and represent a portion of the population not sampled in other years. Because samples from site 6 were atypical, we chose to exclude those fish from the population estimate.

Table 4. Number of rainbow trout sampled and tagged fish recaptured in the Kvichak River by release, recapture location, and week^a, spring 1991.

Rel. Year	Release Subloc.	Release Season	Rel. Week	1991 Sublocation Recaptured						Total		
				2		3		4			5	
				Week 1	Week 2	Week 1	Week 2	Week 1	Week 2		Week 1	Week 2
Igiugig:												
1988		Spring		0	1	0	0	1	0	2		
1989		Spring		0	7	6	2	1	1	17		
1990	2	Spring		1	7	7	5	0	5	25		
	3	Spring		0	2	2	0	0	1	5		
	4	Spring		0	4	8	12	0	9	33		
	6	Spring		3	2	1	3	0	0	9		
		Total Spring '90		4	15	18	20	0	15	72		
1990		Fall		0	2	0	5	0	0	7		
1991	2	Spring	1	4	6	5	1	0	0	16		
	3	Spring	1	3	42	28	4	0	2	79		
	3	Spring	2	0	0	10	0	0	0	10		
	4	Spring	1	0	2	5	24	0	8	39		
	5	Spring	1	0	1	0	0	0	1	2		
	5	Spring	2	0	0	1	0	0	2	3		
		Total Spring '91		7	51	49	29	0	13	149		
Lower Talarik:												
1990		Fall		0	2	1	0	0	0	3		
		Total Number Recaptured		11	78	74	56	2	29	250		
		Total Number Sampled		121	356	155	400	27	224	1,283		

^a Includes multiple recaptures of tagged fish.

Table 5. Tests for random mixing among sublocations between release and recapture events.

H₀: There is no difference in recapture rates by recovery location.

	Sublocation During 1991 Recapture Event		
	2 & 3	4	5
Total captured, 1991	525	371	238
Marked 1989	11	2	3
Not marked 1989	514	369	235
$\chi^2 = 3.83, df = 2, p = 0.147$			
Marked sublocation 2, 1990	13	4	3
Not marked sublocation 2, 1990	512	367	235
$\chi^2 = 2.89, df = 2, p = 0.235$			
Marked sublocations 3 & 4, 1990	12	12	10
Not marked sublocation 3 & 4, 1990	513	359	228
$\chi^2 = 2.17, df = 2, p = 0.337$			
Marked in all sublocations, 1990	30	18	13
Not marked 1990	495	353	225
$\chi^2 = 0.32, df = 2, p = 0.851$			

H₀: There is no difference in recapture rates by release location.

1990 Release Location	Not Recaptured 1991	Recaptured 1991
Sublocation 2	406	20
Sublocation 3 & 4	546	34
Sublocation 6	159	7
$\chi^2 = 1.06, df = 2, p = 0.588$		

Table 6. Releases and recaptures of rainbow trout in the Kvichak River, 1987-1991

Release ^a		Recoveries ^b						
Year	Number	1987	1988	1989	1990	1991	Total	%
All fish \geq 250 mm								
1987	99		7	2	0	0	9	9.1%
1988	540			33	11 ^c	2	46	8.5%
1989	662				58	11 ^d	69	10.4%
1990	1,011 ^e					54	54	5.3%
1991	1,133							
Total Caught		102	542	662	1,012 ^e	1,134		

^a All unique releases of tagged fish, including those recaptured from previous years.

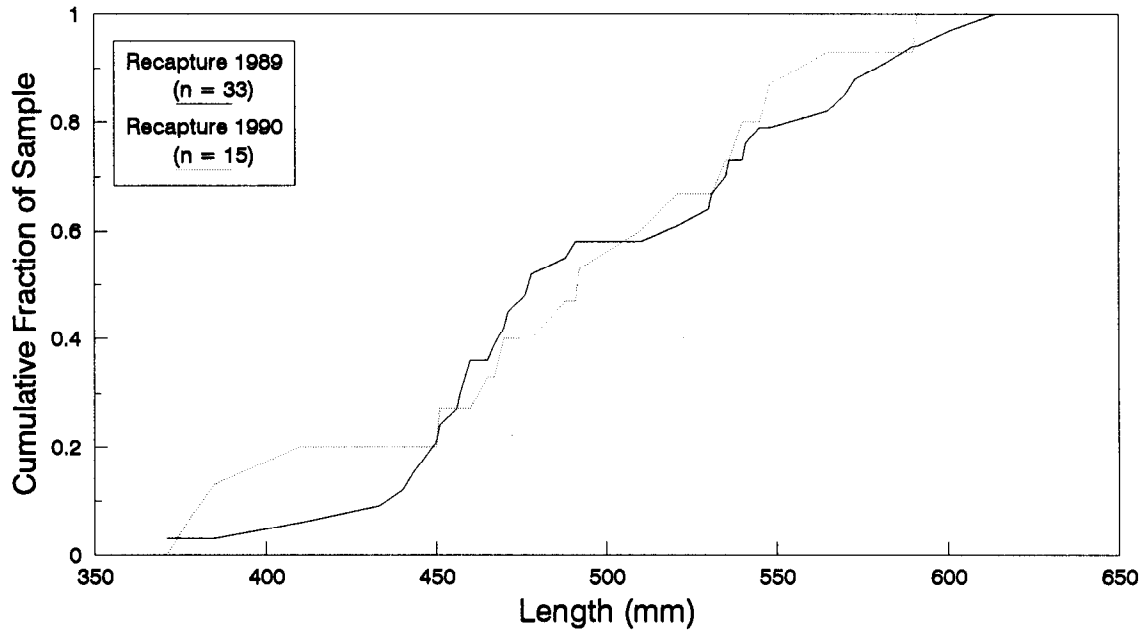
^b Includes only unique recoveries of tagged fish in each year.

^c Four fish that were released in 1988 were caught in 1989, and again in 1990. In 1990 these fish are considered to be recaptures from 1989, not from 1988, and so are not included here.

^d Five fish that were released in 1989 were caught in 1990, and again in 1991. In 1991, these fish are considered to be recaptures from 1990, not from 1989, and so are not included here.

^e Does not include 166 fish captured and released at sublocation 6.

Released in 1988



Released in 1989

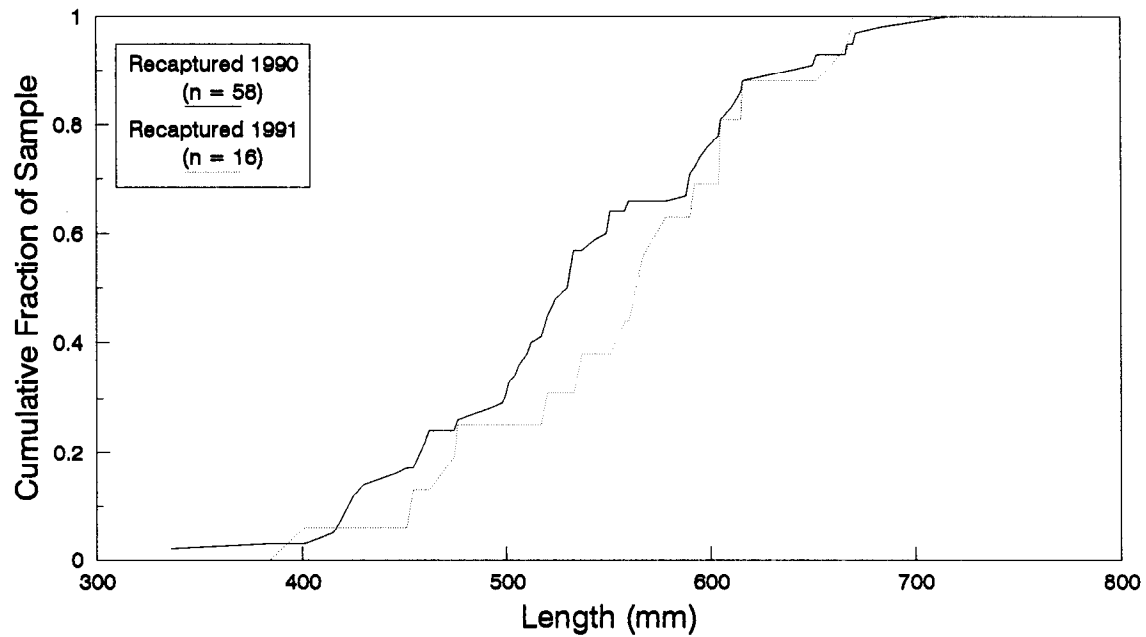


Figure 3. Cumulative length distribution at release of rainbow trout recaptured 1 and 2 years after release for fish released in 1988 and 1989.

Table 7. Consecutive recaptures of rainbow trout released in 1988 and 1989.^a

	1988	1989	1990	1991
Sample sizes	542	662	1,012	1,134
1988 release				
Consecutive recaptures	540	33	4	
% of previous year		6.1%	12.1%	
1989 release				
Consecutive recaptures		662	58	5
% of previous year			8.8%	8.6%

^a Does not include fish captured in sublocation 6 in 1990.

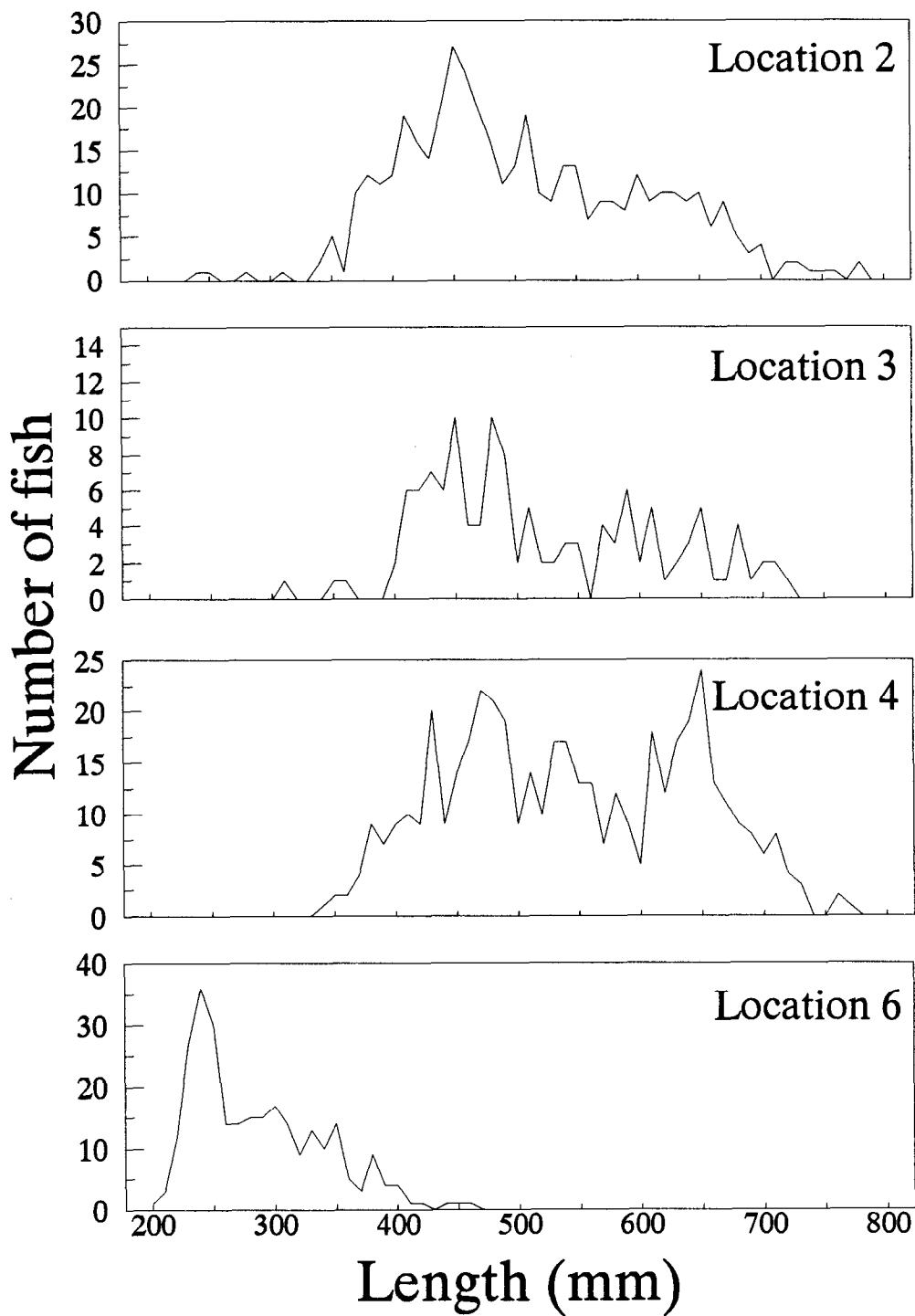


Figure 4. Length frequencies of rainbow trout sampled by location at Igiugig, spring 1990.

Survival, abundance and recruitment of rainbow trout ≥ 250 mm were estimated from this data series (Table 8). The abundance was estimated to be 2,037 (SE = 1,251) in 1988, 2,912 (SE = 775) in 1989, and 4,460 (SE = 1,141) in 1991. Recruitment into the area was estimated at 2,341 (SE = 954) in 1988, and 3,319 (SE = 953) in 1989. Survival from 1987 to 1988 was estimated at 30.3% (SE = 16.9%), from 1988 to 1989 at 28.1% (SE = 6.6%), and from 1989 to 1990 at 39.2% (SE = 9.5%).

Fall Sampling

Age and Size Composition:

In the fall of 1990, 275 rainbow trout were captured in the Copper River using hook and line and sampled for age and size information (Table 9). Mean length was 418 millimeters (SE = 6.91, n = 275) and mean weight was 1,366 g (SE = 64.34, n = 245). Ages ranged from 2 to 9 years with the dominant age groups being 3 (24.3%), 4 (23.8%), 5 (19.7%), and 6 (15.9%) years. Sampling was not conducted in the Copper River in 1992.

A total of 414 rainbow trout were captured and sampled from the Kvichak River in the fall of 1990 (Table 9). Mean length was 414 mm (SE = 5.9) and mean weight was 1,311 g (SE = 64.23, n = 329) (Table 10). Ages ranged from 2 to 10 years and were determined from 387 readable scale samples. Dominant age groups were 3 (14.7%), 4 (24.5%), 5 (22.2%), and 6 (16.3%) years. A total of 530 rainbow trout were captured by hook and line from the Kvichak River and measured for length in 1991 (Table 10). Mean length was 437 mm (SE = 5.22) and mean weight was 1,349 g (SE = 53.26, n = 521). Ages ranged from 2 to 10 years, with age 4 (22.9%), age 5 (27.5%), and age 6 (21.7%) fish dominating.

Fall sampling in 1990 at Lower Talarik Creek resulted in the capture of 320 rainbow trout using hook and line (Table 9). Mean length was 486 mm (SE = 9.38, n = 320). A reliable estimate of mean weight was not possible due to insufficient sample size. Ages ranged from 2 to 10 years with dominant age groups being age 3 (13.7%), age 4 (24.3%), age 5 (11.6%), age 6 (15.5%), age 7 (15.8%), and age 8 (13.4%). In 1991, 500 rainbow trout were captured by hook and line from Lower Talarik Creek and measured for length (Table 10). Mean length and weight were 458 mm (SE = 6.30) and 1,647 g (SE = 65.08, n = 489), respectively. Dominant ages were age 4 (20.4%), age 5 (26.6%), age 6 (21.2%), and age 7 (17.0%).

Seasonal Distribution:

From 1987 to 1991, 6,371 rainbow trout were tagged in the Iliamna drainage. Sport anglers voluntarily reported catching 186 of these tagged fish in the stream-based fall fisheries (Table 11). Most of the recaptures of fish tagged in the Kvichak River in the spring were taken in the fall in the Kvichak River. However, some tagged fish were also recaptured at Lower Talarik Creek, Upper Talarik Creek, and Copper, Newhalen, and Gibraltar rivers. None of the fish tagged in the Kvichak River, or in any other tagging site tributary to Lake Iliamna, were reported recaptured in the Tazimina River. Tazimina recoveries were exclusive to the Tazimina River.

Table 8. Estimates of abundance for rainbow trout over 250 mm in the Kvichak River, during the spring, 1988-1991.

Year	Total Caught (n_i)	Total Released (R_i)	Total Recap (m_i)	$(r_i)^a$	$(z_i)^b$	Marks at Risk ^c		Abundance			Recruitment			Survival					
						M_i	SE	N_i	SE	%RP ^d	B_i	SE	%RP	i	SE	%RP			
1987	102	99	0	9	0														
1988	542	540	7	46	2	30.02	16.06	2,038	1,251.5	120.4	2,340.9	954.5	79.9	0.2806	0.0661	46.2			
1989	662	662	35	69	13	158.13	35.43	2,912	774.5	52.1	3,319.2	953.0	56.3	0.3918	0.0953	47.7			
1990	1,012	1,011	69	54	13	308.20	72.40	4,460	1,141.0	50.1									
1991	1,134	1,133	67																
Average								3,136	620.8	38.8	2,830.1	605.9	42.0	0.3252	0.0642	38.7			

^a Members of R_i that are captured again at least once.

^b Number of fish that are released before event i and captured after event i .

^c Estimated number of marks in the population just prior to event i .

^d Relative precision of the 95% confidence interval.

Table 9. Mean lengths (mm) and weights (g) of rainbow trout, by age group, from samples collected by hook and line from the Copper River, Kvichak River, and Lower Talarik Creek, fall 1990.

	Age Group										
	Unknown	2	3	4	5	6	7	8	9	10	Total
<u>Copper River</u>											
n (Known Age)		7	58	57	47	38	20	8	4		239
Percent		2.9	24.3	23.8	19.7	15.9	8.4	3.3	1.7		100.0
SE		1.09	2.78	2.76	2.58	2.37	1.79	1.17	0.83		
Mean Length	496	268	281	376	428	513	546	549	620		418
SE	14.16	12.67	7.88	8.02	8.51	10.54	10.75	15.67	39.16		6.91
Sample Size	36	7	58	57	47	38	20	8	4		275
Mean Weight	1,882	465	402	910	1,240	2,100	2,535	2,556	3,938		1,366
SE	172.77	135.00	43.00	69.73	71.54	132.46	185.73	175.37	806.32		64.34
Sample Size	32	2	53	52	43	32	19	8	4		245
<u>Kvichak River</u>											
n (Known Age)		15	57	95	86	63	36	24	9	2	387
Percent		3.9	14.7	24.5	22.2	16.3	9.3	6.2	2.3	0.5	100.0
SE		0.98	1.80	2.19	2.12	1.88	1.48	1.23	0.77	0.36	
Mean Length	464	265	291	341	415	474	530	598	640	660	414
SE	30.73	8.58	4.43	4.80	7.62	9.41	12.54	14.18	28.27	12.00	5.90
Sample Size	27	15	57	95	86	63	36	24	9	2	414
Mean Weight	2,213	308	339	540	1,026	1,392	2,001	2,875	3,883	4,150	1,311
SE	333.81	79.49	23.59	43.93	77.48	100.05	162.14	247.71	523.63	150.00	64.23
Sample Size	20	3	33	69	77	59	35	22	9	2	329
<u>Lower Talarik Creek</u>											
n (Known Age)		3	39	69	33	44	45	38	10	3	284
Percent		1.1	13.7	24.3	11.6	15.5	15.8	13.4	3.5	1.1	100.0
SE		0.61	2.05	2.55	1.90	2.15	2.17	2.02	1.10	0.61	
Mean Length	507	238	281	327	428	592	631	667	701	718	486
SE	25.38	22.42	5.31	6.52	16.27	11.30	10.54	9.53	23.50	9.53	9.38
Sample Size	39	3	38	69	33	44	45	36	10	3	320
Mean Weight	2,503			377	378				7		809
SE	2,496.50			123.25	371.50						532.65
Sample Size	2	0	0	4	2	0	0	0	1	0	9

Table 10. Mean lengths (mm) and weights (g) of rainbow trout, by age group, from samples collected by hook and line from the Kvichak River and Lower Talarik Creek, fall 1991.

	Age Group										
	UNKNOWN	2	3	4	5	6	7	8	9	10	TOTAL
<u>Kvichak River</u>											
n (Known Age)		1	40	117	141	111	55	34	10	3	512
Percent		0.2	7.8	22.9	27.5	21.7	10.7	6.6	2.0	0.6	100.0
SE		0.20	1.19	1.86	1.98	1.82	1.37	1.10	0.61	0.34	
Mean Length	419	220	289	331	405	502	567	624	668	549	437
SE	23.44		4.68	3.88	5.23	6.76	7.37	13.89	27.15	149.90	5.22
Sample Size	18	1	40	117	141	111	55	34	10	3	530
Mean Weight	1072		348	480	881	1703	2456	3544	4155	3475	1349
SE	188.01		37.56	19.33	43.14	80.34	113.97	249.28	515.13	1814.93	53.26
Sample Size	18	0	38	114	139	111	55	33	10	3	521
<u>Lower Talarik Creek</u>											
n (Known Age)			13	95	124	99	79	35	13	8	466
Percent			2.8	20.4	26.6	21.2	17.0	7.5	2.8	1.7	100.0
SE			0.76	1.87	2.05	1.90	1.74	1.22	0.76	0.60	
Mean Length	487		278	307	377	499	583	656	666	722	458
SE	23.21		3.60	3.40	5.89	8.25	7.90	8.52	33.73	11.27	6.30
Sample Size	34		13	95	124	99	79	35	13	8	500
Mean Weight	1838		296	408	804	1749	2748	3806	4154	5471	1647
SE	259.32		29.12	33.21	53.32	89.50	103.74	170.98	436.42	147.14	65.08
Sample Size	29		13	93	123	98	78	35	13	7	489

Table 11. Recoveries of tagged rainbow trout caught by recreational anglers in the stream-based fall fisheries of Iliamna, 1987-1990.

Location	Number Released		Igiugig					Lower Talarik			Upper Talarik				Gibraltar		
			1987	1988	1989	1990	1991	1989	1990	1991	1988	1989	1990	1991	1990	1991	
Igiugig	99	Spring 1987	1		1				1								
	540	Spring 1988		3	2	1		3	2		1						
	662	Spring 1989			3	8			4			1			1		
	1,177	Spring 1990				15	7						2	1			
	374	Fall 1990				1	8		1	1							
	1,133	Spring 1991					9				5				2		1
	512	Fall 1991					1										1
Lower Talarik	102	Spring 1987								1							
	194	Fall 1987								2							
	254	Spring 1988			1			5			1						
	301	Fall 1990							10	5							
	486	Fall 1991									5						
Tazimina	84	Fall 1987															
	184	Fall 1988															
	33	Fall 1989															
Copper River	235	Fall 1990															
Totals	6,370		1	3	7	25	26	8	21	18	1	1	2	3	1	2	

-continued-

Table 11. (Page 2 of 2).

Location	Number Released		Newhalen River				Tazimina				Kokhanok		Copper River			Total
			1988	1989	1990	1991	1988	1989	1990	1991	1987	1991	1989	1990	1991	
Igiugig	99	Spring 1987									1					5
	540	Spring 1988	1								1		1			15
	662	Spring 1989		1									1	1	2	22
	1,177	Spring 1990			1											27
	374	Fall 1990														11
	1,133	Spring 1991														17
	512	Fall 1991														2
Lower Talarik	102	Spring 1987						1								2
	194	Fall 1987														2
	254	Spring 1988														7
	301	Fall 1990				1										16
	486	Fall 1991														5
Tazimina	84	Fall 1987							1							1
	184	Fall 1988					12	2	6	1						21
	33	Fall 1989					12	3	4							19
Copper River	235	Fall 1990											2	12		14
Totals	6,370		1	1	1	1	24	6	11	1	2		2	3	14	186

Seasonal distribution of the fish tagged during the spring in the Kvichak River was assessed through estimation of tagged-to-untagged ratios for rainbow trout caught in the fall fisheries in Lower Talarik Creek, Copper River and in the Kvichak River. Recoveries of fish tagged in spring 1990 in the Kvichak River comprised 3.4%, 1.1% and 0% of the 1990 fall samples from the Kvichak River, Lower Talarik Creek, and Copper River, respectively (Table 12). A chi-square test shows that percentages were significantly different at the 5% significance level (Table 12). The odds ratio, $\theta_{1,K}$, was estimated at 3.1, i.e. the chance of encountering a tagged fish at Igiugig in the fall of 1990 is estimated to be three times higher than the chance of finding one at Lower Talarik Creek. This odds ratio has a 90% confidence interval ranging from 1.2 to 8.0.

In the fall of 1990, rainbow trout were tagged and released at three locations: Kvichak River, Lower Talarik Creek, and Copper River. In the spring of 1991, nine of the fall Kvichak River releases were recovered: seven at the Kvichak River, and two at Lower Talarik (Table 13), but no fish were recovered at the Copper River. There was no significant difference in the percentage of fish released in the fall of 1990 from the Kvichak River and Lower Talarik creeks that were recovered at Igiugig the following spring (Table 13), but sample sizes were too small to have much confidence in these results.

DISCUSSION

The abundance estimates for rainbow trout in the Kvichak River, in the spring range from 2,038 in 1988 to 4,460 in 1991, and estimates of survival from 28% to 39%. An important assumption for the multiple-year mark-recapture experiment is that every animal in the population has the same probability of being caught each year given it is alive (Seber 1982). If all of the population is not catchable at the time of sampling, the estimate is still valid as long as mixture has occurred between years, and as long as there is no size or age segregation within the "population" (Seber 1982). The results of our sampling suggest that assumption of equal probability of capture is valid and therefore selection of the Jolly-Seber estimator was appropriate.

The concentration of rainbow trout during the spring in the Kvichak River is largely of spawning fish and can be considered a discrete stock which annually returns to spawn if they are alive.

Rainbow trout tagged in the Kvichak River during the spring were three times more likely to be recaptured there than at Lower Talarik in the fall. No recaptures of rainbow trout tagged in the Kvichak River were made in the Copper River further up Lake Iliamna. This suggests that the trout spawning near the outlet do not distribute evenly throughout the lake. Together, the data from the voluntary reporting of tagged fish by sport fishermen and the estimation of tag ratios suggest that the fish known to gather in the Kvichak River in the spring contribute significantly to the sport fishery that occurs at the outlet in the fall and to a lesser degree the fishery at Lower Talarik Creek. Contribution to other significant fisheries (Copper River, Upper Talarik Creek, Newhalen River, Gibraltar River) appears minor, but nevertheless does occur (Figure 5).

Table 12. Recoveries in fall fishery areas in 1990 of rainbow trout released in the Kvichak River in the spring of 1990.

Fishery	Tagged	Untagged	Total	Percent Tagged
Igiugig	14	400	414	3.4
Lower Talarik	4	351	355	1.1
Copper River	0	275	275	0.0

Ho: There is no difference between Igiugig and Lower Talarik in percent recovered of fish tagged at Igiugig.

$$\chi^2 = 4.25, \quad df=1, \quad p < 0.05$$

Table 13. Recaptures of rainbow trout tagged in the fall of 1990.

	Release in 1990	Recapture in 1991
Igiugig	374	7 (1.87%)
Lower Talarik	301	2 (0.66%)

Ho: There is no difference in percent tagged from two fall taggings:

$$\chi^2 = 1.85, \quad df = 1, \quad p > 0.10$$

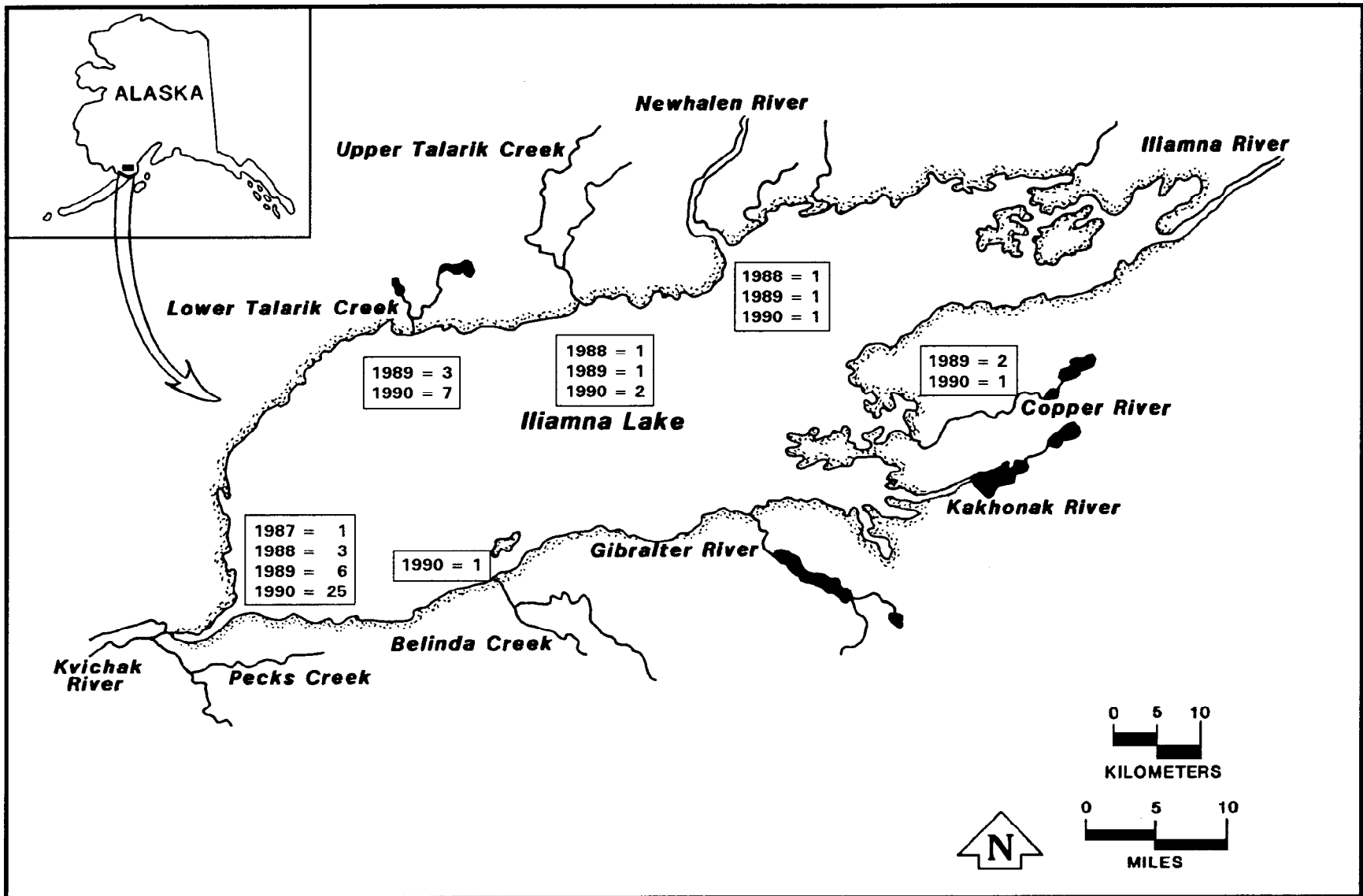


Figure 5. Map of Lake Iliamna with recaptures of rainbow trout tagged and released at Igiugig in the spring, 1987-1990.

Results of this study provide a basis for future management actions regarding Kvichak River rainbow trout. Although the population which gathers at the outlet to Lake Iliamna each spring can not be used as an indicator of general health of Iliamna drainage rainbow trout, this group does comprise an important component of the drainage population. Rainbow trout in the Kvichak River can be considered a discrete stock and the ensuing management implications from such a result are predictable, especially since the Kvichak River offers one of the few opportunities to harvest large rainbow trout in the Iliamna drainage. The Division of Sport Fish should continue periodic monitoring of this population so that undesirable shifts in abundance or stock structure may be detected and addressed in a timely fashion.

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LITERATURE CITED

- Agresti, A. 1990. Categorical data analysis. John Wiley and Sons. New York.
- Brookover, T. E. 1990. Catch, harvest, and size statistics for the rainbow trout fishery in the Tazimina River, Alaska, during 1987 and 1989. Alaska Department of Fish and Game. Fishery Data Series Report No. 112. Juneau.
- Buckland, S. T. 1980. A modified analysis of the Jolly-Seber capture-recapture model. Biometrics 36:419-435.
- Burger, C. V. and L. A. Gwartney. 1986. A radio tagging study of Naknek drainage rainbow trout. U.S. Fish and Wildlife Service. Final Report. Anchorage.
- Conover, W. J. 1980. Practical nonparametric statistics. Second edition. John Wiley and Sons, New York.
- Gwartney, L. A. 1985. Naknek River drainage rainbow trout study in Katmai National Park and Preserve. Alaska Department of Fish and Game, Division of Sport Fish, Dillingham.
- Holmes, R., D. N. McBride, T. Viavant, and J. B. Reynolds. 1990. Electrofishing induced mortality and injury to rainbow trout, Arctic grayling, humpback whitefish, least cisco, and Northern pike. Alaska Department of Fish and Game, Fishery Manuscript No. 90-3, Anchorage.

LITERATURE CITED (Continued)

- Minard, R. E. 1990. Southwest Alaska rainbow trout stock status. Report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Division of Sport Fish, Anchorage.
- Minard, R. E. and D. Dunaway. 1991. Compilation of age, weight and length statistics for rainbow trout samples collected in southwest Alaska, 1954-1989. Alaska Department of Fish and Game, Fishery Data Series No. 91-62, Anchorage.
- Russell, R. B. 1977. Rainbow trout life history studies in Lower Talarik Creek-Kvichak drainage. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Performance Report, 1976-1977, Project F-9-9, 18 (G-II-E):1-48, Juneau.
- Seber, G. A. F. 1982. The estimation of animal abundance and related parameters. Oxford University Press, New York.

