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Stock Assessment of Arctic Grayling in the Nome River and Age Validation of Arctic Grayling in the Eldorado River, Seward Peninsula, Alaska 2000

by
Alfred L. DeCicco

February 2002

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

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour	h
minute	min
second	s

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

FISHERY DATA SERIES NO. 02-01

STOCK ASSESSMENT OF ARCTIC GRAYLING IN THE NOME RIVER AND AGE VALIDATION OF ARCTIC GRAYLING IN THE ELDORADO RIVER, SEWARD PENINSULA, ALASKA 2000

by

Alfred L. DeCicco
Division of Sport Fish, Fairbanks

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska 99518-1599

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Alfred L. DeCicco
Alaska Department of Fish and Game, Division of Sport Fish, Region III,
1300 College Road, Fairbanks, AK 99701-1599, USA

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ABSTRACT

The number of Arctic grayling *Thymallus arcticus* greater than 299 mm in FL was estimated at 551 fish (SE = 120 fish) in a 42-km section of the Nome River, Alaska in June 2000. Arctic grayling captured from the Nome River ranged in length from 308 mm to 494 mm FL and in scale determined age from four to 12 years. Arctic grayling aged 5 - 8 years were most numerous, composing 65% of the estimated population. Arctic grayling from 375 to 475 mm FL composed 86% of the estimated population and Arctic grayling from 426 to 475 mm FL composed 59% of the estimated population. Age validation of Eldorado River Arctic grayling indicated ages determined from otoliths were more reliable than ages determined from scales.

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

INTRODUCTION

The Seward Peninsula-Norton Sound Management Area supports the third largest amount of recreational fishing effort of all management areas in the Arctic-Yukon-Kuskokwim (AYK) Region, but has declined over the past 10 years. Annual sport-fishing effort in freshwater declined from 22,118 angler-days in 1991 to 11,408 angler-days in 1998. Estimates for 1999 were 13,590 angler-days and for 2000 15,678 angler-days near the overall average of 15,466 angler-days (Table 1; Mills 1990-1994; Howe et al. 1995–1996, 2001a, b, c, d, Walker et al. *In prep*). Reported freshwater harvests have included Dolly Varden *Salvelinus malma*, Arctic grayling *Thymallus arcticus*, pink *Oncorhynchus gorbuscha*, coho *O. kisutch*, chum *O. keta*, and chinook salmon *O. tshawytscha*, northern pike *Esox lucius*, whitefish *Coregonus*, and burbot *Lota lota*. From 1980 through 1991, Arctic grayling composed an average of 15% of the harvest of these species, but dropped to an average of 7.9% over the past five years (1995-1999) and composed an average of 24% of the catch (Table 1). The annual harvest remained consistent at about 1,250 Arctic grayling from 1993 through 1997, however it dropped to about 300 fish in 1998 in spite of a relatively high catch of over 12,000 fish. Since 1998, the average harvest has been about 1,400 fish.

The Seward Peninsula is the only area in Alaska outside of Bristol Bay that regularly produces trophy-sized Arctic grayling. Since 1967, 26% 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 that traverse the Seward Peninsula in three general directions from Nome (Figure 1). This road system provides angler access to many waters. During the 1980s ADF&G had concerns about the stock status of Arctic grayling. Angler reports indicated that the abundance of large-sized Arctic grayling appeared to be declining in some streams. In 1988 the Alaska Board of Fisheries reduced the daily bag limit of Arctic grayling on the Seward Peninsula to five per day, five in possession, and 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, 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

Table 1.–Estimated freshwater sport-fish effort, harvest and (catch) of Arctic grayling for Seward Peninsula and Norton Sound streams, 1980-2000.

Year	Number of Anglers	Effort (Angler-Days)	Arctic Grayling Harvest	Arctic Grayling Catch
1980		7,968	1,635	
1981		10,879	2,104	
1982		13,198	6,225	
1983		12,678	8,241	
1984	2,512	12,558	2,349	
1985	3,399	18,141	4,501	
1986	3,381	17,257	4,042	
1987	2,679	20,381	4,600	
1988	3,001	19,456	4,873	
1989	3,052	15,443	4,205	
1990	3,233	18,720	1,378	6,119
1991	3,776	22,118	5,121	23,160
1992	3,543	19,351	492	5,772
1993	3,134	17,055	1,378	13,223
1994	3,016	16,777	1,200	6,853
1995	3,719	17,334	1,037	5,788
1996	2,958	12,334	1,485	10,406
1997	2,773	12,463	1,261	20,187
1998	3,206	11,408	298	12,408
1999	3,124	13,590	1,600	16,132
2000	2,713	15,678	1,203	11,069
Average	3,131	15,466	2,820	11,920
90-99 Average	3,248	16,115	1,525	12,005
95-99 Average	3,156	13,426	1,136	12,984

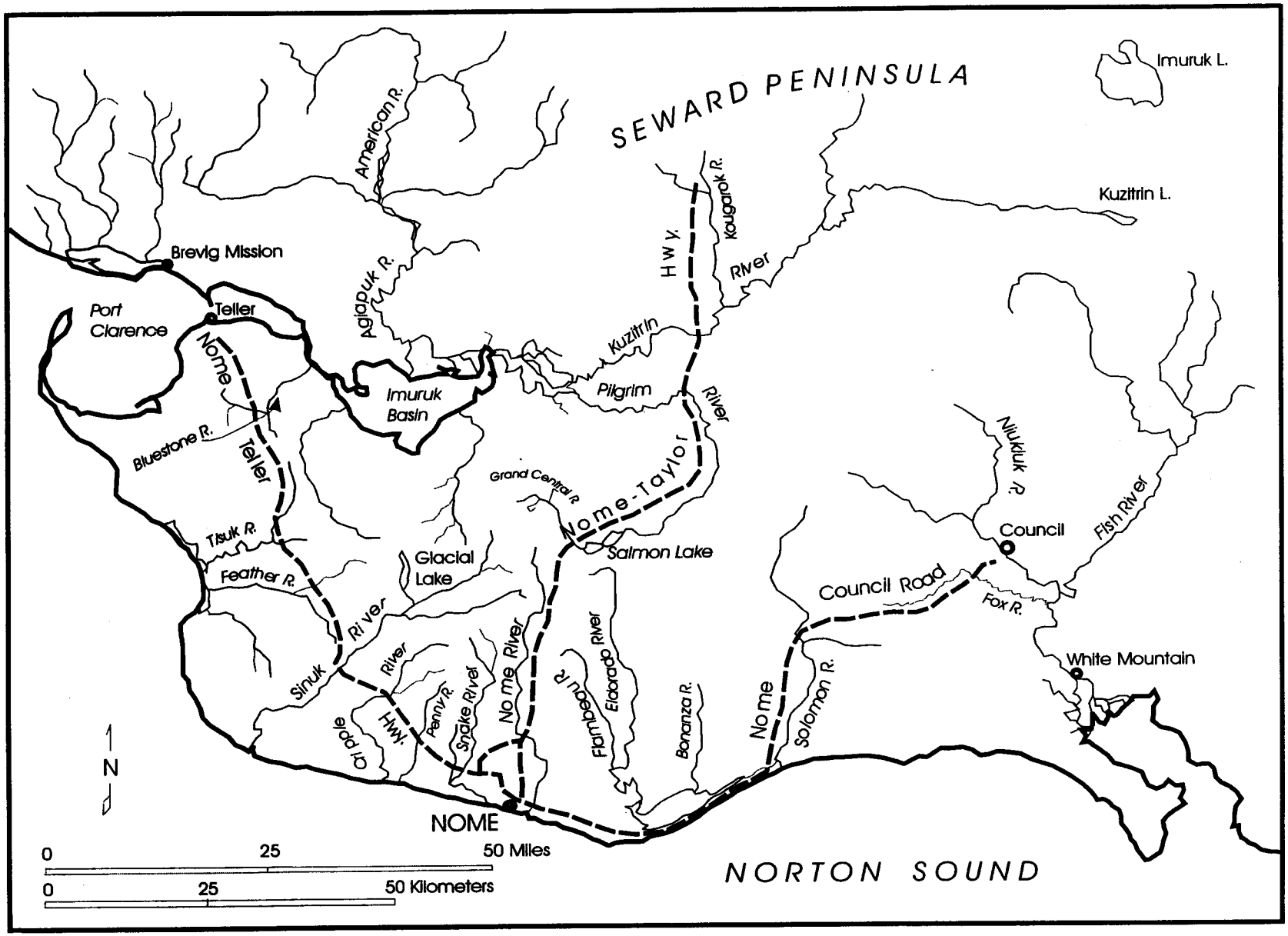

Figure 1.-The southern Seward Peninsula.

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, and 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 determining ages for large Arctic grayling from scales was noted in previous reports (DeCicco 1993–1995). Consequently, an age validation component using oxytetracycline was added to this project in 1994.

Several regulatory changes have 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 of Arctic grayling 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, and in January 2001, the BOF closed subsistence fishing for Arctic grayling in these rivers.

Base line data have been collected on most road accessible Arctic grayling populations. This project serves a population monitoring function that has a long-term goal of maintaining sustained yield and historic abundance and size compositions in managed rivers on the Seward Peninsula through appropriate regulations.

A preliminary effort has been 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 increase recruitment.

Project objectives for stock assessment (R-3-2e part 1) in 2000 were to:

1. estimate the abundance of Arctic grayling greater than 249[1] mm FL in a 42-km index section of the Nome River; and,
2. estimate the age and length compositions of Arctic grayling greater than 249 mm FL in the Nome River.

In addition, mean length-at-age for Arctic grayling in the Nome River was estimated.

METHODS

DESIGN

In 2000, a two event mark-recapture experiment was conducted to estimate the abundance of Arctic grayling ≥250[1] mm FL in a 42-km index section of the Nome River (Figure 2). The locations of marked fish were recorded by river kilometer. The index area extended from the mouth of Hobson Creek downstream to approximately 2 km upstream from the Nome – Council Road bridge near the mouth of the river (Figure 2).

Sampling was performed along the entire length of the river section, working in a downstream direction, during both the mark and recapture events. The marking event was conducted in eight days from June 13 - 21 and the recapture event was conducted from June 21 - 29. The sequence

[1] Fish less than 300 mm FL were not present in samples during this study. Estimates are therefore only germane to fish ≥ 300 mm FL.

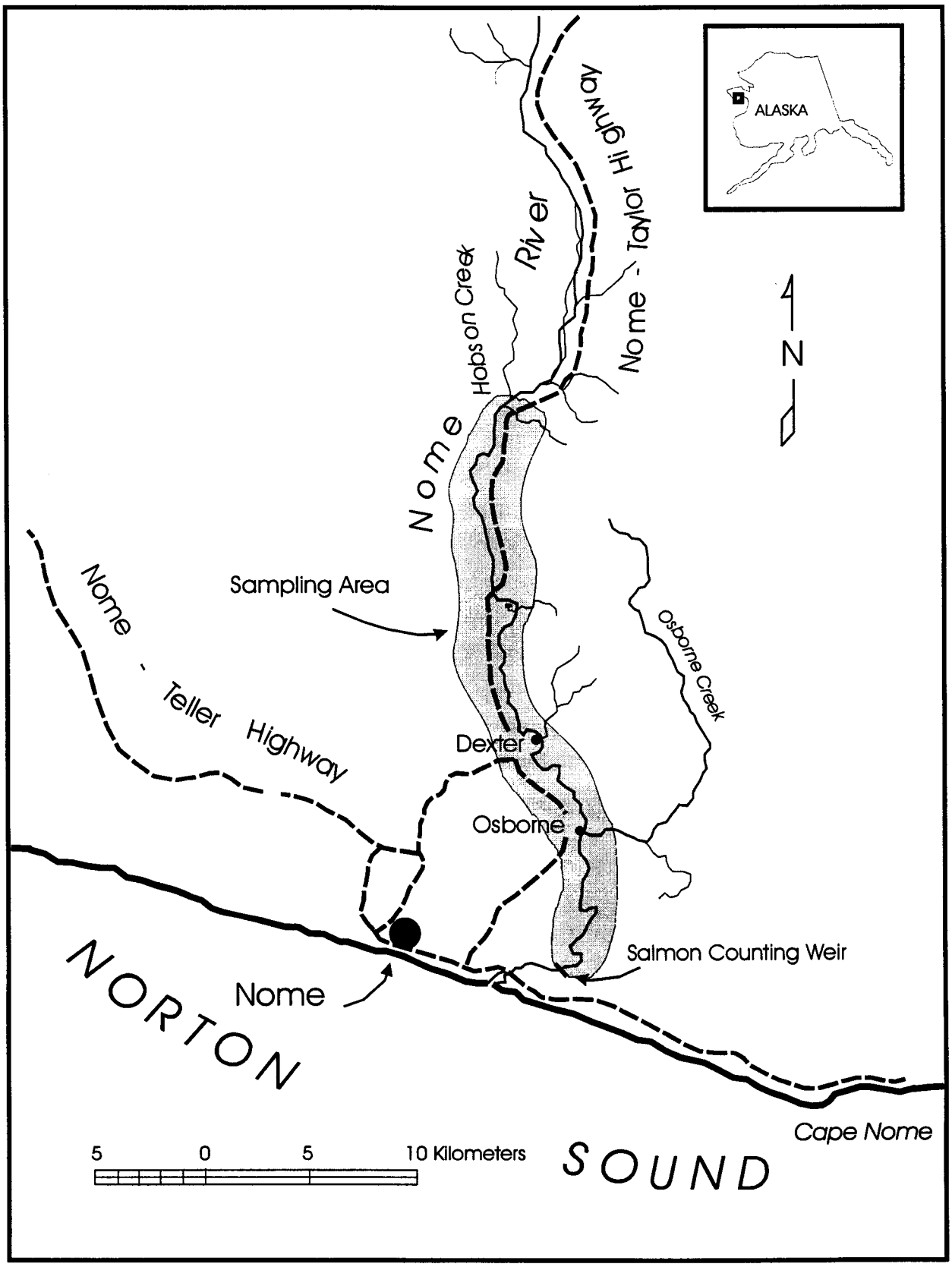

Figure 2.-Area sampled in the Nome River during 2000.

of sampling was the same in both events, resulting in an approximate 8-day hiatus between sampling events for any given location of the river.

SAMPLING GEAR AND TECHNIQUES

Arctic grayling in the Nome River were sampled using hook, line, and assorted terminal gear that ranged 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 foot except the area downstream from Osborne Creek was accessed 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 (Appendix A1) Floy FD-67 internal anchor tags, which were inserted such that the "T" anchor locked between the bases of adjacent dorsal fin rays. Secondary marks were not used because tag loss has not been a significant problem in past Arctic grayling projects on the Seward Peninsula (DeCicco 1990-2000). 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 envelopes used to hold scales, and 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 100ºC) as described by Clutter and Whitesel (1956). Ages were determined by counting annuli from the acetate impressions magnified on a microfiche reader. Age determinations followed procedures outlined by Yole (1975). Scale impressions were read once by a trained scale reader and checked by the project leader. Scale impressions with questionable readings were read a third time as necessary. If the determined age 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 A3).

ESTIMATE OF 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 Nome River. The assumptions necessary for the accurate estimation of abundance were (Seber 1982):

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 the beginning and end of the experiment were close in time (17 days). Assumptions 2 and 3 were examined by testing 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 difference in gear selectivity between events would be indicated (Appendix B1).

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 (kilometers 1-19), Section 2 (kilometers 20-29) and Section 3 (kilometers 30-42). If all tests were significant ($\alpha = 0.05$), it would be inferred that Assumption 2 was not valid. In this case the use of a Darroch two-sample stratified estimate would be appropriate given a closed population.

All fish were released near the point of capture. 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 1990-2000). Assumption 5 was met by the close examination of all fish for the presence of a tag.

The population estimate of abundance and the approximate variance of the estimate using Bailey's estimator (Seber 1982) was:

$$\hat{N} = \frac{M(C+1)}{(R+1)} \text{ and} \tag{1}$$

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

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 experiment. Ages were determined from scales in order to estimate age composition for the population in the assessed area of the Nome 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:

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

Abundance of Arctic grayling by age was estimated as follows:

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

where:

$\hat{N}_i$ = estimated number of fish in age 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:

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

where:

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

LENGTH COMPOSITION

Length composition of Arctic grayling in the assessed area of the Nome 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.

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.

RESULTS

NOME RIVER ARCTIC GRAYLING POPULATION ABUNDANCE

The abundance of Arctic grayling >299 mm FL in the 42-km index section of the Nome River (Figure 2) in 2000 was estimated to be 551 fish (SE = 120 fish; CV = 21.8%). This 42-km index section included the area from the mouth of Hobson Creek downstream to about 2 km upstream from the Nome-Council Road bridge near the mouth of the Nome River.

The fork-length of 80 Arctic grayling captured and marked in the first sampling event ranged from 338 mm to 485 mm. In the second sampling event, 116 captured fish ranged in fork length from 305 mm to 494 mm. Marked fish recaptured (n=16) in the second event ranged from 383 mm to 470 mm in fork length. No tag losses were detected, and four fish (2.1%) out of 184 unique fish examined in the Nome River were killed (all in the first sampling event) during sampling in 2000.

A Kolmogorov-Smirnov two sample test of the cumulative length distributions of Arctic grayling marked in the index section of the Nome River, versus those recaptured during the second sampling event (test 1), failed to detect significant differences ($D = 0.11$; $P = 0.49$; $n_1 = 80$; $n_2 = 16$) 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 ($D = 0.17$; $P= 0.70$; $n_1 = 80$; $n_2 = 116$; Figure 3). Stratification by length was not necessary.

To test for consistency of the Petersen estimator, we grouped data into three strata by river km. The first stratum covered kilometers 1-19, the second stratum covered kilometers 20-29 and the third strata covered kilometers 30-42. Two of the three tests for consistency of the Petersen estimator were not significant. Therefore, a single unstratified Bailey abundance estimate was calculated for Arctic grayling in the index area on the Nome River (Table 2; R vs M; $X^2 = 0.224$, df = 2, $P = 0.894$; R vs C; $X^2 = 4.125$; df = 2; $P = 0.127$). These tests indicated that capture probabilities in event 1 were similar among 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, the locations (river km) where each fish was marked and subsequently recaptured were examined. It was found that 4 of the 16 fish recaptured had not moved, and 14 out of the 16 had moved only 2 km or less (Figure 4). Although there was a general tendency of fish to move a small distance downstream, none had moved more than 3 km and there was no dominant movement pattern indicated that might have affected the validity of the mark-recapture experiment.

AGE AND LENGTH COMPOSITIONS

Age and length composition and abundances by age and size category of Arctic grayling were estimated for the Nome River in 2000. Ages determined from scales ranged from age-3 to age-12. Fish aged eight years composed 21% of the estimated population, and fish aged five to nine years (except for age 8) were relatively evenly distributed making up an additional 67% of the population (Figure 5; Table 3).

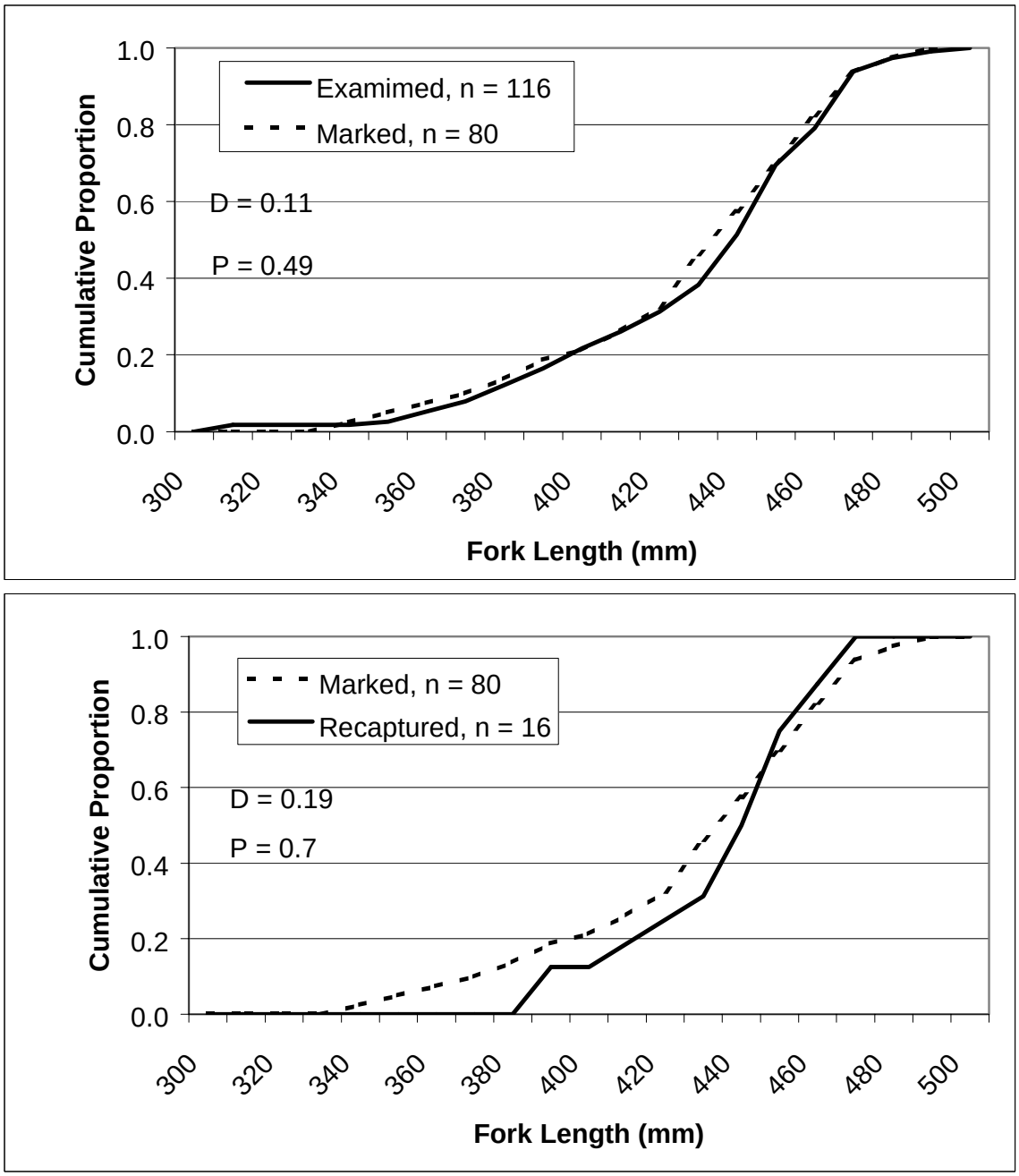

Figure 3.–Cumulative length distribution plots (tests 1 and 2) of Arctic grayling >299 mm FL sampled from the Nome River in 2000.

Table 2.–Number of Arctic grayling ≥ 300 mm FL marked (M), examined (C), and recaptured (R) by location, in the Nome River in 2000.

Marking Location	Number Marked	Number Recaptured			R/M[a]
		1-19	20-29	30-42	
1-19	18	4	1	0	0.28
20-29	33	0	5	0	0.15
30-42	29	0	1	5	0.21
Total	80	4	7	5	
Examined Without Marks:	100	12	37	51	
R/C[b]		0.33	0.19	0.09	

[a] R/M = recapture rate.

[b] R/C = marking rate.

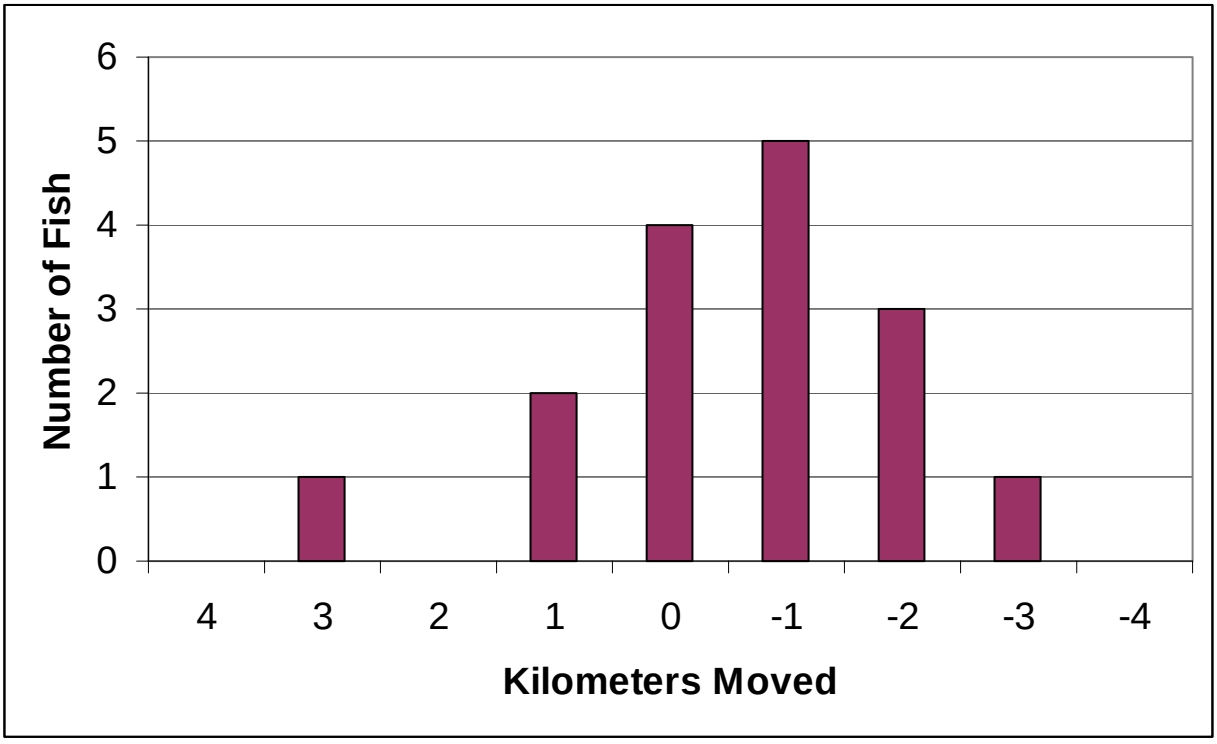

Figure 4.–Kilometers moved between marking location and recapture location of Arctic grayling in the Nome River in 2000.

Figure 5.–Age composition estimates of Arctic grayling from the Nome River in 2000.

Table 3.-Estimated proportion and abundance of Arctic grayling in the Nome River by scale age class, 2000.

Statistic	Age Determined from Scale									
	4	5	6	7	8	9	10	11	12	Total
Sample Size	2	22	25	22	33	20	17	10	5	156
Estimated Proportion	0.01	0.14	0.16	0.14	0.21	0.12	0.10	0.06	0.03	1.00
SE of Proportion	0.00	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.01	
Estimated Abundance	7	78	88	78	117	71	60	35	18	551
SE of Abundance	5	23	25	23	31	21	19	13	8	168

The majority of the estimated population composed the two 25-mm length categories from 426 to 475 mm (59%) with 37% in the 426 – 450 mm FL category (Figure 6; Table 4). The estimates were germane to those fish >299 mm FL and may not apply to the entire population. Very few Arctic grayling smaller than 299 mm FL were captured or observed in the sampling area.

MEAN LENGTH-AT-AGE

Estimates of mean fork length-at-age were calculated for Arctic grayling sampled from the Nome River in 2000 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 Nome River appear to grow rapidly in early life. The 2000 sample and past data show that fish grew rapidly through age-8 or age-9, and then growth slowed in subsequent years. It appears that the growth rate in recent years was similar to that observed in the past. The age - length distribution of Arctic grayling sampled in the Nome River during 2000 is provided in Appendix A2.

ELDORADO RIVER AGE VALIDATION

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 additional marked fish was recaptured in 1999. OTC marks were visible on test otolith cross sections, and in the cases viewed, the number of annuli observed past the OTC mark corresponded to the number of years that had passed between marking and recapture. OTC marks were not visible on scales, however scales taken at the time of marking can be compared with those taken at recapture. Some sets of scales showed increases in age that corresponded to the passage of time, and some did not. In some cases, the total age estimated from otoliths greatly exceeded that estimated from scales.

DISCUSSION

The abundance estimate of 551 Arctic grayling for the Nome River in 2000 applies only to fish >299 mm FL. The area for the river sampled includes the section of river occupied by Arctic grayling during summer months. There are intermittent pools upstream from the sampling area that may contain a few Arctic grayling, but for the most part, the area upstream from the sampled section has fast current and is too shallow to support large numbers of Arctic grayling. This upper section of the Nome River was sampled in 1992, and few Arctic grayling were observed. Estimates of age and size composition similarly apply only to fish larger than 299 mm FL in the sampling area. Age composition estimates may be inaccurate because of inability to estimate ages correctly from scales. It is likely that ages of fish estimated at 6 years or younger are more accurate than those for older fish.

A smaller size components of Arctic grayling in the Nome River may reside downstream of the sampling area in the slower moving reaches of the drainage. There, however, is only a short length of river from the lower bound of the sampling area downstream before the water becomes brackish. As fish reach larger sizes, they may recruit to upstream areas similar to a model developed for interior Alaskan streams (Hughes and Reynolds 1994). The Nome River population of Arctic grayling has been heavily exploited and is at a very low level of abundance relative to historic abundance. It is thought that recruitment into larger size classes is very low

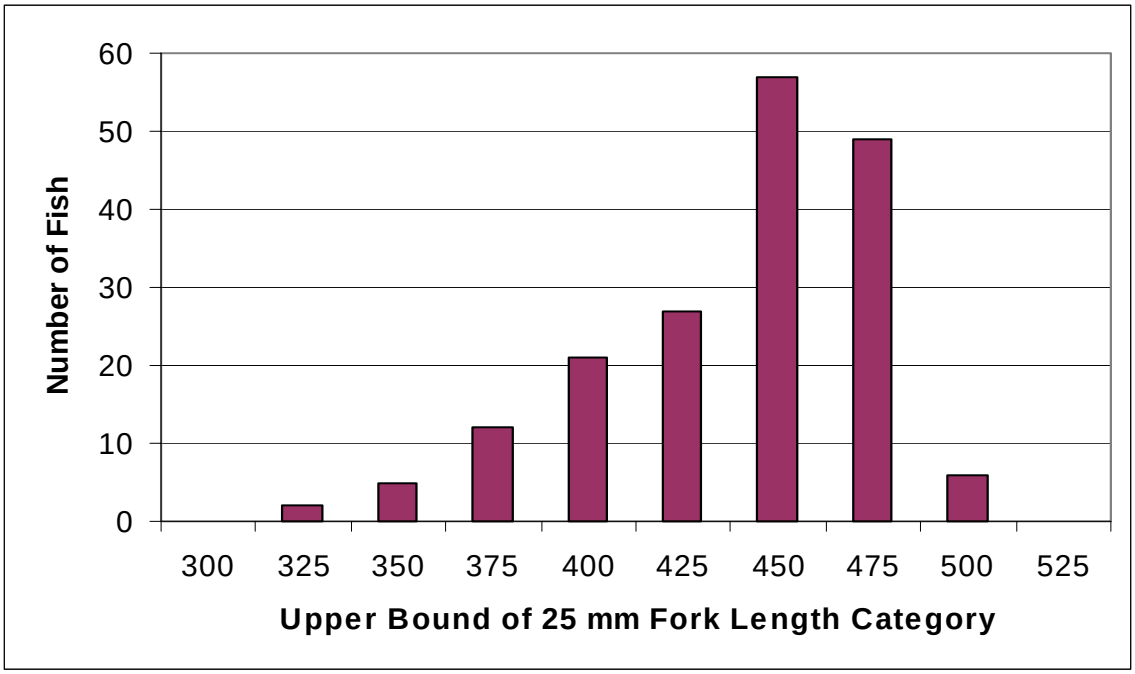

Figure 6.-Length composition estimates of Arctic grayling in the Nome River, 2000.

Table 4.-Estimates of length composition and abundance of Arctic grayling in the Nome River by 25-mm FL increments, 2000.

Statistic	Upper Bound of Fork Length Category								
	325[a]	350	375	400	425	450	475	500	Total
Sample Size	2	5	12	21	27	57	49	6	179
Estimated Proportion	0.01	0.02	0.06	0.11	0.15	0.31	0.27	0.03	1.00
SE of Proportion	0.00	0.01	0.01	0.02	0.02	0.03	0.03	0.01	
Estimated Abundance	6	15	37	65	83	176	151	18	551
SE of Abundance	4	7	13	19	23	43	37	8	154

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

Table 5.-Mean fork length at age for Arctic grayling sampled from the Nome River in 1989-1990, and in 2000.

	Nome River 1991, 1992 and 1997			Nome River 2000			Combined Sample		
Scale Age	Number of Fish	Mean Length (mm/FL)	. SD (mm/FL)	Number of Fish	Mean Length (mm/FL)	SD (mm/FL)	Number of Fish	Mean Length (mm/FL)	SD (mm/FL)
1	1	125	0	---	---	---	1	125	0
2	1	223	0	---	---	---	1	223	0
3	40	264	21	---	---	---	40	264	21
4	128	320	28	2	307	2	130	320	28
5	154	379	42	22	368	21	176	378	40
6	195	378	42	25	412	32	220	382	42
7	157	419	33	22	429	21	179	420	32
8	125	437	26	33	441	19	158	438	25
9	50	444	19	20	455	17	70	447	19
10	26	455	20	17	453	16	43	454	18
11	1	476	0	10	455	16	11	457	16
12	3	488	6	5	474	19	8	479	16
13	---	---	---	---	---	---	---	---	---
14	---	---	---	---	---	---	---	---	---
15	---	---	---	---	---	---	---	---	---

because few small fish are produced annually and naturally mortality rates for young fish in the Nome River are likely high.

Movement of Arctic grayling between sampling events was mostly in one direction but not extensive and it is likely that movement had no impact on the estimate of abundance. In previous stock assessment work on the Nome River during 1992 and 1997, abundance in the same reach of the river was estimated to be 725 fish and 689 fish respectively. In addition, the size range of fish sampled and estimated in these earlier studies was similar to that estimated in this study.

The sport fishery has been closed since 1992, but Arctic grayling have been taken incidentally each winter in the subsistence fishery that targets Dolly Varden. Although Dolly Varden are the primary focus of this fishery, Arctic grayling are sometimes taken, and retained. As a result of this study, the Alaska Board of Fisheries closed the Nome River to subsistence fishing for Arctic grayling during January 2001. Now, any Arctic grayling incidentally captured in the river must be released alive.

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APPENDIX A

Appendix A1.-List of numbered tags and finclips used to mark Arctic grayling from the Nome River in 2000.

Location	Month	No. Fish	Tag Numbers	Color	Fin Clip
Nome River	June	24	36800-36832	Gray	None
Nome River	June	5	36825-36829	Gray	None
Nome River	June	20	36849-36868	Gray	None
Nome River	June	18	36875-36892	Gray	None

Appendix A2.-Age-length distribution of Arctic grayling sampled from the Nome River in 2000.

Length	Age												
(mm)	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													
276-300													
301-325			2										2
326-350				5									5
351-375				9	2								11
376-400				7	8	3							18
401-425				1	8	5	7	2	1				24
426-450					3	11	16	7	8	5	1		51
451-475					4	3	10	11	8	4	1		41
476-500								1		1	3		5
501-525													
Total			2	22	25	22	33	21	17	10	5		157

Appendix A3.-Data files used to estimate parameters of Arctic grayling population in the Nome River in 2000.

Data File[a]	Description
NomeRGr00.xls	Data for Arctic grayling captured from the Nome River during 2000.

[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 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.