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EVALUATION OF ENHANCEMENT EFFORTS FOR RAINBOW TROUT, COHO SALMON, AND CHINOOK SALMON IN SOUTHCENTRAL ALASKA, 1986

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Experiments were conducted to provide information for the development of improved stocking practices for hatchery reared rainbow trout (*Salmo gairdneri* Richardson), coho salmon (*Oncorhynchus kisutch* Walbaum), and chinook salmon (*Oncorhynchus tshawytscha* Walbaum) in landlocked lakes.

Survival and growth of Swanson River strain rainbow trout were compared with survival and growth of Big Lake strain and Kitoi strain rainbow trout. In all cases, survival of Swanson River rainbow trout was greater than that of the other strains. Growth of Swanson River rainbow trout was variable in comparison to that of Big Lake strain. However, Swanson River strain rainbow trout grew faster than Kitoi strain rainbow trout.

Relative survival of age 1 Swanson River strain rainbow trout planted as fingerling by air-drop method was less than that of similar fish stocked by the standard hatchery tank truck release method. Growth of rainbow trout stocked by the two methods was not significantly different.

Research was conducted on Anchorage-area lakes stocked with catchable rainbow trout to estimate appropriate stocking times and stocking densities. Sport effort and catch rates were highest in the three weeks immediately following stocking, and dramatically declined thereafter.

Survival and growth were compared between coho salmon and chinook salmon stocked as fingerling. In all cases, survival of coho salmon was greater than that of chinook salmon. However, growth of chinook salmon was superior to that of coho salmon. Nevertheless, the difference in survival was the critical factor and it is recommended that lake stocking of chinook salmon be discontinued.

KEY WORDS: Southcentral Alaska, stocking practices, rainbow trout, *Salmo gairdneri*, coho salmon, *Oncorhynchus kisutch*, chinook salmon, *Oncorhynchus tshawytscha*, abundance, growth.

INTRODUCTION

Selected landlocked lakes in southcentral and interior Alaska have been stocked with hatchery-reared game fish since 1952. These lakes benefit sport anglers and their associated industries by providing diverse, year-round, fishing opportunities and diverting pressure from already taxed natural stocks. Currently 145 landlocked lakes in southcentral Alaska are stocked on an annual or biennial basis. The majority of these lakes, which range in size from approximately 3 to 200 surface hectares, were barren or contained only threespine stickleback (*Gasterosteus aculeatus* Linnaeus) prior to stocking.

Lakes are stocked with rainbow trout (*Salmo gairdneri* Richardson), Arctic grayling (*Thymallus arcticus* Pallas), or landlocked salmon (*Oncorhynchus spp.* Walbaum) 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. Alaska's wide variety of lake types requires that planting practices be developed and employed that are appropriate for the characteristics of the recipient waters.

Currently, a lack of precise information on what stocking practices provide optimum survival and growth has prevented the Alaska Department of Fish and Game (ADF&G) lake stocking program from reaching its full potential. Research experiments with various strains, stocking sizes, stocking densities, and times of stocking for rainbow trout, Arctic grayling, and landlocked salmon will refine both stocking and sampling procedures. These can then be applied to landlocked lakes throughout Alaska and allow the Sport Fish Division of the Alaska Department of Fish and Game to request specific fish stocks by size and time so hatcheries can produce those fish in the most cost efficient manner.

METHODS

Lake stocking research in 1986 involved sampling of rainbow trout, coho salmon, and chinook salmon which had been experimentally stocked in several Matanuska-Susitna Valley and Kodiak lakes (Figure 1, 2). In addition, a creel survey of four Anchorage area lakes that were stocked with catchable-size rainbow trout was conducted to estimate harvest, effort, and angler use patterns so that appropriate stocking times and densities could be refined.

Comparison of Abundance and Growth of Rainbow Trout

In August 1985, hatchery-reared Swanson River strain and Big Lake strain rainbow trout fingerling, both one generation removed from wild parentage, were stocked in Ravine, Reed, Tigger, and Walby Lakes in the Matanuska-Susitna Valley at densities of approximately 200 fish per surface acre. In September 1986, Johnson Lake was stocked with equal numbers of Swanson River strain and Big Lake strain rainbow trout fingerling at a density of 200 fish per surface acre. Abercrombie, Lilly Pond, Lee, and Margaret Lakes on Kodiak Island were each stocked with equal numbers of Swanson River strain and Kitoi strain rainbow trout fingerling at densities of approximately 200 fish per surface acre in August or September 1985. When two strains of trout were planted in a lake, the Swanson River strain fingerling always received a left ventral clip while Big Lake strain trout (Mat-Su Valley lakes) and Kitoi strain trout (Kodiak Island lakes) received a right ventral clip.

Florence, Honeybee, and "Y" Lakes were stocked with Swanson River strain rainbow trout fingerling and Crystal, Lynne, and "X" Lake were stocked with Big Lake strain rainbow trout fingerling at approximately 200 fish per surface acre in August or September 1985.

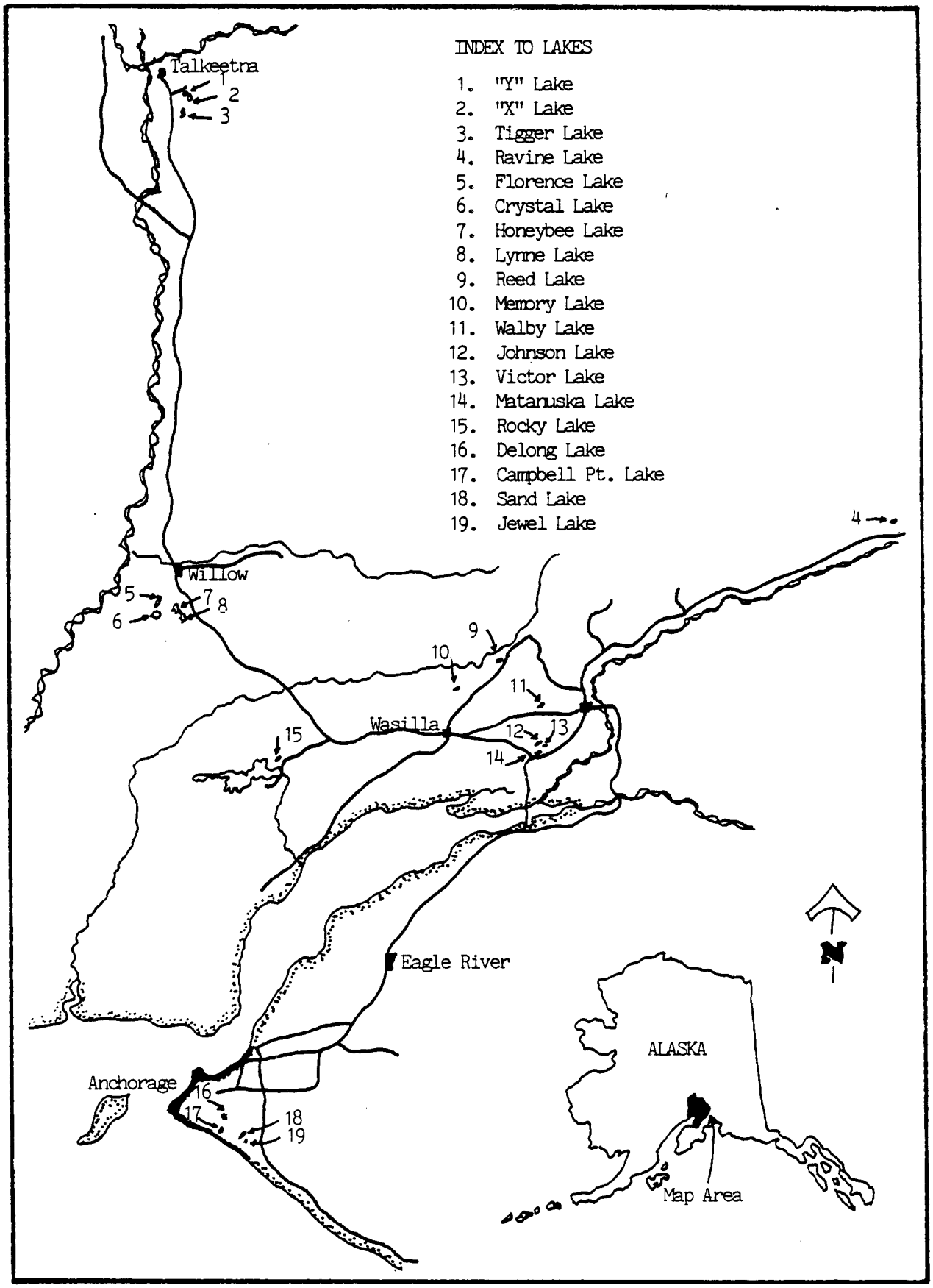

Figure 1. Sample lakes area in Matanuska-Susitna Valley and Anchorage.

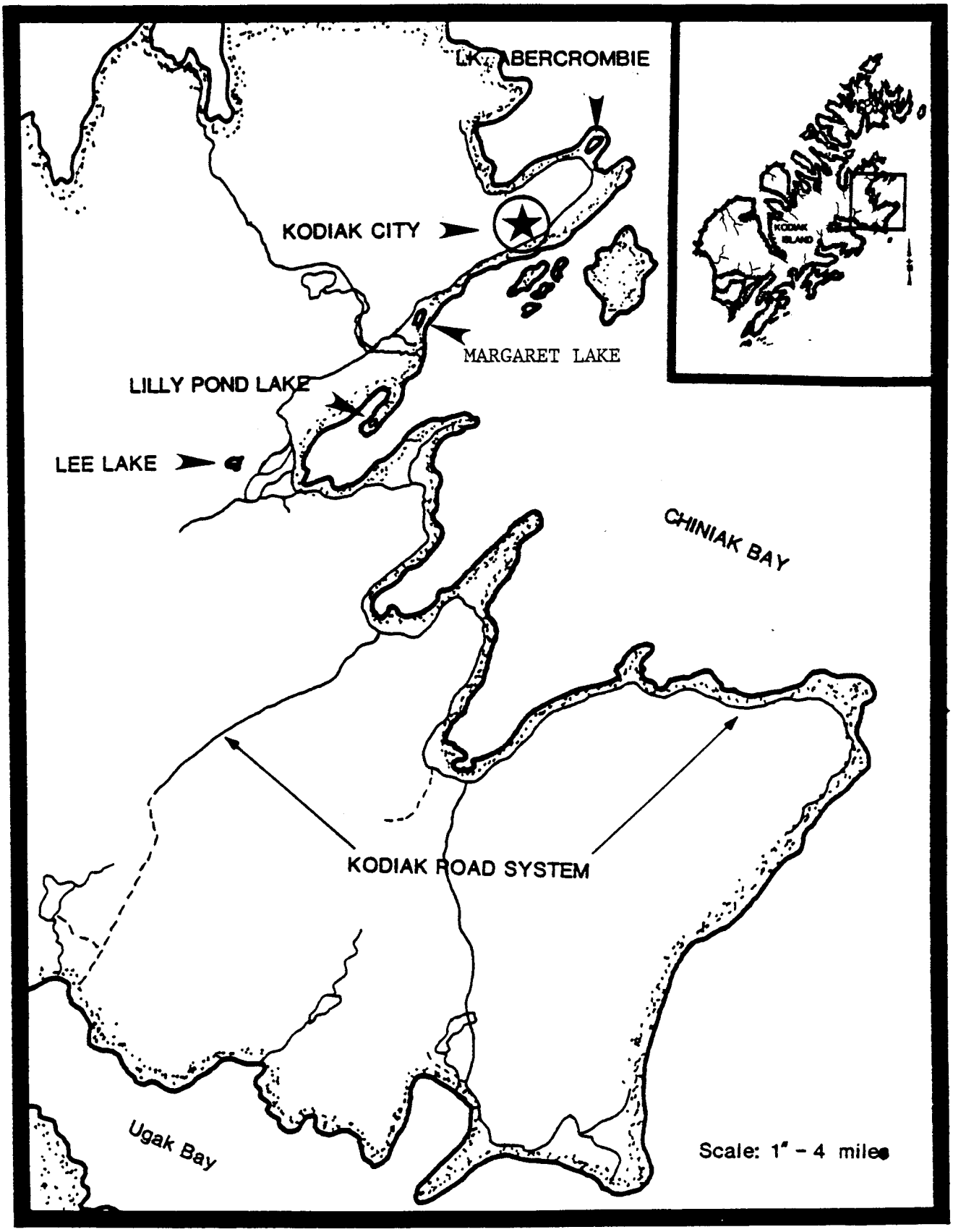

Figure 2. Location of Kodiak rainbow trout research lakes, Kodiak Island, Alaska.

Several southcentral Alaska lakes lack developed vehicle access which prohibits the direct release of hatchery-reared fish. Fish planted in some lakes are transported, in buckets or bags injected with oxygen, from the truck to the release site. Other lakes require use of an all terrain or four wheel drive vehicle, two to three people, and several hours of trip time to accomplish a planting.

An experiment was undertaken to compare relative survival of rainbow trout released directly from a hatchery truck to survival of rainbow trout dropped into the lake from an airplane. In 1985, a Cessna 188 Agtruck equipped with a 1,090 liter fiberglass tank and a 24-volt compressor was contracted to air-drop rainbow trout fingerling into several southcentral Alaska lakes. A total of 9,550 Swanson River strain rainbow trout fingerling were marked with an adipose finclip and released directly into Matanuska Lake from a hatchery truck on 4 September 1985. Within an hour; 9,550 unmarked Swanson River strain fingerling were air-dropped from the Cessna at an altitude of approximately 100 m at an air-speed of 85-90 knots.

Johnson, Memory, Rocky, and Victor Lakes in the Matanuska-Susitna Valley were each stocked with equal numbers of 3.5 g unmarked coho salmon and 13 g chinook salmon fingerling marked with a right ventral clip at densities of approximately 200 fish per surface acre in May and June 1986.

Rainbow trout, coho salmon, and chinook salmon were captured using fyke nets, gill nets, or both. 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. Gill nets were 36.6 m (120 ft) by 1.8 m (6 ft) variable mesh monofilament composed of six square mesh sizes, 12.7 mm (1/2 in), 15.9 mm (5/8 in), 19 mm (3/4 in), 25.4 mm (1 in), 38.1 mm (1-1/2 in), and 50.8 mm (2 in), each in a 6.1 m (20 ft) panel. Fyke nets were set parallel to the shoreline while gill nets were set at right angles to the shoreline. Both fyke nets and gill nets were set in randomly selected sites and directions and fished for approximately 20 hours each.

Age 1 rainbow trout, or age 0+ coho salmon or chinook salmon, captured in fyke nets were placed in a tub oxygenated with a portable 20-lb oxygen bottle and anesthetized with equal parts of MS-222 and Quinate. The catch of each fyke net was enumerated 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 covered by 4.8 mm (3/16 in) knotless nylon mesh. After all fish were in the holding pen, a minimum of 100 of each target strain or species were randomly selected and measured to the nearest millimeter fork length (FL). All fish were then released, with the exception of coho and chinook salmon captured in Johnson Lake on 27 August which were given an adipose finclip before being

released. All fish caught in gillnets were retained and measured to the nearest millimeter (FL).

A 2 by 2 chi-square contingency table was used to test the hypothesis of equal abundance of coho and chinook salmon stocked at equal densities in two lakes and of two rainbow trout strains stocked at equal densities in eight lakes. The rows were considered the treatment (salmon species or rainbow trout strain) and column 1 the number of fish not recaptured of the total number stocked for each group. The students t-test was used to test if the mean lengths of two stocking groups were significantly different. Necessary assumptions for the above analyses are: (1) both salmon species (or rainbow trout strains) are equally susceptible to the capture gear; (2) the capture gear is randomly sampling both populations, i.e., if there are significant differences in length between the populations, the gear is not selective toward one population because of the difference in length; and (3) for the t-test, the lengths are normally distributed random variables.

The abundance of coho and chinook salmon in Johnson Lake were estimated using the Petersen mark-recapture formula (Ricker 1975). Fish were captured for the estimate by fishing 12 fyke nets for four nights then 11 gill nets for seven nights between 7 and 24 October. All salmon caught by fyke nets during this experiment were held in live tanks and transported to Matanuska Lake at the end of the experiment and released.

Comparison of Stocking Strategies in Anchorage Lakes

Four Anchorage lakes were stocked on 23 May 1986 at a density of 300 catchable-size rainbow trout per surface acre. Jewel Lake received 7,844 fish, Sand Lake 20,099 fish, Campbell Point Lake 2,606 fish, and Delong Lake 5,900 fish. A creel survey was conducted to estimate the effort in angler-hours and the rainbow trout harvest and total catch for each lake. The creel survey was conducted from 24 May through 30 July. For each 7 day week during this time period, five days were randomly selected without replacement on which to conduct the creel survey. An angler-day was considered to be 18 hours in duration (from 0600 to 2400 hrs). A starting time for the sample period on a day selected was then randomly chosen from the whole hours between 0600 and 1800 (0600, 0700, 0800, etc.). The four lakes were visited in a random order determined on each sample day. Approximately 1 hour was spent at each lake.

About 10 minutes were spent conducting an angler count and the remaining time spent conducting angler interviews. Both anglers who had completed fishing for the day (complete trip) and anglers still fishing (incomplete trip) were interviewed. The following data were collected from each interviewed angler:

(1) length of time angler fished (to the nearest 5 min);
(2) number of rainbow trout harvested; and
(3) number of rainbow trout released.

Effort was estimated for each lake by two-week temporal strata. The number of angler-hours of effort during stratum t was estimated as follows:

$$(1) \quad \hat{E}_t = H_t \bar{x}_t,$$

where: $\bar{x}_t$ = the mean number of anglers per count for a lake during stratum t, and

H_t = the total number of hours of possible fishing time during stratum t.

The variance of effort was estimated as follows (Schaeffer et al. 1979):

$$(2) \quad V(E_t) = \hat{H}_t (s_t^2/n_t)^2,$$

where: s_t^2 = the sample variance of $\bar{x}_t$, and

n_t = the number of angler counts for a lake during stratum t.

Mean angler effort and mean rainbow trout harvest and catch per angler were estimated from the interview data for each lake by 2 week strata. Mean effort per angler on a lake during stratum t was estimated as:

$$(3) \quad \bar{f}_t = \left(\sum_{i=1}^{D} \sum_{k=1}^{m_i} f_{ik}\right) / \sum_{i=1}^{D} m_i,$$

where: f_{ik} = the effort (in hours) by angler k at the time of the interview on day i,

m_i = the number of anglers interviewed on day i, and

D = the number of days the fishery was open during stratum t.

The variance of mean effort was estimated following a two-stage sample design with days representing the first-stage sample units and anglers the second-stage sample units (Von Geldern and Tomlinson 1973). On a given sample day, the number of second-stage units available was unknown. The variance of mean effort was estimated as follows (Sukhatme et al. 1984):

$$(4) \quad V(\bar{f}_t) = [1 - (d/D)]\, s_B^2/d + \left(\sum_{i=1}^{D} s_{Wi}^2/m_i\right)/dD,$$

where; d = the number of days sampled during stratum t,

s^2_{Wi} = the sample variance of effort for anglers interviewed during day i, and

s^2_B = the between-day variance of angler effort.

The between-day variance, s^2_B, was estimated as follows:

$$(5) \quad s^2_B = [\sum_{i=1}^{D} (\bar{f}_{ti} - \bar{f}_t)^2]/(d-1),$$

where $\bar{f}_{ti}$ = the mean effort per angler on day i of stratum t.

Mean harvest and mean catch of rainbow trout and associated variances were estimated identically to effort except that the corresponding quantities for harvest or catch were substituted for all occurrences of effort (f).

Rainbow trout harvest rate (HPUE) or catch rate (CPUE) for a lake during stratum t was estimated by:

$$(6) \quad HPUE_t = \bar{c}_t/\bar{f}_t,$$

where $\bar{c}_t$ = the mean rainbow trout harvest per angler during stratum t.

The variance of $HPUE_t$ was approximated by the variance for the quotient of the mean of two random variables (Jessen 1978), which is:

$$(7) \quad \hat{V}(\bar{c}_t/\bar{f}_t) \approx (\bar{c}_t/\bar{f}_t)^2 (s^2_c/\bar{c}^2_t + s^2_f/\bar{f}^2_t - 2rs_c s_t/\bar{c}_t\bar{f}_t),$$

where; s^2_c = the two-stage variance estimate for $\bar{c}_t$,

s^2_f = the two-stage variance estimate for $\bar{f}_t$, and

r = the correlation coefficient between the f_{ik} and the c_{ik} in stratum t.

CPUE for a species and its variance were estimated by replacing the number of fish harvested with the number of fish caught (harvest plus those caught and released) in the above formulae.

The rainbow trout harvest during a stratum was estimated by:

(8) $\hat{H}_t = \hat{E}_t HPUE_t$.

The variance of $\hat{H}_t$ was estimated using Goodman's (1960) formula for the variance of the product of two independent random variables which is:

(9) $V(\hat{H}_t) = [\hat{E}_t^2 V(HPUE_t)] + [HPUE_t^2 V(\hat{E}_t)] - [V(\hat{E}_t) V(HPUE_t)]$.

Totals of effort, harvest, and catch for each lake were estimated by summing the estimates for all two-week strata. Estimates of effort and harvest for the strata are considered independent estimates, therefore, the variance of the season total was estimated by the sum of the appropriate variances.

Catch of a species and its variance were estimated by replacing HPUE with CPUE in the above formulae.

The major assumptions necessary for these analyses are:

1. Significant fishing effort occurs only between the hours defined for the angler day,

2. Individual angler effort and angler harvest (or catch) are normally distributed random variables,

3. Incomplete-trip angler interviews provide an unbiased estimate of complete-trip HPUE and CPUE (DiConstanzo 1956).

4. Anglers are interviewed in proportion to their abundance (DiCon stanzo 1956) and interviewed anglers are representative of the total angler population, and

5. Catch rate and length of fishing trip are independent (DiCon stanzo 1956).

RESULTS AND DISCUSSION

Comparison of Abundance and Growth of Rainbow Trout

Swanson River Strain Versus Big Lake Strain Rainbow Trout:

The experiments comparing abundance of Swanson strain and Big Lake strain rainbow trout at age 1 shows significantly higher survival ($P \leq 0.05$) for the Swanson strain trout in Ravine Lake ($X^2 = 57.49$); Reed Lake ($X^2 = 76.58$); Tigger Lake ($X^2 = 68.29$); and Walby Lake ($X^2 = 4.66$) (Table 1). Survival of age 0+ Swanson River strain fish was also significantly greater than Big Lake strain ($X^2 = 750.62$). The greatest differences in abundance between the two strains were in Johnson, Ravine, and Reed Lakes which are free from threespine stickleback.

Table 1. Stocking history, fyke net catch summary, and length data for Swanson River and Big Lake strain rainbow trout in Ravine, Reed, Tigger, Walby, and Johnson Lakes, 1986.

Lake	Strain[1] (Clip)	Date Stocked	Number Stocked	Size Stocked	Date Captured	Number Captured	Catch Ratio SR:BL	Number Measured	Length Mean (mm)	Length Standard Error	Length Range (mm)
Ravine	SR (LV)	08/19/85	2,273	2.36g	06/11/86	398	1.80:1	100	108	1.11	82 - 135
	BL (RV)	08/19/85	2,270	2.60g	06/11/86	221		100	103	0.82	89 - 123
Reed	SR (LV)	08/21/85	4,092	2.36g	06/15/86	718	1.63:1	100	125	1.35	92 - 160
	BL (RV)	08/21/85	4,088	2.60g	06/15/86	441		100	121	1.09	95 - 152
Tigger[2]	SR (LV)	08/20/85	3,193	2.36g	06/17/86	907	1.45:1	100	98	1.24	74 - 130
	BL (RV)	08/20/85	3,195	2.60g	06/17/86	625		100	98	1.02	75 - 124
Walby[2]	SR (LV)	08/23/85	14,706	2.40g	06/06/86	866	1.12:1	100	89	1.29	63 - 127
	BL (RV)	08/23/85	14,607	2.10g	06/06/86	775		100	90	1.25	67 - 116
Johnson	SR (LV)	09/03/86	4,030	2.56g	10/23/86	1,500	3.53:1	106	78	0.60	65 - 91
	BL (RV)	09/03/86	4,030	2.06g	10/23/86	477		102	75	0.48	63 - 86

[1] Strain (Clip): SR = Swanson River; BL = Big Lake; (LV) = left ventral clip; (RV) = right ventral clip.
[2] Tigger and Walby Lakes contain populations of threespine stickleback.

Mean length at age 1 for rainbow trout of each strain were similar within each lake except Ravine Lake where Swanson River fish grew significantly faster than Big Lake fish ($P \leq 0.05$). Big Lake strain trout mean lengths ranged from 90 mm in Walby Lake to 121 mm in Reed Lake while Swanson strain fish mean lengths ranged from 89 mm in Walby Lake to 125 mm in Reed Lake (Table 1). There was a significant difference between mean lengths of age 0+ trout in Johnson Lake ($P \leq 0.05$), with Swanson trout averaging 78 mm and Big Lake trout averaging 75 mm.

Comparisons of growth between Swanson River and Big Lake strains in separate lakes were inconclusive (Table 2). Average lengths of age 1+ Swanson River strain trout ranged from 106 mm in Honeybee Lake to 119 mm in stickleback-free Florence Lake while average length of Big Lake strain ranged from 102 mm in Crystal Lake to 113 mm in "X" Lake.

In general, Swanson River and Big Lake strain rainbow trout had similar growth rates, but survival of Swanson River trout was consistently higher. Completion of comparisons between abundance and growth of Swanson River strain and Big Lake strain rainbow trout in landlocked lakes includes investigation of: (1) performance at older ages; and (2) performance in stickleback-free and stickleback-infested lakes. Equal numbers of Swanson and Big Lake fingerling were stocked in stickleback-free Marion Lake and stickleback-infested Barley, Dawn, and Kalmback Lakes in 1986 for further comparisons of relative survival and growth to age 1 between the two strains. Ravine, Reed, Tigger, and Walby Lakes will be sampled in 1987 to compare mean lengths of Swanson and Big Lake trout at age 2+.

Swanson River Strain Versus Kitoi Strain Rainbow Trout:

Survival of Swanson River strain rainbow trout was higher than that of Kitoi strain in every comparison (Table 3). These differences in survival were significant ($P \leq 0.05$) for Lilly Pond Lake ($X^2 = 34.39$)and Lee Lake ($X^2 = 7.55$); while the difference was not significant for Margaret Lake. Only Swanson strain age 1+ fish were captured in Abercrombie Lake. Gill nets in Lilly Pond and Lee Lakes also captured a significantly greater number of age 2+ Swanson trout than Kitoi trout (Lilly Pond Lake: $X^2 = 6.44$; Lee Lake: $X^2 = 7.32$).

Mean length, as measured at age 1+, of Swanson River strain trout was greater than Kitoi strain in every comparison (Table 3). Mean lengths at age 1+ of Swanson strain trout ranged from 187 mm in Lee Lake to 199 mm in Abercrombie Lake; Kitoi fish ranged from 169 mm in Margaret Lake to 171 mm in Lilly Pond Lake. Swanson River strain rainbow trout were significantly larger than Kitoi strain ($P \leq 0.05$) in Lilly Pond Lake ($t = 6.69$); Lee Lake ($t = 4.15$); and Margaret Lake ($t = 5.12$).

There was no significant difference in Lee Lake between mean lengths of age 2+ Swanson strain rainbow trout at 242 mm and Kitoi strain rainbow trout at 258 mm (Table 3). Age 2+ Swanson trout in Lilly Pond Lake averaged 263 mm and the one age 2+ Kitoi trout captured was

Table 2. Stocking history, net catch summary, and length data for Swanson River strain rainbow trout in Florence, Honeybee, and "Y" Lakes and Big Lake strain rainbow trout in Crystal, Lynne, and "X" Lakes, 1986.

Lake	Strain[1]	Date Stocked	Number Stocked	Size Stocked	Date Captured	Number Captured	Catch per Net-Hour: Fyke Nets	Catch per Net-Hour: Gill Nets	Length: Number Measured	Length: Mean (mm)	Length: Standard Error	Length: Range (mm)
Florence	SR	08/27/85	10,937	2.56g	07/16/86	422	6.39	4.55	422	119	0.42	85 - 131
Crystal[2]	BL	08/28/85	26,875	2.50g	07/16/86	235	3.26	0.46	235	102	0.84	66 - 134
Honeybee[2]	SR	08/27/85	11,603	2.56g	07/15/86	196	3.46	1.56	196	106	0.61	86 - 123
Lynne[2]	BL	08/28/85	14,000	2.50g	07/15/86	602	11.93	2.41	442	105	0.58	68 - 132
"Y"[2]	SR	08/27/85	8,003	2.56g	07/18/86	180	2.74	0.94	180	112	0.77	80 - 131
"X"[2]	BL	09/04/85	20,378	2.38g	07/18/86	276	3.32	1.30	276	113	0.69	84 - 134

[1] Strain: SR = Swanson River; BL = Big Lake.

[2] Crystal, Honeybee, Lynne, "Y", and "X" Lakes contain threespine stickleback.

Table 3. Stocking history, gill net catch summary, and length data for Swanson River and Kitoi strain rainbow trout in Abercrombie, Lilly Pond, Lee, and Margaret Lakes, 1986.

Lake[1]	Strain[2] (Clip)	Date Stocked	Number Stocked	Size Stocked	Date Captured	Number Captured	Catch Ratio SR:K	Length: Number Measured	Length: Mean (mm)	Length: Standard Error	Length: Range (mm)
Abercrombie	SR (LV)	08/30/85	1,826	1.0g	10/14/86	5	5.00:0	5	199	9.85	170 - 223
	K (RV)	08/22/85	2,270	0.9g	10/14/86	0					
Lilly Pond	SR (LV)	09/04/85	788	1.0g	10/10/86	91	3.03:1	88	190	1.51	161 - 228
	K (RV)	08/22/85	800	0.9g	10/10/86	30		30	171	2.06	151 - 195
	SR (LV)	08/16/84	793	2.1g	10/10/86	9	9.00:1	9	263	9.55	235 - 320
	K (RV)	08/14/84	800	0.7g	10/10/86	1		1	275		
Lee	SR (LV)	08/30/85	1,400	1.0g	10/13/86	37	2.18:1	37	187	2.48	150 - 211
	K (RV)	08/22/85	1,400	0.9g	10/13/86	17		17	169	3.34	144 - 204
	SR (LV)	08/16/84	1,417	2.1g	10/13/86	32	2.46:1	32	241	4.89	206 - 353
	K (RV)	08/14/84	1,400	0.7g	10/13/86	13		13	256	8.371	207 - 308
Margaret	SR (LV)	08/30/85	800	1.0g	10/12/86	24	1.50:1	24	196	3.89	166 - 228
	K (RV)	08/22/85	800	0.9g	10/12/86	16		16	169	3.13	150 - 192

[1] Abercrombie Lake contains threespine stickleback and Dolly Varden Char; Lee and Margaret Lakes contain Dolly Varden char.

[2] Strain (Clip): SR = Swanson River; K = Kitoi; (LV) = left ventral clip; (RV) = right ventral clip;

275 mm. However, Kitoi strain trout certainly exhibited superior growth since these fish were only one third the size of Swanson strain fish at time of stocking (0.7 g and 2.1 g, respectively).

These results support previous findings. Murray (1986) compared abundance and mean length of Swanson River and Kitoi strain rainbow trout stocked as fingerling at equal numbers in three Kodiak lakes in 1984. Gill nets fished in October 1985 captured a significantly greater proportion of age 1+ Swanson trout than Kitoi trout in all three lakes; and Swanson trout were significantly larger in each lake than the Kitoi fish.

A further consideration involving the selection of a rainbow trout strain for Kodiak lakes is trout migratory behavior. Several Kodiak lakes, including Kitoi Lake which is the broodstock source for Kitoi strain rainbow trout, have outlet streams to saltwater, many with falls or barriers would eliminate trout ingress. Murray (1986) reported that a small number of Swanson and Kitoi strain age 1 rainbow trout emigrated from a test lake in 1986. A fish trap will be operated in 1987 on the outlet of one of the lakes stocked with Swanson and Kitoi strain trout in 1986 to further evaluate the migratory behavior of the two strains.

Air-Drop Versus Hatchery Truck Plant:

Survival of truck-released fish was significantly ($P \leq 0.05$) greater than that for air-dropped fish ($X^2 = 13.72$) (Table 4). Mean length at age 1 for the two release methods were not significantly different. Since Matanuska Lake is stickleback-free, a further comparison of the two stocking methods will be continued during 1987 in stickleback-infested South Rolly Lake.

Although truck-released fish enjoyed greater survival than did air-dropped fish, greater use of the air-drop method should still be considered. At a cost of $150/hour for the Cessna (average air speed 140 mph), several employee-days and hundreds of vehicle miles could be saved by air-dropping fingerling game fish in lakes not directly accessible to hatchery tank trucks.

Comparison of Stocking Strategies for Anchorage Lakes

Estimated catch rates and harvest rates of rainbow trout were highest in Jewel, Delong, Sand, and Campbell Point Lakes immediately after stocking in late May (Table 5). Estimated effort, catch, and harvest peaked during the first two weeks of June with the exception of Sand Lake where effort peaked on 10 July following a 9 July media campaign directed at increasing angler awareness of the Anchorage lakes sport fishery (Figure 3).

The mean harvest rate (HPUE) during May ranged from 0.56 fish/hour in Jewel Lake to 2.44 fish/hour in Sand Lake. However, by late July, HPUE had dropped to below 0.25 fish/hour in all four lakes (Figure 4). Mean catch rates, ranging from 1.1 fish/hour in Jewel

Table 4. Comparison of hatchery truck and air-drop releases of Swanson River strain rainbow trout in Matanuska Lake, 1986.

Stocking Method	Clip[1]	Date Stocked	Number Stocked	Size Stocked	Date Captured	Number Captured	Catch Ratio AD:NM	Length: Number Measured	Length: Mean (mm)	Length: Standard Error	Length: Range (mm)
Hatchery Truck	AD	09/04/85	9,550	2.20g	05/19/86	1,325	1.15:1	100	131	1.27	98 - 167
Air Drop	NM	09/04/85	9,550	2.20g	05/19/86	1,153		100	132	1.38	103 - 168

[1] AD = adipose clip; NM = no mark.

Table 5. Estimated sport fishing effort, catch, and harvest of rainbow trout in Jewel, Delong, Sand, and Campbell Pt. Lakes, 24 May - 30 July 1986.

Lake	Strata	Number Days Possible	Number Days Sampled	Number of Interviews	Angler Counts: Mean	Angler Counts: Standard Error	Estimated Effort: Total (angler hours)	Estimated Effort: Standard Error	Estimated Catch Rate and Total Catch: Mean Catch Rate (fish/hour)	Estimated Catch Rate and Total Catch: Standard Error	Estimated Catch Rate and Total Catch: Total Catch	Estimated Catch Rate and Total Catch: Standard Error	Estimated Harvest Rate and Total Harvest: Mean Harvest Rate (fish/hour)	Estimated Harvest Rate and Total Harvest: Standard Error	Estimated Harvest Rate and Total Harvest: Total Harvest	Estimated Harvest Rate and Total Harvest: Standard Error
Jewel	5/24-5/31	8	7	134	17.6	4.9	2,530.3	710.9	1.0964	2.84E-02	2,774	782.3	0.5630	8.81E-03	1,425	400.8
	6/01-6/15	15	6	89	16.8	1.8	4,545.0	460.0	0.8164	2.52E-02	3,711	407.9	0.2350	9.81E-03	1,068	121.1
	6/16-6/30	15	7	37	5.9	2.3	1,581.4	616.3	0.6039	3.39E-02	995	374.9	0.3117	2.25E-02	493	194.4
	7/01-7/15	15	4	30	10.5	2.2	2,835.0	588.5	0.1323	1.97E-02	375	94.4	0.1323	1.96E-02	375	94.4
	7/16-7/30	15	5	14	3.2	1.2	864.0	335.1	0.1906	2.77E-02	165	66.9	0.1906	2.77E-02	165	66.9
	Total	68	29	304			12,355.7	1,254.5	0.6459		7,980	965.6	0.2854		3,526	475.9
Delong	5/24-5/31	8	7	66	10.6	4.0	1,522.3	577.6	2.4822	6.02E-02	3,779	1,435.8	0.9946	2.52E-02	1,514	575.4
	6/01-6/15	15	6	59	14.7	2.0	3,960.0	556.3	1.5911	5.50E-02	6,301	910.4	0.7198	2.53E-02	2,850	412.3
	6/16-6/30	15	7	24	4.7	1.1	1,272.9	292.9	0.9781	1.12E-01	1,245	316.6	0.4446	5.01E-02	566	143.7
	7/01-7/15	15	4	17	4.8	1.4	1,282.5	387.8	0.7601	7.58E-02	975	307.5	0.4223	5.53E-02	542	175.9
	7/16-7/30	15	5	4	1.2	0.3	324.0	101.0	0.2222	9.76E-02	72	36.2	0.2222	9.76E-02	72	36.2
	Total	68	29	170			8,361.7	942.8	1.0013		12,372	1,756.8	0.4487		5,544	744.3
Sand	5/24-5/31	8	7	24	5.3	1.3	761.1	187.8	4.5388	2.18E-01	3,454	866.4	2.4402	2.05E-01	1,857	481.0
	6/01-6/15	15	6	40	9.8	1.9	2,655.0	519.0	1.5387	7.62E-02	4,085	821.8	0.8508	4.37E-02	2,259	455.4
	6/16-6/30	15	7	4	1.6	0.6	424.3	165.2	0.0000	0.00E-00	0	0.0	0.0000	0.00E-00	0	0.0
	7/01-7/15	15	4	39	10.5	4.3	2,835.0	1,174.3	0.7663	1.51E-01	2,172	964.4	0.6655	1.57E-01	1,887	861.0
	7/16-7/30	15	5	8	1.6	0.7	432.0	183.1	0.2309	6.33E-02	100	47.6	0.0000	0.00E-00	0	0.0
	Total	68	29	115			7,107.4	1,319.9	1.3804		9,811	1,535.7	0.8446		6,003	1,086.3
Campbell Point	5/24-5/31	8	7	63	6.7	2.3	966.9	324.6	2.1241	5.53E-02	2,054	691.1	1.0345	2.57E-02	1,000	336.5
	6/01-6/15	15	6	67	7.3	2.1	1,980.0	564.9	1.4041	7.88E-02	2,780	806.0	0.7200	2.55E-02	1,426	409.4
	6/16-6/30	15	7	21	4.0	1.7	1,080.0	471.4	0.4480	7.15E-02	484	219.7	0.2240	2.24E-02	242	107.3
	7/01-7/15	15	4	11	2.5	1.7	675.0	447.7	0.6378	1.45E-01	431	287.6	0.6378	1.45E-01	431	287.6
	7/16-7/30	15	5	15	2.0	1.4	540.0	372.2	0.0517	3.95E-02	28	19.8	0.0517	3.95E-02	28	19.8
	Total	68	29	177			5,241.9	992.2	1.1021		5,777	1,121.9	0.5965		3,127	612.7

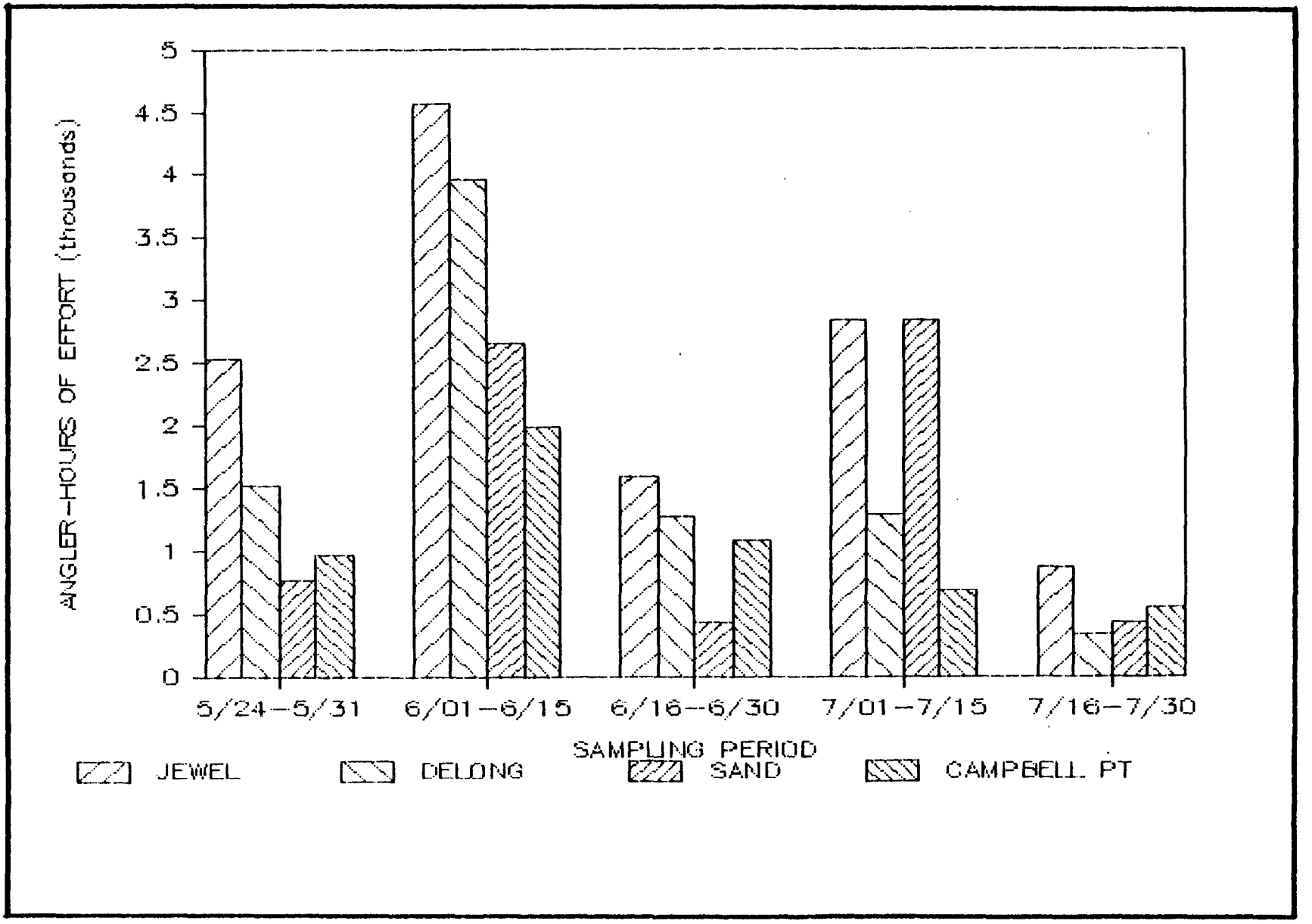

Figure 3. Total sport fishing effort by two week period in Jewel, Delong, Sand, and Campbell Point Lakes, 24 May - 30 July 1986.

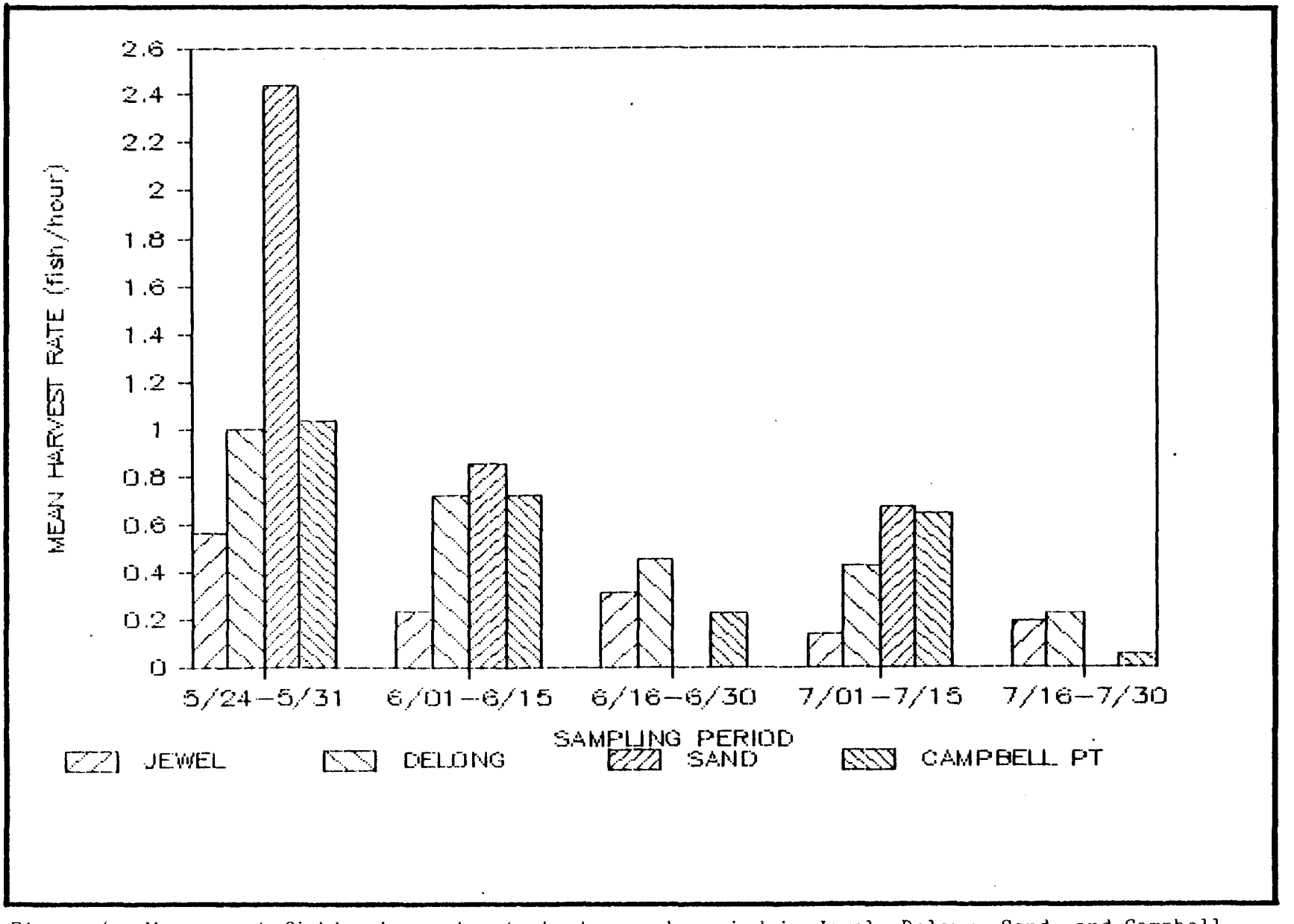

Figure 4. Mean sport fishing harvest rate by two week period in Jewel, Delong, Sand, and Campbell Point Lakes, 24 May - 30 July 1986.

Lake to 4.54 fish/hour in Sand Lake in May also dropped to below 0.25 fish/hour in all four lakes by late July (Figure 5).

Jewel Lake accounted for 37.4% of the total fishing effort at the four lakes but had only 19.4% of the total harvest (Table 6). Delong, Sand, and Campbell Point Lakes all provided a greater percentage of the total harvest in comparison to the percentage of total effort. Delong Lake accounted for the highest catch (34.4%) while only 25.3% of the effort was recorded at this site.

Only 48.8% of the trout stocked in Sand Lake during 1986 were estimated to have been caught during the survey period (Figure 6). Conversely, the total catch in Jewel Lake was essentially equal to the number stocked, and the catch in each Delong lake and Campbell Point Lake was over twice as high as the stocking level. The confidence limits around estimates of harvest for Delong and Campbell Point Lakes encompass the total number stocked (Table 6). However, the estimates do indicate that essentially all of the rainbow trout stocked in Delong and Campbell Point Lakes were harvested during the survey period and that a substantial number were caught more than once.

Currently, catchable size trout are stocked in Anchorage lakes immediately after ice-out. The creel survey in Jewel, Delong, Sand, and Campbell Point Lakes indicates angler participation and rainbow trout harvest were highest during the 3 weeks following stocking (23 May 1986). However, dramatic declines in effort, catch rates, and harvest rates occurred by late June. To provide optimum angling opportunity in all Anchorage stocked lakes throughout the open-water period, recommendations are as follows:

1) Jewel Lake, the most highly visible and heavily fished of the four lakes received 7,844 trout in 1986. Stocking density should be increased to a minimum of 10,000 to 15,000 catchable trout with 60% stocked after ice-out and the remaining 40% stocked the third week in June;

2) Delong Lake, with the second highest estimated angler effort, has fair access and a large part of the shoreline is available to angling by the public. Stocking density should be increased from the 5,900 trout stocked in 1986 to a minimum of 7,500 fish planted on a staggered schedule similar to that of Jewel Lake;

3) Campbell Point Lake, located in a municipal park with the entire shoreline open to the public, received the least angler effort of the four study lakes although survey results suggest the stocked fish were caught rapidly. Stocking density should be increased from the 2,606 trout stocked in 1986 to a minimum of 5,000 fish planted on a staggered schedule; and

4) Sand Lake, a large, deep lake with excellent fish habitat but relatively poor public access, was stocked with 20,099 trout in 1986 to conform to the 300 fish per surface acre stocking rate for

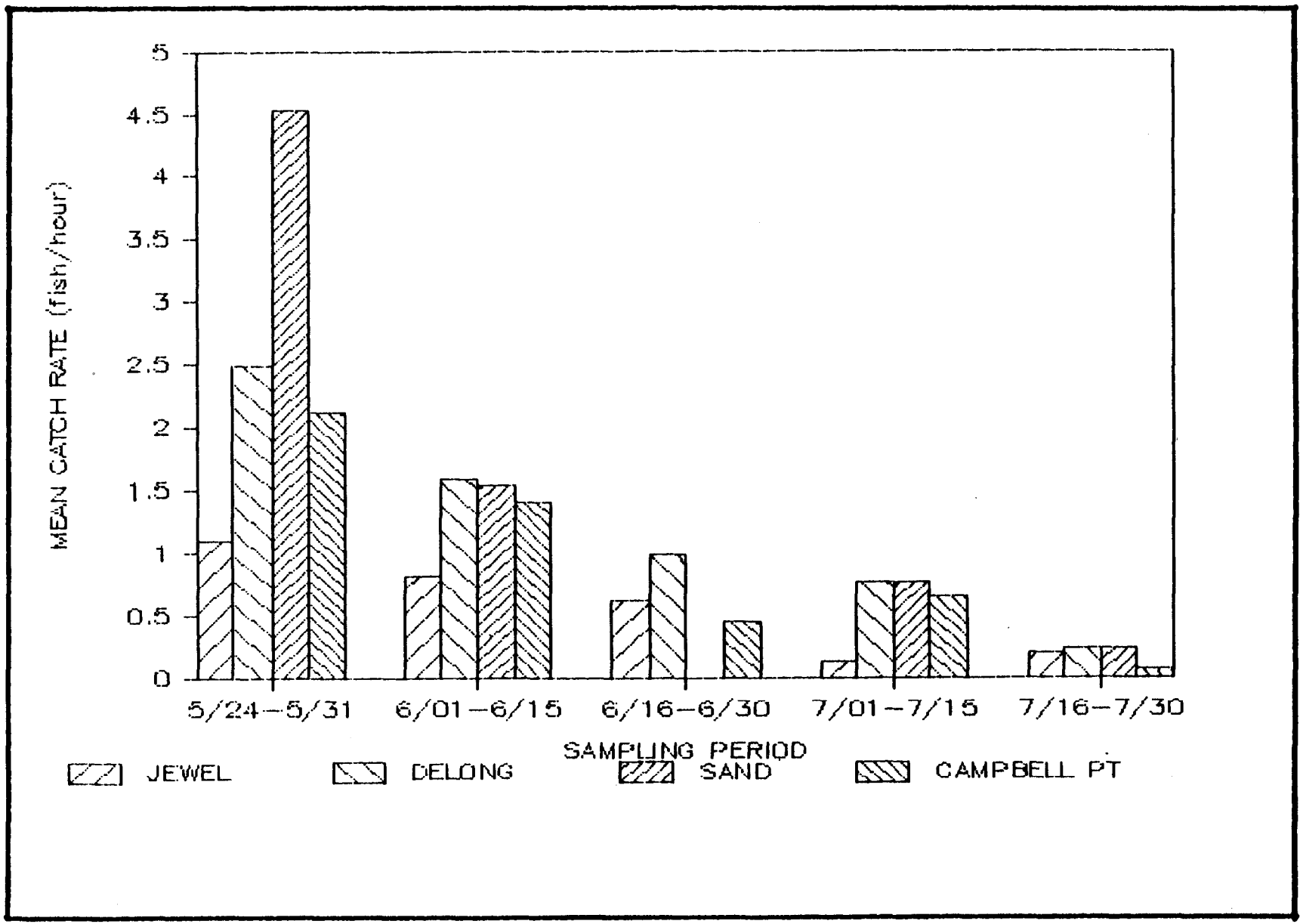

Figure 5. Mean sport fishing catch rate by two week period in Jewel, Delong, Sand, and Campbell Point Lakes, 24 May - 30 July 1986.

Table 6. Stocking history, and estimated total sport fishing effort, harvest, and catch of rainbow trout in Jewel, Delong, Sand, and Campbell Point Lakes, 24 May - 30 July, 1986.

Lake	Surface Area (acres)	Rainbow Trout (number stocked)	Estimated Effort		Estimated Harvest				Estimated Catch			
			Total (angler hours)	Percent of all Lakes	Total	95% Confidence Interval	Harvest/ Number Stocked	Percent of all Lakes	Total	95% Confidence Interval	Catch/ Number Stocked	Percent of all Lakes
Jewel	26.2	7,844	12,355.7	37.4	3,526	2,592 - 4,460	45.0%	19.4	7,980	6,089 - 9,871	101.7%	22.2
Delong	19.7	5,900	8,361.7	25.3	5,544	4,086 - 7,002	94.0%	30.4	12,372	8,933 - 15,811	209.7%	34.4
Sand	67.1	20,099	7,107.4	21.5	6,003	3,872 - 8,134	29.9%	33.0	9,811	6,799 - 12,823	48.8%	27.3
Campbell Point	8.7	2,606	5,241.9	15.8	3,127	1,926 - 4,328	120.0%	17.2	5,777	3,576 - 7,978	221.7%	16.1
	Total	36,449	33,066.7	100.0	18,200		49.9%	100.0	35,940		98.6%	100.0

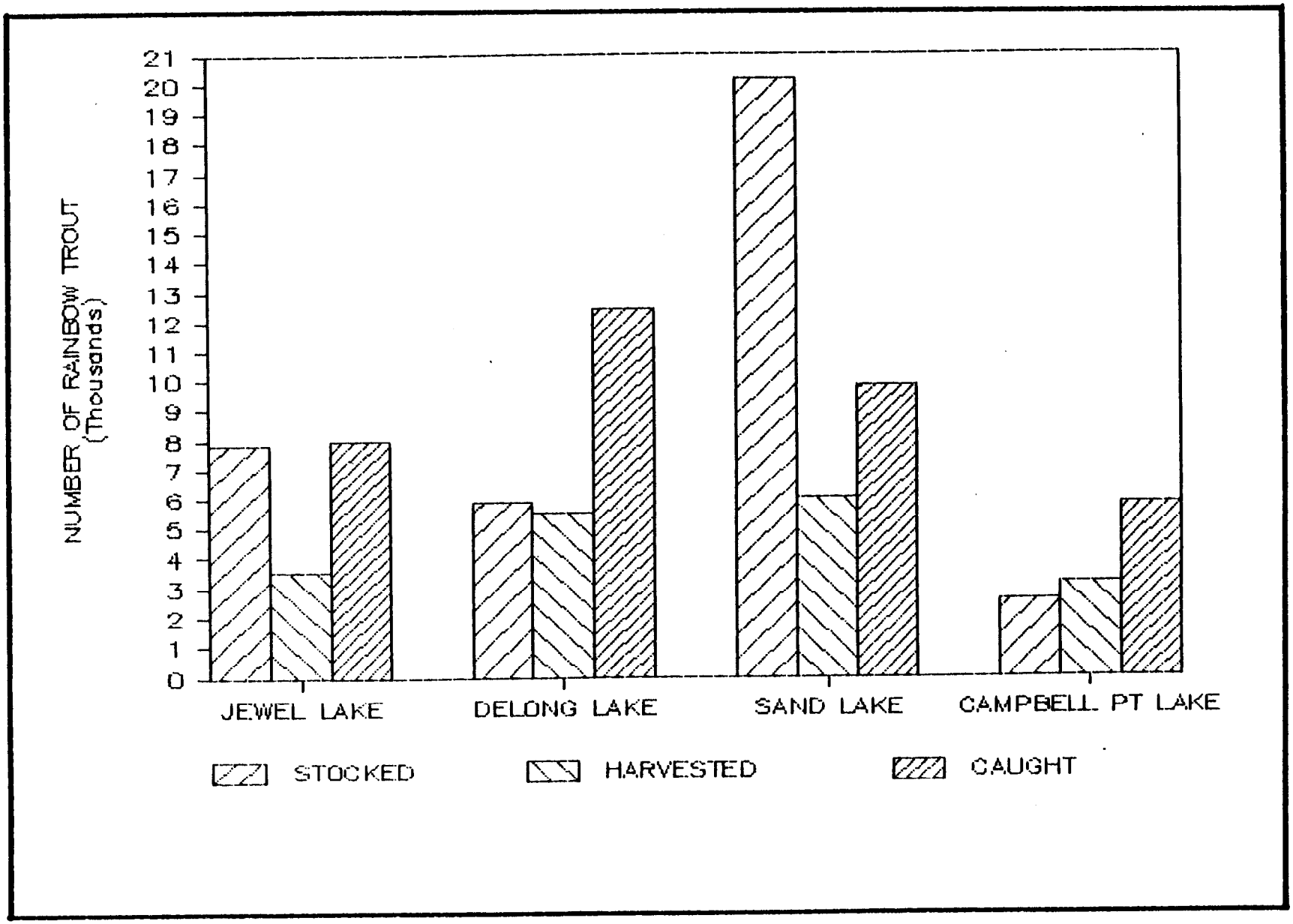

Figure 6. Number of rainbow trout stocked, harvested, and caught in Jewel, Delong, Sand, and Campbell Point Lakes, May - July 1986.

the four lakes. The stocking level should be decreased to 5,000 catchable trout planted after ice-out. If public access is improved in the future, this stocking rate should be increased.

Past stocking densities and Statewide Harvest Report (Mills 1986) harvest estimates and harvest rates should be reviewed to make adjustments in stocking rates and times for all Anchorage lakes. An informational program should be implemented along with detailed maps of all stocked lakes in the Anchorage area to achieve more consistent angler interest.

Landlocked Coho Salmon Versus Chinook Salmon

Relative survival of coho salmon was greater than that of chinook salmon in all comparisons (Table 7). Significantly ($P \leq 0.05$) greater numbers of age 0+ coho salmon were caught than were chinook salmon in Memory Lake ($X^2 = 189.11$), Rocky Lake ($X^2 = 1,616.34$), and Victor Lake ($X^2 = 98.19$). Absolute survival of age 0+ coho salmon in Johnson Lake (85%) was greater than survival of chinook salmon (50%) (Table 8, 9).

Mean length of chinook salmon was significantly greater ($P \leq 0.05$) than that of coho salmon in all three lakes: Memory Lake ($t = 20.20$), Rocky Lake ($t = 20.33$), Victor Lake ($t = 12.48$), and Johnson Lake. However, coho salmon were much smaller than the chinook salmon (approximately 25%) at time of stocking. Therefore, the growth rate of coho salmon was much greater than that of chinook salmon

Nineteen eighty-six was the third and final year of coho salmon and chinook salmon fingerling comparisons of relative survival and growth in landlocked Matanuska-Susitna Valley lakes. Results from three years of research suggest that no more chinook salmon fingerling should be stocked in an attempt to create landlocked salmon fisheries. Instead, research should be continued in hatcheries to accelerate growth of coho salmon to be stocked in landlocked lakes at age 0 following ice-out, and various coho salmon strains should be tested to select a fish that will achieve a catchable size at age 1 in lakes throughout southcentral Alaska.

Table 7. Stocking history, net catch summary, and length data for coho salmon and chinook salmon in Memory, Rocky, Victor, and Johnson Lakes, 1986.

Lake	Species[1] (Fin Clip)	Date Stocked	Number Stocked	Size Stocked	Capture Date(s)	Number Captured	Catch Ratio SS:KS	Length: Number Measured	Length: Mean (mm)	Length: Standard Error	Length: Range (mm)
Memory	SS	05/22/86	8,300	3.52g	10/03/86	427	3.34:1	150	129	0.57	106 - 151
	KS (RV)	06/11/86	8,300	14.15g		128		116	174	0.90	141 - 189
Rocky[2]	SS	05/22/86	4,078	3.52g	09/26/86	1,262	210.33:1	144	107	0.44	91 - 122
	KS (RV)	06/13/86	4,508	13.31g		6		6	154	9.48	140 - 166
Victor	SS	05/22/86	1,364	3.52g	10/02/86	103	34.33:1	103	146	1.07	114 - 174
	KS (RV)	06/12/86	1,340	13.15g		3		3	225	4.51	220 - 234
Johnson	SS	05/22/86	4,030	3.52g	10/07/86-	2,867	1.80:1	211	150	1.02	128 - 255
	KS (RV)	06/12/86	4,038	13.15g	10/24/86	1,589		231	218	0.62	190 - 274

[1] Species (Fin Clip): SS = Coho salmon; KS = Chinook salmon; (RV) = right ventral clip.

[2] Rocky Lake contains threespine stickleback.

Table 8. Fyke net and gill net capture summary for coho and chinook salmon in Johnson Lake, October 1986.

Capture Date	Units[1] of Gear	Number of Coho Salmon Captured: Fyke Nets	Gill Nets	Total	Marked[2] Recaptures	Number of Chinook Salmon Captured: Fyke Nets	Gill Nets	Total	Marked[2] Recaptures
10/07/86	12 FN	571		571	60	471		471	25
10/08/86	12 FN	864		864	66	326		326	18
10/09/86	12 FN	402		402	21	62		62	1
10/13/86	12 FN	270		270	16	118		118	1
10/14/86	11 GN		163	163	2		216	216	4
10/15/86	11 GN		340	340	16		174	174	7
10/16/86	11 GN		107	107	5		98	98	4
10/21/86	11 GN		28	28	2		53	53	2
10/22/86	11 GN		36	36	2		43	43	1
10/23/86	11 GN		58	58	5		16	16	1
10/24/86	11 GN		28	28	1		12	12	1
Totals:		2,107	760	2,867	196	977	612	1,589	65

[1] Fyke nets were fished overnight for 4 nights between 10/07/86 and 10/13/86; Gill nets were fished overnite for 7 nights between 10/14/86 and 10/24/86.

[2] 235 coho salmon were captured, marked, and released on 08/27/86.
82 chinook salmon were captured, marked, and released on 08/27/86.

Table 9. Petersen population estimates of coho and chinook salmon in Johnson Lake, 1986.

	Coho Salmon[1]				Chinook Salmon[2]				
			95% Confidence Interval				95% Confidence Interval		Population
Date of Estimation	Estimated Population	Estimated Survival	Population	Survival	Estimated Population	Estimated Survival	Population	Survival	Ratio SS:KS
08/27/86	3,437	85.3%	2,990-3,995	74.2%-98.1%	2,005	49.6%	1,574-2,557	39.0%-63.3%	1.71:1

[1] 4,030 coho salmon (SS) at 3.52 g each were stocked on 05/22/86; 235 were captured, marked, and released on 08/27/86.

[2] 4,038 chinook salmon (KS) at 13.15 g each were stocked on 06/12/86; 82 were captured, marked, and released on 08/27/86.

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