Fishery Data Series No. 94-19

Arctic Grayling Investigations in the Tok River Drainage During 1993

by

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ABSTRACT

This study was partially undertaken because knowledge of Arctic grayling *Thymallus arcticus* in the Tok River drainage of eastern interior Alaska was deficient in providing direction for the management of the drainage's seasonal Arctic grayling fisheries. Impetus behind the study was recent public concern that the Arctic grayling fishery in the Tok Overflow, a tributary of the Tok River, had severely deteriorated. The study objectives were to estimate the age and size composition of Arctic grayling in the Tok Overflow. These objectives were not met due to the scarcity of fish; however, Arctic grayling were sampled in four other locations in the drainage: the Tok River, Little Tok River, Tok Overflow #2, and Mineral Lake Outlet. The Tok River below the Tok Overflow was found to be an overwintering area for Arctic grayling that disperse upstream at least to Mineral Lake Outlet. Water temperatures indicated the Tok Overflow to be the coldest stream in the study area and likely inhospitable as a summer feeding area for Arctic grayling. Age and size compositions of adult Arctic grayling spawning in Mineral Lake Outlet are presented and compared to similar samples collected in 1988 and 1990. Males were significantly larger than those sampled in prior studies possibly due to four years of restrictive sport fishery regulations. The study provided needed insight of the Arctic grayling resource and habitat in the Tok River drainage and afforded a starting point in addressing public concerns and formulating objectives for future research investigations.

KEY WORDS: Arctic grayling, *Thymallus arcticus*, age composition, size composition, spawning composition, overwintering, water temperatures, Relative Stock Density, Mineral Lake Outlet, Tok Overflow, Little Tok River, Tok River, Tanana River drainage, Dolly Varden, *Salvelinus malma*.

INTRODUCTION

Background

Road accessible fisheries for Arctic grayling *Thymallus arcticus* (hereafter referred to as grayling) in the vicinity of Tok, a community of 1,300 at the junction of the Alaskan and Glenn (Tok Cutoff) highways, are sparse and small in size. These fisheries are, for the most part, concentrated along a 21 km stretch of highway within the Tok River drainage 31 km south of Tok and include the Little Tok River, Tok River, Tok Overflow, and Mineral Lake (Figure 1). The mean annual harvest of grayling is 938 fish of which 613 grayling, or 65% of the total, comes from the Little Tok River (Table 1). These fisheries are either highly seasonal or subject to disruption from glacial, spring, and storm runoff events.

Historically, local fishermen have expressed frustration over the general lack of roadside fishing opportunities in their area. In 1987, this frustration changed to concern over an apparent decline in catch rates and size composition of their accessible grayling fisheries. Initially, their concern centered on the spring fishery at Mineral Lake Outlet which led the Alaska Board of Fisheries to enact regulations to protect grayling in this fishery in 1988[1]. More recently, local concern focused on the grayling fishery at the Tok Overflow, a small spring-fed tributary to the Tok River 21 km by highway below Mineral Lake Outlet. The Tok Overflow historically provided an earlier spring fishery than that of Mineral Lake Outlet. Local anglers have complained of few to no grayling in the Tok Overflow in the past few years (K. Ogden, Alaska Department of Fish and Game, Tok, personal communication). Repeated suggestions have been made to the Alaska Department of Fish and Game (ADF&G) that a stocking plan be formulated with local input to increase grayling abundance and angling opportunity in the Tok area.

Prior grayling research in the Tok River drainage has been limited to Mineral Lake Outlet. Mineral Lake Outlet was included in four studies between 1969 and 1973, which described grayling spawning behavior and migrational timing within the context of determining its potential as an egg-take site for the state's stocking program (Roguski and Tack 1970; Tack 1971, 1972, 1973). More recently, grayling research was conducted at Mineral Lake Outlet in 1988 and 1990 to produce age and length at maturity schedules, growth rates, sex ratios, age and size compositions, abundance, tag recapture rates, and estimates of hooking damage (Ridder 1989; Fleming and Ridder 1991). These recent studies showed size and age at maturity and adult exploitation rates after spawning were lower while length at age were similar in comparison to other spawning stocks in the Tanana River drainage. The 1990 study could not

[1] These regulations included limiting the fishery to catch and release until the first Saturday in June, a 305 mm total length limit, and a no bait restriction. In 1992, the Board accepted local requests for some consumptive use and relaxed the regulations to a two fish daily bag and possession limit with no season or size restrictions while retaining the no bait restriction.

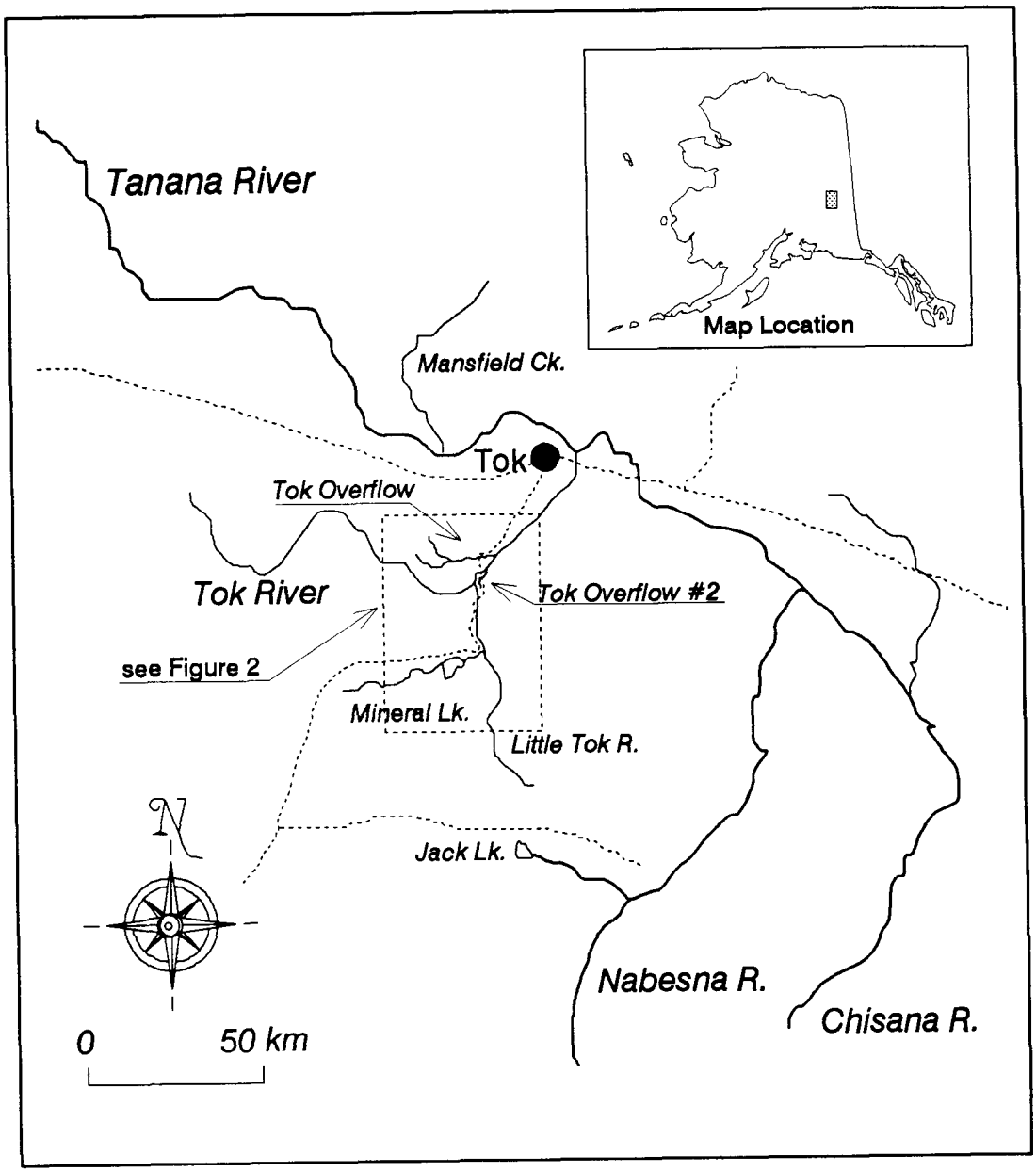

Figure 1. The Tok River drainage.

Table 1. Recreational grayling harvest and angling effort in the Tok and Little Tok River drainages, 1983-1992.

Year	Little Tok River[a] Harvest[b]	Little Tok River[a] Effort[c]	Mineral Lake[a] Harvest	Mineral Lake[a] Effort	Tok Overflow[a] Harvest	Tok Overflow[a] Effort	Tok River[a] Harvest	Tok River[a] Effort
1983	976 (0)	877	0	202	441 (0)	455	357	320
1984	1,025(337)	488	0	436	156 (0)	105	117	87
1985	---	---	69	451	---	---	---	---
1986	1,407(160)	443	---	---	---	---	559	153
1987	66 (0)	67	---	---	79 (0)	163	---	---
1988[d]	473(273)	655	18	93	55 (0)	62	0	93
1989[d]	---	---	0	65	0 (65)	133	200	100
1990[d]	253 (17)	725	84	595	17 (17)	78	51	401
1991[d]	710 (0)	906	49	213	73 (0)	27	0	186
1992	0 (0)	75	45	245	---	---	113	160
Average	613 (98)	530	33	288	117 (12)	146	175	188

[a] Unpublished harvest and effort statistics from the Statewide Harvest Survey (Mills, personal communication).

[b] Harvest is the estimated number of grayling taken. Harvests in parenthesis are of Dolly Varden char *Salvelinus malma*.

[c] Effort is the number of angler-days expended for all species of fish.

[d] Special regulations were in effect on the outlet of Mineral Lake in 1988 through 1991. These special regulations were: 1. Catch and release grayling fishing from 1 April to the first Saturday in June; 2. 12 inch (305 mm) minimum length limit; and, 3. artificial lures or flies only.

detect any difference between the two data sets in age, size, sex, or maturity compositions that could be attributable to regulation changes.

This study was undertaken to collect age and size data for an initial assessment of the status of the population in the Tok Overflow. Knowledge of the characteristics of the population (age and size composition, distribution, and movements) and of the stream itself, are necessary to accurately address local desires for enhancement of the population. The research objective for 1993 was to estimate age and size compositions of grayling greater than 149 mm FL in the Tok Overflow during April, June, and September.

During sampling trips in 1993, grayling were rare in the Tok Overflow and the study's objectives were not met. In order to make the most of field trips and to increase the grayling data from the drainage's accessible waters, the sampling crew surveyed other fishery locations within 21 km of the Tok Overflow (Figure 2). These survey results are included in this report and should be regarded as preliminary. These results include samples of Dolly Varden char *Salvelinus malma* that were made incidentally. The Tok River drainage is the only locale in the Tanana River drainage that supports a significant Dolly Varden fishery. With the exception of harvest estimates from the Statewide Harvest Survey, data on Dolly Varden in the drainages of the Tok and Tanana rivers are non-existent.

Fishery and Area Descriptions

Tok Overflow:

The Tok Overflow supports a locally popular early spring fishery for grayling and Dolly Varden that is concentrated in the outwash pool below the highway culverts. The fishery runs from March through April though recent anecdotes suggest a small fishery continues below the highway crossing throughout the summer. Harvests of grayling from the Tok Overflow have ranged from zero to 441 between 1983 and 1992 with a yearly average of 117 fish (Table 1). Angling effort for all species has ranged from 27 to 455 angler-days with a yearly average of 146 angler-days (Table 1).

The Tok Overflow is a small, spring and run-off fed tributary to the glacial Tok River that originates in the Alaska Range approximately 40 km southwest of Tok (Figure 1). The mainstem of the stream receives overflow during periods of extreme flow in the Tok River and hence its local name. Below its two forks (8 and 10 km long, respectively), the mainstem flows northeast 7 km to the Tok River. The Tok Overflow is crossed by the Glenn (Tok Cutoff) Highway adjacent to a highway pullout located 3 km above the stream mouth. The Tok Overflow flows downstream through two 1.5 m culverts and roughly parallels the highway coming to within 5 m of the highway 1.5 km above the mouth. The lower reach of the Tok Overflow and the reach of the Tok River immediately downstream of the Tok Overflow remains ice free during the winter (Figure 2). These areas may provide an important overwintering habitat for grayling. In contrast, the Tok River above and below the ice free area freezes to the bottom in winter (G. Pearse, Alaska Department of Fish and Game, Fairbanks,

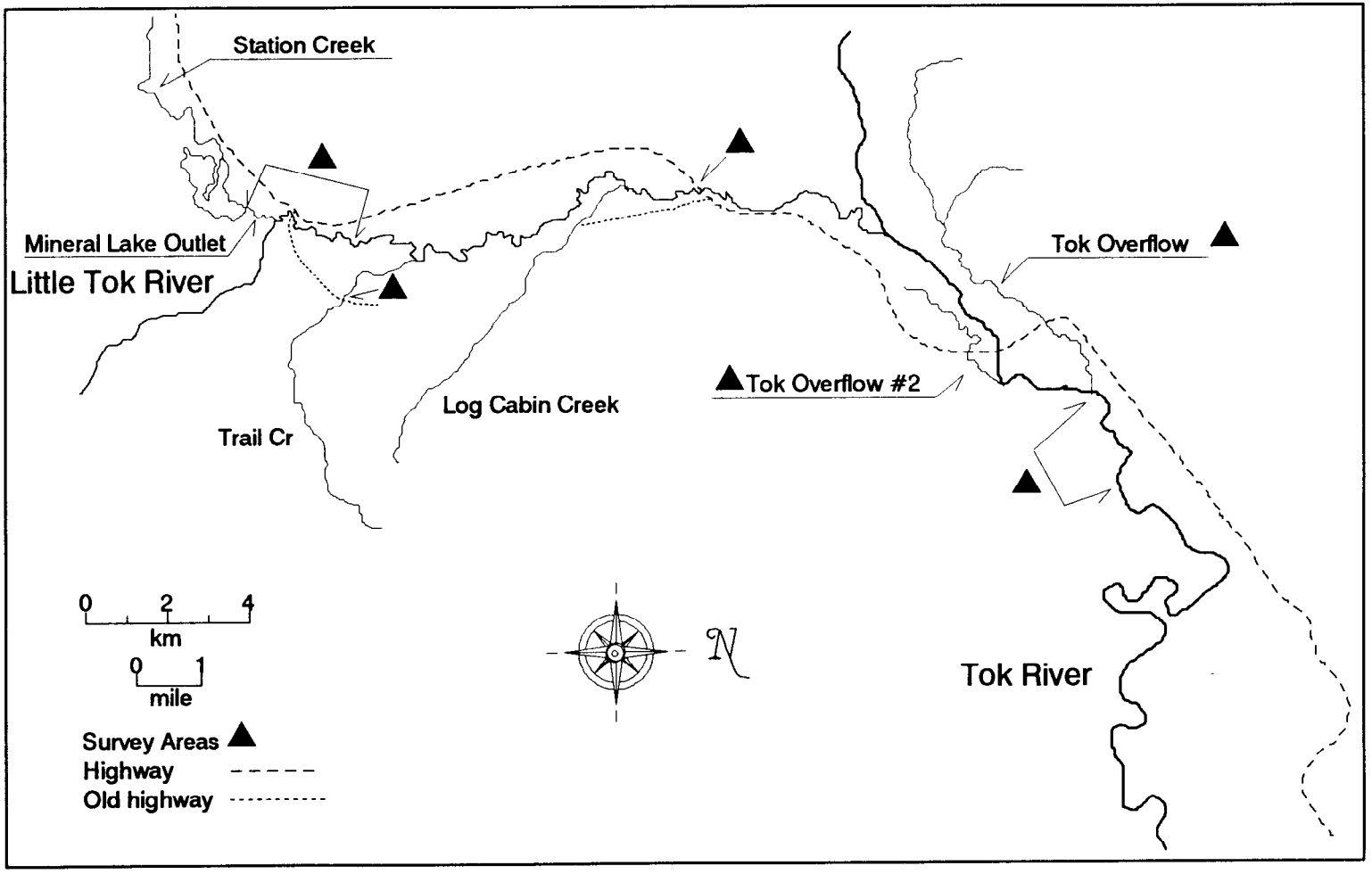

Figure 2. Survey areas in the Tok River drainage in 1993.

and D. Grangaard, Alaska Department of Fish and Game, Tok, personal communications.).

The study area of the Tok Overflow was the lower 5 km of the mainstem which was subdivided into three areas based on accessibility: the upper area, from the culverts 2 km upstream; the middle area, from the culverts 1.5 km downstream to the point adjacent to the highway; and the lower section, 1.5 km downstream to the mouth (Figure 3). The two upstream areas have an average width of 3 m and depths ranging from 0.1 to 1 m and are predominantly composed of 0.3 m deep runs with pool and riffle areas small and infrequent. Substrate is predominantly sand with small gravel in riffle areas and mud in pools and backwaters. A large (9 m by 15 m), 3 m deep outwash pool lies below the highway culverts. At the lower boundary of the middle area and continuing through the lower area to the mouth, the stream becomes deep (1.5 to 3 m) devoid of riffles, and width increases to 8 m. Substrate in the deeper reaches is mud and sand. Aquatic vegetation is sparse in the upper and middle areas and moderately dense in the lower area.

Little Tok River:

The Little Tok River is the largest fishery in the Tok River drainage with estimated grayling harvests that range from 0 to 1,407 fish (average of 613 fish) and Dolly Varden harvests of 0 to 337 fish (average of 98 fish). Effort has averaged 530 angler-days yearly (Table 1). The Little Tok River originates in the Mentasta Mountains and flows over 80 km to its confluence with the Tok River approximately 12 km above the mouth of Tok Overflow. The river is a rapid runoff stream marginally affected by glaciers and is slightly turbid and fishable at low summer flows. The river becomes high and turbid after heavy or persistent rains which make it unfishable. Road access is available at three locations: the Glenn Highway crossing at river kilometer 8; a short side road off the old Glenn Highway at river kilometer 9; and, at the old Glenn Highway bridge (locally known as "Broken Bridge") at river kilometer 25 (immediately downstream of the mouth of Mineral Lake Outlet). Dikes, side roads and the adjacent Glenn Highway in the Broken Bridge area allow direct access to over 1,000 m of the river. The morphology of the river at the upstream access is distinctly different than at the downstream access points. At Broken Bridge, the river is 12 m wide and composed primarily of swift 1+ m deep runs over gravel and small cobble. Pools are deep (2+ m) and generally located on the outside of bends and along cut banks. Riffles are short, swift, and generally 0.5 m deep. The river here is also moderately to heavily fouled with fallen trees, logs and brush which makes navigation impossible and angling difficult. At the downstream access sites, flow diminishes, the river deepens, and riffles and runs are nearly non-existent. Debris is less prevalent making navigation possible. However, angling from shore remains difficult due to dense riparian vegetation and steep, high banks. Sampling the Little Tok River in 1993 occurred at two locations: the access site at river kilometer 9, and the Broken Bridge area.

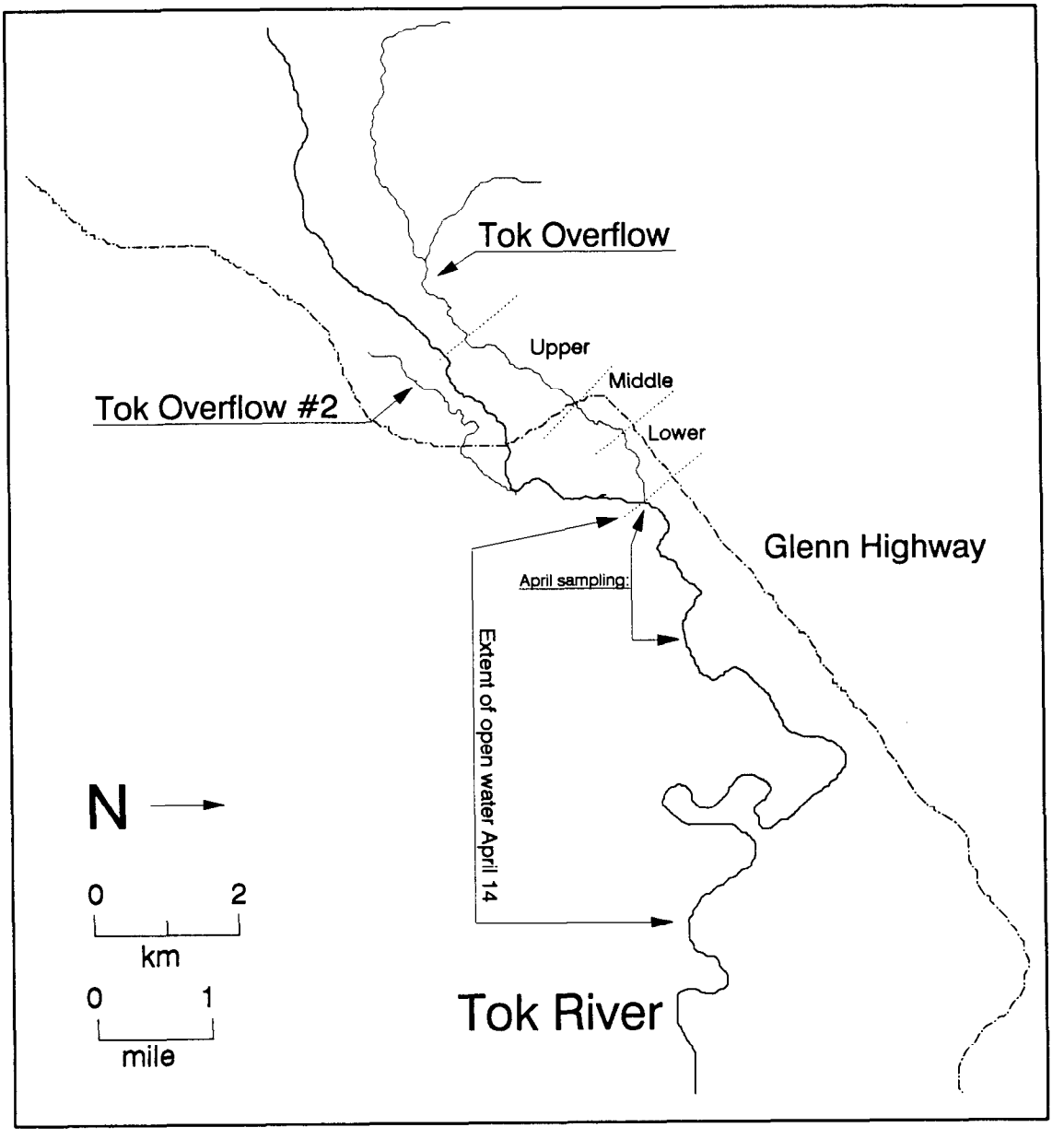

Figure 3. Study areas of the Tok Overflow and Tok River in 1993.

Mineral Lake Outlet:

Mineral Lake Outlet is one of the few spots in interior Alaska that offers highway access to a discrete and concentrated spawning population of grayling. This population has offered a small but popular spring fishery for the residents of Tok and Mentasta since at least the early 1960's (Tack 1974; G. Pearse, Alaska Department of Fish and Game, Fairbanks, personal communication). Between 1983 and 1992, unpublished Statewide Harvest Survey estimates of grayling harvests from Mineral Lake[2] have ranged from 0 to 84 fish (average of 33 fish; Table 1). Angler effort for the same years ranged from 65 to 595 angler-days (average of 288 angler-days). During a creel survey conducted at Mineral Lake Outlet from 19 through 27 May 1973, 45 anglers were interviewed who harvested 170 grayling in 141 angler hours for a harvest rate of 1.21 grayling per angler hour (Ridder 1989).

Mineral Lake Outlet flows approximately 3.2 km from Mineral Lake downstream to the confluence with the Little Tok River. The stream averages 3 m wide and 0.6 m deep with the exception of the lower 200 m of the mouth which averages 12 m wide and 2 m deep. Pools and runs are the dominant water type. Bottom substrate is generally mud with gravel and small cobble located in the riffle and swifter run areas.

METHODS

Four, three day field trips were taken to the Tok River drainage: 13 through 15 April; 11 through 13 May; 22 through 24 June; and, 13 through 15 September 1993. This schedule coincides with seasonal distributions of grayling during the pre-spawning, spawning, summer feeding, and migration to overwintering area periods (Tack 1980).

Due to time constraints and anecdotal evidence of low fish density, visual surveys were conducted at the Tok Overflow in all or part of the study area prior to allocating sampling effort. The surveyor proceeded slowly downstream either in the water along riffle areas, or along the stream bank in pool and run areas, frequently disturbing cover to flush out hiding fish. A canoe with the surveyor in the bow was used in the lower study area for the June and September surveys. Intuitively, such surveys cannot absolutely document the presence or absence of fish. However, the small size, extreme clarity, and dense riparian vegetation of the stream do offer the surveyor the ability to estimate the relative abundance of fish and the potential efficacy and success of any sampling effort. If these surveys of the Tok Overflow indicated that the density of grayling was so low that sampling would be redundant, then effort was redirected to Mineral Lake Outlet, Tok Overflow #2, and Little Tok River.

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[2] It is not known if Mineral Lake Outlet is included in the estimates for Mineral Lake. Also, there is likely confusion for non-local anglers in determining if they are fishing the lower Outlet or the Little Tok River.

Fish were captured with a variety of gear: backpack mounted electroshockers; bag seines (23 x 1.8 m with 6.4 mm mesh); and, hook and line (spinners and flies). Capture gear was determined by stream morphology and practicality i.e., deep water, debris, and velocity, individually or in combinations, would preclude backpack shocking and seining and dictate hook and line. Hook and line methods were used only in the Little Tok River and the mouths of the Tok Overflow and Mineral lake Outlet.

A backpack mounted electroshocker was used in the Tok River to drive grayling downstream out of pools and runs towards a bag seine deployed at the head of a riffle. The backpack unit was then used to block upstream escape as the seine was closed and brought to shore. Two men were employed in the drive and two men controlled the seine.

The middle reach of Mineral Lake Outlet was sampled with the backpack unit and operator positioned in the bow of a canoe. The canoe was maneuvered downstream by one man at the stern. Stunned fish were captured by two dipnetters following alongside or stationed downstream of the shocker. The method was cumbersome and inefficient since visibility was often poor due to displaced mud.

Sampling the head of Mineral Lake Outlet was accomplished with the bag seine in the same manner as 1988 and 1990 sampling (Fleming and Ridder 1991). Repetitive beach hauls were made through a 20 m reach. Captured fish were held in a pen until sampling ended. To sample the area efficiently, three or four short hauls were required due to high fish density and swift current. In 1993, eight seine hauls were made; a series of four hauls to sample the area once with an approximate hour hiatus in between. The hiatus allowed displaced fish to repopulate the spawning site.

Water temperature to within 0.1°C and time of day were recorded at each visit to all locations with a mercury "blood bank" thermometer (-5 to 20°C). These temperature records are presented in Appendix A. In addition, a Ryan Model J thermograph (-5 to 25°C) was placed in the Tok Overflow 30 m upstream of the culverts. The daily high, low, and mean temperatures were interpreted from the thermograph records. Temperatures were likely biased to some degree due the relative interpretation of 0.1°C since both instruments were scaled in 1°C increments. Also, the thermograph failed to function after 6 August due to a water leak. Thus, thermograph data may be biased for an unknown period prior to 6 August.

Estimation of Age and Size Compositions

All captured grayling were measured to the nearest 1 mm fork length (FL). Grayling greater than 149 mm FL were marked with Floy FD-67 anchor tags to monitor movement patterns. For aging, two scales were taken from each newly captured fish from an area located approximately six scale rows above the lateral line just posterior to the insertion of the dorsal fin. The scales were field mounted on gum cards without cleaning. These gum cards were used to make impressions of the scales on triacetate film (30 seconds at 137,895

kPa, at a temperature of 97°C). Ages were determined by the same individual in a single reading with the aid of a microfiche reader according to criteria outlined by Yole (1975).

An estimate of the proportion of grayling in each age class was calculated by:

$$\hat{p}_i = \frac{y_i}{n} \qquad (1)$$

where:

y_i = the number of grayling of age i in the sample; and,
n = the number of grayling in the sample.

The unbiased variance of this proportion is:

$$\hat{V}[p_i] = \frac{\hat{p}_i\,(1 - \hat{p}_i)}{n - 1} \qquad (2)$$

Length at age was calculated as the arithmetic mean fork length of all captured fish in each age class for each sample location and event regardless of capture method. The data is presented in Appendix B.

Size composition of the stock was described with the incremental Relative Stock Density (RSD) indices adopted from Gabelhouse (1984). The RSD categories for grayling are: "stock" (150 to 269 mm FL); "quality" (270 to 339 mm FL); "preferred" (340 to 449 mm FL); "memorable" (450 to 559 mm FL); and "trophy" (greater than 559 mm FL). The RSD indices were estimated with equations 1 and 2, substituting the RSD categories for age classes.

Potential bias in age and size composition estimates due to gear selectivity was not investigated. During the planning of this study, it was assumed that no selectivity would occur in the sampling of the Tok Overflow with the intended gear types. Backpack shocking in a small stream has been shown to exhibit little size selectivity towards grayling (Fleming 1991) and beach seines, especially those with small meshes, can be reasonably expected to sample grayling in shallow waters in proportion to the sizes of fish available. The sampling of other waters was not expected and methods to detect bias could not be employed under the limited sampling schedule. While several gear types were used in Mineral Lake Outlet, they were deployed in various habitats and time periods. Depending on age and time of year, grayling exhibit different preferences among habitats (Tack 1980) and thus a test for differences in sample compositions would not be valid.

All data pertaining to age, length, sex, sampling mortality, tag numbers and colors, capture location, recapture status, and also finclips and tag loss (from previous studies) were recorded on mark sense forms and electronically stored for analysis and archival (see listing of data files in Appendix C).

Sex and Maturity

Sex and maturity were determined in spring samples collected from Mineral Lake Outlet by either sexual dimorphism or the presence of milt or eggs. Dimorphism is evident in differences in length of the dorsal fin (the male dorsal fin usually extends to the adipose fin whereas the female dorsal fin is noticeably shorter; Wojcik 1955) and the swelling of the anal vent and abdomen fullness (gravid) or flaccid (spawned out) in females (Ridder 1989). Some error was associated with the use of these morphological characteristics as the sole determinant of sex. For example, small, mature males may be misclassified as juveniles since their dorsal fin may not reach the adipose and, if recently spawned, they will not give milt. Sex ratios were presented as the ratio of the number of males to females when initially captured.

Maturity of grayling sampled from other locations and other times were determined from maturity schedules developed for the Mineral Lake Outlet population by Clark (1992). While Clark estimated the minimum length at maturity for 50% of the population at 238 mm FL, I have used 239 mm FL for simplicity in presenting length frequencies within 20 mm FL groups.

RESULTS

A total of six trips were taken to the Tok River drainage from 13 April through 15 September 1993. Four of these were three day sampling trips and two were day trips to service the thermograph in the Tok Overflow. All trips included either complete (n = 3) or partial (n = 3) surveys of the Tok Overflow study area. While grayling were observed in the Tok Overflow during one survey and other fish (Dolly Varden and unidentified species) were observed during three surveys, numbers of fish observed in any survey were small (≤57 fish, Table 2). Thus, due to this scarcity, no sampling effort was expended in the Tok Overflow. Sampling effort was shifted to four other areas to define grayling distribution and composition within the Tok River drainage (Figure 2). A total of 1,351 grayling and 23 Dolly Varden were then captured which included 1,215 grayling tagged and released and 36 grayling tag recaptures from 1988 (n = 6), 1990 (n = 23), and this study (n = 7) (Table 3).

Tok Overflow

Grayling were nearly absent from the Tok Overflow during 1993 field trips. Of the six surveys of the Tok Overflow, grayling were found only on 22 June when 56 fish (between 200 and 300 mm FL) were observed (Table 2). All but one grayling were seen in the lower study area within 400 m of the mouth. The largest concentration, 30 grayling, were schooled in deep water within 60 m of the mouth and included one tagged fish whose distinctive, bright, blue tag

Table 2. Summary of foot surveys of the Tok Overflow, 13 April through 13 September 1993.

Date	Area[a]	Reach	Time	Survey Conditions	Fish Observed[b] Number	Fish Observed[b] Size	Temperature °C[c] (time)	Notes
13 April	Upper	Lower 1 km	1000	Excellent	0	---	2.9° (1630)	
"	Lower	Lower 500 m	1030	"	0	---	2.5° (1200)	hook & line
14 April	Middle	All	1000	Excellent	0	---	2.5° (0930)	
6 May	Upper	Lower 300 m	1300	Excellent	0	---	3.1° (1300)	caddis hatch
"	Middle	All	1400	"	0	---	3.6° (1430)	"
11 May	Middle	Culvert pools	1630	Good	0	---	3.2° (1630)	breeze
12 May	Middle	Culvert pools	1230	Good	0	---	3.8° (1230)	breeze
"	Lower	All	1100	Poor	0	---	4.3° (1100)	wind,hook & line
"	adjacent mouth in Tok R.		1100	"	0	---	6.3° (1200)	wind,hook & line
13 May	Middle	Upper 150 m	1630	Excellent	0	---	4.6° (1630)	caddis hatch
22 June	Upper	All	1200	Excellent	1GR	230	4.6° (1730)	
"	Middle	"	1200	"	1Unk	ND	5.3° (1530)	
"	Lower	"	1200	"	55GR[d]	200-320	5.9° (1600)	
6 August	Upper	Lower 1 km	1200	Poor	1DV,1Unk	ND	3.5° (1200)	rain
13 Sept.	Upper	All	1500	Excellent	4DV	150-300	3.2° (1600)	
"	Middle	"	1500	"	0	---	3.5° (1500)	
"	Lower	"	1430	Good	0	---	3.9° (1530)	breeze

[a] Area: Upper, highway culverts upstream 2 km; Middle, highway culverts downstream 1.5 km; Lower, mouth upstream 1.5 km to end of Middle site.
[b] GR = grayling; DV = Dolly Varden; Unk = unknown species.
[c] Temperatures (° C) taken at lower end of sites.
[d] One blue tag observed.

Table 3. Summary of field sampling in the Tok and Little Tok River drainages, 14 April through 14 September 1993.

Date	Location	Gear[a]	Number Fish Sampled[b]	Tags Released	Tags Recaptured[c]
14-15 April:	Tok River	BPS,SE	700	667	1
12-13 May:	Mineral Lake Outlet:				
	Head	SE	383	383	31
	Mouth	HL	34	33	0
23-24 June:	Little Tok River	HL	6	1	1
	Tok Overflow #2	BPS	38 (18)	34	1
	Mineral Lake Outlet:				
	Head	SE	5	0	0
	Middle reach	BPS	48	34	0
	Mouth	HL	12	12	0
13-14 Sept:	Little Tok River	HL	24	22	2
	Tok Overflow #2	BPS	0 (5)	0	0
	Mineral Lake Outlet:				
	Head	SE	86	13	0
	Middle Reach	BPS	19	16	0
Totals			1,351 (23)	1,215	36

[a] Gear: BPS = backpack electroshocker; SE = bag seine; HL = hook and line.
[b] Fish sampled and and tagged are grayling. In parenthesis are number of Dolly Varden sampled.
[c] Recaptured tags include tags from 1988 (n = 6), 1990 (n = 23), and 1993 (n = 7) releases.

indicated it was tagged the preceding April in the Tok River below the Tok Overflow.

Dolly Varden were observed in the upper study area during two surveys. One fish was seen in the partial survey of 6 August and four fish were observed during the complete survey of 13 September. In the latter survey, two char were active on a redd.

Water temperatures in the Tok Overflow from thermometer readings ranged from 2.5°C on 13 April to 5.9°C on 22 June (Appendix A). Temperatures were warmer at the mouth than at the two sites 1.5 and 3 km upstream. Thermograph readings from above the culverts (the most upstream site) between 15 April and 6 August showed daily low temperatures ranged from 2.1 to 4.2°C while daily high temperatures ranged from 2.7 to 4.8°C. These temperatures, both thermograph and thermometer records, were all below temperatures recorded on the same dates at other sites in the drainage (Figure 4, Appendix A).

Tok River

On 14 April, the Tok River had open water that extended approximately 12 km downstream from the mouth of the Tok Overflow (Figure 3). The water was clear with a temperature of 3.0°C. Above the open water, the river was near completely frozen with only a small flow at both banks coming from between ice layers. At the lower boundary of the open water, flow diminished to a trickle and then disappeared under solid ice. On the next survey, 6 May, the river was flowing and turbid at the Glenn Highway bridge (4 km above the mouth of the Overflow) and 77 km downstream at the Alaskan Highway bridge.

A 2.5 km reach of the Tok River immediately below the mouth of the Tok Overflow was sampled by seining on 14 and 15 April (Figure 3) and 700 grayling were captured of which 667 were tagged and released. Beginning 200 m below the mouth of the Tok Overflow, grayling were present in all water types with larger fish concentrated in the heads of pools and deep runs and smaller fish below them and in the riffle areas.

The majority (90%) of the grayling sampled in the Tok River were small (< 240 mm FL) juvenile fish (Figure 5). Fish greater than 200 mm FL made up 57% of the sample. Ninety-eight percent of the grayling were the stock sized fish of the RSD categories (Table 4). While ages ranged from 2 to 8 years, ages 3 and 4 represented over 80% of the sample (42% (SE = 2%) and 44% (SE = 2%) respectively, Table 5).

One tag recapture was in the sample. The fish, a mature, 262 mm FL female, was tagged at 233 mm FL and age 6 on 12 May 1990 in Mineral Lake Outlet.

No fish were observed in the Tok River below the Tok Overflow on 22 June, though turbidity prevented observation into the deeper pools.

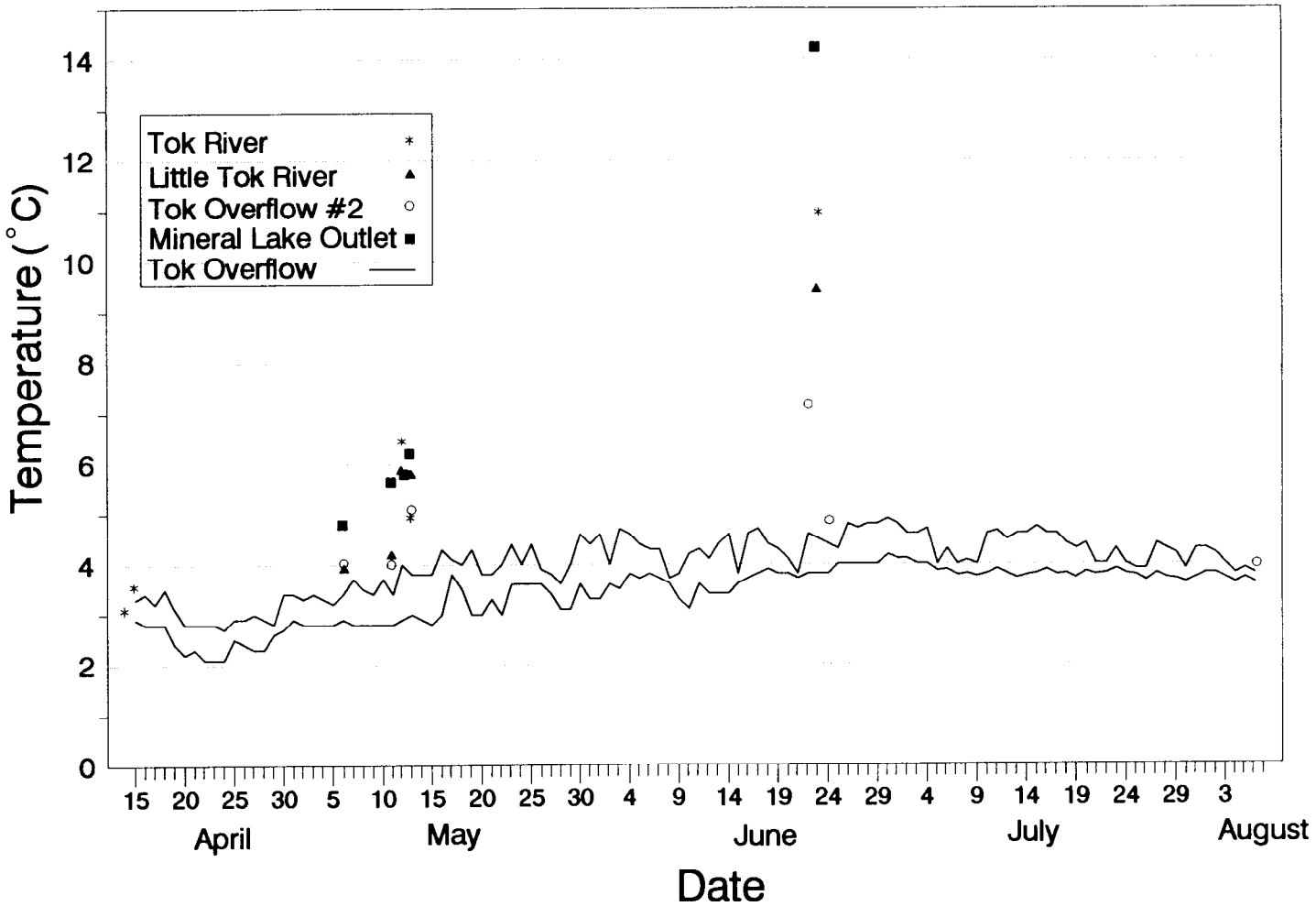

Figure 4. Water temperatures (°C) from five locations in the Tok River drainage, 15 April through 6 August 1993.

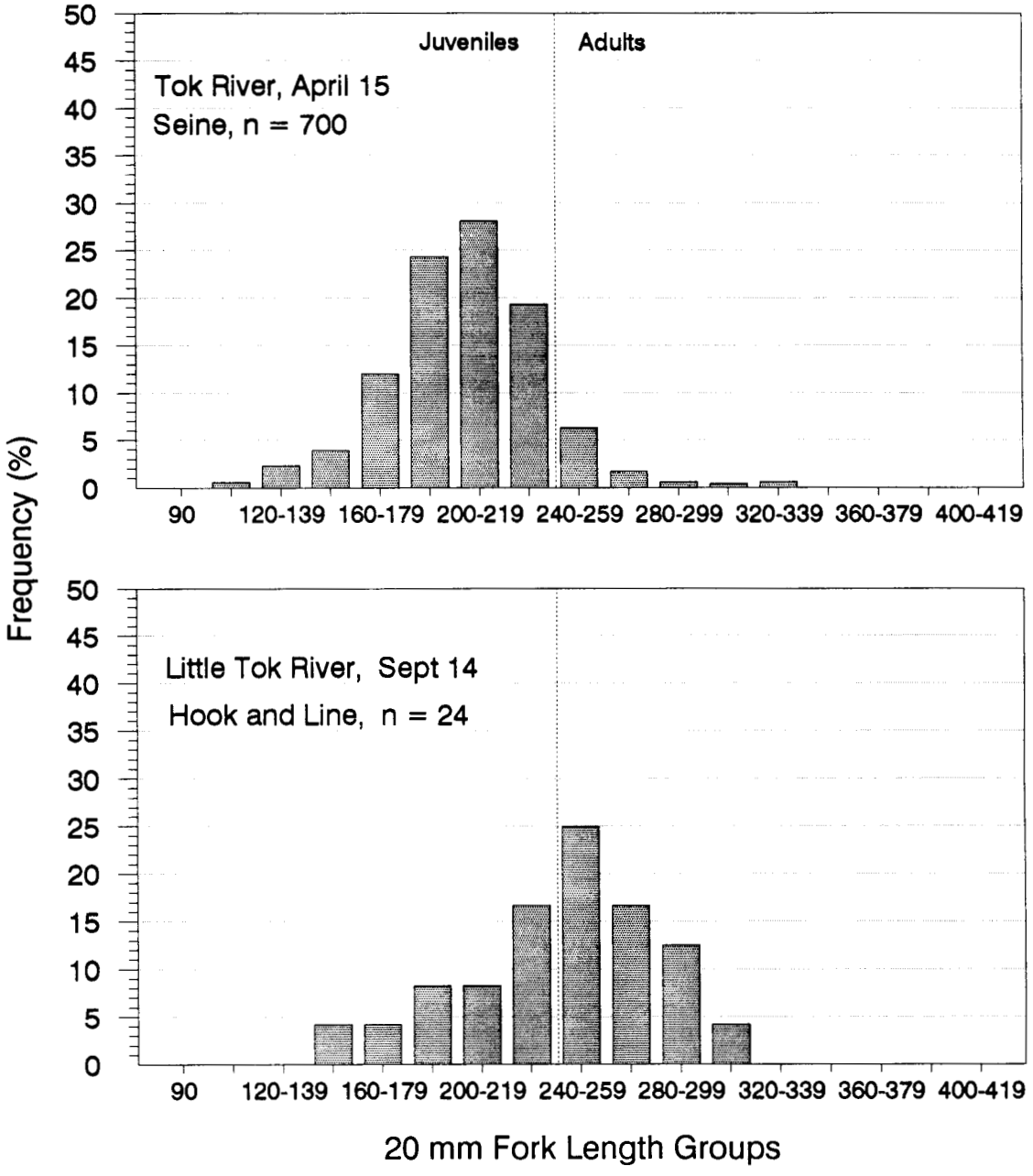

Figure 5. Length frequencies of Arctic grayling sampled in the Tok and Little Tok rivers, 1993.

Table 4. Summary of RSD estimates for grayling (≥ 150 mm FL) sampled in the Tok and Little Tok River drainages, 14 April through 14 September 1993.

	RSD Category[a]				
	Stock	Quality	Preferred	Memorable	Trophy
Tok River:					
4/14-15, seine;					
Number sampled	653	16	0	0	0
RSD	0.98	0.02	---	---	---
Standard Error	<0.01	<0.01	---	---	---
Tok Overflow #2:					
6/24, backpack shock;					
Number sampled	38	0	0	0	0
RSD	1.00	---	---	---	---
Standard Error	---	---	---	---	---
Little Tok River:					
6/23, hook and line;					
Number sampled	5	1	0	0	0
RSD	0.83	0.17	---	---	---
Standard Error	0.15	0.15	---	---	---
9/13-14, hook and line;					
Number sampled	19	5	0	0	0
RSD	0.79	0.21	---	---	---
Standard Error	0.08	0.08	---	---	---
Mineral Lake Outlet:					
head, 5/12, seine;					
Number sampled	216	118	48	0	0
RSD	0.57	0.31	0.13	---	---
Standard Error	0.03	0.02	0.02	---	---
head, 9/14, seine;					
Number sampled	13	0	0	0	0
RSD	1.00	---	---	---	---
Standard Error	---	---	---	---	---

- continued -

Table 4. (Page 2 of 2).

	RSD Category				
	Stock	Quality	Preferred	Memorable	Trophy
Mineral Lake Outlet:					
middle reach, 6/23, backpack shock;					
Number sampled	28	6	0	0	0
RSD	0.82	0.18	---	---	---
Standard Error	0.07	0.07	---	---	---
middle reach, 9/14, backpack shock;					
Number sampled	12	4	0	0	0
RSD	0.75	0.25	---	---	---
Standard Error	0.11	0.11	---	---	---
mouth, 5/13, hook and line;					
Number sampled	30	4	0	0	0
RSD	0.88	0.12	---	---	---
Standard Error	0.06	0.06	---	---	---
mouth, 6/23, hook and line;					
Number sampled	12	0	0	0	0
RSD	1.00	---	---	---	---
Standard Error	---	---	---	---	---

[a] Minimum lengths for RSD categories are (adapted from Gabelhouse 1984):
Stock - 150 mm FL;
Quality - 270 mm FL;
Preferred - 340 mm FL;
Memorable - 450 mm FL; and,
Trophy - 560 mm FL.

Table 5. Age composition estimates and standard errors for grayling sampled in the Tok and Little Tok rivers and Tok Overflow #2, 1993.

Age Class	Tok River[a] 14-15 April seine			Tok Overflow #2 24 June backpack shock			Little Tok River 14 September hook and line		
	n[b]	p[c]	SE[d]	n	p	SE	n	p	SE
0	0	---	---	0	---	---	0	---	---
1	0	---	---	0	---	---	0	---	---
2	13	0.02	0.01	4	0.12	0.06	3	0.14	0.07
3	231	0.42	0.02	11	0.32	0.08	3	0.14	0.07
4	244	0.44	0.02	8	0.24	0.07	12	0.55	0.11
5	49	0.09	0.01	8	0.24	0.07	4	0.18	0.08
6	12	0.02	0.01	1	0.03	0.03	0	---	---
7	1	<0.01	<0.01	1	0.03	0.03	0	---	---
8	1	<0.01	<0.01	1	0.03	0.03	0	---	---
9	0	---	---	0	---	---	0	---	---
10	0	---	---	0	---	---	0	---	---
Total	551	1.00		34	1.00		22	1.00	

[a] In the Tok River, only grayling greater than 149 mm FL were aged.
[b] n = sample size.
[c] p = proportion.
[d] SE = standard error of the proportion.

Mineral Lake Outlet

Three visits were made to the head of Mineral Lake Outlet during May to monitor grayling spawning activity. On 6 May, no fish were observed in the upper 20 m of the outlet (Site 1 of earlier studies) though approximately 60 grayling (including two fish tagged earlier in the Tok River) were seen immediately downstream. Most of these fish were estimated to be less than 250 mm FL. On this date, water temperature was 4.9°C at 1630 hrs and no territorial displays by adult males were observed. On 11 May, water temperature was 5.8°C and grayling were present from Site 1 to the first pool 40 m downstream. The fish were quite active with extensive territorial and spawning displays[3]. On 12 May, a total of eight seine hauls were made through this area, with six of them at Site 1. A total of 383 grayling, all greater than 150 mm FL, were captured. The catch included 31 tag recaptures: six recaptures of fish tagged in 1988 at Mineral Lake Outlet, 22 recaptures of 1990 Outlet tags, and three recaptures of 1993 Tok River tags. Water temperature was 5.9°C at the start of sampling on 12 May.

The 12 May sample was near equally divided between juvenile and adult grayling (from the maturity schedule: n = 184 and 199, respectively; Figure 6). Age 4 grayling represented 31% of the 318 aged fish which was nearly twice the proportion of other individual age classes (Table 6). Within RSD categories, stock sized fish comprised 56% of the sample, 31% were quality sized fish, and 13% were in the preferred category (Table 4).

Within the May sample, 194 (51%) grayling were classed as adults based on morphology or the presence of milt or eggs. The male to female ratio was 3.3:1 (149:45). Ages 6 and 7 were the most numerous comprising 60% of the adult fish sampled (Table 7).

On 13 May, 34 grayling were captured with hook and line after 4 man-hours near of the mouth of Mineral Lake Outlet. These fish were smaller on average than those sampled at Site 1 and were mostly juvenile fish (n = 26 or 76%; Figure 6). Stock sized fish made up 88% of the sample and no preferred sizes were captured (Table 4).

On 23 June, the entire length of Mineral Lake Outlet was sampled and 65 grayling were captured (Table 3). Five grayling, all less than 150 mm FL, were captured by seine at the head (Site 1). In the middle reach, 48 grayling were captured by backpack shocking. Twelve grayling were captured in the vicinity of the mouth by hook and line (12 man-hours in windy conditions). Age 4 fish were the most numerous in the catches and no fish over age 6 were caught (Table 6). The length composition of the combined catches was similar to that found at the mouth in May: 72% (n = 47) of the fish were juveniles

[3] One fish was observed energetically defending a territory and one defensive maneuver landed him headfirst and stranded on the far shore. Rescued by the observer, the fish never revived and died. The fish, a 417 mm FL male and the largest recorded at Mineral Lake Outlet, was tagged at the same site in 1990 at 388 mm FL and 9 years of age.

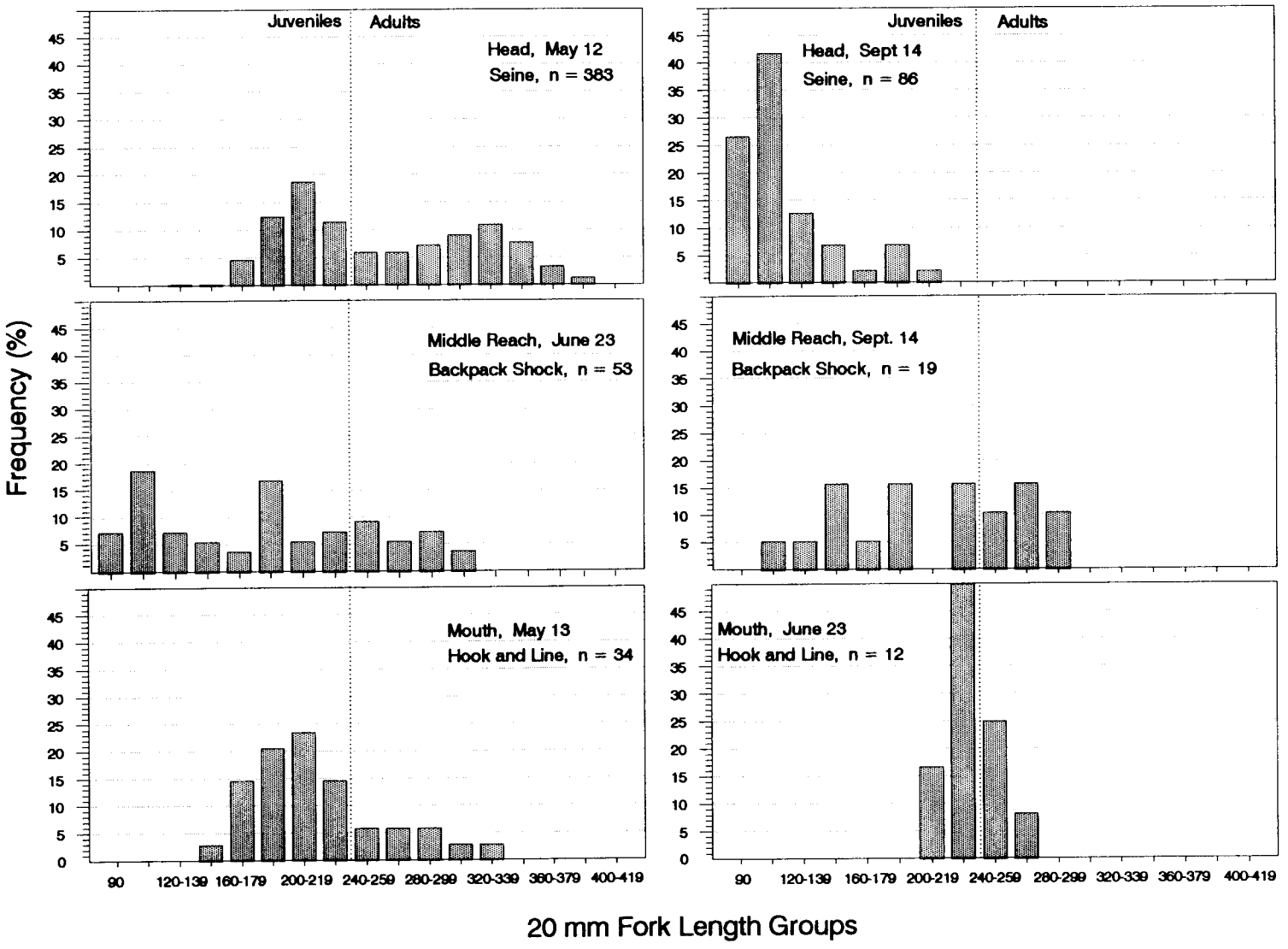

Figure 6. Length frequencies of Arctic grayling sampled from three locations in Mineral Lake Outlet.

Table 6. Age composition estimates and standard errors for grayling sampled in three areas of Mineral Lake Outlet, 1993.

	Head[a] 12 May seine			Mouth 23 June hook and line			Head and Middle 23 June backpack shock			Middle 14 September backpack shock			Head 14 September seine		
Age Class	n[b]	p[c]	SE[d]	n	p	SE	n	p	SE	n	p	SE	n	p	SE
0	0	---	---	0	---	---	3	0.06	0.03	1	0.06	0.06	48	0.56	0.05
1	0	---	---	0	---	---	16	0.30	0.06	4	0.24	0.10	33	0.38	0.05
2	1	<0.01	<0.01	0	---	---	7	0.13	0.05	3	0.18	0.09	5	0.06	0.03
3	54	0.17	0.02	1	0.10	0.10	10	0.19	0.05	5	0.29	0.11	0	---	---
4	98	0.31	0.03	9	0.90	0.10	11	0.21	0.06	2	0.12	0.08	0	---	---
5	39	0.12	0.02	0	---	---	3	0.06	0.03	2	0.12	0.08	0	---	---
6	56	0.18	0.02	0	---	---	3	0.06	0.03	0	---	---	0	---	---
7	44	0.14	0.02	0	---	---	0	---	---	0	---	---	0	---	---
8	20	0.06	0.01	0	---	---	0	---	---	0	---	---	0	---	---
9	5	0.02	0.01	0	---	---	0	---	---	0	---	---	0	---	---
10	1	<0.01	<0.01	0	---	---	0	---	---	0	---	---	0	---	---
Total	318	1.00		10	1.00		53	1.00		17	1.00		86	1.00	

[a] The three areas were the head (Site 1 in Ridder (1989) and Fleming and Ridder (1991)); the middle reach between the head and the mouth; and the mouth (Site 6 in Ridder (1989)).

[b] n = sample size.

[c] p = proportion.

[d] SE = standard error of the proportion.

Table 7. Age composition estimates and standard errors for mature grayling sampled in Mineral Lake Outlet, 12 May 1993.

	All			Males			Females		
Age Class	n[a]	p[b]	SE[c]	n	p	SE	n	p	SE
3	0	---	---	0	---	---	0	---	---
4	11	0.07	0.02	11	0.09	0.03	0	---	---
5	27	0.17	0.03	21	0.17	0.03	6	0.18	0.06
6	54	0.33	0.04	45	0.36	0.04	9	0.24	0.07
7	44	0.27	0.04	33	0.27	0.04	11	0.29	0.07
8	20	0.12	0.03	10	0.08	0.02	10	0.26	0.07
9	5	0.03	0.01	4	0.03	0.02	1	0.03	0.03
10	1	0.01	0.01	0	---	---	1	0.03	0.03
11	0	---	---	0	---	---	0	---	---
Total	162	1.00		124	1.00		38	1.00	

[a] n = sample size.
[b] p = proportion.
[c] SE = standard error of the proportion.

(Figure 6) and 87% were stocked sized fish (Table 4). Water temperatures ranged from 14.2°C at the head to 13.8°C at the mouth.

Mineral Lake Outlet was again sampled on 14 September and 105 grayling were captured (Table 3). Composition, distribution, and relative abundance of grayling were different than the earlier samples. At the head (Site 1), 86 grayling were seined of which all but 14 fish were less than 150 mm FL. In the middle reach, 19 grayling were captured by backpack shocking. Unlike previous surveys of the mouth area, no grayling or other species were observed and no sampling was conducted. While the composition of stocked sized fish in the combined catch (86%; Table 4) was similar to the earlier samples, juvenile fish comprised a larger percentage of the total catch (93%) primarily due to the numbers of age 0 grayling captured at Site 1 (Figure 6 and Table 6). Water temperatures during sampling were in the 8°C range (Appendix A).

Tok Overflow #2

With the exception of the April and August trips, the outwash pool below the culverts at Tok Overflow #2 was surveyed for fish presence and the water temperature recorded. In comparison to the culvert area in the Tok Overflow, water temperatures were 0.5 to 2.5°C warmer on six of the seven days of comparable records (Appendix A). Fish were observed in the outwash pool only during the June and September surveys.

On 24 June, 38 grayling and 18 Dolly Varden were captured by backpack shocker in the 1 km reach from the culverts to the mouth. The catch included one grayling tagged in April in the Tok River. The majority of the fish were caught in the outwash pool though eight grayling were caught in the turbid confluence with the Tok River. Dolly Varden ranged from 101 to 191 mm FL (mean = 142 mm FL, SD = 20; Figure 7). Captured grayling were all stocked sized fish of less than 270 mm FL (Table 4). Juvenile grayling comprised 92% (n = 35) of the catch (Figure 7). Despite the small size of the grayling, their ages ranged from 2 to 8 years (Table 5).

The 14 September sampling covered approximately half the reach of the June sampling due to deep water backed up from an extensive beaver dam near the mouth. No grayling were caught or observed and only five Dolly Varden were captured. The Dolly Varden ranged from 115 to 212 mm FL in length with a mean of 159 mm FL (SD = 33).

Little Tok River

The Little Tok River was briefly sampled with hook and line near the Glenn Highway bridge on 23 June and 13 September. Six grayling (188 to 292 mm FL, mean = 219 mm FL, SD = 37) were caught on 23 June after 3 man-hours of angling. The largest grayling was previously tagged in the Tok River during April. Two grayling, 250 and 268 mm FL, were caught on 13 September after 2 man-hours of angling.

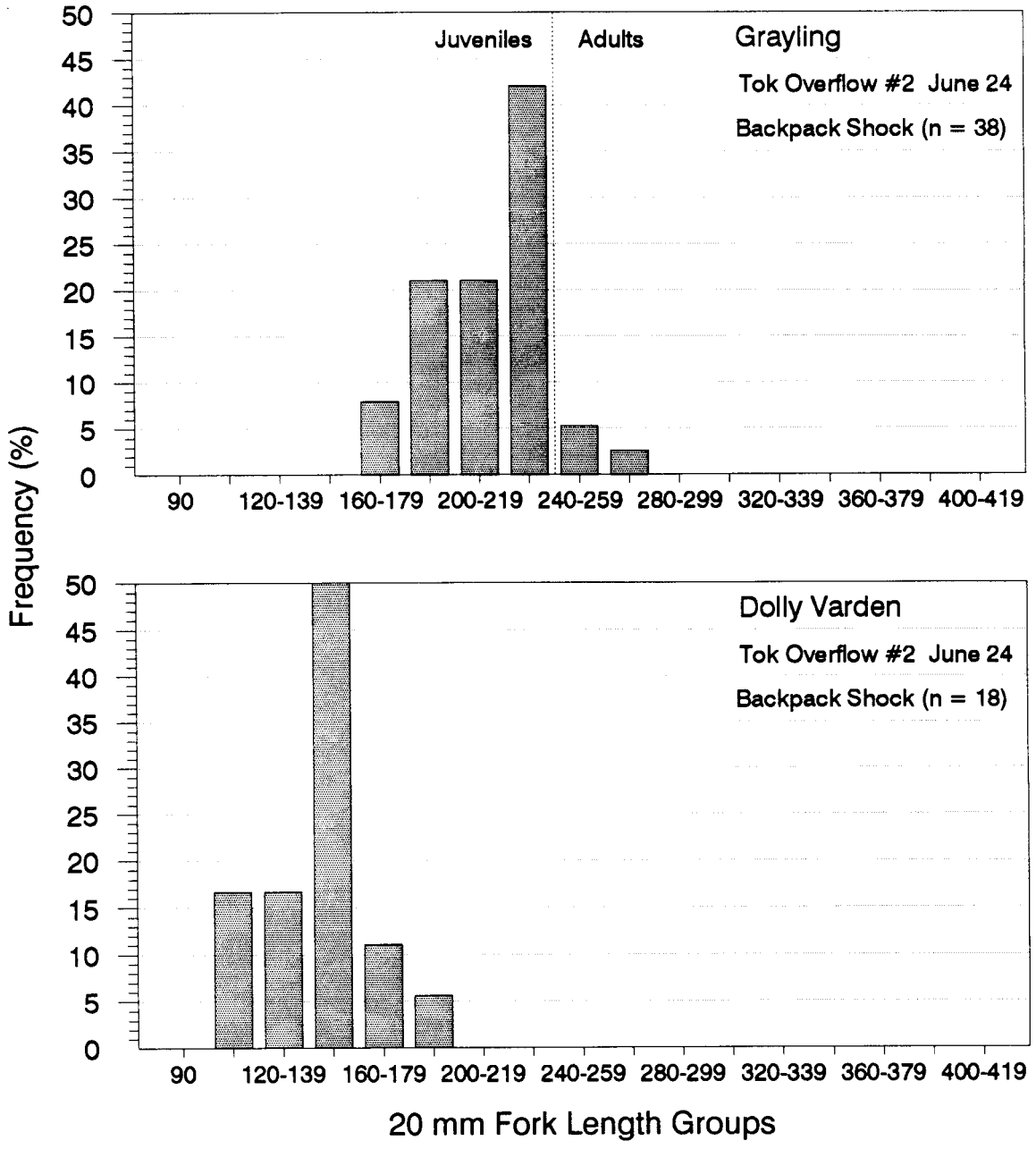

Figure 7. Length frequencies of Arctic grayling and Dolly Varden sampled in Tok Overflow #2, 1993.

More extensive sampling occurred on 14 September along a reach that began at Broken Bridge and extended downstream for 1.5 km. After 11 man-hours of angling, 22 grayling were captured of which two were recaptures of fish tagged in April in the Tok River. All fish were caught well below the diked area surrounding Broken Bridge. The fish ranged in size from 156 to 306 mm FL (mean = 241 mm, SD = 37; Figure 5) with 79% being stock size fish (Table 4). Age 4 fish comprised over half the sample (Table 5).

Angler Recaptures of Tagged Grayling

Anglers reported catching six tagged grayling in the Little Tok River drainage in 1993 (Table 8). Five of these were caught in Mineral Lake Outlet and were from 1993 tagging: two fish from the Tok River and three fish from Mineral Lake Outlet. One recapture was from 1990 tagging in Mineral lake Outlet. Unlike previous years, no recaptures were reported from the Little Tok River.

DISCUSSION

Results from the April sampling trip supported anecdotal evidence that the Tok River below the Tok Overflow is an overwintering area for grayling. Since the Tok Overflow is an integral part of the area in the sense that it provides the "warm" water that keeps the area ice free during winter, the age and size compositions from the Tok River sample could be taken as a proxy estimate of grayling composition in the Tok Overflow. To be valid, grayling use of the Tok Overflow would have to be independent of behavioral differences among size and or maturity classes. Yet, grayling stratify by size or maturity in various habitats and during various seasons (Tack 1980; Ridder 1989; Hughes 1991; Clark 1993). A component of the population that preferred the habitat of the Tok Overflow may be depressed due to poor recruitment, exploitation, a change in habitat, or some other factor. Poor recruitment of year classes due to environmental effects is common in interior Alaska grayling stocks (Clark 1991). Poor recruitment or a stratification by size are indicated in the large decline in composition between age 4 and age 5 (from 44 to 9%, Table 5). While the sample appeared to give precise composition estimates due to sample size, the deep water areas that appeared to hold the largest and, hence, oldest grayling were sampled with difficulty and likely with inefficiency. If grayling were not sampled in proportion to their true abundance, the estimated proportions are biased low by an unknown amount. Mark-recapture techniques could have detected and adjusted for this potential bias (Bernard and Hansen 1992) as well as providing for an abundance estimate. However, the additional effort for the technique could not be scheduled. Nevertheless, the overwintering population in the Tok River below the Tok Overflow in 1993 appears to consist of predominantly small, juvenile grayling. Larger grayling may be missing from the population. These fish may have historically overwintered in the Tok Overflow.

Density of grayling in overwintering areas may also be a factor in the lack of grayling seen in the Tok Overflow. Grayling may overwinter in the Tok Overflow only when population density is high in other areas. Recent densities may be low due to either: an increase in the volume of habitat in

Table 8. Summary of angler reports of grayling tagged in the Tok and Little Tok River drainages, 1988 through 1993.

At tagging: Date	Location	Length	Age	Sex	At recapture: Date	Location	Length	Fate
5/17/88	Mineral Lake Outlet	366	10	M	8/21/88	Mineral Lake Outlet	---	Killed
5/18/88	Mineral Lake Outlet	260	6	F	8/27/88	Little Tok River	255	Killed
5/16/88	Mineral Lake Outlet	238	4		7/02/89	Mineral Lake Outlet	326	Killed
5/10/88	Mineral Lake Outlet	286	5	M	6/18/90	Little Tok River	362	Killed
5/20/88	Mineral Lake Outlet	225	6	F	9/01/91	Little Tok River	---	Killed
5/11/90	Mineral Lake Outlet	309	7	F	9/01/91	Little Tok River	---	Killed
5/12/90	Mineral Lake Outlet	314	6	F	9/01/91	Little Tok River	---	Killed
5/12/90	Mineral Lake Outlet	279	6	M	9/02/91	Mineral Lake Outlet	---	Killed
5/12/90	Mineral Lake Outlet	221	2		9/19/91	Little Tok River	---	Killed
5/14/90	Mineral Lake Outlet	280	5	M	9/19/91	Little Tok River	---	Killed
5/12/90	Mineral Lake Outlet	214	5		5/25/93	Little Tok River	---	Killed
4/15/93	Tok River	203	3		5/20/93	Mineral Lake Outlet	203	Released
4/15/93	Tok River	188	3		5/20/93	Mineral Lake Outlet	178	Released
5/12/93	Mineral Lake Outlet	271	6	M	5/15/93	Mineral Lake Outlet	254	Killed
5/12/93	Mineral Lake Outlet	345	7	M	5/20/93	Mineral Lake Outlet	356	Released
5/13/93	Mineral Lake Outlet	191	3		5/13/93	Mineral Lake Outlet	178	Released

the Tok River from mild winter conditions; a decrease in the population overwintering in the Tok River; a decline in the entire population of the drainage; or a combination of these factors. In April, the density of grayling in the combined 6.5 km surveyed area of the Tok River and Tok Overflow was conservatively estimated (from visual observations) at 1,400 fish greater than 200 mm or 215 grayling per kilometer. This is a medium density when compared to other rivers in interior Alaska[4] but without a complete survey of the overwintering area, it says nothing about the abundance of the area's overwintering population.

Some of the grayling which overwinter in the Tok River disperse upstream to other angler-accessible locations. Seven grayling initially tagged in the Tok River were recaptured throughout the summer in upstream areas by anglers and our field sampling. These fish are then vulnerable to anglers all year long and are probably the highest exploited portion of the population in the Tok River drainage. While homing to spawning and feeding areas have been demonstrated for a number of riverine populations (Ridder 1991; Clark 1993), it has not been shown for overwintering areas though intuitively it exists. Under this assumption, the Tok River fish are a discrete unit of the drainage's population. Over time, directed exploitation could produce the localized low abundance found by local anglers.

The scarcity of grayling in the Tok Overflow during the summer may be due more to low water temperatures (the coldest in the study area) than other factors. Tack (1980) stressed the importance of water temperature in the life history of grayling. He documented grayling response to temperatures during pre-spawning migrations, onset of spawning, and fall movements to overwintering areas. There may also be a temperature threshold during the summer feeding period below which grayling will avoid. Hughes (N. F., Research Associate, Institute of Arctic Biology, University of Alaska, Fairbanks, personal communication) gathered July and August temperature profiles at three sites in each of two spring-fed streams in the Tanana River drainage, the Delta and Richardson Clearwater rivers. Both streams offer high quality fisheries for large grayling. He found that grayling avoided headwater sites where the coldest temperatures (two month daily means of 4.3 and 4.4°C, respectively) were found. Ridder (1981) noted that grayling distribution in Clear Creek, a small spring-fed stream near the Richardson Clearwater River, appeared to be affected by a temperature gradient from head to mouth of 4.0 to 7.0°C, respectively. Proceeding downstream from the creek's head, he neither captured nor observed any grayling till the creek's mid-point. Ridder (1981) noted that temperature also appeared to influence the in-migration of grayling into the Delta Clearwater River for summer feeding. The largest daily capture rate and the first observation of large numbers of grayling occurred when the average river temperature reached 5.0 °C. These observations parallel those made at Tok Overflow and Tok Overflow #2 in that grayling were observed only in water with temperatures greater than 5°C. The temperature profile of Tok

[4] Roach (*In prep*) gave 1993 estimates of grayling density in other rivers of the Tanana River that ranged from 69 per km in the Chatanika River to 217 per km in the Goodpaster River to 433 per km in the Salcha River.

Overflow at the highway crossing was colder than the headwaters of the Delta Clearwater River (Figure 8) and suggests that, during the summer, grayling avoid the majority of the Tok Overflow.

Age, length, and sex compositions of grayling were estimated in May at Mineral Lake Outlet in a similar fashion as in 1988 and 1990 (Ridder 1989; Fleming and Ridder 1991). The earlier studies detected changes in length composition due to the migration of the grayling population during the spawning period and different capture probabilities due to sex stratification by habitat types (males in shallow water, females in pools). The 1993 sample was collected under conditions similar to 1988 and 1990, but the single sample event in 1993 precluded testing and adjusting for possible biases. Yet, if all samples are truncated to include only adult male grayling caught within a very short time interval, bias affecting age and length composition estimates is minimal. Site 1 at Mineral lake Outlet encompassed a spawning area actively defended by males and a sample drawn from this group can be assumed intransient and representative of the adult male population. Ridder (1989) found no bias present in the sample of adult males taken at the site over a four day period.

The length composition of adult males at Mineral lake Outlet in 1993 contained a significantly greater proportion of large fish than either the 1988 or 1990 compositions while the earlier compositions were similar (from KS tests: 1988 vs 1993, $p<0.01$; 1990 vs 1993, $p<0.01$; 1988 vs 1990, $p=0.11$; Figure 9). The 1993 sample had more large fish (>300 mm FL, Figure 10). This size difference was also evident in age compositions where 38% of the 1993 sample was greater than age 6 whereas in 1988 and 1990, 27% and 30%, respectively fell in this age range (Table 9).

The shift in composition towards larger and older males at Mineral Lake Outlet may be due to the following: 1) poor recruitment of younger age classes; 2) the effects of 4 years of a closed spring fishery at Mineral Lake Outlet (1988 through 1991); or, 3) sample timing. The poor recruitment hypothesis is somewhat negated by the domination of ages 3 and 4 found in the other samples (Tables 5 and 6). The causal effect of regulations is strengthened by ancillary data on the increasing rate of hooking damage (HD) found in samples of adult males:

Year	Sample	No.HD	%HD	%SE
1988	125	10	8%	2%
1990	222	34	15%	2%
1993	149	26	17%	3%

which indicates more fish were being released. Sample timing could obfuscate the comparisons if older and larger males were the first to defend territories and, after spawning, were to relinquish territories to the smaller and younger males. Yet there is no evidence of this in grayling and, in all three years, the site was closely monitored for temperatures and signs of territoriality. Sampling began soon after temperatures reached 4°C and territoriality was observed.

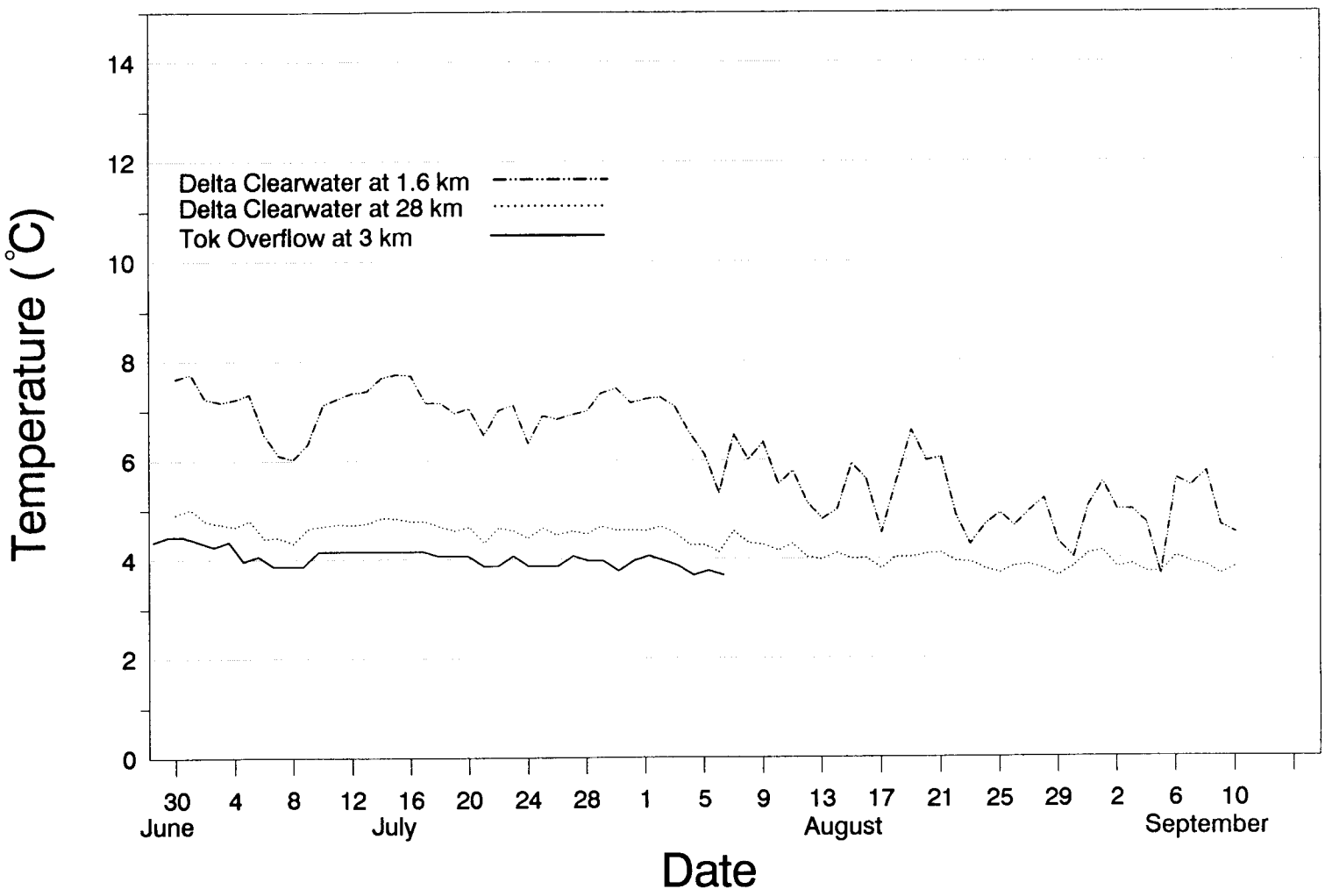

Figure 8. Comparison of daily mean temperatures (°C) between Tok Overflow and Delta Clearwater River, 1993.

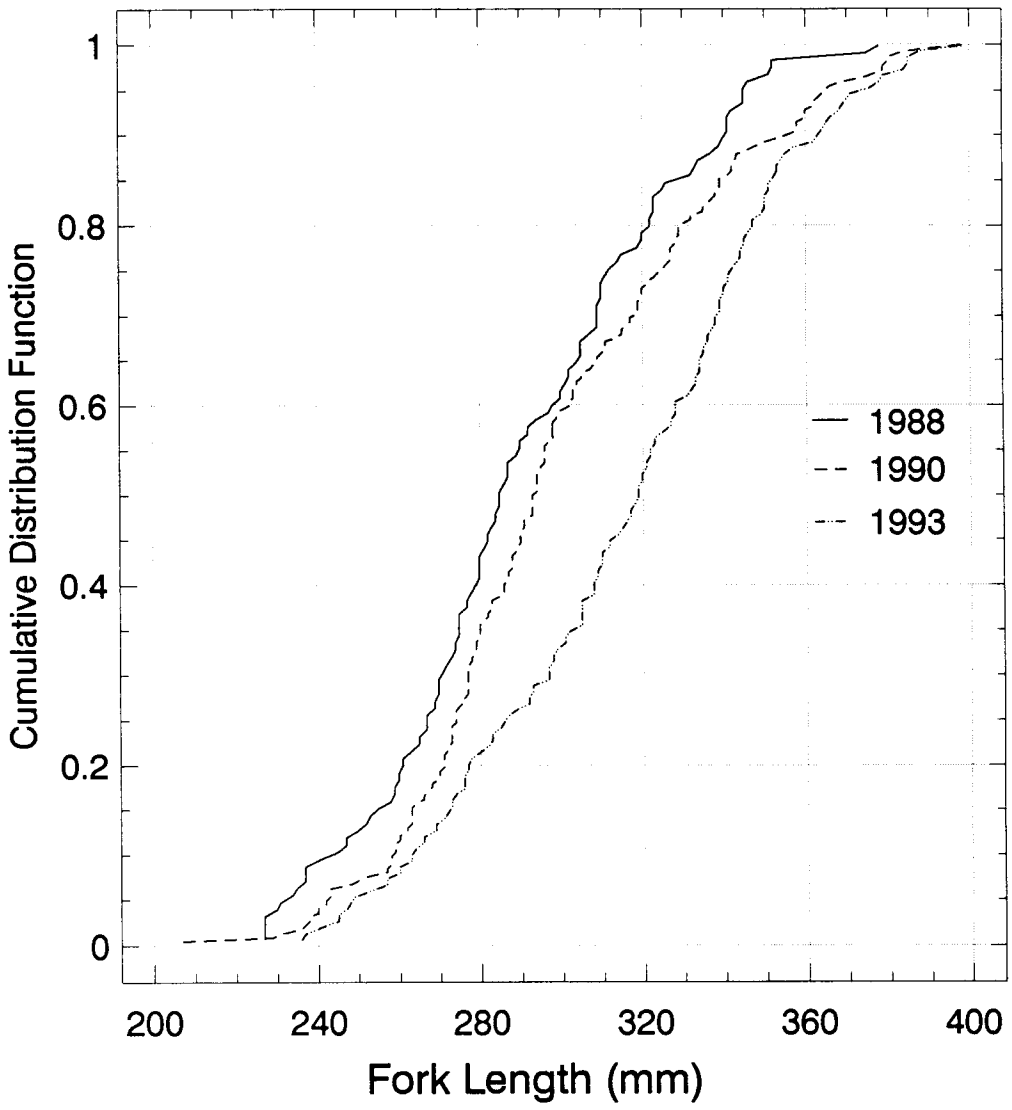

Figure 9. Cumulative length distribution functions of adult male Arctic grayling captured at Mineral Lake Outlet in 1988, 1990, and 1993.

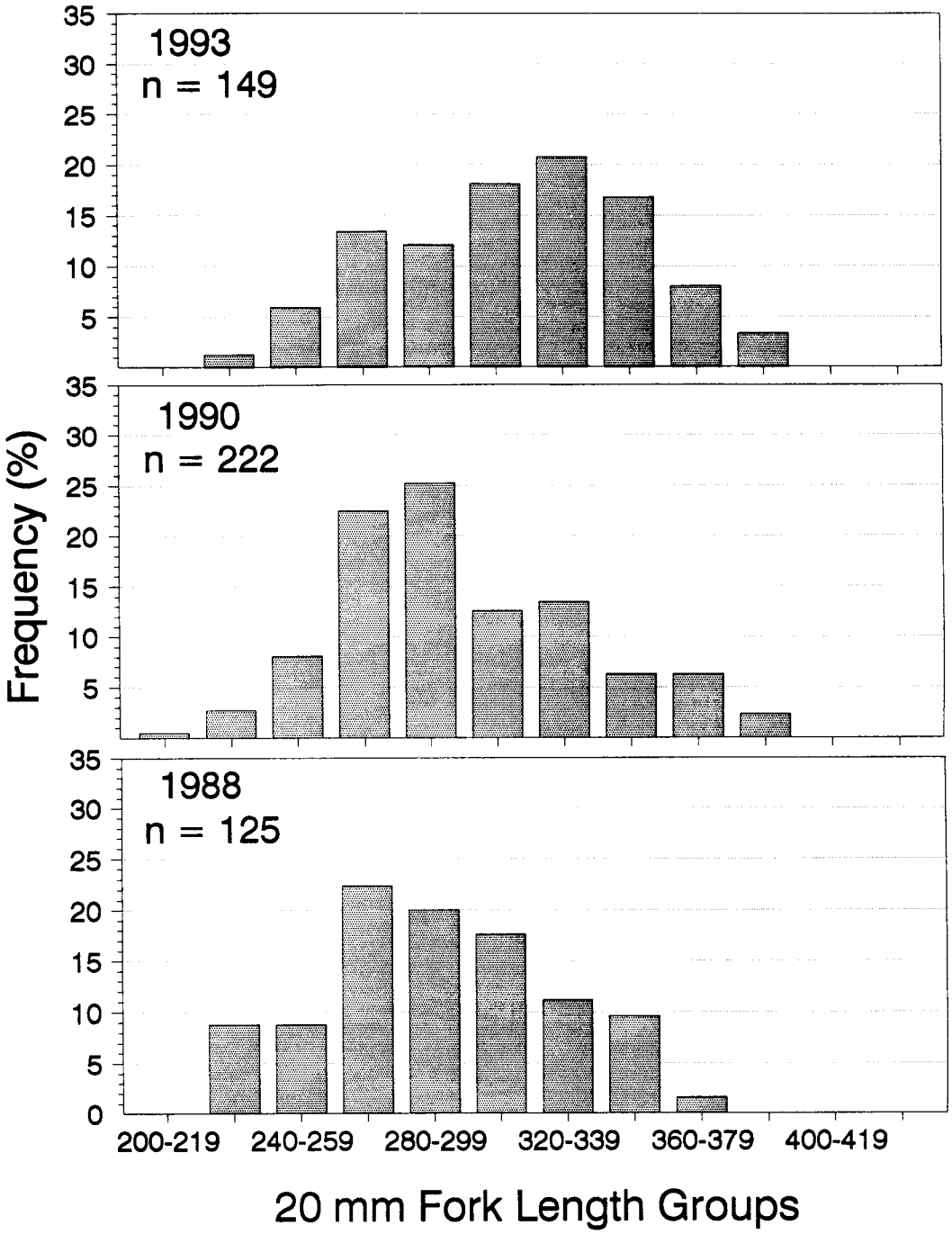

Figure 10. Length frequencies of adult male Arctic grayling captured in Mineral lake Outlet in 1988, 1990, and 1993.

Table 9. Age composition estimates and standard errors for mature male grayling sampled in Mineral Lake Outlet, 1988, 1990, and 1993.

Age Class	17-18 May 1988			11-12 May 1990			12 May 1993		
	n[a]	p[b]	SE[c]	n	p	SE	n	p	SE
2	0	---	---	0	---	---	0	---	---
3	1	0.01	0.01	6	0.03	0.01	0	---	---
4	10	0.10	0.03	24	0.12	0.02	11	0.09	0.03
5	42	0.43	0.05	28	0.14	0.03	21	0.17	0.03
6	19	0.19	0.04	79	0.40	0.04	45	0.36	0.04
7	14	0.14	0.04	35	0.18	0.03	33	0.27	0.04
8	10	0.10	0.03	14	0.07	0.02	10	0.08	0.02
9	0	---	---	7	0.04	0.01	4	0.03	0.02
10	1	0.01	0.01	4	0.02	0.01	0	---	---
11	0	---	---	0	---	---	0	---	---
12	1	0.01	0.01	0	---	---	0	---	---
Total	98	1.00		197	1.00		124	1.00	

[a] n = sample size.
[b] p = proportion.
[c] SE = standard error of the proportion.

Conclusions and Recommendations

Why grayling were absent from the Tok Overflow in April, supposedly within the historical timing of its spring fishery, may be due to a lower abundance as local anglers maintain. Yet, the scarcity of fish may be a result of any number of other poorly understood or unknown factors such as: random chance (fished or surveyed at the "wrong" time); a combination of density dependent, environmental (habitat), and behavioral factors; poor recruitment of one or more year classes; or, a change in grayling distribution and fall movements. Without data on the total area of overwintering habitat and estimates of the abundance of the overwintering population and its distribution, composition, and contribution to upstream fisheries, only speculations can be made from the 1993 study results. Prior to regulatory or enhancement actions, this study should be continued with the objectives of supplying the above data.

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APPENDIX A

Appendix A. Summary of water temperatures recorded in the Tok and Little Tok River drainages, 1993.

	Tok Overflow:						Tok				Little		Mineral Lake Outlet			
	Mouth		at 1.5 km		at culverts		Overflow #2[a]		Tok River[a]		Tok River[a]		Mouth		Head	
Date	°C	Time	°C	Time	°C	Time	°C	Time	°C	Time	°C	Time	°C	Time	°C	Time
4/13	2.5°	1200	---		2.9°	1630	---		---		frozen		frozen		---	
4/14	---		2.5°	0930	2.5°	1100	---		3.0°	1730	---		---		---	
5/6	---		3.6°	1430	3.1°	1300	4.0°	1730	---		3.9°	1530	---		4.9°	1630
5/11	---		---		3.2°	1630	4.0°	1645	---		4.1°	1700	---		5.8°	1800
5/12	4.3°	1130	3.8°	1100	3.8°	1230	---		6.3°	1130	5.9°	1400	---		5.9°	1600
5/13	---		3.6°	1115	3.1°	1130	5.0°	1130	5.0°	1130	5.8°	1145	5.9°	1230	---	
"	---		4.6°	1630	3.8°	1600	---		---		---		6.2°	1330	---	
"	---		---		---		---		---		---		7.5°	1600	---	
6/22	5.9°	1600	5.3°	1530	4.6°	1730	7.1°	1800	---		---		---		---	
6/23	---		---		---		---		---		9.5°	1830	13.8°	1000	14.2°	1130
6/24	---		---		4.2°	1500	4.9°	1500	11.0°	1400	---		---		---	
8/6	---		---		3.5°	1200	4.0°	1230	---		---		---		---	
9/13	3.9°	1530	3.5°	1500	3.2°	1600	3.2°	1630	---		5.8°	1700	---		---	
9/14	---		---		---		2.6°	1000	---		7.6°	1445	8.5°	1230	8.0°	1100

[a] Temperatures recorded at Glenn (Tok Cutoff) Highway crossing. At Tok River, 4/14 and 5/12 temperatures recorded 6.5 km below highway crossing.

APPENDIX B

Appendix B. Summary of mean length at age for grayling sampled from four areas of the Tok River drainage, 14 April through 14 September 1993.

	Tok River: 14-15 April			Mineral Lake Outlet: 12 May			23 June			14 September			Tok Overflow #2: 24 June			Little Tok River: 14 September		
Age Class	n[a,b]	FL[c]	SD[d]	n	FL	SD	n	FL	SD	n	FL	SD	n	FL	SD	n	FL	SD
0	0	---	---	0	---	---	3	44	4	49	99	15	0	---	---	0	---	---
1	1	103	0	0	---	---	16	116	13	37	136	28	0	---	---	0	---	---
2	20	158	18	1	164	0	7	174	14	8	181	10	4	182	8	3	172	12
3	233	191	19	54	192	18	11	203	15	5	242	20	11	206	19	3	214	8
4	244	213	18	98	218	23	20	242	20	2	263	10	8	224	11	12	255	18
5	49	235	18	39	264	40	3	297	9	2	274	11	8	224	18	4	278	22
6	12	281	33	56	302	28	3	286	21	0	---	---	1	264	0	0	---	---
7	1	310	0	44	329	22	0	---	---	0	---	---	1	230	0	0	---	---
8	1	262	0	20	340	28	0	---	---	0	---	---	1	246	0	0	---	---
9	0	---	---	5	377	6	0	---	---	0	---	---	0	---	---	0	---	---
10	0	---	---	1	352	0	0	---	---	0	---	---	0	---	---	0	---	---
Totals	561	203	31	318	260	61	63	193	67	103	134	51	34	215	22	22	241	37

[a] Samples are combined by date and include all gear types.
[b] n is the total number of fish aged.
[c] FL is the mean fork length (mm) at age.
[d] SD is the standard deviation of FL.

APPENDIX C

Appendix C. Data files from sampling grayling populations in the Tok and Little Tok River drainages, 1993.

Data file[a]	Description
U284JLA3.DTA	Sample data for grayling captured in the Tok River, 14 through 15 April 1993.
U604TLA3.DTA	Sample data for grayling and Dolly Varden captured in the Tok Overflow #2, 24 June and 14 September 1993.
U228ALA3.DTA	Sample data for grayling captured at the head of Mineral Lake Outlet, 12 and 13 June 1993.
U2280LA3.DTA	Sample data for grayling captured in Mineral Lake Outlet, 23 June and 14 September 1993.
U2160LA3.DTA	Sample data for grayling captured in the Little Tok River, 23 June and 14 September 1993.

[a] Data files have been archived at and are available from the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1599.