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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. Three years of stocking density experiments were performed in Matanuska-Susitna Valley landlocked lakes between 1989 and 1991, using 1-2 gram rainbow trout of Swanson River origin stocked at densities of 50, 100, 200, 400, 800, or 1,000 fish per surface acre.

Evaluations based on mark-recapture experiments were conducted for 39 rainbow trout plants in 19 study waters. Estimated survivals at age 1 for rainbow trout stocked at a density of 50 fish per surface acre in four lakes in 1990 averaged 35%. Survivals for fish stocked at 100 per surface acre (4 lakes, 11 experiments) averaged 37%; at 200 per surface acre (4 lakes, 10 experiments) averaged 30%; at 400 per surface acre (3 lakes, 6 experiments) averaged 11%; at 800 per surface acre (4 lakes, 7 experiments) averaged 10%; and at 1,000 per surface acre in 1 lake in 1988 the survival was 15%. Abundance of age-1 rainbow trout per surface acre averaged 17, 37, 61, 44, 83, and 161 in lakes stocked at 50, 100, 200, 400, 800, and 1,000 per surface acre, respectively, while estimated mean length of rainbow trout averaged 218 millimeters, 194 millimeters, 178 millimeters, 198 millimeters, 168 millimeters, and 172 millimeters in lakes stocked at 50, 100, 200, 400, 800, and 1,000 per surface acre, respectively.

At an assumed production cost of $0.08 per Swanson River strain rainbow trout fingerling stocked from the Alaska Department of Fish and Game Ft. Richardson hatchery, fish surviving to age 1 in lakes stocked at 50 per surface acre cost an average of $1.19 each. Age-1 rainbow trout in lakes stocked at 100 per surface acre cost an average of $0.32, stocked at 200 per surface acre cost an average of $0.33, stocked at 400 per surface acre cost an average of $1.41, and stocked at 800 per surface acre cost an average of $0.85 each. Age-1 rainbow trout in the one lake stocked at 1,000 per surface acre cost an estimated $0.52 each. Based on the results of 3 years of experiments, it is recommended that lakes planted with only rainbow trout be stocked at 100 fingerlings per surface acre for lakes receiving low angler effort, or 200 fingerling per surface acre for lakes with high angler effort.

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

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 1 to 362 surface acres, were barren or contained only threespine stickleback *Gasterosteus aculeatus* or threespine stickleback and longnose suckers *Catostomus catostomus* prior to stocking. The lakes are stocked with rainbow trout *Oncorhynchus mykiss*, Arctic grayling *Thymallus arcticus*, landlocked salmon *Oncorhynchus*, 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 anglers 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. One of the easiest procedures to control is the stocking density, therefore, the purpose of this study was to investigate different stocking densities to determine if survival and growth could be improved.

This report presents results of the 1991 experiments and a summary of the 3 years of research on the effects of stocking density on the survival to age 1 of rainbow trout in landlocked lakes in Southcentral Alaska. Survival and growth to age 1 were chosen as measures of success in these experiments because they are easily measured parameters, not confounded by differential rates of harvest which affect populations at an older age. All of the lakes stocked with rainbow trout during these investigations (Figure 1) contained threespine stickleback, four lakes had populations of longnose suckers, two lakes contained stocked coho salmon, and two lakes contained stocked Arctic grayling (Appendix A1).

This research will be used to devise stocking procedures that maximize the survival of stocked fish in the most cost-efficient manner. The specific objectives for this project were:

1. to estimate the proportion of rainbow trout, stocked as 1 g-2 g fingerlings at different densities, that are ≥ 165 mm in the fall of the year following stocking;

2. to estimate the abundance and survival to age 1 of rainbow trout stocked as 1 g-2 g fingerlings at different densities; and

3. to test the hypothesis that there is no difference in the number of rainbow trout ≥ 165 mm surviving among lakes stocked at different densities.

METHODS

Rainbow trout of the Swanson River origin were stocked in 12 lakes in the Matanuska-Susitna Valley lakes in 1990 for experiments to be performed in

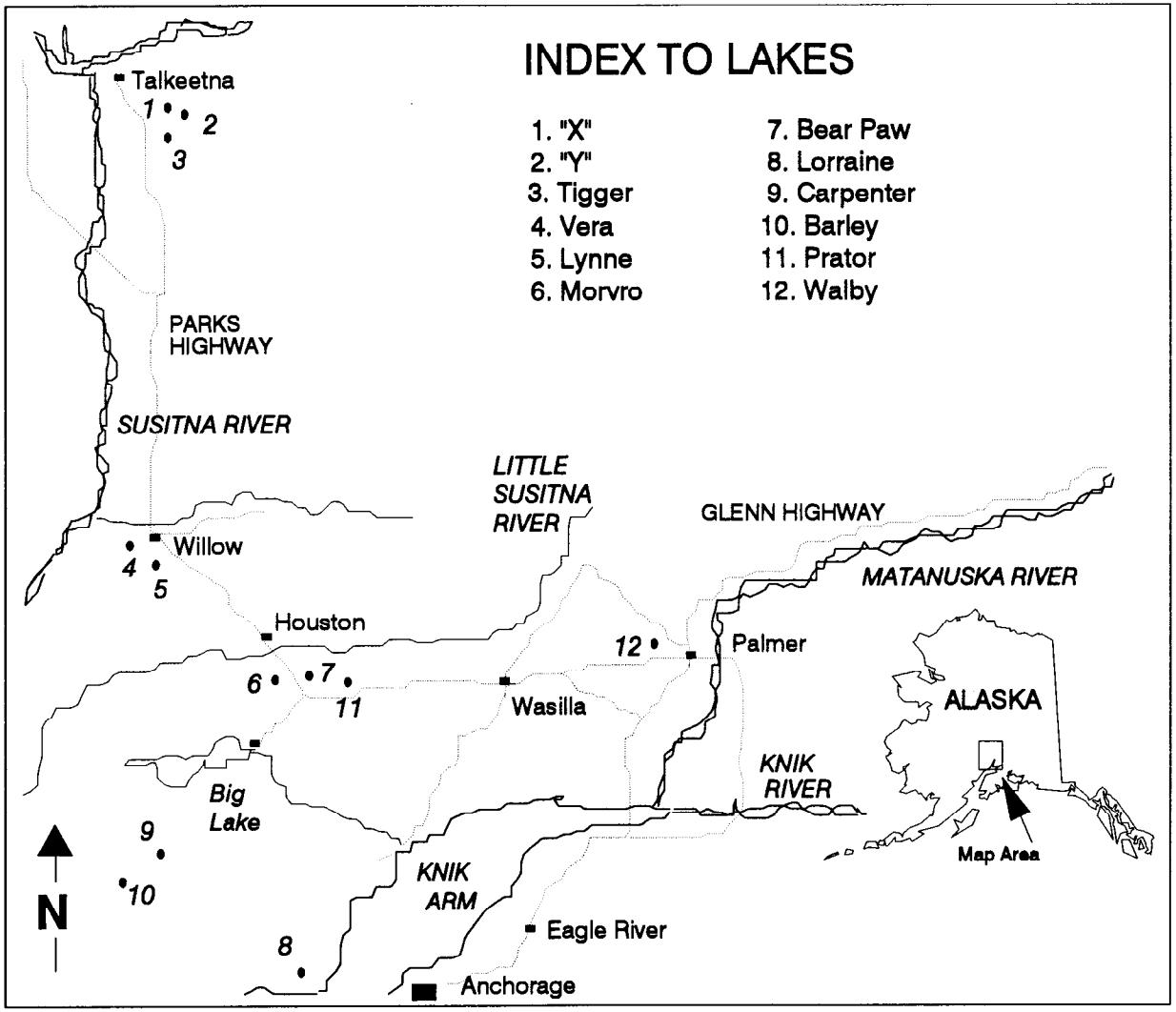

Figure 1. Location of sample lakes in Matanuska-Susitna Valley, 1988-1991.

1991. To determine the effects of stocking density on rainbow trout survival and growth, Bear Paw, Lorraine, Prator, and "Y" lakes were planted with 1 g-2 g rainbow trout fingerlings at approximately 50 per surface acre; Lynne, Tigger, Vera, and Walby lakes were planted with 1 g-2 g rainbow trout fingerlings at approximately 100 per surface acre; and Barley, Carpenter, Morvro, and "X" lakes at approximately 200 per surface acre. Since 1989, 19 lakes have been used in this study, and there have been 39 evaluations of stocking density (Havens 1990, 1991).

Rainbow Trout Sampling

Rainbow trout were captured for marking purposes in May or June 1991, released to mix throughout the lake for approximately 3 months, then sampled for marked-unmarked ratios in September or October 1991.

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 MS-222. 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 1990 sampling, with the exception of Bear Paw, Lorraine, Prator, and "Y" lakes which were not used for experiments in 1990, some age-1 fish were adipose finclipped and these fish were then age 2 during 1991. In 1991, 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. If there was overlap in lengths between age 1 and age 2, this method would result in an underestimate of the number of age-1 rainbow trout. Because few rainbow trout were captured with lengths near the pivotal length, we believe that the bias caused by this method was small.

Age-1 rainbow 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 rainbow trout were marked with a numbered dart tag for use in separating age-1 and age-2 and older fish in the fall, and released. Upon completion of the capture session, all fish were released from the holding pen.

During the fall recapture event in lakes where some overlap appeared to occur between age-1 fish and age-2 and older fish based on length frequency analysis, some fish within the overlap range were sampled from each fyke net for

scales, and the true ages were used to determine the pivotal length for separating age 1 from age 2. As in the spring sampling, few fish had lengths near the pivotal length so we believe that the number of fish potentially assigned to the wrong age by this method was very small and did not significantly affect the age-1 population estimate.

Abundance Estimator

In 1991, population estimates were made for age-1 rainbow trout stocked in 1990 and adipose finclipped in the spring of 1991. Recapture events were in the fall of 1991.

The abundance at time of marking of age-1 rainbow trout, N_1, was estimated by (Ricker 1975):

$$\hat{N}_1 = \frac{(M+1)\,(C+1)}{(R+1)} - 1 \qquad (1)$$

and the variance by:

$$\mathrm{Var}\,(\hat{N}_1) = \frac{(M+1)^2\,(C+1)\,(C-R)}{(R+1)^2\,(R+2)} \qquad (2)$$

where:

M = number of adipose-clipped age-1 fish released in the spring,

C = number of fish captured in the fall, and

R = number of recaptures in the fall.

The assumptions for these estimates were:

1. either there was no recruitment or immigration between sampling events, or there was no death or emigration, or there were none of these;

2. marking did not affect the catchability;

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

4. all fish had an equal chance of being marked in the marking sample, or 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.

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 3 month's growth, the ratio of unclipped to clipped rainbow trout would

be biased. This would lead to a biased estimate of the number of age-1 rainbow trout in the spring, although an estimate of the number of rainbow trout at the time of fall recapture would be correct. Since we were comparing survivals to the spring, not to the fall, the potential bias of the spring estimates was of concern to us. 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:

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 marked fish migrate and mix throughout the lake prior to a recapture sample, or if the recovery effort was equally distributed throughout the lake. To promote mixing of marked and unmarked fish, the marked fish were released near the middle of the lake. In order to test the assumption of complete mixing, a chi-square test of homogeneity was used to test the hypotheses that the ratio of marked to unmarked rainbow trout in fyke nets 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:

$$\hat{S} = \frac{\hat{N}_1}{N_0} \tag{3}$$

where:

N_0 = number stocked, and

$$Var(\hat{S}) = \frac{Var(N_1)}{N_0^2} . \tag{4}$$

Average survivals for each stocking density were calculated. The variance of the average survival for a density was estimated as:

$$Var(\hat{\bar{S}}) = \frac{\sum_{l=1}^{n} Var(\hat{S}_l)}{n^2} , \tag{5}$$

where:

$\hat{S}_l$ = survival in lake l in a year, and

n = number of experiments at this density.

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,

2. the number of age-1 rainbow trout per surface acre per 100 fish stocked per surface acre, and

3. the number of age-1 rainbow trout greater than 164 mm per surface acre per 100 fish stocked per surface acre.

The average of each parameter was calculated among lakes at each stocking density. The variance of each average was calculated as:

$$\mathrm{Var}(\bar{\hat{P}}) = \frac{\sum_{l=1}^{n} \mathrm{Var}(\hat{P}_l)}{n^2}, \qquad (6)$$

where:

$\hat{S}_l$ = parameter of interest in lake 1 in a year.

A non-parametric Kruskal-Wallis one-way ANOVA (Conover 1980) was used to test the null hypotheses that these parameters did not differ among the three treatments or stocking densities. Friedman's analysis of variance by ranks (Conover 1980) was used to compare these parameters among lakes and years. Lakes stocked at 100 fish per surface acre and 200 fish per surface acre were compared for 1989, 1990, and 1991. Lakes stocked at 100, 200, 400, and 800 fish per surface acre were compared for 1989 and 1990.

RESULTS

In 1991, 11 lakes were sampled in the spring and fall (Appendix A2) although problems were encountered in sampling Vera Lake in the fall. On 15 October 1991, over two-thirds of Vera Lake were covered by skim ice and we were able to set only five fyke nets instead of the 20 nets planned. By the following day ice had thickened, and we had to break three of the five nets out of the ice, and as air temperatures continued to drop we discontinued the sampling effort. We captured only 72 age-1 rainbow trout resulting in a large confidence interval for the abundance estimate.

Barley Lake was eliminated from the 1990 stocking experiment because of a partial winterkill. On 20 May 1991, we observed dead rainbow trout in the water along the downwind shoreline. An examination of several dead rainbow trout revealed a wide range of lengths including some age-1 fish. Ten fyke nets set overnight captured only 15 age-1 rainbow trout ranging from 68 mm to 107 mm and one rainbow trout age 2 or older at 268 mm.

When Bear Paw Lake was sampled in the spring, only 44 age-1 rainbow trout were captured and marked, but we did capture over 50 age-2 and older coho salmon stocked as fingerling in 1987 and 1988, and captured and tagged over 30 age-4 rainbow trout stocked as fingerling in 1987. In the fall sample, we captured several hundred age-0 rainbow trout stocked in July 1991 and four age-1 rainbow trout that had been marked during the spring sampling. No coho salmon or age-4 rainbow trout were captured. The low survival of 1990 stocked fingerling may have been due to predation by larger fish. No winterkill was suspected.

1991 Stocking Density Experiments

Population Estimates:

Chi-square tests of homogeneity of clip ratios throughout each lake were not significant in any lakes, indicating that fish mixed throughout each lake between the marking and recapture events (Table 1).

Estimated abundance at age 1 for Swanson River strain rainbow trout stocked at 1.69 g to 2.05 g ranged from 45 in Bear Paw Lake to 9,986 in Carpenter Lake (Table 2). The relative precision for the 95% confidence interval of these estimates ranged from zero to 70%.

Comparisons of the length distributions of clipped and unclipped age-1 rainbow trout were significant for 9 of 11 lakes sampled in the fall (Table 3). Most of the significant tests were for lakes stocked at 100 and 200 rainbow trout per surface acre. For most of these lakes, the ratio of clipped to unclipped rainbow trout increased with increasing size of age-1 rainbow trout. Figure 2 shows age-1 rainbow trout length frequencies for "Y" Lake, where there was no significant difference between clipped and unclipped fish, and Lynne and "X" Lakes, where the difference in length distributions was significant. A possible reason for the varying clip ratios in some lakes is that small age-1 rainbow trout were not vulnerable to the gear in the spring but after 3 months of growth were recruited to the fall sampling. 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 1991, length of age-1 rainbow trout averaged 119 mm, 122 mm, and 100 mm for rainbow trout that had been stocked at densities of 50, 100, and 200 fish per surface acre, respectively (Table 4). Spring is a time of rapid growth, so the spring samples, taken from different lakes across a span of 34 days, can not be compared among lakes. By September or October 1990, lengths of age-1 rainbow trout that had been stocked at 50 per surface acre averaged 195 mm, at 100 per surface acre averaged 182 mm, and at 200 per surface acre averaged 157 mm (Table 4). A one-way analysis of variance found lengths to be significantly different among lakes ($F = 245.15$, $P = 0.000$).

Comparison of Stocking Densities:

The number of fish surviving per surface acre ranged from 1 in Bear Paw Lake to 77 in Lynne Lake; averaging 17, 56, and 59 rainbow trout per surface acre in lakes stocked at 50, 100, and 200 per surface acre; respectively (Table 5).

Table 1. Comparison of mark ratios among groups of fyke nets in selected Matanuska-Susitna Valley lakes, 1991.

Lake	Total Captured	df[a]	Clipped to Unclipped		
			χ^2	P	Ratio
Bear Paw[b]	4				
Lorraine	308	7	7.80	[0.30< P <0.50]	0.257
Prator	49	3	3.43	[0.30< P <0.50]	1.130
"Y"	215	9	7.38	[0.50< P <0.70]	0.215
Lynne	382	7	6.72	[0.30< P <0.50]	0.265
Tigger	239	3	2.26	[0.50< P <0.70]	0.292
Vera	72	2	0.43	[0.80< P <0.90]	0.075
Walby	132	3	1.29	[0.70< P <0.80]	0.189
Carpenter	1,269	5	3.69	[0.50< P <0.70]	0.122
Morvro	641	7	6.65	[0.30< P <0.50]	0.203
"X"	871	7	8.21	[0.30< P <0.50]	0.222

[a] Number of fyke net groups minus 1.

[b] All four rainbow trout captured in Bear Paw Lake had a clip.

Table 2. Population estimates for age-1 rainbow trout of Swanson River origin in selected Matanuska-Susitna Valley lakes, 1991.

Lake	Number Stocked	Number Stocked per acre	Adipose Clipped Spring (Mark)	Recapture Fall		Estimate			
				Total	Adipose Clipped	Abundance	95 % CI Lower	95 % CI Upper	% RP[a]
50 Per Surface Acre:									
Bear Paw Lake	2,250	50	44	4	4	45	45	45	0
Lorraine Lake	6,620	50	660	308	60	3,348	2,637	4,060	21
Prator Lake	4,900	50	452	49	26	839	635	1,043	24
"Y" Lake	1,900	48	235	215	38	1,307	972	1,642	26
100 Per Surface Acre:									
Lynne Lake	7,000	100	1,145	382	80	5,419	4,415	6,423	19
Tigger Lake	1,894	100	249	239	54	1,091	869	1,312	20
Vera Lake	11,050	100	276	72	5	3,370	1,004	5,736	70
Walby Lake	5,390	100	524	132	21	3,174	2,014	4,334	37
200 Per Surface Acre:									
Carpenter Lake	35,280	200	1,092	1,269	138	9,986	8,528	11,445	15
Morvro Lake	17,320	200	1,056	641	108	6,226	5,222	7,230	16
"X" Lake	20,320	200	866	871	158	4,755	4,153	5,357	13

[a] Relative precision of 95% confidence interval.

Table 3. Results of Kolmogorov-Smirnov tests comparing length distributions of clipped and unclipped age-1 rainbow trout in selected Matanuska-Susitna Valley lakes, 1991.

Lake	Number		D	P
	Unclipped	Clipped		
Bear Paw Lake	0	4		
Lorraine Lake	248	60	0.217	0.013
Prator Lake	23	26	0.194	0.638
"Y" Lake	177	38	0.206	0.119
Lynne Lake	302	80	0.206	0.008
Tigger Lake	185	54	0.216	0.033
Vera Lake	67	5	0.657	0.016
Walby Lake	111	21	0.600	0.000
Carpenter Lake	1,131	138	0.275	0.000
Morvro Lake	533	108	0.280	0.000
"X" Lake	713	158	0.245	0.000

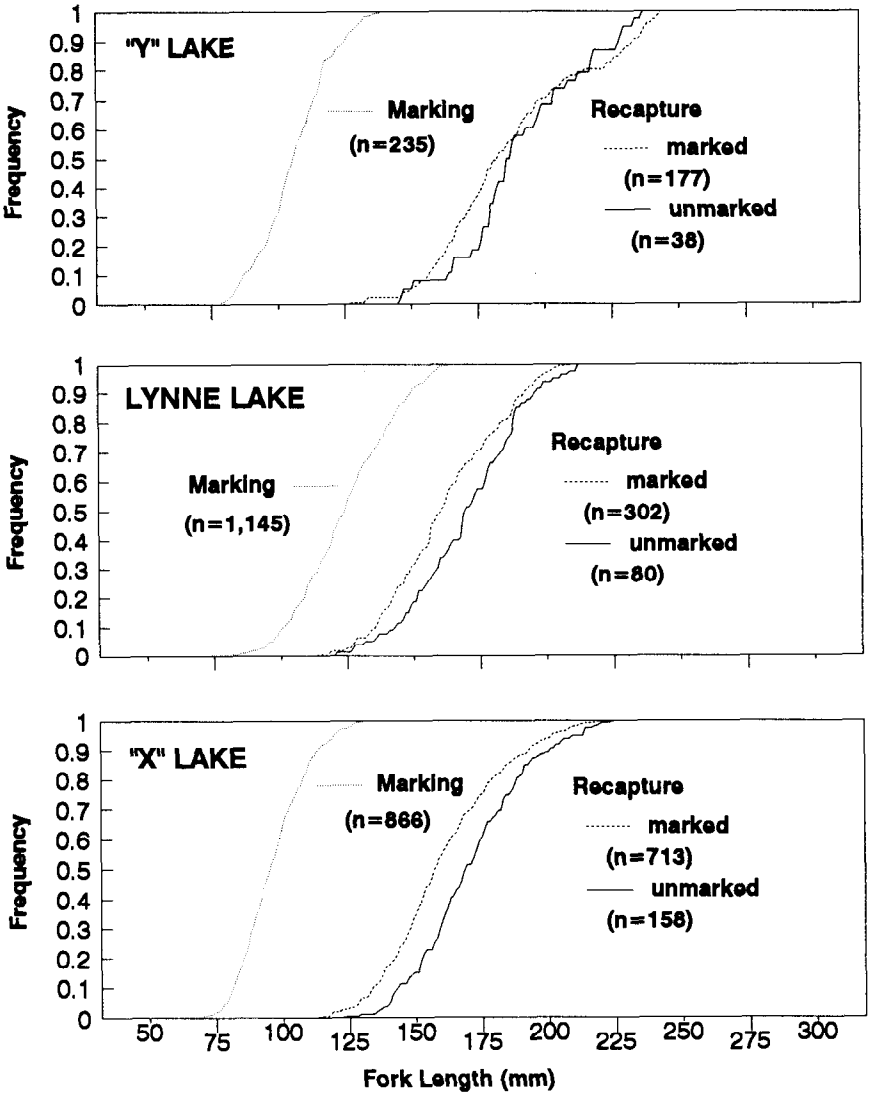

Figure 2. Cumulative length distributions of rainbow trout in the marking event and during the recapture event in "Y", Lynne, and "X" lakes, 1991.

Table 4. Stocking history and length data for age-1 rainbow trout of Swanson River origin captured by fyke net in selected Matanuska-Susitna Valley lakes, 1991.

Lake	Date Stocked	Surface Acres	Number Stocked	Fish/ Acre	Fish/ Shoreline Mile	Size Stocked	Date Captured	Number Measured	Length Mean (mm)	Length SE	Length Range (mm)
50 Per Surface Acre:											
Bear Paw	07/17/90	45	2,250	50	2,045	1.69 g	06/04/91	44	144	2	110-169
							09/25/90	4	279	11	258-312
Lorraine	07/26/90	132	6,620	50	2,878	1.70 g	05/30/91	660	124	1	84-166
							09/17/91	308	195	2	128-277
Prator	07/17/90	98	4,900	50	3,267	1.69 g	05/15/91	452	116	1	75-199
							09/10/91	49	210	6	129-290
"Y"	07/17/90	40	1,900	48	950	1.69 g	06/05/91	235	107	1	79-139
							10/11/91	215	189	2	128-244
							Total Spring	1,391	119	0	75-199
							Total Fall	576	195	1	128-312
100 Per Surface Acre:											
Lynne	07/13/90	70	7,000	100	3,684	2.05 g	05/23/91	1,145	125	1	74-166
							09/25/91	382	164	1	114-212
Tigger	07/26/90	19	1,894	100	2,104	1.70 g	06/12/91	249	124	1	81-184
							09/25/90	239	201	2	128-319
Vera	07/13/90	110	11,050	100	3,946	2.05 g	05/29/91	276	121	1	88-166
							10/16/91	72	182	2	140-218
Walby	07/17/90	54	5,390	100	3,850	1.90 g	05/10/91	524	113	1	68-155
							10/10/91	132	200	4	123-293
							Total Spring	2,194	123	0	68-184
							Total Fall	825	182	1	114-319

-continued-

Table 4. (Page 2 of 2).

Lake	Date Stocked	Surface Acres	Number Stocked	Fish/ Acre	Fish/ Shoreline Mile	Size Stocked	Date Captured	Number Measured	Length Mean (mm)	Length SE	Length Range (mm)
200 Per Surface Acre:											
Carpenter	07/17/90	176	35,280	200	9,284	1.69 g	05/22/91	1,092	100	1	72-136
							09/18/91	1,269	149	1	108-214
Morvro	07/17/90	87	17,320	200	9,622	1.69 g	05/21/91	1,056	104	1	71-145
							10/16/91	641	166	1	119-215
"X"	07/26/90	101	20,320	200	6,350	1.61 g	06/07/91	866	97	1	68-131
							09/27/91	871	163	1	112-224
							Total Spring	3,014	100	0	68-145
							Total Fall	2,779	157	0	108-224

Table 5. Effect of stocking densities on numbers and density of age-1 rainbow trout, 1991.

	Age 1		Number Age 1 Per Acre		95 % CI		Number per Acre per 100 Stocked		Percent > 164 mm		Number > 164 mm per Acre per 100 Stocked		Proportion Survive to Age 1	
	Number	SE	Number	SE	Lower	Upper	Number	SE	Percent	SE	Number	SE	Prop.	SE
50 per Surface Acre														
Bear Paw	45	0.0	1.0	0.0	1.0	1.0	2.0	0.0	100	0.0	2.0	0.0	0.02	0.00
Lorraine	3,348	363.0	25.4	2.7	20.0	30.8	50.6	5.5	82	2.2	41.5	1.2	0.51	0.05
Prator	839	104.3	8.6	1.1	6.5	10.6	17.1	2.1	86	5.0	14.7	0.5	0.17	0.02
"Y"	1,307	170.9	32.9	4.3	24.5	41.4	68.8	9.0	83	2.6	57.1	1.8	0.69	0.09
		Mean	17.0	1.3	14.4	19.5	34.6	2.7	83	1.6	28.8	0.5	0.35	0.03
100 per Surface Acre														
Lynne	5,419	512.2	77.4	7.3	63.1	91.8	77.4	7.3	46	2.6	35.6	3.9	0.77	0.07
Tigger	1,091	113.0	57.7	6.0	46.0	69.4	57.6	6.0	87	2.2	50.1	5.4	0.58	0.06
Vera	3,370	1,207.0	30.5	10.9	9.1	51.9	30.5	10.9	81	4.7	24.7	8.9	0.30	0.11
Walby	3,174	591.8	58.9	11.0	37.4	80.4	58.9	11.0	74	3.8	43.6	8.4	0.59	0.11
		Mean	56.1	4.5	47.2	65.0	56.1	4.5	65	1.7	38.5	3.5	0.56	0.05
200 per Surface Acre														
Carpenter	9,986	744.1	56.6	4.2	48.3	64.9	28.3	2.1	20	1.1	5.7	2.1	0.28	0.02
Morvro	6,226	512.2	71.9	5.9	60.3	83.5	35.9	3.0	54	2.0	19.4	7.0	0.36	0.03
"X"	4,775	307.2	47.1	3.0	41.2	53.0	23.5	1.5	42	1.7	9.9	3.0	0.23	0.02
		Mean	58.5	2.6	53.4	63.7	29.3	1.3	35	0.9	11.6	2.6	0.29	0.01

Rainbow trout considered to be of harvestable size (greater than 164 mm fork length at age 1) averaged 83% of the estimated population of age-1 rainbow trout for the group of lakes stocked at 50 fish per surface acre, 65% in 100 per surface acre lakes, and 35% in 200 per surface acre lakes (Table 5).

Estimated survival rates for fish stocked at 50 fish per surface acre in four lakes averaged 35% (range 2% to 69%), at 100 per surface acre in four lakes averaged 60% (range 30% to 77%), and at 200 per surface acre in three lakes averaged 30% (range 23% to 36%) (Table 2).

The nonparametric analysis of variance did not find significant differences among the three treatment groups for any of the parameters tested (Table 6).

Summary of 1989-1991 Stocking Density Experiments

The following is a summary of 3 years of stocking density experiments in Matanuska-Susitna Valley lakes using Swanson River strain rainbow trout fingerlings (Havens 1990, 1991). In 1988, 15 lakes were stocked with fingerlings ranging in mean size from 1 g to 1.2 g at densities ranging from 100, 200, 400, 800, or 1,000 fish per surface acre. In 1989, 13 of the lakes stocked in 1988 were again stocked with fingerling ranging in size from 1.1 g to 1.5 g at densities ranging from 100, 200, 400, or 800 fish per surface acre; Dawn Lake, stocked at 1,000 fish per surface acre in 1988, was stocked at 800 per surface acre in 1989. In 1990, 11 lakes were stocked: 4 lakes not previously used for density experiments were stocked at 50 fish per surface acre while the remaining 7 lakes, stocked in 1988 or 1988 and 1989, were stocked at 100 or 200 fish per surface acre.

Survival:

Estimated survivals at age 1 for Swanson River strain rainbow trout stocked as fingerlings at a density of 50 fish per surface acre in four lakes in 1990 averaged 35%. Survivals for fish stocked at 100 per surface acre (4 lakes, 11 experiments) averaged 36%, at 200 per surface acre (4 lakes, 10 experiments) averaged 29%, at 400 per surface acre (3 lakes, 6 experiments) averaged 11%, at 800 per surface acre (4 lakes, 7 experiments) averaged 10%, and at 1,000 per surface acre in 1 lake in 1988 the survival was 15% (Table 7, Figures 3 and 4).

Abundance:

The estimated abundance of age-1 rainbow trout ranged from 45 in Bear Paw Lake in 1991 to 15,315 in Carpenter Lake in 1990, while the number of fish surviving per surface acre ranged from 1 in Bear Paw Lake in 1991 to 161 in Dawn Lake in 1989 (Table 7). The number of age-1 rainbow trout per surface acre averaged 17, 36, 59, 44, 82, and 161 in lakes stocked at 50, 100, 200, 400, 800, and 1,000 per surface acre, respectively (Table 7).

Length Distributions:

The estimated mean length of age-1 rainbow trout ranged from 140 mm in Little Lonely Lake in 1990 to 279 mm in Bear Paw Lake in 1991 (Table 8). Age-1 rainbow trout mean length in the fall, for all 3 years of stocking density

Table 6. Results of nonparametric Kruskall-Wallis ANOVA testing hypothesis of no effect of stocking densities on survival and density of age-1 rainbow trout, 1991.

Dependent Variable	K-W statistic	df	P
Number per acre per 100 stocked	2.96	2	0.228
Number over 164 mm per acre per 100 stocked	3.39	2	0.184
Survival to age 1	2.96	2	0.228

Table 7. Effect of stocking density on numbers and density of age-1 rainbow trout, 1989-1991.

	Year Stocked	Surface Acres	Number Stocked	Number Stocked per Acre	Age 1 Number	Age 1 SE	Number Age 1 Per Acre Number	Number Age 1 Per Acre SE	Number per Acre per 100 Stocked Number	Number per Acre per 100 Stocked SE	Number > 164 mm per Acre per 100 Stocked Number	Number > 164 mm per Acre per 100 Stocked SE	Proportion Survive to Age 1 Prop.	Proportion Survive to Age 1 SE	Cost per Age 1 Trout Cost	Cost per Age 1 Trout SE
50 per Surface Acre																
Bear Paw	1990	45	2,250	50	45	0.0	1.0	0.0	2.0	0.0	2.0	0.0	0.02	0.00	$4.00	0.00
Lorraine	1990	132	6,620	50	3,348	363.0	25.4	2.7	50.6	5.5	41.5	1.2	0.51	0.05	$0.16	0.02
Prator	1990	98	4,900	50	839	104.3	8.6	1.1	17.1	2.1	14.7	0.5	0.17	0.02	$0.47	0.06
"Y"	1990	40	1,900	48	1,307	170.9	32.9	4.3	68.8	9.0	57.1	1.8	0.69	0.09	$0.12	0.02
					Mean		17.0	1.3	34.6	2.7	28.8	0.5	0.35	0.03	$1.19	0.02
100 per Surface Acre																
Lynne	1988	70	7,056	101	2,121	107.3	30.3	1.5	30.1	1.5	26.5	1.6	0.30	0.02	$0.27	0.01
Lynne	1989	70	6,990	100	1,672	169.8	23.9	2.4	23.9	2.4	20.6	2.2	0.24	0.02	$0.33	0.03
Lynne	1990	70	7,000	100	5,419	512.2	77.4	7.3	77.4	7.3	35.6	3.9	0.77	0.07	$0.10	0.01
Tigger	1988	19	1,887	100	527	31.1	27.9	1.6	27.9	1.6	25.4	1.6	0.28	0.02	$0.29	0.02
Tigger	1990	19	1,894	100	1,091	113.0	57.7	6.0	57.6	6.0	50.1	5.4	0.58	0.06	$0.14	0.01
Vera	1988	111	10,850	98	4,349	212.7	39.4	1.9	40.1	2.0	38.1	1.9	0.40	0.02	$0.20	0.01
Vera	1989	111	11,025	100	2,526	50.3	22.9	0.5	22.9	0.5	19.7	0.5	0.23	0.00	$0.35	0.01
Vera	1990	111	11,050	100	3,370	1,207.0	30.5	10.9	30.5	10.9	24.7	8.9	0.30	0.11	$0.26	0.09
Walby	1988	54	5,378	100	1,107	19.1	20.5	0.4	20.6	0.4	17.9	0.6	0.21	0.00	$0.39	0.01
Walby	1989	54	5,390	100	364	51.5	6.8	1.0	6.8	1.0	5.6	0.8	0.07	0.01	$1.18	0.17
Walby	1990	54	5,390	100	3,174	591.8	58.9	11.0	58.9	11.0	43.6	8.4	0.59	0.11	$0.14	0.03
					Mean		36.0	1.7	36.1	1.7	28.0	1.3	0.36	0.02	$0.33	0.02
200 per Surface Acre																
Barley	1988	19	3,695	199	2,219	82.2	119.3	4.4	60.1	2.2	48.6	10.6	0.60	0.02	$0.13	0.00
Barley	1989	19	3,720	200	1,402	187.1	75.4	10.1	37.7	5.0	36.2	19.4	0.38	0.05	$0.21	0.03
Carpenter	1988	176	35,255	200	4,574	250.8	25.9	1.4	13.0	0.7	7.7	2.6	0.13	0.01	$0.62	0.03
Carpenter	1989	176	35,280	200	15,315	909.7	86.8	5.2	43.4	2.6	28.2	6.9	0.43	0.03	$0.18	0.01
Carpenter	1990	176	35,280	200	9,986	744.1	56.6	4.2	28.3	2.1	5.7	2.1	0.28	0.02	$0.28	0.02
Morvro	1988	87	17,333	200	2,727	173.4	31.5	2.0	15.7	1.0	14.3	3.9	0.16	0.01	$0.51	0.03
Morvro	1989	87	17,320	200	3,835	342.8	44.3	4.0	22.1	2.0	20.1	7.3	0.22	0.02	$0.36	0.03
Morvro	1990	87	17,320	200	6,226	512.2	71.9	5.9	35.9	3.0	19.4	7.0	0.36	0.03	$0.22	0.02
"X"	1988	101	20,843	206	3,160	185.1	31.2	1.8	15.2	0.9	10.8	3.2	0.15	0.01	$0.53	0.03
"X"	1990	101	20,320	200	4,775	307.2	47.1	3.0	23.5	1.5	9.9	3.0	0.23	0.02	$0.34	0.02
					Mean		59.0	1.5	29.5	0.8	20.1	2.6	0.29	0.01	$0.34	0.01
400 per Surface Acre																
Diamond	1988	139	55,622	400	1,019	28.1	7.3	0.2	1.8	0.1	1.7	0.8	0.02	0.00	$4.37	0.12
Diamond	1989	139	55,600	400	5,100	306.8	36.7	2.2	9.2	0.6	7.0	7.1	0.09	0.01	$0.87	0.05
Kalmback	1988	125	51,850	415	2,820	157.3	22.6	1.3	5.4	0.3	3.8	4.4	0.05	0.00	$1.47	0.08
Kalmback	1989	125	52,000	416	12,108	351.7	96.9	2.8	23.3	0.7	15.1	8.5	0.23	0.01	$0.34	0.01
Long	1988	74	30,575	411	4,885	259.6	65.7	3.5	16.0	0.8	15.3	13.9	0.16	0.01	$0.50	0.03
Long	1989	74	29,914	402	2,641	281.5	35.5	3.8	8.8	0.9	7.9	13.9	0.09	0.01	$0.91	0.10
					Mean		44.1	1.1	10.8	0.3	8.5	3.8	0.11	0.00	$1.41	0.03

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Table 7. (Page 2 of 2).

	Year Stocked	Surface Acres	Number Stocked	Number Stocked per Acre	Age 1 Number	Age 1 SE	Number Age 1 Per Acre Number	Number Age 1 Per Acre SE	Number per Acre per 100 Stocked Number	Number per Acre per 100 Stocked SE	Number > 164 mm per Acre per 100 Stocked Number	Number > 164 mm per Acre per 100 Stocked SE	Proportion Survive to Age 1 Prop.	Proportion Survive to Age 1 SE	Cost per Age 1 Trout Cost	Cost per Age 1 Trout SE
800 per Surface Acre																
Crystal	1988	132	105,415	800	5,504	575.1	41.8	4.4	5.2	0.5	2.5	21.7	0.05	0.01	$1.53	0.16
Crystal	1989	132	105,442	801	11,309	664.0	85.9	5.0	10.7	0.6	0.0	0.0	0.11	0.01	$0.75	0.04
Dawn	1989	12	9,440	800	1,047	40.1	88.7	3.4	11.1	0.4	10.8	27.4	0.11	0.00	$0.72	0.03
Honeybee	1988	58	46,206	797	7,615	422.6	131.3	7.3	16.5	0.9	8.2	51.3	0.16	0.01	$0.49	0.03
Honeybee	1989	58	46,150	796	4,930	387.5	85.0	6.7	10.7	0.8	8.7	44.0	0.11	0.01	$0.75	0.06
Little Lonely	1988	56	44,820	800	4,391	136.2	78.4	2.4	9.8	0.3	1.8	20.5	0.10	0.00	$0.82	0.03
Little Lonely	1989	56	44,805	800	3,534	105.1	63.1	1.9	7.9	0.2	0.7	4.7	0.08	0.00	$1.01	0.03
						Mean	82.0	1.8	10.3	0.2	4.7	11.3	0.10	0.00	$0.87	0.03
1000 per Surface Acre																
Dawn	1988	12	12,376	1,049	1,900	113.0	161.0	9.6	15.4	0.9	9.8	89.9	0.15	0.01	$0.52	0.03

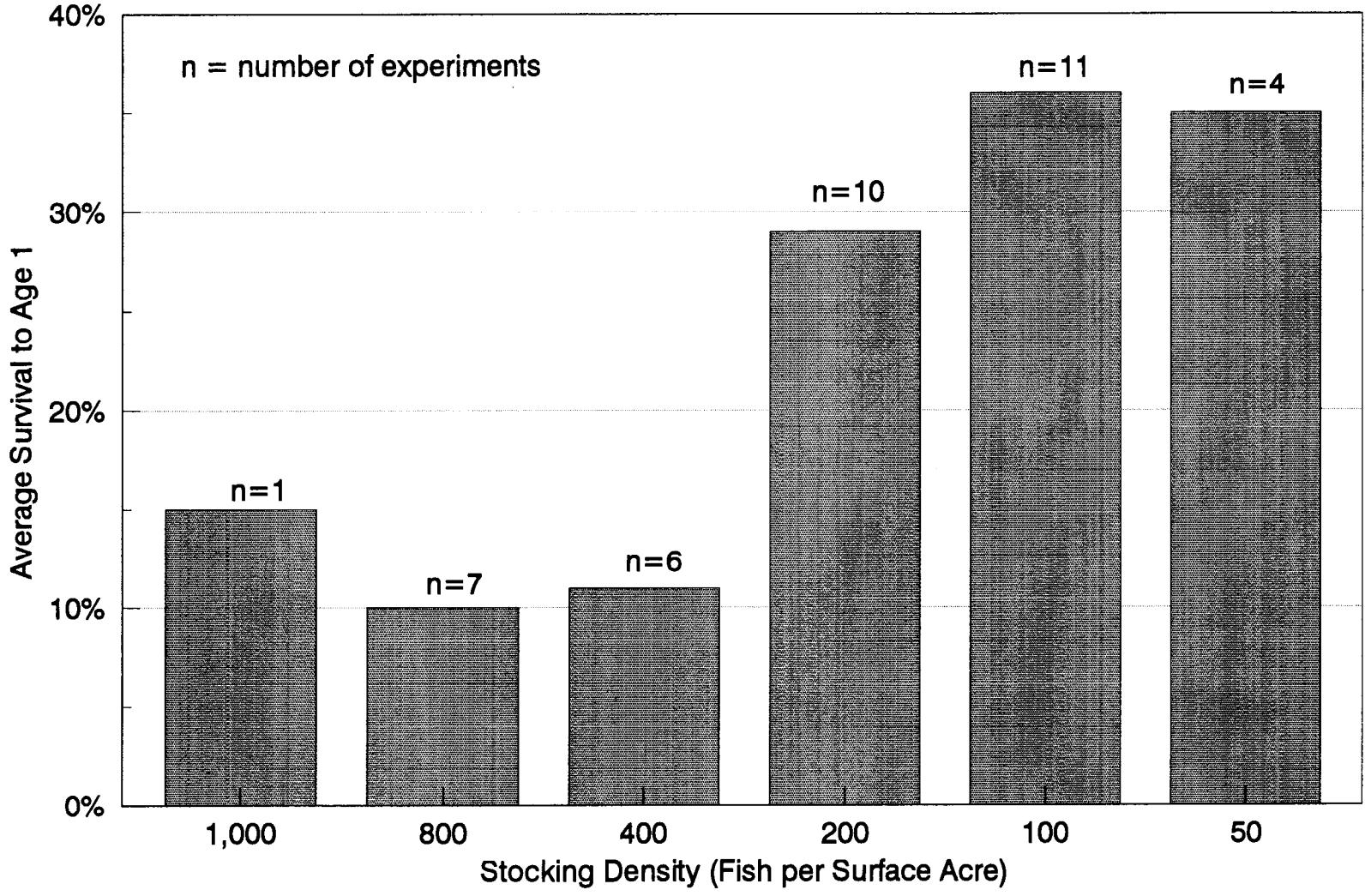

Figure 3. Average rainbow trout survival by stocking density in Matanuska-Susitna Valley lakes, 1989-1991.

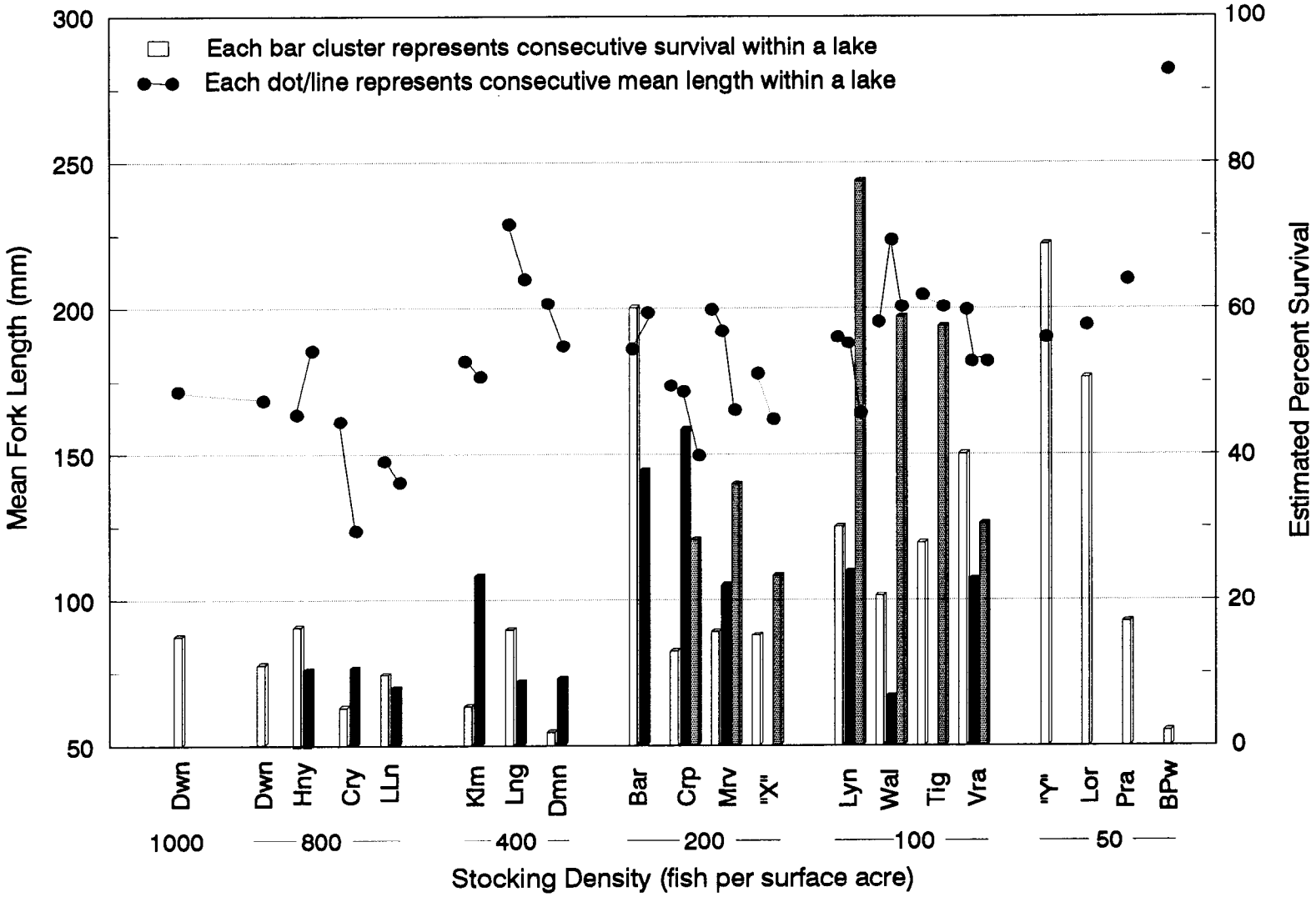

Figure 4. Average rainbow trout survival by stocking density by lake in Matanuska-Susitna Valley lakes, 1989-1991.

Table 8. Stocking history, abundance, and length data for age-1 rainbow trout of Swanson River origin captured by fyke net in selected Matanuska-Susitna Valley lakes, 1989-1991.

Lake	Date Stocked	Number Stocked	Fish/ Acre	Fish/ Shoreline Mile	Size Stocked	Date Captured	Number Caught	Number Measured	Length Mean (mm)	SE	Length Range (mm)	Number Measured > 164 mm	Percent > 164 mm	SE
50 Per Surface Acre:														
Bear Paw	07/17/90	2,250	50	2,045	1.69 g	09/25/91	4	4	279	11	258-312	4	100	0.0
Lorraine	07/26/90	6,620	50	2,878	1.70 g	09/17/91	308	308	195	2	128-277	253	82	2.2
Prator	07/17/90	4,900	50	3,267	1.69 g	09/10/91	49	49	210	6	129-290	42	86	5.0
"Y"	07/17/90	1,900	48	950	1.69 g	10/11/91	215	215	189	2	128-244	178	83	2.6
							576	576	195	1	128-312	477	83	1.6
100 Per Surface Acre:														
Lynne	08/01/88	7,056	101	3,714	1.20 g	09/21/89	512	146	189	2	138-245	128	88	2.7
Lynne	07/19/89	6,990	100	3,679	1.40 g	09/25/90	214	204	187	1	143-220	175	86	2.4
Lynne	07/13/90	7,000	100	3,684	2.05 g	09/25/91	382	382	164	1	114-212	176	46	2.6
Tigger	08/03/88	1,877	99	2,086	1.08 g	09/20/89	140	138	206	2	141-260	126	91	2.4
Tigger	07/26/90	1,894	100	2,104	1.70 g	09/25/91	239	239	201	2	128-319	208	87	2.2
Vera	08/01/88	10,850	98	3,875	1.20 g	09/26/89	1,397	145	199	2	147-262	138	95	1.8
Vera	07/19/89	11,025	100	3,938	1.30 g	09/19/90	682	682	182	1	125-240	587	86	1.3
Vera	07/13/90	11,050	100	3,946	2.05 g	10/16/91	72	72	182	2	140-218	58	81	4.7
Walby	08/01/88	5,378	100	3,841	1.20 g	09/15/89	274	156	195	2	112-280	136	87	2.7
Walby	07/18/89	5,390	100	3,850	1.50 g	10/11/90	78	78	223	5	128-301	65	83	4.3
Walby	07/17/90	5,390	100	3,850	1.90 g	10/10/91	132	132	200	4	123-293	98	74	3.8
							4,122	2,374	188	1	112-319	1,894	80	0.8

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Table 8. (Page 2 of 3).

Lake	Date Stocked	Number Stocked	Fish/ Acre	Fish/ Shoreline Mile	Size Stocked	Date Captured	Number Caught	Number Measured	Length Mean (mm)	SE	Length Range (mm)	Number Measured > 164 mm	Percent > 164 mm	SE
200 Per Surface Acre:														
Barley	08/01/88	3,695	199	4,619	1.20 g	09/28/89	867	143	186	2	140-233	116	81	3.3
Barley	07/19/89	3,720	200	4,650	1.50 g	09/06/90	195	190	199	1	144-246	182	96	1.4
Carpenter	08/01/88	35,255	200	9,278	1.20 g	09/28/89	1,141	161	173	2	120-220	95	59	3.9
Carpenter	07/19/89	35,280	200	9,284	1.10 g	09/28/90	2,145	2,145	171	1	118-223	1,394	65	1.0
Carpenter	07/17/90	35,280	200	9,284	1.69 g	09/18/91	1,269	1,269	149	1	108-214	254	20	1.1
Morvro	07/29/88	17,333	200	9,629	1.00 g	10/03/89	682	150	199	2	130-250	137	91	2.3
Morvro	07/20/89	17,320	200	9,622	1.10 g	09/27/90	611	611	192	1	142-235	556	91	1.2
Morvro	07/17/90	17,320	200	9,622	1.69 g	10/16/91	641	641	166	1	119-215	346	54	2.0
"X"	07/28/88	20,843	206	6,513	1.10 g	09/20/89	485	285	178	1	123-228	202	71	2.7
"X"	07/26/90	20,320	200	6,350	1.61 g	09/27/91	871	869	163	1	112-224	365	42	1.7
							8,907	6,464	169	0	108-250	3,647	56	0.6
400 Per Surface Acre:														
Diamond	07/29/88	55,622	400	20,601	1.00 g	10/05/89	731	156	202	2	139-247	687	94	0.9
Diamond	07/20/89	55,600	400	20,593	1.10 g	10/03/90	765	753	187	1	119-265	581	76	1.5
Kalmback	07/29/88	51,850	415	22,543	1.00 g	10/03/89	318	155	182	2	127-238	223	70	2.6
Kalmback	07/20/89	52,000	416	22,608	1.50 g	10/03/90	2,703	1,598	177	1	113-229	1,757	65	0.9
Long	07/28/88	30,575	411	12,740	1.10 g	09/29/89	1,052	155	229	3	143-340	1,010	96	0.6
Long	07/13/89	29,914	402	12,464	1.50 g	09/14/90	218	218	211	2	132-295	194	89	2.1
							5,787	3,035	186	1	113-340	4,452	77	0.6

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Table 8. (Page 3 of 3).

Lake	Date Stocked	Number Stocked	Fish/ Acre	Fish/ Shoreline Mile	Size Stocked	Date Captured	Number Caught	Number Measured	Length Mean (mm)	SE	Length Range (mm)	Number Measured > 164 mm	Percent > 164 mm	SE
Crystal	08/01/88	105,415	800	37,648	1.20 g	09/29/89	446	138	161	2	103-222	65	47	4.3
Crystal	07/19/89	105,442	801	37,658	1.50 g	09/21/90	987	619	123	1	97-156	0	0	0.0
Dawn	07/19/89	9,440	800	15,733	1.50 g	10/05/90	352	265	209	2	133-261	257	97	1.0
Honeybee	08/01/88	46,206	797	20,090	1.20 g	09/21/89	770	153	165	2	114-218	77	50	4.1
Honeybee	07/19/89	46,150	796	20,065	1.40 g	09/26/90	872	872	186	1	135-243	706	81	1.3
L. Lonely	08/01/88	44,820	800	24,900	1.10 g	09/22/89	1,313	144	148	2	102-189	26	18	3.2
L. Lonely	07/19/89	44,805	800	24,892	1.30 g	09/19/90	1,061	1,008	140	1	103-191	91	9	0.9
							5,801	3,199	158	1	97-261	1,221	38	0.9
Dawn	08/01/88	12,376	1,049	20,627	1.20 g	09/13/89	982	167	172	2	115-230	107	64	3.7

experiments, was 195 mm, 188 mm, 169 mm, 186 mm, 158 mm, and 172 mm in lakes stocked at 50, 100, 200, 400, 800, and 1,000 per surface acre, respectively (Table 8).

Rainbow trout considered to be of harvestable size, that is greater than 164 mm fork length at age 1, comprised 83% of the estimated population for the group of lakes stocked at 50 fish per surface acre, 80% in 100 per surface acre lakes, 56% in 200 per surface acre lakes, 77% in 400 per surface acre lakes, 38% in 800 per surface acre lakes, and 64% in the one lake stocked at 1,000 fish per surface acre (Table 8). The number per surface acre per 100 stocked of age-1 rainbow trout over 164 mm averaged 29, 28, 20, 9, 5, and 10 fish for stocking densities of 50, 100, 200, 400, 800, and 1,000 per surface acre, respectively (Table 7).

Comparison of Stocking Densities:

Friedman's analysis of variance by ranks did not find significant differences among lakes and years for any of the parameters tested (Table 9).

Rainbow Trout Costs:

At an assumed production cost of $0.08 per Swanson River strain rainbow trout fingerling stocked from the Alaska Department of Fish and Game Ft. Richardson hatchery (Bentz et al. 1991), fish surviving to age 1 in lakes stocked at 50 per surface acre cost an average of $1.19 each (Table 7). Age-1 rainbow trout in lakes stocked at 100 per surface acre cost an average of $0.33, stocked at 200 per surface acre cost an average of $0.34, stocked at 400 per surface acre cost an average of $1.41, and stocked at 800 per surface acre cost an average of $0.87. Age-1 rainbow trout in the one lake stocked at 1,000 per surface acre cost an estimated $0.52 each.

The results of 3 years of experiments demonstrated that lakes stocked at all densities on the average produced acceptable numbers of rainbow trout over 164 mm by the end of the first year. The most cost efficient plants for rainbow trout production were at a stocking density of 100 per surface acre, which produced an average of 36 rainbow trout per surface acre at $0.33 each, and a stocking density of 200 per surface acre, which produced an average of 59 rainbow trout per surface acre at $0.34 each.

Computerized data files used to generate these analyses are listed in Appendix A3.

DISCUSSION

Using criteria for fish density and minimum length at age 1 presented by Skaugstad and Clark (1991) for hatchery reared game fish stocked in small Alaska lakes, three of the 39 rainbow trout plants evaluated for stocking density experiments would be judged as having produced an age-1 fish density considered moderately successful (1 to 8 fish per surface acre), while 36 of the stockings would be rated as fully successful (more than 8 fish per surface acre; Table 7). All 39 of the rainbow trout plants achieved an adequate growth rate, i.e., mean length of stocked fish at age 1 was 100 mm or more and all rainbow trout should be large enough to enter the sport fishery at age 2.

Table 9. Results of Friedman's analysis of variance by ranks, testing hypothesis of no effect of lake and year on survival and density of age-1 rainbow trout, 1989-1991.

Comparison	Dependent Variable	Friedman's Statistic	df	P
Lakes stocked at 100 & 200/surface acre, 1989-1991	Number per acre per 100 stocked	3.47	4	0.483
	Number > 164 mm per acre per 100 stocked	2.40	4	0.663
	Survival to age 1	3.47	4	0.483
Lakes stocked at 100, 200, 400, and 800/surface acre, 1989-1990	Number per acre per 100 stocked	13.16	11	0.285
	Number > 164 mm per acre per 100 stocked	17.54	11	0.095
	Survival to age 1	14.59	11	0.204

Two variables not measured during the 3 years of stocking density experiments, are predation of fingerling by previously stocked fish (Havens 1979-1981) and abundance of threespine stickleback which compete with newly introduced fingerlings for food and habitat (Havens 1980-1986, Wenderoff 1982). Both of these factors may adversely affect survival and growth of stocked rainbow trout.

All 19 lakes used for stocking density experiments contained populations of threespine stickleback and were stocked with hatchery reared game fish in 1987 (Appendix A4). Five of the lakes had been stocked only 1 year prior to the first experimental density plants while 14 lakes had been stocked for several years. Size of age-0 rainbow trout fingerling at time of stocking, which averaged 1.1 g in 1988, 1.4 g in 1989, and 1.8 g in 1990, probably had some influence on survival within lakes between years (Havens 1979-1986) but was obscured by the unmeasured abundance of threespine stickleback and previously stocked game fish.

The difference in average mean length for age-1 rainbow trout between stocking groups, and between lakes in a stocking group, appears to have been influenced by the average density of age-1 rainbow trout per surface acre (Table 7). The difference in mean length for age-1 rainbow trout within lakes from year to year may in some cases reflect the annual sampling date, which varied as much as 1 month, but was more likely influenced by the abundance of surviving age-1 rainbow trout, i.e., in general, size at age 1 decreased with an increase in survival (Figure 5).

Although size of age-0 rainbow trout fingerlings at time of stocking can be increased by holding the fish longer in the hatchery, rearing costs also increase. Delaying the stocking date might also reduce the ability of the stocked rainbow trout to avoid predation by, and competition with, stickleback. The target stocking date is mid-July when threespine stickleback densities are normally lowest, i.e., age-2 stickleback have spawned and are dead or dying and young-of-the-year stickleback are too small to effectively compete with newly introduced rainbow trout fingerlings for food (Havens 1984, 1985).

RECOMMENDATIONS

We recommend a rainbow trout fingerling stocking density of 100 fish per surface acre for lakes receiving relatively low angler use, and a stocking density of 200 fingerling per surface acre for heavily utilized lakes.

ACKNOWLEDGEMENTS

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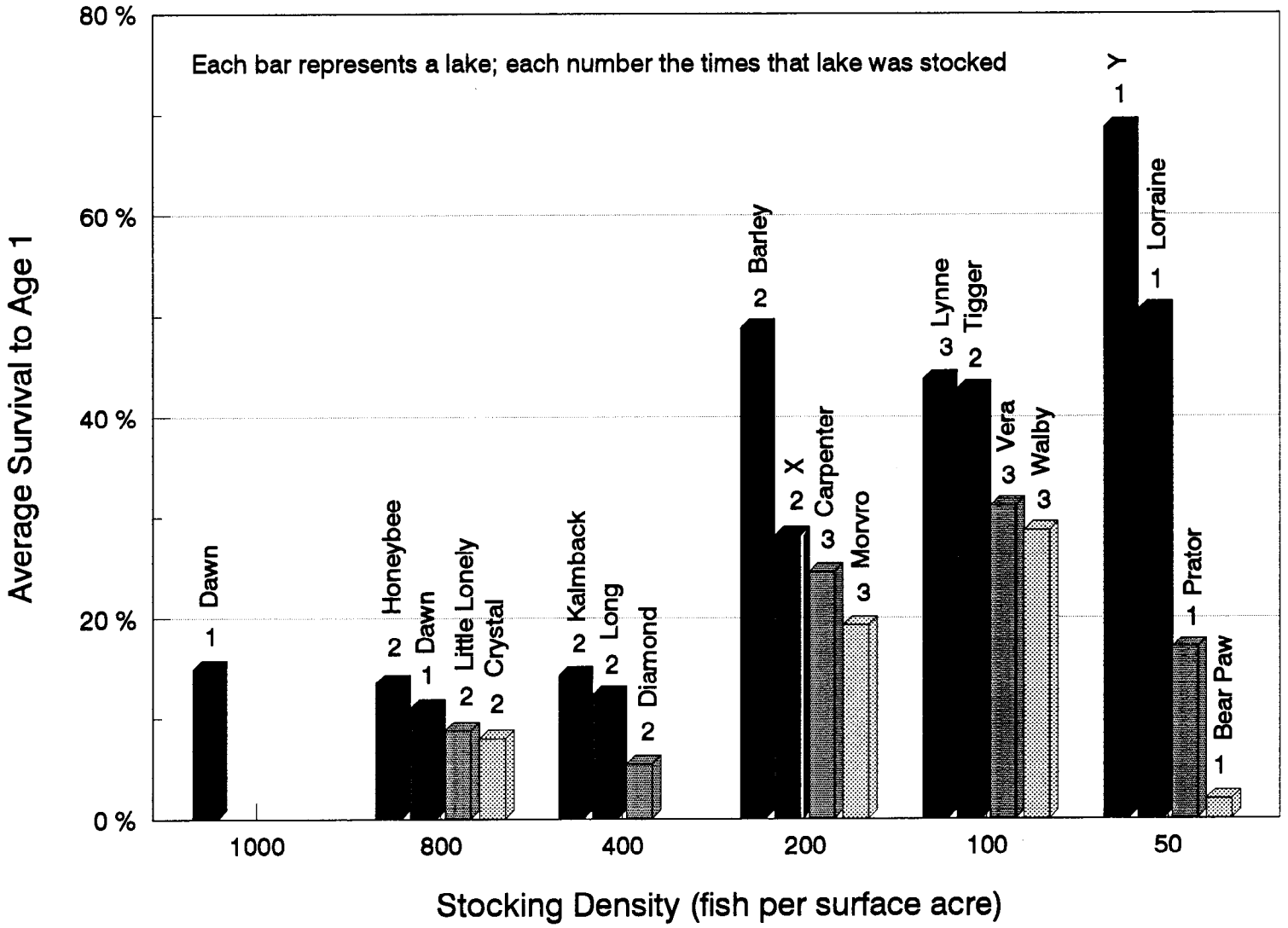

Figure 5. Rainbow trout survival and mean length by stocking density by lake in Matanuska-Susitna Valley lakes, 1989-1991.

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APPENDIX A

Selected Data Summaries and Data Files 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]	Species Present 1988-1991[b]
Bear Paw	45	17	9.9	1.1	0.91	RT,SS,TS
Lorraine	132	24	9.1	2.3	8.24	RT,TS
Prator	98	23	11.7	1.5	0.94	RT,SS,TS
"Y"	39.7	46	16.8	2.0	1.09	RT,GR,TS
Lynne	70	77	28.7	1.9	3.21	RT,TS
Tigger	18.9	33	14.0	0.9	3.14	RT,TS
Vera	110.5	22	11.1	2.8	5.89	RT,LNS,TS
Walby	53.9	18	5.4	1.4	34.44	RT,LNS,TS
Barley	18.6	17	7.2	0.8	17.08	RT,TS
Carpenter	176.4	30	8.1	3.8	3.49	RT,TS
Morvro	86.6	17	10.9	1.8	1.01	RT,TS
"X"[c]	101.4	45	17.0	3.2	1.88	RT,GR,TS
Diamond	139	23	7.6	2.7	3.29	RT,LNS,TS
Kalmback	125	24	13.1	2.3	6.72	RT,TS
Long[c,d]	74.4	55	26.1	2.4	9.73	RT,TS
Crystal	131.7	24	11.7	2.8	1.03	RT,LNS,TS
Honeybee	58	35	13.5	2.3	3.41	RT,TS
L. Lonely	56	63	20.0	1.8	1.59	RT,TS
Dawn	11.8	17	8.1	0.6	3.33	RT,TS

[a] Morphoedaphic index value (MEI) derived by dividing specific conductance by mean depth; can give a gross measure of a lake's potential productivity (Ryder 1965). 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.

[b] Species Codes: GR = Arctic grayling, LNS = longnose sucker, RT = rainbow trout, SS = coho salmon, TS = threespine stickleback.

[c] Both "X" and Long lakes are designated catch-and-release lakes by regulation.

[d] Long Lake in the Kepler-Bradley lakes system.

Appendix A2. Sampling data collected for rainbow trout population estimates from selected Matanuska-Susitna Valley lakes, spring and fall, 1991.

		Spring 1991 Rainbow Trout Sampling						Fall 1991 Rainbow Trout Sampling			
			Number Age 1		Number Age 2 and Older						
Lake	1990 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
Bear Paw	2,250	76	44	0	0	0	32	4	4	0	0
Lorraine	6,620	853	660	0	0	0	193	333	60	6	0
Prator	4,900	452	452	0	0	0	0	49	26	0	0
"Y"	1,900	446	235	0	0	0	211	474	38	28	0
Lynne	7,000	1,374	1,145	0	64	0	229	519	118	3	0
Tigger	1,894	255	249	0	5	0	6	239	80	0	0
Vera	11,050	550	276	0	43	0	274	134	25	2	1
Walby	5,390	592	524	0	15	0	68	152	32	0	0
Carpenter	35,280	1,807	1,092	0	86	0	715	1,708	187	25	3
Morvro	17,320	1,660	1,056	0	123	0	604	828	132	34	1
"X"	20,320	1,133	866	0	0	0	267	1,195	223	21	3

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

Appendix A3. Data files used to produce the 1991 results for this report.

K1980RA1.DTA - Bear Paw Lake fish length and mark data: Spring 1991.
K1980RB1.DTA - Bear Paw Lake fish length, age, and mark data: Fall 1991.
K2480RA1.DTA - Lorraine Lake fish length and mark data: Spring 1991.
K2480RB1.DTA - Lorraine Lake fish length, age, and mark data: Fall 1991.
K1690RA1.DTA - Prator Lake fish length and mark data: Spring 1991.
K1690RB1.DTA - Prator Lake fish length, age, and mark data: Fall 1991.
M190CRA1.DTA - "Y" Lake fish length and mark data: Spring 1991.
M190CRB1.DTA - "Y" Lake fish length, age, and mark data: Fall 1991.
K1970RA1.DTA - Lynne Lake fish length and mark data: Spring 1991.
K1970RB1.DTA - Lynne Lake fish length, age, and mark data: Fall 1991.
M190BRA1.DTA - Tigger Lake fish length and mark data: Spring 1991.
M190BRB1.DTA - Tigger Lake fish length, age, and mark data: Fall 1991.
K2530RA1.DTA - Vera Lake fish length and mark data: Spring 1991.
K2530RB1.DTA - Vera Lake fish length, age, and mark data: Fall 1991.
K1830RA1.DTA - Walby Lake fish length and mark data: Spring 1991.
K1830RB1.DTA - Walby Lake fish length, age, and mark data: Fall 1991.
K2600RA1.DTA - Carpenter Lake fish length and mark data: Spring 1991.
K2600RB1.DTA - Carpenter Lake fish length, age, and mark data: Fall 1991.
K2630RA1.DTA - Morvro Lake fish length and mark data: Spring 1991.
K2630RB1.DTA - Morvro Lake fish length, age, and mark data: Fall 1991.
M190ARA1.DTA - "X" Lake fish length and mark data: Spring 1991.
M190ARB1.DTA - "X" Lake fish length, age, and mark data: Fall 1991.

These data files are archived with Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services Unit, 333 Raspberry Road, Anchorage, Alaska 99518-1599. Contact Gail Heineman or Donna Buchholz (267-2369) for copies of the files and descriptions of the file formats.

Appendix A4. Stocking density in fish per surface acre of Matanuska-Susitna Valley research lakes, 1985-1990.

Lake	Surface Area (acres)	First Year Stocked	Species and Fish per Surface Acre Stocked (Size Stocked where applicable)					
			1985	1986	1987	1988	1989	1990
Bear Paw	45	1982	208 SS	178 SS	100 SS 102 RT 202	198 SS	196 SS	50 RT (1.7 g)
Lorraine	132	1984	221 RT	0	102 RT	100 RT	97 RT	50 RT (1.7 g)
Prator	98	1971	203 SS	203 SS	100 SS 100 RT 200	202 SS	199 SS	50 RT (1.7 g)
"Y"	39.7	1980	202 RT	201 RT	200 RT 200 GR 400	191 RT 98 GR 289	100 RT 45 GR 145	48 RT (1.7 g)
Lynne	70	1953	200 RT	200 RT	100 RT	101 RT (1.2g)	100 RT (1.4g)	100 RT (2.1 g)
Tigger	18.9	1974	338 RT	205 RT	99 RT	99 RT (1.1g)	0	100 RT (1.7 g)
Vera	110.5	1987	0	0	321 RT	98 RT (1.2g)	100 RT (1.3g)	100 RT (2.1 g)
Walby	53.9	1981	544 RT	199 RT	101 RT	100 RT (1.2g)	100 RT (1.5g)	100 RT (1.9 g)
Barley	18.6	1984	0	280 RT	280 RT	199 RT (1.2g)	200 RT (1.5g)	200 RT
Carpenter	176.4	1987	0	0	187 RT	199 RT (1.2g)	200 RT (1.1g)	200 RT (1.7 g)
Morvro	86.6	1987	0	0	430 RT	200 RT (1.0g)	200 RT (1.1g)	200 RT (1.7 g)
"X"	101.4	1980	201 RT	202 RT	108 RT	206 RT (1.1g)	0	200 RT (1.6 g)
Diamond	139	1987	0	0	400 RT	400 RT (1.0g)	400 RT (1.1g)	400 RT
Kalmback	125	1982	0	208 RT	104 RT	415 RT (1.0g)	416 RT (1.5g)	400 RT
Long	74.4	1956	306 RT	201 RT	100 RT	411 RT (1.1g)	402 RT (1.5g)	400 RT
Crystal	131.7	1963	204 RT	200 RT	100 RT	800 RT (1.2g)	801 RT (1.5g)	401 RT
Honeybee	58	1963	200 RT	200 RT	100 RT	797 RT (1.2g)	796 RT (1.4g)	800 RT
L. Lonely	56	1987	0	0	214 RT	800 RT (1.1g)	800 RT (1.3g)	800 RT
Dawn	11.8	1984	390 RT	263 RT	263 RT	1,049 RT (1.2g)	800 RT (1.5g)	800 RT