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Growth, Survival, and Costs of Rearing Rainbow Trout in Floating Net-Pens at Harding Lake, Alaska, 1991

by

Tim R. Viavant

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Alaska Department of Fish and Game

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ABSTRACT

Rainbow trout *Oncorhynchus mykiss* were stocked and subsequently reared in floating net-pens at Harding Lake, Alaska, during the summer of 1991. Fish were reared for seven weeks and were fed a commercially available semi-moist pelletized diet. Fish were fed to satiation (food was presented until fish were observed to no longer feed), or until a ration of 1.5 times that recommended in the Alaska Department of Fish and Game hatchery methods manual was achieved. Fish were sampled periodically to estimate mean length and weight. Fish were stocked into the net-pens at an average weight of 20 grams and released at an average weight of 90.6 grams, an increase in weight of 353 percent in seven weeks. Survival was 98.8 percent. Conversion rates (rate of conversion of fish food to fish biomass) and average growth per degree-day were more favorable in 1991 than that observed for rainbow trout reared in floating net-pens at Harding Lake in 1990. Rainbow trout were reared to catchable size in net-pens at Harding Lake in a shorter time period during 1991 than during 1990. The estimated cost of producing a catchable sized rainbow trout at the net-pen facility in 1991 was $0.74 per fish. Rainbow trout reared in net-pens at Harding Lake were able to utilize a larger daily ration than the ration calculated using Alaska Department of Fish and Game hatchery methods and were able to achieve a faster rate of growth when fed a larger daily ration.

KEY WORDS: Floating net-pens, fish rearing, growth rates, survival, enhancement, rearing costs, Harding Lake, rainbow trout, *Oncorhynchus mykiss*

INTRODUCTION

Most stocking efforts at Harding Lake from 1956 to 1987 were not successful because of low or no returns to the creel, and stocking did not result in any established fisheries. Species stocked included rainbow trout *Oncorhynchus mykiss*, lake trout *Salvelinus namaycush*, coho salmon *Oncorhynchus kisutch*, sockeye salmon *Oncorhynchus nerka*, inconnu or sheefish *Stenodus leucichthys*, and Arctic grayling *Thymallus arcticus*. Most fish were stocked at less than 10 g except for sheefish that were slightly larger. Since 1988, introductions of 40 to 660 g Arctic char *Salvelinus alpinus* have been more successful because efforts were made to stock catchable sized fish (minimum catchable size is 80 g as determined by Doxey, *In prep*) and efforts were made to inform anglers of the best locations for fishing and the best methods to use to catch Arctic char (Viavant and Clark 1991).

Although the establishment of fisheries may be made more successful by stocking larger fish, hatcheries do not have the capacity to produce additional numbers of large fish for all stocking locations requested. In addition, it is more expensive for hatcheries to produce larger fish, because each hatchery is limited to producing a certain amount of fish based on the total biomass that each raceway can accommodate. Because of these factors, an experiment was started in 1990 to determine the feasibility of rearing fish in floating net-pens at Harding Lake (Clark et al. 1991). Several species (rainbow trout, Arctic char, lake trout, Arctic grayling, and sockeye salmon) were reared during summer, 1990. Of these species, rainbow trout started at 20 g were best suited to producing large fish based on survival in the net-pens, size when released, and cost per fish.

Because sport fishery managers desired to establish a rainbow trout fishery in Harding Lake, rainbow trout were again reared in net-pens in 1991. The objectives of this study under Federal Aid Contract F-10-7, Job E-3-1(b) were:

1. to determine the survival of rainbow trout during rearing in the net-pens; and,

2. to estimate the average length and weight of rainbow trout reared in the net-pens bimonthly.

In addition to rearing rainbow trout, two experiments involving Arctic grayling were also conducted at the Harding Lake net-pens in 1991. These experiments dealt with loading densities and feeding frequencies for juveniles (less than 5 g) and the effects of hooking and releasing adults. Results of these experiments will be reported by McKinley (*In prep*) and Clark (*In prep*). However, this report will include the number and size of Arctic grayling at the start and end of these experiments. This information is included because the majority of the costs of operating the net-pens in 1991 were related to these two experiments.

Site Description

Harding Lake is a landlocked, 1,000 ha lake located 54 km south of Fairbanks, Alaska in the Tanana River drainage. Maximum depth is 43 m and surface

elevation is 217 m. The lake is bowl shaped with the littoral zone underlying 33% of the surface. Sediments consist of mostly sand or sand and gravel in shallow areas with some silty areas near shore, and loose organic material and clay in deeper areas (Nakao 1980). Productivity has been characterized as low (LaPerriere 1975, Nakao 1980), and conductivity and alkalinity are lower than other large lakes of the Tanana River drainage. The floating net-pens were located near the northeast shore in 12 m of water. A detailed description of Harding Lake and a history of stocking at Harding Lake can be found in Doxey (1991).

METHODS

Fish Rearing Techniques

On 14 June, 9,460 20 g rainbow trout from the State of Alaska Fort Richardson Hatchery were placed into four 3.6 x 3.6 x 3.6 m pens with a net mesh size of 0.635 cm at Harding Lake. Initial fork-length for this date was not available from the hatchery. The initial fork-length for these fish was estimated (using the condition factor developed for rainbow trout from Fort Richardson Hatchery) as 122 mm. Three pens held 2,500 fish each (1.07 kg/m^3), and the fourth pen held 1,960 fish (0.84 kg/m^3). Fish were fed Biodiet grower feed (Bioproducts Inc.[1]). Optimal pellet size of food was determined from a standardized table (F.R.E.D. Division Staff 1983). During the first sample period (10 - 12 days) fish were fed to satiation, which was approximately twice the daily ration calculated using standard Alaska Department of Fish and Game (ADFG) methods (F.R.E.D. Division Staff 1983). At the end of this sample period, it was determined that not all food was being consumed. For the rest of the rearing period, fish were fed to satiation, or until they had consumed a daily ration which was 1.5 times the daily ration calculated using standard ADFG methods (F.R.E.D. Division Staff 1983), based on a combination of total weight of fish present in the pen, estimated water temperature, anticipated growth rates, condition factors, and conversion factors from hatchery records and results from the experiment in 1990. Daily feed amounts ranged from 2 to 4% of body weight.

Approximately 356,000 fingerling Arctic grayling and 147 adult Arctic grayling from the state operated hatchery at Clear, Alaska were reared at the net-pens while being used in other experiments. These fish were started in the net-pens at various times and sizes (Table 1). Arctic grayling were fed according to the experimental design of each experiment. All surviving Arctic grayling reared in the net-pens were released into Harding Lake during late July or late August.

Temperature

Temperature was measured and recorded continuously at depths of 0.1 m, 1.5 m, and 3.0 m from the surface using Ryan model J-90 thermographs[2]. Cumulative

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[1] Bioproducts, Inc. Fish Feeds Division. P.O. Box 429, Warrenton, Oregon 97146.

[2] Peabody/Ryan. 402 - 6th Street South, P.O. Box 599, Kirkland, Washington.

Table 1. Growth and survival data for fish reared in floating net-pens at Harding Lake, Alaska, 1991.[a]

Species	Number Started	Number Released	Starting Weight (g)	Release Weight (g)	Number Weeks Reared	Percent Weight Gain	Percent Survival
Rainbow trout	9,460	9,347	20.0	90.6	6.8	353	98.8
Arctic grayling	196,000	186,800[b]	0.46	3.9	5.9	748	98.4
Arctic grayling	160,000	150,200[c]	0.77	2.6	4.1	238	95.4

[a] In addition to these fish, 147 Arctic grayling were started in the net pens on 15 June. These fish had an average length of 207 mm on 18 May, prior to being started in the net-pens. These fish were held in the net-pens while being used in a hook and release mortality experiment (Clark *In prep.*). On 25 August, 71 of these fish were released into Harding Lake at an average length of 235 mm, the remaining fish were killed after being used in a gastric evacuation experiment (McKinley *In prep.*).

[b] The difference between the percent survival figure and the numbers stocked and released is due to 6,000 of these fish being killed for sampling purposes. The actual number of non-sampling mortalities was 3,200.

[c] The difference between the percent survival figure and the numbers started and released is due to 2,500 of these fish being killed for sampling purposes. The actual number of non-sampling mortalities was 7,300.

degree-days were calculated as the sum of the mean of the three average daily temperatures from each depth. For the purpose of calculating growth as mm gain per degree-day, the day rainbow trout were placed in the net-pens (14 June) was used as the starting point (zero degree-days). Due to a combination of equipment failure and equipment loss, temperature data were not available until 1 July. Therefore, the number of degree-days accumulated between the 14 June and 1 July 1990 was used to estimate accumulated degree-days for the period from which data were not available in 1991. While temperature data between 14 June and 1 July of 1991 were probably somewhat different than for the same period of 1990, the number of cumulative degree-days for the same period were probably similar, since the number of cumulative degree days between 1 July and 31 July of 1990 and 1991 were quite similar (Figure 1).

Growth

Average weights of fish introduced into the net-pens were estimated at the hatcheries using standard ADFG hatchery methods (F.R.E.D. Division Staff 1983) prior to the transport of the fish to the net-pens. The number of rainbow trout and adult Arctic grayling placed in each pen was determined by counting. The number of fingerling Arctic grayling was estimated by dividing the total weight of fish placed into the net-pens by the average fish weight (calculated prior to fish transport).

Lengths and weights of individual rainbow trout were measured about 10 days after stocking (24, 25, 26 June), 18 days later (13 July), 10 days later (23 July), and about seven days later (30 July and 1 August). Three samples of 50 fish each were measured from each pen for the first sample date, and two samples of 25 were measured from each pen for all following sample dates, since it appeared that two samples of 25 would provide estimates with small enough confidence intervals to satisfy project objectives. Weights of individual fish sampled were accurate to ± 0.5 g (accuracy of electronic scale). Lengths were measured from the tip-of-the-snout to the fork-of-the-tail (fork-length; FL) to the nearest mm. Prior to measurement all fish were anesthetized with CO_2.

Average lengths and weights for rainbow trout were estimated as follows:

$$\bar{y} = \frac{\sum_{i=1}^{n} \sum_{j=1}^{m} \sum_{t=1}^{k} y_{ijt}}{n\ m\ k} \qquad (1)$$

The variances for average fish lengths and weights were calculated as follows:

$$V_{l,w} = (1-f_1) \sum_{i=1}^{n} \frac{S_{1i}^2}{n^2 m} + f_1 f_2 \sum_{i=1}^{n} \sum_{j=1}^{m} (1-f_{2ij}) \frac{S_{2ij}^2}{n^2 m^2 k} \quad ; \qquad (2)$$

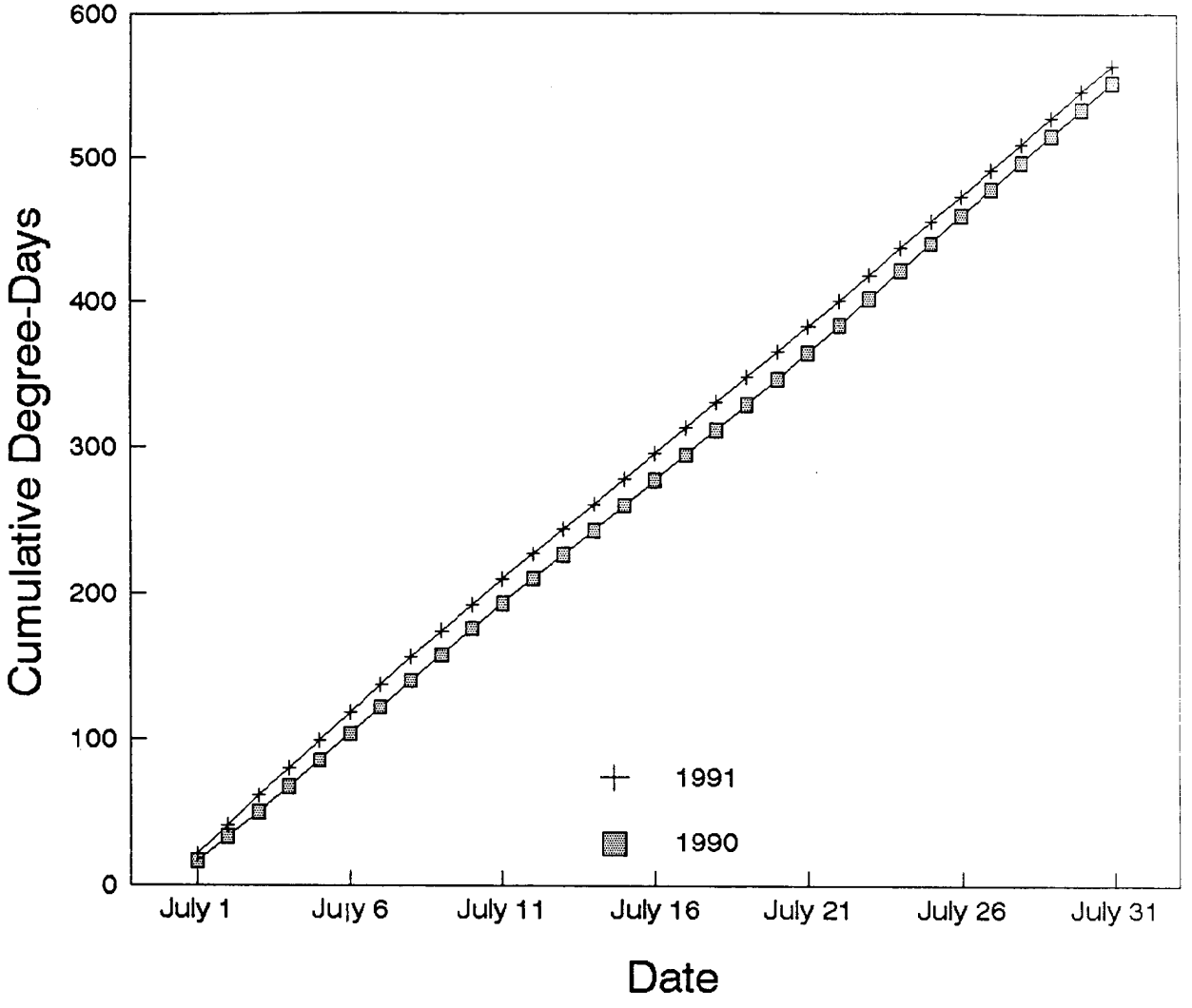

Figure 1. Cumulative degree-days for July 1990 and July 1991 from the Harding Lake net-pens. Degree days are cumulative starting from zero on July 1.

where:

$$S_{1i}^2 = \frac{\sum_{j=1}^{m} (\bar{y}_{ij} - \bar{\bar{y}}_i)^2}{m - 1} \quad ; \tag{3}$$

and,

$$S_{2ij}^2 = \frac{\sum_{t=1}^{k} (y_{ijt} - \bar{y}_{ij})}{k - 1} ; \tag{4}$$

and,

$V_{l,w}$ = variance of average length (V_l) or variance of average weight (V_w);
i = pen;
n = number of pens;
t = a fish measured for length or weight;
k = number of fish measured for length or weight in a sample;
j = a sample;
m = number of samples;
y_{ijt} = length or weight of fish t from sample j from pen i;
f_1 = fraction of fish in pen represented by sample;
f_2 = fraction of fish in sample measured for length or weight;

$\bar{\bar{y}}$ = average length or weight of fish from all samples from pen i; and,

$\bar{y}_{ij}$ = average length or weight of fish from pen i and sample j.

Conversion Rates and Condition Factors

Conversion rates (the rate of conversion of fish food into fish biomass) and condition factors (relative measure of robustness) were calculated using standard ADFG methods (F.R.E.D. Division Staff 1983). Conversion rates were calculated as follows:

$$\text{Conversion rate} = \frac{\text{Weight of feed (g)}}{\text{Weight gain of fish (g)}} . \tag{5}$$

It should be noted that because of the way conversion rates are calculated, smaller numbers represent a better rate of conversion of fish feed into fish biomass than larger numbers.

Condition factors were calculated as follows:

$$\text{Condition factor} = \frac{W}{L^3}\ (1{,}000); \qquad (6)$$

where:

W = weight of fish in g; and,
L = length of fish in mm.

Condition factors are an indication of robustness of fish based on length to weight ratios. Larger condition factors represent fatter fish, smaller condition factors represent thinner fish. Conversion rates and condition factors presented in the results section are arithmetic averages of all sampled fish from all pens for each sampling date.

Survival

Mortality and hence survival of fish in each pen was monitored by removing and enumerating the dead fish from each pen at the beginning of each day. Percent survival was determined by:

$$S = \frac{N - M}{N}\ (100); \qquad (7)$$

where:

S = percent survival,
N = number of fish stocked into each pen, and,
M = total number of mortalities from each pen.

Costs

Because the majority of the costs associated with operating the net-pen facility during 1991 was related to Arctic grayling experiments, the costs associated with rearing rainbow trout were estimated as the proportion of the total staff time, capital costs, and food costs that were judged to be due just to rearing rainbow trout. Capital costs associated with construction of the net-pen facility (Clark et al. 1991) are a one time cost and were amortized over a five year period.

Visitor Counts

During 1990 there were almost 2,500 visitors to the net-pen facility and these visitors showed a great deal of interest in angling from the floating structure. In 1991, to satisfy the desire of the angling public to fish from a floating structure and to relieve visitor pressure from the net-pen facility, a floating fishing dock was anchored about 150 m from the net-pens in 16 m of water. An automatic feeder which continuously dispensed small amounts of fish food into the water was placed on the fishing dock to attract fish. The number of visitors to the floating fishing dock and net-pen

facility was recorded each hour when staff were present at the net-pen facility.

RESULTS

Temperature

Water temperatures in the net-pens ranged from 8.5 to 21.0° C depending on time of day, date, and water depth. Water temperatures remained above 14° C down to 3 m from 1 July until the rainbow trout were released on 1 August. Cumulative degree-days at 0.1 m, 1.5 m, and 3.0 m were 866, 829, and 787, respectively, when the rainbow trout were released. The average cumulative degree-days for this period was 827. While daily temperatures during the month of July varied slightly between 1990 and 1991, the overall rate of accumulation of degree-days was similar during 1990 and in 1991 (Figure 1).

Rainbow Trout

Of the 9,460 rainbow trout that were started in the net-pens, there were 113 mortalities and 9,347 rainbow trout were released into Harding Lake at the end of the experiment. These fish were started at an average weight of 20.0 g (122 mm fork-length as calculated using the condition factor established for rainbow trout at Fort Richardson Hatchery) and released seven weeks later at an average weight of 90.6 g and an average fork-length of 188 mm. Average total weight gain over seven weeks was 353% (Table 1). Length and weight statistics associated with each sampling period are provided in Appendix A. Growth (as measured by mm per cumulative degree-day) during seven weeks of rearing was similar for each sample period (Table 2), at around 0.084 mm per cumulative degree-day. Variability in length and weight were similar for each sample period, except that weight variance was much higher for the last sample period than for any previous sample period (Table 2). Condition factors increased (fish became plumper) over the rearing period (Table 2), but were always within the range of condition factors for this species reared at Fort Richardson Hatchery. Conversion rates started out high (poor rate of conversion) at 1.132 but decreased later in the rearing period to 0.815 (Table 2).

Arctic Grayling

Of the approximately 356,000 Arctic grayling fingerlings started in the net-pens, there were 10,500 mortalities (2.9%) and 8,500 fish were killed for sampling, leaving 337,000 fish that were released into Harding Lake. Two separate groups of Arctic grayling fingerlings were reared at the net-pens, started at different sizes and reared for different time periods. The first group of Arctic grayling were started at 0.46 g and released six weeks later at 3.9 g. Average total weight gain over six weeks was 748% and survival was 98.4%. The second group of Arctic grayling were started at 0.77 g and released four weeks later at an average of 2.6 g. For these fish, average total weight gain over four weeks was 238% and survival was 95.4%.

Table 2. Average lengths, weights, condition factors, conversion factors, and growth per temperature unit for each sample date for rainbow trout reared in net-pens at Harding Lake, Alaska, 1991.

Date	Length (mm)		Weight (g)		Sample Size	Cond. Factor[a]	Conv. Rate[b]	Growth mm/CDD[c]
	Average	SE	Average	SE				
6/25/91	141.2	0.6	28.8	0.7	150	0.0102	1.132	0.083
7/13/91	158.5	1.1	49.4	0.2	50	0.0124	0.945	0.080
7/23/91	176.1	0.4	70.8	0.7	50	0.0129	0.809	0.087
7/31/91	188.5	0.7	90.6	4.1	50	0.0135	0.815	0.085

[a] Condition factor is a relative index of robustness.

[b] Conversion factor is the rate of conversion of fish food into fish biomass.

[c] CDD = cumulative degree-day.

Costs

The estimated cost associated with rearing 9,347 rainbow trout to catchable size was $6,919 or about $0.74 per fish (Appendix B). This cost includes $1,148 for amortized capital costs (construction of the net-pens), $1,848 for labor (the equivalent of one student assistant for seven weeks @ $264 per week), $1,085 for fish food, and $2,838 ($0.30 per fish cost from the hatchery) for 9,460 20.0 g rainbow trout.

Visitor Counts

From 1 July to 27 August, 1,142 people in 422 boats visited the net-pens or the fishing dock during hours when staff were present (Appendix C). Initially, more people visited the net-pen facility; but later in the summer more people were using the floating fishing dock.

DISCUSSION

Growth

Rainbow trout that were started and reared in the net-pens in 1991 grew faster than rainbow trout reared in the net-pens in 1990 (Figure 2). Fish in 1991 had a total weight gain of 353% in seven weeks compared with a total weight gain of 470% in over 11 weeks during 1990. Rainbow trout reared at the net-pens also grew faster during 1991 than during 1990 when growth was adjusted for temperature (Figure 3). Average growth was 0.084 mm/cumulative degree-day in 1991 as compared with an average of 0.054 mm/cumulative degree-day in 1990. While growth rates may be influenced by many variables, the factor most likely responsible for the increase in growth rate between 1990 and 1991 was the higher daily feed rates in 1991 (about 1.5 times the daily feed rate for 1990).

In 1990 the feeding rate was supplied at the maximum recommended for rainbow trout at a given size (F.R.E.D. Division Staff 1983). During initial start up of the experiment in 1991, fish were fed to satiation (until they were observed not taking the food). During this period fish were being fed about twice the maximum recommended amount for rainbow trout of that size (F.R.E.D. Division Staff 1983). At the end of the first sample period it was discovered that food was accumulating on the bottom of the net-pens. For the rest of the rearing period, fish were fed until satiation or until they had consumed a daily ration which was 1.5 times that supplied in 1990. In general, the fish consumed the entire ration of 1.5 times the recommended amount (fish continued to actively feed until the ration was gone and food was not accumulating on the bottom of the pens).

Zooplankton colonized the netting of the pens, and it is reasonable to assume that this additional food source was utilized to an unknown extent by rainbow trout in the net-pens, however, this condition was probably no different in 1991 than in 1990. Initial stocking densities were lower in 1991 than in 1990 (1.0 kg/m^3 in 1991 versus 1.5 kg/m^3 in 1990), and this probably also contributed to faster growth.

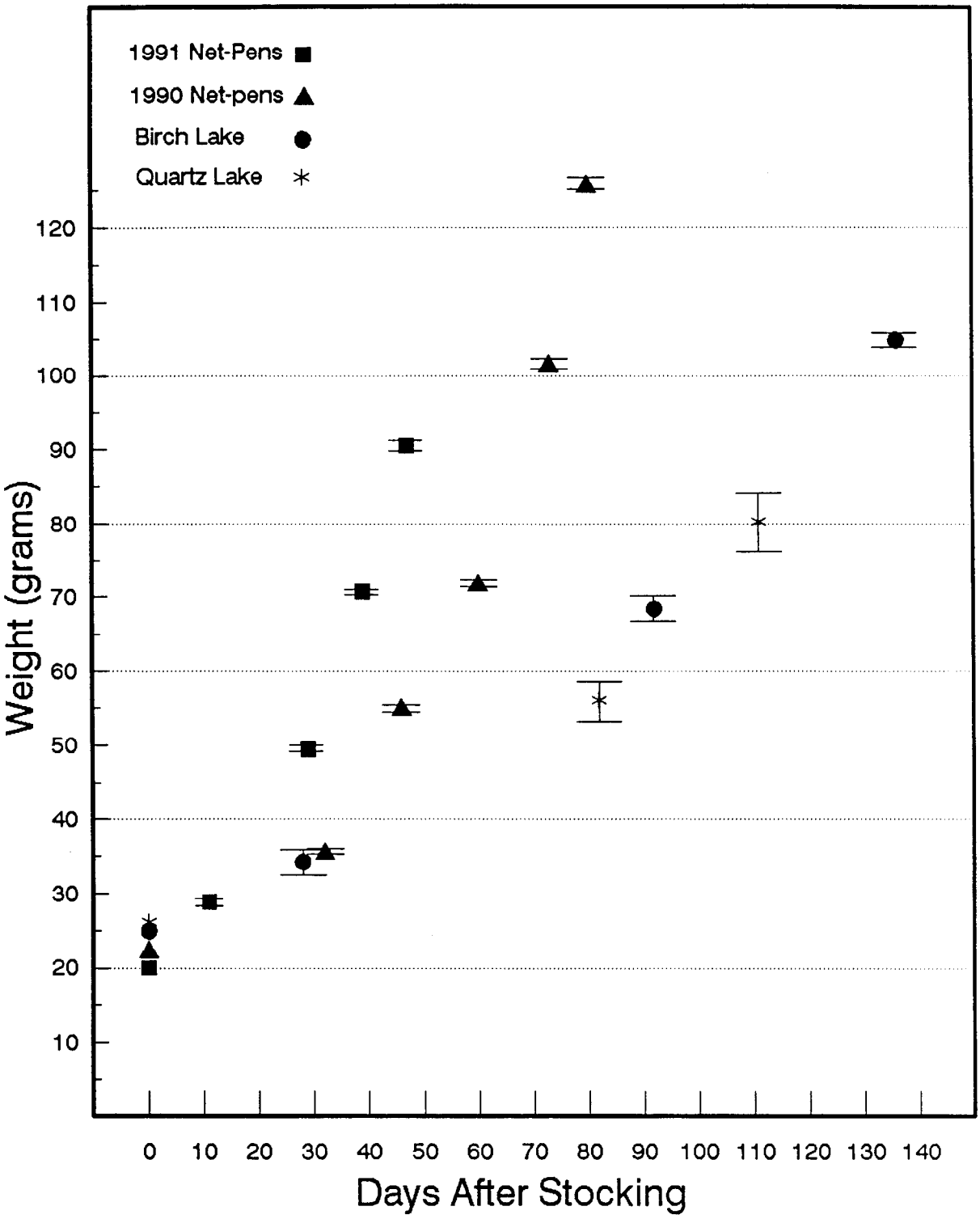

Figure 2. Average weight at time after stocking for subcatchable rainbow trout reared at the Harding Lake net-pens in 1990 and 1991, compared with average weight at time after stocking of rainbow trout stocked into Birch and Quartz lakes in 1988. Horizontal bars represent 95% confidence limits.

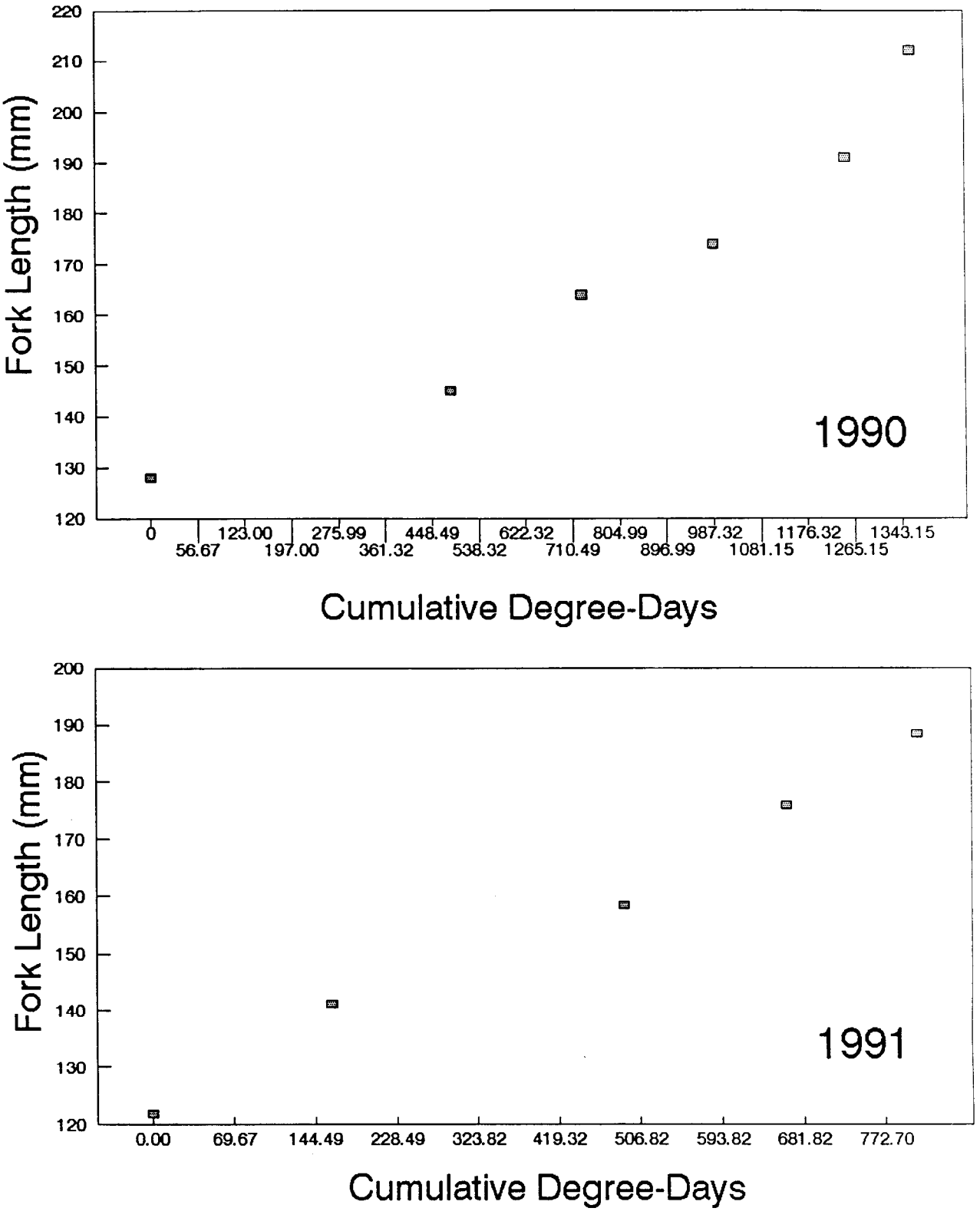

Figure 3. Size in millimeters (fork-length) versus cumulative degree-days for rainbow trout reared in floating net-pens at Harding Lake, Alaska, during 1990 and 1991.

Growth of rainbow trout reared in the net-pens was substantially faster than growth of rainbow trout stocked directly into Birch and Quartz lakes (Figure 2) which are two of the more productive lakes in interior Alaska (Doxey 1989). The average weight of rainbow trout 50 days after stocking in Birch and Quartz lakes was about 42 g compared to 91 g for rainbow trout reared in the net-pens for 49 days. This is probably the result of the constant availability of high quality feed and higher rates of metabolism of the pen reared fish because they were held in warm surface waters.

Conversion Rates and Condition Factors

The conversion rate during the first sample period was not as favorable as during subsequent sample periods (Table 2), and this was probably due to overfeeding during the first sample period. Averaged over the entire rearing period, conversion rates were more favorable in 1991 (0.925) than in 1990 (1.320). There are a number of possible factors that could have led to the more favorable conversion rates during 1991. It is possible that the type of food used was a factor, since only one brand of food was used in 1991 and this brand was used in conjunction with another brand in 1990. Stocking densities were also lower in 1991 than in 1990, which could have led to increased water quality and therefore better overall fish health and food utilization.

Condition factors increased throughout the rearing period, due in part to a high rate of feeding. In addition, fish reared in the net-pens were not subjected to a constant current flow as would be encountered in a hatchery raceway, and it is probable that energy expended by fish in the net pens was therefore lower than fish reared in a raceway. Averaged over the entire rearing period, condition factors were similar for 1991 (0.0123) and 1990 (0.0126).

Survival

Survival during 1991 was very similar to survival during 1990 (98.8% in 1991 and 99.1% in 1990). It is probable that most of the mortality during both years was from handling stress, since most mortalities occurred just after sampling or counting the fish.

Costs

The estimated cost per fish for producing catchable rainbow trout from the net-pen facility was $0.74 per fish. The estimated cost for producing catchable rainbow trout at an Alaskan Hatchery is about $1.00 per fish (Gary Wall pers. comm. 3). It would be misleading to compare these two cost estimates because they were arrived at using different methods. For example the estimated cost per fish at the net-pen facility doesn't include salaries of personnel who supervised the project, and capital costs were amortized. In contrast, the estimated cost per fish at an Alaskan hatchery includes

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[3] Wall, G. personal communication. Alaska Department of Fish and Game, Fisheries Rehabilitation, Enhancement, and Development Division, Fort Richardson Hatchery, P.O. Box 5-337, Ft. Richardson, AK, 99595-0337.

permanent personnel salaries, and does not include any amortization of capital costs. While the two cost estimates are not directly comparable, they are useful indications of the expenditure involved in rearing catchable-size rainbow trout. Costs at the net-pen facility could probably be reduced if more fish were reared, since all costs except fish food are fixed, regardless of the number of fish in the net-pens. It should also be noted that not only do the costs of producing catchable rainbow trout compare favorably with catchable rainbow trout from the hatchery, but any catchable rainbow trout produced at the net-pen facility results in extra production of large rainbow trout because the capacity of the state hatchery system for producing catchable rainbow trout is already fully utilized.

Visitor Counts

Documented visitation to the net-pens was lower than in 1990 (1,142 in 1991 versus 2,494 in 1990), however, visitor data were not collected during the month of June in 1991 but were collected during June of 1990. It is also likely that since 1991 was the second year that the pens were in the lake, fewer people visited out of curiosity, since they had visited the pens during 1990. It should also be noted that recorded visitation to the fishing dock is not an accurate reflection of the total number of visitors, as much of the use of the fishing dock probably occurred while staff were not present to record visitation. Public response regarding the net-pens and particularly the fishing dock was very positive, and anglers reported relatively high rates of success in catching stocked Arctic char from the fishing dock.

CONCLUSIONS

Results of this work in 1991 further support the conclusion of the 1990 pen-rearing project: starting subcatchable rainbow trout in the net-pens as early as possible in June is a viable option for introducing catchable-size fish into Harding Lake by early August. Rainbow trout can be reared in net-pens at Harding Lake economically by using automatic feeders and by rearing more fish each season. Rainbow trout reared in net-pens at Harding Lake can utilize food at a higher daily ration than proscribed in the F.R.E.D. manual (F.R.E.D. Division Staff 1983), and thereby achieve a faster rate of growth than if fed only at the recommended rate. Rainbow trout reared in net-pens at Harding Lake should probably be fed to satiation, however, care should be taken that all food presented is being consumed.

Public response and fishing success by anglers using the fishing dock installed at Harding Lake indicated that the dock was a success at concentrating stocked fish, making them more available to sport anglers. It is therefore recommended that further study be done regarding the feasibility of installing this and perhaps other fishing docks in Harding Lake, perhaps in conjunction with other methods of concentrating fish such as artificial reef structures.

ACKNOWLEDGEMENTS

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APPENDIX A

Appendix A. Average lengths, weights, and associated standard errors by sampling date for rainbow trout reared in floating net-pens at Harding Lake, Alaska, 1991.

Date	Pen Number	Sample Number	Length (mm)		Weight (g)	
			Average	SE	Average	SE
6/24/61	1	1	147	17	34	11
6/24/61	1	2	144	14	22	9
6/24/61	1	3	140	12	29	9
6/25/91	2	1	140	17	27	10
6/25/91	2	2	136	17	27	10
6/25/91	2	3	139	12	25	8
6/25/91	3	1	146	15	33	13
6/25/91	3	2	141	15	30	10
6/25/91	3	3	136	16	26	10
6/26/91	4	1	142	16	32	11
6/26/91	4	2	141	18	30	12
6/26/91	4	3	143	16	30	11
7/13/91	1	1	161	17	50	18
7/13/91	1	2	152	16	50	12
7/13/91	2	1	159	22	51	21
7/13/91	2	2	154	20	48	14
7/13/91	3	1	161	17	48	18
7/13/91	3	2	156	16	47	17
7/13/91	4	1	162	16	49	16
7/13/91	4	2	164	17	53	17

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Appendix A. (Page 2 of 2).

Date	Pen Number	Sample Number	Length (mm) Average	Length (mm) SE	Weight (g) Average	Weight (g) SE
7/23/91	1	1	173	14	66	17
7/23/91	1	2	178	16	71	20
7/23/91	2	1	176	15	69	22
7/23/91	2	2	178	24	76	31
7/23/91	3	1	178	19	70	25
7/23/91	3	2	173	19	67	21
7/23/91	4	1	178	19	75	23
7/23/91	4	2	176	19	72	23
7/30/91	1	1	196	18	96	29
7/30/91	1	2	188	16	82	28
7/30/91	2	1	186	21	92	31
7/30/91	2	2	183	22	84	28
8/1/91	3	1	186	24	90	27
8/1/91	3	2	182	20	80	28
8/1/91	4	1	192	16	93	26
8/1/91	4	2	194	18	106	31

APPENDIX B

Appendix B. Costs associated with rearing subcatchable rainbow trout to catchable size in floating net-pens at Harding Lake, 1991.

Expense Item			Cost (dollars)
Capital costs:[a]			1,148
Operating costs:[b]			
Labor (Student Assistant)	7 weeks	@ $264/week	1,848
Fish cost	9,460 fish	@ $0.30 each	2,838
Fish food	562 kg	@ $1.93/ kg	1,085
Total			$ 6,919

[a] This amount represents 22% (the proportion of pen space used for rearing rainbow trout) of the total capital costs of constructing the net-pens amortized over five years.

[b] Does not include costs of supervision (salary of permanent staff).

APPENDIX C

Appendix C. Public visitation to the net-pen facility and the fishing dock at Harding Lake, Alaska, 1991.

	Net-pen facility		Fishing Dock		Combined	
Date	Number of Boats	Number of People	Number of Boats	Number of People	Number of Boats	Number of People
7/01/91					7	24
7/02/91					3	10
7/03/91					8	19
7/04/91	22	80	4	10	26	90
7/05/91	2	12	1	1	3	13
7/06/91	11	43	3	7	14	50
7/07/91	14	52	6	16	20	68
7/08/91					0	0
7/09/91					7	18
7/10/91					4	9
7/11/91					11	24
7/12/91					6	13
7/13/91	0	0	4	21	4	21
7/14/91	3	11	6	20	9	31
7/15/91					3	9
7/16/91	0	0	1	4	1	4
7/17/91	1	3	1	4	2	7
7/18/91					6	11
7/19/91					8	15
7/20/91	13	39	1	2	14	41
7/21/91	11	27	0	0	11	27
7/22/91	2	8	6	8	7	16
7/23/91					9	26
7/24/91	3	4	4	5	7	9
7/25/91					4	7
7/26/91					9	19
7/27/91					21	58
7/28/91	6	14	11	32	17	46
7/29/91					2	3
7/30/91	1	5	3	6	4	11
7/31/91	2	7	1	2	3	9
8/01/91					2	3
8/02/91					4	16
8/03/91					10	28
8/04/91					7	18
8/05/91					4	9
8/06/91					2	6
8/07/91					4	9
8/08/91					4	8
8/09/91					0	0
8/10/91	16	38	4	16	20	54
8/11/91	8	27	4	12	12	39
8/12/91					7	16

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Appendix C. (Page 2 of 2).

Date	Net-pen facility		Fishing Dock		Combined	
	Number of Boats	Number of People	Number of Boats	Number of People	Number of Boats	Number of People
8/13/91					4	9
8/14/91					3	8
8/15/91	1	2	1	2	2	4
8/16/91	2	10	7	16	9	26
8/17/91					12	38
8/18/91	0	0	14	31	14	31
8/19/91	0	0	6	12	6	12
8/20/91	0	0	5	14	5	14
8/21/91	1	2	4	14	5	16
8/22/91	0	0	4	11	4	11
8/23/91	0	0	4	9	4	9
8/24/91	2	6	11	32	13	38
8/25/91	4	9	7	18	11	27
8/26/91	0	0	3	7	3	7
8/27/91	0	0	1	2	1	2
Totals	125	399	127	334	422	1,142