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Evaluation of Enhancement Efforts for Rainbow Trout in Southcentral Alaska, 1990

by

Alan C. Havens

August 1991

Alaska Department of Fish and Game

Division of Sport Fish

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ABSTRACT

Experiments were conducted to provide information for the development of improved stocking practices for hatchery-reared rainbow trout *Oncorhynchus mykiss* in landlocked lakes.

In a set of experiments, 1+ gram rainbow trout of Swanson River origin were stocked at densities of 100, 200, 400, or 800 per surface acre in July 1989 in landlocked lakes for comparison of survival to age 1 and comparison of mean length at age 1 and age 1+. In May or June 1990, estimated survivals for the trout stocked at 100 per surface acre in three lakes averaged 18 percent, at 200 per acre in three lakes averaged 34 percent, at 400 per acre in three lakes averaged 15 percent, and at 800 per acre in four lakes averaged 11 percent. In September or October 1989, mean lengths at age 1+ for trout stocked at 100 per surface acre averaged 197 millimeters, at 200 per acre averaged 187 millimeters, at 400 per acre averaged 192 millimeters, and at 800 per acre averaged 166 millimeters. We recommend this stocking density experiment be continued an additional year but modified to exclude the 400 and 800 per surface acre densities and add four lakes stocked at 50 per surface acre to determine the effects of annual fingerling releases on trout survival and growth.

In another experiment, 2-3 gram triploid (sterile) rainbow trout and diploid (normal) rainbow trout of the Swanson River origin were stocked at approximately equal densities in Johnson Lake in September 1989 to continue comparisons of survival and mean length at age 1. Survival at age 1 for the triploid group was estimated at 58 percent while estimated survival for diploid trout was 69 percent. Mean lengths at age 1+ were 196 millimeters and 217 millimeters for the triploid and diploid trout, respectively. Survival of the 1988 stocked triploid trout to age 2 was 11 percent with a 300 millimeter mean length at age 2+, while diploid trout survival to age 2 was 10 percent, and age-2+ mean length was 320 millimeters. Triploid rainbow (100 percent determined to be triploid as in the 1989 plant) and diploid trout were planted in Johnson Lake in 1990. We recommend this experiment be continued to determine if sterile fish have a greater rate of growth and survival through several age classes.

In another experiment, 2.5 gram select (selected at the hatchery for rapid growth and early spawning) rainbow trout and production (normal) rainbow trout of the Swanson River origin were stocked at approximately equal densities in Reed Lake in August 1989 for comparisons of survival and mean length at age 1. Survival at age 1 for the select group was estimated at 26 percent while estimated survival for production trout was 32 percent. Mean lengths at age 1+ were 269 millimeters and 276 millimeters for the select and production trout, respectively. We recommend this experiment be continued to determine if the select fish have a greater rate of growth and survival through several age classes.

KEY WORDS: Southcentral Alaska, lake stocking practices, rainbow trout, *Oncorhynchus mykiss*, abundance, growth, survival.

INTRODUCTION

Stocked lakes benefit sport anglers and industries related to sport fishing by providing diverse, year-round fishing opportunities and by diverting pressure from natural stocks. In Southcentral Alaska, selected landlocked lakes have been stocked on an annual or biennial basis with hatchery-reared game fish since 1952. The majority of these lakes, ranging in size from approximately 3 to 200 surface hectares, were barren or contained only threespine stickleback *Gasterosteus aculeatus* prior to stocking. The lakes are stocked with rainbow trout *Oncorhynchus mykiss*, Arctic grayling *Thymallus arcticus*, landlocked salmon *Oncorhynchus spp.*, or Arctic char *Salvelinus alpinus* depending on the nature of the water to be stocked, the availability of fish for stocking, and the desires of the angling public for diversified fishing opportunities.

To date, the stocking program has had mixed results. Although stocked fish contribute to the sport catch and harvest, survival of stocked fish has been poor. The impact of stocking procedures on the resultant survival and growth of stocked fish must be determined.

This report presents research results on the effects of brood stock selection, triploidy, and stocking density on the survival of rainbow trout in landlocked lakes in Southcentral Alaska. This research will be used to devise stocking procedures that maximize the survival of stocked fish in the most cost-efficient manner.

METHODS

Rainbow trout of the Swanson River origin were stocked in 17 Matanuska-Susitna Valley lakes (Figure 1, Appendix A1) in 1989 for experiments to be performed in 1990 (Appendix 2). To determine the effects of stocking density on rainbow trout survival and growth, Lynne, Tigger, Vera, and Walby lakes were planted with 1 gram rainbow trout fingerlings at approximately 100 per surface acre; Barley, Carpenter, Morvro, and "X" lakes at approximately 200 per acre; Diamond, Kalmback, and Long (K/B) lakes at approximately 400 trout per surface acre; and Dawn, Crystal, Honeybee, and Little Lonely lakes at approximately 800 per surface acre.

To determine if there were significant differences in survival and growth between Swanson River strain triploid (sterile) rainbow trout and Swanson River strain diploid (normal) rainbow trout, 2,057 fingerlings that had been exposed to temperature shock at the egg stage and 2,017 normal fingerlings were planted at a size of 2.65 and 3 grams, respectively, in Johnson Lake in September 1989. The triploid fingerlings, of which 100% were estimated to be triploid by blood analysis (Carmen Olito, Ft. Richardson Rainbow Trout Brood Stock Center, personal communication), were marked with a right ventral finclip whereas the normal fingerlings received a left ventral finclip. Johnson Lake is closed to sport fishing.

To determine if there were significant differences in survival and growth between Swanson River strain "select" (selected at the hatchery brood stock facility for early spawning and rapid growth) rainbow trout and production

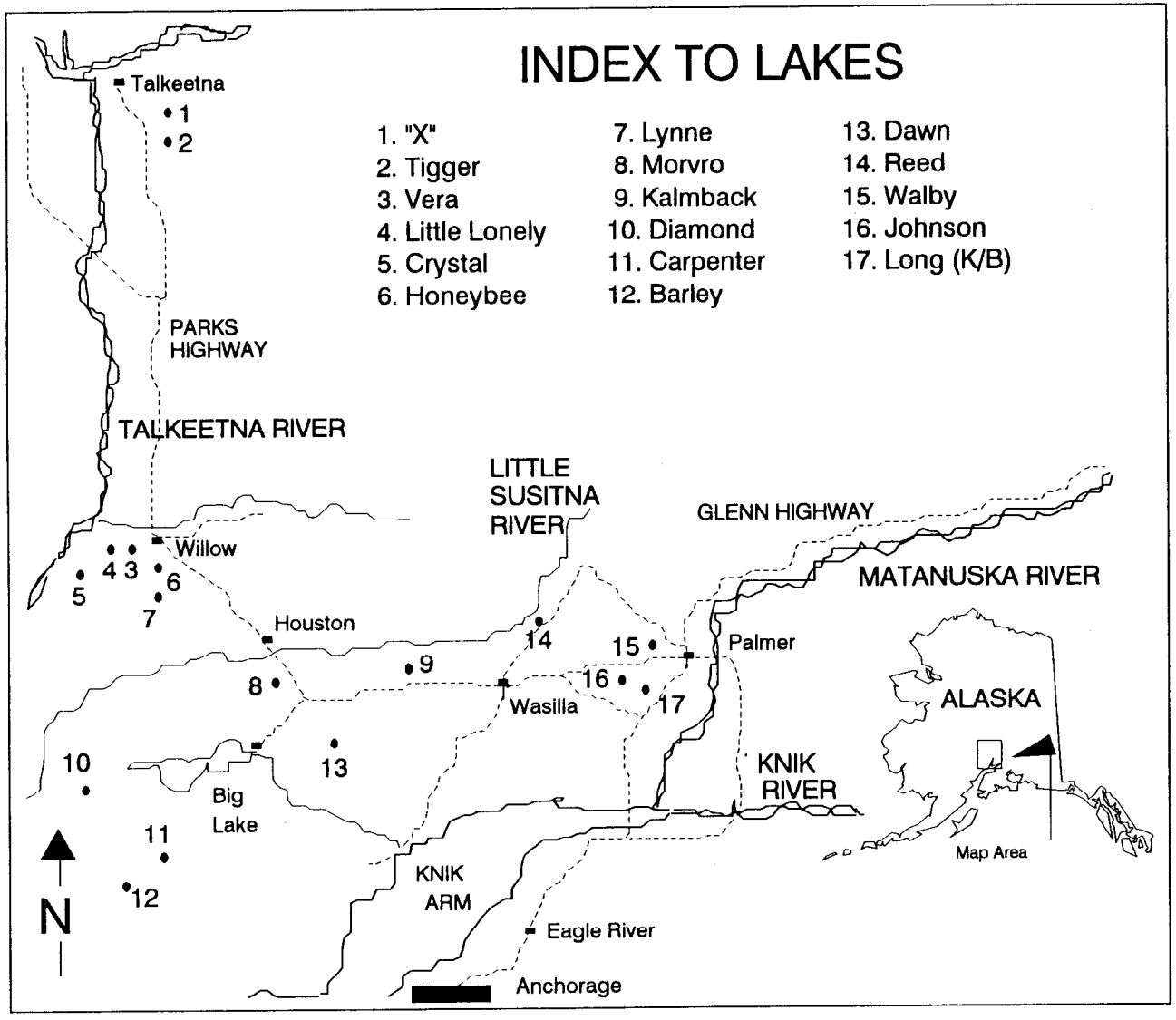

Figure 1. Sample lakes area of the Matanuska-Susitna Valley, 1989-1990.

Swanson River strain "normal" rainbow trout, 1,912 select fingerlings and 1,916 normal fingerlings were planted at a size of 2.5 grams in Reed Lake in August 1989. The select fingerlings were marked with a right ventral fin clip whereas the normal fingerlings received a left ventral finclip.

Rainbow Trout Sampling

Rainbow trout were captured for marking purposes in May or June 1990, released to mix throughout the lake for approximately 3 months, then sampled for marked-unmarked ratios in September or October 1990.

Rainbow trout were captured using fyke nets. The fyke nets were 2.7 m (9 ft) in length, 0.8 m (30 in) in diameter, and included two 0.9 m (3 ft) by 6.1 m (20 ft) wings (two square aluminum frames and six steel or aluminum hoops supported the entrance and body of the fyke net). Internal throats, body, and wings were 4.8 mm (3/16 in) square mesh knotless nylon. Salmon eggs were used as bait in fyke nets. Fyke nets were set parallel to the shoreline in randomly selected sites and directions and fished for approximately 24 hours each.

Rainbow trout captured in fyke nets were placed in a tub, oxygenated with a portable 7.5 kg (20 lb) oxygen bottle, and anesthetized with equal parts of MS-222 and Quinate. The fish caught were measured for fork length (FL) to the nearest millimeter.

During the spring marking event, it was necessary to distinguish between unmarked age-1 and age-2 fish in the field. Age-1 and age-2 fish were distinguished by length. However, it was necessary to establish a pivotal length for each lake due to differences in growth. During the 1989 sampling, some age-1 fish were adipose finclipped and these fish were then age 2 during 1990. In 1990, the first couple of trap loads for each lake were examined for the smallest adipose finclipped fish. The length of this fish was then used as the pivotal length during the spring marking event for that lake. Since some overlap between ages occurred in the spring, fish were sampled for scales and the true ages were used to correct for mis-aging in the field using procedures presented later in this document.

Age-1 trout were adipose finclipped (during the marking session) and placed in a 1.2 m (4 ft) by 1.2 m (4 ft) by 2.4 m (8 ft) covered holding pen made of plastic pipe enclosed with 4.8 mm (3/16 in) knotless nylon mesh; age-2 and older trout were marked with a numbered dart tag and released. Upon completion of the capture session fish were released from the holding pen. In the spring and fall, all untagged diploid and triploid age-2 trout in Johnson Lake were marked with a numbered anchor tag before release and in the fall all age-1+ rainbow trout in Johnson Lake and Reed Lake were marked with a numbered anchor tag for identification in following years.

Abundance Estimator

In 1990, two population estimates were made, the first of age-1+ rainbow trout stocked in 1989 and adipose finclipped in the spring of 1990, and the second

of age-2+ and older rainbow trout, tagged in the spring of 1990. Recapture events for both groups were in the fall of 1990.

Growth Recruitment:

The methods of Robson and Flick (1951) were used to separate the two groups in the fall; the trout which were too small to tag and received adipose finclips and were considered age 1+, and the larger trout which received tags and were considered age 2+ and older. This was necessary as the length frequencies of the two age groups had overlapped in the fall due to growth.

The number of untagged fish for each marked fish within any length interval i to i+1 was represented by μ_i, and for any length class should be equal to the ratio of total number of untagged to total tagged (Seber 1982). The method of Robson and Flick (1951) compares this ratio for each length class to the ratio for all fish at that size and larger. If there has been no growth recruitment of smaller fish since tagging, there should be no significant difference in this ratio for a length class when compared to the overall ratio for larger fish. The quantity, μ_{r+1}, represented the tagged-to-untagged ratio for all lengths above the smallest size, r, at which recruitment was found to be non-significant. This ratio was estimated by:

$$\bar{\mu}_{r+1} = \frac{\sum_{i=1}^{m+1-r} \mu_{r+i}}{m+1-r} \qquad [1]$$

where:

m = the number of marked fish, and

$$Var(\bar{\mu}_{r+1}) = \frac{\sum_{i=1}^{m+1-r} (\mu_{r+i} - \bar{\mu}_{r+i})^2}{(m+1-r)(m-r)} . \qquad [2]$$

Abundance Estimate for Age-2+ and Older Rainbow Trout:

The ratio of untagged to tagged rainbow trout from size classes found to have been fully recruited to the taggable population was used to estimate the population abundance of age 2+ and older by:

$$N_2 = (T+1)\ (\bar{\mu}_{r+1}+1) - 1 \qquad [3]$$

where:

T = number of tagged fish released, and

$$\text{Var}(N_2) = (T+1)^2 \text{ Var}(\bar{\mu}_{r+1}). \quad [4]$$

Abundance Estimate for Age-1+ Rainbow Trout:

The abundance of age-1+ rainbow trout for any length class, ℓ, that were too small to be tagged in the spring was estimated by:

$$n_{1s} = n_{1u} - \bar{\mu}_{r+1}\, m_1 \quad [5]$$

where:

n_{1s} = unrecruited rainbow trout in sample between sizes ℓ and ℓ-1,

n_{1u} = all untagged rainbow trout between size ℓ and ℓ-1, and

m_1 = number of tagged rainbow trout between ℓ and ℓ-1.

The total number of rainbow trout in the fall sample (C) that were not of taggable size in the spring was then the sum of all the n_{1s} over all size classes.

Adipose-clipped age-2 rainbow trout captured in the fall sample were assumed to be unrecruited to taggable size in the spring. Their abundance was calculated in the same manner as for age-1+ rainbow trout.

The abundance at time of marking of age-1+ rainbow trout, N_1, was estimated by:

$$\hat{N}_1 = \frac{(M+1)\,(R+1)}{(C+1)} - 1 \quad [6]$$

and the variance by:

$$\text{Var}\,(\hat{N}_1) = \frac{(M+1)\,(C+1)\,(C-R)\,(M-R)}{(R+1)^2\,(R+2)} \quad [7]$$

where:

M = number of adclipped age-1+ fish released in the spring.

This was a minimum estimate of variance as the variance due to μ_{r+1} was unaccounted for.

The assumptions for both of these estimates were:

1. there was no recruitment or immigration into the population or emigration out between sampling events,

2. marking did not affect the catchability,

3. all fish had an equal chance of being caught in the recapture sample or marked fish had completely mixed with unmarked fish prior to the recapture sample, and

4. there was no marking mortality and all recaptured fish were recorded.

An additional assumption must be made that all age-1+ fish taken in the fall sampling were equally vulnerable to the gear in the spring. If some age 1+ were not vulnerable to the gear in the spring, but were vulnerable in the fall due to three month's growth, the ratio of unclipped to clipped trout would be biased. A Kolmogorov-Smirnov test was used to test the hypothesis that the length distribution of clipped and unclipped fish in the age-1+ group taken in the fall did not differ.

Equal Probability of Capture:

Marked fish were released at approximately the middle of each lake. An important assumption of the Petersen estimator is that marked fish are completely mixed with the unmarked population, or that all fish have equal probability of capture. This assumption would be met if the separate marked fish migrate and mix throughout the lake prior to a recapture sample, or if the recovery effort was equally distributed throughout the lake. In order to test this assumption, a chi-square test of homogeneity was used to test the hypotheses that the ratio of marked to unmarked rainbow trout in fyke nets fished in various areas did not change around the perimeter of each lake.

Survival of Age-1+ Rainbow Trout

Survival to age 1+ of stocked rainbow trout was estimated as:

$$S = \frac{\hat{N}_1}{N_0} \qquad [8]$$

where:

N_0 = number stocked, and,

$$Var(S) = \frac{Var(N_1)}{N_0^2} . \qquad [9]$$

Effect of Stocking Densities

The effect of stocking density on survival and growth of rainbow trout was evaluated by comparison among treatments of:

1. survival of rainbow trout to age 1+ from stocking in the previous year,

2. the number of rainbow trout per acre per 100 fish stocked per acre, and

3. the number of fishery recruits[1] per acre per 100 fish stocked per acre (rainbow trout greater than 165 mm in the fall of 1990).

A non-parametric Kruskal-Wallis one-way ANOVA was used to test the null hypotheses that these parameters did not differ among the four treatments or stocking densities.

RESULTS AND DISCUSSION

In 1990, 17 lakes were successfully sampled in the spring and 15 in the fall (Appendix A2). Some problems were encountered in sampling four lakes.

On 29 May 1990, we observed water levels had increased in Lynne Lake to a point where a fish passable stream was flowing between Lynne and Honeybee lakes through a culvert that normally had a 2-3 foot drop into Honeybee Lake. Honeybee Lake water level was 11 feet higher than in fall 1989. The tagging crew estimated there were approximately 20 age-1, 60 age-2, and 20 age-3 or older (spawning size) rainbow trout in the interconnecting stream on that date. The tagging crew marked fish in Lynne Lake on 30 May and in Honeybee Lake from 31 May through 8 June. During that time period, the numbers of rainbow trout in the interconnecting stream decreased daily as someone partially dammed the stream flowing out of Lynne Lake. A total of eight rainbow trout between 172 mm and 329 mm were recaptured in Honeybee Lake that had been tagged in Lynne Lake on 30 May. On 14 June, there was evidence that someone had used heavy equipment and loads of gravel to permanently dam the stream where it flowed out of Lynne Lake; lake water levels were receding, there was a drop-off at the Honeybee Lake end of the culvert, and no fish were observed in the stream. At the time we stocked fingerling rainbow on 13 July 1990, water levels in both Lynne and Honeybee lakes had receded almost down to levels observed in fall 1989, the interconnecting stream was still dammed, and no fish were observed in the small trickle of water between the two lakes. At the time of sampling for recapture in September 1990, the stream was still dammed and no fish were observed; we captured three trout in Lynne Lake that had been tagged in Honeybee Lake and one Lynne Lake tagged trout was captured in Honeybee Lake. Those rainbow trout were between 176 mm and 245 mm at time of marking and probably moved between the lakes within a few days of being tagged. It is unlikely there was much movement of smaller age-1 rainbow trout between the two lakes.

Tigger Lake and "X" Lake were eliminated from the experiment. During the fall sampling session in 1989, no age-0+ rainbow trout were observed in either lake. During the spring marking session in 1990 in Tigger Lake, no age-1 rainbow trout were observed, although we did tag 38 age-2 and older trout. On 19 June 1990 we sampled "X" Lake; water levels in both "Y" and "X" lakes had increased to a point where the lakes were interconnected via a narrow dead-water channel. Fyke nets caught Arctic grayling and age-1 rainbow trout that

[1] Fishery recruits in 1991.

were able to swim into "X" Lake from "Y" Lake after ice-out. At that time we installed a fish-proof dam between the two lakes. We marked all rainbow trout captured in "X" Lake. The fish-proof dam was still in place when "X" Lake was stocked on 26 July 1990. We did not get back to sample Tigger or "X" lakes in fall 1990 as they had iced-up by the time we completed sampling the other 15 experimental lakes.

Equal Probability of Capture

During the spring marking session, rainbow trout were released at approximately the middle of each lake. During the fall recapture session, we measured and recorded the numbers of marked and unmarked fish captured in each fyke net. Comparison of the ratio of marked to unmarked age-1+ trout using chi-square tests of homogeneity were not significant in any lakes for the clip ratios, but the tagged-to-untagged ratios were significantly different in 4 of the 15 lakes sampled during the fall (Table 1). However, in these four lakes (Carpenter, Diamond, Crystal and Dawn lakes), the number of recaptured tags was small, with tag-to-untagged ratios less than 2%.

Stocking Density Experiments

Population Estimates:

The estimates of age-2+ and older trout, after accounting for growth recruitment, ranged from 600 to 9,400 trout (Table 2). The number per surface acre ranged from 4.5 to 162 fish per acre, averaging 63, 44, 50, and 59 fish per acre in the lakes stocked at 100, 200, 400, and 800 fish per acre, respectively (Table 2). The most variability was found among lakes stocked at 800 per surface acre, with Crystal Lake estimated to have 4.5 fish per acre and Honeybee Lake 162 fish per acre. One lake, Kalmback Lake, did not have sufficient tag recoveries to allow an estimate of rainbow trout age 2+ and older. The precision of the estimates ranged from 4% to 51% (Table 2).

The abundance of age-1+ trout ranged from 364 in Walby Lake to 15,315 in Kalmback Lake (Table 3). The number of fish surviving per surface acre ranged from 6.7 in Walby Lake to 96.9 in Kalmback Lake, averaging 18, 69, 56, and 81 trout per acre in lakes stocked at 100, 200, 400, and 800 per acre, respectively. The relative precision of these estimates ranged from 6% to 26% (Table 3).

Comparisons of the length distributions of clipped and unclipped age-1+ rainbow trout were significant for 7 of 13 lakes sampled in the fall (Table 4). Most of these significant tests were for lakes stocked at 400 and 800 trout per acre (Table 4). For most of these lakes, the ratio of clipped to unclipped trout increased with increasing size of age-1+ trout. In Walby Lake, stocked at 100 per acre, no rainbow trout in the smallest size range, 110-200 mm, were clipped, but the clip ratio did not vary significantly for the larger age-1+ trout. The smaller size group was culled from the unclipped trout prior to making the abundance estimate. A possible reason for the varying clip ratios in some lakes is that small age-1+ trout were not vulnerable to the gear in the spring but after 3 months of growth were recruited to the fall sampling. The result of this would be to overestimate the abundance of

Table 1. Comparison of mark ratios among fyke nets in selected Matanuska-Susitna Valley lakes, 1990.

Lake	Sample Size	df	Tagged to Untagged			Clipped to Unclipped		
			χ^2	P	Ratio	χ^2	P	Ratio
Johnson	1,117	19	35.38	0.013	0.862	27.77	0.088	0.739
Reed	205	9	3.75	0.927	0.518			
Lynne	359	9	9.28	0.412	0.032	11.32	0.250	0.419
Vera	1,433	9	8.72	0.464	0.030	19.03	0.025	0.343
Walby	141	16	14.98	0.526	0.052	16.59	0.413	0.549
Barley	276	9	6.78	0.660	0.074	11.99	0.213	0.533
Carpenter	2,296	8	24.44	0.002	0.008	11.28	0.186	0.125
Morvro	848	9	13.83	0.128	0.019	8.58	0.477	0.275
Diamond	860	9	28.47	0.001	0.019	5.37	0.801	0.333
Kalmback	2,747	9	16.50	0.057	0.000	18.54	0.029	0.429
Long (K/B)	386	12	5.73	0.929	0.051	14.48	0.271	0.538
Crystal	1,017	19	40.56	0.003	0.013	30.35	0.048	0.258
Honeybee	1,284	9	21.50	0.011	0.109	12.84	0.170	0.237
Little Lonely	1,611	16	9.82	0.456	0.232	22.70	0.012	0.851
Dawn	380	9	25.78	0.002	0.013	4.11	0.904	1.303

Table 2. Population estimates for age-2+ and older rainbow trout in selected Matanuska-Susitna Valley lakes, 1990.

Lake	Tagged In Spring	Recovered In Fall	Unmarked per Marked Estimate	Unmarked per Marked Variance	Abundance Estimate	95% CI Lower	95% CI Upper	% RP[a]	Number per Surface Acre
Lynne Lake	485	11	11.78	1.729	6,209	4,957	7,462	20	88.7
Vera Lake	441	41	18.60	0.996	8,662	7,798	9,527	10	78.4
Walby Lake	292	7	3.11	0.136	1,204	992	1,415	18	22.3
Barley Lake	277	19	3.28	0.010	1,188	1,134	1,242	5	63.9
Carpenter Lake	758	17	7.56	1.862	6,498	4,468	8,528	31	36.8
Morvro Lake	167	15	14.57	11.220	2,615	1,512	3,718	42	30.2
Diamond Lake	461	17	4.53	0.250	2,553	2,101	3,006	18	18.4
Kalmback Lake	136	1							
Long Lake	688	18	7.93	0.625	6,151	5,084	7,218	17	82.7
Crystal Lake	256	13	1.33	0.362	598	295	901	51	4.5
Dawn Lake	134	5	5.00	1.540	809	481	1,137	40	68.6
Little Lonely Lake	1533	284	1.77	0.003	4,242	4,080	4,404	4	2.8
Honeybee Lake	1304	86	6.19	0.041	9,387	8,868	9,906	5	161.8

[a] Percent relative precision = 1.96 * SE.

Table 3. Population estimates for age-1+ rainbow trout of Swanson River origin in selected Matanuska-Susitna Valley lakes, 1990.

Lake	Adipose Clipped Spring (Mark)	Fall		Abundance Estimate	95% CI		% RP[a]
		Total	Adipose Clipped		Lower	Upper	
Lynne Lake	466	214	59	1,672	1,340	2,005	20
Vera Lake	694	628	172	2,526	2,249	2,803	11
Walby Lake	191	58	30	364	285	444	22
Barley Lake	271	195	37	1,402	1,035	1,769	26
Carpenter Lake	1,557	2,142	217	15,315	13,532	17,098	12
Morvro Lake	569	598	88	3,835	3,163	4,507	18
Diamond Lake	1,191	765	178	5,100	4,499	5,701	12
Kalmback Lake	3,071	2,703	685	12,108	11,418	12,797	6
Long Lake	715	213	57	2,641	2,089	3,193	21
Crystal Lake	2,380	987	207	11,309	10,007	12,610	12
Dawn Lake	587	352	197	1,047	969	1,126	7
Little Lonely Lake	1,507	1,061	452	3,534	3,328	3,740	6
Honeybee Lake	828	683	114	4,930	4,170	5,689	15

[a] Percent relative precision = 1.96 * SE.

Table 4. Results of Kolmogorov-Smirnov tests comparing length distributions of clipped and unclipped age-1+ rainbow trout in selected Matanuska-Susitna lakes, 1990.

Lake	Number		D	P
	Unclipped	Clipped		
Lynne Lake	196	79	0.145	0.19
Vera Lake	610	246	0.118	0.02
Walby Lake	73	34	0.614	0.001
Barley Lake	156	37	0.146	0.55
Carpenter Lake	1,921	216	0.075	0.23
Morvro Lake	517	89	0.151	0.06
Diamond Lake	584	167	0.255	0.001
Kalmback Lake	1,997	662	0.171	0.001
Long Lake	157	51	0.152	0.33
Crystal Lake	767	196	0.305	0.001
Dawn Lake	158	201	0.072	0.74
Little Lonely Lake	658	526	0.242	0.001
Honeybee Lake	551	100	0.162	0.024

age-1+ trout recruited to the gear in the spring. However, at the same time, we also want to account for the age-1+ trout that were too small to be taken in the spring, but that were available in the fall. Thus the estimates of abundance and of survival to age 1+ in the spring must be considered biased to some unknown degree for these lakes.

Length Distributions:

In May or June 1990, mean length of age-1 rainbow trout averaged 118 mm, 108 mm, 107 mm, and 102 mm for trout that had been stocked at densities of 100, 200, 400, and 800 fish per acre, respectively (Table 5). By September or October 1990, mean lengths of age-1+ rainbow trout that had been stocked at 100 per acre averaged 197 mm, at 200 per acre averaged 187 mm, at 400 per acre averaged 192 mm, and at 800 per acre rainbow trout mean length was 166 mm (Table 5).

Comparison of Stocking Densities:

Estimated survivals at age 1+ for Swanson strain rainbow trout stocked at 1 g at a density of 100 fish per surface acre in three lakes averaged 18% (range 7% to 24%), at 200 per acre in four lakes averaged 34% (range 22% to 43%), at 400 per acre in three lakes averaged 15% (range 9% to 23%), and at 800 per acre in four lakes averaged 11% (range 8% to 11%) (Table 6).

Rainbow trout considered to be of harvestable size, that is greater than 164 mm fork length at age 1+, averaged 85% of the estimated population for the group of lakes stocked at 100 fish per acre, 84% in 200 per surface acre lakes, 77% in 400 per surface acre lakes, and 47% in 800 per surface acre lakes (Table 7). Two of the lakes stocked at 800 fish per surface acre produced less than 10% age-1+ trout over 164 mm.

The number per acre of age-1+ trout over 164 mm averaged 15, 56, 41, and 40 fish per acre for stocking densities of 100, 200, 400, and 800 per acre. The number of trout over 164 mm produced per 100 stocked per acre averaged 15, 28, 10, and 5 for stocking densities of 100, 200, 400, and 800 per acre (Table 7).

The nonparametric analysis of variance did not find significant differences among the four treatment groups for survival or total number of trout per acre per 100 stocked (Table 8). The test comparing the number of fish per acre over 165 mm per 100 stocked among treatments was found to be significant at the 10% significance level ($\chi^2 = 7.1$, $P = 0.07$, $df = 3$).

The results demonstrated that lakes stocked at 400 and 800 per acre produced significantly fewer rainbow trout over 165 mm by the end of the first year than lakes stocked at lower densities.

Recommendations:

We recommend this stocking density experiment be continued an additional year but modified to exclude the 400 and 800 per surface acre densities and add four lakes stocked at 50 per surface acre to determine the effects of annual fingerling releases on trout survival and growth.

Table 5. Stocking history and length data for age-1 rainbow trout of Swanson River origin captured by fyke net in selected Matanuska-Susitna Valley lakes, 1990.

Lake	Date Stocked	Number Stocked	Fish/ Acre	Fish/ Shoreline Mile	Size Stocked	Date Captured	Number Measured	Length Mean (mm)	Length SE	Length Range (mm)
Lynne	07/19/89	6,990	100	3,679	1.40 g	05/30/90	466	121	1	76-158
						09/25/90	204	187	1	143-220
Tigger	07/13/89	2,020	107	2,245	1.50 g	06/22/90	0			
Vera	07/19/89	11,025	100	3,938	1.30 g	06/15/90	694	133	1	83-173
						09/19/90	682	182	2	125-240
Walby	07/19/89	5,390	100	3,850	1.50 g	05/11/90	191	99	1	68-132
						10/11/90	78	223	5	128-301
Barley	07/19/89	3,720	200	4,650	1.50 g	05/11/90	271	101	1	76-130
						09/06/90	190	199	1	144-246
Carpenter	07/19/89	35,280	200	9,284	1.10 g	05/23/90	1,557	109	1	78-140
						09/28/90	2,145	171	1	118-223
Morvro	07/20/89	17,320	200	9,622	1.10 g	05/31/90	569	113	1	71-148
						09/27/90	611	192	2	142-235
"X"	07/13/90	20,487	202	6,402	1.50 g	06/22/90	0			

-continued-

Table 5. (Page 2 of 2).

Lake	Date Stocked	Number Stocked	Fish/ Acre	Fish/ Shoreline Mile	Size Stocked	Date Captured	Number Measured	Length Mean (mm)	Length SE	Length Range (mm)
Diamond	07/20/89	55,600	400	20,593	1.10 g	05/18/90	1,191	93	1	64-127
						10/03/90	753	187	1	119-265
Kalmback	07/20/89	52,000	416	24,174	1.50 g	05/23/90	3,071	114	1	67-157
						10/03/90	1,598	177	1	113-229
Long (K/B)	07/13/89	29,914	402	12,464	1.50 g	05/18/90	715	114	1	74-153
						09/14/90	218	211	2	132-295
Crystal	07/19/89	105,442	801	37,658	1.50 g	06/15/90	2,380	91	1	57-135
						09/21/90	619	123	1	97-156
Honeybee	07/19/89	46,150	796	20,065	1.40 g	06/08/90	828	119	1	75-168
						09/26/90	872	186	1	135-243
Little Lonely	07/19/89	44,805	800	24,892	1.30 g	06/08/90	1,507	97	1	66-123
						09/19/90	1,008	140	1	103-191
Dawn	07/19/89	9,440	800	15,733	1.50 g	05/10/90	587	102	1	75-168
						10/05/90	265	209	2	133-261

Table 6. Survival from stocking in 1989 of age-1+ rainbow trout (of Swanson River origin) in selected Matanuska-Susitna Valley lakes, 1990.

Lake	Number Stocked at Age-0	Number Estimated at Age-1+	Number per Surface Acre	95% CI Lower	95% CI Upper
Lynne Lake	6,900	1,672	24.2	19.4	29.1
Vera Lake	11,025	2,526	22.9	20.4	25.4
Walby Lake	5,390	364	6.8	5.3	8.2
Barley Lake	3,720	1,402	37.7	27.8	47.5
Carpenter Lake	35,280	15,315	43.4	38.4	48.5
Morvro Lake	17,320	3,835	22.1	18.3	26.0
Diamond Lake	55,600	5,100	9.2	8.1	10.3
Kalmback Lake	52,000	12,108	23.3	22.0	24.6
Long Lake	29,914	2,641	8.8	7.0	10.7
Crystal Lake	105,442	11,309	10.7	9.5	12.0
Dawn Lake	9,440	1,047	11.1	10.3	11.9
Little Lonely Lake	44,805	3,534	7.9	7.4	8.3
Honeybee Lake	46,150	4,930	10.7	9.0	12.3

Table 7. Effect of stocking densities on numbers and density age-1+ rainbow trout.

Lake	Surface Acres	Number per acre	Number per acre per 100 stocked	Percent > 164 mm in 1990	Number > 164 mm per acre per 100 stocked
Lynne Lake	70.0	23.8	23.8	86	20.5
Vera Lake	110.5	22.8	22.8	86	19.6
Walby Lake	53.9	6.7	6.7	83	5.6
Barley Lake	18.6	75.4	37.7	96	36.2
Carpenter Lake	176.4	86.8	43.4	65	28.2
Morvro Lake	86.6	44.3	22.1	91	20.1
Diamond Lake	139.0	36.7	9.2	76	7.0
Kalmback Lake	125.0	96.9	24.2	65	15.7
Long Lake	74.4	35.5	8.9	89	7.9
Crystal Lake	131.7	85.9	10.7	0	0.0
Dawn Lake	11.8	88.7	11.1	97	10.8
Little Lonely Lake	56.0	63.1	7.9	9	0.7
Honeybee Lake	58.0	85.0	10.6	81	8.6

Table 8. Results of nonparametric Kruskall-Wallis ANOVA testing hypothesis of no effect of stocking densities on survival and density of age-1+ rainbow trout.

Dependent Variable	K-W statistic	P
Number per acre per 100 stocked	4.44	0.218
Percent over 164 mm	1.60	0.659
Number over 164 mm per acre per 100 stocked	7.12	0.068
Survival to age 1+	4.58	0.205

Rainbow trout fingerlings were stocked in July 1990 at densities of 50, 100, and 200 fish per surface acre for estimates of survival and mean length to be performed in 1991. Length samples of age-0+ fingerlings were taken in September or October 1990 during the recapture session of the 1990 experiments and are presented in Appendix A3.

Triploid and Diploid Rainbow Trout

Estimated survivals at age-1 for Swanson strain diploid (LV) and triploid (RV) rainbow trout stocked at 3 g and 2.65 g, respectively, at a combined density of 101 fish per surface acre in Johnson Lake were 69% and 58%, respectively (Table 9). These estimates were significantly different and consistent with a similar experiment performed in 1989. During 1989, only 37% of the experimental group stocked as triploids in 1988 were actually triploid, survival for the diploid trout was estimated at 53% as compared to 46% for triploid trout (Havens 1990).

Survival of the 1988 stocked diploid trout to age 2 was 10% or a 19% survival from age 1 to age 2 (Table 10), while survival of triploid trout to age 2 was 11% or a 24% survival from age 1 to age 2. Estimates of survival to age 2 were not significantly different.

Diploid and triploid rainbow trout were stocked in 1988 and subsequently measured for length four times over a 2-year period (Table 11). Mean length of diploid and triploid fish was not significantly different in any of these four sampling events. Similarly, diploid and triploid rainbow trout were stocked in 1989 and subsequently measured for length two times over a 1-year period (Table 12). Again, mean length of these two treatment groups was not significantly different.

Recommendations:

A portion of the rainbow trout stocked in 1988 should be collected in 1991 at age 3 to determine the percentage of trout marked with an RV finclip exhibiting triploid characteristic restricted gonad development as compared to the LV finclipped trout. The 1989 and 1990 stockings should be evaluated for differences in survival and growth to at least age 3. Results from the 1988 stocking were compromised due to incomplete success in creating triploid fish.

Select and Production Rainbow Trout

Estimated survivals at age 1 for the production group was 32% and 26% for the select group (Table 13). Mean length of production and select fish was not significantly different in either of the two times that they were sampled over a 1-year period (Table 14).

Recommendations:

If select rainbow trout are still envisioned as a potential production-level stocking product, then evaluation of these two groups should be continued.

Table 9. Population estimates for age-1 diploid (LV) and triploid (RV) rainbow trout of Swanson River origin in Johnson Lake, 1990.

Lake	Date Stocked	Number Stocked	Size Stocked	Summer 1990 Number Marked	Fall 1990 Total Captured	Fall 1990 Marked Recaptures	Population Estimate	Population 95% CI	Survival Estimate	Survival 95% CI
Johnson	09/15/89	2,017 LV	3.00 g	620	481	215	1,386	1,275 - 1,496	69%	63% - 74%
		2,057 RV	2.65 g	527	487	215	1,193	1,102 - 1,284	58%	54% - 62%

Table 10. Population estimates for age-2 diploid (LV) and triploid (RV) rainbow trout of Swanson River origin in Johnson Lake, 1989-1990.

Lake	Date Stocked	Number Stocked	Size Stocked	Sample Year	Summer 1990 Number Marked	Fall 1990 Total Captured	Fall 1990 Marked Recaptures	Population Estimate	Population 95% CI	Survival Estimate	Survival 95% CI
Johnson	09/13/88	1,000 LV	2.00 g	1989	165	308	95	534	477 - 592	53%	48% - 59%
				1990	38	78	29	103	89 - 116	10%	9% - 12%
				1990			Survival from 1989 abundance estimate:			19%	17% - 22%
		977 RV	2.00 g	1989	144	277	89	448	401 - 494	46%	41% - 51%
				1990	39	72	26	108	90 - 126	11%	9% - 13%
				1990			Survival from 1989 abundance estimate:			24%	20% - 28%

Table 11. Stocking history and length data for age-2 diploid (LV) and triploid (RV) rainbow trout of Swanson River origin captured by fyke nets in Johnson Lake, 1989-1990.

Lake	Date Stocked	Number Stocked	Fish/ Acre	Size Stocked	Date Captured	Number Measured	Length		
							Mean (mm)	SE	Range (mm)
Johnson	09/13/88	1,000 LV	25	2.00 g	07/17/89	165	166	1	128-206
					10/13/89	307	220	1	147-286
					06/08/90	38	274	4	232-327
					10/10/90	78	320	2	275-364
		977 RV	24	2.00 g	07/17/89	144	163	2	120-207
					10/13/89	250	214	1	159-272
					06/08/90	39	255	4	197-317
					10/10/90	72	300	3	254-364

Table 12. Stocking history and length data for age-1 diploid (LV) and triploid (RV) rainbow trout of Swanson River origin captured by fyke nets in Johnson Lake, 1990.

Lake	Date Stocked	Number Stocked	Fish/ Acre	Size Stocked	Date Captured	Number Measured	Length		
							Mean (mm)	SE	Range (mm)
Johnson	09/15/89	2,017 LV	50	3.00 g	06/08/90	620	140	1	111-176
					10/10/90	481	217	1	165-269
		2,057 RV	51	2.65 g	06/08/90	527	124	1	82-173
					10/10/90	487	196	1	136-246

Table 13. Population estimates for age-1 select (RV) and production (LV) rainbow trout of Swanson River origin in Reed Lake, 1990.

Lake	Date Stocked	Number Stocked	Size Stocked	Summer 1990 Number Marked	Fall 1990 Total Captured	Fall 1990 Marked Recaptures	Population Estimate	Population 95% CI	Survival Estimate	Survival 95% CI
Reed	08/17/89	1,916 LV	2.50 g	221	82	29	614	454 - 775	32%	24% - 40%
		1,912 RV	2.50 g	195	96	37	500	390 - 610	26%	20% - 32%

Table 14. Stocking history and length data for age-1 select (RV) and production (LV) rainbow trout of Swanson River origin captured by fyke nets in Reed Lake, 1990.

Lake	Date Stocked	Number Stocked	Fish/ Acre	Size Stocked	Date Captured	Number Measured	Length		
							Mean (mm)	SE	Range (mm)
Reed	08/17/89	1,916 LV	98	2.50 g	05/29/90	221	133	1	103-170
					10/05/90	82	276	2	201-337
		1,912 RV	98	2.50 g	05/29/90	195	126	1	89-163
					10/05/90	96	269	3	191-368

Continued Evaluation

Stocking was continued in 1990 to further evaluate stocking densities, performance of triploid fish, and performance of select fish.

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APPENDIX A

Selected Data Summaries for Stocked Lakes

Appendix A1. Selected physical and chemical parameters of Matanuska-Susitna Valley research lakes.

Lake	Surface Area (acres)	Maximum Depth (feet)	Mean Depth (feet)	Shoreline Length (miles)	Morphoedaphic Index Value[a]
Lynne	70	77	28.7	1.9	3.21
Tigger	18.9	33	14.0	0.9	3.14
Vera	110.5	22	11.1	2.8	5.89
Walby	53.9	18	5.4	1.4	34.44
Barley	18.6	17	7.2	0.8	17.08
Carpenter	176.4	30	8.1	3.8	3.49
Morvro	86.6	17	10.9	1.8	1.01
"X"	101.4	45	17.0	3.2	1.88
Diamond	139	23	7.6	2.7	3.29
Kalmback	125	24	13.1	2.3	6.72
Long (K/B)	74.4	55	26.1	2.4	9.73
Crystal	131.7	24	11.7	2.8	1.03
Honeybee	58	35	13.5	2.3	3.41
Little Lonely	56	63	20.0	1.8	1.59
Dawn	11.8	17	8.1	0.6	3.33
Johnson	40.3	46	20.0	1.1	7.85
Reed	19.5	20	10.4	0.9	8.17

[a] Morphoedaphic index value (MEI) derived by dividing specific conductance by mean depth; can give a gross measure of a lake's potential productivity. This can be related to other lakes within a region that are similar in respect to climate and general nature of the ionic composition of their waters.

Appendix A2. Sampling data collected for rainbow trout population estimates from selected Matanuska-Susitna Valley lakes, spring and fall, 1990.

		Spring 1990 Rainbow Trout Sampling						Fall 1990 Rainbow Trout Sampling			
			Number Age 1		Number Age 2						
Lake	1989 Number Age 0 Stocked	Total Captured	Adipose Clipped	Tagged	Ad Clips[a] Captured	Adipose Clipped	Tagged	Total Captured	Total AD Clips[a] Captured	Number Tags Recaptured	Number Tagged AD Clips[a] Recaptured
Lynne	6,990	951	466	0	142	25	460	359	106	11	2
Vera	11,025	1,135	694	0	138	10	441	1,431	366	41	11
Walby	5,390	483	191	2	122	0	292	77	43	7	2
Barley	3,720	548	271	0	175	0	277	276	96	19	12
Carpenter	35,280	2,315	1,557	0	202	0	758	2,296	255	17	8
Morvro	17,320	736	569	0	66	0	167	844	180	15	7
Diamond	55,600	1,652	1,191	0	111	0	461	855	214	17	4
Kalmback	52,000	3,207	3,071	0	43	0	136	2,703	685	1	0
Long (K/B)	29,914	1,403	711	0	280	4	688	378	134	18	7
Crystal	105,442	2,636	2,380	0	81	0	256	923	200	13	0
Honeybee	46,150	2,312	828	4	452	0	1,304	1,260	241	121	18
Little Lonely	44,805	3,040	1,507	1	780	0	1,533	1,575	705	285	146
Dawn	9,440	721	587	0	78	0	134	380	215	5	3

[a] Ad clips = rainbow trout with adipose clips.

Appendix A3. Stocking history and length data for age-0 rainbow trout of Swanson River origin captured by fyke net in selected Matanuska-Susitna Valley lakes, 1990.

Lake	Date Stocked	Number Stocked	Fish/ Acre	Fish/ Shoreline Mile	Size Stocked	Date Captured	Number Caught	Catch/ Net Hour	Number Measured	Length Mean (mm)	Length SE	Length Range (mm)
Bear Paw	07/17/90	2,250	50	2,045	1.69 g							
Lorraine	07/26/90	6,620	50	2,878	1.70 g							
Prator	07/17/90	4,900	50	3,267	1.69 g							
"Y"	07/17/90	1,900	48	950	1.69 g							
Lynne	07/13/90	7,000	100	3,684	2.05 g	09/25/90	2,274	9.59	119	102	1	72-124
Tigger	07/26/90	1,894	100	2,104	1.70 g							
Vera	07/13/90	11,050	100	3,946	2.05 g	09/19/90	357	0.84	109	94	1	71-115
Walby	07/17/90	5,390	100	3,850	1.90 g	09/14/90	552	0.83	145	84	1	58-110
Barley	07/17/90	3,720	200	4,650	1.69 g	09/06/90	277	0.73	108	85	1	65-110
Carpenter	07/17/90	35,280	200	9,284	1.69 g	09/28/90	455	2.18	120	85	1	59-105
Morvro	07/17/90	17,320	200	9,622	1.69 g	09/27/90	2,387	5.73	117	92	1	66-108
"X"	07/26/90	20,320	200	6,350	1.61 g							

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Appendix A3. (Page 2 of 2).

Lake	Date Stocked	Number Stocked	Fish/ Acre	Fish/ Shoreline Mile	Size Stocked	Date Captured	Number Caught	Catch/ Net Hour	Number Measured	Length Mean (mm)	Length SE	Length Range (mm)
Diamond	07/17/90	55,600	400	20,593	1.90 g	10/03/90	1,477	3.35	153	88	1	60-113
Kalmback	07/17/90	50,000	400	21,739	1.90 g	09/28/90	377	1.04	211	84	1	65-105
Long (K/B)	07/26/90	29,776	400	12,407	1.70 g	09/14/90	207	0.30	144	84	1	67-105
Crystal	07/13/90	52,772	401	18,847	1.93 g	09/21/90	5,321	6.14	281	72	1	52- 90
Honeybee	07/13/90	46,395	800	20,172	1.96 g	09/26/90	2,999	6.59	194	102	1	70-132
Little Lonely	07/13/90	44,820	800	24,900	2.05 g	09/19/90	1,708	3.81	118	72	1	58- 95
Dawn	07/17/90	9,440	800	15,733	1.69 g	10/05/90	1,618	3.75	141	92	1	74-110
Johnson	09/14/90	2,020 LV[a]	50		8.40 g	10/10/90	224	0.43	224	95	1	72-122
		2,020 RV[b]	50		7.10 g	10/10/90	112	0.22	112	90	1	69-110
Reed	08/02/90	1,832 LV[a]	94		1.50 g	10/05/90	305	0.65	145	100	1	77-129
		1,862 RV[b]	95		1.50 g	10/05/90	324	0.69	155	107	1	79-128

[a] Left ventral clip.

[b] Right ventral clip.