Fishery Data Series No. 96-21

Assessment of Arctic Grayling in Selected Streams of the Seward Peninsula, 1995

by

Alfred L. DeCicco

August 1996

Alaska Department of Fish and Game

Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd
Spell out acre and ton.	

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s
Spell out year, month, and week.	

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

The number of Arctic grayling *Thymallus arcticus* over 239 mm in FL was estimated at 578 fish (SE = 87) in a 12 km index section of the lower Pilgrim River. The density was 48 Arctic grayling/km. Arctic grayling captured from the Pilgrim River ranged from 165 to 475 mm in FL and from 2 to 13 years of age. The majority of Arctic grayling (53%) were in the "preferred" Relative Stock Density category in the lower Pilgrim River. Abundance was not estimated in the upper Pilgrim River during 1995 because an insufficient number of fish were recaptured. Arctic grayling in the Snake River showed greater increases in length during years of high pink salmon *Oncorhynchus gorbuscha* abundance than during years of low pink salmon abundance. Of 51 Arctic grayling captured and released in the Eldorado River, 41 were injected with OTC for later recapture in order to validate aging techniques; 10 already had been injected during 1994.

Key words: Arctic grayling, *Thymallus arcticus*, population abundance, age composition, length composition, Seward Peninsula, Snake River, growth, Pilgrim River, Eldorado River, pink salmon, *Oncorhynchus gorbuscha*.

INTRODUCTION

The Seward Peninsula-Norton Sound area of western Alaska supports the second largest amount of recreational fishing effort in the Arctic-Yukon-Kuskokwim (AYK) region. From 1980 to 1994, an annual average of 15,797 freshwater angler-days of fishing effort occurred in this area (Mills 1981-1994, Howe et al. 1995). Reported freshwater fish harvests consisted 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 through 1991, Arctic grayling had comprised an average of 19.4% of the harvest of these species, but dropped to 6.5% from 1992 through 1994 (Table 1).

The Seward Peninsula is the only area in Alaska outside of Bristol Bay which regularly produces trophy-sized Arctic grayling. Of 116 Arctic grayling registered with the Alaska Department of Fish and Game (ADF&G) Trophy Fish Program between 1967 and 1994, 31 (27%) were from the Seward Peninsula (ADF&G *Unpublished*). Since 1984, 17 of 33 Arctic grayling registered in this program (52%) came from the Seward Peninsula.

Although not connected by road to the state highway system, the Nome area has approximately 420 km of maintained gravel roads which traverse the Seward Peninsula in three general directions from Nome (Figure 1). This road system provides angler access to many waters.

Local concerns about the stock status of Arctic grayling and angler reports that the abundance of large-sized Arctic grayling appeared to be declining in some streams 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 (381 mm).

The first studies conducted by ADF&G on the basic life history and angler utilization of fish in the freshwaters of Seward Peninsula began in 1977 and continued through 1979. Nine streams were

Table 1.-Estimated freshwater sport fish harvests (catches are in parentheses) for Seward Peninsula and Norton Sound streams, 1980-1994. Data from the Alaska statewide sport fish harvest survey (Mills 1981-1994, Howe et al. 1995).

	Harvests (Catches) in Number of Fish						
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
1989	15,443	8,548	7,003	4,205	648	10	453
1990	18,720	11,227	3,765	1,378	1,957	33	299
		(24,705)	(9,118)	(6,119)	(4,145)	(33)	(315)
1991	22,118	8,928	10,365	5,121	1,429	116	1357
		(15,561)	(25,425)	(23,160)	(4,257)	(116)	(1,409)
1992	19,351	11,778	2,178	492	479	0	46
		(35,473)	(5,726)	(5,772)	(3,742)	(0)	(165)
1993	17,055	6,634	5,702	1,378	537	96	95
		(16,920)	(21,961)	(13,223)	(2,117)	(107)	(196)
1994	11,757	12,215	2,981	1,200	376	0	67
		(21,048)	(7,254)	(6,853)	(1,731)	(0)	(172)
MEAN	15,797	9,963	5,564	3,490	630	26	502
		(23,187)	(13,897)	(11,025)	(3,198)	(51)	(451)

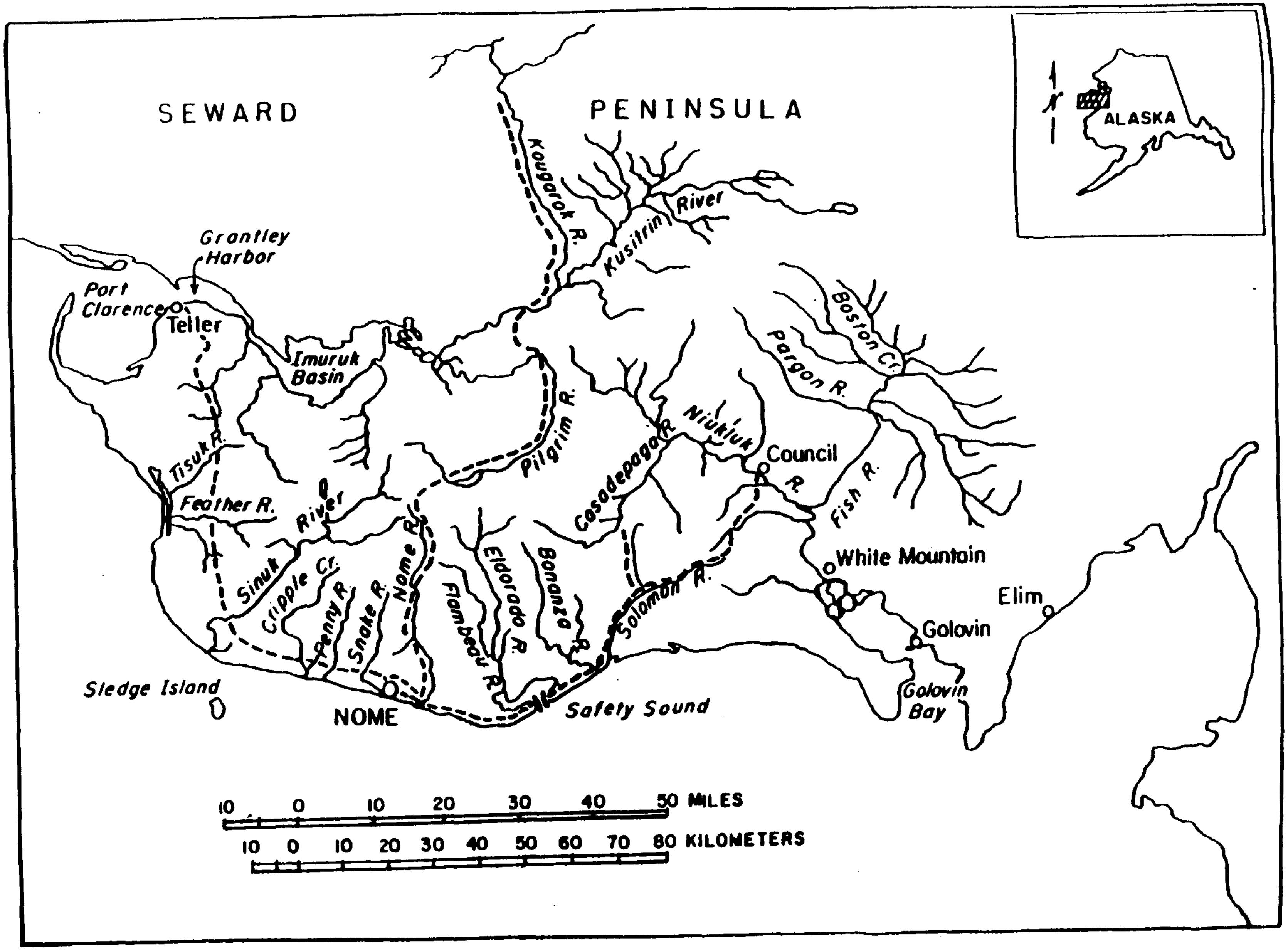


Figure 1.-The southern Seward peninsula showing roads and road accessible waters.

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 Seward Peninsula rivers and to estimate average catch and harvest per unit effort on surveyed 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. Since 1989, population abundance, age at length, size and age composition have been estimated for Arctic grayling on the Niukluk, Fish, Pilgrim, Nome, Snake and Sinuk rivers (DeCicco 1990-1995). Problems assigning ages to large Arctic grayling have been noted in recent years (DeCicco 1993-1995). Consequently, an age validation component was added to this project in 1994.

Several regulatory changes have recently been implemented based on data collected from this study. The Nome and Solomon rivers have been closed to Arctic grayling fishing by emergency order and will remain closed until it is determined that the populations have recovered. The daily bag and possession limits for Arctic grayling in both the Snake and Pilgrim rivers have been reduced to two per day, only one of which may be over 15 inches (381 mm) in length.

The long term goal of this project is to achieve sustained yield fisheries for Arctic grayling populations through regulation. Project objectives in 1995 were to:

1) estimate the abundance and age and length compositions of Arctic grayling greater than 249 mm FL in a 12-km section of the Pilgrim River downstream of the Beam Road bridge;
2) estimate the abundance and age and length compositions of Arctic grayling greater than 249 mm FL in a 42-km section of the Pilgrim River from Salmon Lake downstream to the Beam Road bridge;
3) test the hypothesis that there are no growth differences in Arctic grayling from the Snake River during years of high and low pink salmon abundance; and,
4) capture, mark with floy tags and a substance to fluoresce the bone structure and release Arctic grayling in the Eldorado River for an age validation study planned for 1996.

In addition, mean length-at-age for Arctic grayling in the Snake, Pilgrim and Eldorado rivers was estimated.

METHODS

SAMPLING GEAR AND TECHNIQUES

Arctic grayling were sampled using hook and line, and a 50-m x 2-m, 6.5-mm mesh beach seine on the Snake and Pilgrim rivers (Figures 2 and 3). Access to the Snake, Eldorado and upper Pilgrim rivers was by inflatable raft, while the lower Pilgrim river was sampled using a 4.8 m outboard jet powered riverboat.

Each Arctic grayling was measured to the nearest mm in fork length. Fish over 149 mm FL in the Pilgrim and Eldorado rivers 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

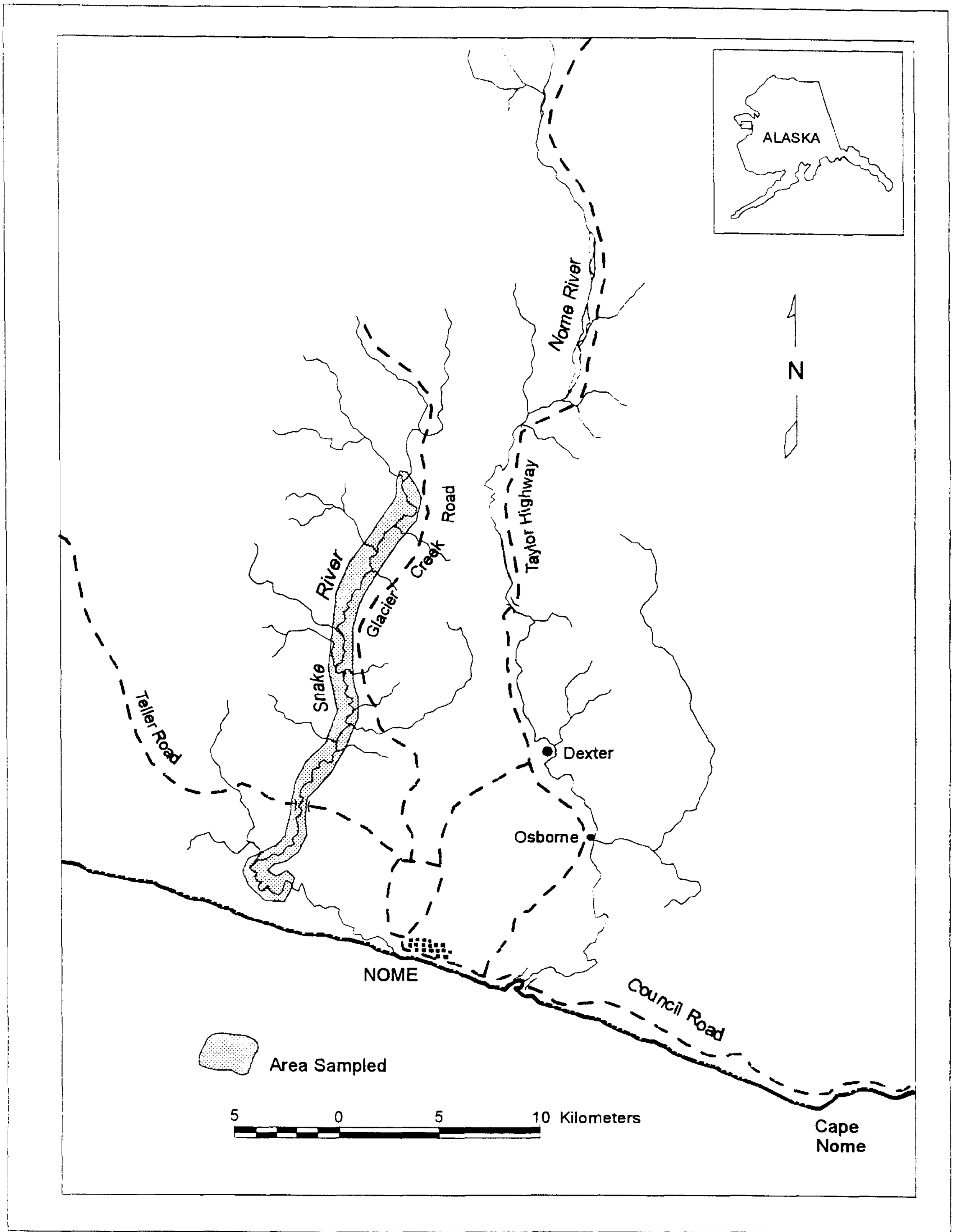


Figure 2.-The Snake River with area sampled during 1995.

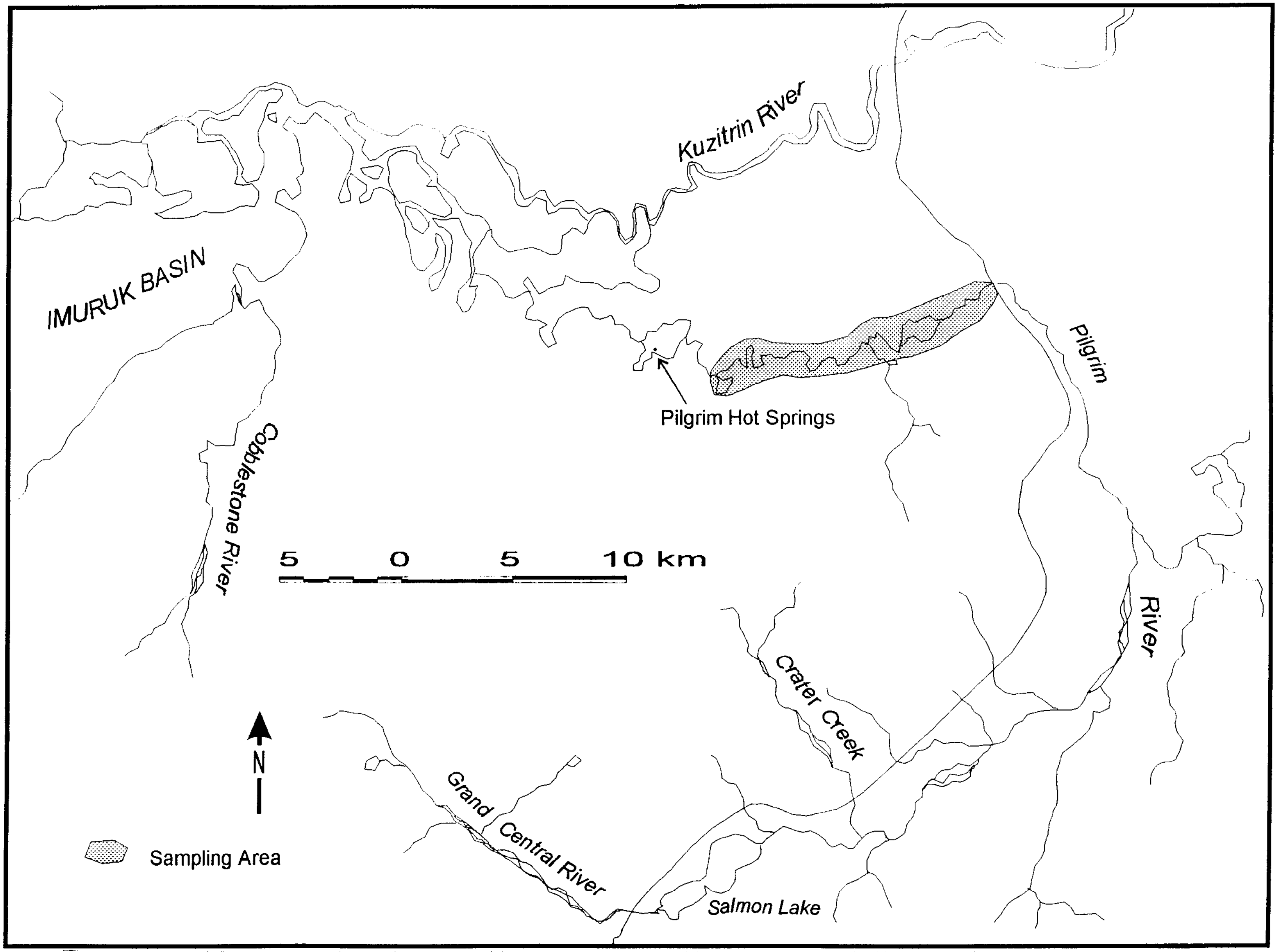


Figure 3.-The Pilgrim River with area sampled during 1995.

rays. Each fish was also marked with a partial fin clip (Appendix A1). Arctic grayling in the Snake River were marked by punching a hole in the upper lobe of the caudal fin to eliminate the possibility of repeat sampling. Scales for age determination were taken from the left side of the fish approximately midway between the dorsal fin and the lateral line down from the posterior insertion of the dorsal fin. Data were recorded on standard ADF&G 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^o C). Ages were determined by counting annuli from the acetate impressions using a microfiche reader. All scale impressions were read by a trained scale reader and the project leader. Age determinations follow procedures outlined by Yole (1975). Scale impressions for which questionable ages were assigned were read a third time as necessary. If the age assignment was still in question, the age sample was discarded. Regenerated scales were not aged. Data files were archived with ADF&G Research and Technical Services (RTS) in Anchorage (Appendix B1).

POPULATION ABUNDANCE ESTIMATE

A modified Petersen mark-recapture experiment (Bailey 1951, 1952) was used to estimate the abundance of Arctic grayling in sections of the Pilgrim River. Sampling for the two-event population estimates was performed in each of the river sections. The entire length of each river section was sampled during both the mark and recapture 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 capture probability in the first event or the second event, or marked fish mix completely with unmarked fish during the second sampling event;
3. marking does not affect capture probability in the second event;
4. marks are not lost between events; and,
5. marked fish can be recognized from unmarked fish.

Assumption 1 could not be tested directly. It was assumed that neither mortality nor recruitment occurred because both events were close together in time. Assumptions 2 and 3 were tested with two Kolmogorov-Smirnov two-sample tests (Conover 1980). The first test compared the cumulative length distribution of fish marked in the first sampling event (mark event) with the cumulative length distribution of marked fish recaptured during the second sampling event (recapture event). In the second test, the cumulative length distribution of fish captured during the marking event was compared to the cumulative length distribution of all fish captured during the recapture event (Seber 1982). If the results of the first test showed that the samples were different ($P < 0.05$), size selectivity between samples was indicated. If the results of the second test showed that the samples were different ($P < 0.05$), recruitment, migration, or some other factor affecting the size distribution of the two samples was indicated. A more complete tracking of test results and consequences is contained in Bernard and Hansen (1992). All fish were released within the reach of the river in which they were captured. To meet conditions of assumption 4, all tagged fish were also marked with an appropriate fin clip or punch (Appendix A1). Finclips or hole punches were chosen so as to not duplicate those used for fish from a given river in previous years. Assumption 5 was met by the close examination of all fish for the presence of the double mark or fin punch.

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

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

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

where:

- M = the number marked during the first event;
- C = the number captured during the second event;
- R = the number captured during the second event with marks from the first event;
- $\hat{N}$ = the estimated abundance of Arctic grayling during the first event; and,
- V = the approximate variance of the abundance estimate.

AGE COMPOSITION

Scales were collected from Arctic grayling sampled in conjunction with the abundance growth and age experiments. Ages were assigned to scales as indicated above to estimate age composition for the populations in sections of the Pilgrim River. The proportions of fish in each age category were estimated as multinomial proportions (Cochran 1977).

The proportion in each category was estimated as:

$$\hat{p}_i = \frac{n_i}{n} \quad (3)$$

where:

- n_i = the number in the sample from age category i;
- n = the sample size; and,
- p_i = the estimated fraction of the population that is made up of age category i.

The unbiased variance of this proportion was estimated as:

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

Abundance of Arctic grayling by age was estimated as follows:

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

where:

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

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

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

Variances for Equation 5 were estimated using Goodman's (1960) formula:

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

where:

$V[\hat{N}]$ was obtained from the mark recapture analyses (see equation 2).

LENGTH COMPOSITION

Length composition of Arctic grayling residing in the lower Pilgrim river was estimated in 25 mm length increments and as Relative Stock Density (RSD) categories (modified from Gabelhouse 1984). The RSD categories used for Arctic grayling were: "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 the proportion of fish in size categories followed the same procedures used for age composition (equations 3 and 4). Abundance estimates by RSD category were calculated using equations 5 and 6.

MEAN LENGTH-AT-AGE

Mean length-at-age was calculated as the arithmetic mean length of all fish assigned the same age. Samples were combined across years to increase sample sizes. Standard deviations of the mean lengths of each age class were calculated using standard procedures.

AGE VALIDATION

Arctic grayling were captured in the Eldorado River in order to validate aging techniques. Each fish was anesthetized by bubbling CO_2 into the holding water, measured to the nearest mm FL, weighed to the nearest 25 g using a Chatillion spring scale, and given an interperitoneal injection of oxytetracycline (OTC) in order to permanently mark bony structures (Bumguardner 1991, Campagna and Neilson 1982). Each fish was injected with 25mg/kg OTC (Beamish and McFarlane 1987), and tagged with an individually numbered Floy tag. In addition, the adipose fin was removed to allow for later identification of fish which may have shed tags. Scales were collected from each fish for aging. Otoliths were collected from all dead fish.

RESULTS

POPULATION ABUNDANCE ESTIMATE

The abundance of Arctic grayling in 1995 was estimated in the index section of the lower Pilgrim River. Abundance could not be estimated for the upper Pilgrim River because only four tagged fish were recaptured during the second sampling event.

The marking event on the lower Pilgrim River (Figure 3) was conducted during four days in late July and the recapture event was conducted during four days in early August after a ten day hiatus. The smallest of 113 Arctic grayling marked was 165 mm FL and the smallest of 188 Arctic grayling examined during the second event was 239 mm FL. The smallest marked fish recaptured from the lower Pilgrim River was 244 mm FL. The abundance estimate for the lower Pilgrim River was calculated for Arctic grayling > 239 mm FL.

In the 12 km section of the Pilgrim River downstream from the Beam Road bridge, the estimated abundance of Arctic grayling greater than 239 mm FL was 578 fish (SE = 87 fish, CV = 15%). A total of 107 Arctic grayling greater than 239 mm FL were marked during the first event (18 to 21 July). During the recapture event (1 to 4 August), 188 Arctic grayling > 239 mm FL were examined of which 34 had tags from the marking event. No tag losses were detected, and no fish were killed during sampling in 1995.

A Kolmogorov-Smirnov two sample test of the cumulative length distributions of Arctic grayling > 249 mm FL marked versus those recaptured during the recapture event (test 1) failed to detect significant differences ($D = 0.16$, $P = 0.53$, $n_1 = 105$, $n_2 = 34$). A similar test of those marked in the first event and those examined in the second event (test 2) did detect significant differences ($D = 0.21$, $P < 0.01$, $n_1 = 105$, $n_2 = 187$; Figure 4). A single unstratified abundance estimate was calculated for Arctic grayling greater than 239 mm FL and only fish from the second sampling event were used to estimate age and length composition. Fish from both samples were used for the length at age and for the age-length distribution (Appendix A2).

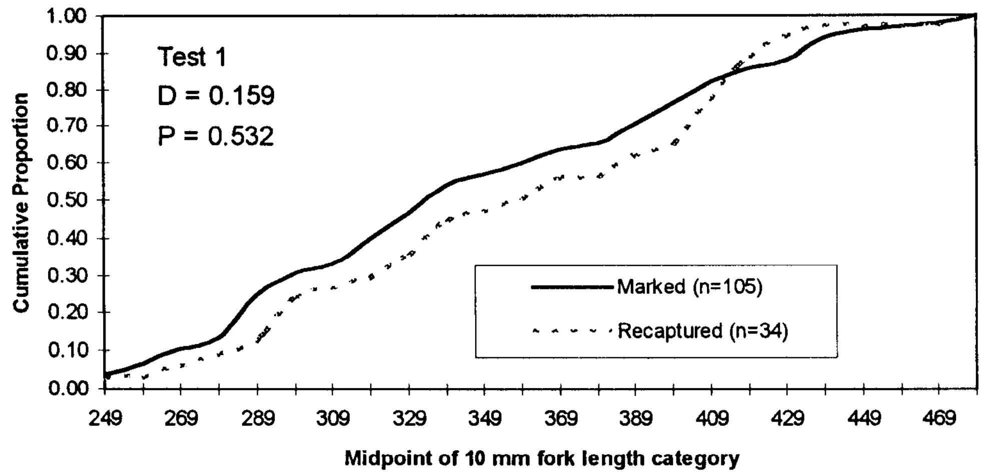
AGE COMPOSITION

Ages of Arctic grayling captured during the second sampling event in the lower Pilgrim River ranged from ages 3 to 12. Estimates of age composition and abundance by age class were restricted to fish larger than 239 mm FL (Table 2). Age-5, 6 and 7 Arctic grayling comprised 63% of the population with ages 5 and 6 being most abundant (23% and 22%, respectively). Arctic grayling sampled from the upper Pilgrim, Snake and Eldorado rivers were also examined for age in 1995 (Figure 5). Scale ages ranged from 3 to 12, with age 7 in the Snake and upper Pilgrim rivers, and age 9 in the Eldorado River, most strongly represented.

LENGTH COMPOSITION

Length composition of Arctic grayling in the lower Pilgrim River was estimated in 25 mm increments (Table 3) and as Relative Stock Density (RSD) categories (Table 4). The length distribution in 25 mm increments of Arctic grayling sampled from the Snake, Eldorado and upper Pilgrim rivers are presented in Figure 6.

Arctic grayling in the preferred category comprised 53% of the population in the lower Pilgrim River in 1995. The quality category was also strongly represented (33%). Only small proportions of stock size and smaller Arctic grayling were captured in any of the rivers sampled during 1995. Examination of the length distribution of all Arctic grayling >175 mm FL sampled during



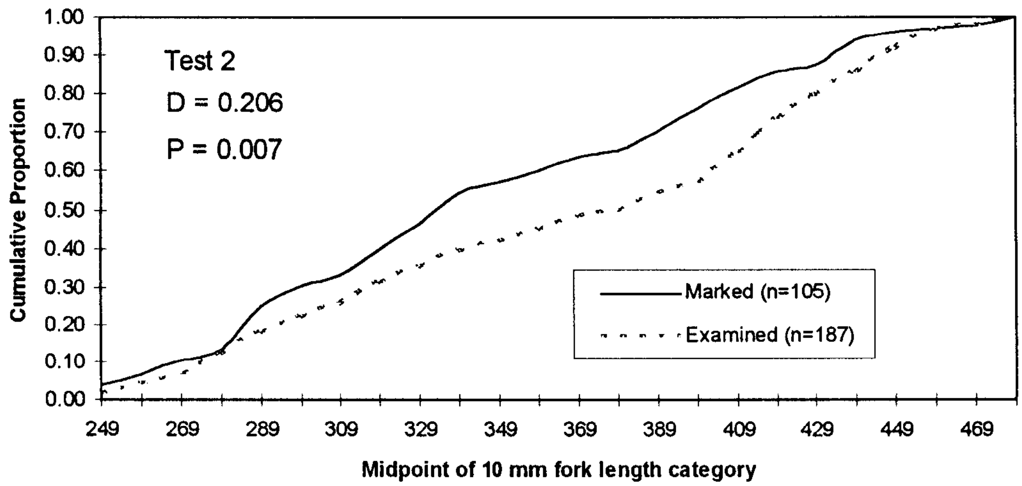


Figure 4.-Cumulative length distribution plots (tests 1 and 2) of Arctic grayling >239 mm FL sampled from the lower Pilgrim River in 1995.

Table 2.-Estimated proportion and abundance of Arctic grayling in the lower Pilgrim River by age class, 1995.

	Age										
Statistic	3	4	5	6	7	8	9	10	11	12	Total
Pilgrim R. (fish > 239 mm FL)											
Sample Size	4	14	36	35	29	11	11	11	4	2	157
Estimated Proportion	0.03	0.09	0.23	0.22	0.18	0.07	0.07	0.07	0.03	0.01	1.00
SE of Proportion	0.01	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.01	0.01	
Estimated Abundance	15	52	133	129	107	40	40	40	15	7	578
SE of Abundance	8	15	28	27	24	13	13	13	8	5	154

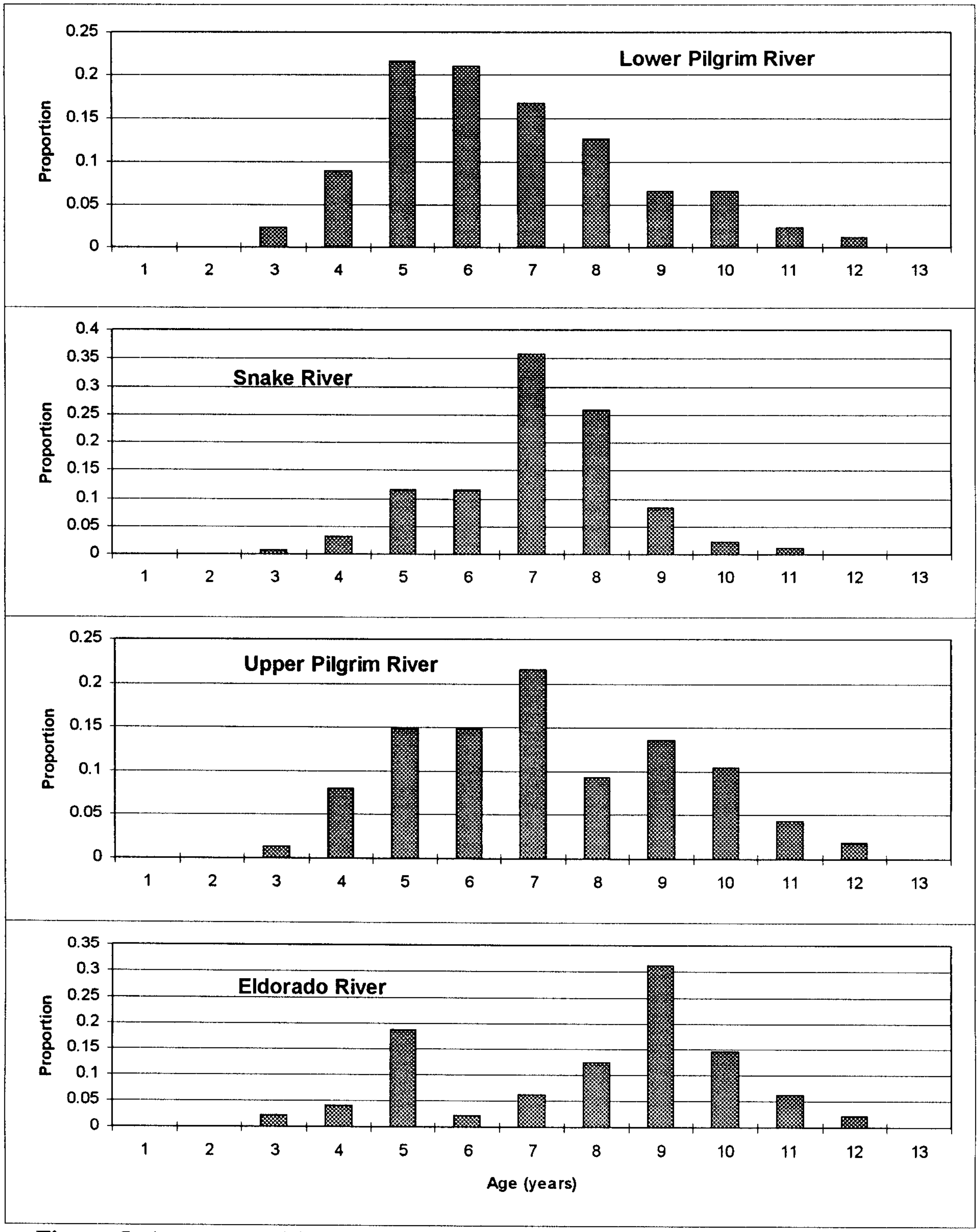


Figure 5.-Age composition estimates of Arctic grayling from the lower Pilgrim River, and age distribution of Arctic grayling sampled from the upper Pilgrim, Snake and Eldorado rivers in 1995.

Table 3.-Estimated proportion and abundance of Arctic grayling in the lower Pilgrim River by 25 mm FL increments, 1995.

	Length Category (mm)											
Statistic	250	275	300	325	350	375	400	425	450	475	500	Total
Pilgrim R. (fish > 239 mm FL)												
Sample Size	4	18	19	22	14	14	16	38	30	11	1	187
Estimated Proportion	0.02	0.10	0.10	0.12	0.07	0.07	0.09	0.20	0.16	0.06	0.01	1.00
SE of Proportion	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.01	
Estimated Abundance	12	56	59	68	43	43	49	117	93	34	3	578
SE of Abundance	6	15	15	17	13	13	14	24	21	11	3	152

Table 4.-Estimated proportion and abundance of Arctic grayling in the lower Pilgrim River by RSD category, 1995.

	RSD Category				
	Stock	Quality	Preferred	Memorable	Trophy
Pilgrim R. (fish >239 mm FL)					
Number sampled	13	62	99	14	0
Proportion	0.07	0.33	0.53	0.07	0
SE of proportion	0.02	0.03	0.04	0.02	0
Abundance	40	190	304	43	0
SE of abundance	12	35	50	13	0

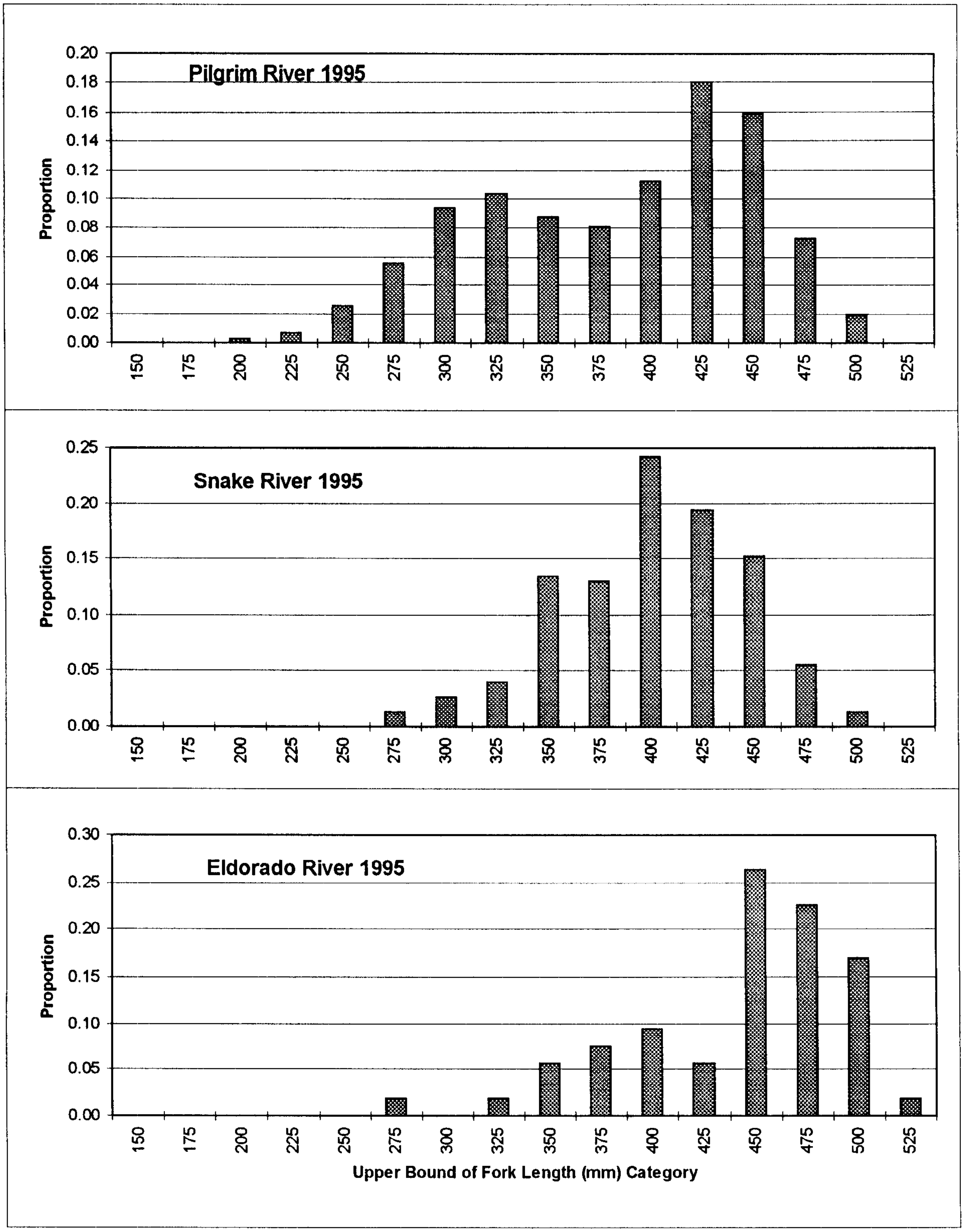


Figure 6.-Length distribution in 25 mm increments of Arctic grayling sampled from the Snake, Pilgrim and Eldorado rivers in 1995.

1995 (Table 5) shows high proportions of fish within limited length ranges in each of the rivers. In the Snake River 43.7% of the Arctic grayling were between 376 and 425 mm FL with a smaller length mode (326-375 mm FL) comprising 26.3% of the sample. In the Pilgrim River, 33.9% of the Arctic grayling were from 401 to 450 mm FL with an additional 38% of the sample evenly distributed over a wider range of smaller sizes (276-400 mm FL). Arctic grayling sampled from the Eldorado River were larger with 67.9% > 425 mm FL.

Mean Length-at-Age

Estimates of mean fork length-at-age were calculated for Arctic grayling sampled from the Snake, Pilgrim, and Eldorado rivers (Table 6). When data were available, they were combined across years. Arctic grayling in the Snake and Pilgrim rivers had similar mean lengths throughout their entire age range, while those in the Eldorado River were larger at all ages greater than five years. Age and length distributions of Arctic grayling sampled are provided in Appendices A2-A4.

Upper Pilgrim River

Abundance was not estimated for the upper Pilgrim River because too few fish were recaptured. During the first sampling event, 98 Arctic grayling were marked. During the second sampling event, 97 Arctic grayling were examined and marked. Of these, only four carried marks from the first sampling event. Fish from both samples were combined to present data on length-at-age (Table 6), length distribution (Table 5), age distribution (Figure 5), and age-length distribution (Appendix A3).

Eldorado River Age Validation

A total of 53 Arctic grayling were captured from the Eldorado River during 1995. Of the 51 that were measured and released alive, 10 (20%) carried marks from 1994; 41 were tagged and injected with OTC for later recapture in order to validate aging techniques. Assuming a similar recapture rate in the future, we should be able to obtain the desired sample of marked fish in 1996. Fish captured in 1995 ranged in length from 270 to 505 mm FL, and in weight from 200 to 1,700 g. The weight-length relationship is shown in Figure 7. Two fish died during sampling, both were aged with otoliths at 16 years while scales gave ages of 10 and 11 years.

Length Increase of Snake River Arctic Grayling

Growth as increase in fork length was investigated from 1991 through 1995 providing four sets of paired length measurements, one year apart, from tagged fish. During these years, the magnitude of the pink salmon run in this and other nearby rivers varied greatly (Table 7). In the Snake River, pink salmon escapement was very low in 1991, 1993. Aerial surveys conducted by the Division of Commercial Fisheries enumerated 190 pink salmon in 1991 and none were counted in 1993. The exact number counted is less relevant than the fact that very few pink salmon were seen, and there were probably very few present in the river. During 1994 and 1996, 24,700 and 63,850 pink salmon were enumerated during aerial surveys. Again, the exact number counted is less relevant than the fact that there were a large number present during each of these years, probably more than two orders of magnitude larger spawning escapements than during 1991 and 1993. Comparisons of the linear regressions of fork length on growth increment (Figure 8) showed that the slopes were not different ($P = 0.6713$) but that the y-intercepts were significantly different ($P = 0.0001$) among all years. The two years of high pink salmon abundance were the years with the highest y-intercepts indicating that growth of Arctic grayling is faster in those years than in years

Table 5.-Length distribution in 25 mm increments of Arctic grayling >175 mm FL sampled from Seward Peninsula rivers during 1995.

Fork Length (mm)	Snake River Number Sampled	Proportion	SE	Pilgrim River Number Sampled	Proportion	SE	Eldorado River Number Sampled	Proportion	SE
176-200	0	0.000	0.000	1	0.002	0.002	0	0.000	0.000
201-225	0	0.000	0.000	3	0.006	0.004	0	0.000	0.000
226-250	0	0.000	0.000	12	0.026	0.007	0	0.000	0.000
251-275	5	0.013	0.006	26	0.056	0.011	1	0.019	0.000
276-300	10	0.026	0.008	44	0.094	0.014	0	0.000	0.015
301-325	15	0.039	0.010	48	0.103	0.014	1	0.019	0.000
326-350	51	0.134	0.017	41	0.088	0.013	3	0.057	0.000
351-375	49	0.129	0.017	38	0.082	0.013	4	0.075	0.000
376-400	92	0.242	0.022	52	0.112	0.015	5	0.094	0.034
401-425	74	0.195	0.020	84	0.180	0.018	3	0.057	0.045
426-450	58	0.153	0.018	74	0.159	0.017	14	0.264	0.067
451-475	21	0.055	0.012	34	0.073	0.012	12	0.226	0.062
476-500	5	0.013	0.006	9	0.019	0.006	9	0.170	0.056
501-525	0	0.000	0.000	0	0.000	0.000	1	0.019	0.015
Total	380	1.000		466	1.000		53	1.000	

Table 6.-Mean fork length-at-age of Arctic grayling in Seward Peninsula rivers sampled during 1994.

	Snake River 1991-1995			Pilgrim River 1990-1995			Eldorado R.1988, 1993-1995		
Age	Number of Fish	Fork Length (mm)	Standard Deviation (mm/FL)	Number of Fish	Fork Length (mm)	Standard Deviation (mm/FL)	Number of Fish	Fork Length (mm)	Standard Deviation (mm/FL)
1	29	139	67	---	---	---	---	---	---
2	14	208	16	9	193	22	---	---	---
3	158	265	17	139	254	30	4	265	19
4	623	283	30	270	292	29	19	290	16
5	664	322	30	292	324	36	29	337	41
6	678	346	34	324	355	38	17	371	42
7	477	383	36	312	386	36	21	411	26
8	422	407	34	219	405	35	42	442	24
9	248	430	30	183	425	32	53	450	25
10	101	434	20	106	432	29	24	463	17
11	29	446	20	40	442	38	13	461	18
12	5	433	32	11	449	22	5	480	10
13				1	475	---	---	---	---

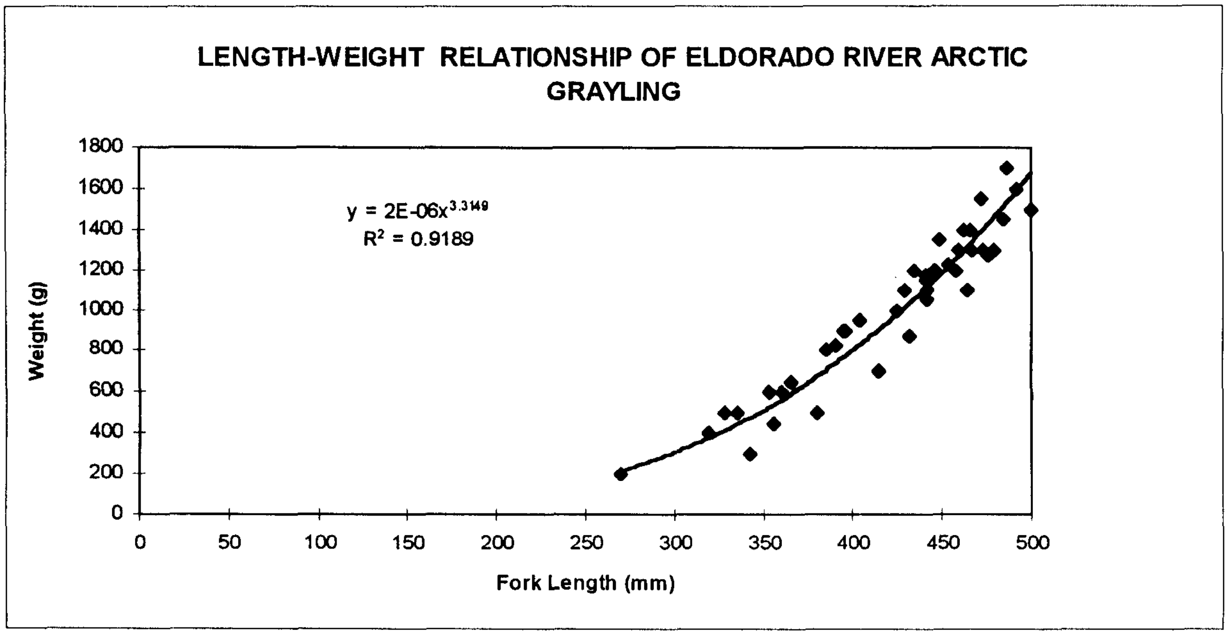


Figure 7.-Length-weight relationship of Arctic grayling from the Eldorado River in 1995.

Table 7.-Aerial estimates of pink salmon escapements into the Snake River and nearby streams (1991-1995)[a].

RIVER	1991	1992	1993	1994	1995
Sinuk River	14,680	292,400	5,120	492,000	1,250
Snake River	190	24,700	0	63,850	917[b]
Nome River	4,690	255,700	8,941	141,116[b]	13,890[b]
Solomon River	3,640	37,250	900	53,890	350

[a] Aerial survey data from Division of Commercial Fisheries Management and Development, Nome, Alaska.

[b] Expanded tower count.

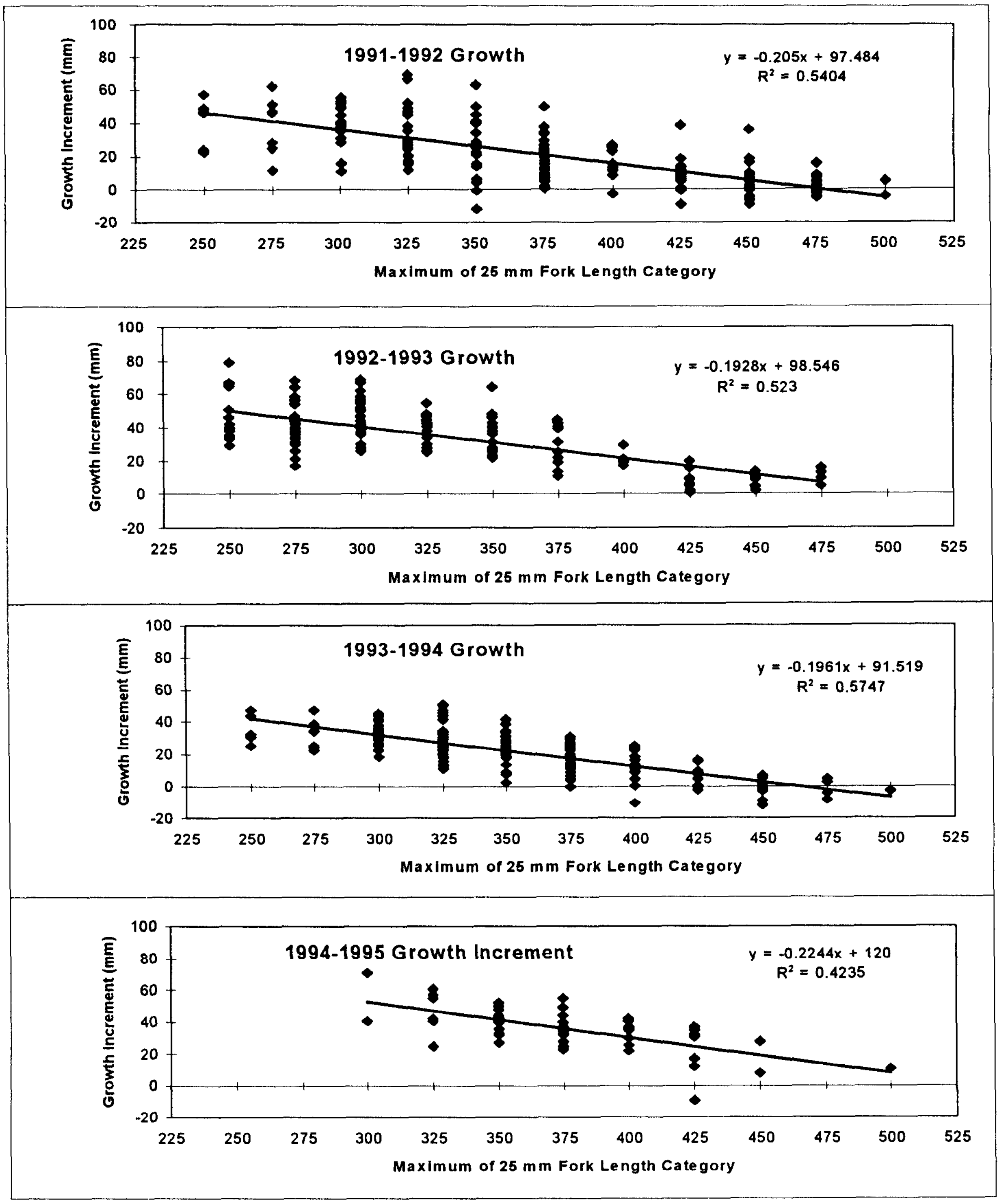


Figure 8.-Regressions of annual growth increments by 25 mm initial fork length category for Arctic grayling from the Snake River during two years of low (1991-1992 and 1993-1994) and two years of high (1992-1993 and 1994-1995) pink salmon abundance.

of low pink salmon abundances. This becomes even more apparent when all four years of data are viewed together (Figure 9). The least square means of the growth increment for the two years of low pink salmon abundance were 23.74 mm (1991) and 20.98 mm (1993); while comparable estimates for the two years of high pink salmon abundance were 28.90 mm (1992) and 39.21 mm (1994).

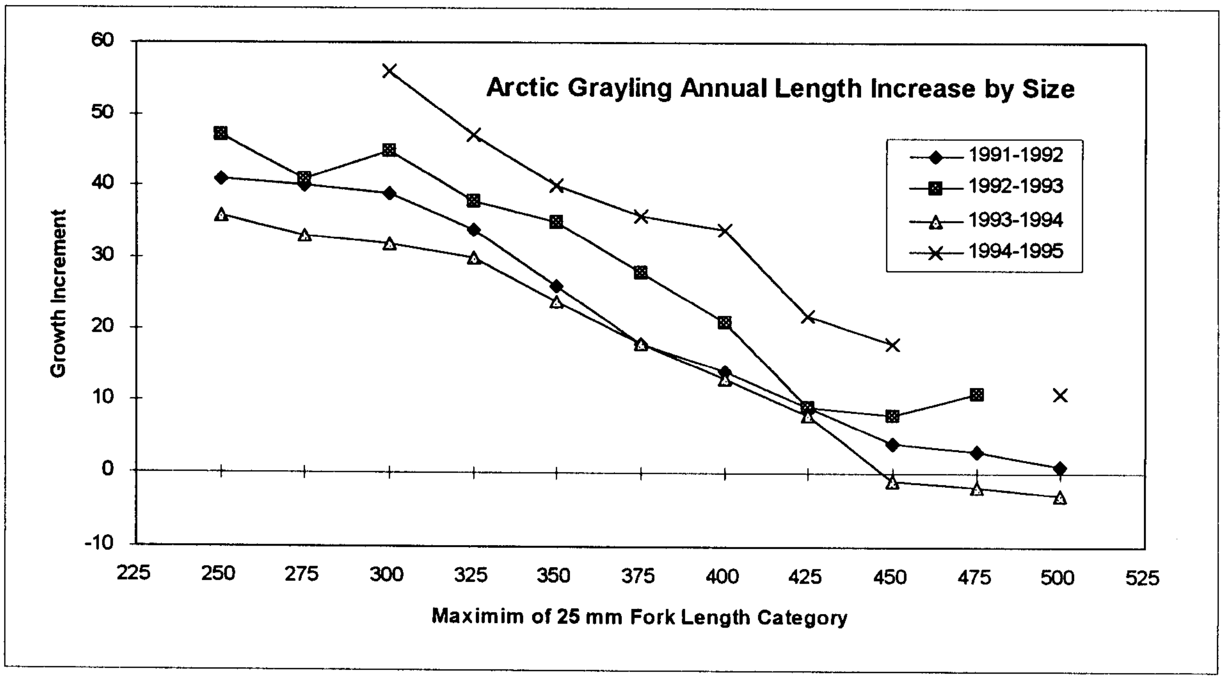


Figure 9.-Annual growth increments by 25 mm initial fork length category for Arctic grayling from the Snake River during two years of low (1991-1992 and 1993-1994) and two years of high (1992-1993 and 1994-1995) pink salmon abundance.

Analysis of covariance using length as a continuous covariate was used to compare the mean growth increment in each year of high pink salmon abundance to the mean of the low abundance years combined. Both comparisons were found to be significantly different (P = 0.0001 for each).

DISCUSSION

The abundance estimate reported for the lower Pilgrim River applies only to the size ranges indicated and are thought to be unbiased. Age and size composition estimates similarly apply only to the indicated size ranges and are likely biased high in relation to the entire Arctic grayling population of the river because small fish were probably not adequately sampled. Size selectivity was indicated during the first sampling event on the lower Pilgrim River and only the second sample was used to estimate age and size composition. A combination of beach seine and rod and reel were used to sample fish and it is thought that samples represented length ranges of fish present in this section of the Pilgrim River. Due to an underestimate of the effort required to adequately sample the upper Pilgrim River, only four fish were recaptured and this precluded an abundance estimate for this section of the river. With additional effort, the Arctic grayling population in the upper river can be adequately sampled in the future. Only two fish were recaptured in the upper river that had been originally marked in the lower index area during past years suggesting that there is not a lot of movement from the lower to the upper reaches of the river at the time of sampling.

DeCicco (1994) suggested that strong pink salmon returns in Nome area streams during 1992 may have provided a significant additional source of food for resident fish species resulting in increased annual growth increments for Arctic grayling between 326 and 400 mm FL. A similar benefit to the Arctic grayling populations was expected from the large runs of pink salmon which also occurred in 1994. Although some pink salmon are present in all years, large runs have not occurred in the Nome area since 1984. Data from 1991 through 1995 suggest that there is a correlation not only among years of high and low abundance and growth, but also a relationship between the magnitude of the pink salmon run and the mean growth increment during the years of high abundances. For example, the least squares mean growth increment of 29 mm and 39 mm for 1992 and 1994 correlated with estimated pink salmon abundances of 24,700 and 63,850 respectively.

There are several reasons why Arctic grayling, and probably other resident species may benefit from large runs of salmon. During spawning, large numbers of salmon eggs not deposited in the gravel drift along the bottom. These eggs are an excellent high energy food source for resident fish. In years when there are more salmon, there are more eggs. After spawning, salmon die and their carcasses decompose in the stream and on the stream banks. Carcasses exposed to air invite flies to lay their eggs. Maggots are flushed into streams during rains and when stream levels rise, providing another food source for resident fish. Some freshwater fish species, most notably, rainbow trout *O. mykiss* are known to consume decomposing salmon flesh. During the spring following large spawning escapements, millions of pink salmon fry migrate downstream to the sea. Resident fish, Arctic grayling included, consume pink salmon fry during their seaward migration. In addition, during the act of spawning, salmon dig in the stream bottom to construct redds. Although it has not been quantified, cumulative redd construction by a large escapement of pink salmon mobilizes a large amount of insect drift providing an increase in this normally available food.

Skopets and Prokop'yev (1990) found that Arctic grayling in their second year of life had considerably higher growth rates in years of high pink salmon abundances in the Bol'shaya River, Russia. They also found that when strong alternate year runs of pink salmon continued for several cycles, that significant growth differences in the fourth year of life were not found, and proposed that productivity from strong returns of pink salmon carried over to the next year providing an overall increase in productivity of the ecosystem. If strong Nome area pink salmon runs continue in alternate years, it may be found that Arctic grayling populations will show benefits for several successive years, but data suggest that most benefit is attained during the year with the largest runs.

During 1994, 60 Arctic grayling in the Eldorado River were measured, weighed and injected with OTC for age validation. During 1995, 10 of the 53 Arctic grayling captured carried marks from 1994. Based on this level of recapture, it is recommended that we return to this river in 1996 and collect a marked sample to conclude this experiment. With two cohorts of injections, the final sample will provide for two possible outcomes to compare between aging structures. It should be possible to capture 23 fish with marks as called for in the operational plan for this project (DeCicco 1994).

It is recommended that studies on the Pilgrim River continue to include the upper section in order to estimate abundance there for at least one year.

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LITERATURE CITED

ADF&G (Alaska Department of Fish and Game). *Unpublished.* Trophy fish program history (1967-1990). Alaska Department of Fish and Game, Juneau.

ADF&G. 1994. Aerial Survey Catalog, Division of Commercial Fisheries Management and Development, Nome, Alaska.

Alt, K. T. 1978. Inventory and cataloging of sport fish and sport fish waters of western Alaska. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1977-1978, Project F-9-10, 19(G-I).

Alt, K. T. 1979. Inventory and cataloging of sport fish and sport fish waters of western Alaska. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1978-1979, Project F-9-11, 20(G-I).

Alt, K. T. 1980. Inventory and cataloging of sport fish and sport fish waters of western Alaska. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1979-1980, Project F-9-12, 21(G-I).

Alt, K. T. 1986. Inventory and cataloging of sport fish and sport fish waters of western Alaska. Part B: Nowitna and Fish\Niukluk River study, western Alaska creel census, and sheefish enhancement assessment. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1984-1985, Project F-9-17, 26(G-I), Juneau.

Bailey, N. J. T. 1951. On estimating the size of mobile populations from capture-recapture data. Biometrika 38: 293-306.

Bailey, N. J. T. 1952. Improvements in the interpretation of recapture data. Journal of Animal Ecology 21: 120-127.

Beamish, R. J., and G. A. McFarlane. 1987. Current trends in age determination methodology. Pages 15-42 *in* R. C. Summerfelt and G. E. Hall, editors. Age and growth in fish. Iowa State University Press, Ames.

Bernard, D. R. and P. Hansen. 1992. Mark-recapture experiments to estimate the abundance of fish. Special Publication No. 92-4. Alaska Department of Fish and Game, Anchorage.

Bumguardner, B. W. 1991. Marking subadult red drums with oxytetracycline. Transactions of the American Fisheries Society 120:537-540.

Campagna, S. E. and J. D. Neilson. 1982. Daily growth increments in otoliths of starry flounder (*Platichthys stellatus*) and the influence of some environmental variables in their production. Canadian Journal of Fisheries and Aquatic Sciences 39:937-942.

Cochran, W. J. 1977. Sampling techniques, third edition. John Wiley and Sons, New York, New York.

Conover, W. J. 1980. Practical nonparametric statistics, second edition. John Wiley and Sons, New York.

DeCicco, A. L. 1990. Seward Peninsula Arctic grayling study 1989. Alaska Department of Fish and Game, Fishery Data Series No. 90-11, Anchorage.

DeCicco, A. L.. 1991. Seward Peninsula Arctic grayling study 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-24, Anchorage.

DeCicco, A. L. 1992. Assessment of selected stocks of Arctic grayling in streams of the Seward Peninsula, Alaska, during 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-13, Anchorage.

DeCicco, A. L. 1993. Assessment of selected stocks of Arctic grayling in streams of the Seward Peninsula, Alaska, during 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-36, Anchorage.

DeCicco, A. L. 1994. Assessment of selected stocks of Arctic grayling in streams of the Seward Peninsula, Alaska, During 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-12, Anchorage.

DeCicco, A. L. 1995. Assessment of selected stocks of Arctic grayling in streams and a survey of Salmon Lake, Seward Peninsula, Alaska, 1994. Alaska Department of Fish and Game, Fishery Data Series No. 95-19, Anchorage.

Gabelhouse, D. W. 1984. A length-catagorization system to assess fish stocks. North American Journal of Fisheries Management 4:273-285.

Goodman, L. A. 1960. On the exact variance of products. Journal of the American Statistical Association 66:708-713.

Howe, A. H., G. Fidler and M. J. Mills. 1995. Harvest, catch and participation in Alaska sport fisheries during 1994. Alaska Department of Fish and Game, Fishery Data Series No. 95-24, Anchorage.

Merritt, M. F. 1989. Age and length studies and harvest surveys of Arctic grayling on the Seward Peninsula, 1988. Alaska Department of Fish and Game, Fishery Data Series No. 79, Juneau.

Mills, M. J. 1981. Alaska statewide sport fish harvest studies (1980). Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Performance Report, 1980-1981, Project F-9-13, 22(SW-I-A), Juneau.

Mills, M. J. 1982. Alaska statewide sport fish harvest studies (1981). Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Performance Report, 1981-1982, Project F-9-14, 23(SW-I-A), Juneau.

Mills, M. J. 1983. Alaska statewide sport fish harvest studies (1982). Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Performance Report, 1982-1983, Project F-9-15, 24(SW-I-A), Juneau.

Mills, M. J. 1984. Alaska statewide sport fish harvest studies (1983). Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Performance Report, 1983-1984, Project F-9-16, 25(SW-I-A), Juneau.

Mills, M. J. 1985. Alaska statewide sport fish harvest studies (1984). Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Performance Report, 1984-1985, Project F-9-17, 26(SW-I-A), Juneau.

Mills, M. J. 1986. Alaska statewide sport fish harvest studies (1985). Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Performance Report, 1985-1986, Project F-10-1, 27(RT-2), Juneau.

Mills, M. J. 1987. Alaska statewide sport fish harvest studies (1986). Alaska Department of Fish and Game, Fishery Data Series No. 2, Juneau.

Mills, M. J. 1988. Alaska statewide sport fish harvest studies (1987). Alaska Department of Fish and Game, Fishery Data Series No. 52, Juneau.

Mills, M. J. 1989. Alaska statewide sport fish harvest studies (1988). Alaska Department of Fish and Game, Fishery Data Series No. 122, Juneau.

Mills, M. J. 1990. Harvest and participation in Alaska sport fisheries during 1989. Alaska Department of Fish and Game, Fishery Data Series No. 90-44, Anchorage.

LITERATURE CITED (Continued)

Mills, M. J. 1991. Harvest, catch, and participation in Alaska sport fisheries during 1990. Alaska Department of Fish and Game, Fishery Data Series No. 91-58, Anchorage.

Mills, M. J. 1992. Harvest, catch, and participation in Alaska sport fisheries during 1991. Alaska Department of Fish and Game, Fishery Data Series No. 92-40, Anchorage.

Mills, M. J. 1993. Harvest, catch, and participation in Alaska sport fisheries during 1992. Alaska Department of Fish and Game, Fishery Data Series No. 93-42, Anchorage.

Mills, M. J. 1994. Harvest, catch, and participation in Alaska sport fisheries during 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-28, Anchorage.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters, second edition. Charles Griffin and Co., Ltd. London, U.K.

Skopets, M. B., and N. M. Prokop'yev. 1990. Biological characteristics of subspecies of the Arctic grayling in northeastern Asia. I. The Kamchatkan grayling-*Thymallus arcticus mertensi* Journal of Ichthyology, 30 (4) 564-576.

Yole, F. 1975. Methods of aging fish species common to rivers and lakes of the northern Yukon Territory, 1972-1974. *in* L. Steigengerger, M. Elson, P. Bruce, Y. Yole editors. Northern Yukon Fisheries Studies 1971-1974. Volume 2. Prepared for Environmental Social Program, Northern Pipelines.

APPENDIX A

Appendix A1.-List of numbered tags and finclips used to mark Arctic grayling from the Pilgrim River in 1995.

Location	Month	No. Fish	Tag Numbers	Color	Fin Clip
Lower Pilgrim R.	Aug	221	55606 - 55826	Green	Lower Caudal
Upper Pilgrim R.	July	188	10275 - 10462	Gray	Upper Caudal

Appendix A2.-Age-length distribution of Arctic grayling sampled from the Snake River in 1995.

	AGE													
Length (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
101-125														
126-150														
151-175														
176-200														
201-225														
226-250														
251-275			2	2										4
276-300				4	1	1	1							7
301-325				4	7	2	1	1						15
326-350				1	18	16	6	3	1					45
351-375					10	8	18	9						45
376-400					2	8	42	26	2					80
401-425						3	33	27	7	2				72
426-450					1	2	20	16	9	4	2			54
451-475							2	5	7	1	1			16
476-500								1	2	1				4
501-525														
Total			2	11	39	40	123	88	28	8	3			342

Appendix A3.-Age-length distribution of Arctic grayling sampled from the Pilgrim River in 1995.

	AGE													
Length (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
101-125														
126-150														
151-175		2												2
176-200			1											1
201-225			1	1	1									3
226-250			7	2	4									13
251-275			2	10	9	4								25
276-300			1	16	15	7								39
301-325				7	17	19	1	1						45
326-350			1	6	17	8	2	1						35
351-375				1	11	10	8	4						34
376-400					4	10	24	10	1	1				50
401-425					4	11	30	14	7	7				73
426-450					1	5	14	10	18	14	3	4		69
451-475						1	1	3	7	9	5	2	1	29
476-500									1	1	3	1		6
501-525														
Total		2	13	43	83	75	80	43	34	32	11	7	1	424

Appendix A4.-Age-length distribution of Arctic grayling sampled from the Eldorado River in 1995.

	AGE													
Length (mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
101-125														
126-150														
151-175														
176-200														
201-225														
226-250														
251-275			1											
276-300														1
301-325				1										1
326-350				1	1									2
351-375					4									4
376-400					3		1		1					5
401-425						1	2							3
426-450								2	7	2				11
451-475								1	4	3	2			10
476-500								3	2	2	1	1		9
501-525									1					1
Total			1	2	8	1	3	6	15	7	3	1		47

33

APPENDIX B

Appendix B1.-Data files used to estimate parameters of Arctic grayling populations on the Seward Peninsula in 1995.

Data File[a]	Description
W0120LA5.DTA	Data for Arctic grayling captured from the Snake River during 1995.
W006ALA5.DTA	Mark and recapture data for Arctic grayling captured from the Lower Pilgrim River during 1995.
W006BLA5.DTA	Mark and recapture data for Arctic grayling captured from the Upper Pilgrim River during 1995
W0110LA5.DTA	Data for Arctic grayling captured from the Eldorado River during 1995.

[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.