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TANANA ARCTIC GRAYLING STUDY

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ALASKA DEPARTMENT OF FISH AND GAME
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STATE OF ALASKA

Bill Sheffield, Governor

Annual Performance Report for

TANANA DRAINAGE ARCTIC GRAYLING

BY

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ALASKA DEPARTMENT OF FISH AND GAME
Don W. Collinsworth, Commissioner

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Volume 27

Study G

RESEARCH PROJECT SEGMENT

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Name: Sport Fish Investigations of Alaska

Project: F-10-1

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Study Title: DISTRIBUTION, ABUNDANCE, AND NATURAL HISTORY OF THE ARCTIC GRAYLING IN THE TANANA DRAINAGE

Job: G-8

Job Title: Tanana Drainage Arctic Grayling

Cooperators: Rolland Holmes, William Ridder, Robert Clark

Period Covered: July 1, 1985 to June 30, 1986

ABSTRACT

This project monitored the stock status, population dynamics, and fisheries of the major grayling populations of the Tanana River drainage. Estimates or indices of grayling abundance were made on the Chena, Chatanika, Salcha, Goodpaster, Delta Clearwater, and Richardson Clearwater Rivers. The trend toward a decline in grayling numbers continued in most rivers in 1985. Abundance indices were the lowest ever recorded for the Delta Clearwater River. Poor recruitment to younger-year classes over the past several years is the major cause; fishing mortality to older-age classes is another factor. Recruitment to specific year classes in the Chena River has been poor in 3 of the past 4 years and is poorest in years when river discharge is high.

Creel surveys were conducted on four spring grayling fisheries and two summer grayling fisheries. Catch rates were highest in the Shaw Creek fishery. The total harvest goal of 1,000 grayling was exceeded by about 400 fish. This fishery was stopped by emergency order after only 4 days of fishing. Almost 2,000 grayling were harvested from the Chena River Dam site spring fishery. These spring fisheries create the opportunity for overharvesting the larger prespawning grayling. Harvest and catch rates on the upper Chena River were at historic lows mainly because of poor weather, high water, and lower grayling abundance in younger-year

classes. Enhancement activities were continued on the Delta Clearwater and Chena Rivers. Experimental stocking of Tanana drainage grayling stocks were performed using both hatchery- and pond-rearing techniques.

A dynamic pool model of the grayling population of the Chena River was developed to test the effect of seven management strategies (under increasing effort, stable fishing effort, and a fishing closure during May) on the population structure and fishery. After 30 years of simulation under each strategy, a 10- or 12-inch minimal length limit appeared to provide the most positive results (i.e., increased population numbers, average length of the stock, number of spawners, catch, and size of the catch). Refinement of the model's input variables should result in improved results in future years.

KEY WORDS

Arctic grayling, interior Alaska, Tanana drainage, electrofishing, population estimates, creel census, population dynamics, river stocking, migration, model.

BACKGROUND

Arctic grayling, *Thymallus arcticus* (Pallas), is the most valuable sport fishery resource of interior Alaska. Grayling consistently rank second or third in total Alaska freshwater sport harvest by species. Interior waters provide about 60% of this harvest, making the Interior and, particularly, the Tanana drainage the largest grayling fishery in North America. With increasing human population, tourism, and improving access to fishing, angling pressure on Tanana drainage stocks is increasing approximately 10% annually. The popularity of the grayling is exemplified by the fact that it is consistently rated as the number one sport species by interior Alaskan fishermen. Holmes (1981) found that over 90% of Fairbanks fishermen fish for grayling each year.

This study was conducted on the naturally occurring grayling populations in the Tanana drainage (Fig. 1); the major emphasis was directed at the stocks that support the largest fisheries. These major stocks are found in the Chena, Salcha, Chatanika, and Goodpaster Rivers; Delta and Richardson Clearwaters; Badger and Piledriver Sloughs; Shaw Creek; and Fielding and Tangle Lakes. Past studies on Tanana drainage grayling have provided a good general knowledge of grayling life history (Roguski and Winslow 1969; Roguski and Tack 1970; Tack 1971-1976, 1980; Hallberg 1977-1982; Holmes 1983-1985; Peckham and Ridder 1979; Ridder 1980-1985). Studies in the Delta Junction area have concentrated on determining the complex movements of grayling between the bog/clearwater/glacial river systems of the area. Ridder (1985) describes these systems. Studies in the Fairbanks area have emphasized the population dynamics of grayling and how they have been affected by fisheries in the large runoff rivers of the area, especially the Chena River (Holmes 1985). However, the status of these stocks and the effects of the current fisheries on these stocks are only generally known. The goal of this project is to clearly define the population parameters and determine the management actions

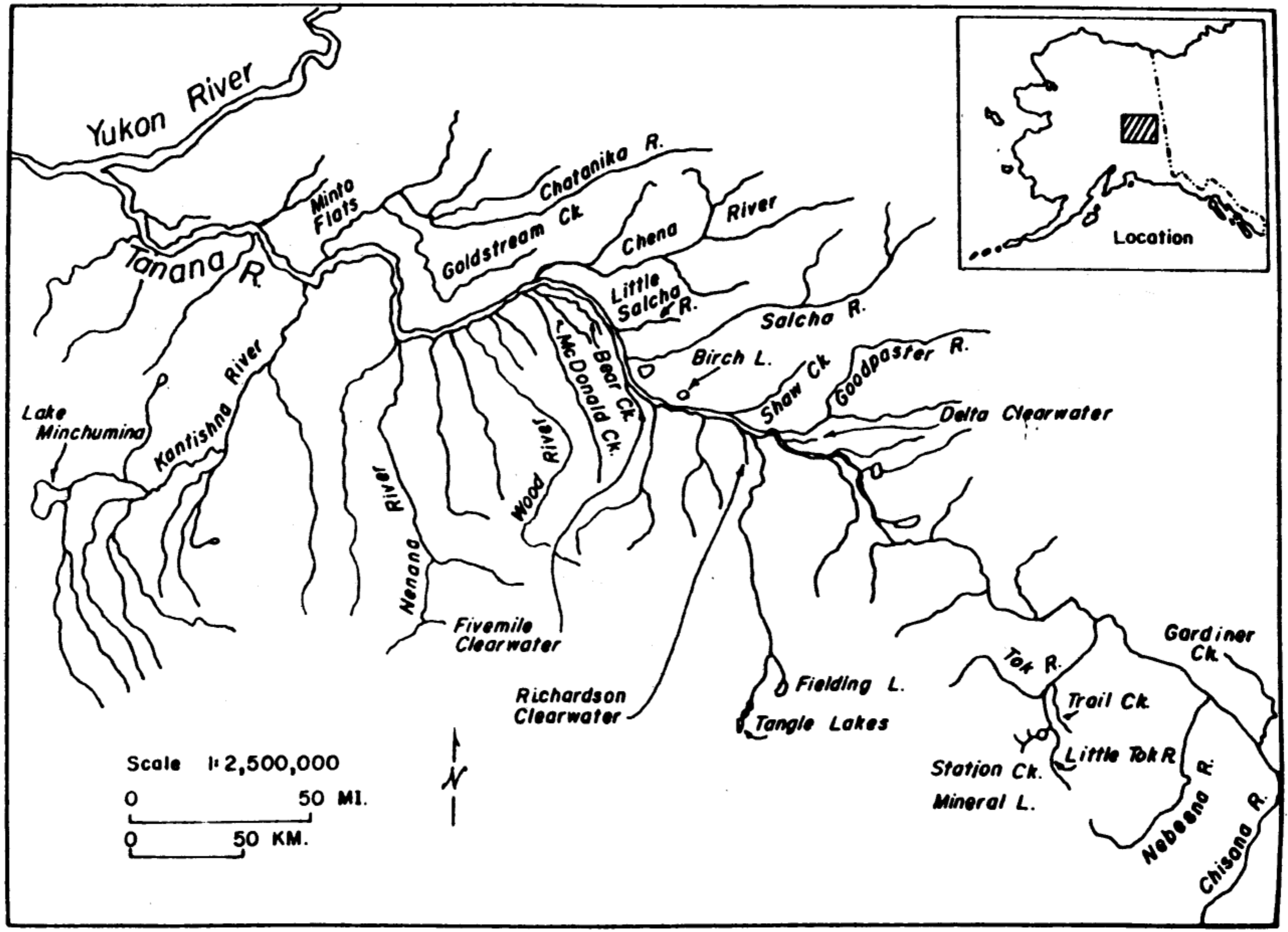

Figure 1. Tanana Drainage Grayling Research Areas.

needed to maintain or improve the structure of these naturally occurring grayling populations.

RECOMMENDATIONS

Management

1. Harvest goals for the spring Shaw Creek fishery should be developed.

2. Stocking of grayling fingerlings into the Delta Clearwater River should continue.

3. Best methods (fry, hatchery fingerlings, pond fingerlings) of stock enhancement should continue to be evaluated for lakes and rivers of the Interior.

4. Regulation changes of high-use grayling fisheries should be evaluated.

5. An annual grayling egg take should be conducted on the Goodpaster River.

Research

1. Whole river population estimates of age-3 and older grayling should be performed on the Chena River, Richardson Clearwater River, Shaw Creek, and Fielding Lake.

2. Population estimates of age-3 and older grayling should be performed on two index sections of the Goodpaster River.

3. Electrofishing catch per unit of effort (CPUE) estimates of age-3 and older grayling should be performed on each of two, 3-mile sections of the Delta Clearwater River as an index of stock abundance.

4. Beach seine CPUE estimates of age-0 grayling should be performed on the Chena, Salcha, Chatanika, and Goodpaster Rivers and Badger Slough as an index of subrecruit cohort strength.

5. Fyke trap or beach seine CPUE estimates of age-1 and 2 grayling should be performed as an index of subrecruit cohort strength in the Delta Clearwater River.

6. The mean length and age composition should be estimated for the Chena, Salcha, Chatanika, Delta and Richardson Clearwater Rivers, Caribou Creek, and Fielding Lake.

7. The average annual mortality rate for age-3 to age-8 grayling should be estimated for the Chena River.

8. The effect of river discharge on stock recruitment should be evaluated for the Chena and other area rivers.

9. A dynamic pool model that describes the interactions between sport fishing and life history aspects of grayling on the Chena River should be developed.

10. The proportional contribution of stocked grayling to the population and harvest of the Chena and Delta Clearwater Rivers should be estimated.

11. The effect of grayling rearing methods and stocking time on recruitment of enhancement fish to the Delta Clearwater River should be evaluated.

12. The relative survival and costs of stocking sac-fry and fingerling grayling in lakes should be evaluated.

13. Creel censuses to estimate angler effort, harvest, and CPUE and to sample the catch should be performed on the upper Chena River, Delta Clearwater River, Fielding Lake, Shaw Creek, and Chena Dam site grayling fisheries.

14. Creel census estimates of angler CPUE should be made of the Tangle Lakes, Badger Slough, and Piledriver Slough grayling fisheries.

15. The proportion of quality-size fish (≥300mm fork length) harvested in each censused fishery should be estimated.

16. The mean length composition of each year class harvested in all the censused fisheries should be estimated.

17. Composition of anglers (age, residency, mode of fishing, sex, etc.) in each of the censused fisheries should be estimated.

18. Perceptions of anglers concerning proposed regulation changes in the censused fisheries should be evaluated.

OBJECTIVES

A. Chena River/Badger Slough

1. To provide accurate (90% CI, ±20% of $\bar{x}$) in-season and post season estimates of: a)effort (angler hours), b) grayling catch-per-hour (CPUE); c) total grayling harvest, and d) rate of exploitation (percent mortality due to recreational fishing) by the upper Chena River grayling fishery.

2. To accurately estimate (90% CI ±20% of $\bar{x}$) proportional contribution of each age class to the upper Chena River grayling harvest and hence, rate of exploitation by age class.

3. To estimate the proportional contribution of stocked grayling to the upper Chena River fishery and hence, rate of exploitation of stocked grayling.

4. To accurately estimate (90% CI ±25% of $\bar{x}$) CPUE of adult grayling in the Badger Slough spring grayling fishery.

5. To accurately estimate (90% CI ±25% of $\bar{x}$) the proportional contribution of each age class of adult grayling harvested within the Badger Slough spring fishery.

6. To accurately estimate (90% CI ±25% of $\bar{x}$) the total number and size composition of catchable-size grayling within specific age classes (3-8) for the entire Chena River, as a yearly abundance index and for estimation of dynamic rates such as mortality, survival, and growth.

7. To estimate (90% CI ±25% of $\bar{x}$) CPUE of subcatchable size fish within specific age classes (ages 0-2) as an index of sub-recruit cohort strength in the Chena River.

8. To develop methods of producing large (100+ mm) juvenile grayling for stocking into the Chena River to supplement natural recruitment to weak year classes.

9. To estimate on a yearly basis, dynamic rates of specific cohorts of the exploited grayling stocks of the Chena River including: total, natural and fishing mortality; survival; exploitation; growth; and recruitment.

10. To model harvest levels and population abundance and composition for continuing evaluation of the effect of increasing angling effort and potential regulation changes on Chena River grayling stock structure and sustainable yield.

11. To locate and delineate grayling spawning and overwintering areas in the Chena River system.

12. a) To estimate the abundance and composition of spawning grayling in Badger Slough; b) to develop a grayling stock recruitment relationship for Badger Slough; c) to estimate the contribution of Badger Slough-spawned grayling to the total Chena River recruitment; d) to estimate the exploitation rate of Badger Slough grayling; e) to monitor timing of spawning and movements of all age groups of grayling into and out of Badger Slough; and f) to monitor homing of grayling to natal streams.

B. Salcha, Chatanika, and Goodpaster River

1. To accurately estimate (90% CI ±25% of $\bar{x}$) the total number and size composition of catchable size grayling

within specific age classes (3-8) for a 3 mile index section of the Goodpaster, Salcha, and Chatanika Rivers as a yearly index of abundance and for determination of dynamic rates such as mortality, survival and growth.

2. To accurately estimate (90% CI ±25% of $\bar{x}$) CPUE of subcatchable size fish within specific age classes (ages 0-2) as an index of sub-recruit cohort strength in the Goodpaster, Salcha, and Chatanika Rivers.

3. To estimate, model, and evaluate population abundance, age structure, mortality, recruitment, survival, growth, and exploitation rates of the Goodpaster, Chatanika, and Salcha Rivers.

4. To locate and delineate grayling spawning and overwintering areas in the Salcha, Chatanika, and Goodpaster Rivers.

5. To obtain 300,000 fertilized Arctic grayling eggs from the Goodpaster River.

C. Spring Fisheries (Boondox, Piledriver, Little Chena)

1. To accurately estimate (90% CI ±25% of $\bar{x}$) CPUE of adult grayling in three Fairbanks area spring grayling fisheries (Boondox Slough, Piledriver Slough, and the Lower Chena River).

2. To accurately estimate (90% CI ±25% of $\bar{x}$) the proportional contribution of each age class of adult grayling harvested within the three Fairbanks area spring fisheries.

3. To locate and delineate grayling spawning and overwintering areas in the Little Chena River and Piledriver Slough.

D. Shaw Creek and Caribou Creek

1. To accurately estimate (90% CI ±10% of $\bar{x}$) effort, CPUE and harvest of grayling during the spring Shaw Creek fishery.

2. To accurately estimate (90% CI ±10% of $\bar{x}$) age, size, and sex composition of the exploited Shaw Creek grayling stock.

3. To accurately estimate (90% CI ±10% of $\bar{x}$) abundance and age, size, and sex composition of spawning grayling in Caribou Creek.

4. To estimate, model, and evaluate population abundance, age structure, mortality, recruitment, survival, growth, and exploitation rate of Shaw and Caribou Creek grayling populations.

5. To evaluate grayling movements as they relate to spawning, recruitment, and overwintering in the bog stream/clearwater river complex near Delta Junction.

6. To monitor homing of grayling to natal streams (Caribou Creek).

E. Fielding and Tangle Lakes

1. To accurately estimate (90% CI ±25% of $\bar{x}$) the CPUE of Arctic grayling harvested in the Fielding Lake and Tangle Lakes fisheries.

2. To accurately estimate (90% CI ±25% of $\bar{x}$) age and size composition of Arctic grayling harvested in the Tangle Lakes and Fielding Lake fisheries.

3. To accurately estimate (90% CI ± 25% of $\bar{x}$) age and size composition for Fielding and Tangle Lakes grayling stocks.

4. To index, model and evaluate population abundance, age structure, mortality, recruitment, survival, growth, and exploitation rates of Fielding and Tangle Lakes grayling population.

F. Delta and Richardson Clearwater

1. To accurately estimate (90% CI ±25% of $\bar{x}$) the CPUE of Arctic grayling harvested in the Delta Clearwater River.

2. To accurately estimate (90% CI ±25% of $\bar{x}$) age, size, and sex composition of Arctic grayling harvested in the Delta Clearwater River fishery.

3. To accurately estimate (95% CI ±25% of $\bar{x}$) population numbers and size composition of Arctic grayling within specific age classes (3-8) in the Delta and Richardson Clearwater Rivers as a yearly index of abundance and for determination of dynamic rates such as mortality, survival, and growth.

4. To estimate, model, and evaluate population abundance, age structure, mortality, recruitment, survival, growth, and exploitation rates of the Delta and Richardson Clearwater River grayling populations.

5. To evaluate grayling movements as they relate to spawning, recruitment, and overwintering in the bog stream/clearwater river complex near Delta Junction.

6. To evaluate stocking methods and brood sources of stocked grayling and their contribution to the Delta Clearwater River fishery.

TECHNIQUES USED

Unless otherwise noted in the text, all capture, sampling, and analytic techniques are the same as reported by Ridder (1982), Ridder (1983), and Holmes (1985). All sampling and analytical techniques for the dynamic pool model are described in that section.

FINDINGS

Harvest Studies

Spring grayling fisheries:

The spring grayling fisheries (Badger and Piledriver Sloughs, Shaw Creek, and the Chena Dam site) are the first open-water fisheries of the season. Fishing usually begins with the first breakup of the smaller streams. In 1985 fishing began around 1 May, and creel census activities continued until 31 May. These fisheries occur during spawning migrations of grayling, and intensive fishing effort on these spawning concentrations often results in large catches of adult fish. In the Delta Junction area, Shaw Creek is the major spring fishery. In the Fairbanks area, three spring fisheries were monitored for CPUE and catch composition information (Table 1).

Shaw Creek. The Shaw Creek spring fishery takes place in the Tanana River one half mile on either side of the creek's mouth. Grayling congregate in back eddies, bank margins, and below riffle areas awaiting break-up and access to upstream spawning areas. Due to yearly changes in the Tanana's braided channels, these holding areas also change and can affect the availability of fish to anglers on foot. The nearest boat launch is 12 mi upstream. The mouth of Shaw Creek is located beside the Richardson Highway. In 1985 the Tanana River at Shaw Creek broke up on 25 April and was fishable on the 27th. The fishery was censused daily from 8 a.m. to 10 p.m. from 27 April to 30 April. The fishery was closed by emergency order at midnight on 30 April, following a management plan that set a 1,000-fish harvest quota.

Angling effort was 970 angler hours, based on a total count within the above time period. The estimated total harvest and its 90% confidence limit was 1,533 ±162 grayling. Approximately half the effort in the fishery came on the fourth day. The emergency order was announced 24 hours previously.

Table 1. Catch-per-unit-effort and size composition of the harvest of grayling from the major grayling fisheries of interior Alaska, 1985.

Fishery	Gr. Kept Per Hour (mean ± 90% CI)	Total Gr. Caught Per Hour (mean ± 90% CI)	Proportion of Harvest >270mm (± 90% CI)	Proportion of Harvest >300mm (± 90% CI)	Average Fork Length (mean ± 90% CI) (mm)
Badger Sl.	0.51±0.17	0.78±0.20	27.4% ± 8.0%	8.3% ± 5.0%	250 ± 33
Chena Dam Site	0.62±0.25	1.52±0.85	64.4% ± 10.3%	33.9% ± 10.1%	287 ± 34
Piledriver Slough	0.66±0.24	1.05±0.27	4.0% ± 5.1%	0%	250 ± 29
Upper Chena River	0.22±0.06	0.30±0.07	59.4% ± 7.8%	29.2% ± 7.3%	273 ± 27
Shaw Creek	1.58±.017	3.38±0.29	90.0% ± 3.0%	61.2% ± 6.0%	308 ± 4
Delta Clearwater River	0.47±0.10	0.64±0.14	77.9% ± 7.0%	54.7% ± 10.1%	299 ± 5
Fielding Lake	0.34±0.08	0.84±0.20	82.4% ± 7.4%	69.6% ± 9.7%	318 ± 8
Tangle Lakes	0.39±0.10	1.23±0.27	53.0% ± 11.6%	34.3% ± 13.7%	277 ± 7

The composition of anglers interviewed in 1985 is as follows: residents, 58% (Delta, 15%; Fairbanks, 75%; other, 10%); military and dependents, 20%; nonresidents, <1%; and unknown, 22%. The success rate of these anglers showed that 55% harvested their limit of five fish, while 12% harvested none. The age composition of the harvest (90% confidence intervals) from a sample of 185 grayling is shown in Table 2.

As in past years, the harvest is composed predominantly of adult grayling. From a sample of 412 grayling, 85.2 ±3.7% (90% CI) were classed as adults. The male to female sex ratio was 0.93:1. Mean length and 90% CI for males was 324 ± 3mm; for females, 299 ± 4 mm; for unknowns, 297 ± 9 mm.

Badger Slough. CPUE of harvested grayling for the Badger Slough spring fishery was 0.51 grayling per hour with a 90% confidence interval of ± 0.17 grayling per hour. This CPUE represents a drop from the 1984 estimate, but it is within the range of historic catch rates for the fishery. The CPUE for all fish captured (including fish which were caught and released) was 0.78 ± 0.20 grayling per hour. The average size of harvested grayling was 250 mm and about 27% ± 8.0% of the harvest consisted of spawning-size fish.

Piledriver Slough. Piledriver Slough is a slough of the Tanana River originating about 30 mi east of Fairbanks. Dike construction from the Moose Creek Flood Control Project blocked the source of Piledriver Slough in the late 1970's. With the silty waters of the Tanana blocked, Piledriver Slough began to flow clear spring water. A fishery has recently developed on the grayling that now occupy the clear water stream. Catch rates were monitored on Piledriver Slough for the first time in 1985. CPUE of harvested grayling was slightly higher than that of Badger Slough, 0.66 ± 0.24 grayling per hour. CPUE for all fish captured was 1.05 ± 0.27 grayling per hour. The mean size of fish harvested was 250 ± 29 mm fork length. Only 4.0% ± 5.1% of the fish harvested from Piledriver Slough were of spawning size. This indicates that perhaps Piledriver Slough has not been running clear water long enough to develop a large spawning run.

Chena Dam Site. This is an area of the Chena River directly below the Chena Dam site control structure. Because road access has become available since the construction of the dam and ice breakup occurs quite early, the area has become a very popular one for spring grayling fishing. Creel census activities were begun here for the first time in 1985. High water after 18 May effectively stopped this fishery, so the creel census was concluded at this time. The average CPUE was 0.62 ± 0.25 grayling per hour. With catch and release fishing included, the CPUE becomes 1.52 ± 0.85 grayling per hour. A very large proportion of the grayling harvested there were of spawning size (64.4% ± 10.3%). Over 33% ± 10.1% of the harvest consisted of quality-size fish (≥300-mm fork length). This high proportion of large grayling captured indicates that this fishery is harvesting fish from the upstream spawning run of Chena River grayling. The fact that the total catch rate is much higher than the CPUE of harvested grayling indicates that, unlike some other area grayling fisheries, fishermen are selecting for the largest fish.

Table 2. Age Compositions and 90% confidence intervals of Arctic grayling harvested from six rivers and two lakes of interior Alaska, 15 May-15 September 1985.

	Shaw Creek 4/27-4/30			Badger Slough 5/1-5/31			Piledriver Slough 5/1-5/31			Delta Clearwater River 5/15-9/2			Chena River Dam Site 5/15-5/18			Upper River 5/8-9/5			Tangle Lakes 6/30-8/30			Fielding Lake 6/30-8/30		
Age Class	n	p	90% CI (±p)	n	p	90% CI (±p)	n	p	90% CI (±p)	n	p	90% CI (±p)	n	p	90% CI (±p)	n	p	90% CI (±p)	n	p	90% CI (±p)	n	p	90% CI (±p)
1										1	0.01	0.13				1	0.01	0.19						
2										11	0.07	0.12				2	0.02	0.19	16	0.12	0.13	5	0.04	0.14
3				15	0.18	0.19	8	0.13	0.24	2	0.01	0.13				9	0.09	0.19	33	0.25	0.12	11	0.09	0.14
4	1	0.01	0.12	16	0.19	0.19	32	0.53	0.17	26	0.16	0.12				4	0.04	0.19	29	0.22	0.13	9	0.07	0.14
5	42	0.23	0.11	25	0.30	0.18	18	0.30	0.21	49	0.30	0.11	11	0.20	0.24	30	0.30	0.16	17	0.13	0.13	34	0.27	0.13
6	67	0.36	0.10	10	0.12	0.20	2	0.03	0.25	29	0.18	0.12	12	0.21	0.23	23	0.23	0.17	24	0.18	0.13	33	0.26	0.13
7	47	0.25	0.10	7	0.08	0.21				32	0.20	0.12	22	0.39	0.20	18	0.18	0.18	12	0.09	0.14	26	0.20	0.13
8	16	0.09	0.12	2	0.02	0.21				10	0.06	0.13	8	0.14	0.24	10	0.10	0.19	2	0.02	0.14	6	0.05	0.14
9	7	0.04	0.12	9	0.11	0.20				3	0.02	0.13	2	0.04	0.26	3	0.03	0.19				3	0.02	0.14
10	5	0.03	0.12										1	0.02	0.26	1	0.01	0.19						
11																								
n	185			84			60			163			56			101			133			127		
Model Age	6			5			4			5			7			5			3			5		

Because this fishery takes place over a small area, it is possible to obtain accurate angler counts and, therefore, an estimate of angler hours and harvest. During the 18 days of the creel census, an estimated 1,831 ± 701 angler hours were expended to harvest an estimated 1,136 ± 1,235 grayling. Of this harvest, an estimated 731 fish were spawning adults. Even though this is a short-duration fishery, a large number of large fish are harvested, and it will be important to monitor the fishery more closely in future years.

Upper Chena River:

The upper Chena River creel census was conducted from 8 May through 5 September on waters accessible from above Mile 26 of the Chena Hot Springs Road. During this period, an estimated 10,613 angler hours (90% confidence interval of ±863) were expended to harvest 2,335 grayling (90% confidence interval of ±682 grayling) (Table 3). The estimated catch per unit effort (CPUE) of 0.22 grayling per hour (90% confidence interval of ±0.061 grayling per hour) is the lowest recorded catch rate for the upper Chena River sport fishery (Holmes 1985). With catch-and-release fishing included, the CPUE increased to only 0.30 grayling per hour (90% confidence interval of ±0.068 per hour).

Poor weather and high runoff during a large portion of the summer probably accounted for the second-lowest angler effort estimate in 15 years on the upper Chena. The combination of a low CPUE and low angler use produced the lowest recorded sport harvest from the upper Chena River fishery.

For a better comparison with prior years, creel census results from 1 June through 31 August were calculated. High water levels and poor year classes combined to make the 1985 estimates of harvest, angler use, and CPUE historic lows for the June through August time period. A constant decline in the angler effort and harvest on the upper Chena fishery has occurred since 1980 (Holmes 1985). This steady decline may be the result of consistent overharvest of larger fish combined with a series of poor recruitment years caused by high water. Low catch rates may be causing fishermen to seek alternative fishing sites and management alternatives to improve the numbers and age-class structure of the fishery may be needed.

The harvest of grayling in 1985 consisted almost entirely of grayling older than age 4 (Table 2). The average size of fish harvested was 273 mm. The low proportional contribution of the age-3 and 4 cohorts (which normally are the dominant year classes) to both the creel and the population contributed significantly to the low total CPUE and the large average size of fish harvested from the upper Chena. Almost 60% of the fish harvested from the Chena were large enough to spawn, and almost 30% were quality size (≥300 mm fork length) (Table 4).

Delta Clearwater River:

Creel census on the Delta Clearwater River was conducted from 20 May to 2 September 1985 using a stratified random-sampling schedule of 18 weekend days and holidays and 16 weekdays. A boat was used to contact

Table 3. Creel census results from the upper Chena River grayling creel census 8 May - 5 September 1985.

Period	Angler Hours Weekday	Angler Hours Weekend	Angler Hours Total	Gr. Kept Per Angler Hour	Total Gr. Caught Per Angler Hour	Harvest	Mean Fork Length (mm)
May 8-31 & Sept 1-5			1,880	0.14	0.17	263	
June	1,344	1,500	2,844	0.15	0.21	427	302
July	1,654	1,696	3,350	0.13	0.28	436	259
August	1,710	830	2,540	0.42	0.49	1,067	269
Total	4,708	4,026	10,614±863	0.22±0.06	0.30±0.07	2,335±682	273±27

Average length of fishing trip 2.38 ±0.38 hours

Angler Composition	Percent
Resident	79
Tourist	14
Military	7

Table 4. Size composition of the havest of grayling sampled from several of the major grayling fisheries of interior Alaska, 1985. Proportional Stock Density (PSD) are given from the proportion of spawning size fish harvested (>270 mm) and for the proportion of quality size grayling (>300 mm) harvested.

Fishery	Number of Grayling >150 mm	Number of Grayling >270 mm	Number of Grayling >300 mm	PSD (%) >270 mm	PSD (%) >300 mm
Upper Chena R.	106	63	31	59.4	29.2
Badger Slough	84	23	7	27.4	8.3
Piledriver Slough	63	4	0	6.3	0
Chena River Dam Site	59	38	20	64.4	33.9
Shaw Creek	412	371	252	90.0	61.2
Fielding Lake	125	103	87	82.4	69.9
Tangle Lakes	134	71	46	53.0	34.3
Delta Clearwater R.	172	134	94	77.9	54.7

anglers over the 14 mi of river censused. A total of 182 boat and 66 shore anglers were individually contacted. CPUE estimates and 90% confidence intervals of harvested grayling for boat and shore anglers were 0.50 ± 0.12 and 0.40 ± 0.20 fish per hour, respectively. Combining both angler types gave an overall harvest rate of 0.47 ± 0.10 fish per hour. Including fish released, the overall catch rate was 0.64 ± 0.14 grayling per hour.

The composition of interviewed anglers in 1985 is as follows: residents, 83%; military and dependents, 8%; nonresidents, 8%; and unknown, 1%. Only 4% of all anglers harvested the five grayling bag limit while 66% killed no fish.

The age composition of 163 fish in the harvest sample is shown in Table 2. Recruitment to the fishery of age-1 to age-4 fish (25%) was much improved over the 3% found in the 1984 sample. However, recruitment was still below the previous 7-year mean of 39% (Ridder 1985). The 1983 year class was especially well represented at 7% of the sample, when compared to the previous 7-year mean of 2% for age-2 fish. Of the 11 age-2 fish in the sample, five (45%) were enhancement grayling transplanted into the river at age-1+ in 1984.

Since 1980 mature adult grayling have been more prevalent in the harvest sampling. Due to the strong year classes of 1975-1978, they have risen from 17% of the sample in 1980 to 48% and 46%, respectively, in 1984 and 1985. The 7-year mean for this group is 30% (Ridder 1984).

The size composition of the harvest sample is shown in Table 4. Greater than 77% of the sample represented mature grayling (>270 mm), and over 54% were quality size (>300 mm; 11.9 in).

Fielding Lake:

Fielding Lake is a 1,660-acre oligotrophic lake with an elevation of 2973 ft; it is located in the Alaska Range 65 mi south of Delta Junction. A 2-mile gravel road constructed in the 1950s connects the lake with the Richardson Highway. The lake supports a fishery on grayling, lake trout, and burbot. Based on mean yearly values from Mills (1982-1985), fishing pressure on all species is 1,685 angler-days; 1,982 grayling, 276 lake trout, and 245 burbot are harvested annually.

A creel census was conducted at Fielding Lake from 30 June to 25 August 1985. A fishing day was divided into two 6-hour periods from 0900 to 1500 and 1500 to 2100 hours. Because of logistical and labor force constraints, the census schedule was nonrandom; sampling of one period occurred in each of 10 weekend days and 3 weekdays.

A total of 181 angler interviews was collected, with 96% representing completed fishing trips. Boat anglers made up 66% of the total; the rest were shore anglers. The harvest rates with 90% confidence intervals for boat and shore anglers were 0.33 ± 0.08 and 0.31 ± 0.16 grayling per hour, respectively; total catch rates (including catch and release fishing) were 0.66 ± 0.19 and 1.00 ± 0.43 grayling per hour, respectively. Collectively, anglers at Fielding had a harvest rate of 0.34 ± 0.08 and a catch rate of 0.84 ± 0.20 grayling per hour (Table 1).

The above estimated catch rates for grayling are probably low, because of the failure to accurately distinguish anglers fishing for grayling from those fishing for lake trout. During a trip anglers will sometimes fish for both species. Although 17 lake trout were tabulated during the census (versus 175 grayling), the majority of effort is directed toward grayling. This effort was heaviest in July when 18.6 anglers were contacted per period. In August, contacts dropped to 6.3 per period.

The age composition of 127 grayling sampled from angler creels at Fielding are shown in Table 2. The majority of fish (80%) were adults (age 5 and older), and the mean length was 318 mm (Table 1). The catch of these fish was greatest during the month after ice-out. Most fish were harvested in one shallow bay and along the shoreline adjacent to the mouth of the drainage from Two-bit Lake. The younger fish were harvested exclusively by shore anglers fishing the lake's outlet stream.

The composition of anglers was 75% residents, 12% military, 5% nonresidents, and 8% unknown. Sixty-three percent of these anglers harvested no grayling, while only 6% had their 5 grayling bag limit.

Tangle Lake System:

Tangle Lakes is a lake-stream system approximately 20 mi long that includes five named lakes and nearly 70 mi of tributary streams; it comprises the headwaters of the Delta River. The Denali Highway roughly bisects the system by crossing the half-mile-long Tangle River between Upper Tangle and Round Tangle Lakes. There are campgrounds adjacent to the river. The majority of the system is a National Wild and Scenic River.

The system supports a popular grayling fishery and smaller, lake trout and burbot fisheries. Mean yearly estimates from Mills (1978-1985) are 6,606 angler-days of effort with a harvest of 6,264 grayling, 873 lake trout, and 118 burbot.

Creel censusing of Tangle Lakes ran from 16 June to 30 August 1985. The sampling design was the same as described for Fielding Lake, except that interviews were gathered in a roving survey because of the mile separation of the access points to the upper and lower system.

Of the 258 anglers interviewed, 187 (72%) represented completed trips. Of these, boat anglers comprised 59% and shore based anglers, fishing mostly in the Tangle River, comprised the rest. Based on completed trip interviews, boat and shore anglers had harvest rates (90% confidence intervals) of 0.33 ± 0.10 and 0.39 ± 0.20 grayling per hour, respectively. For total catch rates, boat anglers caught 0.73 ± 0.21 grayling per hour; shore anglers, 1.25 ± 0.42. Collectively, all anglers had a harvest rate of 0.36 ± 0.10 and a catch rate of 0.94 ± 0.21 grayling per hour (Table 1).

Forty percent of the anglers interviewed fished the Tangle River, 51% fished Round Tangle Lake, and 9% fished Upper Tangle Lake. The harvest rates at these locations were 0.37, 0.28, and 0.54 grayling per hour respectively.

Of the anglers interviewed, 82% were residents, 12% nonresidents, 4% military, and 2% unknown. As with Fielding Lake and the Delta Clearwater River, 69% of these anglers harvested no grayling, and 4% took their limit of 5 fish.

The age composition of the harvest sample is shown in Table 2. The harvest was predominantly made up of fish age 4 and younger. This is due to the higher catch rate and fishing pressure occurring on the Tangle River where smaller grayling predominate. Seining of these areas in late August showed them to be prime rearing areas. Based on personal observations and angler interviews, the larger grayling are accessible in the lakes in the vicinity of inlets during a short period after ice-out and again in late August and September.

The size composition of the sample is given in Table 4. Despite the young age of the sample, 53% were were mature fish greater than 270 mm long.

Stock Structure and Indices

Badger Slough:

Stock structure analysis of Badger Slough was performed by Hughes (1986) as a portion of his graduate research studies at the University of Alaska, Fairbanks; a complete summary of his findings is available. Hughes (1986). His sampling techniques included a spring weir to capture in-migrating fish, beach seining of fish in the summer, and a fall weir to sample out-migrating fish. A total of 1,176 fish was captured in the spring weir, of which 867 were grayling (Table 5). During summer seining, 242 grayling were captured. Only one of these fish was of mature size, supporting the prior assumption that most adults leave the system after spawning. Of the 732 fish captured during the operation of the fall weir, 75% were grayling. Over 85% of these out-migrating grayling were age 0.

Most of the objectives of the Badger Slough grayling population study were not met because of sampling problems with the operation and location of the weirs. Estimates of total numbers of spawners entering and age-0 grayling leaving the system were not obtained, because the weirs were not fish tight and too few mark recoveries were obtained from the creel census and other sampling.

Chena River:

As in past years, Schnabel mark-recapture population estimates (Ricker 1985) of grayling greater than 150 mm were performed using a boat-mounted electrofishing unit. Daily electrofishing passes through each section were continued until the desired precision of the estimate was reached or until capture rates declined. The mark-recapture

Table 5. Numbers of each species caught in the upstream weir operated at the mouth of Badger Slough between 4 April and 3 May 1985.

Species	Number
Arctic grayling	867
Humpback whitefish	186
Round whitefish	121
Least cisco	1
Longnose sucker	1

population estimate calculations of grayling greater than 150 mm for the Chena River index sections (Table 6) were stratified by length group in an attempt to minimize bias caused by higher capture rates of larger grayling. These estimates were generally higher than in 1985; however, the new estimating technique probably accounts for the increases (Holmes 1985). Based on these estimates the population estimate for the lower 104 mi of the river is 112,391 grayling (90% confidence interval of ± 88,475). Again, this whole river estimate is larger than that obtained in past years, but this difference is probably accounted for by the new stratified population-estimating technique. Because of the very low harvest in the Chena in 1985, the rates of exploitation and fishing mortality are probably much lower than in the past. These values will be estimated when the statewide creel census estimates for 1985 become available.

Age structure of the Chena River grayling is presented in Table 7. The age-5 cohort was quite strong, comprising 32% of all the fish sampled. The age-3 and age-4 cohorts, which normally make up the bulk of the fish in the stock, were both quite weak. The relative strength of these cohorts was predicted (Holmes 1985) based on the magnitude of the river discharge in their natal years. The age-2 cohort comprised 16% of the sampled fish, which is well above the average for this age group; therefore, this should result in a very strong age-3 year class in 1986. However, both the 1984 and 1985 year classes were weak, indicating that in 3 years the major portion of the stock will be represented by four weak and only one strong year classes. The ramifications of the present stock structure, estimates of dynamic rates, and the potential for change in the population are discussed in the dynamic-pool model section of this report. The average size by age of Chena River fish is presented in Table 8. The combined average lengths of fish sampled in 1985 were 192 mm, 204 mm, 214 mm, 236 mm, and 258 mm for Chena River sections 2b, 8a, dam site, 10b, and, 12 respectively. These estimates demonstrate the tendency for larger and older fish to occur progressively upstream in the Chena. These estimates are all significantly higher than in 1984 ($p < 0.05$) because of the shift in the dominant age class from age 4 to age 5. The much larger size of Salcha River grayling (Table 8) indicates that the more intensive fishery of the Chena River may harvest the fastest growing individuals and, thus, reduce the average size of the fish in the population.

Salcha River:

The estimated number of grayling per mile for a 4-mi section of the Salcha River (50 river miles from the mouth) was 796 (90% confidence interval of ± 629). Because of low capture rates with the boat-mounted electrofishing system, hook-and-line capture was also utilized. The average size of the fish sampled was 320 mm (95% confidence interval of ± 4.9 mm). The growth rate of these Salcha River fish is much greater than that of the Chena and Chatanika River grayling populations (Fig. 2). The larger average size is also reflected in an older age composition, when compared with other Interior rivers (Table 7). Age-6 fish were the most common age class of the Salcha River; whereas, age 5 was the most common age class in other area rivers. Additional

Table 6. Population estimates and 95% confidence intervals of Arctic grayling greater than 150 mm in fork length in five rivers of interior Alaska, 1985.

River	Section	River Miles	Dates	Number Marked	Number Recaptured	Schnabel Estimate Fish/Mi.	Schnabel Estimate 95% CI
Chena	2b	8-11	July 10-17	336	44	303	147-459
	8a	26-29	6/26-7/2	492	65	434	302-576
	Damsite	46-49	6/26-7/8	323	25	533	374-692
	10b	66-69	7/22-7/31	487	21	1,849	487-4,856
	12	85-88	6/12-6/24	380	21	1,747	883-2,629
Chatanika			8/20-8/23	132	20	188	132-282
Salcha			8/5-8/9	205	6	796	205-1,702
Goodpaster		3-6	June 25-26	189	7	734	381-1,545
		3-6	August 6-13	307	42	640	473-887
		15-18	August 6-13	303	45	524	392-720
		combined				582	433-803
Richardson	I	0-3	July 22-26	106	18	311	197-523
Clearwater	II	3-6	July 22-26	73	15	131	79-235
	III	6-8	July 22-26	46	15	805	487-1,438
		0-8	July 22-26	247	29	310	216-468

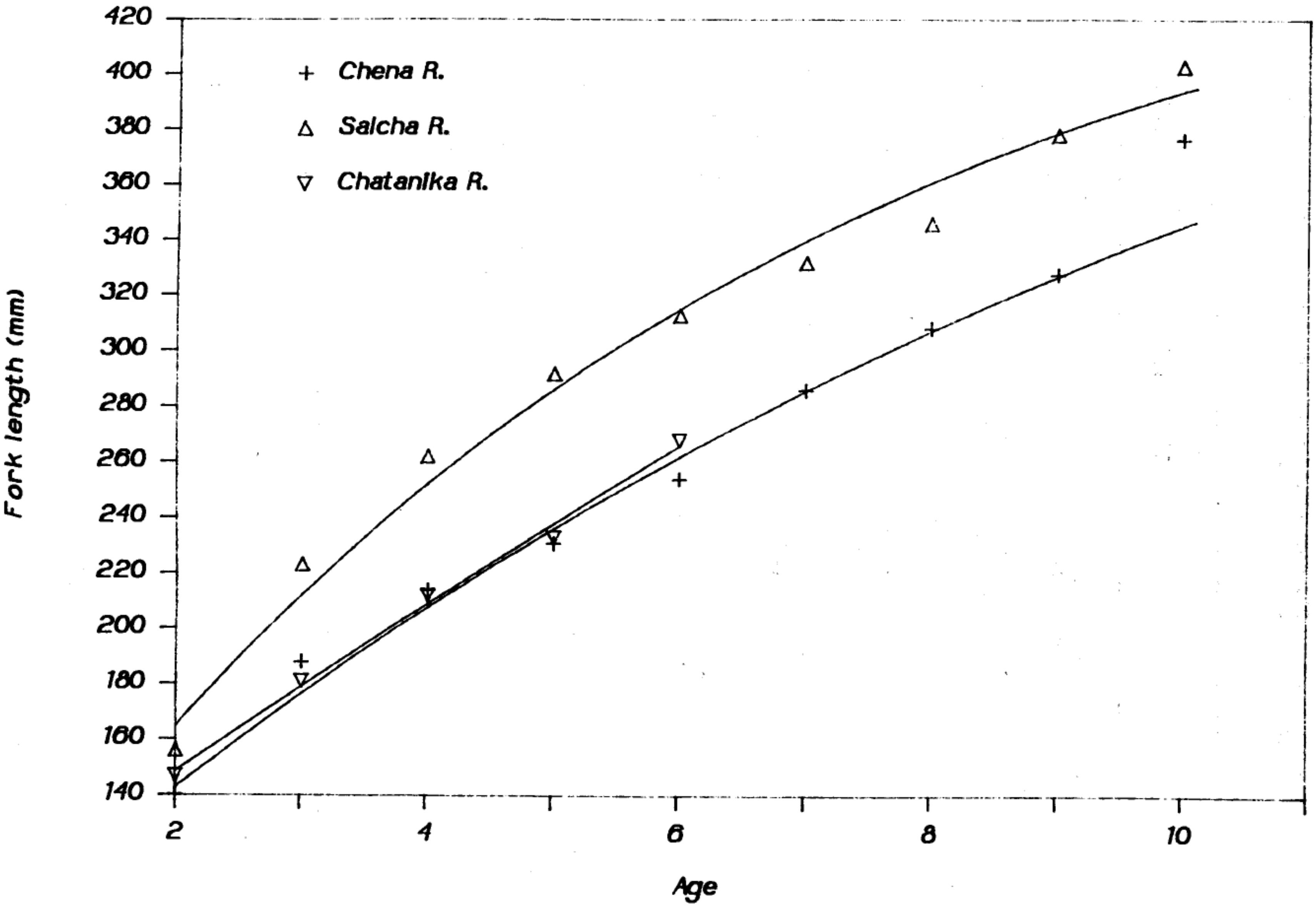

Figure 2. Von Bertalanfby growth curves for the Chena, Salcha, and Chatanika Rivers, 1985.

Table 7. Age proportions and associated 95% confidence intervals of Arctic grayling captured during population sampling in seven rivers and two lakes of Interior Alaska, 1985.

	Goodpaster River* 6/25-6/26			Goodpaster River* 8/6-8/8			Richardson Clearwater* 7/22-7/26			Delta Clearwater* 7/8-7/12			Chena River* 6/12-7/31			Salcha River* 8/5-8/9		
Age Class	n	p	95% CI (±p)	n	p	95% CI (±p)	n	p	95% CI (±p)	n	p	95% CI (±p)	n	p	95% CI (±p)	n	p	95% CI (±p)
1	20	0.08	0.12	26	0.07	0.10	7	0.02	0.11				42	0.02	0.04			
2	37	0.14	0.11	182	0.51	0.07	12	0.04	0.11	4	0.03	0.17	300	0.16	0.04	2	0.01	0.13
3	44	0.17	0.11	27	0.08	0.10	4	0.01	0.11				203	0.11	0.04	13	0.06	0.13
4	33	0.13	0.11	22	0.06	0.10	10	0.03	0.11	2	0.02	0.17	267	0.14	0.04	3	0.01	0.13
5	79	0.30	0.10	69	0.19	0.09	13	0.04	0.11	6	0.05	0.17	609	0.32	0.04	29	0.13	0.12
6	25	0.10	0.12	18	0.05	0.10	48	0.15	0.10	25	0.20	0.16	182	0.10	0.04	69	0.32	0.11
7	16	0.06	0.12	15	0.04	0.10	64	0.20	0.10	33	0.25	0.16	188	0.10	0.04	58	0.26	0.11
8	4	0.02	0.12	1	0.00	0.10	54	0.17	0.10	20	0.16	0.16	80	0.04	0.04	25	0.11	0.13
9							53	0.17	0.10	17	0.13	0.16	30	0.02	0.05	18	0.08	0.13
10							36	0.11	0.10	10	0.08	0.17	2	0.00	0.05	2	0.01	0.13
11							15	0.05	0.11	6	0.05	0.17						
12							4	0.01	0.11	2	0.02	0.17						
13										2	0.02	0.17						
Totals	258			360			320			127			1,903			219		
Model Age	5			2			7			7			5			6		

(continued)

Table 7. (Cont'd) Age proportions and associated 95% confidence intervals of Arctic grayling captured during population sampling in seven rivers and two lakes of Interior Alaska, 1985.

	Chatanika River* 8/20-8/23			Caribou Creek** 6/5-6/20			Tangle Lakes*** 8/26-8/30			Tangle Lakes* 8/26-8/30			Fielding Lake*** 8/19-8/23			Fielding Lake* 8/19-8/23		
Age Class	n	p	95% CI (±p)	n	p	95% CI (±p)	n	p	95% CI (±p)	n	p	95% CI (±p)	n	p	95% CI (±p)	n	p	95% CI (±p)
0							2	§0.01	0.09							3	0.01	0.13
1				18	0.05	0.10	154	0.34	0.06	1	§0.01	0.13	149	0.36	0.07	89	0.38	0.10
2	131	0.55	0.09	55	0.14	0.09	187	0.41	0.06	53	0.24	0.10	219	0.53	0.06	75	0.32	0.11
3	5	0.02	0.13	42	0.11	0.09	66	0.14	0.07	58	0.26	0.10	38	0.09	0.08	35	0.15	0.12
4	31	0.13	0.12	46	0.12	0.09	29	0.06	0.08	53	0.24	0.10	8	0.02	0.08	12	0.05	0.13
5	59	0.25	0.11	97	0.25	0.09	9	0.02	0.08	32	0.15	0.10	1	§0.01	0.08	9	0.04	0.13
6	12	0.05	0.12	81	0.21	0.09	7	0.02	0.08	18	0.08	0.11				4	0.02	0.13
7				37	0.10	0.09	2	§0.01	0.08	4	0.02	0.11				5	0.02	0.13
8				8	0.02	0.10	1	§0.01	0.08							2	0.01	0.13
9				1	0.00	0.10												
10				1	0.00	0.10												
Totals	238			386			457			219			415			234		
Model Age	2			5			2			3			2			1		

* electroshocking (at Fielding and Tangle Lakes includes fyke trapping)
** weir captures
*** seining

Table 8. Mean fork length (mm) at age and associated 95% confidence intervals for Arctic grayling captured in eight rivers and two lakes of Interior Alaska, 1985.

	Goodpaster River* 6/25-6/26			Goodpaster River* 8/6-8/8			Richardson Clearwater* 7/22-7/26			Delta Clearwater* 7/8-7/12			Chena River* 6/12-7/31			Salcha River* 8/5-8/9		
Age Class	n	Average length (mm)	95% CI (±mm)	n	Average length (mm)	95% CI (±mm)	n	Average length (mm)	95% CI (±mm)	n	Average length (mm)	95% CI (±mm)	n	Average length (mm)	95% CI (±mm)	n	Average length (mm)	95% CI (±mm)
1	20	108	9	26	113	7	7	119	15	0			42	108	6			
2	37	135	4	182	147	2	12	144	10	4	159	44	300	141	2	1	156	
3	44	190	4	27	208	4	4	232	19	0			203	188	2	13	223	10
4	33	224	5	22	236	6	10	257	8	2	297	76	267	215	2	3	262	23
5	79	245	4	69	253	4	13	278	11	6	302	17	609	233	1	29	292	5
6	25	269	8	18	284	7	48	309	6	25	329	9	182	254	3	69	313	5
7	16	284	11	15	292	11	64	337	6	33	349	8	188	285	3	58	332	4
8	4	323	40	1	295		54	357	6	20	364	8	80	308	4	25	346	6
9							53	375	6	17	369	11	30	330	7	18	378	11
10							36	385	7	10	406	13	2	337	40	2	403	180
11							15	409	10	6	400	10						
12							4	415	28	2	416	67						
13										2	439	57						
Totals	258			360			320			127			1,903			219		
Mean Length		213			188			330			351			223			284	

(Continued)

Table 8. (Cont'd) Mean fork length (mm) at age and associated 95% confidence intervals for Arctic grayling captured in eight rivers and two lakes of Interior Alaska, 1985.

	Chatanika River 8/20-8/23			Caribou Creek** 6/5-6/20			Tangle Lakes*** 8/26-8/30			Tangle Lakes* 8/26-8/30			Fielding Lake*** 8/19-8/23			Fielding Lake* 8/19-8/23		
Age Class	n	Average length (mm)	95% CI (±mm)	m	Average length (mm)	95% CI (±mm)	n	Average length (mm)	95% CI (±mm)	n	Average length (mm)	95% CI (±mm)	n	Average length (mm)	95% CI (±mm)	n	Average length (mm)	95% CI (±mm)
0							2	63	99							3	59	15
1				18	104	7	154	131	2	1	117		149	136	3	89	126	5
2	131	147	2	55	139	4	187	192	2	53	188	4	219	168	2	75	176	4
3	5	181	23	42	208	8	66	243	4	58	235	4	38	216	8	35	217	8
4	31	212	7	46	252	5	29	277	6	53	278	5	8	265	9	12	262	17
5	59	233	5	97	272	3	9	313	12	32	303	5	1	271		9	320	15
6	12	268	10	81	291	4	7	332	11	18	326	9				4	341	12
7				37	315	6	2	357	13	4	338	10	5	364	10			
8				8	343	15	1	378								2	400	13
9				1	388													
10				1	382													
Totals	238			386			457			219			415			234		
Mean Length		184			243			190	5		253	6		163	3		180	9

* electroshocking
** weir captures
*** seining

estimates of Salcha River dynamic rates (mortality, exploitation, etc.) will be conducted in future years as more cohort data become available.

Chatanika River:

The estimated number of grayling per mile for a 2-mile section of the Chatanika River (2 miles below the Elliott Highway bridge) was 283 fish (90% confidence interval of ± 113 fish per mile). This population level is similar to that found in the past 2 years (Holmes 1985). The average size of the 269 fish captured (184 mm with a 95% confidence interval of ± 5.4 mm) is slightly lower than that found in most areas of the Chena River, but the average sizes at each age are similar (Figure 2). The age composition of the population is similar to that of the Chena and Goodpaster Rivers, except that the age-2 cohort is much stronger than the former (Table 7). The fact that the age-2 and age-5 cohorts are strong in these rivers indicates that factors affecting young-of-the-year (YOY) survival are probably the same in each river. As in past years, only a very small portion of the population is of spawning size. Addition estimates of Chatanika River dynamic rates (mortality, exploitation, etc.) will be conducted in future years as additional cohort data become available.

Goodpaster River:

Three population estimates of grayling greater than 150 mm in fork length were made in each of two 3-mile sections of the Goodpaster River in 1985. These sections have been included in nine yearly estimates since 1973 (Ridder 1984). The first estimate in 1985, conducted on 25 and 26 June (mile 3-6), was hampered by high-water conditions. Catch rates over the 2 days of sampling declined from 0.88 grayling (≥150 mm) per minute of electrofishing to 0.13. With a 95% confidence interval of 381-1545, a Schnabel estimate based on 6 trials was 734 grayling per mile (Table 6). The June 1984 Peterson estimate for this section was 625 grayling per mile, with a 95% confidence interval of ±380 (Ridder 1985).

The second population estimate was performed from 6 to 13 August and included the above section and a second section located at river miles 15-18. This time the river remained clear, and the resulting catch rate was 1.17 grayling (≥150 mm) per minute. Based on 9 trials in each section, the Schnabel estimate for the lower section was 640 grayling per mile. The Schnabel estimate for the upper section was 524 grayling per mile. Combining the 2 sections provides an estimate of 582 grayling per mile (95% confidence interval of 433-803). This estimate is similar to the June 1984 Peterson estimate of 510 ±165 grayling per mile and the 9-year average of 598 grayling per mile (Ridder 1984). The later timing of the estimate and resulting recruitment of fish into the ≥150-mm range must be considered before any direct comparisons between years are made.

The age compositions and mean lengths at age from catch sampling during the June and August electrofishing are given in Tables 7 and 8, respectively. The June sample is remarkable for its unusual modal age of 5. In all previous years, the modal age has alternated between 3 and 4 (Peckham 1983). The August sample indicates this shift to age 5 is due to the poor recruitment of the 1981 and 1982 year classes. The predominance of the 1983 year class in this and other samples (Table 7) indicates a strong year class with good recruitment.

Richardson Clearwater River:

The lower 8 mi of the Richardson Clearwater River was sampled with electrofishing gear daily from 22 to 26 July 1985. The sampling gear, length, and general timing were the same as in previous years (Ridder 1985). The gear's total CPUE for grayling was 1.22 fish per minute (73.2 fish per hour). Unlike what occurred during the Delta Clearwater River sampling, the CPUE was quite constant over the four runs in each section.

The river was divided into 3 physically distinct sections for population estimations. Section 1 ran from the mouth to a point approximately 3 mi upstream, locally know as the "Lake". The section is made up of 3 to 6-ft-deep, 100 to 300-yd-long pools and 1- to 2- ft-deep runs/riffles of the variable lengths. Section II, also 3 mi long, runs from the lake to a much shorter upper lake; this section is generally wider and shallower than the other sections. Section III, 2 mi long, runs from the upper lake up to the second tributary; it is the narrowest section (15-30 ft wide) and consists predominantly of 3- to 4-ft-deep pools with short dividing riffles and runs. The combined lower two sections are approximately 0.5 mi shorter than the "lower section" used in previous reports (Ridder 1985). The upper section has been used in abundance estimates since 1982.

Schnabel estimates for grayling per mile were done separately for each section and for the whole 8 mi. They are shown with their 95% confidence intervals in Table 6. The population estimates for Sections I-III, respectively, were 698, 367, and 1,392 grayling. The whole river estimate of 2,405 had a 95% confidence interval of ±874 (± 36%).

The whole river Peterson estimate was 3,114 ± 1,175 (± 38%). It was based on additional marking (M=325) and recapture (R=30, C=297) effort in nonrandom locations selected by the best catch rate.

Since 1977 the number of grayling captured by an electrofishing boat in one downstream river pass has been used as an index of relative abundance in monitoring general population trends. The 142 grayling captured in the first 8-mi pass in 1985 compares to the 138 captured in 1983. In Section III, where Ridder (1984, 1985) found the index to be significantly correlated to mark-recapture population estimates and to visual counts, the fish per mile index was 42, down slightly from the previous 2 years. The population estimate for the section is also slightly less than the estimates of the previous 2 years, though still well within their 95% confidence intervals.

While abundance is similar to 1984, the age composition of the 1985 sample continues to become more weighted towards older and larger grayling (Table 7). In the 1985 sample, 51% of the grayling were age 8 and older. The 1980-1984 mean composition of this age group is 13.8%. Recruitment to the age-4 and age-5 cohorts was very poor. This poor recruitment as well as the increasing mortality of the now abundant older fish point to an upcoming decline from present population levels. The prognosis is hedged because of the complexity of recruitment to these summer "feeding" populations and to the statistical significance of the available data. Ridder (1984, 1985) has noted inconsistencies in recruitment of some year classes that appeared poor at younger-age classes yet stronger in subsequent years.

Delta Clearwater River:

On 6 days between 8 and 15 July 1985, 4 miles of the upper river (miles 14 to 17) were sampled with an electrofishing boat to determine age and length samples and a mark-recapture, Schnabel population estimate. The river (mile 4 to 17) was also sampled in one pass to obtain an index of relative abundance (total grayling caught) for comparison to indices obtained yearly since 1975.

The Schnabel estimate was meaningless (90% CI ± 180%) because of an apparent emigration of grayling from the upper 3 mi during the course of the sampling. Catches from the first to the last sampling day declined dramatically. No fish were sampled in the upper 2 mi during the last three trials. This experience and the significant differences found in catch rates over three electrofishing trials of the same section in 1983 (Ridder 1984) indicate that displacement of grayling occurs because of repetitive electrofishing. It also emphasizes the difficulty with this gear type in obtaining population estimates in the Delta Clearwater River.

The 1985 relative abundance index of 46 is the lowest recorded in the 12 years of monitoring the river. The data on the accuracy and precision of the indexing method is ambiguous and, thus, must be viewed in general terms and evaluated in relation to other parameters. The catch rate index in the lower river is similar to those of the preceding 2 years. These recent index values are much lower than the 11-year mean index of 43. The younger-age classes that frequent this river section have shown poor recruitment in recent years. Angler catch rates, which have fallen in the same period, are significantly correlated with these indices and are additional supporting evidence for the declining population trends indicated by the indexing (Ridder 1984).

The age composition and corresponding mean lengths found in sampling the 1985 electrofishing catch are shown in Tables 7 and 8. As in the Richardson Clearwater River, the age composition continues a trend toward higher proportions of older grayling. Grayling of age classes 9 and older made up 30% of the sample, compared to the previous 10-year mean of 4%. These 1974-1976 year classes have significantly influenced every sample since their first recruitment in 1977. Continued poor recruitment of the 1980 thru 1982 year classes is evident in their low composition of 7%. The 1983 year class appears to be quite strong, and in conjunction with enhancement efforts, it hopefully will increase future population levels.

Caribou Creek:

The postspawning migration of grayling from Caribou Creek was sampled from 4 June to 15 June 1985, using a weir described by Ridder (1982). A total of 1,190 fish of 8 species were captured in the downstream trap over the 11-day period: 386 grayling, 256 humpback whitefish, 100 round whitefish, 341 least ciscoes, 52 longnose suckers, 53 lake chubs, and one each of slimy sculpin and northern pike. As in 1983, water temperatures during the period were fairly constant, ranging from 10°C on the 4 June to 8°C on the 10 June to 11°C on the 14 June. Because of the record snowpack and high run-off of the region, the mean water level of 38 inches at the weir was the highest recorded. The level ranged from 30 inches at the start of trapping to 49 inches at the end. The water continued to rise daily from 60 inches on the 16 June to 86 inches on the 24 June. Temperatures remained in the 8°-10°C range over this latter period. These water records are mentioned because of their effects on grayling year class strengths, as mentioned later in this report.

The age composition of the grayling catch is shown in Table 7. Characteristic of previous samples, this out-migration consisted predominantly of age-4 and older fish. The mean length at age is similar to previous years and is given in Table 8.

The grayling catch was the lowest of the 6 years of sampling. The catch per day (CPUE) was 35.1, which is comparable to the 5-year mean of 116.5 (range of 98.6 to 135.0) per day. The CPUE for adult grayling (15.2) is comparable to the mean of 59.5 (range 41.6 to 76.2).

The low catch rate is not indicative of a drastic drop in population abundance; rather, it represents a change either in grayling usage or out-migration patterns. Several factors indicate that this is the case. First, Ridder (1985) showed a correlation between grayling abundance at the Richardson Clearwater and Shaw and Caribou Creeks. The high catch rate during the spring fishery at Shaw Creek and the relatively unchanged population levels and age compositions found in the Richardson Clearwater indicate that dramatic population declines have not occurred. Second, recapture rates (number of tags in sample ≥200 mm) of fish tagged in previous Caribou Creek sampling have been on the average twice as great as Richardson Clearwater or Shaw Creek. The recapture rate at Caribou Creek in 1985 (6.8%) was less than the 9.7% and 15.0% found at Shaw Creek and Richardson Clearwater, respectively. The rates in the latter waters were slightly higher than in 1984, while the rate at Caribou Creek was significantly below the 33.7% found in 1984. Finally, concentrations of grayling were reported in normally marshy areas below Caribou Creek. This indicated that the grayling were displaced because of high water.

Estimates of abundance and various dynamic rates for the 1985 sample have been used in the development of a management plan for Shaw Creek's spring fishery. These estimates should be refined by a calculation of growth rate and a determination of its relation to tag recaptures. All the necessary recapture data of tagged Caribou fish sampled at Shaw Creek, Richardson Clearwater and other waters have yet to be entered on computer files.

Fielding Lake:

Sampling of grayling in Fielding Lake was conducted from 19 to 23 August, using fyke traps, seines, and an electrofishing boat. Ages and lengths were determined for 649 grayling, 217 burbot, and 13 lake trout captured by the three methods. The grayling age composition and the mean length at age by gear type are given in Table 7 and 8, respectively.

Seining at the lake outlet stream was limited to the first quarter mile below the lake. This area has the best access to the drainage and is heavily fished by picnickers and campers visiting the adjacent campground. The stream was first electrofished from the lake to a point just above the first riffle. A 50-ft seine haul to the riffle captured 519 grayling; of these, the first 415 were sampled (Table 7 and 8). The majority of the sample (89%) was comprised of juvenile fish (ages 1 and 2).

Despite the seine's small mesh (3/8 in), the absence of young-of-the-year grayling and the smaller yearlings suggests the area is not a spawning area or at least not preferred by the smaller fish. The older fish may be represented less because of the angler harvest occurring in the previous 2 months. The low incidence of mouth damage (9.9%) that can be assumed to be caused by angling is unexpected, considering the accessibility of the population and the frequent catch and release noted during creel censusing. Additional sampling throughout the season should be undertaken to determine probable movements, composition changes, and abundance estimates.

Fyke traps and electrofishing captured 120 and 125 grayling, respectively. The 264 hours of fyke-trapping eleven suitable locations surrounding the lake provided a catch rate of 0.45 grayling per hour. The average catch per set night was 7 grayling. The fyke traps were generally set in 3 to 4 ft of water and attached to shore by a 50-100 ft lead. From observation, they captured predominantly grayling of the first three age classes. Shoreline electrofishing was more successful with the larger fish; this method was most effective at night. Ninety-six percent of the gear's catch came from an area 0.5 mi on either side of the inlet stream located in the northeastern half of the lake. This is a favorite area of boat-anglers. The percentage of mouth damage in this sample was 20.0%. Here, the electrofishing catch rate was 97.3 grayling per hour. The average catch rate from night shocking the lake's shoreline was 27.1 grayling per hour. As with seining, electrofishing should be conducted throughout the season to determine movements and composition changes.

Because of sample bias, unequal effort between gears, and population stratification, no attempts were made to estimate the dynamic rates of the population. This sampling of the lake's grayling population is the first acquisition of data, and it will provide direction to future sampling for rate and abundance estimates.

Tangle Lakes:

Sampling of fish populations at Tangle Lakes was conducted from 15 to 30 August 1985 using the same gear that was used at Fielding Lake. Sampling was limited to the lower Tangle River (between Upper and Round Tangle Lakes), Round Tangle and Shallow Tangle Lakes, and the short interconnecting streams below these lakes. A total of 676 grayling and 203 burbot was captured by the three methods. The age compositions and mean lengths of the grayling sample by gear type are given in Tables 7 and 8, respectively.

A total of 457 grayling was captured by seining. In two hauls in the Tangle River, 102 grayling were captured. Two hauls in the outlets of Round and Shallow Tangle Lakes captured 355 grayling.

Age structure of grayling sampled by seining showed a similar pattern to that of Fielding Lake; age-0 to age-2 fish comprised 75% of the sample. Unlike Fielding, this population sample had a greater mean length (Table 8) and a larger proportion of fish ≥150 mm. These larger fish were also more affected by angling pressure, with a 25% incidence of mouth/hooking damage compared to Fielding's 9%. In easily accessible areas (near roads), the proportion of fish with mouth damage was 47%. The rate of hooking damage found in the boat-accessible outlet streams of Round and Shallow Tangle Lakes was 16.1%.

Electrofishing of Round Tangle Lake at night and the two lower interconnecting streams by day gave catch rates of 93.2 and 67.9 grayling per hour, respectively. The major portion of the catch (84%) was made within 100 ft of inlets (Tangle River and Landmark Gap Creek) and in the lower interconnection streams. The larger grayling were caught in the greatest numbers at the mouth of Tangle River.

Fyke trapping (240 trap hours) was ineffective, with a catch rate of 0.07 grayling per hour (a total of 16 fish captured). The grayling catch averaged 1.5 fish per set. Nine sets were located in Round Tangle Lake, nine in Shallow Tangle Lake, and one in their connecting stream. As at Fielding Lake, only juvenile fish were caught in fyke traps.

Considering the size and make-up of the Tangle system, additional sampling should be conducted systematically throughout the drainage to determine movements and seasonal abundance and develop a sampling scheme that will provide a representative sample of its grayling population. Only then will estimates of abundance and dynamic rates be meaningful.

Recruitment Indices

Delta Clearwater River:

Fyke-trapping at Mile One Slough on the lower Delta Clearwater River during the seasonal in-migration of juvenile grayling in late April has been conducted routinely since 1976. Principally employed in the evaluation of the grayling-enhancement program discussed later in this report, Ridder (1985) found a slightly significant correlation between CPUE (grayling catch per trap day) and the electrofishing index of older grayling 2 years later. As such, the trapping also affords a rough index of the complex recruitment to the river's fishery.

A summary of the numbers of species caught and the length frequencies of the grayling catch at Mile One Slough from 23 April to 8 May 1985 and the mean values from the 6 years 1978-1984 are given in Table 9. The low CPUE of 16.5 grayling per day found this year, which is second only to 1982, may not be an indicator of low future abundance; it was unexpected but is not considered unusual. The 1984 grayling catch gave a high CPUE of 62.5 fish per day because of exceptionally large numbers of age-1 fish of the 1983 year class. The similar low rates for the three other predominant species in the catch suggest an environmental factor that, if not directly affecting abundance, indirectly affects emigration to the system and/or the efficiency of the gear. Ridder (1983, 1984) observed that extended river temperatures of greater than 5°C resulted in larger daily catches.

The length compositions in Table 9 are divided into ranges that are related to age classes. The first two ranges are considered specific to grayling of age classes 1 and 2 (Ridder 1985). For the second consecutive year, yearling fish have been above average in their composition in the catch, while the age-3 and older fish have been below average or absent. Future sampling will determine if these compositions are due to the real strength of the younger-year classes or, rather, the weakness of the older classes. The latter situation is indicated in the July electrofishing samples in this and other area rivers (Table 7).

Chena River:

Beach seine CPUE of young-of-the-year grayling was again used as an index of abundance of this year class. The 1983 prediction of high abundance and the 1984 prediction of low abundance appear to have been accurate, based on subsequent catches during electrofishing population sampling. In 1985 the whole-river CPUE of YOY grayling was 3.5 grayling per 100 ft of beach seined (95% confidence interval of ± 1.2). This value is significantly higher than the drastically low estimate for 1984 ($p < 0.05$); however, this estimate is an order of magnitude less than that obtained in 1983, indicating that the 1985 year class will again be quite weak. These estimates of YOY abundance are negatively correlated with river discharge, as are the abundance estimates of older age groups (Holmes 1985). As in the past, YOY abundance was greatest in the lower sections of the river where the slower and deeper water appears to be the preferred rearing habitat. In the future, YOY index- sampling effort will be concentrated in the lower river sections. The mean length of age-0 grayling was 59.5 mm ± 1.2 mm. Because they are sight feeders, the growth rate of YOY grayling is correlated with discharge and turbidity. The 1985 average length is significantly less ($p < 0.05$) than the average YOY grayling size in 1983 (a year with low discharge).

Salcha and Chatanika Rivers:

Beach seine CPUE estimates of YOY grayling abundance were performed for the first time in 1985 in these rivers. As with the Chena River,

Table 9. Summary of numbers of each species caught and length frequencies of Arctic grayling at Mile One Slough, Delta Clearwater River, 1978-1984 and 1985.

Species	Length Range	6 year mean* 1978-1984 Number	Percent	1985 Number	Percent
Arctic grayling	60-109	429	40	172	69
	110-169	386	36	56	23
	170-229	172	16	19	8
	230-269	64	6	1	<1
	270-309	22	2		
	≥310	4	<1		
	Total	1,077		248	
Round whitefish		366		73	
Coho salmon		1,629		952	
Humpback whitefish		37		11	
Least cisco		15		41	
Burbot		13		10	
Northern pike		<1		0	
Slimy sculpin		5		8	
Longnose sucker		5		4	
	Total	3,147		1,339	
	Trap days	17		15	

* from Ridder, 1985.

estimates of YOY CPUE were very low in both the Salcha and Chatanika Rivers. In the Salcha River, the seine CPUE was only 0.15 grayling per 100 ft of beach seined (95% confidence interval of ± 0.05). The average size of the Salcha River YOY grayling was only 43 mm ± 8.5 mm. In the Chatanika River, the mean YOY CPUE for 20 seine hauls was 0.34 grayling per 100 ft of beach seined (95% confidence interval of ± 0.23). The average size of the Chatanika River YOY grayling was only 50.3 mm ± 2.6 mm. High water from heavy summer rain and turbidity caused by placer mining in Chatanika River tributaries probably account for the very low average size of these age-0 grayling. The close proximity of the Chatanika and Salcha Rivers to the Chena River suggests that they probably possess similar hydrologic conditions. Therefore, it is not surprising that YOY abundance, which is affected by river discharge, would be similar in each of these rivers. This relationship will be evaluated in the future.

Badger Slough:

The fall out-migration weir located below Nordale Road did not provide a complete count of out-migrating YOY grayling because it was not fish-tight. However, over 300 YOY grayling were caught in one 100-ft beach seine haul of Badger Slough below Nordale Road. This indicates that, although recruitment to the Chena was low in 1985, recruitment in Badger Slough, which is not subject to major flow fluctuations, was not low. In order to index subrecruit cohort strength in the future, a series of beach seine hauls will be performed in Badger Slough. This sampling may include mark-recapture population estimates, if time and logistics permit.

Population Model

Analysis of Dynamic Rates:

Dynamic-Pool Model of the Chena River. A dynamic-pool model was developed to assess changes in Arctic grayling population and catch composition on the Chena River when exposed to a range of management regimes. Seven management regimes were considered: (1) no change in management from the present regulations, (2) catch-and-release fishing, (3-5) imposing three different minima-size limits on the fishery, and (6-7) imposing two different maxima-size limits on the fishery.

Description of variables:

Variables used in the model (Table 10) were developed as follows: The fishable population ($N_{i.}$) was defined to be all fish greater than age 3 (Equation 6). Estimates of the fishable population were made from electrofishing population estimates in the four 3-mile index sections (2b, 8a, dam site, and 10b), representing the various habitat types of the lower 79 mi of the Chena River. Each population estimate and its variance was expanded by the number of river miles in that habitat category (e.g., a population estimate of 200 fish/mile in a 20-mi habitat section gives an estimate of 4,000 fish).

Table 10. Equations used in the dynamic-pool model of Arctic grayling on the Chena River, 1985.

Name	Equation
1. Rate of Fishing	$F_{..} = -\ln(1-\mu)$
2. Baranov Catch	$C_{ij} = [F_{ij}(1-e^{-Z_{ij}}) N_{ij}]/Z_{ij}$
3. Beverton-Holt	$R_{ia} = 1/[(\alpha/S_i) + a]$
4. Discharge/Recruit	$R_i = 397 - 0.184D_{i-3}$
5. Parental Stock	$S_i = (\sum_{j=5}^{10} N_{ij})/79$ (per mile)
6. Fishable Population	$N_i = \sum_{j=3}^{10} N_{ij}$; where
	i = year of simulation,
	j = age class,
	α = recruitment parameter,
	a = recruitment parameter,
	μ = exploitation rate,
	Z_{ij} = age-specific total mortality rate.
	N_{ij} = age-specific population

Recruitment (R_i) was defined as numbers of age-3 grayling per mile determined from electrofishing population estimates. Age-3 grayling were used as an index of recruitment because their higher susceptibility to electrofishing capture than age-0, age-1 or age-2 grayling yielded more precise estimates of abundance. Age-3 grayling also entered the fishery with a mean length of 188 mm.

Discharge (D_i) was defined as the mean discharge in cubic feet per second (cfs) occurring over May, June, and July. Discharge was used as one predictor of recruitment strength. According to Holmes (1983, 1984), a significant linear relationship exists between numbers of age-3 grayling per mile and discharge in the natal year (Table 10, Equation 4).

Age-specific instantaneous total mortality rates (Z_{ij}) were developed from cohort analysis performed on age-3 through age-8 grayling from 1980 to 1984 and with data from Holmes (1983, 1984) and Hallberg (1981, 1982). Cohort analysis was used to remove the effect of variable year-class strength from the mortality estimates.

Age-specific instantaneous fishing mortality rates (Fij) were developed from the mean exploitation rate of all age classes over the years 1980 to 1984. Exploitation rate was defined as the estimated number of grayling harvested in the lower Chena River (Mills 1980-1984) divided by the electrofishing population estimate from the lower 79 mi of the Chena River in the same year. Mean exploitation rate was converted into instantaneous fishing mortality rate using Equation 1 (Table 10). Mean instantaneous total mortality rate was determined by averaging total mortality rates over years 1980-1984 and over ages 3 to 8. Mean fishing mortality rate was then subtracted from mean total mortality rate to obtain natural mortality rate (M). Natural mortality rate was assumed to be constant over all ages and was subtracted from the age-specific total mortality rates derived above to obtain age-specific fishing mortality rates. Manipulation of rate functions (as described above) results in dependent estimates of fishing and natural mortality.

The spawning stock of grayling (Si) was defined as the numbers of age-5 and older grayling per mile, as determined from electrofishing population estimates in the lower 79 mi of the Chena River (Table 10, Equation 5). Most grayling have spawned at least once by the time they reach a length of 270 mm in the Chena, representing an average age of 5 years.

Spawning stock was used as another predictor of recruitment strength (age-3 grayling). A Beverton-Holt type stock-recruitment relationship (Beverton and Holt 1957) was developed to predict recruitment strength adjusted for a minimal mean discharge of 630 cfs (Table 10, Equation 3). Numbers of recruits per mile from years 1979 through 1985 were adjusted to a minimal discharge of 630 cfs, using the linear relationship described above (Equation 4). Numbers of age-5 and older fish per mile were used from the natal years 1976 through 1982 as an estimate of spawning stock. The resulting equation produces numbers of adjusted recruits per mile (Ria) from the number of age-5 and older grayling per mile in the natal year (3 years before recruitment). Adjusted recruits were then scaled to actual recruits (Ri), using the relationship between recruit strength and natal year discharge.

Age-specific catches (Cij) were simulated (Table 10, Equation 2) with the Baranov catch equation (Ricker 1975); which assumes that natural mortality and fishing mortality occur simultaneously and that average abundance of the stock over the year is used to equate catch for the year.

Aspects of simulation:

A total of seven 30-year simulations were to be run; each one represented a variation in the imposed regulations, ranging from no change in current regulations to a catch-and-release grayling fishery. Length at legal harvest was varied from 150 to 300 mm (6 to 12 inches) for a minimal length limit and from 250 to 300 mm (10 to 12 inches) for a maximal length limit.

Discharge was simulated with a Monte-Carlo design based on Markov probabilities (Duda and Hart 1973) of an eight-state system (less than 433 cfs, 434 to 833 cfs, 834 to 1,233 cfs, 1,234 to 1,500 cfs, 1,501 to 1,767 cfs, 1,768 to 2,167 cfs, 2,168 to 2567 cfs, and greater than 2,567 cfs of discharge) in May, June, and July of 1968 to 1985. The starting population was modeled from data collected in 1985 on the Chena River. The 1985 whole-river (lower 79 mi) population estimate was apportioned by age class from aging data collected during population estimates.

Harvest during the model was converted to mean length by applying mean lengths at age to each age-specific harvest and pooling the results. Harvest was also converted to biomass by applying mean weights at age (Tack 1973) in the same manner as length. Catches and the whole population were monitored for changes in length composition during simulation. Proportional stock density (Anderson 1978) was used to describe changes in length composition of the catch and population. Stock-sized fish were defined as those fish greater than 3 years of age; quality-sized fish, as those fish greater than 8 years of age.

Management regimes:

Seven management regimes were assessed for 30 years: (1) No change in current regulations of 5 grayling per day, no size limit, (2) a 200-mm (8 inch) minimal legal length of harvest, (3) a 250-mm (10 inch) minimal legal length of harvest, (4) a 300-mm (12 inch) minimal legal length of harvest, (5) catch-and-release, (6) a 250-mm maximal legal length of harvest, and (7) a 300-mm maximal legal length of harvest. Natural and fishing mortality were held constant for all 30 years, and hooking mortality of caught-and-released grayling was 5%.

A second set of the seven management regimes was run with fishing mortality increasing at approximately 1% per year over current fishing mortality rates. Natural and hooking mortality were kept constant through time as above.

A third set of the seven management regimes was run with a catch-and-release grayling fishery from 1 January to 31 May for every year of the 30 years simulated. Fishing mortality was reduced by a percentage of current fishing mortality at the start of each year, depending upon

Chena River discharge during the simulated May catch-and-release fishery.

Assumptions:

The major assumptions made in simulating the Arctic grayling fishery on the Chena River are as follows: (1) natural mortality rate was held constant for all simulations, (2) hooking mortality rate was assumed to be constant at 5 %, (3) growth was not affected by increased fishing or instituted legal length of harvest, and (4) recruitment of Arctic grayling follows a Beverton-Holt relationship with parental stock.

Input variables:

Electrofishing population estimates from the lower 79 mi of the Chena River yielded a whole-river estimate of 44,007 grayling (95% C.I. of 14,681 to 101,943 grayling) age 3 or older (Table 11). The large variance associated with the whole-river population estimate is mainly due to an imprecise estimate for section 10B. From the population estimate, an estimate of 384 spawners per mile was calculated.

The relationship between natal year discharge and number of age-3 grayling per mile can be described by the equation: Recruits = 397 - 0.184 x natal year discharge (Fig. 3; $r = 0.94$, $df = 1,5$, $p < 0.05$). The regression represents discharge from the years 1976 to 1982 and recruitment from the years 1979 to 1985.

Cohort analysis of age-3 to age-8 grayling for the years 1980 to 1984 yielded mean age-specific total mortality rates of 0.40 to 0.96 (Table 12). The mean instantaneous total mortality rate (all ages) was 0.69. The mean exploitation rate was 0.25, as determined from population and harvest estimates for the years 1980 to 1984 (Table 13), giving an instantaneous fishing mortality rate of approximately 0.48. Instantaneous natural mortality was determined by subtraction ($M=Z-F$) to be 0.21 for all age classes. Age-specific instantaneous fishing mortality rates ranged from 0.19 to 0.58, as determined by subtraction (Table 14, $F=Z-M$).

Stock/recruitment was described by regressing discharge adjusted recruitment divided by parental stock on discharge adjusted recruitment (age-3 grayling per mile adjusted for discharge) for the natal years 1976 to 1980 (Fig. 4; $n = 5$, $r = 0.97$, $df = 1,3$, $p < 0.05$). From the regression, a Beverton-Holt relationship was derived that describes the density-dependent relationship between parental stock and subsequent recruitment 3 years later (Fig. 5).

Simulated June discharge, based on the eight-state Markov probabilities, ranged from 340 to 2,139 cfs during the 30-year period (Fig. 6). Mean discharge during the 30-year simulation was 1,186 cfs (95% confidence interval of 989 to 1,383 cfs). Simulated mean discharge was significantly lower than the mean discharge from actual June measurements taken from 1968 to 1985 (mean = 1,316 cfs, 95% C.I. = 1,158 to 1,474 cfs, n = 18).

Table 11. Population estimates and 95 percent confidence intervals for the lower 79 miles of the Chena River, 1985.

Age	Estimate	95% Confidence Interval
3	5,650	2,419 - 11,240
4	8,008	3,103 - 17,174
5	20,483	6,409 - 48,861
6	4,957	1,706 - 11,404
7	2,973	700 - 7,833
8	1,476	226 - 4,249
9	401	117 - 990
10	59	1 - 192
All Ages	44,007	14,681 - 101,943

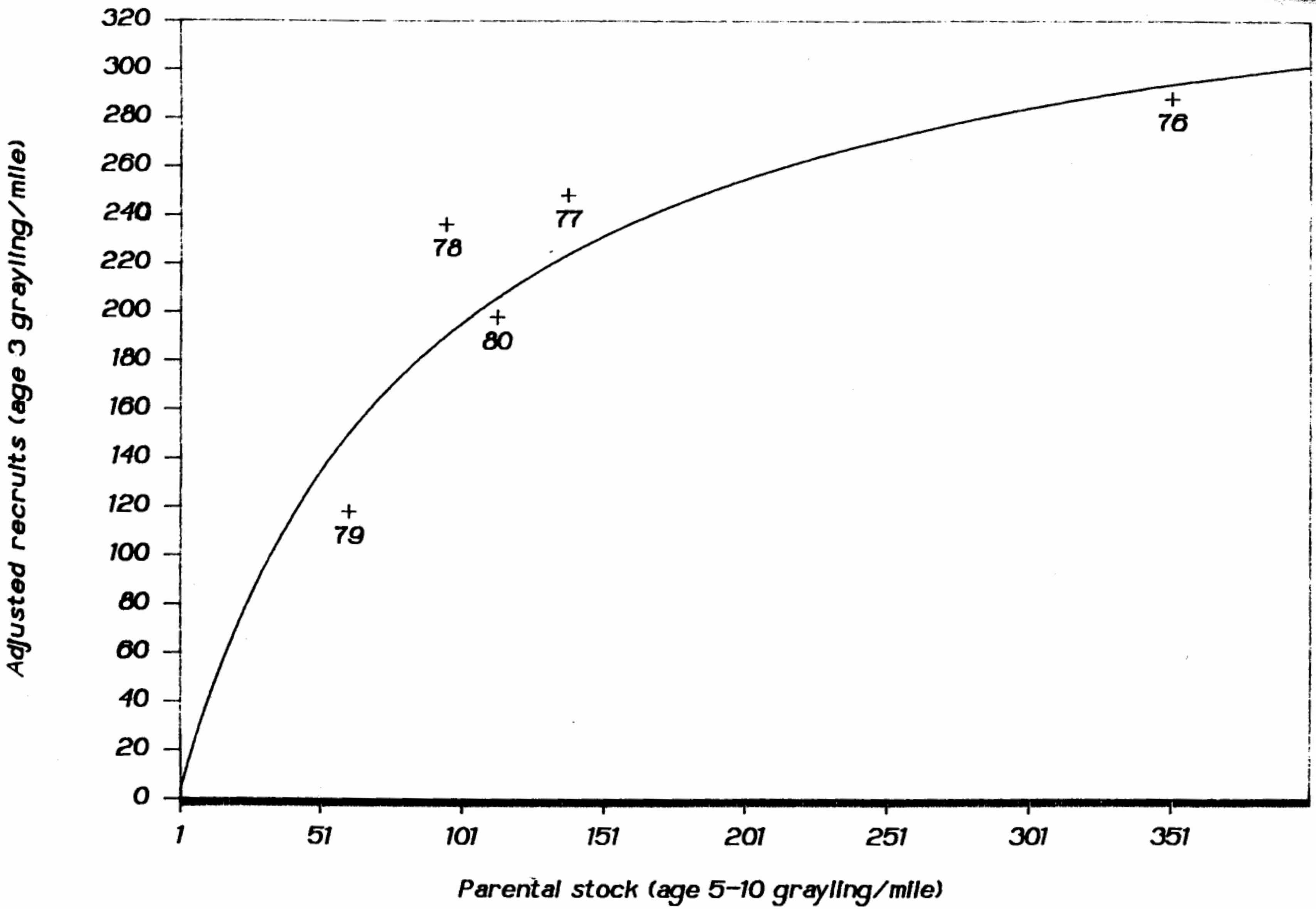

Figure 3. Numbers of age-3 grayling per mile plotted against average discharge during the months May, June, and July during the natal year. Numbers next to data points are the natal years of each cohort. Data are from the Chena River, 1976-1985.

Table 12. Cohort analysis of age-3 to age-8 grayling for the years 1980 to 1984, Chena River. Mean total mortality is the instantaneous rate of total mortality for an age class, averaged over all years.

Age	Year Sampled					Mean Total Mortality
	1980	1981	1982	1983	1984	
3	227	415	71	348	78	
						0.40
4	231	90	354	63	350	
						0.48
5	93	132	68	158	47	
						0.56
6	57	66	42	65	77	
						0.96
7	10	17	38	19	18	
						0.61
8	1	8	26	8	18	

Table 13. Exploitation rate of Arctic grayling on the lower 79 miles of the Chena River, determined from population and harvest estimates for 1980 to 1984.

Year	Population Estimate *	Harvest Estimate **	Exploitation Rate
1980	48,926	18,520	0.38
1981	57,469	10,814	0.19
1982	47,370	11,117	0.23
1983	52,278	7,894	0.15
1984	46,430	13,850	0.30

* From Hallberg (1980-1982), Holmes (1983-1984)
** From Mills (1980-1984)

Table 14. Age-specific instantaneous mortality rates used to model the lower Chena River fishery.

Age	Total (Z)	Fishing (F)	Natural (M)
3	0.40	0.19	0.21
4	0.48	0.27	0.21
5	0.56	0.35	0.21
6	0.79	0.58	0.21
7	0.79	0.58	0.21
8	0.79	0.58	0.21
9	0.79	0.58	0.21
10	0.79	0.58	0.21

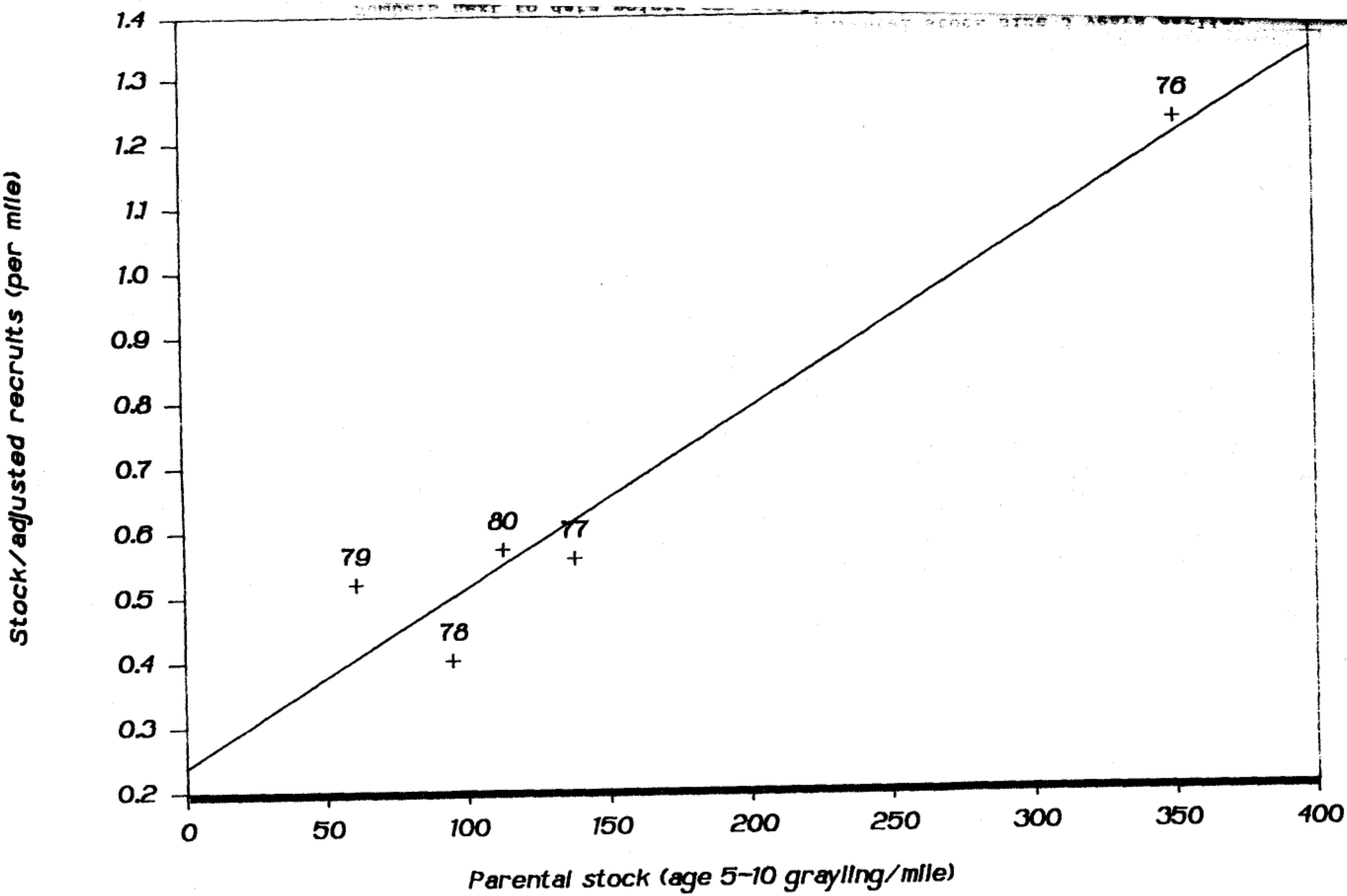

Figure 4. Parental stock plotted against parental stock divided by discharge adjusted recruits per mile for the natal years 1976 to 1980. Data are from the Chena River, 1979-1983.

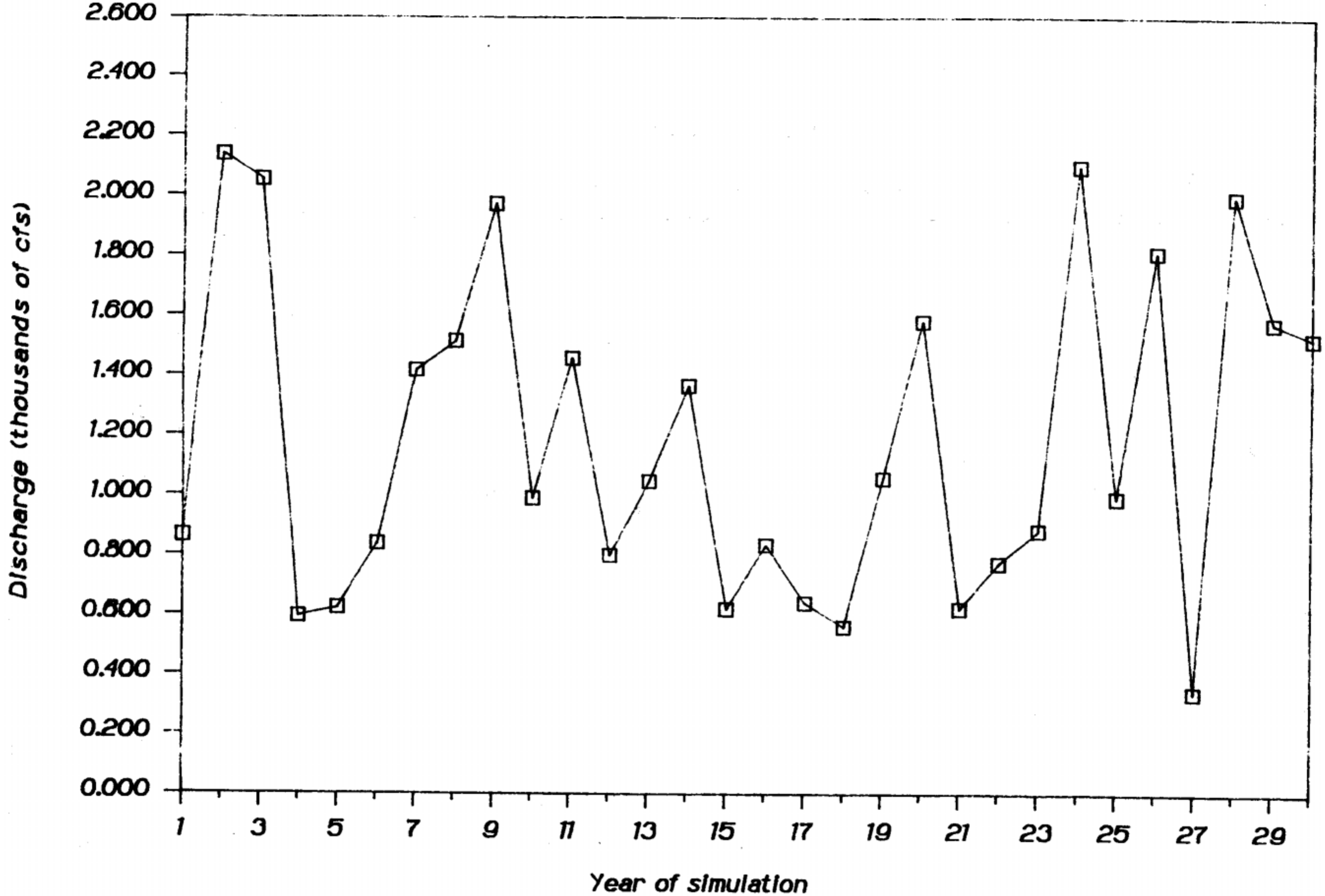

Figure 5. Beverton-Holt type stock-recruitment relationship describing the dependence of discharge adjusted recruitment on parental stock size 3 years earlier. Numbers next to data points are natal year of the recruits.

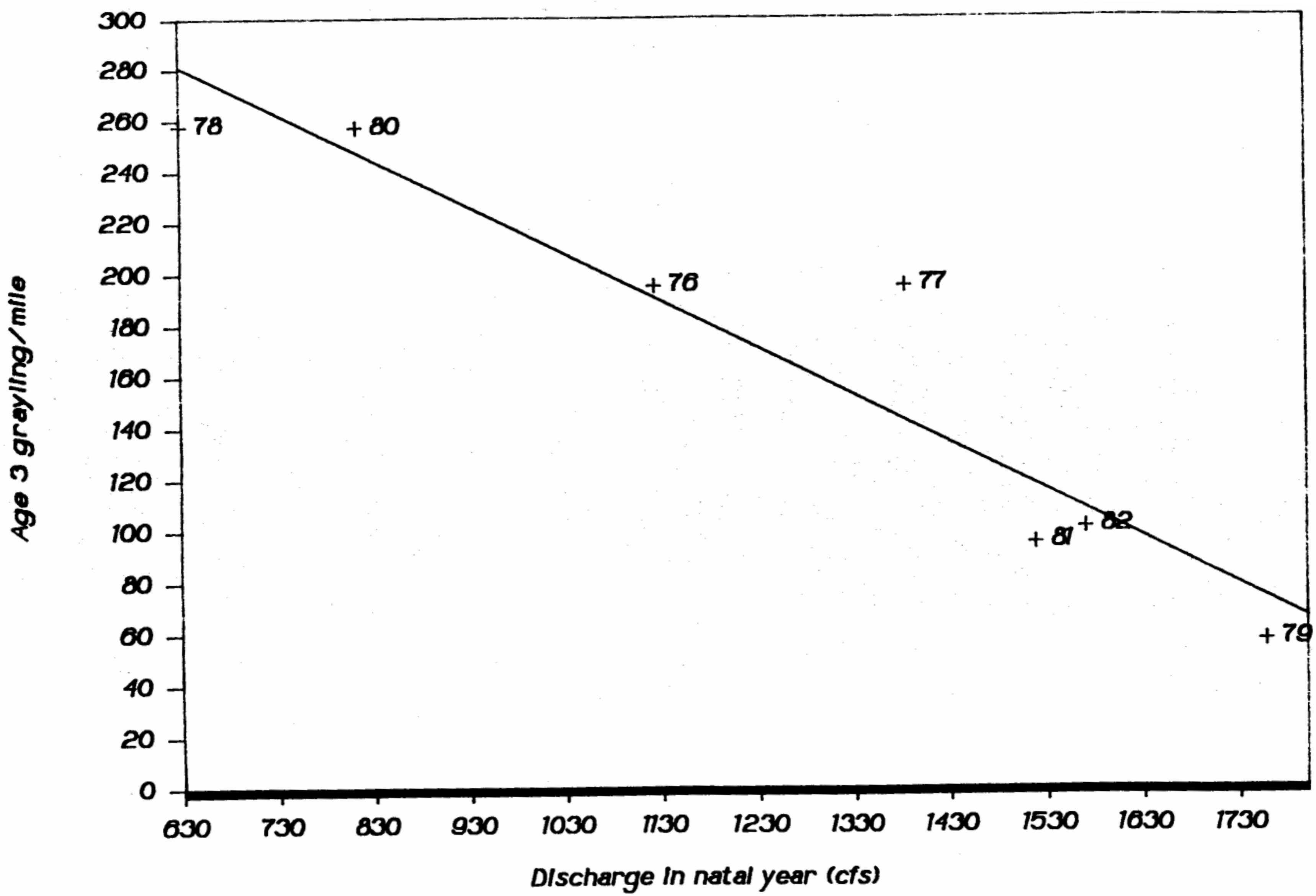

Figure 6. Simulated discharges based upon Markov probabilities of an eight-state system, as derived from actual discharges measured during May, June, and July at the Two Rivers gauging station, Chena River 1968-1985. Simulated discharge for the years 1 through 3 are actual discharges from the years 1983 to 1985.

Modeling results - Constant Effort Scenario:

The no regulation change regime produced a range of populations from 30,290 to 76,917 grayling in 79 mi of river (Table 15). Year-to-year variation in population was due to the effect of natal year discharge on recruitment. These numbers are comparable to the actual population estimate of 44,007 grayling in 1985. Catches were also relatively stable during the 30-year simulation. Catches ranged from 8,089 to 14,436 grayling per year. Over the 30 years of simulation, the population remained relatively stable in numbers; no significant decline or increase occurred. Population and catch proportional stock densities (PSD) also remained stable.

Institution of a 200-mm minimal legal length of harvest regulation produced no appreciable increase in population or catch over that of the no regulation change. Population and catch in numbers ranged from 32,647 to 83,954 grayling and 8,089 to 17,200 grayling, respectively. PSD values for population and catch did not change from that of the no management change regime. As a result of a length limit, harvest reductions ranged from 0 to 51% of no management change harvest levels.

Increasing the minimal legal length of harvest to 250 mm resulted in 12% to 50% increases in population and 9% to 90% increases in catch over the no management change regime. Population and catch in numbers ranged from 38,002 to 100,486 grayling and 10,559 to 24,640 grayling, respectively during 30 years of simulation. PSD values for population and catch also increased, ranging from a 4% to 10% increase, compared to the no management change regime. Harvests of 3,395 to 10,962 grayling per year were observed, which represented a decrease of 14% to 68% from the no management change regime.

An additional increase to a 300-mm legal length of harvest resulted in 18 to 109% increases in population and 16% to 150% increases in catch over the no management regime. Population ranged from 46,710 to 117,187 grayling and catches ranged from 13,914 to 31,671 grayling per year. Population PSD values increased from 7% to 24% of the no management change regime, while catch PSD values ranged from 7% to 28% higher than the no management change regime. Harvest decreased from 36% to 94% of the no management change regime, ranging from 753 to 5,940 grayling per year.

Catch-and-release regulations resulted in populations from 19% to 118% and catches from 18% to 210% higher than the no management change regime. No fish were harvested during the catch-and-release regime. PSD values ranged from 7% to 28% higher and 3% to 33% higher than the no management change regime for populations and catches, respectively.

A 250-mm maximal legal length of harvest produced 15% to 62% higher populations of grayling than the no management change regime, while catches ranged from 16% to 118% greater than the no management change regime. Populations ranged from 42,256 to 102,494 grayling, and catches ranged from 13,873 to 24,661 grayling for 30 years of simulation. Population PSD was 9% to 23% higher than the no management change regime. Catch PSD was 3% to 30% higher than the no management change

Table 15. Summary of management regimes simulated for the constant effort scenario, lower Chena River fishery simulation. Model numbers represent the regimes as follows: 1 - no change in management, 2 - 8 inch minimum length limit, 3 - 10 inch minimum length limit, 4 - 12 inch minimum length limit, 5 - catch-and-release, 6 - 10 inch maximum length limit, 7 - 12 inch maximum length limit.

Model	Population Range	PSD Range	Catch Range	PSD Range	Harvest Range
1	30,290 - 76,917	0.08 - 0.34	7,363 - 14,786	0.14 - 0.53	7,363 - 14,786
2	32,647 - 83,954	0.08 - 0.34	8,089 - 17,200	0.14 - 0.52	6,036 - 14,406
3	38,002 - 100,486	0.12 - 0.43	10,559 - 24,640	0.18 - 0.55	3,395 - 10,962
4	43,907 - 117,187	0.17 - 0.54	13,914 - 31,998	0.28 - 0.70	753 - 5,940
5	43,907 - 123,552	0.19 - 0.55	14,120 - 35,253	0.31 - 0.72	0
6	42,256 - 102,494	0.16 - 0.50	13,873 - 24,661	0.29 - 0.70	2,602 - 11,769
7	33,896 - 83,163	0.10 - 0.36	9,126 - 16,333	0.18 - 0.55	885 - 9,201

regime. Harvests of grayling ranged from 2,602 to 11,769, 16% to 78% lower than the no management change regime.

The alternative maximal legal length of harvest of 300 mm resulted in 3% to 13% increases in population and 4 to 26 percent increases in catch. PSD values for population and catch were only slightly higher than the no management change regime (1% to 8% increase for population PSD and 3% to 11% increase for catch PSD). Harvests were comparable to the no management change regime.

Modeling results - Increasing Effort Scenario:

The increasing effort model attempted to simulate an increase in fishing mortality due to population growth in the Fairbanks area. Fishing mortality was increased by approximately 1% of the present fishing mortality every 1 year for 30 years. A summary of the following results can be found in Table 16.

The no management change regime resulted in a decline in population and catch over the 30-year simulation. Population in numbers started at 43,907 in year 1 of the simulation, declined to 26,281 in year 15, and declined to 7,207 in year 30. Catches of 16,742 to 4,507 grayling were observed during the simulation. PSD values and harvest also declined.

The 200-mm minimal legal length of harvest regime resulted in an increase in population and catch over the no management change regime, but a 30-year trend of decline was observed. Population size increased from 1% to 157% over the no management change regime, while catches increased from 5% to 186% over the no management change regime. PSD values declined from 32% to 1% for population and catch during 30 years of simulation. Harvest varied considerably during the 30-year simulation and ranged from a increase of 109% to a decrease of 30% from the no management change regime.

A 250-mm minimum legal length of harvest regime resulted in a recovery of population levels for the 30 years simulated. Population and catch ranged from 37,905 to 90,848 grayling and 10,955 to 70,572 grayling, respectively. A 30-year trend of recovery was observed for this management regime, with catches equaling and exceeding populations during some of the years of simulation. Increases in population ranged from 12% to 775% over the no management change regime, while catches increased 9% to 1,466% over the no management change regime. Despite increasing yearly population and catch, the PSDs for population and catch declined during the 30 years of simulation, implying decreases in numbers of larger (300 mm or greater) grayling in the population and catch. Harvest during the 30 years of simulation was variable from year to year, ranging from 3,893 to 13,006 grayling with no apparent trend over time.

Increasing the minimal legal length of harvest to 300 mm resulted in variable but increasing population over the 30 years simulated. Population size ranged from 43,907 to 111,625 grayling, peaking at 111,625 grayling in year 28 and at 108,005 grayling in year 19. Alternatively, catch showed a clear increase over the 30 years

Table 16. Summary of management regimes simulated for the increasing effort scenario, lower Chena River fishery simulation. Model numbers represent the regimes as follows: 1 - no change in management, 2 - 8 inch minimum length limit, 3 - 10 inch minimum length limit, 4 - 12 inch minimum length limit, 5 - catch-and-release, 6 - 10 inch maximum length limit, 7 - 12 inch maximum length limit.

Model	Population Range	PSD Range	Catch Range	PSD Range	Harvest Range
1	7,207 - 57,001	0.01 - 0.53	4,507 - 15,135	0.01 - 0.53	4,507 - 15,135
2	18,583 - 62,158	0.01 - 0.52	8,345 - 31,508	0.01 - 0.52	5,672 - 20,651
3	37,907 - 90,848	0.07 - 0.55	10,955 - 70,572	0.07 - 0.55	3,470 - 14,530
4	43,907 - 111,625	0.32 - 0.70	13,914 - 102,495	0.32 - 0.70	753 - 9,250
5	43,907 - 123,552	0.31 - 0.72	14,120 - 127,431	0.31 - 0.72	0
6	24,132 - 75,304	0.31 - 0.70	13,873 - 43,857	0.31 - 0.70	2,602 - 27,495
7	8,361 - 61,688	0.04 - 0.53	5,273 - 19,253	0.04 - 0.53	5,129 - 17,947

simulated, ranging from 13,914 to 102,495 grayling. Population and catch PSD stabilized during 30 years of a 300-mm minimal legal length of harvest with increasing effort. PSD values ranged from 0.32 to 0.70 for the population and catch, generally varying from year to year with no apparent trend. Harvest was also variable from year to year, peaking at 9,250 grayling for year 24.

Catch-and-release management under the increasing effort scenario resulted in variable but increasing population, as seen in the 300-mm minimal legal length of harvest management regime. Population size peaked on year 28 with 123,552 grayling and ranged from 43,907 to 123,552 grayling. Catches increased during 30 years of simulation, ranging from 14,120 to 127,431 grayling per year. PSD values for population and catch were stable over the 30 years simulated but slightly higher than that of the 300-mm minimal legal length of harvest regime. Catch and population PSD values ranged from 0.31 to 0.72.

A 250-mm maximum legal length of harvest resulted in variable but declining population size over the 30 years simulated. Population size ranged from 24,132 to 75,304 grayling, peaking at year 6 of the simulation. Catches generally increased over the 30 years simulated, ranging from 13,873 grayling in year 1 to 39,294 grayling in year 22 of the simulation. PSD values for population and catch varied considerably, peaking at 0.70 in year 10 and ranging from 0.29 to 0.70 over the 30 years simulated. Harvest also varied considerably during the 30 year simulation, ranging from 2,602 grayling in year 1 to 27,495 grayling in year 28 but dropping to 7,111 grayling by year 30.

Population size during the 300-mm maximal legal length of harvest declined in much the same manner as the no management change regime. The population peaked at 61,688 grayling in year 6 and declined steadily to 8,361 grayling in year 30 of the simulation. Catches also declined, but the variation between years was much higher than that seen in population size. Catch ranged from 17,319 grayling in year 28 to 5,273 grayling in year 30 of the simulation. PSD values for population and catch declined steadily over the 30 years simulated, peaking at 0.57 in year 2 and declining to 0.03 in year 28 of the simulation. Harvest was variable over the 30 years simulated, peaking at 17,947 in year 19 and declining to 5,129 in year 30 of the simulation.

Modeling results - May Catch-And-Release Scenario:

To simulate a catch-and-release fishery during the month of May, the age-specific instantaneous fishing mortalities were reduced by 35% if simulated discharge was equal to or less than 1,100 cfs or reduced by 15% if simulated discharge was greater than 1,100 cfs. Data collected during the upper Chena River creel census shows a relationship between percentage of the total harvest taken in May and the discharge occurring during the May fishery (Table 17). Hooking mortality during the May closure was assumed to be 5%. Starting values for age-specific instantaneous fishing mortality were the same as used in the constant effort scenario. A summary of the following results can be found in Table 18.

Table 17. Comparison of May harvest and total harvest for the upper Chena River fishery (Hallberg 1980-1982; Holmes 1983-1984). May discharge is in cubic feet per second (cfs).

Year	Harvest		May	
	May	Total	Proportion	Discharge
1980	4,139	16,390	0.25	716
1981	5,675	13,549	0.42	1,056
1982	2,409	12,603	0.19	2,056
1983	4,160	10,821	0.38	1,066
1984	1,390	9,263	0.15	1,981
1985	263	2,335	0.11	2,802

Table 18. Summary of management regimes simulated for the May closure scenario, lower Chena River fishery simulation. Model numbers represent the regimes as follows: 1 - no change in management, 2 - 8 inch minimum length limit, 3 - 10 inch minimum length limit, 4 - 12 inch minimum length limit, 5 - catch-and-release, 6 - 10 inch maximum length limit, 7 - 12 inch maximum length limit.

Model	Population Range	PSD Range	Catch Range	PSD Range	Harvest Range
1	35,052 - 86,088	0.17 - 0.56	9,503 - 18,819	0.17 - 0.56	7,121 - 14,871
2	36,497 - 90,948	0.17 - 0.55	9,977 - 20,809	0.17 - 0.55	5,378 - 12,244
3	40,584 - 103,579	0.20 - 0.61	11,936 - 26,622	0.20 - 0.61	3,102 - 11,218
4	43,907 - 118,084	0.29 - 0.71	13,943 - 32,312	0.29 - 0.71	665 - 5,597
5	43,907 - 123,552	0.31 - 0.72	14,120 - 33,766	0.31 - 0.72	0
6	43,907 - 108,475	0.31 - 0.67	13,918 - 27,926	0.31 - 0.67	2,352 - 10,852
7	38,103 - 92,588	0.21 - 0.59	11,076 - 21,048	0.21 - 0.59	4,427 - 13,138

The no management change regime produced population sizes that ranged from 35,052 grayling in year 4 to 86,088 grayling in year 28 of the simulation. Catches tended to increase during the model, ranging from 9,503 grayling in year 4 to 18,819 grayling in year 19 of the simulation. PSD values for population and catch ranged from 0.17 in year 7 to 0.49 in year 27 of the simulation.

Changing to a 200-mm minimal legal length of harvest produced population sizes that ranged from 36,497 grayling in year 4 to 90,948 grayling in year 28. The catch ranged from 9,977 grayling in year 4 to 20,809 grayling in year 19 of the simulation. PSD values for population and catch also increased from a low of 0.17 in year 7 to a high of 0.49 in year 27; the same values as the no management change regime. Harvest was either reduced or increased slightly from the no management change regime, ranging from 5,557 grayling in year 13 to 12,244 grayling in year 24.

Increasing the legal length of harvest to 250 mm resulted in 10% to 40% increases in population and 7% to 50% increases in catch over the no management change regime. Population sizes ranged from 40,584 grayling in year 4 to 103,579 grayling in year 28. Catches ranged from 11,936 grayling in year 4 to 26,622 grayling in year 19. PSD values for population and catch ranged from 0.20 in year 7 to 0.55 in year 27, representing an increase over the 200-mm minimum and no management change regimes. Harvest ranged from 3,102 grayling in year 4 to 11,218 grayling in year 22.

An additional increase to a 300-mm legal length of harvest resulted in population sizes that ranged from 43,907 grayling in year 1 to 118,084 grayling in year 28 of the simulation. Catches ranged from 13,943 grayling in year 1 to 32,312 grayling in year 19. PSD values for population and catch ranged from 0.34 in year 1 to 0.66 in year 27, or a 1% to 20% increase over the no management change regime. Harvest ranged from 665 grayling in year 1 to 5,597 grayling in year 24, although the harvest was composed of 300-mm (12 inches) or greater grayling.

The catch-and-release management regime produced population sizes, catches, PSD values, and harvest that are identical to the catch-and-release regime for the constant effort scenario.

A 250-mm maximal legal length of harvest for the May catch-and-release scenario produced population sizes that ranged from 43,907 grayling in year 1 to 108,475 grayling in year 28 of the simulation. Catches of grayling during simulation ranged from 13,918 in year 1 to 27,926 in year 19. PSD values for population and catch ranged from 0.31 in year 7 to 0.67 in year 27. Harvest of 250-mm or longer grayling ranged from 2,352 in year 4 to 10,852 in year 28.

The 300-mm maximal legal length of harvest produced population sizes that ranged from 38,103 grayling in year 4 to 92,588 grayling in year 28 of the simulation. The range of population sizes produced was only 3% to 10% greater than that of the no management change regime. Catches ranged from 11,076 grayling in year 4 to 21,048 grayling in year 19, which is an increase of 4% to 18% over the no management change regime.

PSD values for population and catch were similar to the no management change regime, ranging from 0.22 in year 7 to 0.55 in year 27. Harvest was also similar to the no management change regime, ranging from 5,416 grayling in year 10 to 13,138 grayling in year 28 of the simulation.

Discussion:

To simplify the matter of comparing the relative costs and benefits of each management regime from each scenario, the discussion will be restricted to year 30 of each run of the model (Table 19). Each run of 30 years was simulated with the same 30-year sequence of discharge and stock-recruitment relationship so that any one year can be compared among the different regimes and scenarios. In addition, the mean length of the catch and biomass of the harvest can be compared between regimes and scenarios.

Several benefits are accrued from institution of a legal length of harvest. Population size increases as does the size composition of the population, translating to more spawners available to spawn the next year. Additionally, the catches and their size composition also increase, translating to a greater mean length in the catch. Therefore, two objectives can be met with a length limit: (1) increase the number of spawners to offset the effects of discharge on subsequent recruitment 3 years hence, and (2) increase recreation by increasing the catch and mean length of the catch. All of the scenarios simulated show the same general trend of increasing population and catch parameters with exclusion of more of the fishable population from harvest.

Alternatively, the cost of excluding some or all of the fishable population from harvest is decreased harvest by numbers and biomass. As the legal length of harvest reduces the possible number of fish that can be harvested, the actual number harvested drops. Even though the average weight of individuals that are available for harvest is higher (as in the minimal legal length of harvest regimes), the numbers harvested do not offset the biomass that could be harvested if there were no legal length limits. The recreational aspect of keeping grayling for consumption is sacrificed for the biological and alternative recreational aspects of increased numbers and average length in catch and population.

Therefore, the objective is to create the greatest benefits with the least cost. The decision rests upon the views of the users of the Arctic grayling resource. The anglers perception of recreation must be polled to determine reasonable actions for management. If the numbers and quality of the catch are major factors influencing recreation of anglers, then catch-and-release is probably the better alternative. If the recreational value of taking some fish home to consume is high, then no change in management or one of the less restrictive length limits is the better alternative.

Table 19. Summary of population, catch and harvest for year 30 of the constant effort, increasing effort, and may closure scenarios. Model numbers represent the regimes as follows: 1 - no change in management, 2 - 8 inch minimum length limit, 3 - 10 inch minimum length limit, 4 - 12 inch minimum length limit, 5 - catch-and-release, 6 - 10 inch maximum length limit, 7 - 12 inch maximum length limit.

Scenario	Model	Pop'n	PSD	Catch	PSD	Catch Mean Length (mm)	Harvest	Harvest Biomass (kg)
Constant effort	1	46,012	0.12	11,419	0.18	228	11,419	1,392
	2	53,920	0.12	13,654	0.19	229	11,738	1,558
	3	72,203	0.17	20.753	0.23	234	4,769	985
	4	83,918	0.26	26,121	0.36	246	2,483	786
	5	90,553	0.30	28,351	0.40	251	0	0
	6	65,117	0.28	19,396	0.39	249	3,638	319
	7	50,514	0.16	12,946	0.25	236	1,791	1,185
Increasing effort	1	7,207	0.03	4,507	0.03	215	4,507	436
	2	18,583	0.03	12,930	0.03	216	9,442	1,055
	3	63,073	0.07	70,572	0.07	226	5,090	812
	4	78,684	0.32	102,995	0.32	240	2,995	872
	5	90,553	0.40	120,847	0.40	251	0	0
	6	24,132	0.38	23,494	0.38	245	7,111	538
	7	8,361	0.05	5,273	0.05	217	5,129	490
May closure	1	55,803	0.23	14,991	0.23	235	9,746	1,257
	2	62,080	0.23	16,908	0.23	235	9,655	1,343
	3	75,312	0.27	22,285	0.27	239	3,979	1,050
	4	85,444	0.38	26,752	0.38	247	1,978	633
	5	90,553	0.40	28,351	0.40	251	0	0
	6	72,501	0.39	21,920	0.39	249	3,942	357
	7	60,465	0.28	16,569	0.28	240	8,862	979

Enhancement

Goodpaster River Egg Take:

The Goodpaster River was electrofished on 20 and 21 May 1985 from mile 7.5 to the mouth. This was one day after the main mouth was ice-free enough to allow access. A total of 525 grayling was collected, at a mean catch rate of 1.7 fish per minute (101 grayling per hour). Adult fish comprised 45% of the catch. The electrofishing catch rate was 0.77 grayling per minute. Males numbered 87 and had a mean length of 322 mm (95% confidence interval of ±13mm). Females numbered 151 with a mean length of 313 ± 15mm. The adults were fairly evenly distributed throughout the area fished but were localized to the quieter waters on the inside of bends and to the tails of swift runs. On 20 May an examination of 62 females determined 40% were ripe; 87% of 53 males were ripe. To speed maturation, 132 females and 84 males were selected, moved to a small oxbow lake, sorted by sex, and held in a covered holding pen. River temperatures ranged from 2°C on 20 May to 5°C on 23 May. The pond's temperature ranged from 7°C in the morning to 13°C in the evening over the same period.

The egg take on 23 May was conducted by Alaska Department of Fish and Game, Sport Fish Division personnel. By this time 83% of the females were ripe to some degree, and eggs were taken from 114 fish. A total of 388,000 eggs was collected for an average fecundity of 3,404 eggs per female. The eggs were held in one-gallon jars in iced coolers and transported to Clear Hatchery.

On 20 September 3,270 hatchery-reared Goodpaster fingerlings were transported by riverboat and stocked into the Goodpaster River at Mile 3. They were all fin-clipped for possible recapture in future sampling. The Goodpaster River is one source of recruitment to the Delta and Richardson Clearwater Rivers. Recapture of these stocked fish may shed some additional light into the complex recruitment strategies of grayling in these spring-fed river systems.

Delta Clearwater River:

A total of 34,883 grayling (33,694 fingerlings and 1,189 age-1+ subcatchables) was stocked into the Delta Clearwater River in 1985. This was the largest stocking in the past 8 years of the enhancement program. This was the first year in which fingerlings from a local brood source were used. As in 1983, two rearing methods (pond-rearing and hatchery culture), were used to supply the fingerlings for later evaluations on the stocking success of each. All fingerling pond-reared fish and 50% of hatchery fish received fin clips prior to stocking, while the subcatchables (stocked in June and October) received Floy anchor tags. Table 20 summarizes brood sources, rearing method, stocking levels, sizes (fish per pound and mean length), and marks for the four groups stocked into the river in 1985. All fish were in good condition at the time of stocking, and mortalities were minimal.

The pond-rearing was highly successful in 1985; 12,744 fingerlings were produced. West Pond was stocked with 25,000 fry in late June, yielding 4,306 fish (mean length of 95 mm); this represents a minimal survival

Table 20. Sources, locations, stocking dates and levels, fish per pound, mean lengths, and marks of grayling stocked into the Delta Clearwater River, 1985.

Brood Source	Rearing Locations	Date Stocked	Number Stocked	Fish/ Lb.	Mean Length	Marks: Type	Number
Jack Lake *	ponds	6/14	551	--	172	Tag	all
Goodpaster R.	ponds	10/1	12,744	41	103	Lp	all
Goodpaster R.	hatchery	9/20	20,950	97	76	Ad	50%
Jack Lake *	ponds	10/3	638	--	211	Tag	all

Totals: * Age 1+ = 1,189
Age 0+ = 33,694
34,883

rate of 17.2%. OP Lake, which was also stocked with 25,000 fry,gave the highest survival rate of the pond program to date, 33.8%. Since fyke-trapping was less effective than in previous years because of extremely high water levels and very poor trap locations, this survival rate is also considered minimal. The two useful traps captured 8,438 grayling. The mean length of these young-of-the-year grayling was 110 mm.

A summary of the 1985 recaptures of tagged grayling that were stocked in the river at age 1+ is given in Table 21. The recapture rate (recaptures divided by the number stocked) of the angler returns was 1.1% for the early summer 1984 plants and 3.2% for the fall plants. These first-year rates are similar or below those found for the 1979 age-1+ plant (4%) and for wild fish (5%-7%) (Ridder 1980).

A summary of the 1985 recaptures of the 1983 and 1984 fingerling plants is given in Table 22. The 1984 plant comprised 35% of the age-1 grayling captured in April. One age-1+ individual (157 mm) that had been stocked in June represented the entire age class in the harvest sample. It was caught on 15 August at its stocking site and was 171 mm long. The 1983 stocking made up 25% of age-2 fish in the spring sample (18% of the cohort in 1984) and 50% and 82% of the electrofishing and harvest samples, respectively. Nine of these fish were tag recaptures from the age-1+ plants: six were from the September plant, and three were from the June plant. The fourteen stocked fish in the spring sample represented four different stockings as follows: one each from the August hatchery and pond plants; and 5 and 6 each from the September hatchery and pond stockings, respectively.

Chena River:

The first returns of enhancement grayling from the Chena River were obtained in 1985. In 1984 about 1,500 pond reared grayling were released into the upper Chena River. During population sampling in June 1985, 19 age-1 grayling were captured. Based on average size and circuli counts, 11 of these fish were classified as pond-enhancement grayling (Holmes 1985). These grayling average 146 mm ± 3 mm in length and had an average of 15.7 circuli to the first annulus. On the other hand, the 9 wild-stock grayling averaged only 93 mm ± 4.8 mm in length and had an average of 8 circuli to the first annulus. One age-1 pond-enhancement grayling was harvested from the upper Chena River fishery in late August. This grayling was 182 mm in length, which is the size of the age-2 and age-3 wild-stock grayling.

In 1985 four rearing ponds were utilized for enhancement of the Chena River (Table 23). These ponds were stocked with sac-fry in June. The fingerlings (average length 110 mm) were recaptured with fyke traps, coded-wire tagged, adipose fin-clipped, and stocked into the upper Chena River in late September. A total of 6,800 fingerlings was stocked into the Chena. The summer survival estimates (6.5%-10.5%) are accurate because netting of the ponds was continued until catches dropped to near zero. Returns of these fish to the population and fishery will be evaluated in future years.

Table 21. Date and number stocked and number of 1985 recaptures by source of the 1983 and 1984 Year Classes of pond-reared grayling tagged and transplanted at Age 1+ into the Delta Clearwater River.

Date Stocked	Number Stocked	Sampling Recaptures	Angler Reported Recaptures
5/25/84	597	0	6
6/08/84	412	2	6
9/23/84	125	4	4
6/14/85	551	3	2
10/3/85	638	NA*	NA*

* Fish not available to capture.

Table 22. Number and sample compositions of 1985 recaptures from all plants of two year classes (1983 and 1984) made into the Delta Clearwater River from 1983 to 1985.

Sample Type	N	1984 Age Class I N Total	Plants	1983 Age Class II N Total	Plants
Fyke trap	248	172	60	56	14
Electrofishing	127	0	0	4	2
Harvest	163	1	1	11	9
Totals:	538	173	61	71	25
Enhancement Composition:	16%	35%		35%	

Table 23. Locations, sac-fry stocking levels, and number of fingerlings stocked into the Chena River from the enhancement ponds in 1985.

Pond Location (Chena Hot Springs Road)	Number of Fry Stocked in Pond	Number of Fingerlings Stocked in the Chena River	Percent Survival
Mile 32.9	40,000	4,200	10.5
Mile 33.2	20,000	1,300	6.5
Mile 38.3	20,000	1,300	6.5
Mile 43.7	20,000	0	*

* fingerling grayling were observed in this pond, however, their average length (~70mm) was too small to be captured in our fyke traps.

Critical Habitat Evaluations

Surveing and mapping of spawning and overwintering areas were proposed for most of the waters with large grayling populations near the Interior's road system. These are the populations that are most likely to be adversely affected by development. Grayling are especially vulnerable at spawning and overwintering times because they are concentrated into small areas.

In 1985 high spring water levels in the Chena and other rapid runoff-type streams forced the cancellation of spawning-habitat mapping in these areas. On Badger Slough, however, all spawning and rearing areas were marked on aerial photographs (Hughes 1986). These spawning locations maps are stored at Sport Fish Division offices in Fairbanks.

Mapping of overwintering areas continued with the use of radio transmitters that had been surgically implanted (tagged) into Arctic grayling in the Chena and Salcha Rivers. Previous studies (Tack 1980) indicated that Chena River fish probably overwinter in the lower Chena, while grayling in smaller rivers, such as the Salcha River move out to the Tanana River to overwinter. Because of transmitter failure, little was learned from the four fish tagged in the Chena River; the maximal transmitter life was 75 days. As expected, no Chena River fish left the system to overwinter; although, one fish moved to the mouth of the Chena in the early winter, where it remained until its tag stopped transmitting. In the Salcha River, four large grayling were tagged in early October. Transmitter life averaged about 130 days. One grayling, which had been tagged in the lower 10 mi of the Salcha, moved almost immediately 20 mi downstream into the Tanana River to overwinter. The other grayling tagged in the lower river moved to the mouth of the Salcha River where it remained for the rest of the winter. The other two grayling, which had been tagged at river mile 30 of the Salcha, moved only a few miles downstream and remained in the Salcha for the entire winter. All Salcha River overwintering sites were located, and general habitat measurements were taken. All fish were in shallow pools (4 ft deep) with gravel bottoms and moderate currents (2 fps): More precise habitat measurement and netting of overwintering areas were not performed because of time constraints.

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