VOL 15

Alaska Department of Fish and Game

JAMES W. BROOKS, COMMISSIONER

Division of Sport Fish

FEDERAL AID IN FISH RESTORATION
JULY 1, 1973 THROUGH JUNE 30, 1974

STUDY R-1

DISTRIBUTION, ABUNDANCE AND NATURAL HISTORY OF THE ARCTIC GRAYLING IN THE TANANA RIVER DRAINAGE

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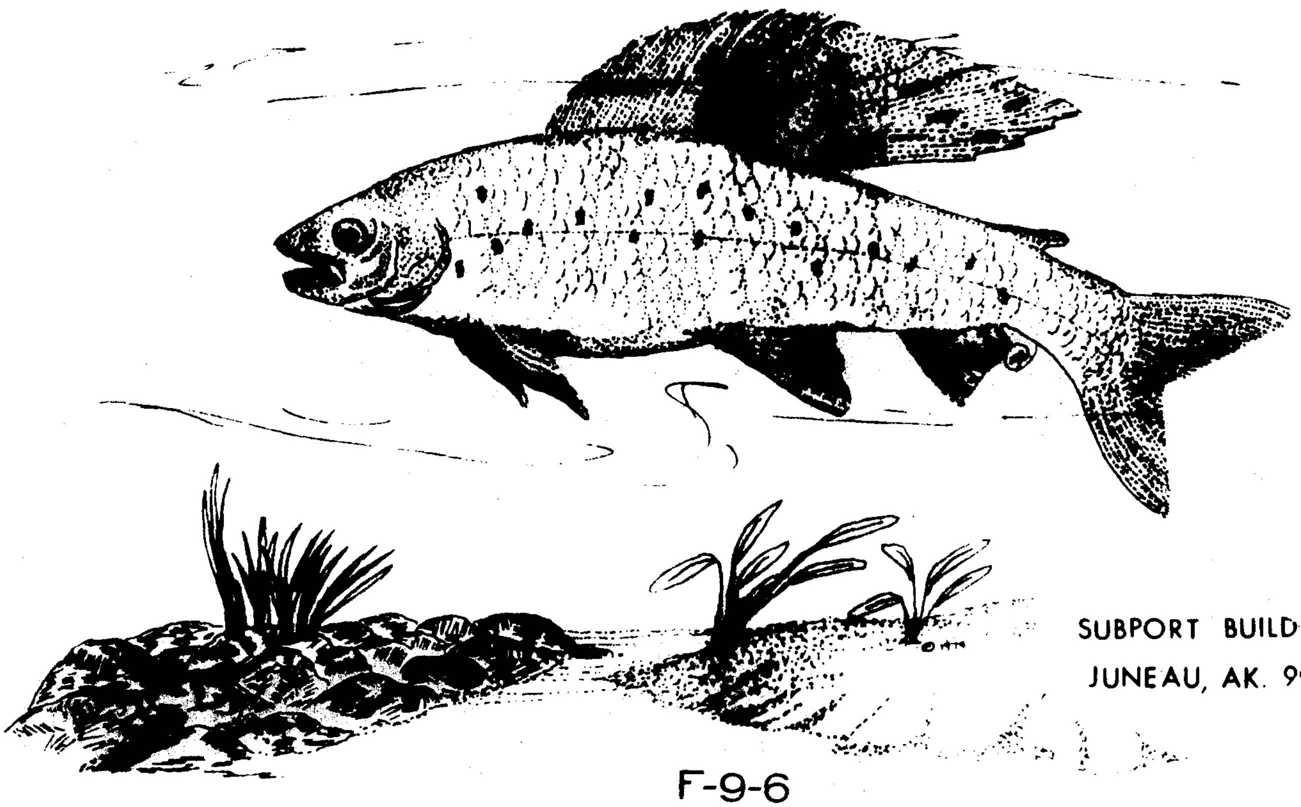

SUBPORT BUILDING
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Volume 15 STUDY R-I

STATE OF ALASKA

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Annual Performance Report for

DISTRIBUTION, ABUNDANCE, AND NATURAL HISTORY OF THE ARCTIC GRAYLING IN THE TANANA RIVER DRAINAGE

by

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RESEARCH PROJECT SEGMENT

State: ALASKA

Name: Sport Fish Investigations of Alaska.

Project No.: F - 9 - 6

Study No. R - I

Study Title: DISTRIBUTION, ABUNDANCE, AND NATURAL HISTORY OF THE ARCTIC GRAYLING IN THE TANANA RIVER DRAINAGE.

Period Covered: July 1, 1973 to June 30, 1974.

ABSTRACT

Population estimates of Arctic grayling, Thymallus arcticus, greater than 150 mm fork length were 293, 424, 243, and 500 per km in four sections of the lower 80 km (50 mi) of the Chena River. Three of these were lower than estimates for the same sections in 1972. Grayling in the four sections were predominately immature (less than 270 mm fork length) and 96.5% were less than 5 years old.

An estimated 4,479 anglers fished 8,511 hours in Badger Slough between April 5 and May 31, 1973. These anglers caught and kept an estimated 11,064 fish of which about 90% were grayling, for an overall harvest rate of 1.3 fish (1.2 grayling) per hour.

The spring migration of grayling in the Goodpaster River reached 53 km (33 mi) April 29, 1973 coincident with rising water temperature and flow volume. Mature and immature grayling, round whitefish, Prosopium cylindraceum, and northern pike, Esox lucius, were all migrating up the river during late April and early May.

The Schumacher-Eschmeyer population estimates for the three Goodpaster River study areas taken from mouth to headwaters were 485, 297, and 91 grayling per km. The grayling population was stratified during the summer with predominately immature fish in the lower 53 km (33 mi), a mixture in the next 45 km (28 mi), and predominately large adults in the upper 87 km (54 mi) of the study area.

Annual survival rate of Goodpaster River grayling averages 54% between ages III and XII. Age VI is under-represented, probably as a result of the 1967 flood, and an unexplained sharp decline occurs between ages VII and VIII. Fishing accounts for about 11% of all mortality.

Lateral line scales averaged 92.4 for Goodpaster River grayling. Full maturity of both sexes was reached at 310 mm fork length and age VI for males and age VII for females. Some fish were mature at age V and 260 mm fork length. The annual increment of growth increased until age V when it reached 51 mm per year, then declined. Ovaries of 22 gravid female grayling had a mean weight of 40.7 gm and 5,044 eggs, with a mean fresh egg diameter of 2.1 mm.

Young-of-the-year grayling first form scales at a fork length of 35 - 38 mm. They reach a mean length of 60 mm by winter and have an average of 6 scale circuli. The first scale annulus is formed in June after one year of life. Fry reared in the upper reaches of the Goodpaster River grow slower than those reared in the lower river.

Grayling began spawning May 11 near the Goodpaster River mouth but not until May 18 at 53 km.

RECOMMENDATIONS

It is recommended that:

1. Grayling population estimates and age class frequency be determined for the Goodpaster, and Chena rivers.

2. The effects of electrofishing and handling be determined for Arctic grayling and other species as time permits.

3. The growth and distribution of fry and yearling grayling be determined for the Chena River.

4. Effort to determine the winter distribution of Arctic grayling be continued.

TECHNIQUES USED

The Goodpaster River was divided into sections and areas as described in Table 1. The Chena River sections appear in Table 2.

TABLE 1. Goodpaster River Study Section, 1973.

Area	River Section	Land Mark	River Miles	Section Length km	Section Length mi.
1	1	Flagged tree	0-3	4.8	3
1	2	Flagged tree	3-6	4.8	3
1	3	Flagged tree	6-9	4.8	3
1	4	Flagged tree	9-12	4.8	3
1	5	Flagged tree	12-15	4.8	3
1	6	Flagged tree	15-18	4.8	3
1	7	Flagged tree	18-21	4.8	3
1	8	Flagged tree	21-24	4.8	3
1	9	Flagged tree	24-27	4.8	3
1	10	Flagged tree	27-30	4.8	3

TABLE 1. (cont.) Goodpaster River Study Section, 1973.

Area	River Section	Land Mark	River Miles	Section Length km	mi.
1	11	3 mi. below the confluence of North and South Forks	30-33	4.8	3
2	12	Forks to Winter trail crossing	33-36	4.8	3
2	13	Winter trail to Central Creek	36-61	40.0	25
3	14	Central Creek to Indian Creek	61-74	20.8	13
3	15	Indian Creek to Glacier Creek	74-86	19.2	12
3	16	Glacier Creek to Slate Creek	86-102	25.6	16
3	17	Slate Creek to Eisenmenger Fork	102-115	20.8	13

TABLE 2. Chena River Study Sections

Section Number	Section Name	River Miles*	Section Length km	mi.
1	Mouth to University Ave.	0-6 (0-9.7)	9.7	6
2a	University Ave. to Peger Road	6-8 (9.7-12.9)	3.2	2
2b	Peger Road to Wendell Street	8-11 (12.9-17.7)	4.8	3
3	Wendell St. to Wainwright RR Bridge	11-14.5 (17.7-23.3)	5.6	3.5
4	Wainwright RR bridge to Badger Slough	14.5-21.5 (23.3-34.6)	11.3	7
5	Badger Slough		26.6	16.5

TABLE 2. (cont.) Chena River Study Sections

Section Number	Section Name	River Miles*	Section Length km	mi.
6	Badger Slough to Little Chena	21.5-25	5.6	3.5
7	Little Chena River		99.0	61.5
8	Little Chena to Nordale Slough	25-31.5 (40.3-50.7)	10.5	6.5
9a	Nordale Slough to Bluffs	21.5-55.5 (50.7-89.4)	38.6	24
9b	Bluffs to Bailey Bridge	55.5-63 (89.4-101.4)	12.1	7.5
10	Bailey Bridge to Hodgins Slough	63-79 (101.4-127.2)	25.8	16
11	Hodgins Slough to 90 mi. Slough	79-90 (127.2-144.9)	17.7	11
12	90 Mi. Slough to 1st Bridge	90-92 (144.9-148.1)	3.2	2
13	First Bridge to 2nd Bridge	92-94.5 (148.1-152.1)	4.0	2.5
14	Second Bridge to North Fork	94.5-102 (152.1-164.2)	12.1	7.5
15	North Fork of Chena River		56.4	35
16	East Fork of Chena River		99.8	62

A boat mounted electrofishing unit described by Van Hulle (1968) and Roguski and Winslow (1969) was used to capture Arctic grayling for population and frequency studies in the Chena River and of the Goodpaster River.

Hook and line with small spinners was used to cpature grayling in Area III of the Goodpaster River. Monofilament gill nets 7.5 m x 1.8 m (25' x 6') with mesh sizes from 5.1 cm - 12.7 cm (2" - 5") stretch measure were used to capture grayling during the spring upstream migration.

A 7.5 m x 1.2 m (25' x 4') seine with 0.95 cm (3/8" in) mesh and a 15.2 m x 1.8 m (50' x 6') bag seine with 0.95 cm mesh were used to capture fry and yearling grayling.

A Ryan 45 day recording thermograph was used to monitor water temperature at 53 km (33 mi) Goodpaster River.

A Hach Model AL-36-WR water test kit was used to determine dissolved oxygen, carbon dioxide, alkalinity, and pH.

A Friden Model 1155 calculator was used for most statistical caculations.

Relative water depths were determined by a graduated staff anchored in the river bottom.

Population estimates were made using the techniques of Schnabel, Schumacher and Eschmeyer, Schaefer, and Bailey, as described in Ricker (1958). Calculations of survival rates also follow those outlined in Ricker.

Floy FD-67 tags were used for all marking during population studies.

Grayling scales used for age determination were mounted on 20 mil acetate, using a heated press at 35,000 pounds pressure for 20 seconds. The scales were individually cleaned prior to mounting. A Bausch and Lomb microprojector was used to read the scales. The scales were read by two readers and those for which unresolved differences persisted were discarded.

A creel census station maintained near the Goodpaster River mouth yielded data on angler usage and catch and collected angler tag returns. Randomized counting periods were used to estimate usage while interviews with departing anglers yielded catch data.

Job R-I-A Population Structure, Migratory Patterns and Habitat Requirements of the Arctic Grayling.

OBJECTIVES

1. Determine year class fluctuations of the grayling populations in the Tanana Drainage with emphasis on the Goodpaster River system.

2. Determine grayling movement patterns and estimate population numbers within the Goodpaster River system and summer distribution in this river.

3. Relate abundance of Goodpaster River grayling to habitat quality.

FINDINGS

Chena River Studies

Population Estimates:

Grayling, *Thymallus arcticus*, population estimates were conducted in Sections 2a, 2b, and 6 of the Chena River and in the area of the proposed dam site, km 71 - 76. These estimates are presented in Table 3. Table 4 compares population estimates obtained from 1968 to the present. Population levels have declined since 1971 in Sections 2a and 2b. Section 6 has shown a slight increase in grayling per km while the grayling population at the dam site has decreased since 1972. A cyclic population fluctuation is suspected (Tack, 1973) and will be closely monitored.

TABLE 3. Grayling Population Estimates, Chena River, 1973.

River Section	Date	Length of Section km (mi.)	Number Marked	Schnabel Estimates Gr/km (Gr/mi)		95% Confidence Limits Gr/km
2a	7/10-7/13	3.2 (2)	241	293	(469)	218-502
2b	7/3-7/1	4.8 (3)	630	424	(679)	354-545
6	7/16-7/17	4.8 (3)	469	243	(389)	203-312
Dam Site (km 71 - 76)	7/18-7/19	4.8 (3)	445	500	(800)	379-806

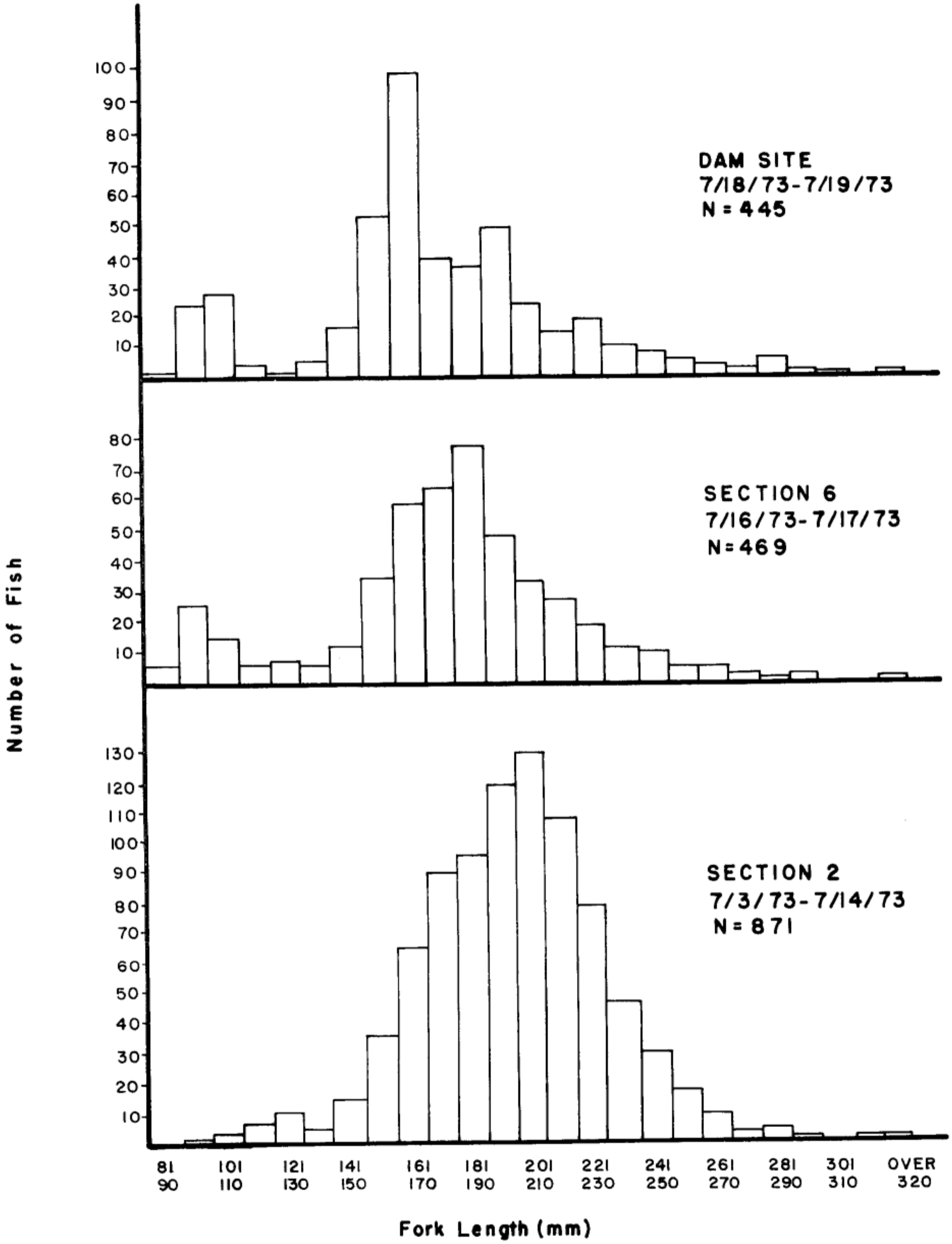

FIGURE I. LENGTH FREQUENCIES OF GRAYLING CAPTURED BY ELECTROFISHING FROM THREE AREAS OF THE CHENA RIVER. 1973

TABLE 4. Grayling Population Estimates for Various Sections of the Chena River, 1968-1973. (Expanded from Tack, 1973).

River Section	Year	Dates	Gr/km	(Gr/mi)
2a	1971	8/30-9/3	684	(1,095)
	1972	6/22-6/26	416	(666)
	1973	7/10-7/13	293	(469)
2b	1968	---------	684	(1,095)
	1969	---------	1,181	(1,890)
	1970	7/2-7/10	1,540	(2,465)
	1971a	6/2-6/7	2,036	(3,257)
	1971b	8/30-9/3	2,338	(3,741)
	1972	6/22-6/26	919	(1,471)
	1973	7/3-7/14	424	(679)
6	1968	---------	282	(452)
	1969	---------	571	(913)
	1970	5/26-5/30	481	(769)
	1971	6/21-6/24	368	(589)
	1972	6/19-6/20	207	(331)
	1973	7/16-7/17	243	(389)
Dam Site	1972	6/27-6/29	1,140	(1,824)
	1973	7/18-7/19	500	(800)

Length Frequency:

The length frequencies obtained while conducting population estimates in the Chena River indicate a predominance of immature grayling (less than 270 mm fork length) from the upper sampling limit at km 76, to the lower sampling limit at km 10 (Figure 1). Samples from anglers' creels at Badger Slough showed that 93% of the grayling caught were less than 270 mm fork length.

Age and Growth:

Two hundred scales were randomly chosen from a sample of 973 grayling captured from the lower Chena River below river km 76 (Table 5). No age VI grayling were captured either by electrofishing or by anglers, further substantiating the speculation that the flood of 1967 produced a high mortality rate on young-of-the-year fish (Tack, 1971) or that this group was distributed in other sections of the river (Tack, 1972).

TABLE 5. Length and Age Composition of 200 Grayling Taken by Electrofishing from the Lower Chena River, 1973.

Length Group (mm)	Age Class I	II	III	IV	V	VI	VII	Total
91-110	7							7
111-130	4							4
131-150		3	3					6
151-170		16	29	1				46
171-190		4	25	5				34
191-210		1	33	14				48
211-230		1	23	8				32
231-250			3	6	1			10
251-270			4	1	1			6
271-290			1	1	2			4
291-310					2			2
over 310							1	1
Totals	11	25	121	36	6	0	1	200
Mean Fork Length (mm)	110.5	166.8	194.3	215	279.2			

Capture Rates:

The capture rates for all species encountered were recorded along with the population estimates to further assess their use as indices of abundance and as a means of expressing the relative abundance of fish captured (Table 6). In Sections 2a and 2b, where population levels went down, the capture rate of grayling went down also compared to the 1972 capture rate (Tack, 1973). In Section 6, where the population level went up, the capture rate for grayling went up also. However, at the dam site where the population level was down from 1972, the capture rate was up. There is no apparent reason for this last inconsistency except that rain showers and winds occurred during sampling of this section, resulting in river turbidity and probably enabling the capture of more fish in less time than in clear water conditions.

TABLE 6. Capture Rate of Grayling and Associated Fish Species in Selected Sections of the Chena River By Electrofishing, 1973.

	Fish Per Hour*						
	GR	RWF	S	NP	BB	Other Whitefish	Hours Shocked
Sec. 2a	60.7	41.6	67.4	2.6	.86	18.5	3.97
Sec. 2b	144.8	41.5	108.6	0	0	0	4.35
Sec. 6	107.3	70.3	72.3	.2	0	11.0	4.37
Dam Site in Sec. 9a	112.7	62.4	24.8	.8	0	0	3.95

*GR - Grayling
RWF - Round whitefish (*Prosopium cylindraceum*)
S - Longnose sucker (*catostomus catostomus*)
NP - Northern pike (*Esox lucius*)
BB - Burbot (*Lota lota*)
Other Whitefish - humpback whitefish (*Coregonus pidschian*)
least cisco (*Coregonus sardinella*)

Creel Census

Badger Slough:

Badger Slough, a spring-fed tributary of the Chena River, was censused from April 5 - May 15 employing a random sampling design, stratified to take into account peak fishing periods both on weekends and weekdays. Censusing was irregular from May 1 - 15 and stopped completely on May 15. Thus the tabulated results for May are based partly on projections obtained from the April statistics.

Calculated results are obtained on the basis of 224 angler interviews and are summarized in Table 7.

TABLE 7. Badger Slough Creel Census Results, April 5 - May 31, 1973.

	Calculated Angler Hours				
	Weekdays		Weekends		
Dates	6 AM - 2 PM	2 PM - 10 PM	6 AM - 10 PM	10 AM - 10 PM	Total
4/5-4/30	686	1,418	310	1,512	3,926
5/1-5/31	869	1,436	390	1,890	4,585
				Total Anglers Hours	8,511

Interview Results (224 anglers):	Number	Percent
Hours Fished	426	
Number Resident Anglers	160	71.4
Number Military Anglers	50	22.3
Number Non-resident Anglers	14	6.3
Fish Caught and Retained	556	55.5
Fish Caught and Released	445	44.5
Total Fish Caught*	1,001	100
Catch Per Angler Hour (fish retained)	1.3	
Grayling Per Angler Hour	1.17	
Catch Per Angler Hour (total catch)	2.4	
Mean Hours Per Angler Trip	1.9 (1 hour 54 mins.)	
Total Calculated Angler Trips	4,479	
Calculated Harvest (April)	5,104	
Calculated Harvest (May)	5,960	
Calculated Total Harvest*	11,064	
Calculated Total Grayling Harvest	9,958	

*Approximately 10% of total is whitefish.

Angler catch was sampled during the interviews. The mean length of grayling taken was 212 mm (range 135-310).

Seven percent of the 143 fish sampled were greater than 269 mm fork length. Grayling are considered mature at 270 mm (Tack, 1971). Their presence further indicates a spawning population utilizing Badger Slough, as first noted by Tack (1973).

A summary of past and present Badger Slough creel census is presented in Table 8.

TABLE 8. Summary of Badger Slough Creel Census Totals, 1968-1973.

Year	Dates	Angler Hours	Hours Per Trip	Grayling Per Hour	Total Grayling Harvest	Mean Length (mm)
1968*	4/17-5/31	8,970	1.86	0.82	7,355	200
1969**	4/12-5/31	6,929	1.80	0.80	5,542	---
1970***	5/1-5/31	6,206	1.54	0.43	2,669	---
1972****	4/8-5/24	7,174	2.00	0.86	6,170	232
1973	4/5-5/31	8,511	1.90	1.17	9,958	212

*From Roguski and Winslow, 1969
**From Roguski and Tack, 1970
***From Tack, 1971
****From Tack, 1973

The total angler hours (8,511) are the highest since 1968 (8,970), and there was a dramatic increase in catch per hour in 1973 (1.17) as compared to a previous high of 0.86 in 1972. This resulted in a much higher harvest in 1973 (9,958) than the previous high of 7,355 harvested in 1968.

Goodpaster River Studies

The Spring Migration:

A tent camp was established at the confluence of the North and South forks of the Goodpaster River (Figure 2) April 9, 1973. On April 9, there was some open water in the North Fork but none in the South Fork or main river.

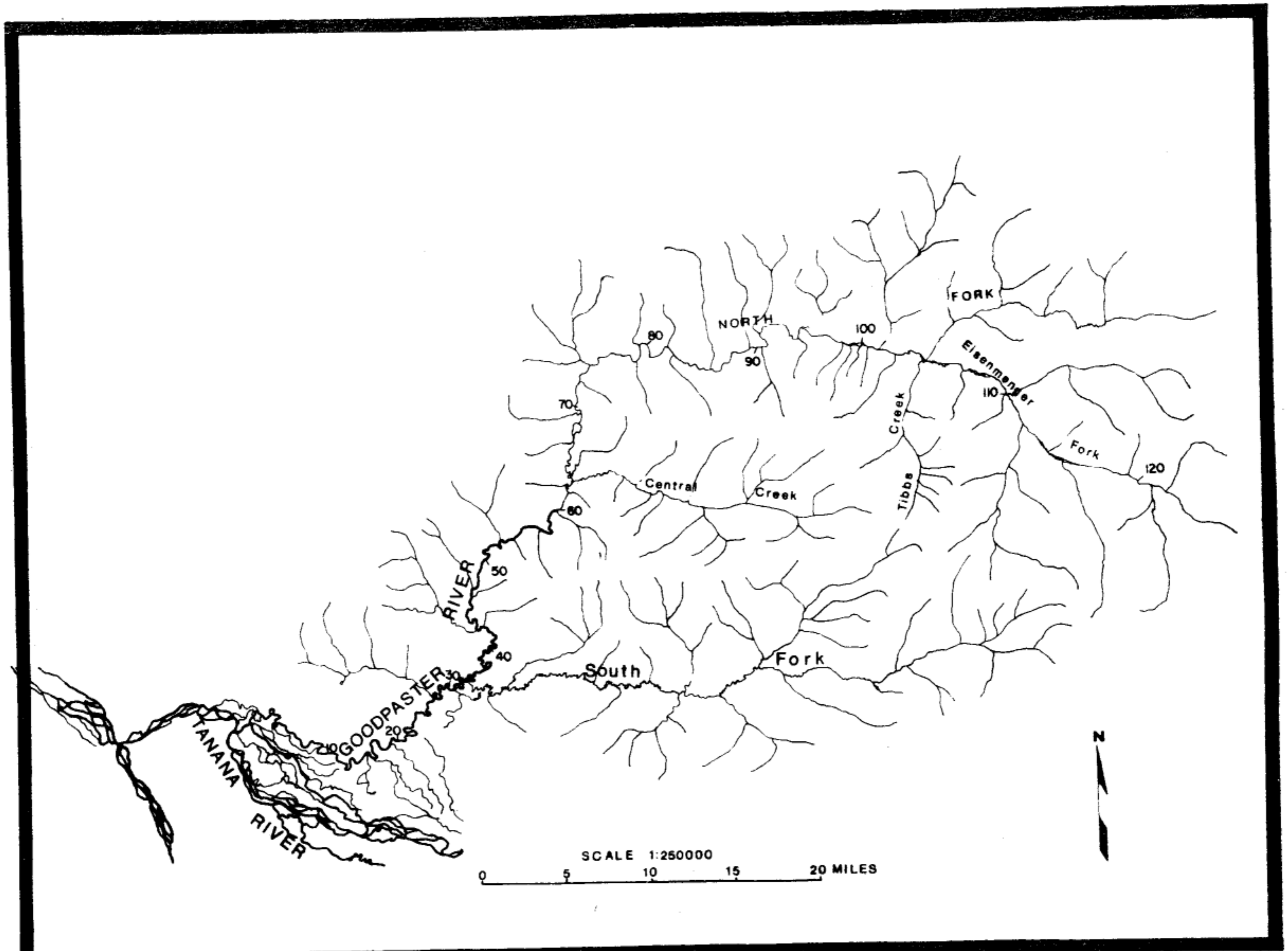

FIGURE 2. GOODPASTER RIVER DRAINAGE

However, considerable melt was occurring daily and leads in the ice opened in the main river by April 15. The South Fork remained ice covered in the vicinity of its mouth until about May 3 when one riffle became ice-free. Breakup occurred May 4 and ice flowed from both forks until May 6.

The time of arrival and relative magnitude of fish movement past the forks was monitored with gill nets. The nets were fished in ice-free areas and under the ice. Under-ice sets were generally more effective. The nets were moved frequently as breakup progressed to protect them from moving ice. Netting effort was about the same throughout the period from April 9 until May 8.

The first grayling was captured April 16. On April 18, two grayling were taken and again on April 25 two grayling were caught. On April 29 grayling began moving steadily up past the netting site and were caught in increasing numbers thereafter. Figure 3 relates the capture of grayling to water temperature and relative water depth. All three lines were smoothed by a moving average of three. Since both water temperature and depth began increasing noticeably about the same time grayling began moving consistently, neither of these factors stands out as a stimulus to movement.

Round whitefish, Prosopium cylindraceum, and northern pike, Esox lucius, were also caught during the period of netting. The 113 round whitefish captured during the spring netting ranged in length from 25 - 41 cm fork length (mean 32 cm). Smaller round whitefish may have been moving but were not caught by the relatively large mesh nets used.

The five northern pike captured during spring netting were all mature, nearly ripe males ranging from 45 - 57 cm fork length. These fish had empty stomachs and were heavily infested with intestinal tapeworms.

On May 13, during a shocking run from km 53 (33 mi) down to the mouth, four ripe pike were captured at about km 35 (22 mi). These fish were apparently spawning in the main Goodpaster River, which in the area between 32 km (20 mi) and 38 km (24 mi) meanders slowly with no riffles. The bottom is sandy and the banks are grass covered down to the mean low water line.

A total of 248 grayling was captured by gillnet and angling during the sampling period. Seventy-two (29%) were injured by the nets, so were autopsied. The remainder were tagged and released. Of the mature fish autopsied, 18 (36%) were females and 32 (64%) males. Twenty-two of the autopsied grayling were immature and 25 of the tagged fish were judged immature (fork length < 270 mm), thus 19% of all grayling captured were immature. The autopsied fish were considered a representative sample. Thus, it appears that either there are nearly twice as many males as females in the population or males move up river earlier than females. The latter seems more likely. Immature grayling were taken from the onset of the run.

Sampling with gill nets was terminated on May 8. During the next four days 278 grayling were tagged and 20 sampled in the vicinity of the forks using a boat mounted electrofishing unit. The final tally of grayling tagged in the

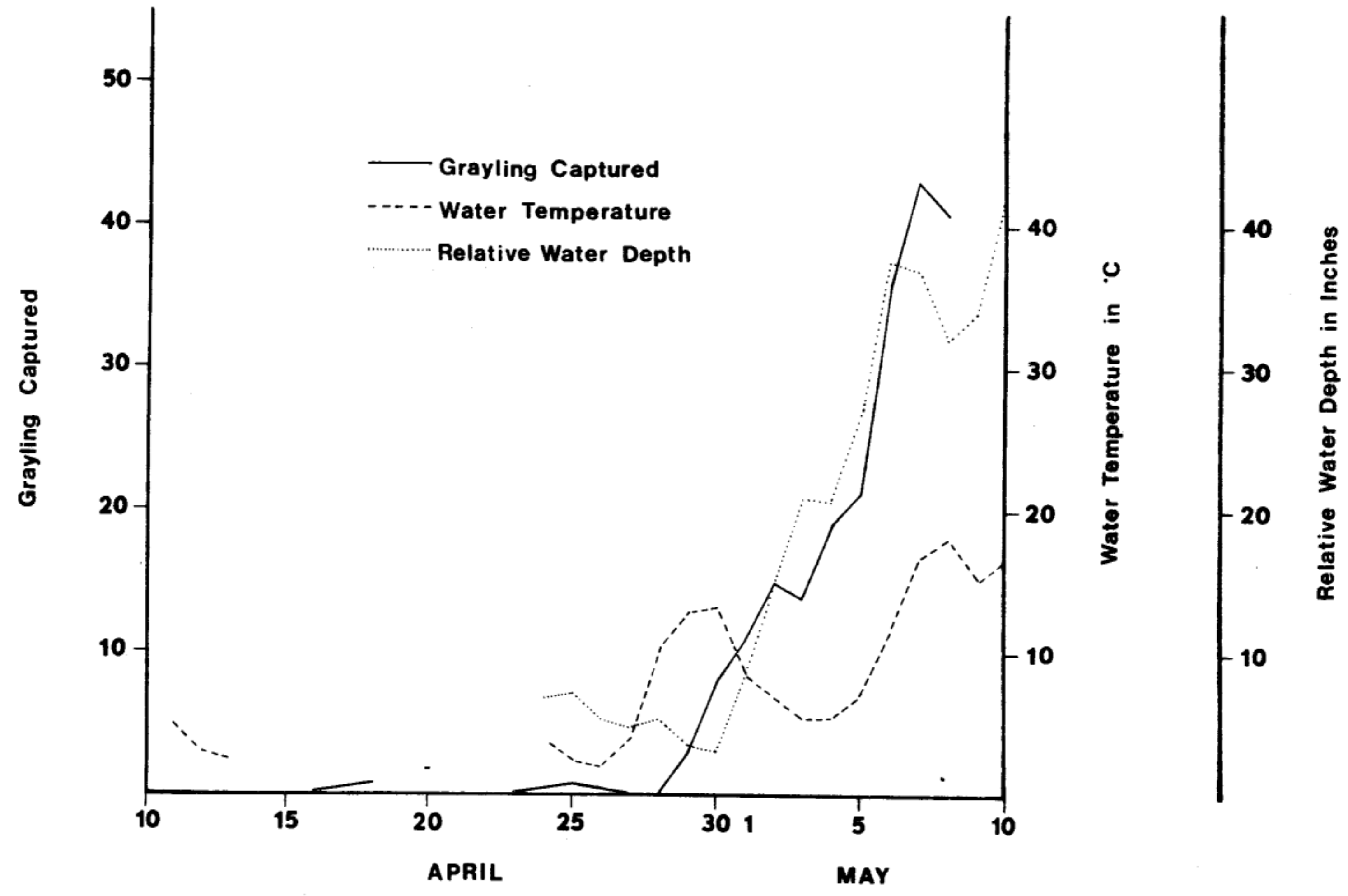

FIGURE 3. RELATIONSHIP OF RELATIVE WATER DEPTH AND WATER TEMPERATURE TO ONSET OF GRAYLING MIGRATION, GOODPASTER RIVER, 1973.

vicinity of the forks prior to spawning was 400. Fifty-six of these tags were recovered, 45 by our crew and 11 by anglers. Of the 45 recaptures for which we have reliable information, seven showed upstream movement, 18 showed downstream movement, and 20 were captured within three miles of where they were tagged. The data were further analyzed as to the capture method used at initial tagging. Of the grayling initially captured by gillnet, two were recaptured upstream and 13 showed no movement. Of those initially captured by the shocker boat, five were recaptured upstream, 18 downstream, and 20 showed no movement.

The relatively large number of grayling showing downstream movement following initial capture by electrofishing was unexpected since the tagging was done during the upstream spawning migration and most of the fish tagged were adults. There is little doubt that some trauma is caused by both electrofishing and gillnetting and it appears from these data that electroshocking may significantly affect normal migration patterns. Further investigation of the effect of electrofishing on grayling migratory behavior is advised.

The Tagging Program

Several tag and recapture population estimation techniques were used simultaneously to evaluate their respective performances practicality in rivers.

The tagging program initiated on Arctic grayling of the Goodpaster River had four objectives: 1) to facilitate the use of a Schaefer population estimate, 2) to facilitate the calculation of population size and mortality rate by the Bailey Triple Trellis method; 3) to study inter- and intra-stream movements; 4) to facilitate the validation of scale aging.

The individual requirements for the Schaefer Method and the Bailey Method are outlined in Ricker (1958). The sample design used to accomplish all the above objectives is discussed here as it was carried out in this program.

1. One hundred fifteen miles of the main Goodpaster River and its North Fork were divided into 17 sections, described in Table 1, to provide the spatial stratification required for the Schaefer population estimate. The sections were grouped into three areas on the basis of homogeneity of river characteristics, capture methods used, and length frequency of grayling captured in the first sample period. Area I includes Sections 1 through 11 which comprise the slow meandering portion of the river between the mouth and the confluence of the North and South forks. Area II includes Sections 12 and 13, the lower 45 km (28 mi) of the North Fork from its confluence with the main river to Central Creek. Area III includes Sections 14 through 17, the upper North Fork and lower part of Eisenmenger Fork. Area III had relatively fewer pools and more long fast riffles than Area II.

2. Sampling began on June 1, after most migration of age III and older grayling was completed. Each area was sampled as a unit

and sampling was completed in as short a time as possible (two to five days). Sampling periods in each area were separated by approximately one month. Areas I and II were sampled with electrofishing equipment. Area III was sampled by hook and line.

3. Each fish captured, while anesthetized, had the fork length recorded, several scales removed, a Floy FD 67 tag applied, and the left pelvic fin removed. This information, along with the capture location and date, provided the basic information for the migration and scale validation studies.

The tag data have been key punched and stored on magnetic tape at the University of Alaska Computer Center. Migration analysis will follow the 1975 field season when a maximum number of tag returns should be on hand. Recapture information will be stored on the tape following each field season.

Data on scales taken from the same fish after at least one year's growth will become available in 1974 and will be analyzed then.

The sampling scheme was adhered to rather well and it is felt that biases resulting from variations in capture method were minimized at least in Areas I and II. Some bias may have occurred in Area III where grayling may have learned to avoid the Mepps spinners used on all three sample periods. Inspection of length frequency data indicated that grayling under about 150 mm fork length were not being captured representatively, so all of these fish were removed from the data prior to statistical analysis.

Tag loss is another possible source of bias. An estimate of tag loss rate during the summer was obtained by noting the number of grayling recaptured that had the left pelvic fin removed but had no tag. A tag scar was usually visible as well. Over the course of the summer, 271 grayling with a left pelvic fin clip were examined by Fish and Game personnel. Seventeen of these had lost the tag, for a loss rate of 6.3%. This apparently straightforward estimate was confounded by the overlooked fact that the left pelvic fin had been removed from about 1,500 grayling tagged in the Goodpaster River during the two preceding years.

The effect of these 1971 and 1972 tags is estimated by the rate of recovery of pre-1973 tags during the study of 5.4%. If the effect of time lapse between initial tagging and recapture is disregarded, the best estimate of tag loss rate is 6%.

Table 9 summarizes the data used in calculating the Schaefer and Bailey population statistics. These data exclude all fish under 150 mm fork length and are adjusted for tag loss.

Schnabel and Schumacher - Eschmeyer Methods

The data in Table 9 were used to calculate a population estimate by the improved Schnabel method (Ricker, 1958; p. 102) as in previous years' work. The confidence limits were calculated using the inverted variance formulae

TABLE 9. Summary of Tag and Recapture Data Used in Making Grayling Population Estimates for the Goodpaster River, 1973

River Section	No. Fish Tagged in Period			Angler Recaps, Between			Fish & Game Recaps. on			Total Fish Captured in	
	1*	2*	3*	Periods 1 & 2	Periods 2 & 3 Fish Tagged on Run 1	Periods 2 & 3 Fish Tagged on Run 2	Period 2	Period 3 Fish Tagged on Run 1	Period 3 Fish Tagged on Run 2	Period 2	Period 3
Area I	1,449	879	635	14	11	4	56	31	35	990	744
Area II	209	352	273	3	1	0	2	4	10	377	303
Area III	230	185	182	0	0	0	9	2	8	206	204
Total	1,888	1,416	1,090	17	12	4	67	37	53	1,573	1,251

*Values reflects 6% tag loss rate reduction.

in Ricker (1958; p. 101). The Schumacher - Eschmeyer estimate and confidence limits were also calculated according to Ricker, pages 102 and 103.

These two estimators are based on the same sampling design and differ only in that the Schumacher - Eschmeyer formula assumes non-random mixing of marked and unmarked fish, whereas the Schnabel assumes random mixing.

A comparison of the two methods (Table 10) reveals rather close agreement for the population estimate but considerable differences in the confidence limits. The Schumacher - Eschmeyer confidence limits were considerably better for Area I and the combined areas and considerably worse for Areas II and III. The apparent explanation is that the number of fish tagged and recaptured was far fewer in Areas II and III than in Area I and the Schumacher - Eschmeyer method is less reliable than the Schnabel method when the recapture rate is low.

TABLE 10. Population Estimates of Arctic Grayling over 150 mm Fork Length in Three Areas of the Goodpaster River, 1973.

	Length of Area		Schnabel Estimate		Schumacher-Eschmeyer Estimate	
	km	mi	GR/km	95% Confidence Limits GR/km	GR/km	95% Confidence Limits GR/km
Area I	53	33	480	411-590	485	471-501
Area II	45	28	322	223-732	297	163-1,673
Area III	87	54	81	57-164	91	54-290
Combined	185	115	241	209-287	243	232-256

The Schaefer Population Estimate

The Schaefer method was developed for estimating fish populations that are stratified (Schaefer, 1951). Though it was originally used to estimate salmon runs by stratifying them according to time, it is also applicable to situations requiring spatial stratification. The Schaefer Method was applied in the present study because of its ability to handle movement between spatial strata (the 17 Goodpaster River study sections). Grayling population estimates were made for the three areas separately and for the entire study area using pooled data (Table 11). Estimates were calculated following the July sampling period and after the August sampling period. Evaluation of the results is difficult because expressions for variance were not found.

TABLE 11. Population Estimates of Grayling over 150 mm Fork Length for Three Areas of the Goodpaster River As Determined by the Schaefer Method, 1973.

Area	Length of Area km	Length of Area mi	Number of Sections In Area	Population Estimates After July Sampling Gr/km	Population Estimates After Aug. Sampling Gr/km
I	53	33	11	416	537
II	45	28	2	*	325
III	87	54	4	46	134
Combined	185	115	17	326	287

*Insufficient recaptures for calculation.

However, results of the Schnabel and Schumacher - Eschmeyer methods should compare closely to those of the Schaefer method for the entire study area, as movement between sections or areas would have a negligible effect on the former two estimators in this case. Here the Schaefer estimates of 60,293 after July sampling and 53,063 after August sampling are both considerably higher than the estimates (both about 45,000) obtained from the other two estimators.

The Schaefer, like the Schnabel and Schumacher - Eschmeyer methods, estimates the population at the time tagging begins. The Schaefer method was found to have no advantage over the Schnabel sampling method for grayling because movement out of the study area affects both estimators adversely, and no additional information is gained through use of the more complex Schaefer method.

The Bailey Population Method

The results of the Bailey population estimates appear quite different from those of the previous three estimators (Table 12). This is probably because the sampling requirements for accurate calculations were not met in Areas II and III. The problem generally was that not enough fish were marked on the initial sampling period, so that subsequent sampling contained too few recaptures.

TABLE 12. Estimated Population of Arctic Grayling over 150 mm Fork Length in the Goodpaster River, 1973 as Determined by the Bailey Triple Trellis Method.

Area	Length Area km	Length Area mi	Population Estimates GR/Km Mid June	Mid July	Late August
I	53	33	425	247	174
II	45	28	*	358	*
III	87	54	21	10	6
Combined	185	115	191	125	39

*Insufficient data for calculation.

In Area I, marking rates were sufficient to produce good results which agree fairly well with those obtained by the other three estimators. There is, however, a difficulty in comparing this estimator with the others, in that the Bailey method estimates the population at the time of the second sampling, whereas the others estimate the population at the time of the first sampling. The survival rate obtained from the Bailey method was used to estimate the population at first and third sampling (Table 12).

The potential of this method for yielding important information about the dynamics of the population warrants its further consideration. However, before this method is employed it should be determined that sufficient sampling capability is available to carry out the rather stringent requirements of the sampling regime.

The Goodpaster River Creel Census

The census was conducted by a man stationed near the mouth of the Goodpaster River. A temporary wood frame shelter, a creel census booth, and three large signs were constructed at the site. The signs, one upstream, one downstream, and one at the station encouraged boaters to stop. The booth was equipped with census forms and information of interest to anglers including regulations, informational leaflets, and a description of the project being conducted on the river that summer. The census taker was responsible for: 1) making counts of boats and people per boat according to a predetermined random schedule, and 2) providing information to arriving parties and obtaining interviews from departing parties.

The census considered only anglers arriving by boat and did not count boats or personnel of the military river boat operators training school. A small number of anglers were known to have arrived by light aircraft on wheels at the Central Creek airstrip, km 98 (61 mi) on the river. No float equipped aircraft were observed utilizing the river during the summer but they have landed in the lower Goodpaster River in past years. Military personnel were once observed fishing after arriving by helicopter. Probably no more than 25 anglers used air transportation to the Goodpaster River.

A system of counting boats and people during random periods was used because it was impossible for one person to count 100% of the time. Therefore, the days were divided into four-hour periods from 7:00 AM until 11:00 PM. The sampling of these periods was stratified so that one quarter of the periods on Monday through Thursday (weekdays) and one half of the periods on Friday, Saturday, Sunday and holidays (weekends and holidays) were sampled. During a four-hour period designated for sampling, the census taker recorded the number of boats going upstream and downstream and the number of people per boat, thus providing the basis for estimating total number of boats and people using the river during the summer.

The number of boat trips was calculated by averaging the upstream and downstream counts and is presented in Table 13 for each month of the census. An expanded estimate of the number of boat trips (414) from breakup in early May until freezeup about October 1 was arrived at by adding one-half the June value for May and one-half the August 1 to September 3 value for the remainder of September.

TABLE 13. Results of Goodpaster River Creel Census, 1973

Boat Trips

	Weekdays	Weekends and Holidays	Totals
June 1 - June 30	16	70	86
July 1- July 31	30	75	105
Aug. 1 - Sept. 3	40	80	120
			311

Expanded estimate* 414

Fishery Statistics

	June	July	Aug.	Total	Expanded Estimate
People per boat	1.96	2.44	2.01		
Anglers per boat	1.49	1.93	1.15		

TABLE 13. (cont.) Results of Goodpaster River Creel Census, 1973.

Fishery Statistics

	June	July	Aug.	Total	Expanded Estimated
Estimated total anglers	128	201	139	468	602
Anglers days	190	353	174	717	899
Angler hours	745	1,053	381	2,179	2,741
Grayling Caught per angler hour	2.08	1.71	2.96		
Grayling kept per angler hour	0.92	0.69	1.63		
Grayling caught	1,550	1,800	1,128	4,478	5,817
Grayling kept	686	276	621	1,583	2,236
Anglers keeping over 5 grayling per trip	63	50	29	142	188
Anglers keeping over 5 grayling per day	14	6	14	34	48
Mean Fork Length (mm)	229(n=57)	273(n=84)	291(n=100)	241	
Range of Length (mm)	150-355	190-385	190-405		

*The expanded estimate is calculated by adding one half the June value for May and one half the August value for September to the total for the three sampled months.

The interviews of departing parties provided the data for calculation of the number of anglers, angler days, angler hours, and the number of grayling caught and kept (Table 13).

Anglers who had stopped at the creel census station on their way upstream and indicated an interest were given a ruler and asked to measure all the grayling they kept. Measurements were obtained on 241 angler-caught grayling. The mean fork length of angler caught grayling by month appears in Table 13.

The 2,236 grayling kept by anglers came primarily from Area I of the Goodpaster River. This represents an annual fishing mortality rate of 9% in this area.

Mature grayling (over 310 mm fork length) made up 25.6% of the total estimated catch, or 572 fish. Most of the adult grayling were taken in August when these larger fish were beginning to move downstream. During the census period only 34 of 468 anglers averaged more than five grayling per day. Thus we may characterize the Goodpaster River fishery as relatively small, concentrated on subadult grayling in the lower 53 km (33 mi) of the river, and with anglers being selective in the few fish they keep.

Length Frequency:

The distribution of grayling in the Goodpaster River according to size was studied over 185 km (115 mi) of the river, thus including all habitat types except the headwater tributaries too small to navigate with a rubber raft. Sampling was done by electrofishing in Sections I through 13 and by hook and line in Sections 14 through 17. Gill nets that were fished overnight while sampling in Sections 14 through 17 showed the hook and line sampling to be representative.

The mean fork length of grayling in each section by month (Figure 4) shows a stratification of the population. Sections 13 and 14 between river km 58 (36 mi) and 118 km (74 mi) are transitional from the low mean size of the lower river to the much greater mean size grayling in the upper 64 km (40 mi) sampled. Means for the May samples in Sections 1 through 11 were higher than those in the same sections in June, July, and August because many adult grayling destined to move further upstream were spawning in the lower river at this time.

Because of the importance of knowing how the grayling population was distributed in the river throughout the study period, the length frequency for each month in each area was graphed (Figures 5, 6, and 7). It is apparent from these figures that each area maintains its same general length frequency pattern throughout the summer. The disappearance of the peak at about 200 mm in Area I is probably the result of fishing, Upstream migration is probably a factor in this reduction of fish over 200 mm fork length but a minor one as little increase in this size group is seen in the Area II profile. In Area III the 260 mm peak declines and is gone by August. A possible explanation of this may be that the larger grayling force this smaller group into tributary streams through territorial feeding competition as described by Vascotto (1970).

The distribution by length of grayling in small headwater tributaries is not well understood. However a survey of the upper reaches of the South Fork of the Goodpaster River revealed the presence of age II and III grayling in the uppermost ends of the tributaries. The stream was less than 0.25 m wide and fell 16 - 20 cm between small pools at this point. Larger grayling were not found until the stream was about 2 m wide. Further investigation of the use grayling make of these small headwater streams is needed.

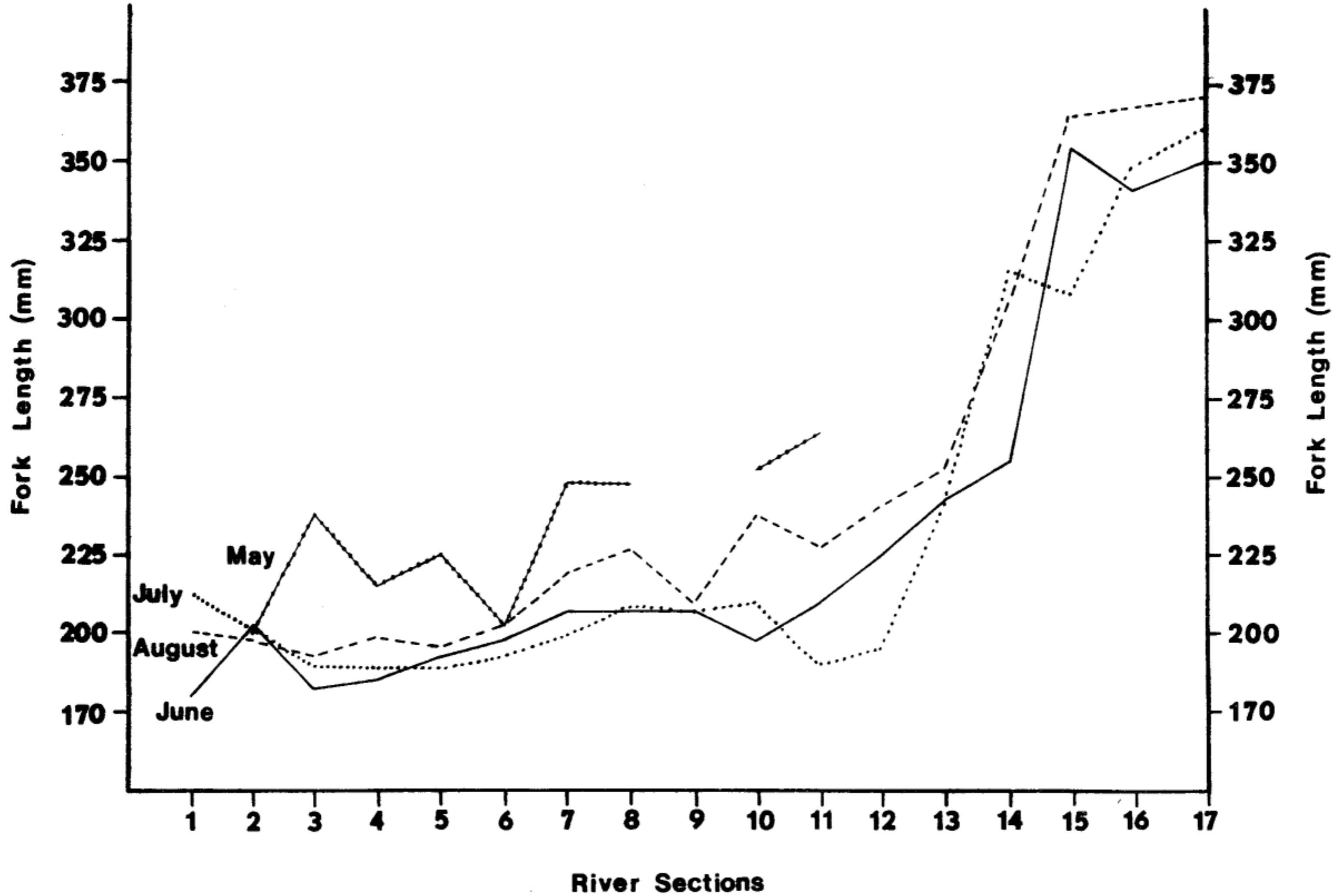

FIGURE 4. MEAN FORK LENGTH OF ARCTIC GRAYLING BY RIVER SECTION BY MONTH IN THE GOODPASTER RIVER, 1973

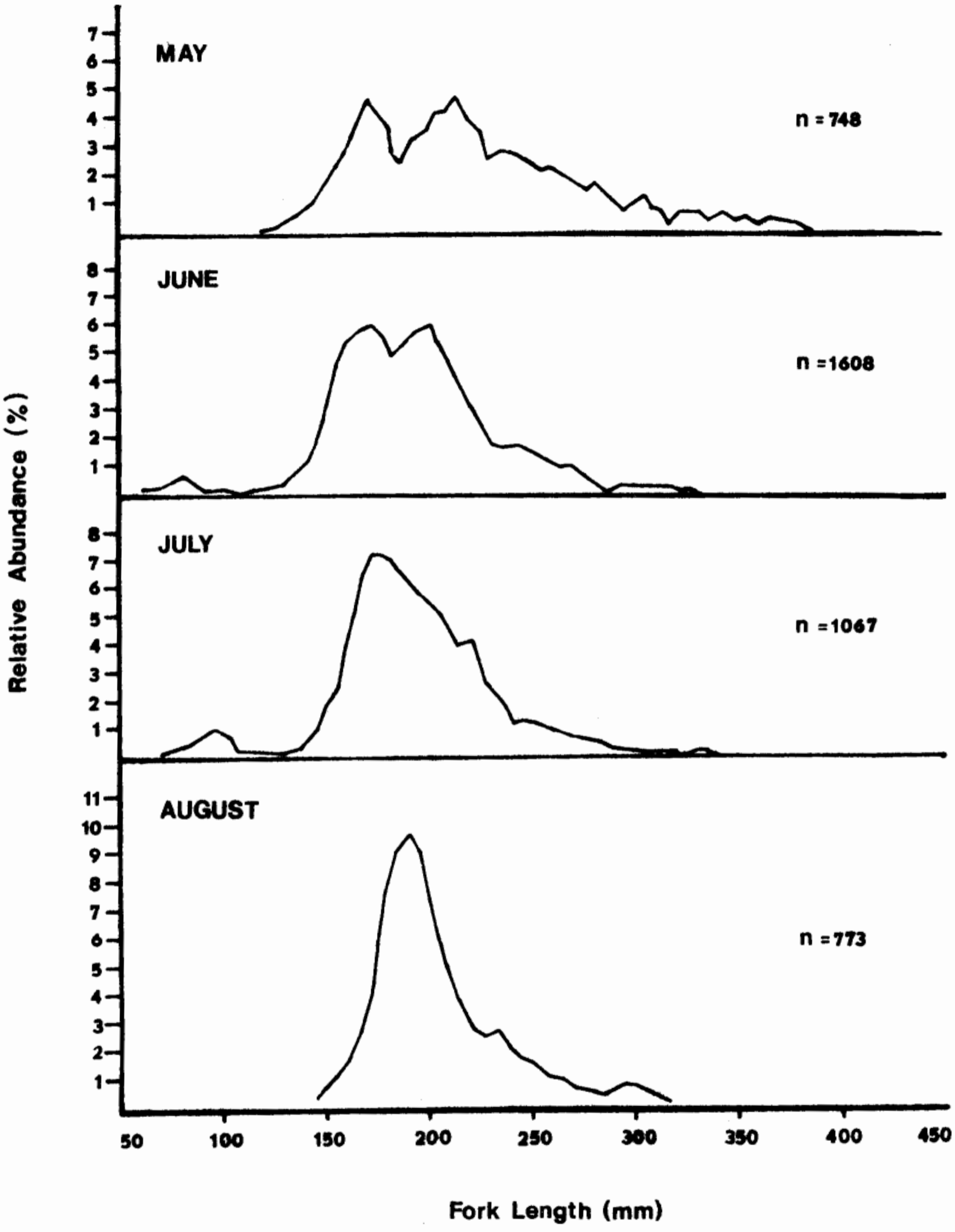

FIGURE 5. LENGTH FREQUENCY DISTRIBUTION BY MONTH FOR AREA I OF THE GOODPASTER RIVER, 1973.

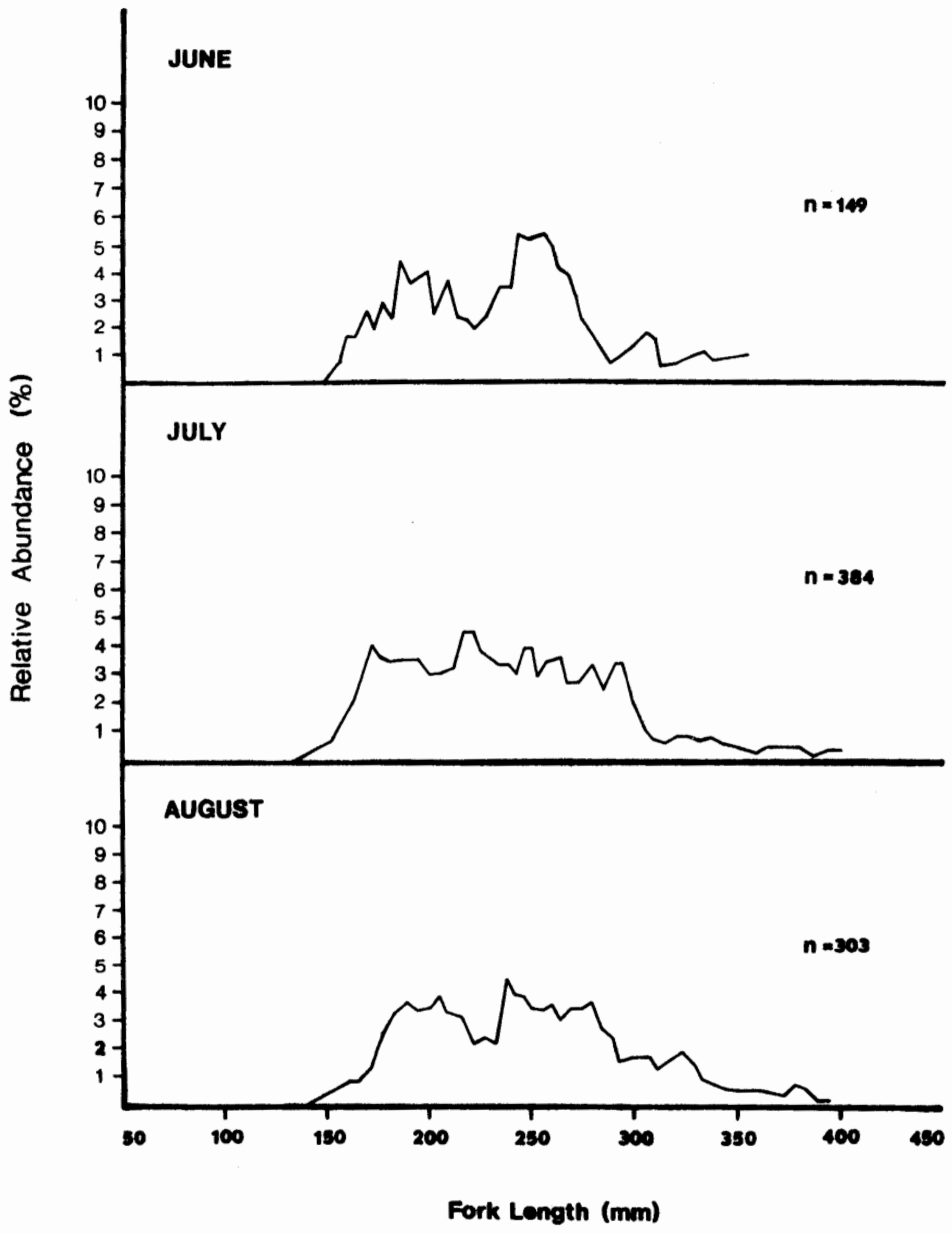

FIGURE 6. LENGTH FREQUENCY DISTRIBUTION BY MONTH FOR AREA II OF THE GOODPASTER RIVER, 1973.

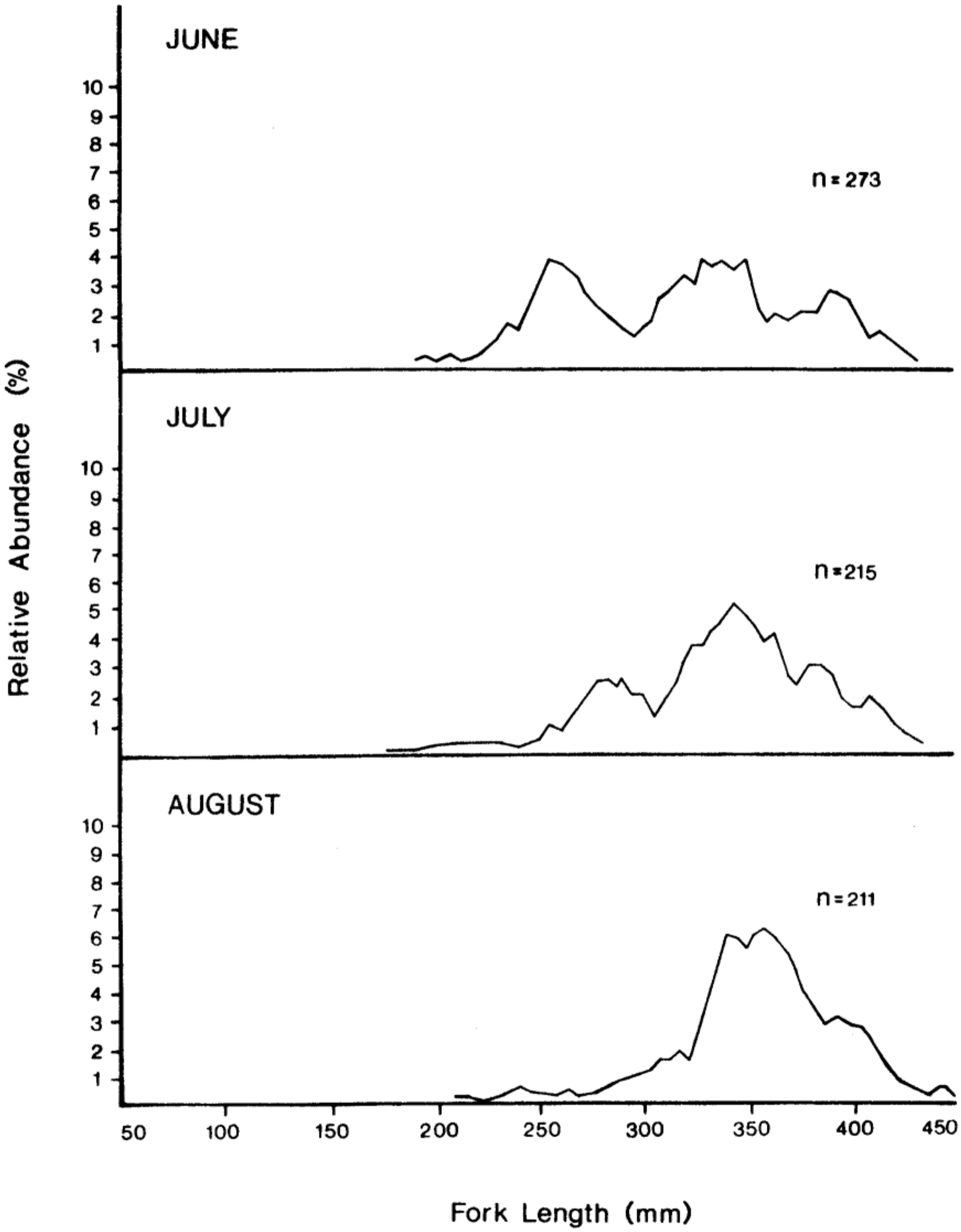

FIGURE 7. LENGTH FREQUENCY DISTRIBUTION BY MONTH FOR AREA III OF THE GOODPASTER RIVER, 1973.

Population Statistics From Age Frequency Data:

The population statistics for Goodpaster River grayling were determined from random subsamples of 98 - 100 fish from each of the three areas. The relation of the subsample to the total sample in each area was as follows:

	Whole Sample			Sub Sample		
	Area I	Area II	Area III	Area I	Area II	Area III
n	3,448	836	699	100	100	98
Mean Fork Length (mm)	196	244	335	191	238	325

The subsample represents slightly smaller fish but probably not sufficiently smaller to adversely affect the age composition. The initial sample is felt to fairly represent the extant population in the area during the summer of 1973. It was recognized, prior to sampling, that grayling populations stratify throughout a river system with relatively few but larger fish in the headwaters, and gradually more smaller fish encountered downstream. Thus, sampling was stratified into the three areas used throughout this study.

Scales from each fish in the subsamples were used to determine age. The age by area differed markedly as shown in Figure 8. Figure 9 shows the combined age frequency distribution for the three areas. The combined frequencies are the means of the three areas weighted by the Schnabel population estimate of grayling per mile in each area.

The problem of obtaining a representative sample has been solved for the 185 km (115 mi.) section of river studied for all age classes except 0, I, and II. Larger subsamples would improve the data and, of course, more accurate population estimates for Areas II and III would have improved the data. However, it is felt the calculated relationships of age class frequencies are close to the actual.

The curves of the age frequencies for Areas I and II (Figure 8) each have only two year classes in the descending part of the curve that are useful for calculation of survival rate. The survival rates derived from the area curves are affected by migration between areas, but if migration rate is constant, a change in survival rate over the years could be attributable to fishing effort. This concept of survival rate may be especially useful in Area I, where most of the fishing effort takes place and also most of the recruitment occurs.

In Area I, survival rate between the two best represented age classes, Age III and IV, is 44%. Comparing age class III with all older age classes gives an annual mortality rate of 67% or a survival rate of 33%, indicating that survival rate drops off after age IV. In the case of Area I, this could mean an increase of fishing effort or migration out of the area. From the near absence of age V and older grayling in this area, outmigration is probably the major factor.

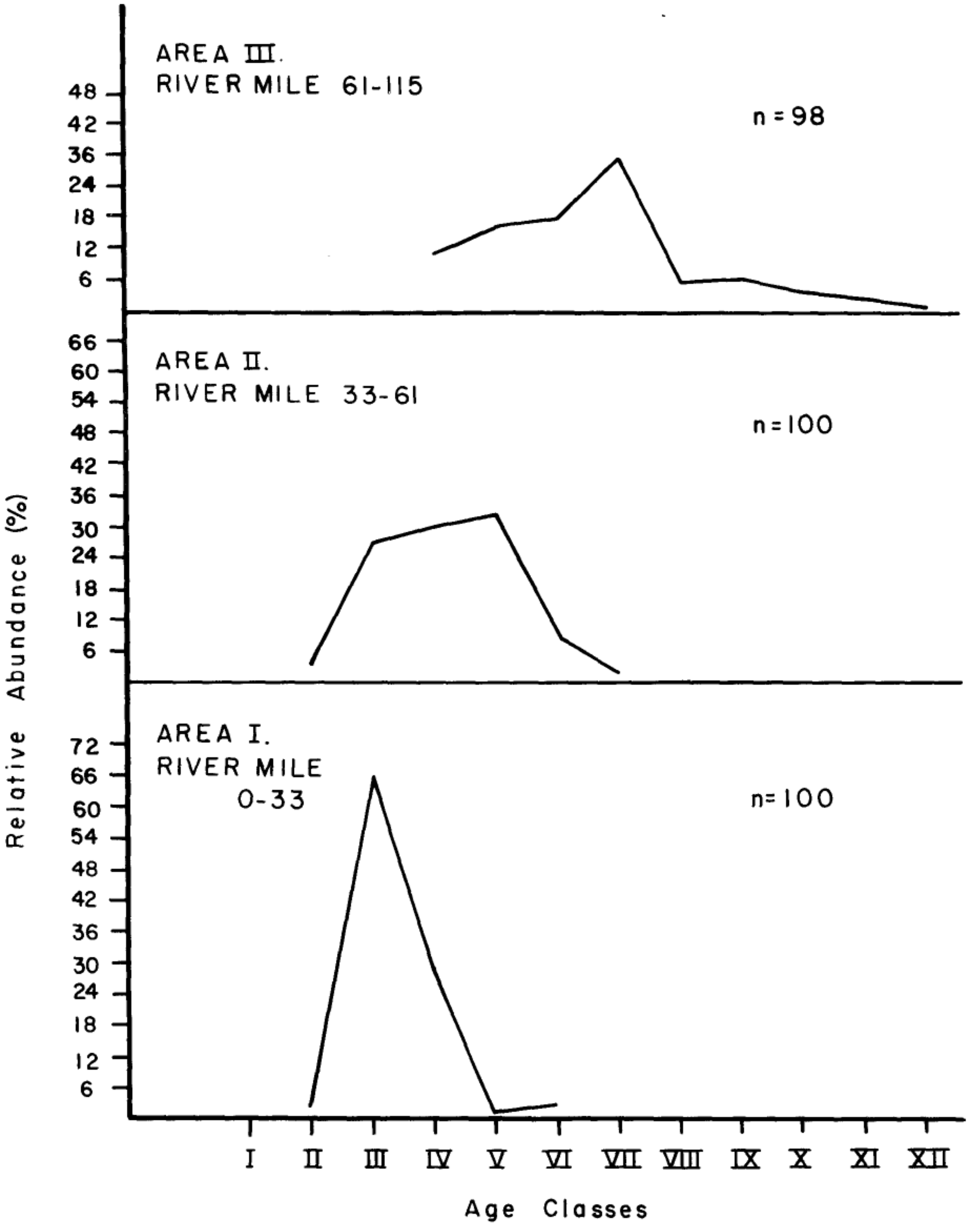

FIGURE 8. AGE FREQUENCY OF ARTIC GRAYLING IN THREE AREAS OF THE GOODPASTER RIVER, 1973, AS DETERMINED FROM RANDOM SAMPLES OF ALL GRAYLING CAPTURED IN RESPECTIVE AREAS.

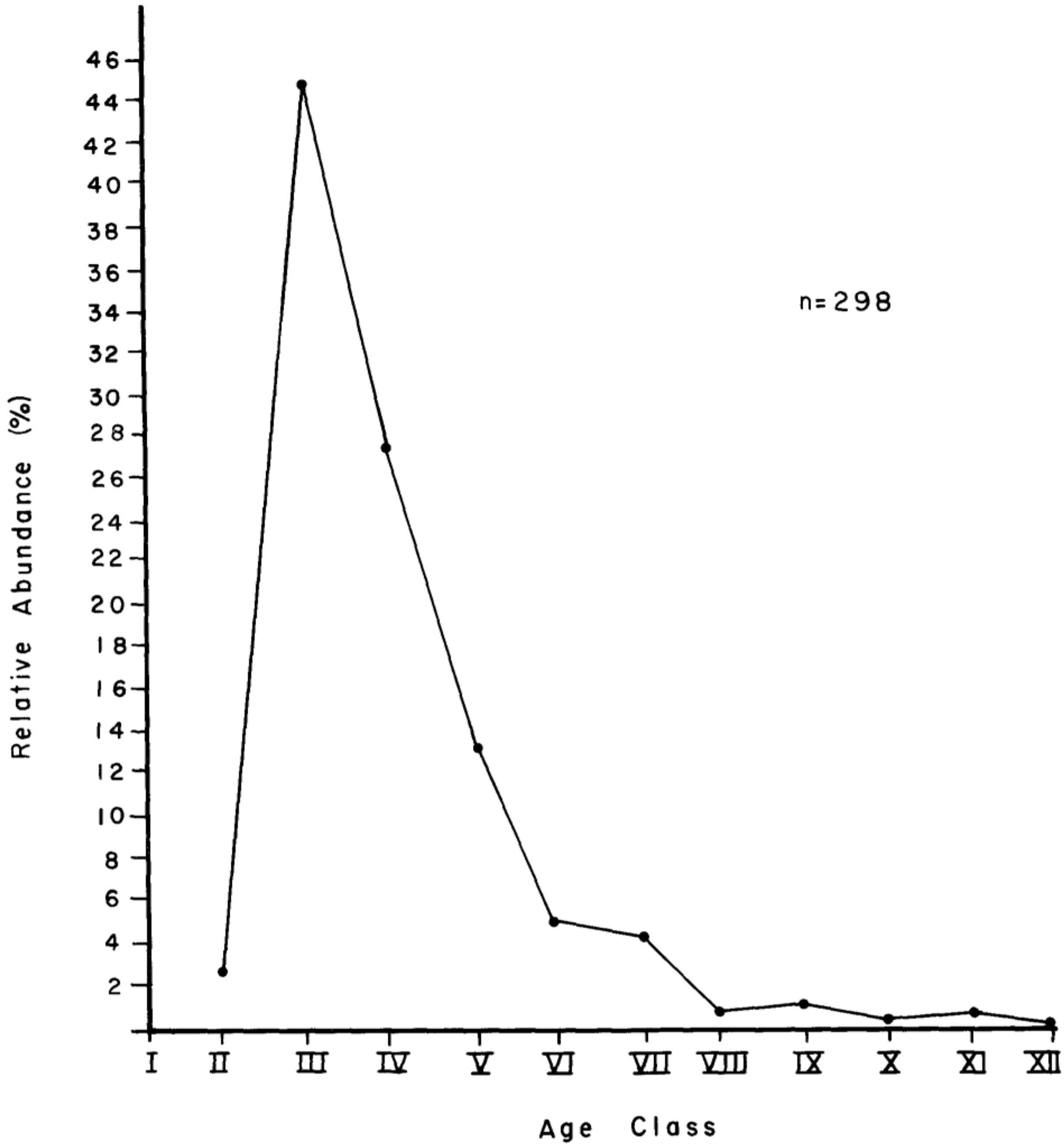

FIGURE 9. AGE FREQUENCY OF ARCTIC GRAYLING IN THE GOODPASTER RIVER, 1973, DEVELOPED FROM AGE FREQUENCIES FOR THREE SECTIONS OF THE RIVER COMBINED BY USING THE ESTIMATED POPULATION DENSITY IN EACH AREA AS A WEIGHTING FACTOR.

The survival rate between age classes V and VI in Area II is 23% and between age V and all older age classes, 24%.

In area III survival between age classes VII and VIII is 14% but increases to 35% when age class VII is compared with all older age classes. Migration into Area III appears to occur from age IV through VII, thus survival rate after age VII should be representative of the overall population if the rate is constant for the population.

Survival and mortality rates based on the weighted mean of frequencies for the three areas (Figure 9) are given in Table 14. The apparent under-representation of age class VI causes the data to be somewhat erratic. The depressed value for age class VI is probably the result of severe mortality of this group as young-of-the-year fish during the record flood in 1967 as noted by Tack (1971) for the Chena River.

The curve shown in Figure 9 can be divided into three parts: 1) the ascending arc; 2) the descending arc between age III and VIII; and 3) the descending arc between age VIII and XII. Age class II is not representatively sampled. Age III may or may not be representative but is felt to be taken representatively by the methods used. Mortality rate is relatively high between age III and VIII, then drops off between VIII and XII. It appears that once grayling reach age VIII and spend summers feeding in the inaccessible portion of the Goodpaster River above about km 98 (mile 61) survival rate is fairly high (74%). Of primary concern, then, is the second part of the curve, between ages III and VIII where the survival rate averages 48%. Angling, most of which is done in Area I where age III and IV grayling predominate, probably contributes to the high mortality rate of age IV fish (52%). Age III grayling are not generally desirable to anglers and show a mortality rate of only 38%. Also of interest is the sharp drop between ages VII and VIII. More than a single year's data is needed to explain this problem.

Table 14 also shows the magnitude of each age class above age II in the 185 km (115 mi) section of river sampled. If the survival rate is constant, and we take as an average the comparison of age III with all older age classes (54%), the magnitude of age classes II, I, and 0 are 37,460, 69,578, and 129,232, respectively. If this extrapolation is correct, the total hatch of eggs from only 26 female grayling would perpetuate the stock at this level. However there are about 3,144 adult females represented in this sample which would produce about 16 x 10^6 eggs. This would indicate an egg-to-fry survival rate of 81%.

The above expansions and extrapolations are only intended to give an idea of the magnitudes involved not specific quantities. The large losses between deposited eggs and recruited age III fish may be much harder to control than the relatively small losses occurring after recruitment.

TABLE 14. Vital Statistics of the Goodpaster River Arctic Grayling Population Obtained from Age Frequency Data, 1973.

Age Class	Percent Frequency	Annual Survival Rate	Instantaneous Mortality Rate i	Annual Mortality Rate a = 1 - S	Population Magnitude % Freq. x Schnabel Estimate of 45,000 GR, Age III and Older
II	2.72				
III	44.82				20,169
		.618	.48	.381	
IV	27.71				12,469
		.480	.73	.518	
V	13.31				5,990
		.391	.94	.609	
VI	5.20				2,340
		.827	.19	.173	
VII	4.30				1,935
		.107	2.23	.892	
VIII	0.46				207
		----	--	----	
IX	0.55				248
		.673	.40	.330	
X	0.37				166
		.757	.28	.244	
XI	0.28				126
		.321	1.17	.690	
XII	0.09				40

Fishing Mortality vs. Natural Mortality

The foregoing discussion of survival rate and its complement, mortality rate, has considered all mortality cases combined. It is possible to estimate the portion of mortality due to fishing from the creel census data presented in Table 13. An estimated 2,236 grayling were caught and kept by anglers during the summer of 1973. This would have reduced the overall population of 45,000 grayling to 42,764 for an annual fishing mortality rate of 5%. The total annual mortality rate was 46%, so the annual natural mortality rate was 41%. Thus, for all fish age III and older the annual fishing mortality accounts for only 10.9% of all mortality.

Population Statistics Obtained from Bailey Triple Trellis Method

The population statistics obtained by this method (Table 15) are regarded as less satisfactory than those obtained from age frequency data because the requirements of the marking scheme were not fully met for the Bailey method. In Areas II and III, too few fish were marked on the initial sampling period to provide sufficient recaptures for accurate calculations.

In Area I sampling conformed quite well to the requirements and the results for this area agree rather well with those obtained by age frequency data. The indication that recruitment rate is less than mortality rate is misleading because sampling was cut off between year classes II and III rather than at a particular length. To adequately measure recruitment the lower size limit of marking would be a length past which most age II fish grew during the study.

Capture Rate:

The relative capture rate of the various species susceptible to electrofishing provides an index of their relative numbers (Figure 10). The index is rough and was biased by the fact that grayling was the target species during all sampling.

However, it is felt the data show the correct ranking of species by abundance Round whitefish and longnose suckers are probably more abundant than indicated.

The decline in the capture rate of grayling in Area I through the summer reflects the decline in population shown by the Bailey population estimates (Table 12). The decline in Area I corresponds with an increase in Area II.

Meristics and Morphometrics

Data on dorsal and pelvic fin development were collected and will be used in comparative studies on the variation of these characters between and within populations. The mean lateral line scale count of 28 Goodpaster River grayling was 92.4 with a range of 85 - 98. This compares very closely with the mean of 92.5 (range 79 - 101, n = 197) for the Chena River (Tack, 1973).

TABLE 15. Vital Statistics of the Goodpaster River Arctic Grayling Population Obtained by the Bailey Triple Trellis Method During the Summer of 1973.

Statistic	Area I	Area II	Area III	Combined
Survival rate between first & second sampling	.5224	*	.1787	.5282
Recruitment rate between second & third sampling	1.3169		2.9854	1.3674
Instantaneous rate of mortality=$i_{1,2}$	.6494		1.7218	.6384
$i_{1,2}$ per day	.0176		.0465	.0172
Instantaneous rate of recruitment $Z_{2,3}$	.2753		1.0937	.3129
$Z_{2,3}$ per day	.0081		.0322	.0092
Instantaneous rate of population change	-.0094		-.0144	-.0080
Actual change	-.4190		-.5315	-.3470
Population at first sampling	22,547		1,817	35,346
Population at second sampling	13,100	16,128	851	23,081
Population at third sampling	9,231		556	7,135

*Insufficient data for calculations

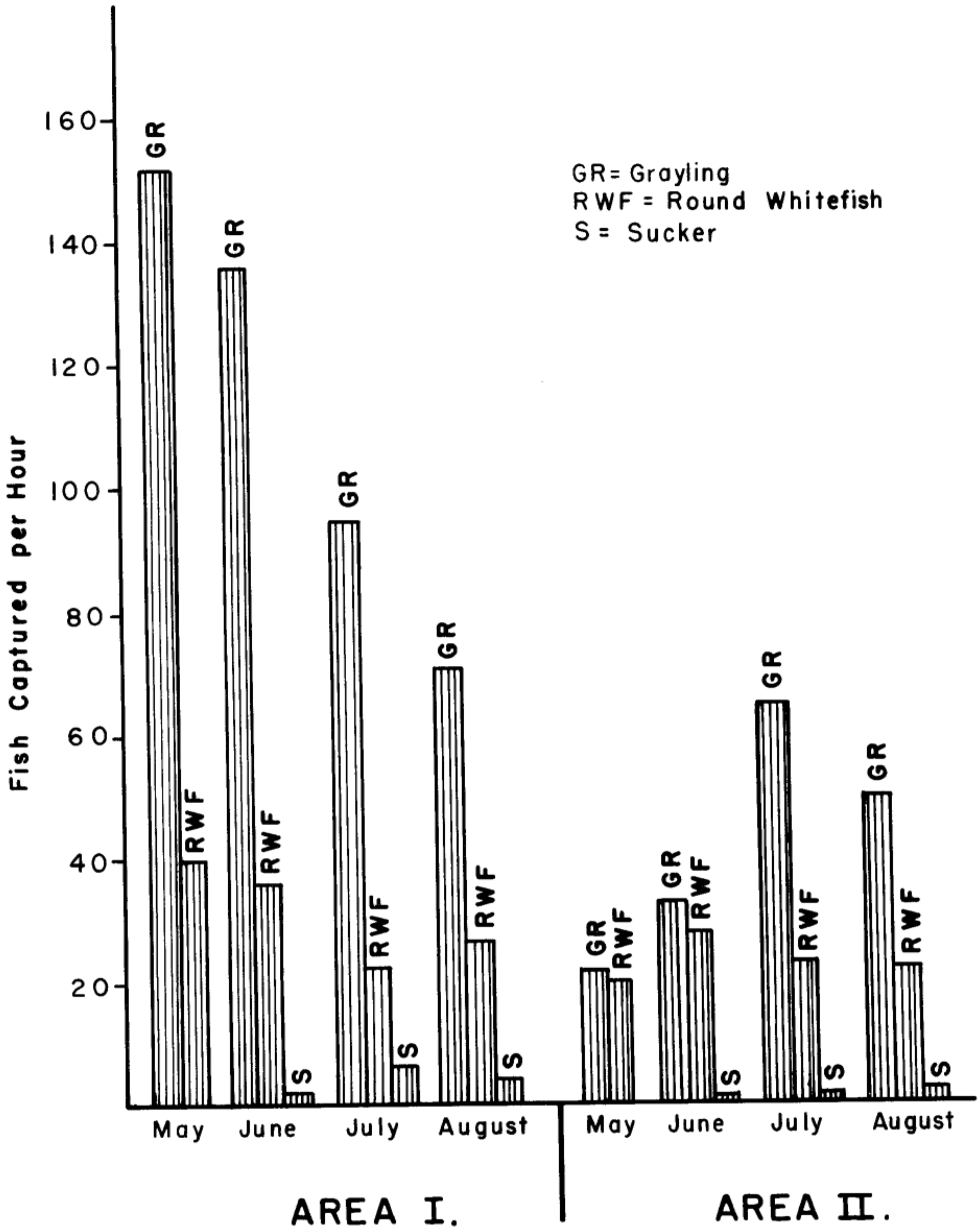

FIGURE 10. CAPTURE RATE OF GRAYLING, ROUND WHITEFISH, AND SUCKERS BY BOAT-MOUNTED ELECTROFISHING UNIT ON THE GOODPASTER RIVER, 1973.

Length-Weight Relationship

Data from 92 grayling captured during spring netting were used to establish a length-weight curve for Goodpaster River grayling (Figure 11). The points in Figure 11 are mean weights by 5 mm length groups. The line was fitted by inspection and was extrapolated for later use in calculating stream biomass.

Length and Age at Maturity

Both male and female grayling captured at the forks of the Goodpaster River during April and May 1973 reached 100% maturity in the population at 310 mm fork length (Table 16). All males age VI and older were mature, while females were not 100% mature until age VII. Males began maturing at 290 mm fork length and 5 years of age. Females began maturing at 260 mm fork length and 5 years of age.

TABLE 16. Length at Maturity of Arctic Grayling Captured in the Goodpaster River, Spring, 1973.

		Females		Males	
Fork Length (mm)	Age	n	Number Mature	n	Number Mature
less than 250	IV	3	0	6	0
	V	1	0	1	0
250-259	IV	1	0		
	V	3	0	1	0
260-269	IV			1	0
	V	3	1	2	0
270-279	V	1	0	1	0
	VI	1	0	1	0
280-289	V	1	1	3	0
	VI	2	1	2	0
290-299	V	1	0	5	4
	VI	1	1		
300-309	V			1	0

Table 16. (cont) Length at Maturity of Arctic Grayling Captured in the Goodpaster River, Spring, 1973.

Fork Length (mm)	Age	Females n	Females Number Mature	Males n	Males Number Mature
	VI	2	1	2	2
	VII	1	1		
310-319	VI	1	1	5	5
	VII	1	1		
320-329	V	1	1		
	VI			2	2
	VII	1	1	1	1
330-339	V			1	1
	VI			3	3
	VII	2	2		
	VIII	1	1		
340-349	VII	2	2	3	3
	VIII	2	2	1	1
350 and over	VII			1	1
	VIII			2	2
	IX	1	1	7	7
	X	1	1	3	3
	XI			1	1

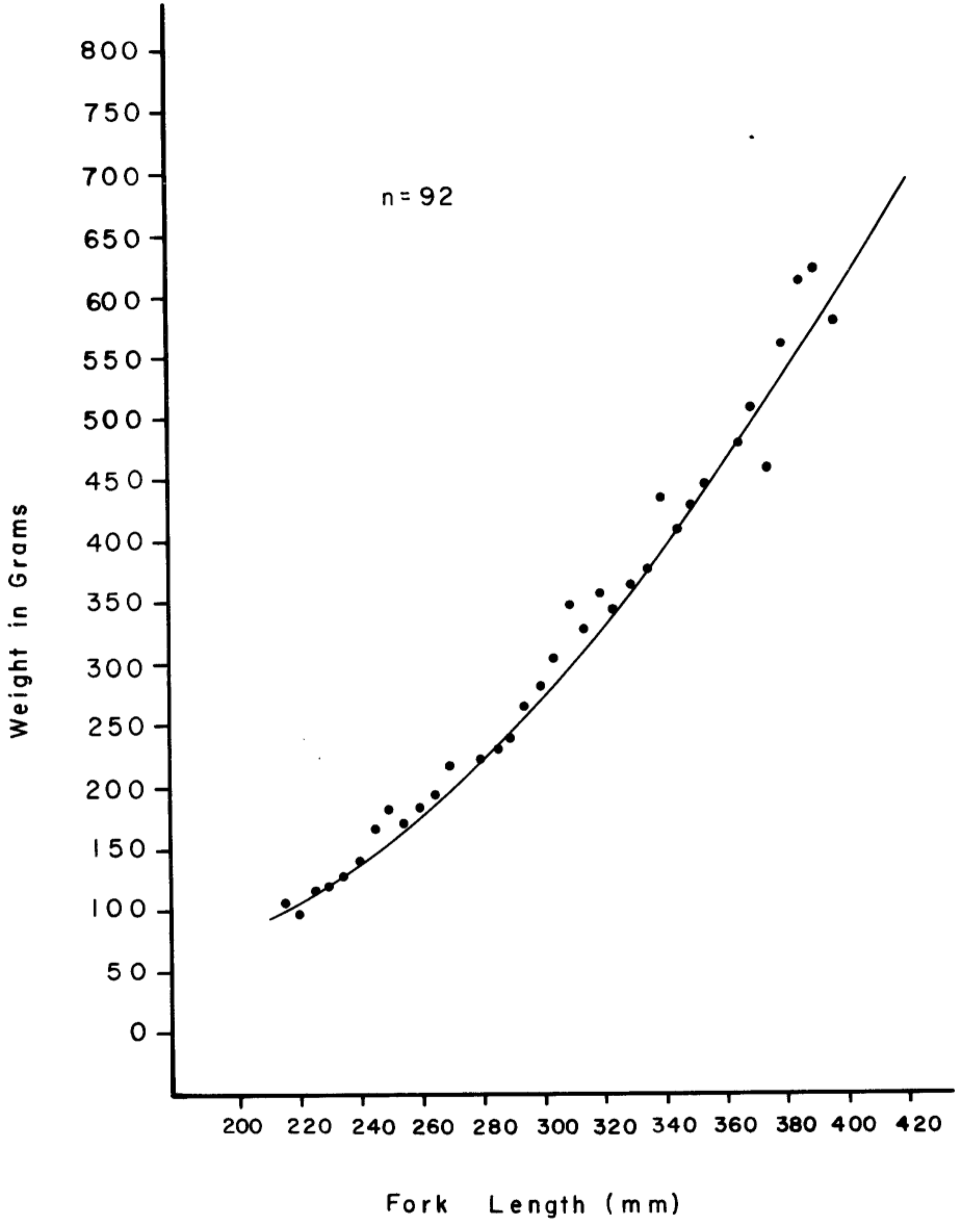

FIGURE 11 , WEIGHT TO LENGTH RELATIONSHIP OF GRAYLING CAPTURED DURING APRIL AND MAY, 1973, AT THE FORKS OF THE GOODPASTER RIVER.

The situation in the Goodpaster is in sharp constrast to that found in the Chena River and at Mineral Lake Outlet. Chena River grayling are 100% mature at 270 mm fork length for both males and females (Roguski and Tack, 1970).

At Mineral Lake Outlet, grayling began maturing at age IV and reached 100% maturity at age VI and 270 mm fork length (Tack, 1971).

The age, or size, or both at which fish mature is genetically controlled and is often characteristic of a genetically isolated population. The explanation for the greater age and larger size at maturity among Goodpaster River grayling may be that the Goodpaster grayling have a history of relatively light exploitation, especially of older fish that migrate to the upper river during the summer. The Chena River and Mineral Lake Outlet populations have been heavily harvested for at least 10 years and were moderately harvested for 30 years before that. Since the larger fish are preferentially sought by anglers, there would be an increased selective pressure on grayling maturing at a larger size and also on grayling maturing at an older age.

When the population is fished to the point where most of the spawning is done by first year spawners, the selective pressure will strongly favor the genotype producing maturity at a small size and early age. Further study of the effect of exploitation on the population genetics of the Arctic grayling is needed. The effect of fishing on potential maximum size and age also needs investigation since it may well be related to the growth characteristics of early maturing fish.

Age and Growth of Goodpaster River Grayling

Ages of a random subsample of 298 grayling from a total of 4,983 grayling captured throughout the summer of 1973 were determined by scales. A plot of the mean fork lengths by age class is shown in Figure 12. The annual increment of growth in length increases until age V when it reaches 51 mm per year. Between ages VI and IX the growth increment remains fairly constant at about 27 mm. After age IX the increment drops to about 10 mm per year.

Egg Counts

Ovaries from 22 mature and 13 immature Goodpaster River grayling were collected during the two week period prior to spawning in 1973. The mean fresh weight for the immature grayling ovaries was 1.2 gm (range 0.3 - 2.8 gm). Egg size, ovary size, and mean egg counts for the mature fish are presented in Table 17. The linear regression of egg number on fork length and the least squares equation for the line is shown in Figure 13.

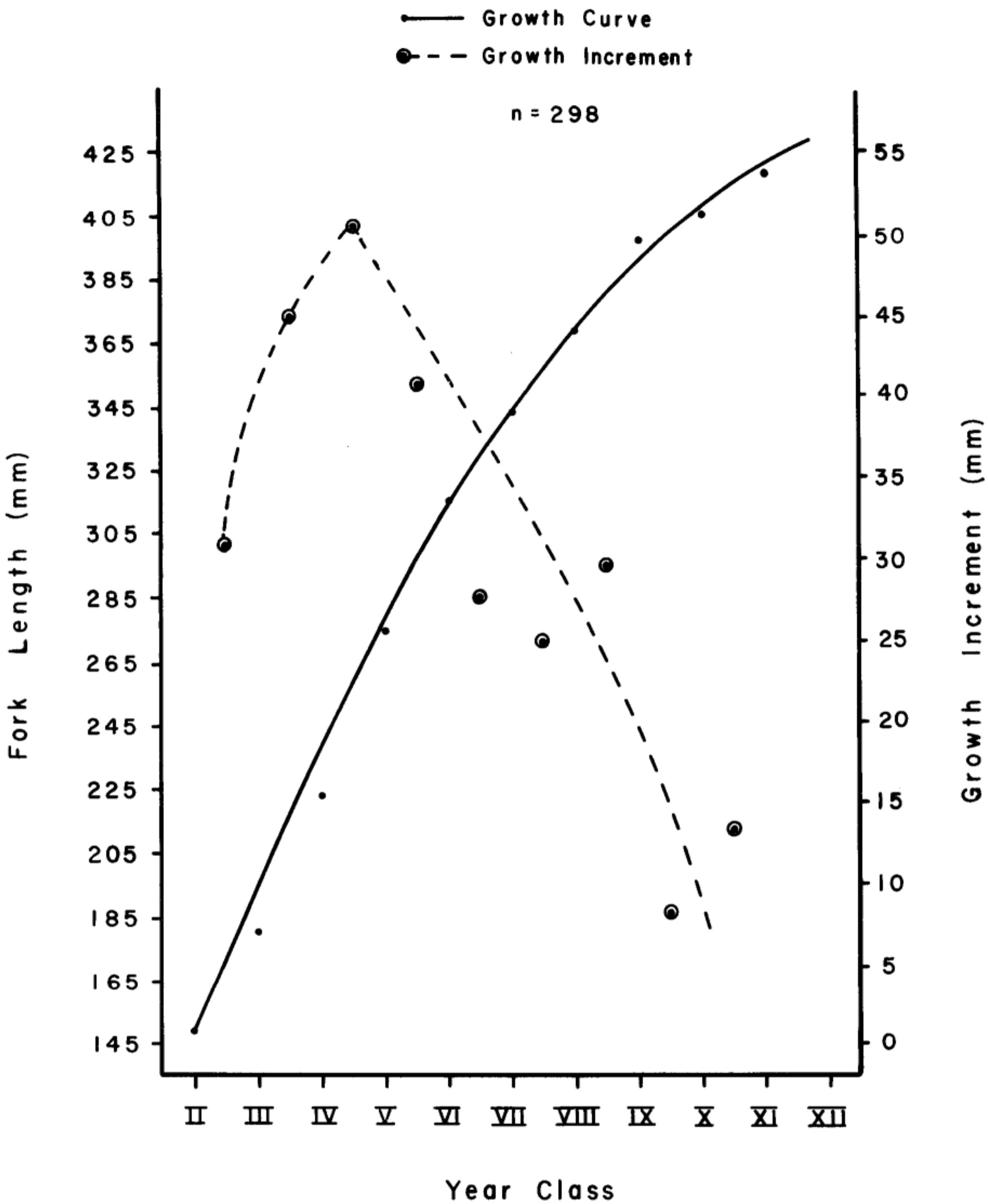

FIGURE 12 . GROWTH OF GOODPASTER RIVER GRAYLING CALCULATED FROM OBSERVED LENGTHS OF FISH COLLECTED THROUGHOUT THE SUMMER OF 1973.

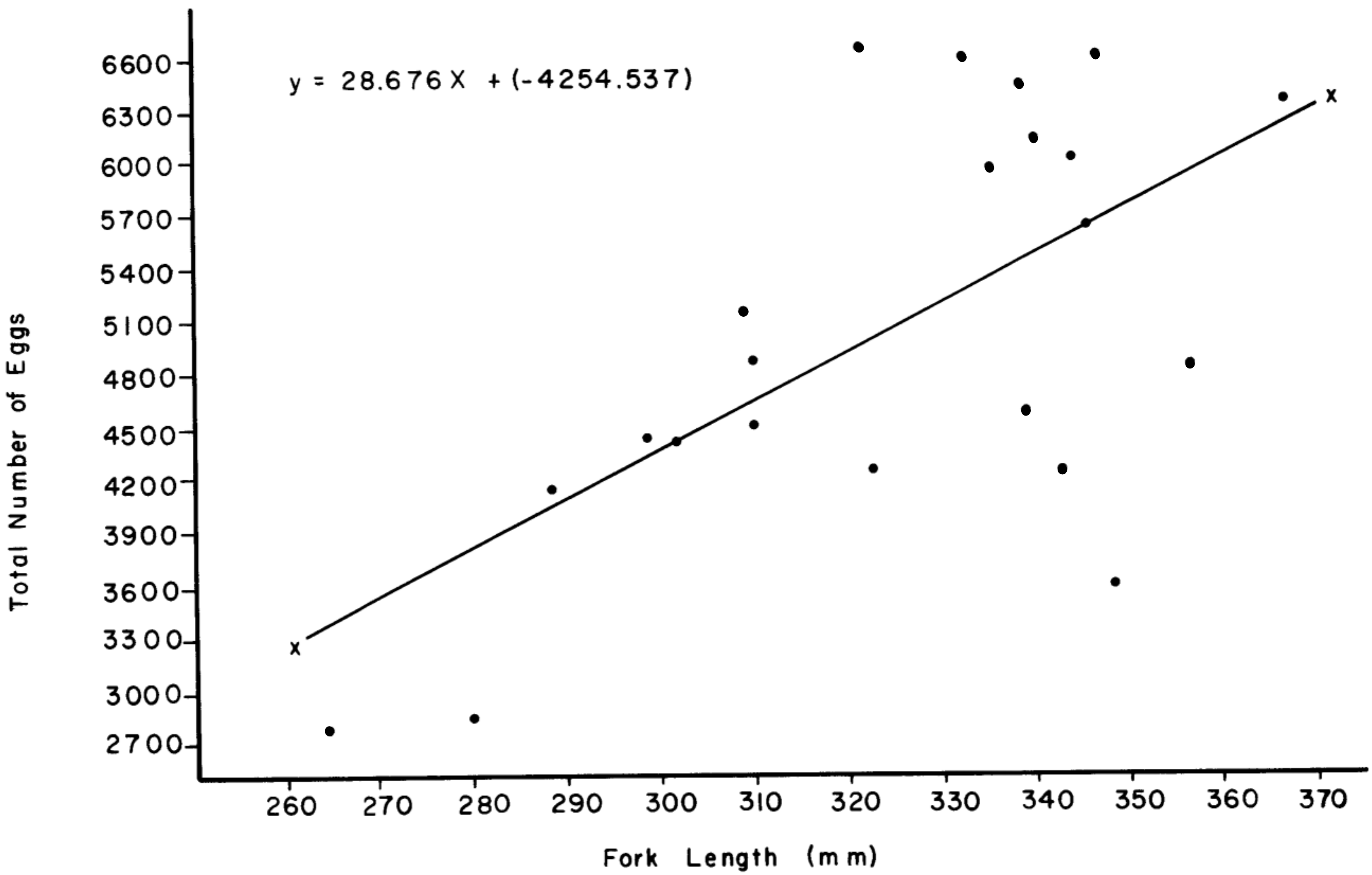

FIGURE 13 . LINEAR REGRESSION OF EGG NUMBER ON FORK LENGTH FOR 22 ADULT FEMALE GRAYLING FROM THE GOODPASTER RIVER, SPRING 1973.

TABLE 17. Characteristics of Eggs and Ovaries from 22 Gravid Female Goodpaster River Grayling, 1973.

Fork Length (mm)		Fresh Ovary Weight (gm)	Fresh Egg Diameter (mm)	Preserved Egg Diameter (mm)	Eggs Per ml	Ovary Volume (ml)	Total Eggs
$\bar{x}$	324	40.7	2.1	2.2	177	29.2	5,044
Range	264-366	7.5-63.3	1.9-2.4	2.0-2.4	150-230	12-42	2,760-6,660

Biomass Distribution:

The biomass of grayling by study area in the Goodpaster River was calculated by multiplying the Schnabel population estimate for each area by the percent occurrence of each 5 mm length group to obtain the number of fish in each length group. This value was then multiplied by the mean weight of grayling for each 5 mm length group obtained from the length-weight regression (Figure 11). The results (Table 18) are subject to the limitations of the population estimates, the degree of which are greater for Areas II and III than for Area I.

TABLE 18. The Calculated Biomass of Arctic Grayling over 150 mm Fork Length in Three Areas of the Goodpaster River, 1973.

Area	Length of Area km	mi.	Calculated Biomass (kg)	Biomass in kg per km
I	53	33	2,397	45
II	45	28	2,555	57
III	87	54	2,843	33

The standing crop of biomass differs markedly from the numerical standing crop because of the stratification of size groups within the system. The weight of fish supported per km of river is highest in Area II. However if the surface area of stream is considered, Area III would probably be about the same as Area II because of its smaller width.

Job R-I-B Early Life History of Arctic Grayling in the Goodpaster River.

OBJECTIVES

1. Determine grayling spawning areas in the Goodpaster River.

2. Determine grayling spawning time in various parts of the Goodpaster River.

3. Determine growth and scale development of grayling fry throughout the river.

Growth and Scale Development

Scales first appear on Chena River grayling at a fork length of 35 - 38 mm (Tack, 1971). This range appears to hold for Goodpaster River grayling as well (Table 19). The addition of circuli then follows growth in length quite closely, so that circuli counts can be used to estimate length and vice-versa.

The first annulus forms during June the year after hatching. All yearling grayling taken on June 25 exhibited one to five circuli outside the annulus, whereas only 4 of 13 yearlings taken June 10 had an annulus. The annulus was easily seen even with as few as two circuli between the focus and the annulus. No misreadings were apparent out of 230 scales read.

A possible problem could occur if age 0 fish went into the winter before forming a scale and at least one circulus (less than 40 mm fork length) but this does not appear to happen in the Goodpaster River (Figure 14).

From a sample of 106 yearling grayling, the mean number of circuli to the first annulus was 6.34, ranging from 2 - 11. The estimated fork length (from Table 19) of a grayling with this mean count would be about 60 mm, which compares very well with the observed means for the May and September samples (Figure 14).

The effect of such widely varying growth during the first growing season seems to diminish slightly during the next growing season. Age 0 fish that stopped growing at four circuli were 23 mm shorter than fish with nine circuli prior to annulus formation; however, by July of the following year these two groups were separated by only 14 mm. On the basis of number of circuli added beyond the annulus (Table 19) growth appears quite uniform during the second growing season, independent of size at the start of the second season.

The apparent drop in mean size between the September young-of-the-year sample and the May yearling sample is probably an artifact caused by sampling only the lower 30 miles of the Goodpaster River in September, whereas the May sample which was taken between river km 34 and 58 would probably contain fish reared much further upstream during the previous year. Figure 15 shows the generally slower development of age 0 fish in the upper sections of the river.

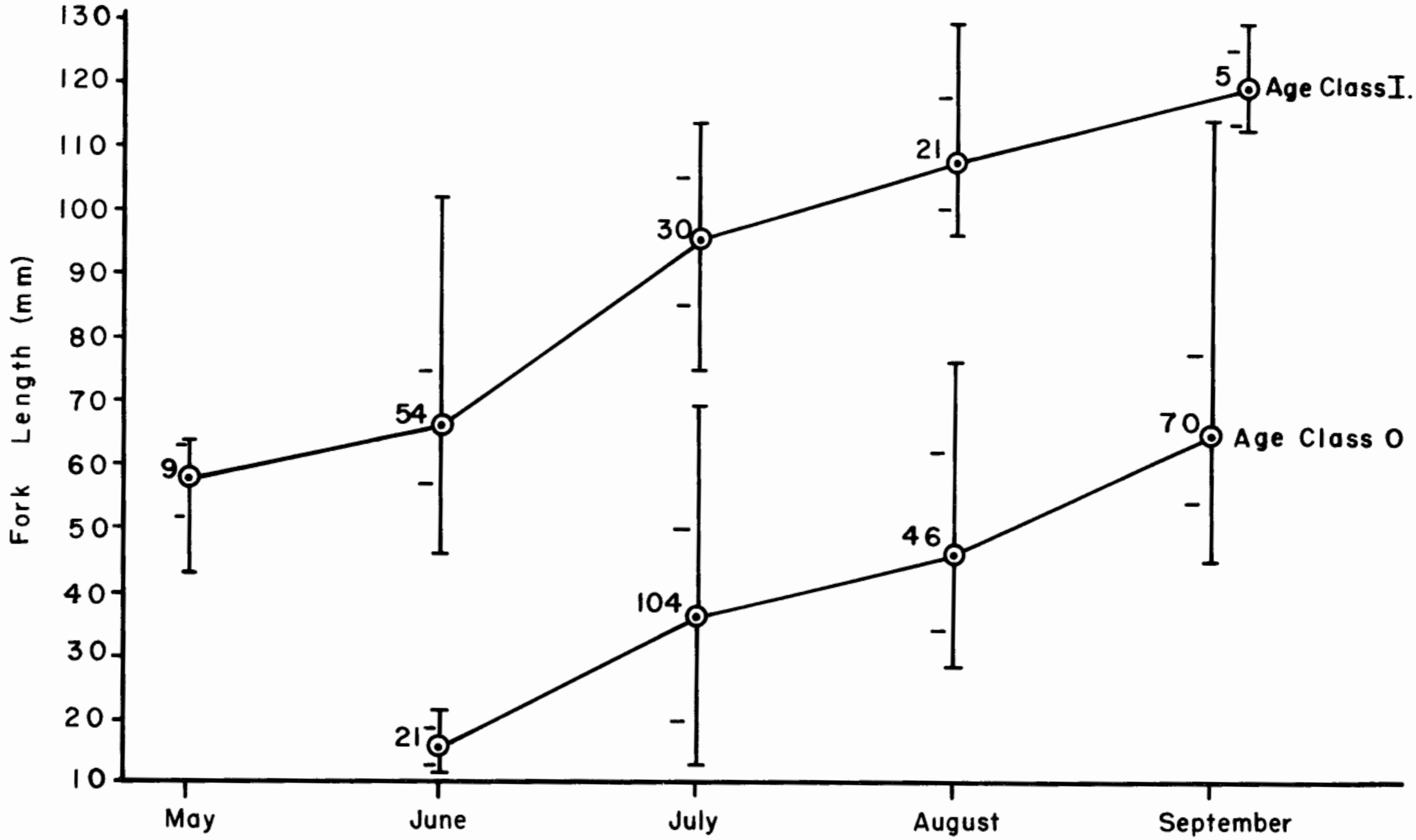

FIGURE 14. GROWTH OF YOUNG-OF-THE-YEAR AND YEARLING GRAYLING IN THE LOWER 70 MILES OF THE GOODPASTER RIVER, 1973, SHOWING THE MEAN (CIRCLED), RANGE (VERTICAL BAR), AND ONE STANDARD DEVIATION (LEFT HORIZONAL TICK), AND NUMBER OF FISH TAKEN DURING EACH MONTH.

TABLE 19. Growth and Scale Development of Age 0 and Age I Grayling in the Goodpaster River, 1973.

No. of Circuli (To 1st Annulus for Age I)	Age Class 0 Fork Length (mm)			July Sample			August Sample		
	n	Mean	Range	n	Mean Fork Length (mm)	Mean Circuli outside annulus	n	Mean Fork Length (mm)	Mean Circuli outside annulus
0	1	37							
1	1	37							
2	2	40	37-42						
3	2	42	39-44						
4	10	47	38-57	6	89	7.0			
5	15	52	41-67	4	87	6.5	3	101	9.3
6	21	57	50-68	6	95	8.2	1	111	9.0
7	39	62	54-75	5	100	8.4	6	106	8.8
8	27	66	56-77	3	103	9.0	5	110	8.6
9	4	70	65-76	5	103	8.2	4	116	8.5
10	4	79	75-89						
11	8	82	67-93						

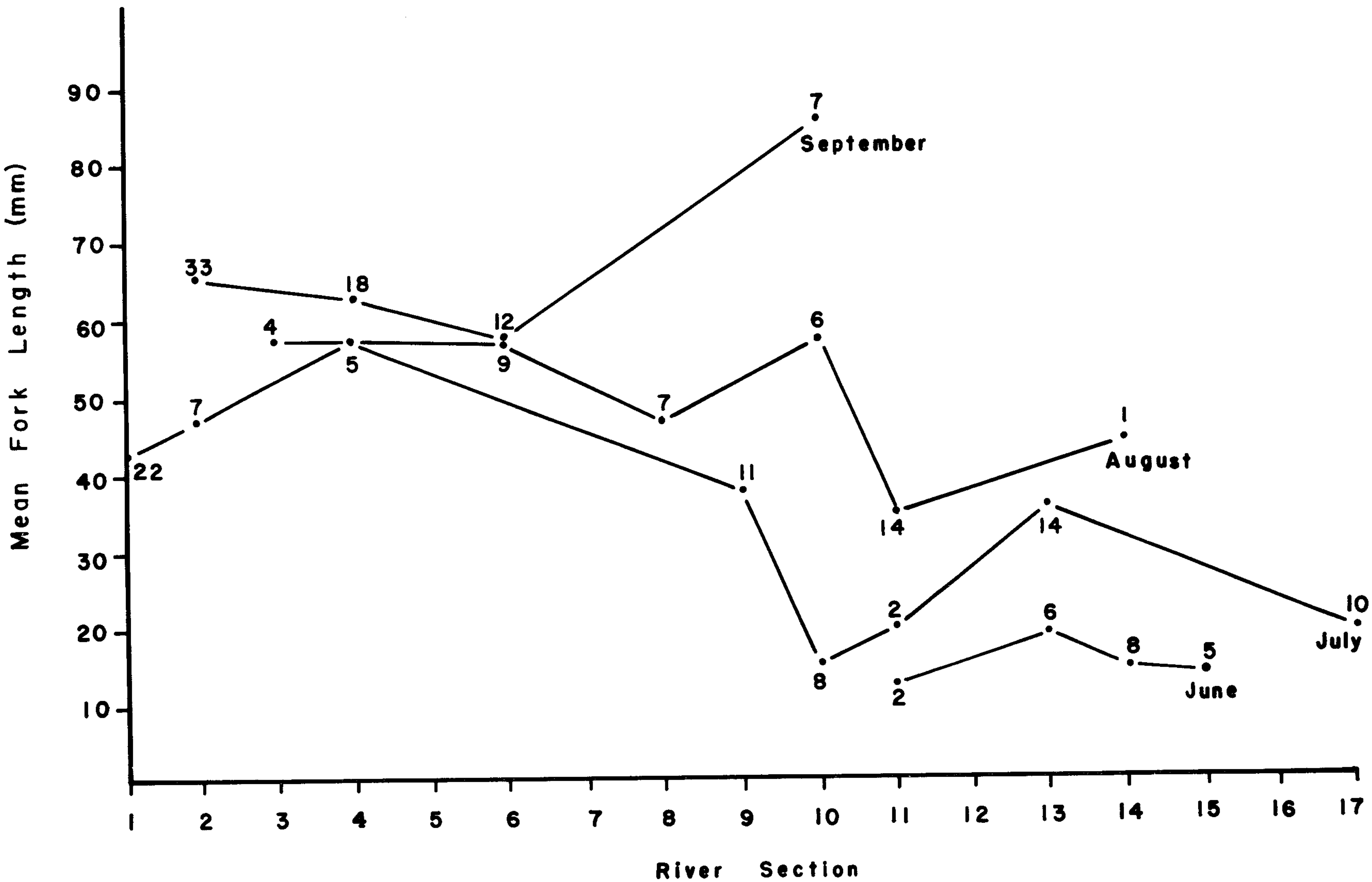

FIGURE 15. MEAN FORK LENGTH AND NUMBER IN SAMPLE OF AGE CLASS 0 ARCTIC GRAYLING BY RIVER SECTION BY MONTH, GOODPASTER RIVER, 1973.

Another possible explanation for the small mean size of the May sample as compared to the September sample could be that inferior growing conditions existed in 1972. The September 1973 sample represents age 0 fish going into the winter at above average length (66.1 mm) and above average circuli numbers (7.87). Only one out of 70 fish had five circuli; the others had from 6 to 11. The condition of age 0 fish in late fall and early spring may be a useful indicator to the relative quality of a growing season for grayling. Larger samples than used in this study would be needed for May and September and these would have to be taken similarly year after year.

Spawning Distribution and Timing

The spring netting study described earlier in this report revealed large numbers of gravid grayling moving upstream past the 53 km (33 mi) site in late April and early May. On May 10 the river was electrofished intermittently between 53 km and the mouth, revealing many gravid grayling throughout the section. The water temperature rose to a maximum of 1.5°C at 53 km and 3.7°C at the mouth on this day. The weather remained warm for the next two days, and on May 13 the lower 53 km was again electrofished in search of spawning grayling. The water temperature reached 4°C at 2 PM on this day and ripe grayling were captured on most riffles below 29 km (18 mi). Not all gravid grayling were ripe at this time. On May 14 the water temperature rose rapidly to 4°C and reached a maximum of 7.5°C near the mouth.

Spawning probably began about May 11 near the mouth and according to Figure 16 about May 18 at km 53 (temp. = 4°C).

Gravid grayling were known to be moving up both the North and South forks of the river prior to spawning, but the extent of their migration is not known. It is probable that the farther upstream they travelled the later they would spawn.

Fry Distribution

During July an extensive search for grayling fry was conducted throughout the 185 km (115 mi) long study area and fry were found over the entire distance. Grayling fry were also found 26 km up the South Fork of the Goodpaster River, which was the upper limit of survey. Fry at 185 km on the North Fork averaged 19.7 mm fork length on July 25 and those at 42 km on the South Fork, 17 mm fork length on July 23. At 9.6 km (6 mi) of the main Goodpaster River fry averaged 47 mm fork length on July 15.

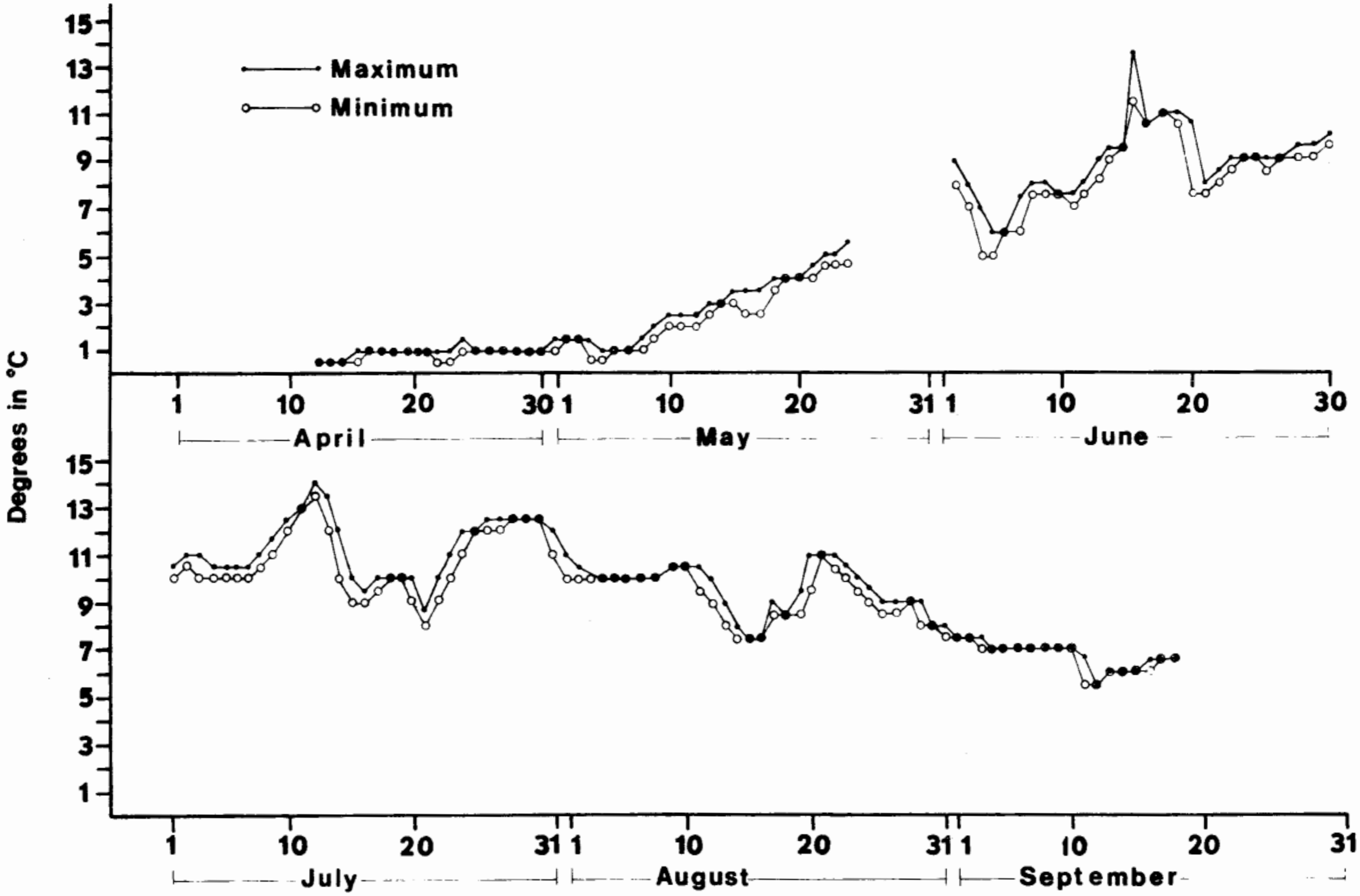

FIGURE 16. TEMPERATURE PROFILE AT CONFLUENCE OF NORTH AND SOUTH FORKS OF THE GOODPASTER RIVER, 1973

Job R-I-C The Winter Ecology of the Arctic Grayling in the Tanana River Drainage with Special Emphasis on the Goodpaster River System.

OBJECTIVES

1. To develop methods of sampling grayling during the winter months.

2. Determine overwintering areas and conditions extant in overwintering areas.

Winter Distribution

On March 1 and 2, 1973 the lower 8 km (5 mi) of the Goodpaster River was surveyed. Six holes were bored through the 76 cm (30") of ice. Water was flowing under the ice in all locations except at the immediate mouth of the river. At this site there was an obvious drop in the ice surface from the Goodpaster River to the Tanana River, indicating the Goodpaster River ice was resting on the bottom. This indication was later verified when the Tanana River ice melted away from the mouth of the Goodpaster River, revealing the bed of the Goodpaster. Apparently the Goodpaster River water was moving through the river bed gravel into the Tanana River.

The water in the Goodpaster River above the mouth contained 4 to 5 ppm of dissolved oxygen, 45 ppm CO_2, 68 ppm total alkalinity and had a pH of 6.5. The water temperature was 0.3°C. The water depth under the ice ranged from 15 cm in a riffle area to 270 cm in a large hole.

Water quality seemed suitable for grayling survival but angling with salmon eggs was ineffective.

Between March 28 and April 1 electrofishing was used to search for grayling in the Tanana River adjacent to the Goodpaster River mouth and about 10 km down the Tanana River from the Goodpaster River mouth. Very few grayling were captured, although large numbers of round whitefish were taken. It is possible that grayling remained under the iced-over portion of the Tanana River at this time.

On April 10, netting was begun 53 km (33 mi) up the Goodpaster River as described previously in this report. This netting indicated that grayling from the Goodpaster River overwintered somewhere downstream from the 53 km site. It seems probable that most grayling left the Goodpaster River and overwintered in the Tanana River or some other tributary of the Tanana.

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