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SEWARD PENINSULA ARCTIC GRAYLING STUDY 1989[1]

By

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ABSTRACT

Stock status of Arctic grayling *Thymallus arcticus* was investigated in the Niukluk River and Arctic grayling were sampled for age and length in the Sinuk River during 1989. Both rivers are located on the Seward Peninsula. Population abundance, age composition, length composition, growth, and Relative Stock Density were estimated. The estimated abundance in a 22 kilometer section of the Niukluk River was 3,032 Arctic grayling over 200 millimeters in fork length (standard error = 816) or 138 fish per kilometer. Fish of age six and seven were most strongly represented. Arctic grayling ranged from 147 millimeters to 477 millimeters in fork length with a mean fork length of 352 millimeters. The majority of fish (84 percent) were in the "preferred" Relative Stock Density category. Sinuk River Arctic grayling ranged in age from four to 11 years, and in fork length from 308 to 528 millimeters with a mean of 449 millimeters. The majority of fish (80 percent) were in the "memorable" Relative Stock Density category. Sinuk River Arctic grayling grew faster and reached a larger size at age than Niukluk River fish. Growth of Arctic grayling from both rivers was successfully modelled with the von Bertalanffy growth equation.

KEY WORDS: Arctic grayling, *Thymallus arcticus*, electrofishing, population abundance, age composition, length composition, Relative Stock Density, growth, Seward Peninsula, Niukluk River, Sinuk River.

INTRODUCTION

The Seward Peninsula-Norton Sound area of western Alaska supports the second largest recreational fishery in the Arctic-Yukon-Kuskokwim (AYK) region. From 1980 to 1988, an average of 14,724 freshwater angler-days were fished in this area (Mills 1981-1989; Figure 1). Reported freshwater fish harvests in this area consist primarily of Dolly Varden *Salvelinus malma*, Arctic grayling *Thymallus arcticus*, pink, coho, chum, and chinook salmon *Oncorhynchus spp.*, northern pike *Esox lucius*, whitefish *Coregonus spp.*, and burbot *Lota lota*. From 1980 to 1988, Arctic grayling have accounted for an average of 20.1% of the harvest of these species. Arctic grayling have represented 25.4% of the overall harvest in 1987 and 1988. This, coupled with the fact that in 1988 the harvest of Arctic grayling was greater than the harvest of Dolly Varden for the first time, suggests that the sport fishery for Arctic grayling is growing in relative importance to area anglers (Table 1).

The Seward Peninsula is the only area in Alaska outside of Bristol Bay which regularly produces trophy-size Arctic grayling. Of 102 Arctic grayling registered with the Alaska Department of Fish and Game Trophy Fish Program between 1967 and 1987, 25 (24.5%) were from the Seward Peninsula (ADFG 1987).

Although the Nome area is not connected by road to the state highway system, the Seward Peninsula contains approximately 420 km of gravel roads which are maintained by the State of Alaska Department of Transportation from May through September. These roads originate in Nome and traverse the Seward Peninsula in three general directions: the Beam Road extending to the north, the Teller Road to the west, and the Council Road to the east (Figure 2). This road system sets Nome apart from most other rural Alaskan communities and provides angler access to many streams on the Seward Peninsula.

As indicated by catch and harvest statistics (Table 1) fishing pressure can be quite high on accessible streams. Subsistence harvests of Arctic grayling, although not monitored, have raised concern regarding stock status among local anglers who, along with ADFG staff in Nome, indicated that the abundance of large-size Arctic grayling appeared to be declining in some streams. These concerns led the Alaska Board of Fisheries to promulgate a regulation in 1988 which reduced the daily bag limit of Arctic grayling on the Seward Peninsula to five per day, five in possession, with only one over 15 inches (380 mm).

The first studies conducted by ADFG on the basic life history and angler utilization of fish on the Seward Peninsula began in 1977 and continued through 1979. Nine streams were surveyed for fish presence and 147 Arctic grayling were sampled for age, weight, and length. Angler counts were conducted periodically on 15 different streams (Alt 1978, 1979, 1980). Between 1979 and 1984, 88 Arctic grayling from the Fish/Niukluk rivers were sampled for age, length, and weight (Alt 1986). During 1988, a project was initiated to survey Arctic grayling stocks on 10 Seward Peninsula rivers and to estimate average catch and harvest-per-unit of effort of Arctic grayling on those streams (Merritt 1989). A total of 887 Arctic grayling were tagged and sampled for length and age on the Nome, Snake, Sinuk, Solomon, Eldorado, Pilgrim, Kuzitrin, Niukluk and Fish rivers and Boston Creek. In addition, 32 anglers were interviewed on Seward Peninsula streams.

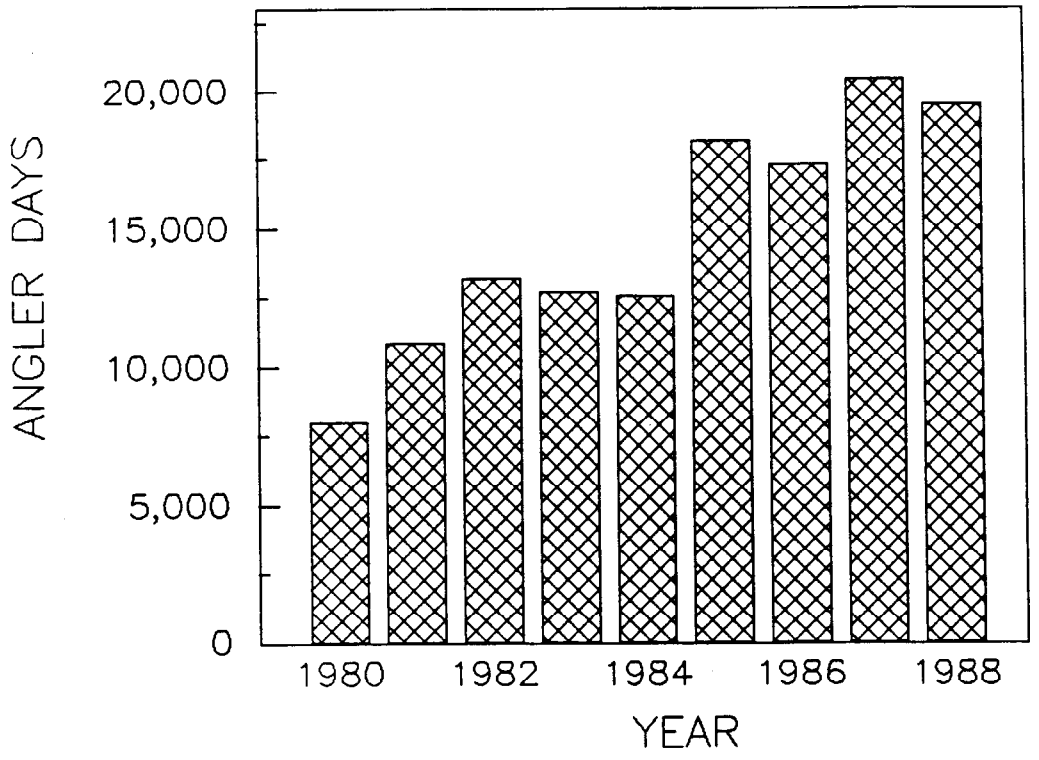


Figure 1. Freshwater sport fishing effort on Seward Peninsula and Norton Sound streams, 1980 - 1988.

Table 1. Freshwater sport fish harvests for Seward Peninsula and Norton Sound streams, 1980 to 1988[a].

Year	Days Fished	Salmon All Species	Dolly Varden	Arctic Grayling	Northern Pike	Burbot	Whitefish
1980	7,968	10,840	5,811	1,635	284	0	353
1981	10,879	6,564	3,981	2,104	303	0	123
1982	13,198	19,757	6,498	6,225	210	0	597
1983	12,678	10,189	9,779	8,241	798	0	148
1984	12,558	13,881	4,260	2,349	208	13	39
1985	18,141	3,401	5,695	4,501	56	175	70
1986	17,257	9,610	5,381	4,042	699	0	510
1987	20,381	5,415	5,506	4,600	906	0	272
1988	19,456	10,460	4,437	4,873	564	36	655
Mean	14,724	10,013	5,705	4,286	448	25	307

[a] Data from Alaska statewide sport fish harvest surveys (Mills 1981 thru 1989).

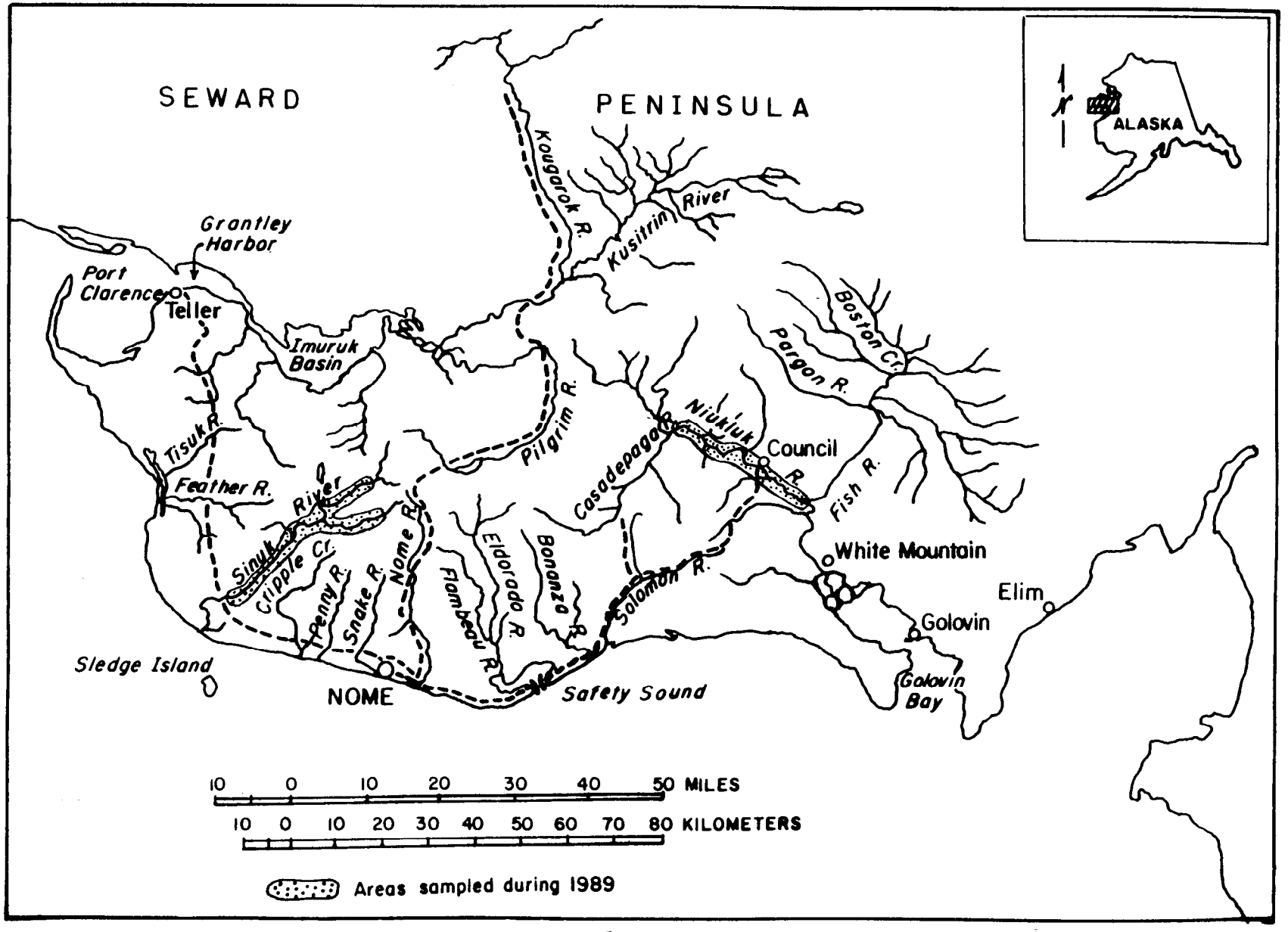


Figure 2. Study areas on the Seward Peninsula.

This project is a continuation of the work begun in 1988 by Merritt (1989). Long-term goals of the project are to:

1) define sustainable yield for Arctic grayling stocks in Seward Peninsula drainages; and to,

2) achieve sustainable yield sport fisheries for Arctic grayling populations through regulation.

Project objectives in 1989 were to estimate:

1) the abundance of Arctic grayling greater than 200 mm in fork length in a 32 km section of the Niukluk River;

2) age composition, length composition and Relative Stock Density (RSD) of Arctic grayling greater than 200 mm in a 32 km section of the Niukluk River; and,

3) the mean length-at-age of Arctic grayling in the Sinuk River.

METHODS

Sampling Gear and Techniques

Sampling of Arctic grayling in the Niukluk River (Figure 3) was performed using a pulse-DC electrofishing system mounted on a 5.4 m long riverboat. Input voltage (240 VAC) was provided by a 2,500 W single-phase Kawasaki gas powered generator. A variable voltage pulsator (Coffelt Manufacturing Model VVP 3C) was used to generate output current. Six anodes were constructed of 9.5 mm diameter twisted steel cable 1.5 m long and attached equidistantly to the cross member of a 3.5 m long retractable "T-boom" attached to a platform on the bow of the boat. The aluminum hull of the riverboat was used as the cathode. Output voltages varied between 180 and 240 VDC and amperage varied from 1.8 to 4 A. The pulse rate was held around 80 Hz.

Sampling was conducted along the banks of the Niukluk River. The electrofishing boat was directed downstream along each bank at a speed slightly above that of the current in order to maintain steerage of the vessel. All Arctic grayling seen were collected when possible by two technicians with dip nets located on the boat's bow platform which was equipped with a safety rail. Captured fish were immediately placed in one of two 0.6 m diameter black plastic water-filled tubs. Fish were sampled after 20-30 had been captured, or after a river subsection had been fully traversed. Each Arctic grayling was measured to the nearest mm in fork length (FL). Fish over 200 mm FL were tagged with individually-numbered Floy FD-67 internal anchor tags which were inserted such that the "T" anchor locked between the base of adjacent dorsal fin rays. Scales were taken for aging.

Arctic grayling from the Sinuk River (Figure 4) were sampled with hook and line during a four day period in early August. Access to the headwaters of

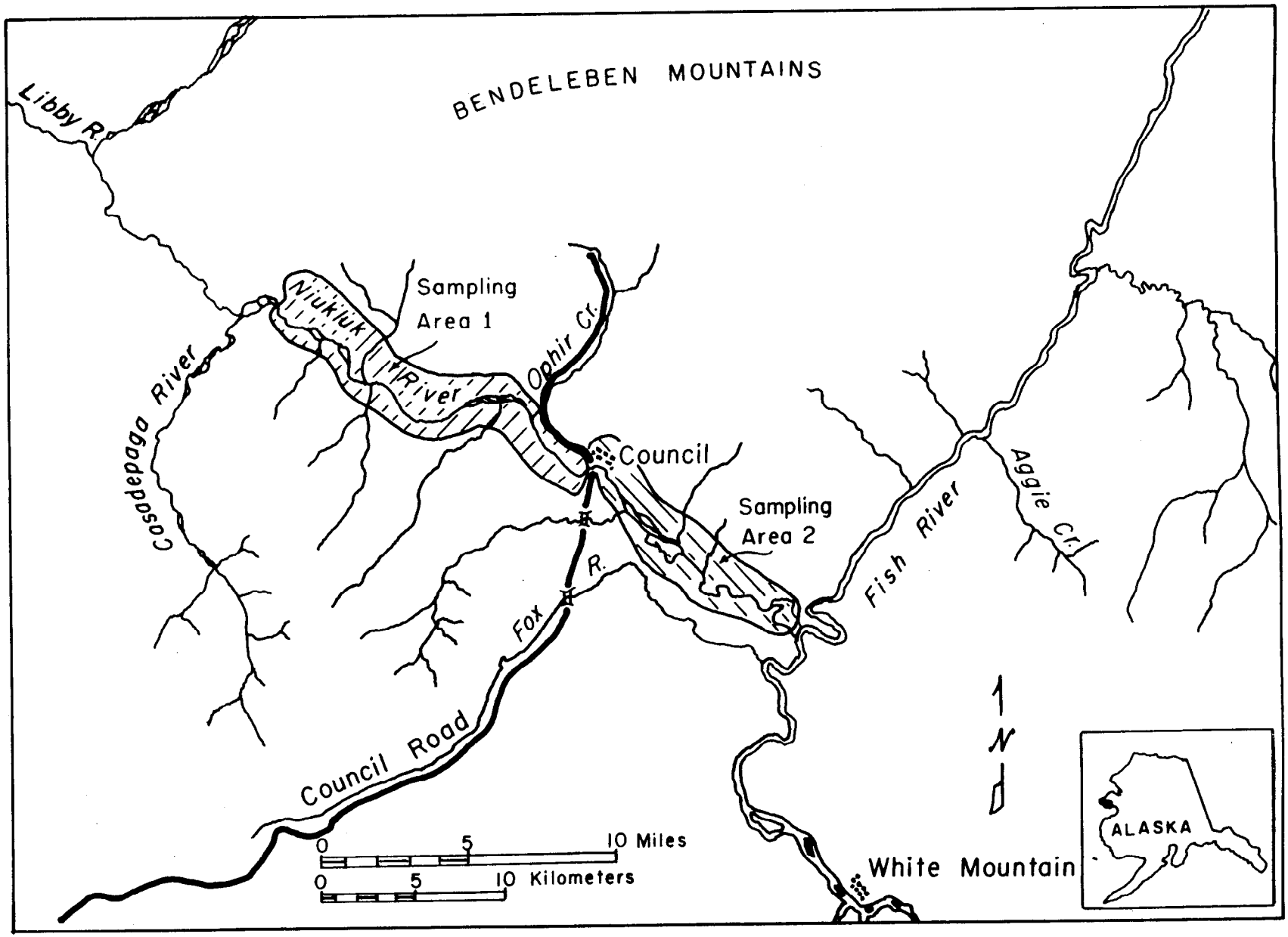


Figure 3. The Niukluk River with the area sampled during 1989.

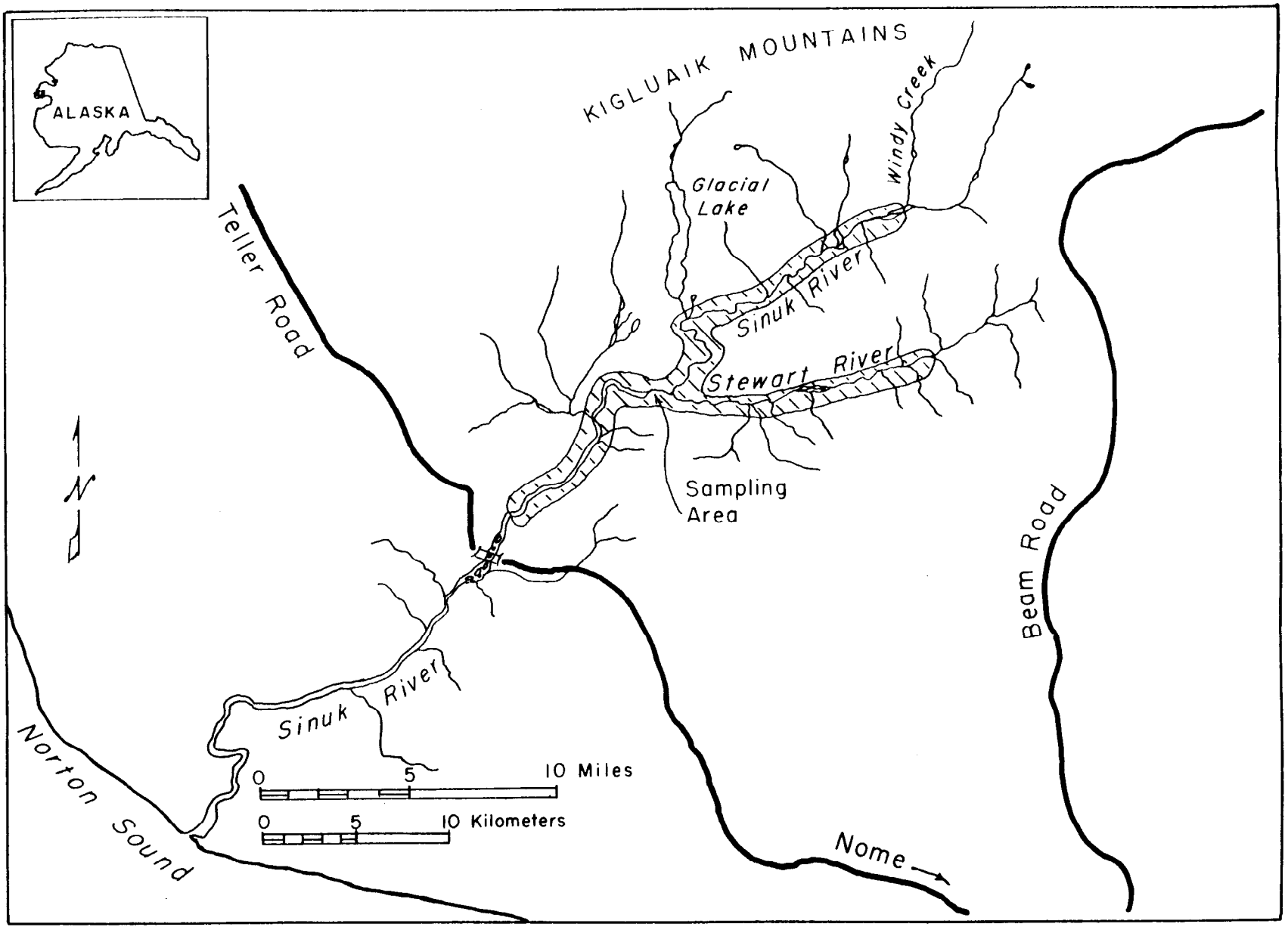


Figure 4. The Sinuk River with the area sampled during 1989.

the river was gained using a Bell Jet Ranger helicopter under contract to the Bureau of Land Management (BLM). The river was floated using two 3.7 m Avon Redshank inflatable rafts and oars. Seines, although available, were not used because of the presence of large boulders throughout much of the river. All Arctic grayling were sampled and tagged as described above.

Data were recorded on standard ADFG Tagging-Length forms (version 1). Scales were cleaned with detergent and water, mounted on gummed cards, and acetate impressions were made (30 seconds at 7,000 kg/cm^2, at 100°C). Ages were determined by counting annuli from the acetate impressions using a microfiche reader.

Niukluk River Population Estimate

A modified Peterson mark-recapture experiment (Chapman 1951) was used to estimate the abundance of Arctic grayling greater than 200 mm FL in the lower 38 km of the Niukluk River. The river was divided into two sections, one 22 km section extended from the mouth of the Casadepaga River downstream to the community of Council, and the other 16 km section extended from Council downstream to the Niukluk's confluence with the Fish River (Figure 3).

Sampling for the two-event population estimates was performed in each of the two river sections. The entire length of each river section was sampled once during both the mark and recapture events. Five days of electrofishing effort were expended sampling fish during the mark event (three days in the upper section and two days in the lower) and a like amount of effort was expended during the recapture event. There was a two day hiatus between sampling events.

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

1. there is neither mortality nor recruitment between sampling events (closed population);

2. fish have an equal probability of capture between events or marked fish mix completely with the unmarked population between sampling events;

3. marks are not lost between events; and,

4. marked fish can be recognized from unmarked fish.

Assumption 1 could not be tested directly except by the lack of presence of fish marked in one section in the adjacent section during the recapture event. It was assumed the population was closed because both events were close together in time. Assumption 2 was tested with a Kolmogorov-Smirnov (Conover 1980) test. All fish were released within the reach of the river in which they were captured. To meet assumption 3, all fish were double marked with a floy tag and a left ventral fin clip. Assumption 4 was met by the close examination of all fish and by the presence of the double mark.

Population abundance and the approximate variance of the estimate were calculated with the following formulas (Seber 1982):

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

$$\hat{V}[N] = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)^2(R+2)} \qquad (2)$$

where:

M = the number marked during the first period;

C = the number captured during the second period;

R = the number captured during the second period with marks from the first period;

$\hat{N}$ = the estimated abundance of Arctic grayling during the first sampling event; and,

V = the approximate variance of the abundance estimate.

Age and Size Composition

Samples of Arctic grayling for age and size composition were collected in conjunction with the abundance estimate on the Niukluk River and during the size-at-age sampling on the Sinuk River. The proportions of fish in each size, age, and sex category were estimated as multinomial proportions (Cochran 1977).

The proportion in each category was estimated as:

$$\hat{p}_j = \frac{n_j}{n} \qquad (3)$$

where:

n_j = the number in the sample from group j;

n = the sample size; and,

p_j = the estimated fraction of the population that is made up of group j.

The unbiased variance of this proportion was estimated as:

$$\hat{V}[\hat{p}_j] = \frac{\hat{p}_j(1-\hat{p}_j)}{n-1}; \quad (4)$$

Abundance of Arctic grayling by size and age was estimated as follows:

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

where:

$\hat{N}_i$ = estimated number of fish in age or size category i;

$\hat{p}_i$ = estimated proportion of fish in age or size category i; and,

$\hat{N}$ = estimated abundance of Arctic grayling.

Variances for Equation 5 are from Goodman (1960):

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

where:

$$\hat{V}[\hat{p}_i] = \frac{\hat{p}_i(1-\hat{p}_i)}{n-1}; \text{ and,}$$

n = number of Arctic grayling sampled.

Relative Stock Density

The RSD categories were estimated for Arctic grayling in the Niukluk and Sinuk rivers (Gabelhouse 1984). The RSD categories for Arctic 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). Estimates of these categories follow the same procedures used for age, sex, and size composition (equations 3 and 4).

Mean Length-at-Age

Mean length-at-age was calculated as the arithmetic mean length of all fish assigned the same age. Variances were calculated as the squared deviations from the mean. Standard errors of the mean (SE) were calculated as the square root of the variance divided by the square root of the sample size.

Growth characteristics were estimated with length-at-age data. The von Bertalanffy growth model (Ricker 1975) was chosen to calculate absolute growth (L_t) at ages 1 through 11 years:

$$L_t = L_\infty(1-e^{-K(t-to)}) \quad (7)$$

Model parameters were the theoretical maximum length (L_∞), the Brody growth coefficient (K), and the theoretical length at age 0 (t_o). Parameters were fitted by nonlinear regression with the Marquardt compromise (Marquardt 1963). The range of parameter values chosen for iteration by the model were L_∞: 300 to 700 mm by 100 mm increments; K: 0 to 0.4 by 0.1 increments; and t_o: -2.0 to 2.0 mm by 0.5 mm increments. A correlation matrix of the parameters was also generated by the model.

RESULTS

Niukluk River Population Abundance

A total of 303 Arctic grayling were marked in river section 1 between 17 and 20 July and 139 fish were marked in river section 2 between 20 and 21 July. During the recapture event (24 to 26 July) 109 Arctic grayling were examined from section 1 of which 10 had marks from the first sampling event. Six fish (1.4%) died as a result of electroshock sampling. All fish recaptured in section 1 with tags had been marked in that section. In section 2, 48 fish were examined during the recapture event, from 26 to 27 July, of which none had been marked during the first event. The estimated abundance of Arctic grayling over 200 mm FL in the 22 km section of the Niukluk River between the mouth of the Casadepaga River and Council (section 1) was 3,032 fish (SE = 816 Arctic grayling, CV = 26.9%) No abundance estimate could be calculated for the 16 km section between Council and the Fish River (section 2) because no marked fish were recaptured.

Kolmogorov-Smirnov plots of the cumulative length distributions of Arctic grayling sampled in river section 1 suggested no differences between the sample marked and the sample examined in the recapture event ($D = 0.12$, $P = 0.20$); the sample examined in the recapture event and the sample of tagged fish recaptured in that event ($D = 0.24$, $P = 0.64$); or the sample originally marked and those recaptured in the second event ($D = 0.29$, $P = 0.38$).

Capture rates using electrofishing gear varied between the marking and the recapture events. In section 1 (upstream of Council) approximately 469 minutes of electrofishing during the marking event resulted in the capture of 303 Arctic grayling for a catch-per-unit of fishing effort (CPUE) of 0.65 fish. In section 2 (downstream of Council) approximately 245 minutes of electrofishing during the marking event resulted in the capture of 139 Arctic grayling for a CPUE of 0.57 fish. During the recapture event, one week later, 458 minutes of electrofishing in section 1 resulted in the capture of 109 Arctic grayling for a CPUE of 0.23 fish, while in section 2, 258 minutes of electrofishing resulted in the capture of 48 Arctic grayling for a CPUE of 0.18 fish.

Relative Stock Density

Relative Stock Densities for Arctic grayling sampled in the Niukluk River show that the majority of fish (85%) were in the preferred category (Table 2; Figure 5). Of the estimated 3,032 Arctic grayling in section 1, 2,605 fish

Table 2. Relative Stock Density (RSD) of Arctic grayling (> 150 mm FL) captured in the Niukluk and Sinuk rivers, 17 July - 4 August 1989.

	RSD Category[a]				
	Stock	Quality	Preferred	Memorable	Trophy
Niukluk River					
Section 1					
Number sampled	1	109	312	4	0
RSD	<0.01	0.26	0.73	0.01	0.00
Standard Error	<0.01	0.02	0.02	<0.01	0.00
Abundance	7	776	2,221	28	0
Standard Error	7	218	601	16	0
Section 2					
Number sampled	7	108	108	0	0
RSD	0.03	0.48	0.48	0.00	0.00
Standard Error	0.01	0.03	0.03	0.00	0.00
Total					
Number sampled	8	217	420	4	0
RSD	0.01	0.33	0.65	0.01	0.00
Standard Error	<0.01	0.02	0.02	<0.01	0.00
Sinuk River					
Number sampled	0	4	59	82	0
RSD	0.00	0.03	0.41	0.57	0.00
Standard Error	0.00	0.01	0.04	0.04	0.00

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

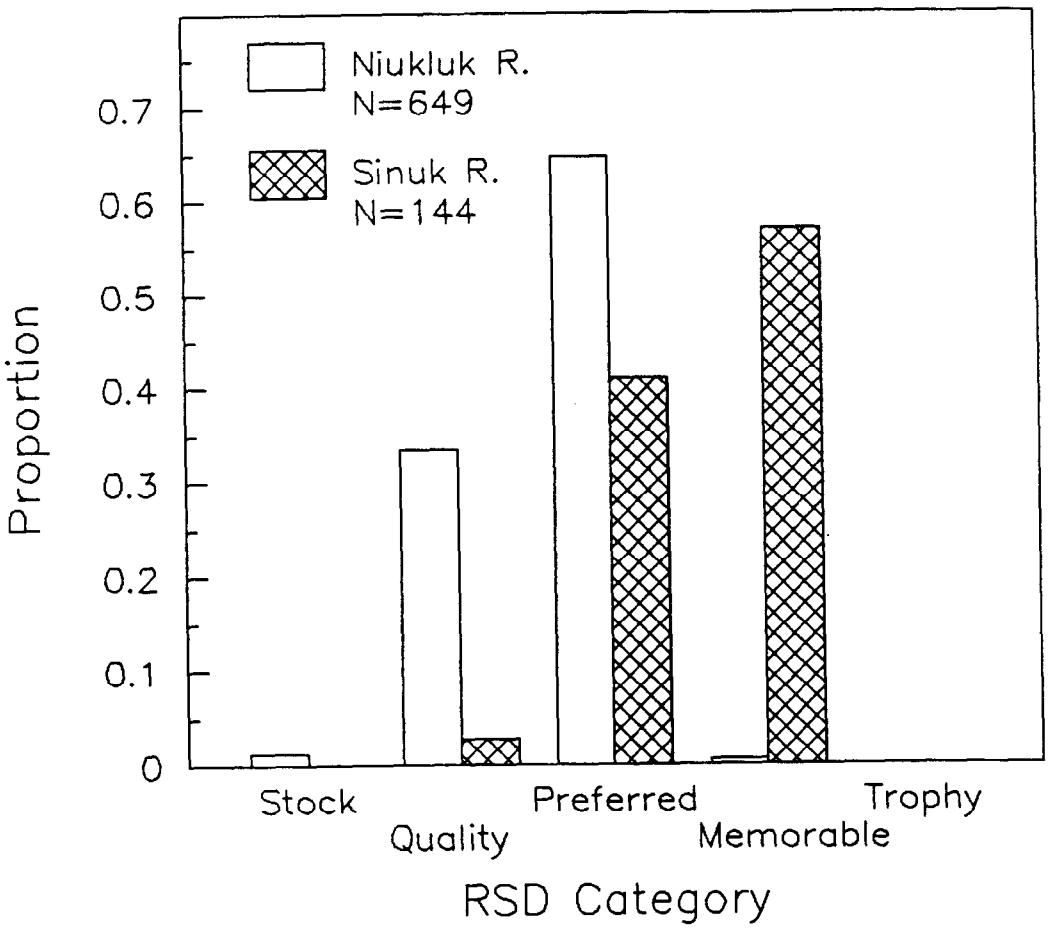


Figure 5. Relative Stock Density of Arctic grayling sampled from the Niukluk and Sinuk rivers during 1989.

(SE = 703 fish, CV = 27%) were in the preferred category and none were in either the stock or trophy categories. The RSD composition was significantly different in samples from the two sections of the Niukluk River (χ^2 = 27.32, df = 3, P < 0.01). There were more fish in the stock and quality categories and fewer memorable fish in the lower river section. Proportions in the preferred category were similar for both sections.

Relative Stock Densities were significantly different between the Niukluk and Sinuk River samples (χ^2 = 455.13, df = 2, P < 0.01). Arctic grayling sampled in the Sinuk River were larger in size than those in the Niukluk River with 80% of the sample being in the memorable category while only one fish sampled was smaller than the preferred category (Table 2; Figure 5).

Age and Length Composition

Age composition of samples taken from sections 1 and 2 of the Niukluk River were not significantly different (χ^2 = 5.04, df = 4, P > 0.95; Table 3; Figure 6). Of the estimated 3,032 Arctic grayling present in area 1, an estimated 1,316 (SE = 362 fish, CV = 28%) were age 6 and an estimated 1,214 (SE = 336 fish, CV = 28%) were age 7. The age composition of Arctic grayling sampled in the Niukluk River was significantly different from those sampled in the Sinuk River (χ^2 = 55.52, df = 5, P < 0.01). Higher proportions of older age class fish were present the Sinuk River sample (Table 3). Arctic grayling of ages 6, 7, and 8 comprised 29, 30, and 27%, respectively, in the Sinuk River sample while age classes 6 and 7 (42 and 41%, respectively) dominated the Niukluk River sample.

Arctic grayling sampled from the Niukluk River ranged in fork length from 147 to 477 mm FL, with a mean length of 352 mm FL and with 70% of the sample between 325 mm and 399 mm FL (Table 4; Figure 7). Arctic grayling from the Sinuk River were larger than those from the Niukluk River. Sinuk River fish ranged in fork length from 308 mm to 528 mm FL, with a mean length of 449 mm FL and with 70% of the sample between 425 and 499 mm FL. Cumulative length distributions of Arctic grayling sampled from the Niukluk and Sinuk rivers were significantly different (D = 0.80, P < 0.05; Figure 8).

Mean Length-at-Age

Mean fork lengths were greater for Arctic grayling of all age classes in the Sinuk River than in the Niukluk River (Table 5). While growth rates were rapid for fish in the Niukluk River to age 5, growth rates were very rapid in the Sinuk River for Arctic grayling up to age 6, resulting in larger size-at-age in the Sinuk River population (Figure 9). At age 5, the mean fork lengths of Niukluk River and Sinuk River fish were 346 and 401 mm FL, respectively, while at age 6, Niukluk River fish were 352 mm FL and Sinuk River fish were 432 mm FL. The oldest Arctic grayling in the Niukluk River sample were age 10 while the oldest Sinuk River fish were age 11.

Parameter estimates for the von Bertalanffy growth equation were generated for Arctic grayling from the Niukluk and Sinuk rivers (Table 6; Figure 10). The theoretical maximum lengths were 394 mm FL (SE = 4) for Niukluk River fish and 504 mm FL (SE = 29) for Sinuk River fish. The Brody growth coefficient was

Table 3. Estimates of age composition and abundance of Arctic grayling from section 1 of the Niukluk River, and estimates of age composition for the Niukluk and Sinuk rivers.

Age	2	3	4	5	6	7	8	9	10	11	Totals
Niukluk R.											
Section 1[a]											
N[b]	0	0	3	29	155	143	22	3	2	0	357
P[c]	0.00	0.00	0.01	0.01	0.43	0.40	0.06	0.01	0.01	0.00	1.00
SE[d]	0.00	0.00	<0.01	0.01	0.03	0.03	0.01	<0.01	<0.01	0.00	
Abundance[e]	0	0	25	246	1,316	1,214	187	25	17	0	3,030
SE[f]	0	0	16	79	362	336	63	16	12	0	
Section 2[g]											
N	1	1	4	9	73	81	15	0	0	0	184
P	0.01	0.01	0.02	0.05	0.40	0.44	0.08	0.00	0.00	0.00	1.00
SE	0.01	0.01	0.01	0.02	0.04	0.04	0.02	0.00	0.00	0.00	
Total[h]											
N	1	1	7	38	228	224	37	3	2	0	541
P	<0.01	<0.01	0.01	0.07	0.42	0.41	0.07	0.01	<0.01	0.00	1.00
SE	<0.01	<0.01	0.01	0.01	0.02	0.02	0.01	<0.01	<0.01	0.00	
Sinuk R.											
N	0	0	3	5	39	40	36	3	5	3	134
P	0.00	0.00	0.02	0.04	0.29	0.30	0.27	0.02	0.04	0.02	1.00
SE	0.00	0.00	0.01	0.02	0.04	0.04	0.04	0.01	0.02	0.01	

[a] Upper Niukluk, from Council 22 km upstream.
[b] The sample size.
[c] The estimated proportion of Arctic grayling in the age class.
[d] Standard error of the proportion.
[e] Estimated abundance in that river section by age class.
[f] Standard error of the abundance estimate.
[g] Lower Niukluk, from Council 16 km downstream.
[h] The total Niukluk River sample, both sections combined.

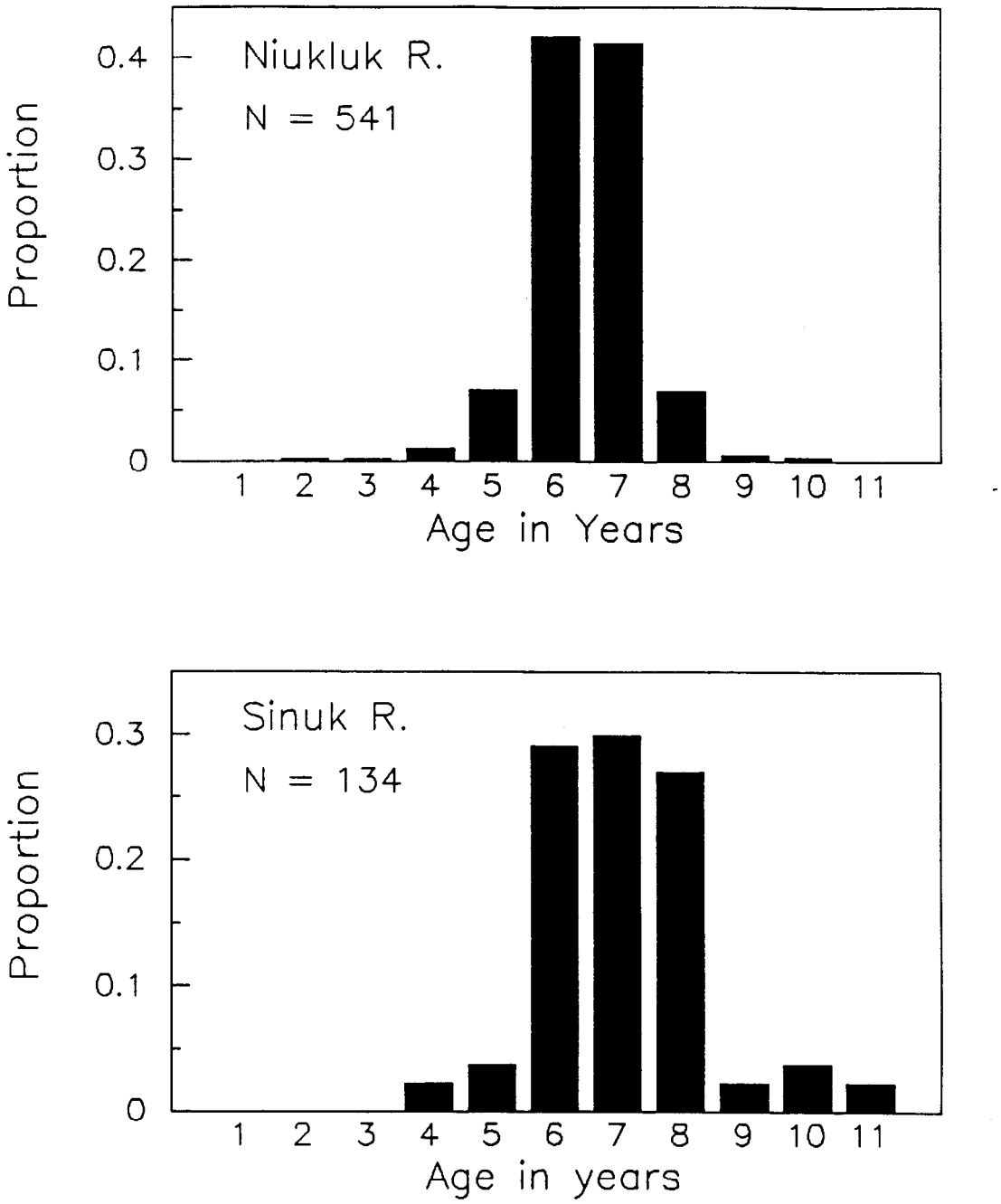
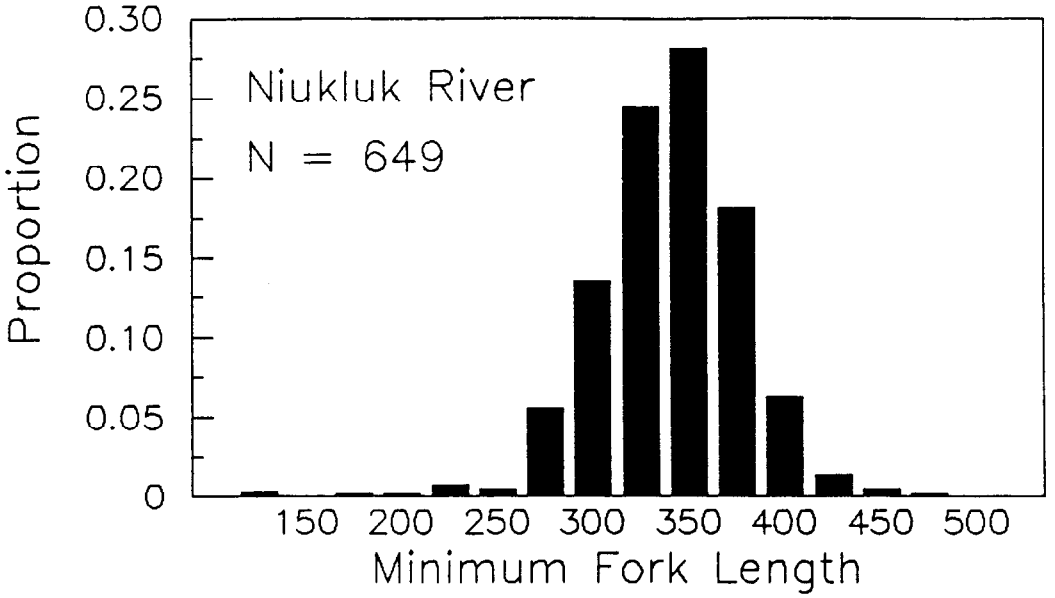


Figure 6. Age composition of Arctic grayling sampled from the Niukluk and Sinuk rivers during 1989.

Table 4. Length composition of Arctic grayling sampled from the Niukluk and Sinuk rivers by 25 mm increment.

Fork Length Range (mm)	Niukluk River			Sinuk River		
	N[a]	P[b]	SE[c]	N	P	SE
125 - 149	2	<0.01	<0.01	0	0.00	0.00
150 - 174	0	0.00	0.00	0	0.00	0.00
175 - 199	1	<0.01	<0.01	0	0.00	0.00
200 - 224	1	<0.01	<0.01	0	0.00	0.00
225 - 249	5	0.01	<0.01	0	0.00	0.00
250 - 274	3	0.01	<0.01	0	0.00	0.00
275 - 299	36	0.06	<0.01	0	0.00	0.00
300 - 324	88	0.14	0.01	1	0.01	0.01
325 - 349	159	0.25	0.02	4	0.03	0.01
350 - 374	182	0.28	0.02	8	0.06	0.02
375 - 399	118	0.18	0.02	8	0.06	0.02
400 - 424	41	0.06	0.01	9	0.06	0.02
425 - 449	9	0.01	0.01	31	0.21	0.03
450 - 474	3	0.01	<0.01	40	0.28	0.04
475 - 499	1	<0.01	<0.01	32	0.22	0.04
500 - 524	0	0.00	0.00	11	0.08	0.02
525 - 549	0	0.00	0.00	1	0.01	0.01
Total 125 - 549	649	1.00		145	1.00	

[a] Number of fish in fork length range.
[b] Estimated proportion of fish in fork length range.
[c] Standard error of the proportion.



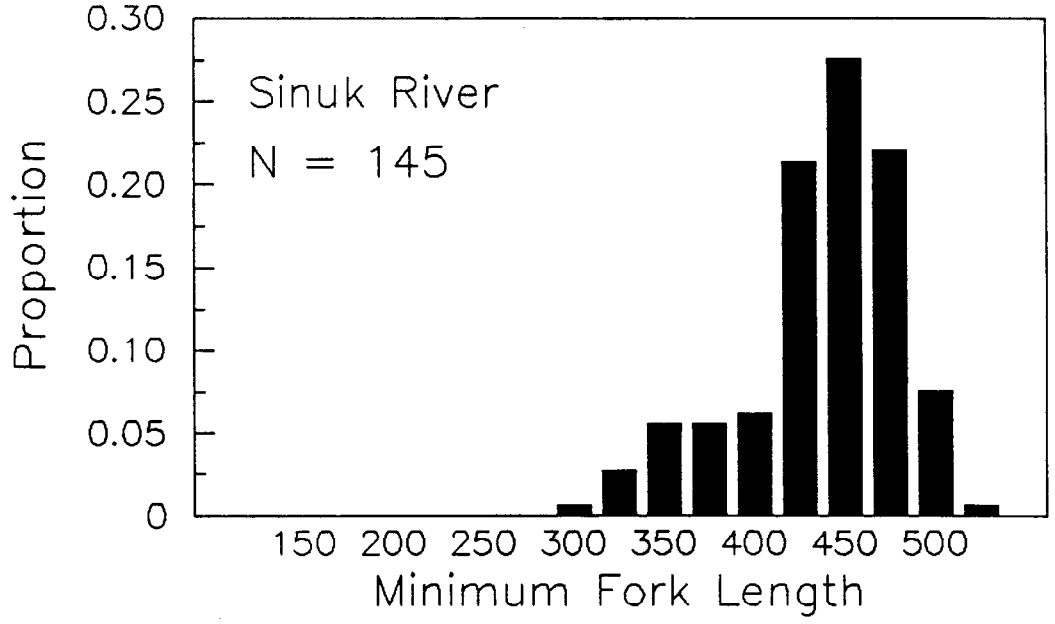


Figure 7. Length composition of Arctic grayling sampled from the Niukluk and Sinuk rivers during 1989.

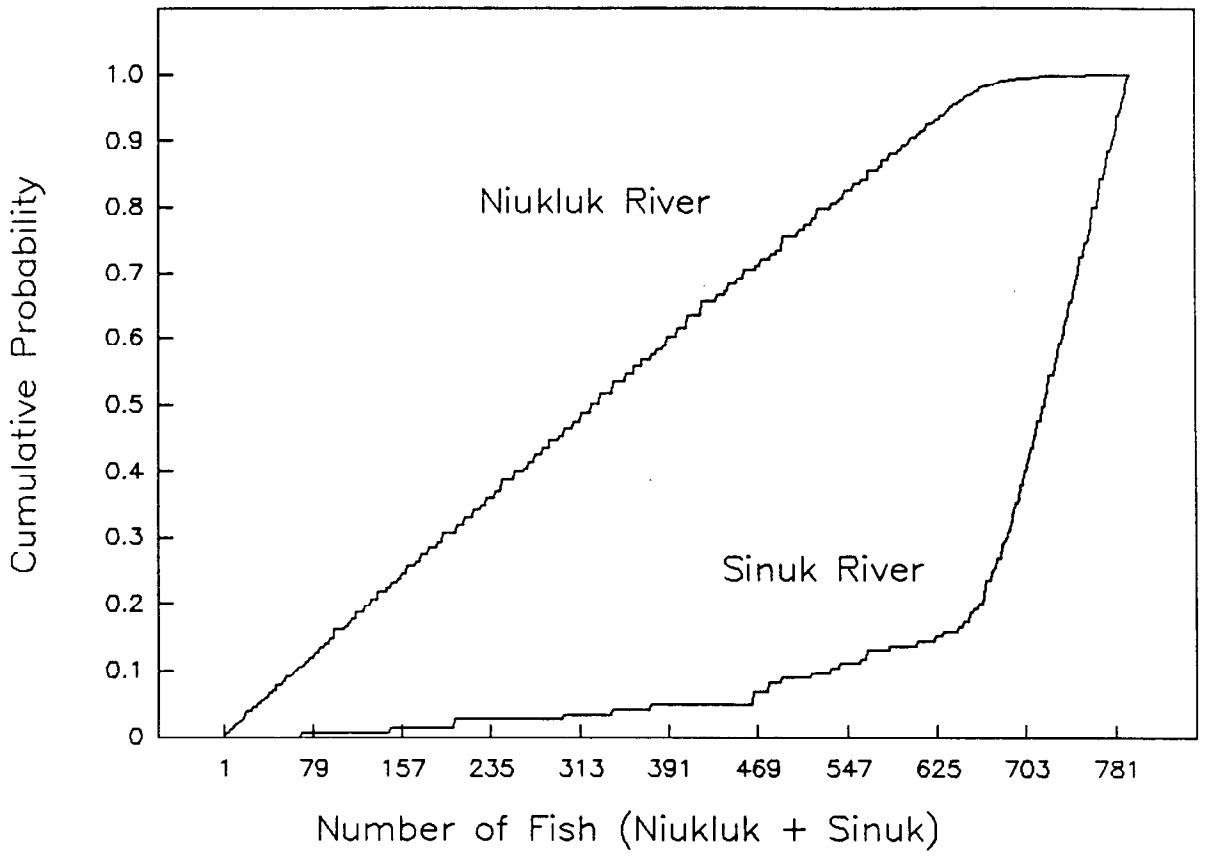


Figure 8. Cumulative length distribution of Arctic grayling sampled from the Niukluk and Sinuk rivers during 1989.

Table 5. Mean fork length-at-age of Arctic grayling sampled from the Niukluk and Sinuk rivers during 1989.

	Niukluk River			Sinuk River		
Age	n[a]	FL[b]	SE[c]	n	FL	SE
2	1	147	0	0	---	---
3	1	215	0	0	---	---
4	4	273	22	3	360	24
5	38	346	5	5	401	23
6	228	352	2	39	432	7
7	224	354	2	40	444	6
8	37	358	6	36	470	5
9	3	406	27	3	470	7
10	2	448	14	5	470	10
11	0	---	---	3	501	2
Totals and Means[d]	649	352	1	134	449	4

[a] n is the number of fish of this aged from samples taken in 1989.
[b] FL is the arithmetic mean fork length in millimeters.
[c] SE is the standard error of FL.
[d] Totals and means include fish sampled for which ages could not be determined.

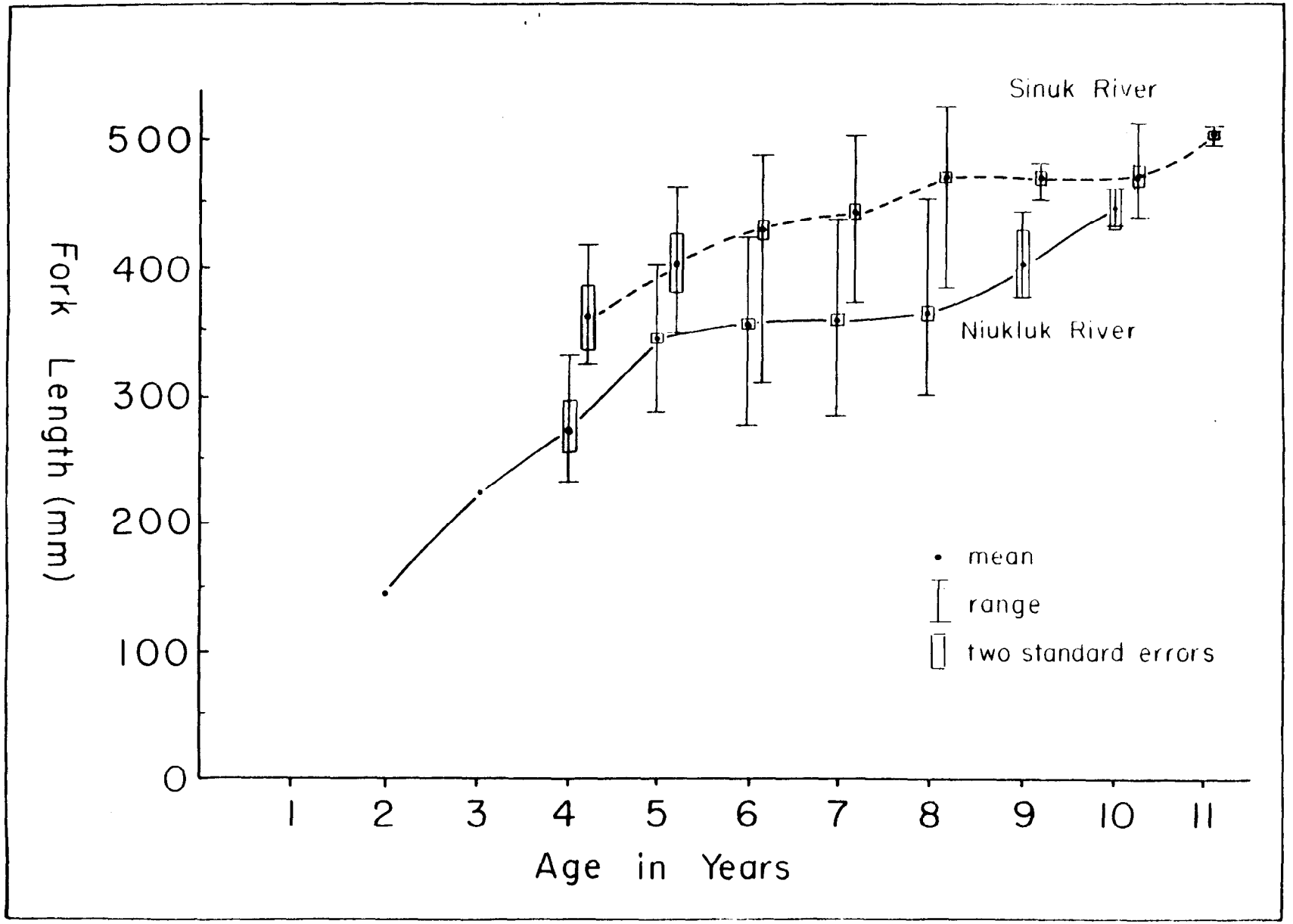


Figure 9. Mean length-at-age of Arctic grayling sampled from the Niukluk and Sinuk rivers during 1989.

Table 6. Parameter estimates and standard errors of the von Bertalanffy growth model[a] for Niukluk and Sinuk River Arctic grayling.

Parameter	Niukluk River Estimate	Niukluk River SE	Sinuk River Estimate	Sinuk River SE
L_∞[b]	364	4	504	29
K[c]	.71	.09	.32	.15
t_o[d]	1.42	.23	-0.04	1.78
Corr[e](L_∞,K)	-0.87	---	-0.95	---
Corr(L_∞,t_o)	-0.49	---	-0.85	---
Corr(K,t_o)	0.79	---	0.97	---
Sample size	541		124	

[a] The form of the von Bertalanffy growth model (Ricker 1975) is as follows: $l_t = L_\infty (1 - \exp(-K (t-t_o)))$. Estimates were accomplished through nonlinear regression using the Marquardt compromise (Marquardt 1963).
[b] Theoretical maximum length.
[c] Brody growth coefficient.
[d] Theoretical length at age 0.
[e] Correlation.

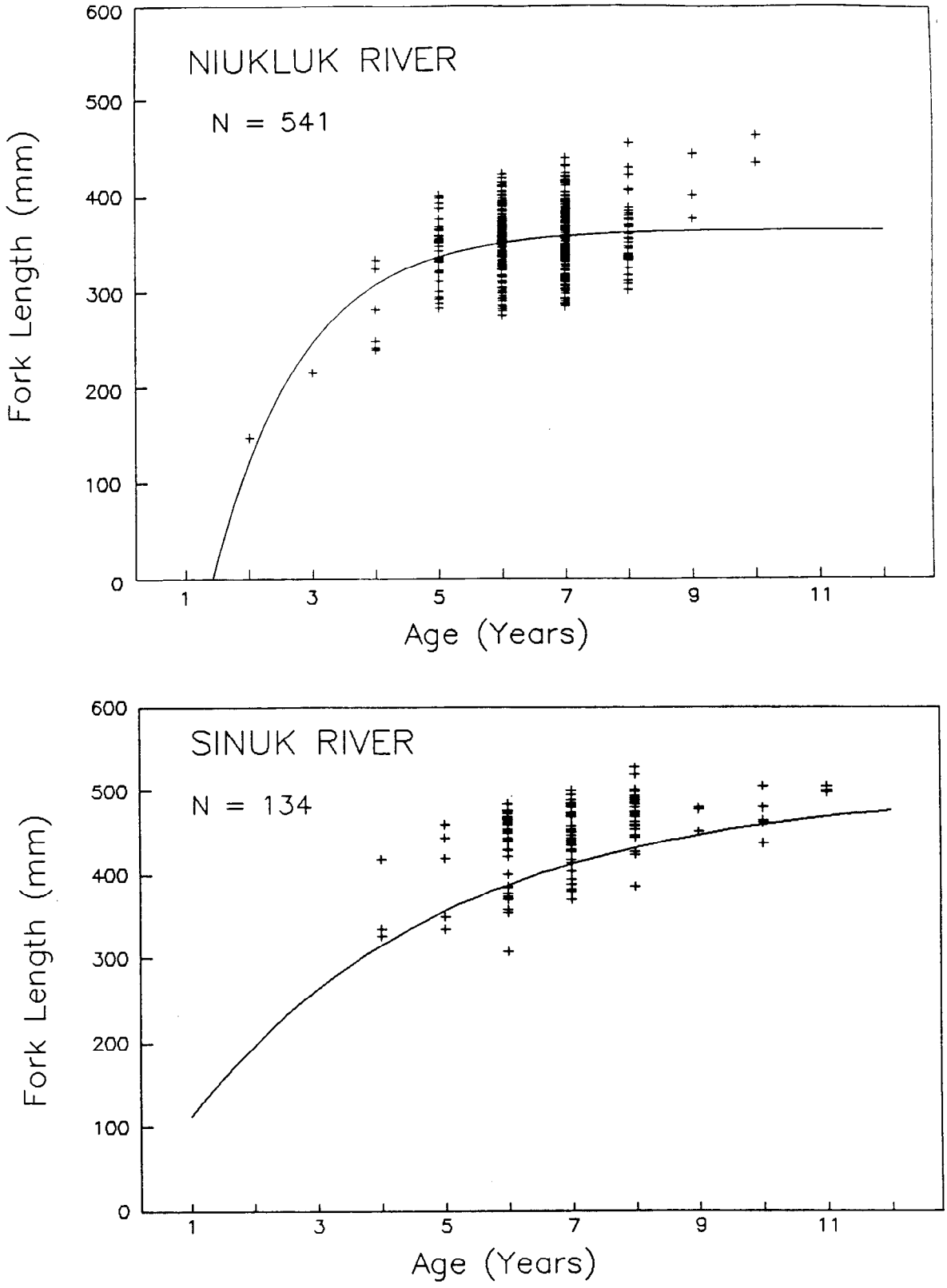


Figure 10. Growth curves of Arctic grayling from the Niukluk and Sinuk rivers, 1989.

0.71 (SE = 0.09) for Niukluk River fish and 0.32 (SE = 0.15) for Sinuk River fish.

DISCUSSION

The Niukluk River population estimate was designed to encompass the entire section of the river from the Casadepaga to the mouth, however, the number of fish recaptured in the downstream section was insufficient to calculate an estimate. The CPUE using electrofishing was much lower during the recapture event in both sections of the Niukluk River due primarily to a change in the clarity of the water. Very clear water during the recapture event allowed fish to see the approaching boat and avoid it. Fish were often observed moving ahead of the boat and then moving around it outside the effective range of the electrical field.

Small Arctic grayling were conspicuously absent from the Niukluk River samples. Although more small fish were captured in section 2 of the Niukluk than in section 1, the number was minimal. This was probably due to either the inability of the capture gear to sample the habitats of small fish or to a lack of small fish in sections of the river that were sampled. Merritt (1989) found that beach seines caught smaller Arctic grayling than did hook and line gear in Seward Peninsula streams, yet in the Niukluk River, where the catch per beach seine was the highest of all streams (8.5 fish per haul), she only captured four fish younger than age 5. This suggests that small Arctic grayling use a different part of the Fish/Niukluk River system. More sampling effort with different capture gears is necessary before this can be determined conclusively. Small Arctic grayling were also lacking in the Sinuk River sample. This was in part due to the fact that hook and line was the only capture method used. High water levels from unusually heavy rainfall, the widespread presence of large rocks, and swift water velocities prevented the effective deployment of beach seines. In addition, the lower 24 km of the river was not sampled. Immature Arctic grayling are often found to inhabit certain portions of some streams (Armstrong 1986). Young age classes of Arctic grayling were found in greatest abundance in the lower reaches of the Chena River (Tack 1980).

Growth was more rapid for Arctic grayling from the Sinuk River than for Arctic grayling from the Niukluk River, but fish in both rivers grew more rapidly than those from interior streams (Armstrong 1986). The mean fork length of age 5 Arctic grayling from the Niukluk River was 345 mm. After age 5, growth slowed probably coincident with the onset of sexual maturity. Sinuk River fish averaged 401 mm FL at age 5 and exhibited rapid growth to age 6 when they averaged 431 mm FL. Subsequent to age 6, growth slowed. It is probable that sexual maturity occurs at age 6 in this population. The Sinuk River population is virtually unexploited resulting in high proportions of large, older fish.

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APPENDIX A

Appendix A1. List of numbered tags placed in Arctic grayling in the Niukluk and Sinuk rivers during 1989.

Location	Dates	Total	Tag Numbers	Color
Niukluk River	7/18/89 - 7/28/89	90	50000 - 50089	Green
		530	50091 - 50620	Green
Sinuk River	7/31/89 - 8/4/89	77	51000 - 51076	Green
		8	51078 - 51085	Green
		1	51087	Green
		26	51100 - 51125	Green
		26	51200 - 51225	Green