Fishery Data Series No. 00-29

Stock Assessment of Arctic Grayling in the Fish River, Seward Peninsula, Alaska 1999

by
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November 2000

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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Development and publication of this manuscript were partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-14, Job No. R-3-2(e).

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This document should be cited as:
DeCicco, A. L. and M. J. Wallendorf. 2000. Stock assessment of Arctic grayling in the Fish River, Seward Peninsula, Alaska 1999. Alaska Department of Fish and Game, Fishery Data Series No. 00-29, Anchorage.

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ABSTRACT

The number of Arctic grayling *Thymallus arcticus* greater than 299 mm in FL was estimated at 7,902 fish (SE = 1,131fish) in a 25-km section of the Fish River, Alaska in 1999. Arctic grayling captured from the Fish River ranged in length from 165 mm to 505 mm FL and in age from two to 15 years. Arctic grayling aged 7, 8, and 9 years were most numerous, comprising 64% of the estimated population. Arctic grayling from 400 to 475 mm FL comprised 82% of the estimated population with 37% of the population between 426 and 450 mm FL. In addition, the size of fish in the population had increased from 1991. The estimated population in this section of the Fish River was almost three times that estimated in 1991 (2,900 fish; SE=424). On the Nome River only one surviving Arctic grayling was recaptured from a rearing pond as part of an experimental restoration effort.

Key words: Arctic grayling, *Thymallus arcticus*, population abundance, age composition, length composition, Seward Peninsula, Fish River, experimental restoration.

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. Over the past 10 years, annual sport-fishing effort has declined from 22,118 angler-days in 1991 to 11,408 angler-days in 1998, with an annual average of 15,208 angler-days (Mills 1990-1994, Howe et al. 1995-1999). Reported freshwater harvests consisted primarily of Dolly Varden *Salvelinus malma*, Arctic grayling *Thymallus arcticus*, pink, coho, chum and chinook salmon *Oncorhynchus*, northern pike *Esox lucius*, whitefish *Coregonus*, and burbot *Lota lota*. From 1980 through 1991, Arctic grayling comprised an average of 15% of the harvest of these species, but dropped to an average of 7.4% over the past five years while Arctic grayling have comprised an average of 21% of the catch (Table 1; Mills 1981-1994, Howe et al. 1995-1999). The annual harvest remained fairly consistent at about 1,100 Arctic grayling from 1993 through 1997, however it dropped drastically to about 300 fish in 1998 in spite of a relatively high catch of over 12,000 fish.

The Seward Peninsula is the only area in Alaska outside of Bristol Bay that regularly produces trophy-sized Arctic grayling. Since 1983, 25% of the Arctic grayling registered in the Alaska Department of Fish and Game (ADF&G) Trophy Fish Program have come from the Seward Peninsula (ADF&G *Unpublished*).

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. ADF&G 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 that 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 TL (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 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 1978-1980). Between 1979 and 1984, 88 Arctic grayling from the Fish/Niukluk rivers were sampled for age,

Table 1.-Estimated freshwater sport-fish harvests and (catches) for Seward Peninsula and Norton Sound streams, 1980-1998.

	Harvests and (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	16,777	12,215	2,981	1,200	376	0	67
		(21,048)	(7,254)	(6,853)	(1,731)	(0)	(172)
1995	17,334	5,316	2,908	1,037	215	45	247
		(14,250)	(7,806)	(5,788)	(1,856)	(56)	(321)
1996	16,777	12,138	3,662	1,192	410	0	27
		(29,208)	(7,140)	(6,342)	(1,747)	(0)	(54)
1997	12,540	6,387	4,263	1,256	362	148	208
		(20,864)	(17,745)	(20,117)	(1,747)	(289)	(595)
1998	11,408	9,830	2,240	298	75	84	0
		(39,414)	(5,711)	(12,408)	(452)	(93)	(288)
MEAN	15,792	9,638	5,081	2,954	553	35	421
		(23,572)	(11,987)	(11,087)	(2,469)	(77)	(391)

Data from Mills (1981-1994) and Howe et al. (1995, 1999).

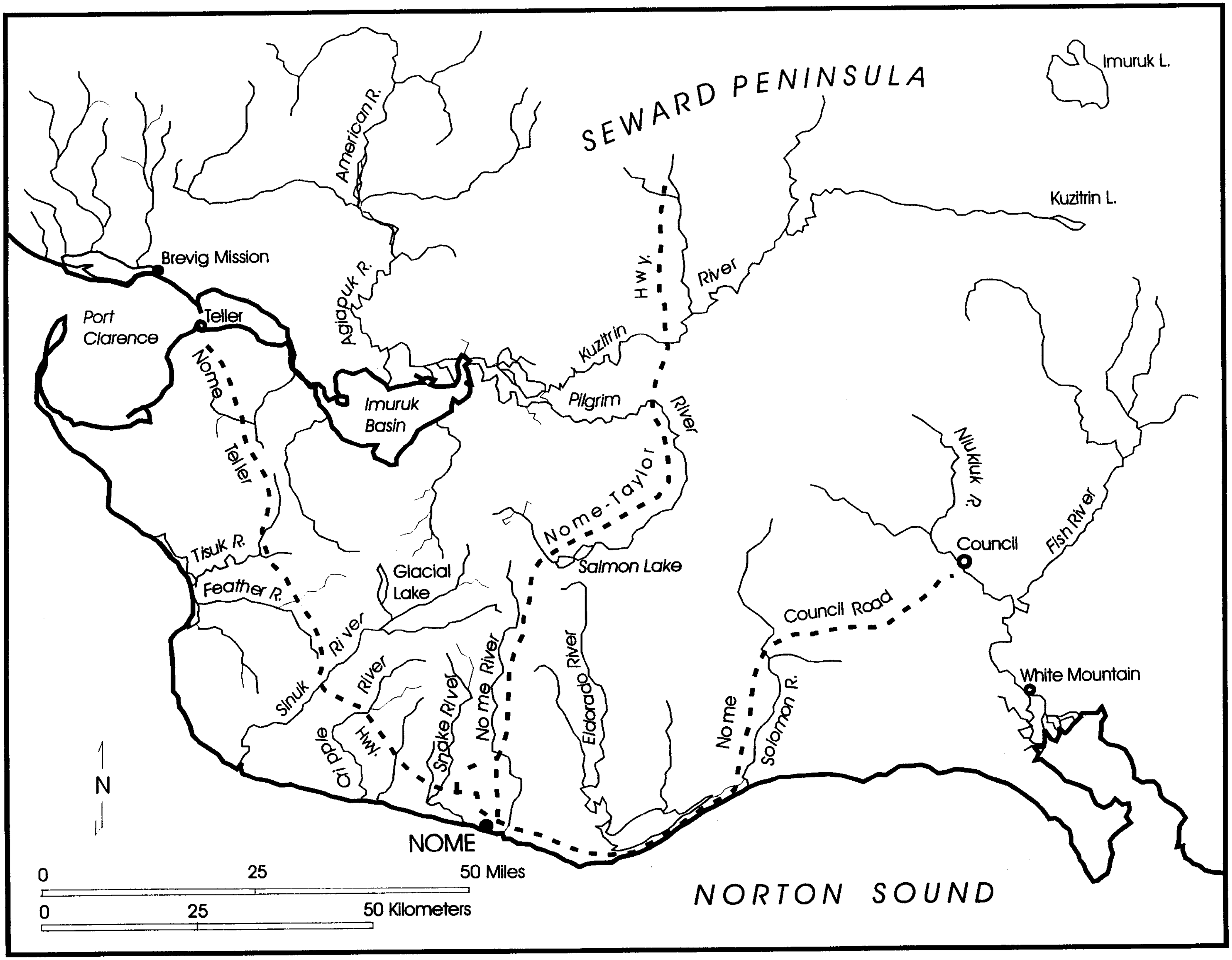

Figure 1.-The southern Seward Peninsula.

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 1990-1999). Problems with assigning ages to large Arctic grayling from scales have been noted in recent years (DeCicco 1993-1995). Consequently, an age validation component using oxytetracycline was added to this project in 1994.

Several regulatory changes have recently been implemented based on data collected from these studies. 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 total length. Very low abundances in the Nome and Solomon rivers resulted in the closure of these waters to Arctic grayling fishing by emergency order in 1992. These rivers were closed to fishing for Arctic grayling by the Board of Fisheries in December 1997 after it was determined that abundances had not changed with five years of closure to sport fishing. In 1999, the winter subsistence fisheries on the Solomon and Nome rivers were closed to the harvest of Arctic grayling by emergency order. Base line data have been collected on most road accessible Arctic grayling populations and this project has taken on a population monitoring function with a long-term goal to achieve sustained yield fisheries for Arctic grayling populations through appropriate regulation.

The Arctic grayling population in the Nome River is depressed; even with the sport fishery closed the last five years, the population has not increased. A preliminary study was initiated to determine if restoration of the Arctic grayling population in the Nome River, by enhancing young-of-the-year (YOY) survival, is a feasible approach to increasing recruitment.

Project objectives for stock assessment (R-3-2e part 1) in 1999 were to:

1. estimate the abundance of Arctic grayling greater than 249 mm FL in a 25-km index section of the Fish River upstream from the mouth of the Niukluk River;
2. estimate the age and length compositions of Arctic grayling for given length ranges in the Fish River; and,
3. estimate the proportion of correctly aged otoliths from Arctic grayling marked with oxytetracycline and recaptured in the Eldorado River.

In addition, mean length-at-age for Arctic grayling in the Fish River was estimated and gonads of fish collected from the Eldorado River for age validation were examined to document maturity.

Project objectives for the Nome River restoration study (R-3-2e part 2) were to:

1. capture surviving Arctic grayling in the in the Banner Creek gravel pit and move them to the Nome River;

If at least 134 surviving Arctic grayling are captured, then:

2. capture 6,000 young of the year grayling in the Nome River and move them to rear in the Banner Creek gravel pit; and,

3. estimate the contribution of these fish to the population of Arctic grayling in the Nome River after three or four years.

METHODS

DESIGN

A two event mark-recapture experiment was conducted to estimate the abundance of Arctic grayling ≥250 mm FL in a 25-km index section of the Fish River in the canyon upstream from the mouth of the Niukluk River (Figure 2). The river section was divided into geographic areas and the locations of marked fish were recorded by river kilometer. The index area extended from the confluence of Cache Creek downstream for 25 km to approximately 5 km downstream from Glacier Creek.

Sampling was performed along the entire length of each river section, sequentially working in a downstream direction, during both the mark and recapture events. The marking event was conducted in nine days from June 22 to 30. The recapture event was conducted in eight days from July 8 to 15. The sequence of sampling was the same in both events, resulting in an approximate 17-day hiatus between sampling events for a given location of the river.

SAMPLING GEAR AND TECHNIQUES

Arctic grayling in the Fish River were sampled using hook and line with assorted terminal gear ranging from typical spinning lures to dry and wet flies, and a 65-m x 2-m, 6.5-mm mesh beach seine. Access to the river was by a 5.5 m outboard jet-powered riverboat. Each Arctic grayling was measured to the nearest mm in fork length. Fish over 249 mm FL in the first sample were tagged with sequentially numbered Floy FD-67 internal anchor tags, inserted such that the "T" anchor locked between the bases of adjacent dorsal fin rays (Appendix A1). Secondary marks were not used because tag loss has not been a significant problem in past Arctic grayling projects on the Seward Peninsula. 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 in accordance with Scarnecchia (1979). Data were recorded on standard ADF&G Tagging-Length forms (version 1), and electronically transferred to spreadsheets for analysis. Scales were cleaned with detergent and water, mounted on gummed cards, and acetate impressions were made (30 s at 7,000 kg/cm^2 at 100°C) as described by Clutter and Whitesel (1956). Ages were determined by counting annuli from the acetate impressions using a microfiche reader. Age determinations followed procedures outlined by Yole (1975). Scale impressions were read twice by the project leader. Scale impressions with questionable readings 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 A2).

FISH RIVER POPULATION ABUNDANCE

A two-sample approach using a Petersen mark-recapture estimator (Seber 1982) as modified by Bailey (1951, 1952) was used to estimate the abundance of Arctic grayling in the Fish River. The assumptions necessary for the accurate estimation of abundance in a closed population were (Seber 1982):

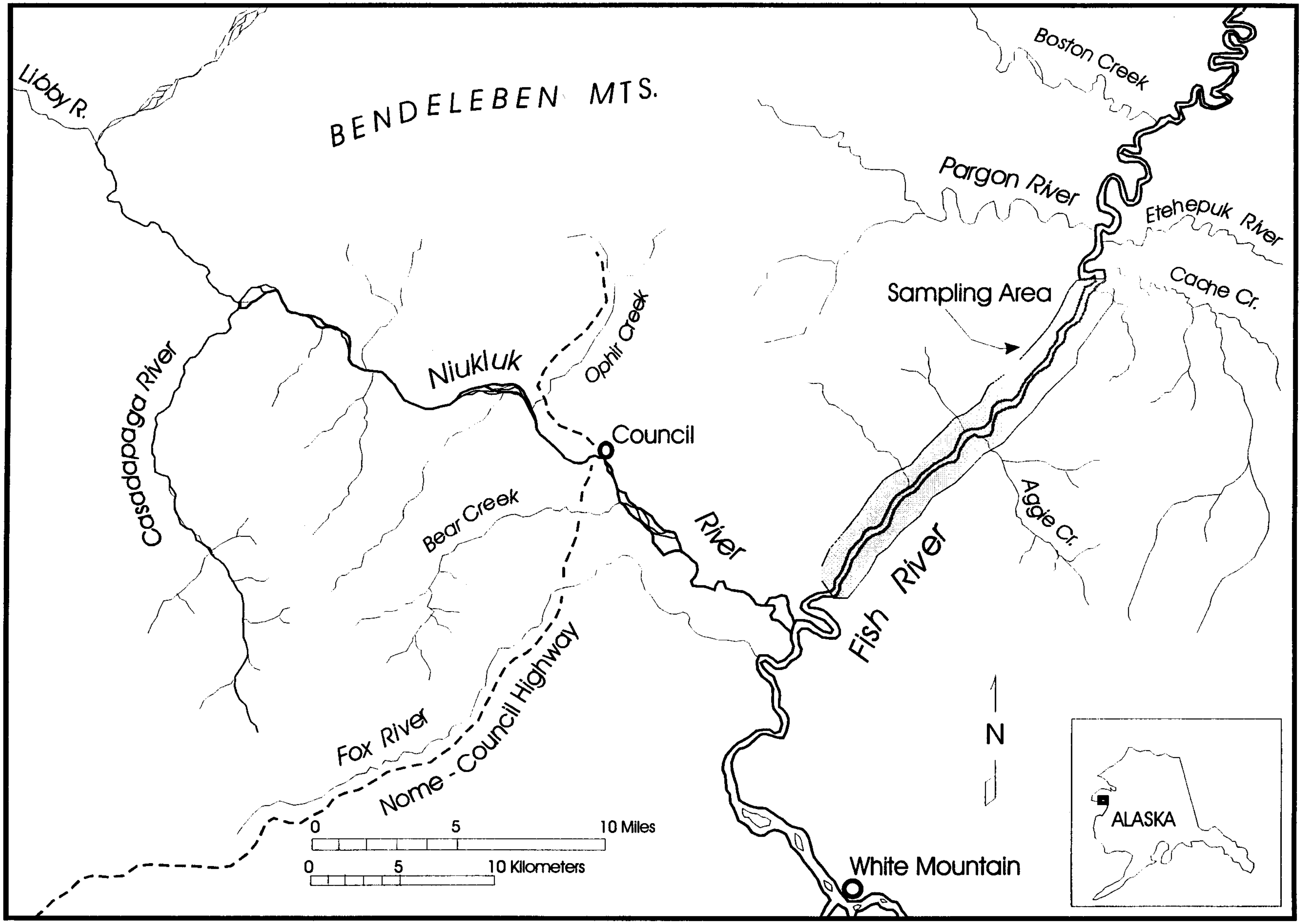

Figure 2.-Area sampled in the Fish River during 1999.

1. the population was closed (no change in the number or composition of the population during the experiment);

2. fish had an equal capture probability in the first event or the second event, or marked fish mixed completely with unmarked fish between first and second sampling events;

3. marking did not affect capture probability in the second event;

4. marks were not lost between events; and,

5. marked fish were recognized from unmarked fish.

Assumption 1 could not be tested directly. It was assumed that neither mortality nor recruitment occurred between events because both events were close together in time. Assumptions 2 and 3 were tested for differences in catchability by length 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. If the results of the first test were statistically significant ($\alpha = 0.05$), unequal catchability by size in the second sample was indicated. If the results of the second test were significant, recruitment, migration, or some other factor affecting the size distribution of the two samples was indicated. These tests are described in more detail in Appendix B1.

All fish were released within the reach of the river in which they were captured. It was assumed that fish did not lose marks (Assumption 4) because tag loss has not been a problem in any previous studies of Arctic grayling in this area (DeCicco 1990-1998). Assumption 5 was met by the close examination of all fish for the presence of a tag.

In addition to catchability by length, diagnostic tests for consistency of a Petersen estimate (Seber 1982; page 438) were conducted to investigate the validity of Assumption 2 with regard to catchability among geographic strata. Locations for marked, examined and recaptured fish were grouped into Section 1 for kilometers 1-9 and Section 2 for kilometers 10-25. If all tests were significant ($\alpha = 0.05$), incomplete mixing or unequal probability of capture by geographic area would be indicated, requiring the use of a Darroch two-sample stratified estimate.

The population abundance estimate and the approximate variance of the estimate were calculated with Bailey's estimator (Seber 1982):

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

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

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; and,

$N =$ population abundance.

AGE COMPOSITION

Scales were collected from Arctic grayling sampled in conjunction with the abundance and age experiments. Ages were assigned to scales in order to estimate age composition for the population in the assessed area of the Fish River. The proportions of fish in each age category were estimated as multinomial proportions (Cochran 1977; Thompson 1987).

The proportion in each category when no adjustments were needed was estimated as:

$$\hat{p}_i = \frac{n_i}{n} \tag{3}$$

where:

$n_i =$ the number in the sample from age category i;

$n =$ the sample size; and,

$\hat{p}_i =$ the estimated fraction of the population that is made up of age category i.

The unbiased variance of this proportion was estimated as:

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

Abundance of Arctic grayling by age was estimated as follows:

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

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:

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

where:

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

LENGTH COMPOSITION

Length composition of Arctic grayling residing in the assessed area of the Fish River was estimated in 25-mm length increments. Estimates of the proportion of fish in size categories followed the same procedures used for age composition (equations 3 and 4). Abundances and their variances by length category were estimated 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 lengths of each age class were calculated.

ELDORADO RIVER AGE VALIDATION

Arctic grayling have been captured in the Eldorado River as part of an ongoing study to validate aging using oxytetracycline (OTC). Injected into the body cavity of a fish, OTC marks bony structures that can be used to validate ages in fish (Frost et al. 1961; McFarlane and Beamish 1987). Fish captured with Floy tags or adipose fin clips, indicating that they carried (OTC) marks, were collected, kept cool and frozen at the first opportunity. Scales were collected from each fish not carrying a fin clip or tag. Frozen fish were transported to Fairbanks where otoliths were removed for age validation.

NOME RIVER ARCTIC GRAYLING RESTORATION

In an attempt to enhance survival of Arctic grayling fry during their first winter, young-of-the-year Arctic grayling were captured with beach seines in the Nome River just upstream from Osborne (Figure 3) and transferred to an arm of the Banner Creek gravel pit (Figure 4) during July 1998. This arm of the gravel pit was isolated from the main part of the pit with a small mesh plastic fence prior to the introduction of fry. In addition, the arm was sampled with baited minnow traps and 419 potential competitors for food and oxygen were removed in 1998. During June 1999, surviving fry were removed from the pit, marked, and placed in the Nome River. Water samples were taken from the Banner Creek gravel pit in July and tested for dissolved oxygen. Zooplankton were sampled using a 0.2 m plankton net with 153 μ mesh. Zooplankton were washed into a 125-ml polypropylene bottle containing 10-ml straight formaldehyde, resulting in a mixed 10% formalin solution. Zooplankton samples were sent to the ADF&G Limnology Laboratory in Soldtona, Alaska for analysis. Dissolved oxygen was measured using a standard Hach kit during the fall and winter.

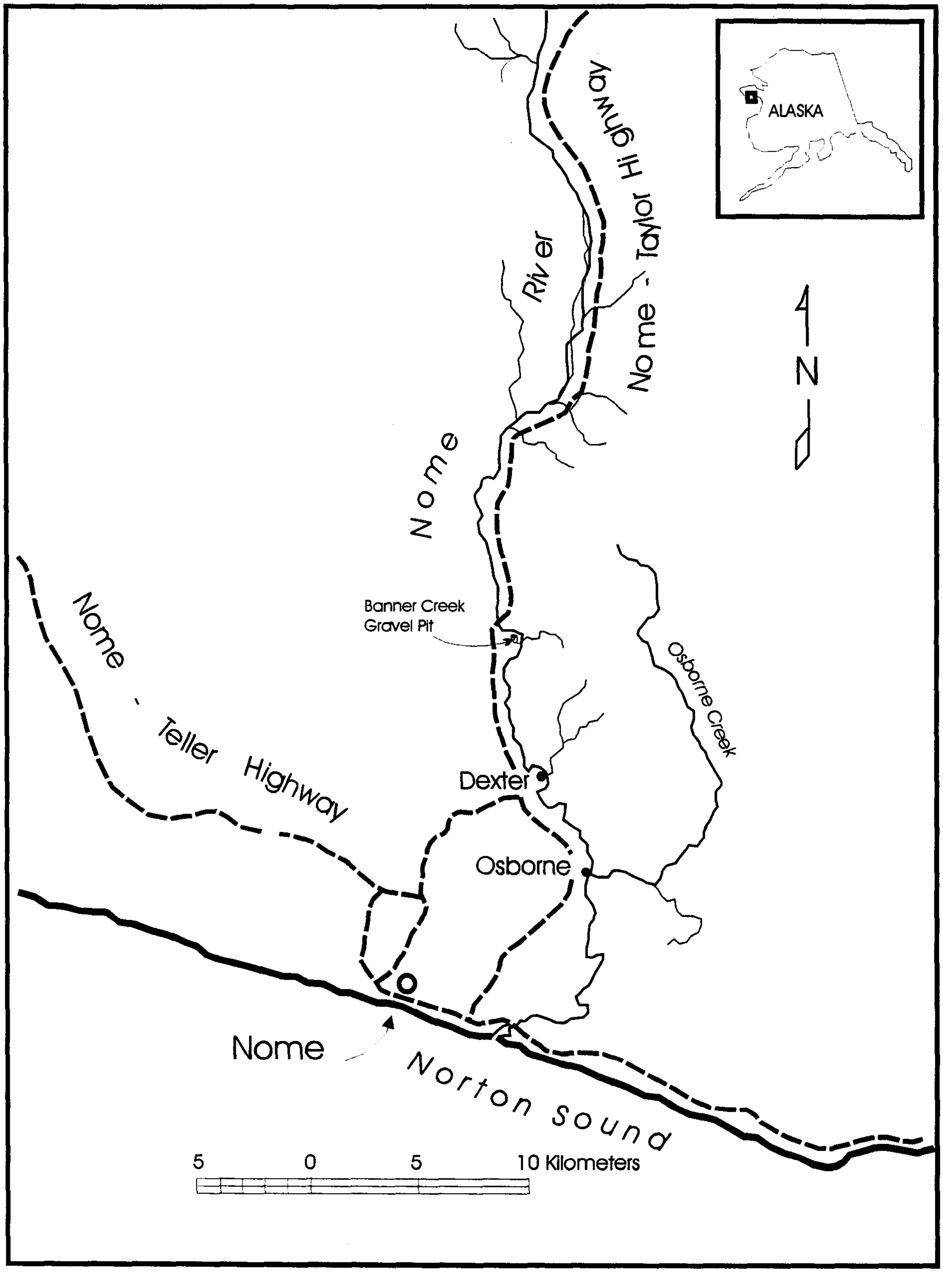

Figure 3.-The Nome River drainage showing the location of the Banner Creek gravel pit.

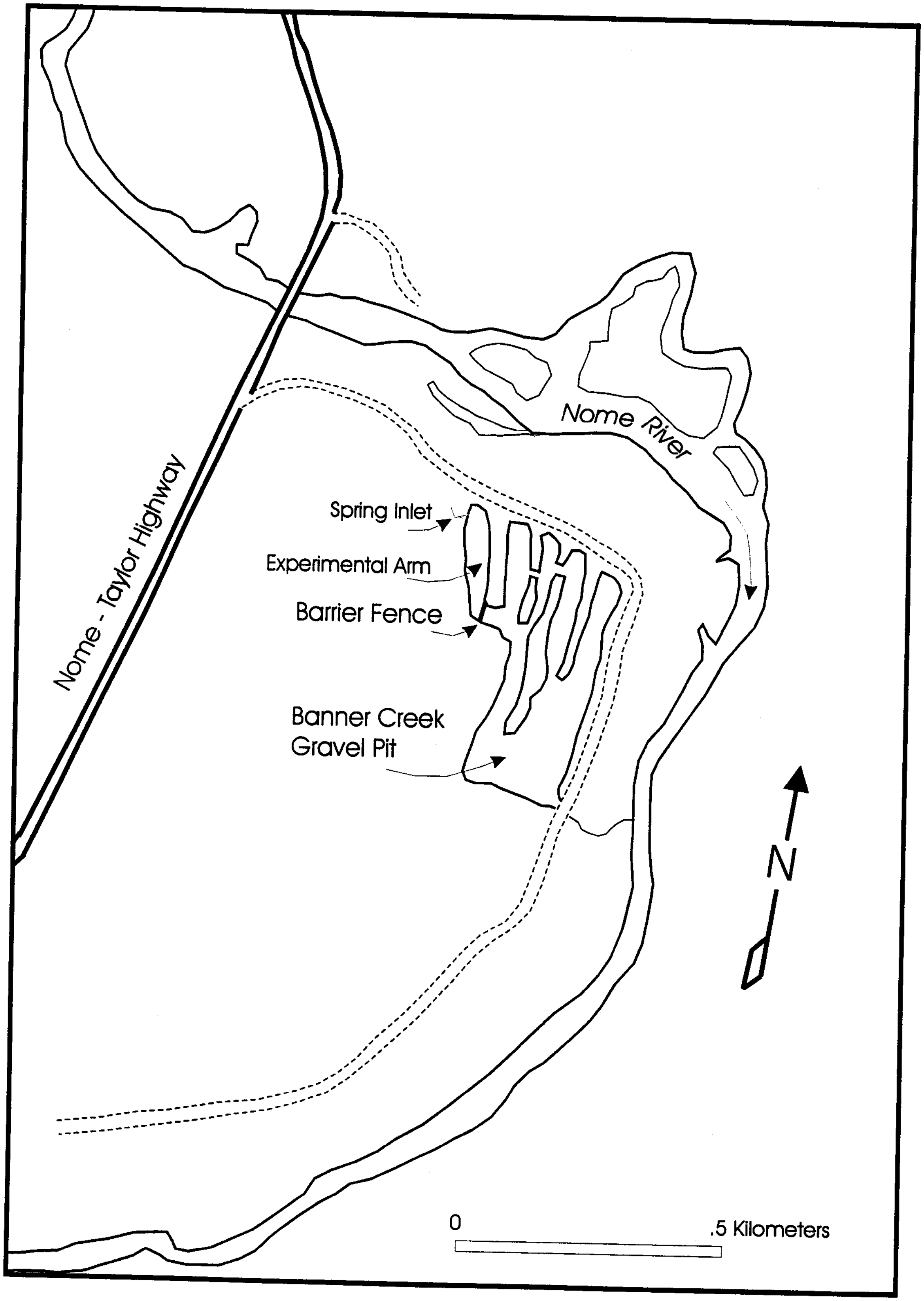

Figure 4.-The Banner Creek gravel pit.

RESULTS

FISH RIVER POPULATION ABUNDANCE

The fork-length range of Arctic grayling captured in the first sampling event ranged from 165 mm to 505 mm. In the second sampling event, fish ranged in fork length from 271 mm to 497 mm. Marked fish recaptured in the second event ranged from 310 mm to 490 mm in fork length. The abundance estimate was therefore calculated only for fish >299 mm FL.

The abundance of Arctic grayling >299 mm FL in the 25-km index section of the Fish River (Figure 2) in 1999 was estimated to be 7,902 fish (SE = 1,131 fish; CV = 14.3%). This index section included the area from the mouth of Cache Creek downstream to 5 km below Glacier Creek.

The smallest of 622 Arctic grayling >299 mm FL marked and released in the index area of the Fish River was 304 mm FL and the smallest of 557 Arctic grayling examined during the second event was 300 mm FL. The smallest of the 43 marked fish recaptured was 310 mm FL. No tag losses were detected, and only nine fish (<1%) out of 1,189 unique fish examined in the Fish River were killed during sampling in 1999.

A Kolmogorov-Smirnov two sample test of the cumulative length distributions of Arctic grayling > 299 mm FL marked in the index section of the Fish River, versus those recaptured during the second sampling event (test 1), failed to detect significant differences ($D = 0.132$; $P = 0.453$; $n_1 = 622$; $n_2 = 43$) between the samples. A similar test of those marked in the first event and those examined in the second event (test 2) failed to detect significant differences ($D = 0.066$; $P= 0.17$; $n_1 = 622$; $n_2 = 557$; Figure 5). Stratification by length was not necessary.

We grouped data into two strata by river km. The first stratum covered kilometers 1-9 and the second stratum covered kilometers 10-25. Since one of the three tests for consistency of the Petersen estimator was not significant, a single unstratified Bailey abundance estimate was calculated for Arctic grayling in the index area on Fish River (Table 2; R vs C; $X^2 = 2.817$; $df = 1$; $P = 0.093$). This indicated that capture probabilities in event 1 were similar between strata.

Since K-S test 2 failed to detect significant differences in the length distributions of the first and second samples, fish from both samples were combined and used for the length-at-age, length composition, age composition, and age-length distribution (Appendix A2).

To determine if movement of Arctic grayling between sampling events might have influenced the estimate of abundance, both the river sections and the locations (river km) where fish were marked and subsequently recaptured were examined. When movement was examined with location data by river km from the marking to recapture event, it was found that 29 of the 43 fish had not moved, 17 had moved upstream, and six had moved downstream (Figure 6). Since most of the fish that moved traveled 6 km or less (39 of 43 fish recaptured), this was not considered important enough to require adjustment of the mark-recapture experiment.

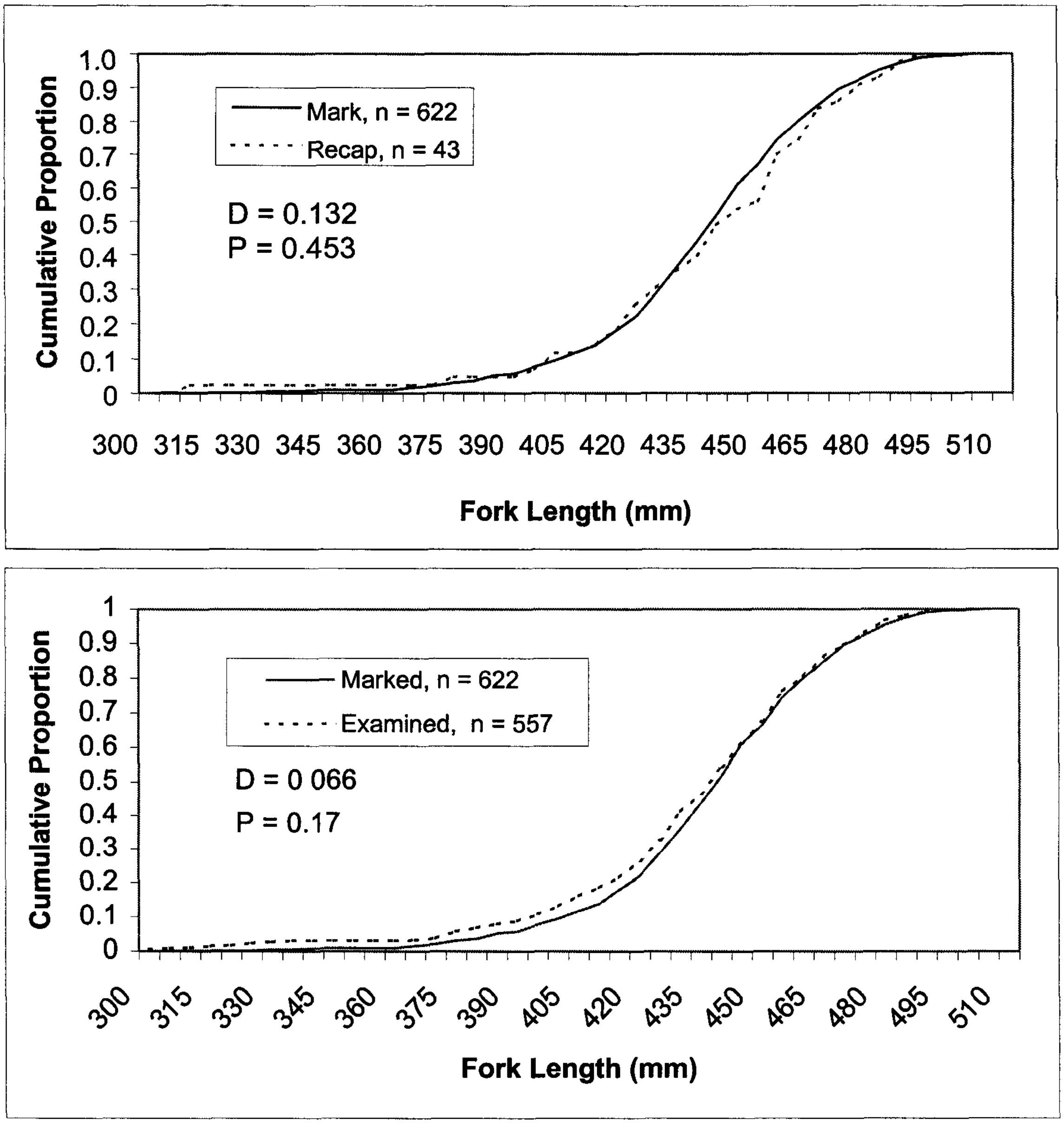

Figure 5.-Cumulative length distribution plots (tests 1 and 2) of Arctic grayling >299 mm FL sampled from the Fish River in 1999.

Table 2.-Counts of Arctic grayling ≥ 300 mm FL marked (M), examined (C), and recaptured (R) by location, 1999.

Marking Location	Number Marked	Number Recaptured 1-9	Number Recaptured 10-25	R/M[a]
1-9	192	19	3	0.11
10-25	430	3	18	0.05
Total	622	22	21	
Examined Without Marks:	514	190	324	
R/C[b]		0.10	0.06	

[a] R/M = recapture rate.

[b] R/C = marking rate.

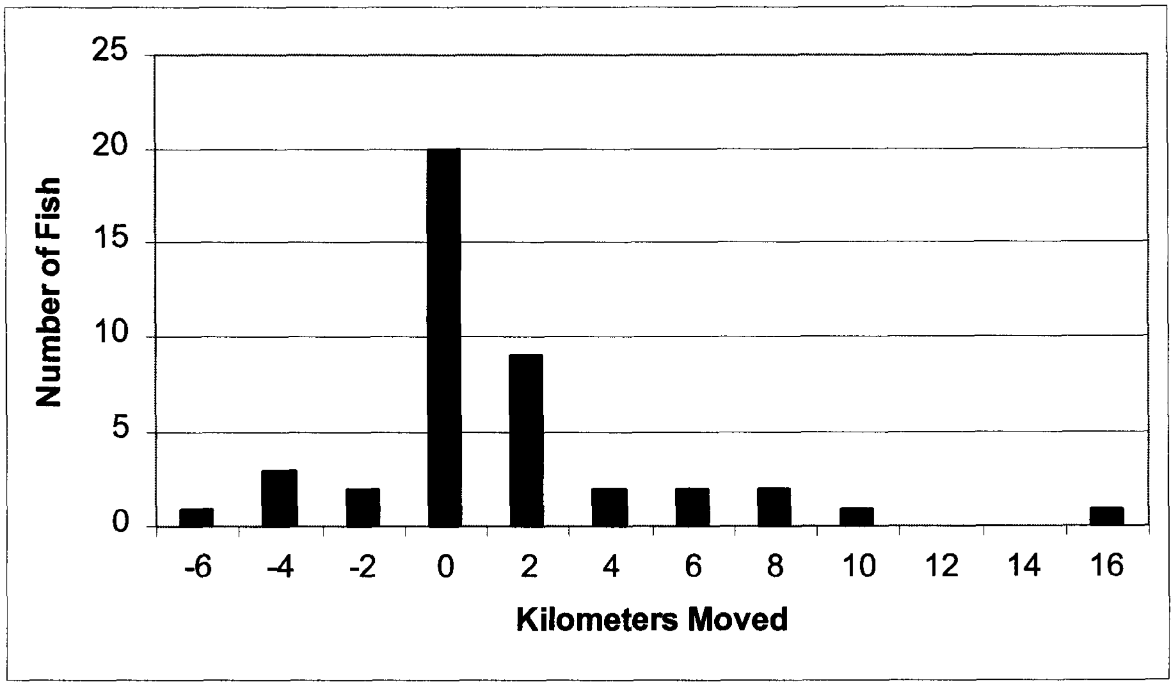

Figure 6.-Movement in km between marking location and recapture location of Arctic grayling in the Fish River in 1999.

AGE AND LENGTH COMPOSITIONS

Age and length composition and abundances by age and size category of Arctic grayling were estimated for the Fish River in 1999. Ages determined from scales of Arctic grayling from the Fish River ranged from three to 15 years. Fish aged seven and eight years comprised 45% of the population, and fish aged nine and 10 years comprised an additional 27% of the population (Figure 7; Table 3).

The majority of the population comprised the three 25-mm length categories from 400 to 475 mm (82%) with 37% in the 425 – 450 mm FL category (Figure 8; Table 4). The estimates were germane to those fish >299 mm FL and may be biased in relation to the entire population. However, very few Arctic grayling smaller than 299 mm FL were captured or observed in the sampling area of Fish River, and it is thought that if size bias exists, it is small and composition estimates are representative of the population that resides in this part of the river.

MEAN LENGTH-AT-AGE

Estimates of mean fork length-at-age were calculated for Arctic grayling sampled from the Fish River in 1999 and presented with past data (Table 5). In addition, when data were available, they were combined across years. Like most Arctic grayling populations in Seward Peninsula waters, those in the Fish River appear to grow rapidly in their early years. The 1999 sample shows that fish grew rapidly through age-10, and then growth slowed in subsequent years. It appears that the growth rate in recent years has exceeded that of the past. This may be due to a change in river productivity, or may be due to aging error. However, neither large nor very old fish were present in the earlier samples. The age - length distribution of Arctic grayling sampled in the Fish River during 1999 is provided in Appendix A2.

ELDORADO RIVER AGE VALIDATION

During 1994, 60 Arctic grayling in the Eldorado River were measured, weighed and injected with oxytetracycline (OTC) for age validation. During 1995, 43 additional Arctic grayling were captured and marked with OTC. In 1996, 11 of 75 Arctic grayling that were captured carried OTC marks. In 1997, 6 of 93 Arctic grayling captured from the Eldorado River carried OTC marks from 1994 or 1995, including one fish which had lost its tag. During 1998 no OTC marked fish were captured, however one was recaptured in 1999. All recaptured fish were killed and frozen whole for later analysis. The first trial was a failure, but when another filter cube was used that excited a wavelength range closer to that emitted by OTC, marks were visible. The remainder of the sample will be analyzed during the upcoming year and results will be submitted to a peer-reviewed journal for publication.

NOME RIVER ARCTIC GRAYLING RESTORATION

On July 22 and 23, 1998 a total 670 young-of-the-year Arctic grayling were introduced into the experimental arm of Banner Creek gravel pit. The mean length of 98 fry sampled from those captured for introduction in 1998 was 29.1 mm (SD = 1.69 mm).

Dissolved oxygen level was measured at 11.6 mg/l from a water sample taken from the ice covered gravel pit on November 6, 1998. The zooplankton found were: 46 Chironomidae, 19

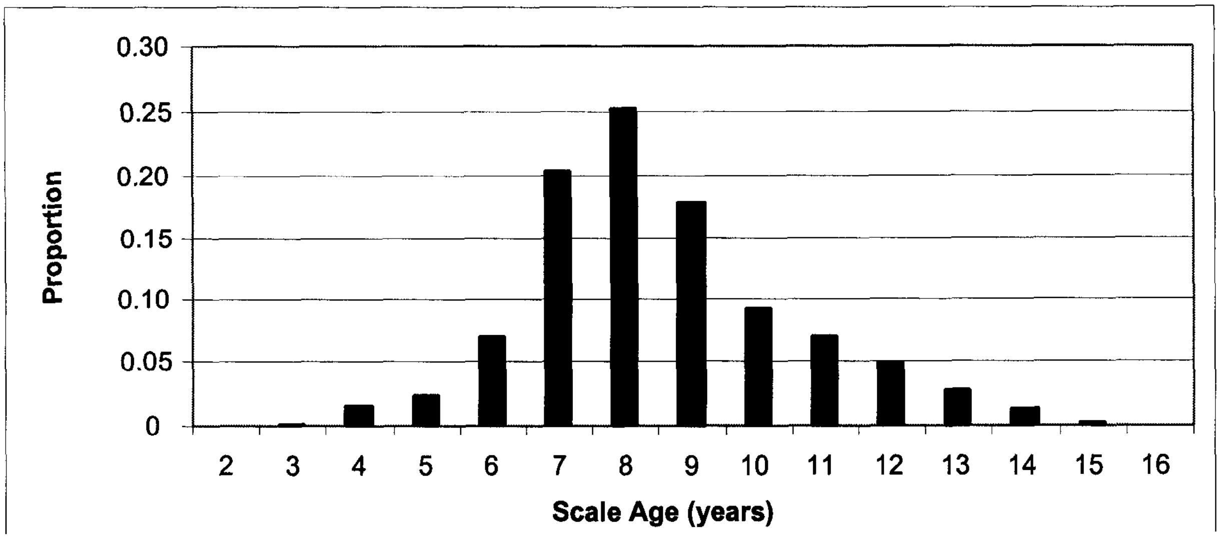

Figure 7.-Age composition estimates of Arctic grayling from the Fish River in 1999.

Table 3.-Estimated proportion and abundance of Arctic grayling in the Fish River by scale age class, 1999.

Fish River	Scale Age													
Statistic	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
Sample Size	1	11	16	48	140	174	123	64	48	34	19	9	2	689
Estimated Proportion	0.002	0.016	0.023	0.070	0.203	0.253	0.179	0.093	0.070	0.049	0.028	0.013	0.003	1.00
SE of Proportion	0.001	0.005	0.006	0.009	0.015	0.016	0.014	0.011	0.009	0.008	0.006	0.004	0.002	
Est. Abundance	11	126	184	550	1,606	1,995	1,412	734	550	390	218	103	23	7,902
SE of Abundance	11	42	52	109	259	314	232	136	109	85	56	37	16	1,461

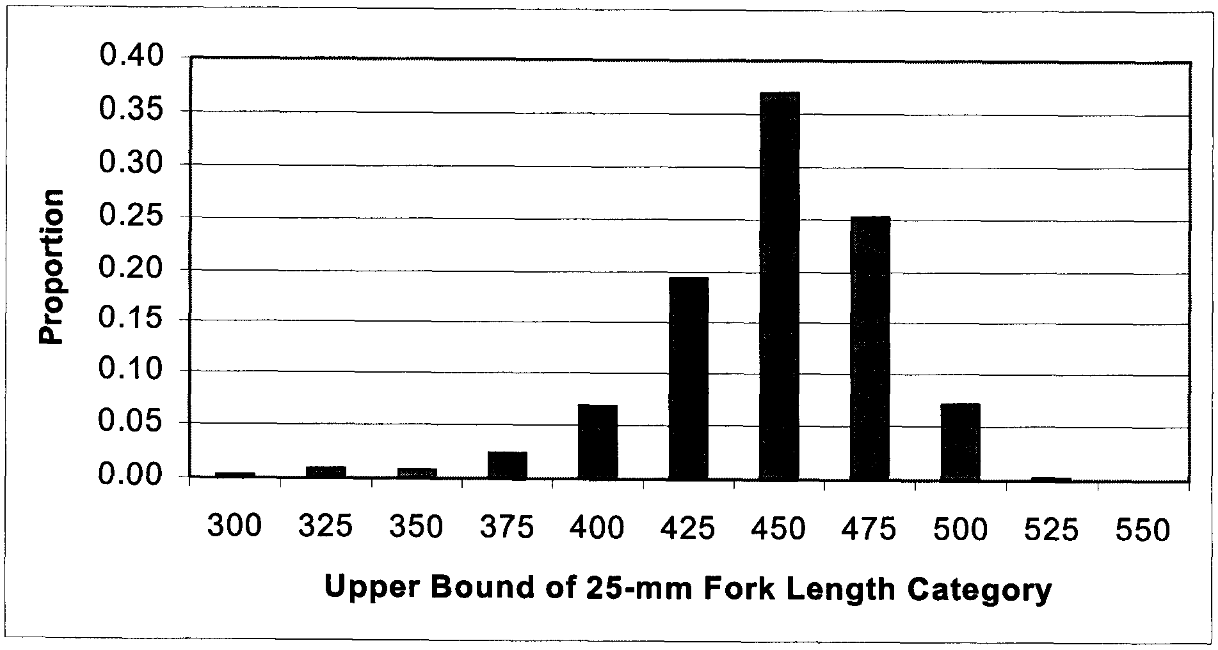

Figure 8.-Length composition estimates of Arctic grayling in the Fish River, 1999.

Table 4.-Estimates of length composition and abundance of Arctic grayling in the Fish River by 25-mm FL increments, 1999.

	Upper Bound of Fork Length Category									
Statistic	325[a]	350	375	400	425	450	475	500	525	Total
Sample Size	13	9	27	78	220	419	287	81	2	1,136
Estimated Proportion	0.012	0.008	0.024	0.069	0.194	0.369	0.253	0.071	0.002	1.00
SE of Proportion	0.003	0.002	0.004	0.007	0.011	0.013	0.012	0.007	0.001	
Estimated Abundance	90	63	188	543	1,530	2,915	1,996	563	14	7,902
SE of Abundance	36	22	44	97	237	432	303	100	10	1,283

[a] Includes fish from 300 to 325 mm FL.

Table 5.-Mean fork length at age for Arctic grayling sampled from the Fish River in 1989-1990, and in 1999.

	Fish River 1989 and 1990			Fish River 1999			Combined Sample		
Scale Age	Number of Fish	Mean Length (mm/FL)	Std. Dev. (mm/FL)	Number of Fish	Mean Length (mm/FL)	Std. Dev. (mm/FL)	Number of Fish	Mean Length (mm/FL)	Std. Dev. (mm/FL)
1	1	92	---	---	---	---	1	92	---
2	17	167	22	---	---	---	17	167	22
3	33	230	21	1	300	---	34	232	24
4	22	281	32	11	316	14	33	300	38
5	33	356	33	16	367	30	49	382	49
6	186	381	22	48	407	27	234	386	25
7	484	382	21	140	424	22	624	391	28
8	368	382	22	174	435	22	542	399	33
9	76	383	22	123	444	21	199	421	37
10	6	389	16	64	453	20	70	448	27
11	---	---	---	48	457	19	48	457	19
12	---	---	---	34	463	17	34	463	17
13	---	---	---	19	461	21	19	461	21
14	---	---	---	9	467	16	9	467	16
15	---	---	---	2	487	11	2	487	11

Oligochaeta and 1 Coleoptera (G. Todd, Alaska Department of Fish and Game, Commercial Fisheries, Soldotna Lab, personal communication). These benthic organisms are expected in non-moving water with mud substrate. Biomass was not able to be estimated from the single plankton tow. During June 1999, the gravel pit was trapped in an attempt to capture surviving Arctic grayling. Only one Arctic grayling was captured, and the experiment was deemed a failure. However, another pond that appears to be more suitable was found nearby (Appendix A4). Plankton tows were conducted in both ponds in 1999 and are yet to be analyzed. Dissolved oxygen under 2 m of ice on April 13, 2000 was measured at 11 mg/l in the unsuccessful pond with a water temperature of 0.5°C. On the same day, 12.3 mg/l O^2 was found in the nearby pond with a water temperature of 1.0°C.

DISCUSSION

The abundance estimate, 7,902 for the Fish River in 1999 applies only to Arctic grayling >299 mm FL and is thought to be unbiased for the section of the river sampled. Age and size composition estimates similarly apply only to fish larger than 299 mm FL in the sampling area. They are thought to be unbiased for the range of sizes covered, but larger length categories may be biased high in relation to the Arctic grayling population of the entire Fish/Niukluk river system. Since very few small fish were captured or observed in the Fish River, it is thought that the estimated size composition was representative of the Arctic grayling population within the reach of the river sampled. The smaller size components of the population likely reside somewhere downstream of the sampling area in slower moving reaches of the drainage. As fish reach larger sizes, they likely recruit to upstream areas similar to a model developed for interior Alaskan streams (Hughes and Reynolds 1994).

Both hook and line and beach seines were used to capture fish during both sampling events. However, much of the study area was unsuitable for beach seining because of a paucity of gravel bars, and high water during the first sampling event. The question of hook-shyness affecting recapture rates has been raised. If this condition occurs, it would result in an abundance estimate that is biased high. Sampling was designed to test whether hook-shyness affected the recapture rate of Arctic grayling during this project on the Fish River. In the design, fish were to be marked with beach seine and rod and reel in approximately equal numbers. During the first sampling event, water was high and strong current flows precluded the effective use of the beach seine, hence, the vast majority of fish were marked with rod and reel. Because the beach seine could not be effectively used during the first sampling event, the potential problems relating from hook shyness were not investigated in this project. This question remains to be addressed.

Movement of Arctic grayling between sampling events was quite extensive, but not in one direction, and resulted in mixing between sampling events rather than fish leaving the sampling area. During the first sampling event, fish were distributed relatively evenly throughout the 25-km sampling area. However, during the second sampling event, fish were concentrated in schools located at the mouths of cool water tributary streams. The upper reaches of the Fish River drain an extensive wetland area and during times of hot summer weather, the water temperature in the Fish River rises dramatically. During the first sampling event, the temperature of the mainstem Fish River ranged from 10 to 13.5 °C. Because of hot sunny weather, water temperatures ranged from 17 to 20.5 °C during the second sampling event, and declined on the last day to 15.5 °C. Small tributary streams such as Glacier Creek and Aggie Creek maintained temperatures between 8 and 11 °C, their plumes providing thermal refuge to Arctic grayling living in this river.

In previous stock assessment work on the Fish River during 1989 and 1990, abundance in the same reach of the river was estimated to be 2,900 fish during both years, less than half of what was found in 1999. In addition, the size range of fish present in these earlier studies was much smaller than those present today. We believe that all of these estimates are valid and that the higher level of abundance found in 1999 has resulted from a combination of factors. Prior to 1979 a small cable-drawn ferry, that carried only a few cars, was used to cross the entrance to Safety Sound. This effectively limited vehicular traffic between Nome and Council until 1979 when the bridge was completed over Safety Sound allowing easy access to Council, the Niukluk, and Fish rivers via the highway system. The daily bag limit during the 1970s and into the mid 1980s was 15 Arctic grayling per day with a possession limit of 30 fish. The quality of sport fishing for Arctic grayling was very high. The liberal limit combined with improved access resulted in high harvests. In addition, there were targeted subsistence fisheries for Arctic grayling in both the Fish and Niukluk rivers. In 1986, after repeated reports from anglers that the quality of grayling fishing had declined, the BOF reduced the daily bag limit to its current level of five fish per day with only one allowed greater than 15-in in length. Hook and release fishing for Arctic grayling has been gaining in popularity in the Nome area. During the past three years, many Nome area long-time anglers have reported that Arctic grayling fishing in the Fish and Niukluk rivers is as good as it has ever been. The results of this project support this contention, and corroborate work conducted on the Niukluk River in 1998 that found higher abundance and larger size composition of the Arctic grayling population in that fork of the drainage. We believe that we are just now seeing population level effects of the combination of changes in fishing practices (more hook and release, and no longer any grayling-directed subsistence net-fishing) and from the more restrictive regulations put into place in 1986.

There have been long-standing winter subsistence fisheries on the Fish and Niukluk rivers. Fish are harvested by jigging through holes in the ice. These fisheries are primarily directed toward Dolly Varden, but Arctic grayling are also taken. Although estimated harvests from this winter fishery are not available, the relative abundance and size composition of the Arctic grayling populations in the Fish and Niukluk rivers suggest that overall harvests in this system, both subsistence and sport, are sustainable at current levels of effort.

The experimental project to restore the Nome River Arctic grayling population by rearing fry over the winter in the Banner Creek gravel pit was a failure. Only one surviving Arctic grayling was captured in 1999. However, another nearby pond was investigated and may be suitable for this use. Temperature recorders were placed in the unsuccessful pond and the new one. Plankton tows were conducted and samples were sent to the ADF&G Limnology Lab in Soldotna for analysis. Dissolved oxygen levels during late winter appeared to be adequate in both ponds (11.9 and 12.2 mg/l; April 13, 2000). Dam construction by beaver, resident in the failed pond, have raised the water level making containment of fish in the experimental arm of the pond difficult. The new pond has very small outflow and, although part of the Banner Pit complex, is an independent drainage. Dolly Varden, slimy sculpin, and coho salmon juveniles were observed in the new pond. This has more extensive shallow areas and some emergent vegetation, suggesting higher productivity than the old pond. It is recommended that this attempt at restoration of the Nome River Arctic grayling population be continued at this new location. If the natural recruitment process in the Nome River can successfully be enhanced, the population may recover to the point that some fishing can be allowed in the future.

It is recommended that the status of Nome area Arctic grayling populations continue to be assessed on a rotational basis in order to determine population trends. The Arctic grayling population in the Snake or Pilgrim rivers should be next up for assessment.

ACKNOWLEDGMENTS

I would like to thank Michael "Wolf" Cartusciello and Patrick Lewis for their amiable and able assistance in the field and the staffs of the Commercial Fisheries and Wildlife Conservation Divisions in Nome for their logistical support.

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APPENDIX A

Appendix A1.-List of numbered tags and finclips used to mark Arctic grayling from the Fish River in 1999.

Location	Month	No. Fish	Tag Numbers	Color	Fin Clip
Fish River Sec. 1	June	146	19128-19273	Gray	None
Fish River Sec. 2	June	162	19274-19435	Gray	None
Fish River Sec. 3	June	166	19436-19601	Gray	None
Fish River Sec. 4	June	142	19602-19743	Gray	None

Appendix A2.-Age-length distribution of Arctic grayling sampled from the Fish River in 1999.

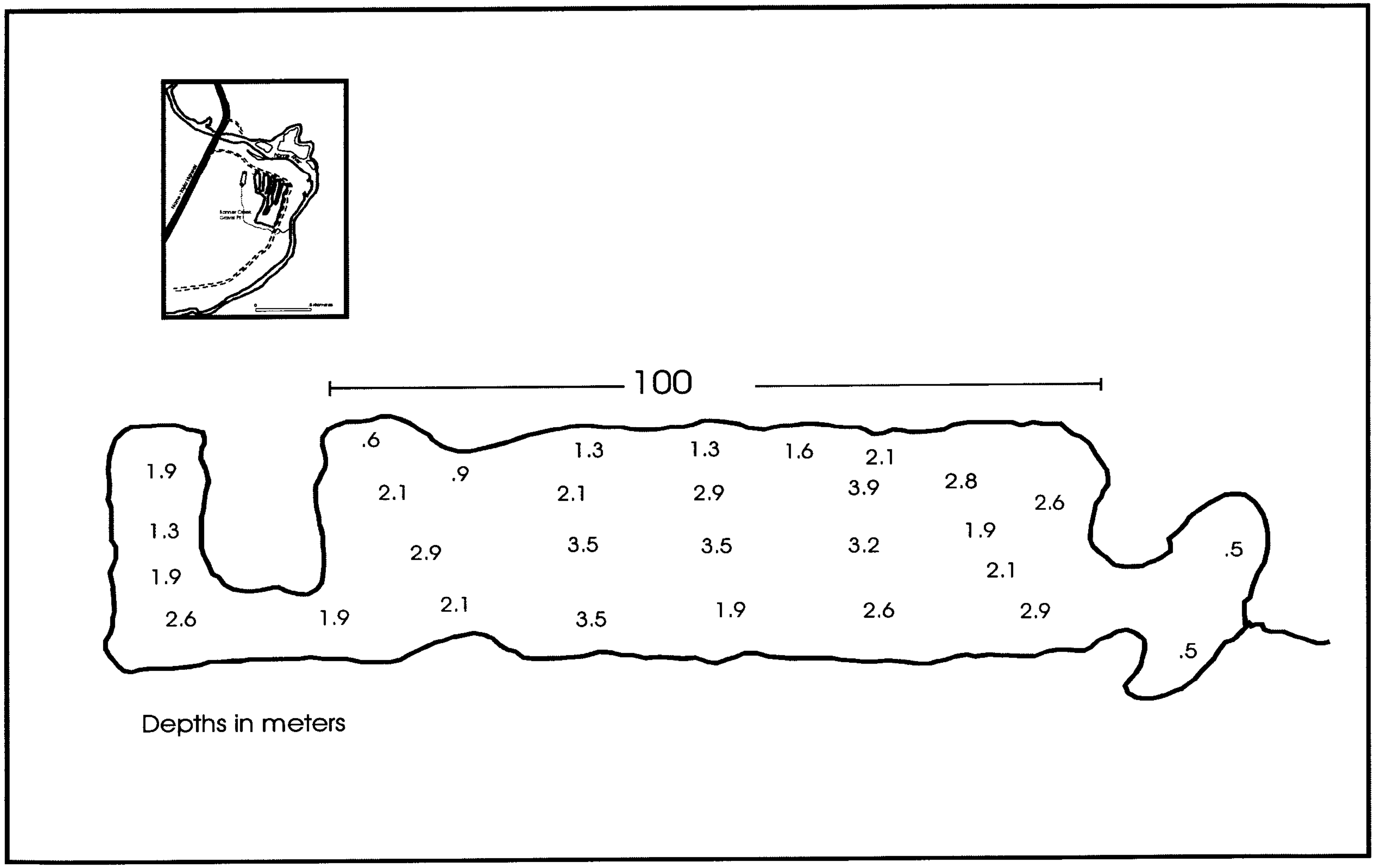
Length	Age														
(mm)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total
101-125															
126-150															
151-175	3														3
176-200	3														3
201-225	1														1
226-250		2													2
251-275		2													2
276-300		5	2												7
301-325			6	1			1								8
326-350			3	4											7
351-375				5	4	6		1							16
376-400				5	21	11	12	4	1						54
401-425					10	61	35	16	3	3		1			129
426-450				1	9	44	80	48	26	14	8	7	2		239
451-475					3	16	45	47	24	22	19	5	4		185
476-500					1	1	2	7	10	8	7	6	3	2	47
501-525										1					1
Total	7	9	11	16	48	139	175	123	64	48	34	19	9	2	704

Appendix A3.-Data files used to estimate parameters of Arctic grayling populations on the Seward Peninsula in 1997.

Data File[a]	Description
W00501LO11999.DTA	Data for Arctic grayling captured from the Fish River during 1999.

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

Appendix A4.-Map showing gravel pit proposed for Arctic grayling restoration in the Nome River.



APPENDIX B

Appendix B1.- Methodologies to compensate for bias due to unequal catchability by length.

Case	Result of First K-S Test[a]	Result of second K-S test[b]	Inferred Cause
I[c]	Fail to reject H_o	Fail to reject H_o	There is no size-selectivity during either sampling event.
II[d]	Fail to reject H_o	Reject H_o	There is no size-selectivity during the second sampling event, but there is during the first sampling event.
III[e]	Reject H_o	Fail to reject H_o	There is size-selectivity during both sampling events.
IV[f]	Reject H_o	Reject H_o	There is size-selectivity during the second sampling event; the status of size-selectivity during the first event is unknown.

a The first K-S (Kolmogorov-Smirnov) test is on the lengths of fish marked during the first event versus the lengths of fish recaptured during the second event. H_o for this test is: The distribution of lengths of fish sampled during the first event is the same as the distribution of lengths of fish recaptured during the second event.

b The second K-S test is on the lengths of fish marked during the first event versus the lengths of fish captured during the second event. H_o for this test is: The distribution of lengths of fish sampled during the first event is the same as the distribution of lengths of fish sampled during the second event.

c Case I: Calculate one unstratified abundance estimate, and pool lengths and ages from both sampling events for size and age composition estimates.

d Case II: Calculate one unstratified abundance estimate, and only use lengths and ages from the second sampling event to estimate size and age composition.

e Case III: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Pool lengths and ages from both sampling events and adjust composition estimates for differential capture probabilities.

f Case IV: Completely stratify both sampling events and estimate abundance for each stratum. Add abundance estimates across strata. Also calculate a single abundance estimate without stratification.

Case IVa: If stratified and unstratified estimates are dissimilar, discard unstratified estimate and use lengths and ages from second event and adjust these estimates for differential capture probabilities.

Case IVb: If stratified and unstratified estimates are similar, discard estimate with largest variance. Use lengths and ages from first sampling event to directly estimate size and age compositions.