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Arctic Grayling, *Thymallus arcticus*, Culture

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F-27-R

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Volume 3, Number 1

RESEARCH PROJECT SEGMENT

State: Alaska

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Cooperators: David J. Parks, Timothy E. Burke, Donald A. Bee

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ABSTRACT

The Alaska Department of Fish and Game (ADF&G), Fisheries Rehabilitation, Enhancement and Development (FRED) and Sport Fish Divisions have coordinated efforts to enhance the important Arctic grayling, *Thymallus arcticus*, sport fishery within Alaska by artificial propagation. All fish-culture operations were conducted at Clear Hatchery.

Two separate stocks of Arctic grayling were utilized as egg sources for the production program. Moose Lake was the primary source, supplying 2,819,900 (90%) eggs. The hatchery brood-year (BY) 1986 broodstock was spawned at two years of age, and over 316,000 eggs were taken.

Over 3.0 million Arctic grayling eggs were incubated and 1,861,506 unfed fry were released into 21 lakes and streams statewide. Approximately 450,000 fry were used in a rearing program, and 195,600 eggs were sent to another research facility.

Two rearing experiments were conducted: (1) an oxygen contactor was installed on two troughs to provide >110% saturation of oxygen and <100% saturation of nitrogen, and (2) Biodiet was fed to two lots and Oregon Moist Pellet (OMP) was fed to four control lots. Water temperatures for all eight lots were heated from 13.0°C to 18.0°C.

Overall survival from the unfed fry-to-fingerling stage for healthy fish is projected at approximately 30.0%. A forecasted 135,000 Arctic grayling fingerlings at 4.0 g are to be stocked into approximately 20 lakes and rivers statewide. An infestation of *Costia* sp. caused an unexpected loss of fish to reduce the number of fingerlings available to less than the goal.

KEY WORDS: Arctic grayling, *Thymallus arcticus*, rearing, Moose Lake.

INTRODUCTION

Clear Hatchery is a public facility operated by the ADF&G, FRED Division. It is located on Clear Air Force Base, approximately 140 km south of Fairbanks, Alaska on the Parks Highway (Figure 1).

The ADF&G hatchery program for Arctic grayling, *Thymallus arcticus*, has existed since 1961. Until 1983 the program consisted of taking eggs from the wild spawning stocks, incubating them to the fry stage, and releasing the unfed fry into lake systems. This program had limited success for two reasons: (1) wild Arctic grayling spawning operations were logistically difficult and subsequent incubation difficulties resulted in production goals that were rarely achieved, and (2) the survivals from the unfed-fry stage to the adult stage were very low.

Fish-culture procedures were refined to augment survival and reduce competition and cannibalism. Successful culture of Arctic grayling fry depends on (1) the manipulation of the environment to provide adequate water flow to supply oxygen and remove metabolites, (2) suitable water temperatures for growth, and (3) a reliable, commercially produced diet. Prior to 1983 all

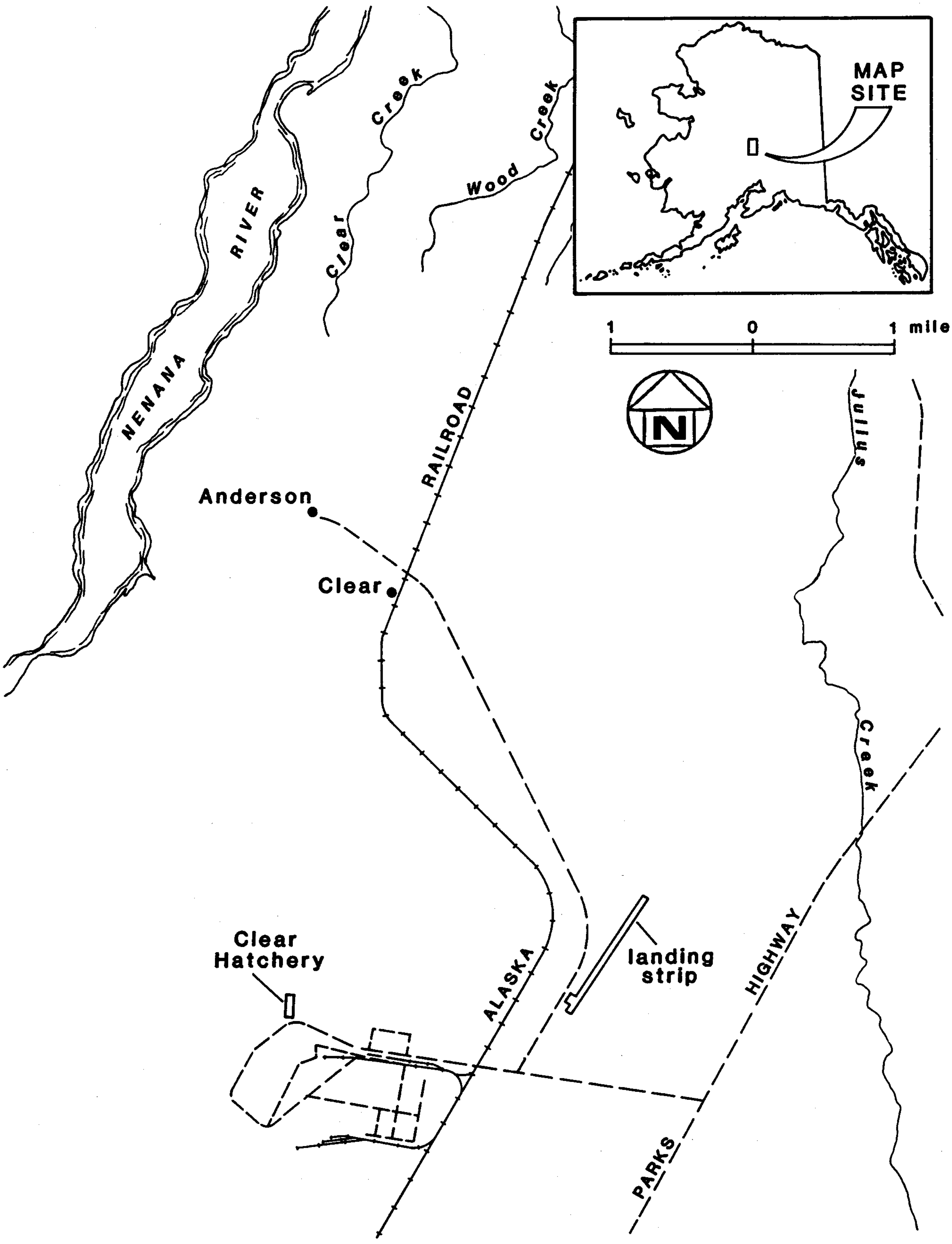

Figure 1. Location of Clear Hatchery.

attempts at intensive Arctic grayling culture had been unsuccessful; however, subsequent research has helped to make intensive culture of Arctic grayling feasible and a fry-to-fingerling fish culture possible; a survival rate of 75% is now considered achievable. One important constraint limiting the Arctic grayling enhancement program in Alaska is the problem of obtaining sufficient numbers of eggs. The primary sources may fail; therefore, new secondary sources of wild broodstocks are being evaluated. Consequently, investigation of Butte Lake as a potential wild-egg source was attempted. The best approach in creating a predictably reliable source of eggs, however, may be to develop a hatchery broodstock. Previously, only Lord (1932) has reported success in establishing a small hatchery broodstock, but given the logistical difficulties and expense of a wild egg take, this may be worth the effort.

GOALS

The goals of the Arctic grayling program at Clear Hatchery include two components: (1) production of fish for enhancement projects, and (2) refinement of experimental culture techniques. To utilize available resources most efficiently, it is necessary to develop procedures and procure equipment to produce 210,000, 4-g fingerlings at Clear Hatchery with a 75% survival rate from egg to fingerling. To provide means to attain long-term goals, it is necessary to identify and develop alternate wild egg-take sources and determine the feasibility of developing and implementing a viable, domestic Arctic grayling hatchery broodstock.

FIVE-YEAR OBJECTIVES

1. Conduct Arctic grayling egg takes (2.0 million eggs) at Moose Lake (the primary wild broodstock).

2. Continue to assess adult Arctic grayling availability at Jack, Tahneta, and Butte Lakes and Goodpaster River as alternative broodstocks.

3. Release 210,000, 4-g fingerlings in waters selected by the ADF&G, Sport Fish Division.

4. Implement the following experimental Arctic grayling culture techniques:

   a. Evaluate the success of egg incubation and survival to the fry stage in Heath® incubators modified with fine screens.

   b. Conduct experiments to determine optimal loading densities in incubators.

   c. Conduct experiments to determine optimal conditions for growth and survival of fry fed various commercially produced diets.

   d. Rear groups of fry at different densities in start-up troughs.

   e. Rear experimental lots of fry at different light intensities.

® Mention of commercial products and trade names does not constitute endorsement by ADF&G, FRED Division.

f. Rear experimental lots of fry at water temperatures between 14°C and 20°C.

5. Rear 450 Arctic grayling to maturity and monitor growth and maturation.

6. Successfully incubate eggs taken from broodstock grown to maturity at the hatchery.

MATERIALS AND METHODS

Broodstock Evaluation

Three stocks of Arctic grayling were evaluated to determine their run timing, number of available adults, and quality, quantity, and viability of eggs (Figure 2): (1) Moose Lake in the Copper River drainage; (2) Clear Hatchery, which experimental broodstocks originated from, and Moose Lake; and (3) Butte Lake in the Nenana River drainage.

Moose Lake:

Moose Lake adult Arctic grayling were captured in a wooden trap as they migrated upstream into Our Creek. Adults were dip netted from the trap, sorted according to their sex, counted, and placed in net pens to ripen.

Hatchery Broodstock:

On 9 August 1987 the remaining 990 experimental hatchery broodstock were equally divided between two tanks. Fish in Tank 4 were fed Rangens® rainbow trout, *Salmo gairdneri*, broodstock diet, and those in Tank 5 were fed Silvercup® rainbow trout

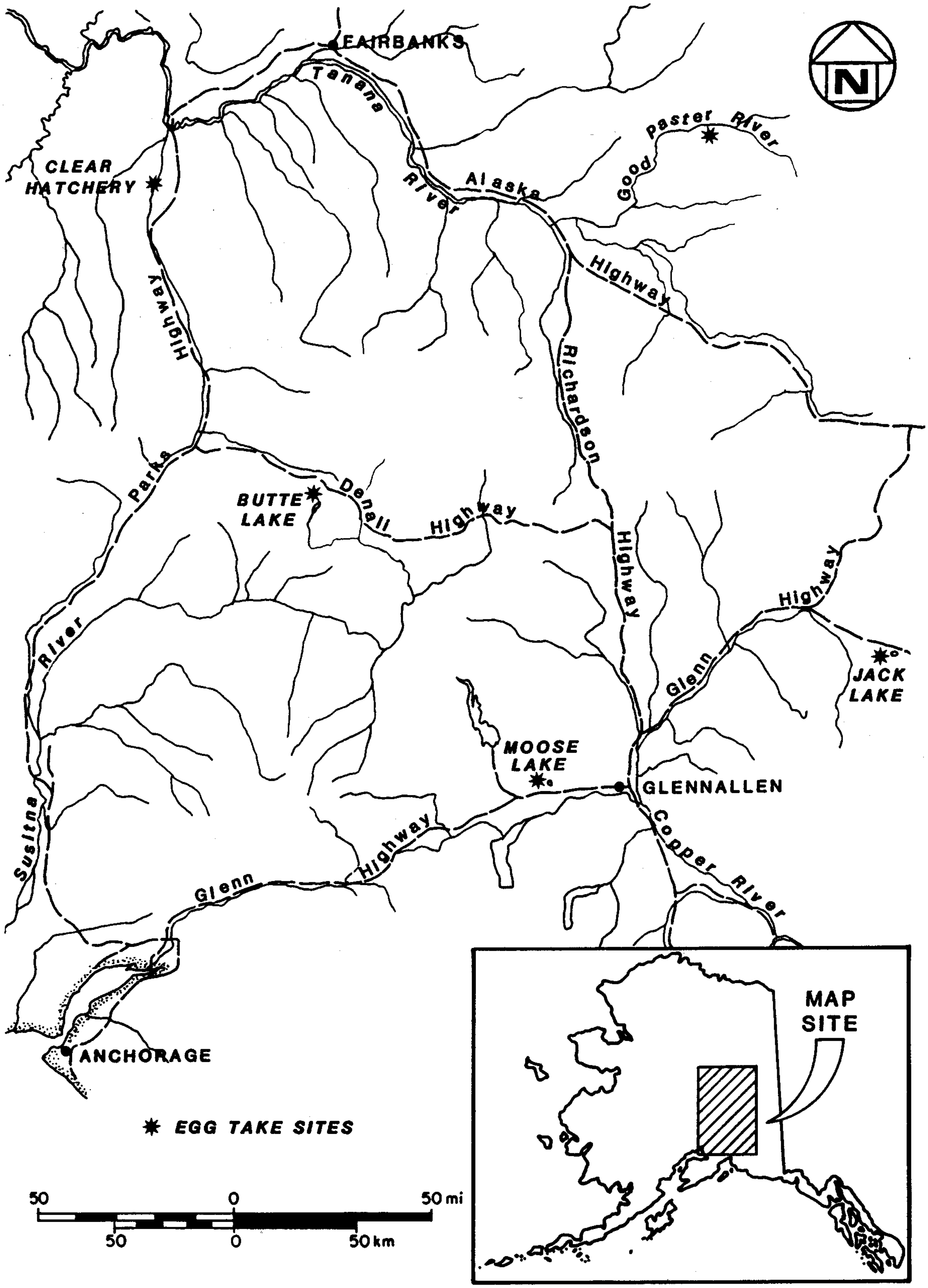

Figure 2. Location of Arctic grayling egg-take sites for Clear Hatchery.

broodstock diet. These diets were fed to the respective lots of fish through May 1988.

Starting on 21 April 1988, the water temperature for the hatchery Arctic grayling broodstock from BY 1986 was gradually raised from 3.7°C to 8.7°C over a 37-day period. On 25 May 1988 the adults were anesthetized with carbon dioxide and checked to determine the presence of eggs and the degree of ripeness. The total lengths (mm) of the fish were measured and they were weighed (g) and separated into tanks according to their sex. Sperm motility was checked and they appeared viable.

Butte Lake:

A two-person crew went to Butte Lake (*See* Figure 2) on 15 June 1988 to evaluate its potential as an egg-take site. Few adult Arctic grayling were caught using various methods of capture: 4-cm stretch-mesh gill net and a 2-cm-mesh fyke net that were fished in numerous locations at the northern end of the lake (Figure 3), and hook-and-line. Conditions did not warrant remaining at the location, so personnel departed on 17 June 1988.

<u>Egg Take</u>

Prior to spawning, adult males and females from Moose Lake and the hatchery broodstock were anesthetized with carbon dioxide. All adults were spawned alive by hand-stripping.

Eggs from the Moose Lake Arctic grayling were fertilized and water-hardened at the egg-take sites, cooled with lake ice, and transported to the hatchery. The eggs from Moose Lake were transported from the Gakona Airport to the Clear Airport via aircraft.

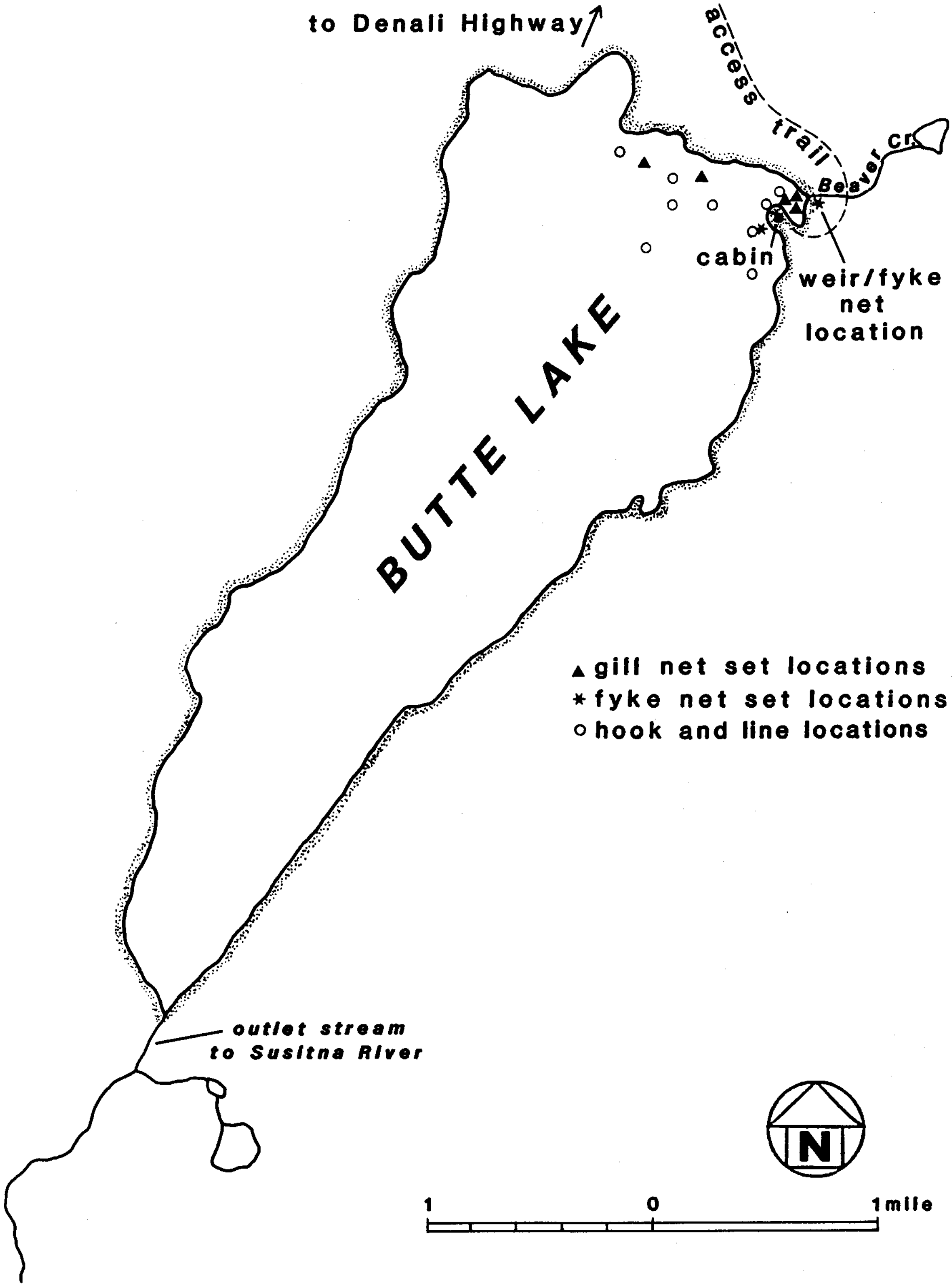

Figure 3. Butte Lake adult Arctic grayling capture locations.

Incubation

Eggs were disinfected for 10 min in a Betadine® (100 mg/liter) bath before they were brought into the hatchery (Wood 1974). Each stock was isolated from the other stocks to minimize the likelihood of disease transmissions. Eggs were incubated in stacked Heath Techna® trays with fine-mesh (10.2 mesh/cm) and coarse-mesh (4.5 mesh/cm) screens. Approximately 30,250-75,625 eggs (i.e., 1.0-2.5 liters of eggs) were placed in each tray. Daily 15-min formalin treatments (1:600) were applied to minimize fungal growth (Wood 1974). Water temperatures (monitored daily) averaged 9.8°C and ranged from 7.0°C to 14.0°C. Water flows were set at 19 liters/min. The developmental rate of some lots of eggs was manipulated to stagger the emergence of fry so that different lots for experiments could be obtained. Fry in the coarse-mesh screens were allowed to migrate volitionally downward and were either drained out or trapped in the lower trays and subsequently drained out. Fry in the fine-mesh screens were retained in the trays until physically capable of swimming-up and then ponded.

Rearing

All start-up rearing, including fish for experimental studies, was conducted in 442- x 54- x 28-cm Heath Techna start-up troughs with a 28-cm standpipe to maintain a usable volume of 660 liters. After more than 1.8 million fry were released, approximately 425,000 and 25,500 swim-up fry from Moose Lake and the domestic hatchery stock, respectively, were held for rearing. Fry from the Moose Lake broodstock were divided into eight troughs of 50,000 fry each (4.0 kg/m^3). The remaining 25,000 Moose Lake fry and the 25,500 fry from the hatchery broodstock were loaded into a ninth trough for rearing.

Each trough was divided into three sections of 220 liters each. Tail and divider screens had 0.5-mm perforations. Fry were initially stocked in the lowest section of each trough; as maximum densities were achieved, the next upper-divider screen was removed to increase the amount of rearing area space.

Initially, water flow was 15-19 liters/min in each trough, but this was adjusted to maintain a minimal dissolved-oxygen concentration of 7.0 mg/liter. Water velocities were kept low enough to prevent fry impingement against screens. Dissolved-oxygen concentrations were monitored weekly. The mean-water temperature for the Moose Lake stock was increased from 13.0°C to a maximum of 18.0°C, with one 12,000-watt electrical immersion heater per two troughs.

Experimental Rearing

Two separate, concurrent, 14-day experiments were conducted with the eight troughs of BY-1988 Arctic grayling. Upon termination of the experiment, the remaining fry were reared for production release.

Two troughs were provided with an oxygen-contactor system to aid in removal of dissolved nitrogen and to increase dissolved-oxygen concentration within the water supply. Traditionally, with the heated water system and the initial degassing procedure, the water has 100.0%-105.0% of saturation for dissolved nitrogen and 95.0%-98.0% of saturation for dissolved oxygen, and total dissolved gasses varied from 102.0% to 105.0%. After utilization and stabilization of the contactor system, dissolved-oxygen concentrations were maintained at approximately 120.0%-130.0% saturation, nitrogen at 90.0%-95.0%, and total dissolved gasses at 101.0%-103.0%.

Fry were fed two diets: (1) two lots were fed Biodiet® starter with a double-vitamin (DV) pack and extra vitamin C to provide a level of 3,200 mg/kg; and (2) the remaining six were fed Oregon Moist Pellet IV® (OMP) starter mash with a DV pack and extra vitamin C to provide a level of 3,200 mg/kg. Both feeds were ground in a mortar with a pestle and sifted to obtain the required small particle size and to increase acceptability. Feed was dispensed at 5-min intervals for 24 hours each day; a rate of up to 37% body weight/day with Loudon North Star® automatic feeders. Previous experiments indicated that Arctic grayling fry are photopositive and congregate in rearing troughs where the desired illumination is present. Consequently, fluorescent lights were installed under the feeder's spread bars and along the entire length of the trough to provide approximately 300 foot-candles of light at the water surface 24 hours/day.

Troughs were cleaned daily, and dead fry were enumerated and removed. Weights (g) and total lengths (mm) were measured when the fry emerged and at 14-day intervals thereafter until release. When maximum densities were achieved in the troughs, the fingerlings were transferred into a 17.0- x 2.0- x 0.8-m concrete raceway where they are being reared until their release. In the raceways, they were fed by automatic feeders every 10 min for 24 hours/day.

Stocking

Fry were transported to stocking sites by placing a maximum of 19 liters of water and 30,000 fry into each plastic bag; oxygen was added and the bags were sealed. The bags were placed into coolers, iced, and transported by plane or truck to various release sites. Most of the unfed fry were planted by ADF&G, Sport Fish Division biologists.

Fingerlings will be transported by hatchery personnel in a 1,900-liter fish-transport tank to the release site. Tank loadings of 0.16 kg of fish/liter of water will be used. In all releases, every effort will be made to minimize differences in water temperature between the transport tanks and receiving water.

RESULTS

Broodstock Evaluation

A total of 21.6 million eggs was potentially available from the Moose Lake stock between 8 May and 18 May 1988. In addition, approximately 0.75 to 1.0 million eggs were potentially available from the hatchery broodstock of 350 adult females (Table 1). This egg take was the least time-consuming and logistically simple.

Broodstock evaluation at Butte Lake was inconclusive in 1988 because of an early "ice-out" and subsequent early spawning. All females captured (Table 2) were spawned-out and negated further investigations at that time. It is estimated that hatchery personnel arrived approximately 7 to 10 days after the start of natural spawning activities. Preliminary data gathered through the Sport Fish Division, however, indicate that there is a healthy population, and Butte Lake appears to be a viable location for future egg takes.

Egg Take

The egg take at Moose Lake was conducted on 18 May. Approximately 2.8 million eggs were taken from 330 females. Average fecundity was 8,545 eggs/female. A male-to-female ratio of 1:1 was used.

The hatchery broodstock (BY 1986) spawned at two years of age. Egg takes were conducted on 26 May, 31 May, and 2 June to obtain a total of 316,000 eggs from 96 females. The average fecundity was low--at 3,292 eggs/female. Eggs were extremely small and averaged 94,328 eggs/liter.

Table 1. Characteristics of Arctic grayling broodstocks, 1988.

Brood-stock	Spawning period	Sex	Numbers of adults		Average fecundity	Number of eggs	
			Captured	Spawned		Potential	Actual
Moose	8 May to	M	2,288	330			
Lake	18 May	F	2,527	330	8,545	21,593,000	2,819,850
Hatchery	26 May to	M	350	96			
	6 June	F	350	96	3,292	1,152,000	316,000
					TOTAL	22,745,000	3,135,850

Table 2. Arctic grayling adults captured at Butte Lake, 15 June - 17 June, 1988.

Method	Hours of effort	Number Fish	Sex	Spawning Condition
Hood & Line	12	1	Male	Spawned out
Fyke net	36	4	Sub-adults	
		10	Fingerling	Immature
Gill net	18	6	Males	
		6	Females	Spawned out

Incubation

The water temperature within the incubators averaged 8.0°C throughout the 33-day incubation period, resulting in an accumulation of 200 to 310 temperature units (TU). Survival rates for green eggs to fry was 81.1% from Moose Lake. The survival rate of the eggs from the hatchery broodstock fed the Silvercup diet was 8.5% and the Rangens, 7.6%. Nearly all of the mortality that occurred among these lots of eggs happened within five days after fertilization.

Experimental Rearing

Unexpectedly high mortality began among these fish shortly after the start of the experiment and, after 18 days, an infestation of *Costia* sp. was diagnosed. Upon recommendation of the FRED Division Pathology Section, water temperature was lowered to 12.5°C, feed levels were reduced, and a 1:6,000 formalin treatment was administered for one hour. Unfortunately, this occurrence compromised the validity of experimental data for the feed study as well as the oxygen-contactor system, and no additional data was collected until after 36 days. The results that were collected suggest, however, that the growth (mm/TU) of fish fed Biodiet was similar to that of fish fed OMP (Table 3). Because of the mortality attributed to the *Costia* sp. outbreak, the experiments to evaluate the survival rates of fish fed different feeds and fish reared in the "oxygen-contacted" water were terminated.

During the past years, the mortality has rapidly decreased after the initial 14 days of rearing; however, mortality remained relatively high for the next 14 days which, consequently, contributed to the low-expected overall survival of 30.0% from fry to fingerling (Table 4). In addition, there was a low-level incidence of scoliosis and lordosis, estimated between 5% and 8%,

Table 3. Growth of Arctic grayling fry from Moose Lake broodstock during a 36-day feeding period, 1988.

Treatment	Replicate	Water (C) temperature	Average weight (g)		Average length (mm)		Average daily (mm) gain	Average gain (mm)/ TU/day
			Start	End	Start	End		
OMP IV (DV)	-A	15.2	0.0162	0.303	14.7	33.1	0.51	0.034
OMP IV (DV)	-B	15.1	0.0162	0.312	14.7	32.7	0.50	0.033
	Avg						0.51	0.033
BIODIET (DV)	-C	14.9	0.0162	0.306	14.7	31.9	0.48	0.032
BIODIET (DV)	-D	14.9	0.0162	0.342	14.7	32.5	0.49	0.033
	Avg						0.49	0.033

Table 4. Arctic grayling survival rates and production, 1988.

		Emergent fry				Forecasted		
Brood stock	eggs taken & incubated	Number emerged	Survival (%)	Number released	Number reared	survival (%) to fingerling	Number for release	Size at release (g)
Moose Lake	2,819,900a/	2,286,500	81.1	1,861,500	425,000	30%	127,500	4.0 g
						30%	3,450	4.0 g
						30%	4,200	4.0 g
Hatchery	316,000	25,500	8.1	-0-	25,500	30%	7,650	4.0 g
TOTAL	3,135,900	2,312,000		1,861,500	450,500		135,000	

a/ A total of 195,600 eyed eggs were shipped to Arizona Game and Fish Department.

present among fish fed both diets, even though both diets contained additional vitamin C.

Stocking

Over 1,861,500 unfed Arctic grayling fry were stocked into 21 lakes statewide (*See* Table 4). A total of 195,600 green and eyed eggs was shipped to the Arizona Game and Fish Department for research and development. A forecasted 135,000, 4.0-g Arctic grayling fingerling produced at Clear Hatchery are scheduled for release during late-August to mid-September each year.

DISCUSSION

Broodstock Evaluation and Egg Take

Broodstock investigations during 1986, 1987 (Parks et al. 1986; 1987), and 1988 demonstrated that approximately 19.5 million or more Arctic grayling eggs are available from the wild source. Moose Lake will remain the primary source because of its large adult fish population, early spawning period, and excellent quality and quantity of eggs (*See* Table 1). This site, however, has poor access, requiring a 5-km trip by all-terrain vehicles. Jack Lake (Parks et al. 1987) will remain as the primary backup source because the run timing is 7 to 10 days later than Moose Lake, the population is large enough to meet the 2 million-egg egg-take goal, and there is an excellent quality and quantity of eggs. Access to this site is excellent, but the adult capture operation is hampered by ice and high water because Lower Twin Lake breakup occurs during the egg take. An egg take on the Goodpaster River is the most likely to fail because of its inaccessibility and the difficult adult-capture conditions during the breakup period. The adult population size is small, and a potential limit of 400,000 eggs makes this source a poor candidate for a primary egg-take site. This broodstock is very important, however, as an egg-take source for Arctic grayling stocking projects in the Yukon River drainage.

Proper evaluation of Butte Lake was not completed due to an inaccurate forecast of run timing. Subsequent programs will ensure timely assessment of the spawning run. It does appear, however, that adults can be easily captured from Butte Lake by merely setting a fyke net across the largest inlet stream (Beaver Creek) (*See* Figure 3) as the adults migrate upstream to spawn. Minor environmental changes are necessary to implement such a program. Butte and Tahneta Lakes are designated as the secondary backup broodstock sources (Parks 1986, unpublished data).

Gall (1974) reported that the percentage of eggs reaching the eyed-stage increased as egg size increased in lots of hatchery-reared rainbow trout. It is also apparent that the larger-sized eggs from wild Arctic grayling broodstock survive better than the smaller-sized eggs from the hatchery broodstock (*See* Table 4). Poor nutrition or the small eggs from the young adults probably led to the failure of the embryos to develop longer than 5 days after fertilization. During FY 1988 the broodstock were divided into two experimental lots to evaluate the effects of different commercial rainbow trout broodstock diets on egg survival. Eggs from the lot of fish fed Silvercup had a 8.5% survival, while eggs from the other lot fed Rangens had a 7.6% survival. Post-spawning mortality of domestic stock was less than 10% for BY-1986 adults (Moose Lake source). Most of the mortality, as observed during previous years, resulted from *Saprolegnia* infections after spawning or other handling.

Experimental Rearing

Some of the most important factors affecting fry survival in the hatchery include the water temperature, diet, timing of feeding, food density, fish density, and light intensity. Arctic grayling fry reared at 18°C for 13 days survived better (68.4%) than those reared in 20°C, but growth was only slightly greater for fish reared at 18°C than 20°C (Parks et al. 1986). With the results from previous years' study, we have concluded that optimal growth and survival can be attained when Arctic grayling fry are reared at a water temperature of 18°C. When Arctic grayling are reared at 18°C, a fry-to-fingerling survival rate of approximately 65% can be reasonably expected. With a 75% survival rate from green egg to emergence, the overall survival rate from green egg to fingerling is nearly 50%.

Arctic grayling fry are photopositive and they move to areas of the trough where the preferred illumination is present. If lighting for newly ponded fry is inadequate, the fry tend to settle on the bottom until crowding causes suffocation (Parks et al. 1986). Although we did not conduct experiments to compare different levels of light intensity, our lighting level of 300 fc appears to have been adequate.

The nutritional requirements of Arctic grayling, like those of many other cold-water fishes, are poorly known. Arctic grayling fry, however, will die if they do not start feeding within the first 10 to 14 days at water temperatures of 18°C. Those fry that start feeding, however, appear to eat and grow well (at least through the fingerling stage) with the high-protein feeds of OMP IV-DV and Biodiet DV. Early adaptation to these diets is essential to reduce starvation during the prefingerling stage of intensive culture. Fry should be ponded as soon as they are able to swim to the surface. Since the first 8 days after swim-up are the most critical, fry should be fed to excess at least once every 5 min for 24 hours/day. Because of the inconclusive experiment to evaluate Biodiet, this feed study should be repeated, but the preliminary data suggest that Biodiet is not detrimental to the fry.

Results from other diet experiments suggest that Arctic grayling require extra vitamin C in their diet. It is important to provide fresh lots of feed, because vitamin C deteriorates rapidly during storage. We have not determined, however, if vitamin C is lost through our grinding and sieving process that reduces particle size, or if Arctic grayling fry require more vitamin C than other species. Even though feeds fed this year had extra vitamin C added, it appeared that this year's diets did not meet the nutritional needs of our fry and even greater amounts of vitamin C may be needed.

The Arctic grayling fingerling production and survival will not meet the production goals. ADF&G, Sport Fish Division originally requested approximately 210,000 fingerlings for stocking; the projected production of 135,000 fingerlings will be 36% less than the amount requested. The expected survival rate from fry to fingerling was 50%; the actual survival rate will probably be 30%.

CONCLUSIONS

A total of 2.8 million Arctic grayling eggs was taken from fish at Moose Lake. The Jack Lake broodstock will be the primary backup egg-take site if the Moose Lake egg take fails; the Tahneta and Butte Lakes stocks will be the secondary backup locations. A total of 1,861,500 fry was released into many lakes and streams, and a projected total of 135,000, 4.0-g fingerlings is expected to be released into over 20 lakes and streams during September 1988.

Experimental Arctic grayling cultural techniques that have been developed at Clear Hatchery for several years have been successful. We have learned that (1) eggs should be loaded into incubator trays at a rate of up to 1.0-2.5 liters of eggs/tray,

(2) Arctic grayling eggs should be incubated in trays with large-mesh screens, but these should be transferred to trays with fine-mesh screens before hatching, (3) rearing density should be approximately 200 fry/liter, and (4) light intensity should be 300 fc evenly distributed for 24 hours/day.

Excellent growth of fry can be achieved with finely ground OMP IV-DV and Biodiet-DV starter with extra vitamin C that is provided at 5-min intervals for 24 hours/day. The most critical period for survival of Arctic grayling fry is the initiation of feeding during the first 10-14 days of rearing.

Arctic grayling are annual spawners, and 96 BY-1986 Moose Lake females spawned as two-year-olds in 1988. This produced 316,000 eggs, of which 8.1% survived.

RECOMMENDATIONS

Broodstock Evaluation

1. Continue maximum growth rate for both the BY-1986 and BY-1987 Moose Lake hatchery broodstock. Adjust water temperature and photoperiod according to their natural environment. If possible, rear fish outside to provide natural photoperiod and allow water temperature to decrease during the winter months as much as possible.

2. Feed Silvercup or Rangens rainbow trout broodstock diet with extra vitamin C.

Egg Take

1. Continue to use Moose Lake as the primary broodstock for spawning operations.

2. Use Jack Lake and Tahneta Lake broodstocks as primary backups.

3. Continue evaluation of Butte Lake for additional broodstock information.

4. Calculate the egg-take goal for Moose Lake with planning assumptions of 75% egg-to-fry and 65% fry-to-fingerling survival rates (i.e., approximately 50% from green egg to fingerling).

Incubation

1. Load incubators with densities of 1.0-2.5 liters of eggs/tray.

2. Treat eggs daily with formalin.

3. Incubate eggs in trays with large-mesh screens. Prior to hatching, transfer them to trays with fine-mesh screens.

Rearing

1. Initial fry-rearing density should be 200 fish/liter.

2. Feed OMP IV-DV or Biodiet-DV starter with 3,200 mg vitamin C/kg every 5 min for 24 hours/day.

3. Provide even-lighting conditions over the entire trough at approximately 300 fc for 24 hours/day at water surface.

4. Provide 18°C water during the first 14 days of rearing.

5. Conduct a rearing experiment to reevaluate Biodiet.

6. Conduct light-intensity experiment using lighting levels of 75, 150, and 225 fc.

ACKNOWLEDGMENTS

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REFERENCES

Gall, G. A. E. 1974. Influence of size of eggs and age of female on hatchability and growth in rainbow trout. Calif. Fish and Game. 60: 26-35.

Lord, R. F. 1932. Notes on Montana graylings at the Pittsford Vt., Experimental Trout Hatchery. Trans. Amer. Fish. Soc: p. 171-178.

Parks, D., T. Burke, and D. Bee. 1986. Arctic grayling culture. Federal Aid in Sport Fish Restoration. F-23-R. 1(5). 28 p.

Parks, D., T. Burke, and D. Bee. 1987. Arctic grayling culture. Federal Aid in Sport Fish Restoration. F-23-R. 2(1). 28 p.

Wood, J. W. 1974. Diseases of Pacific salmon, their prevention and treatment. State of Washington Department of Fisheries. 82 p.