Fishery Data Series No. 94-44

Evaluation of Stocked Game Fish in Birch, Quartz, Chena, and Harding Lakes, 1993

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ABSTRACT

In 1991, the Alaska Department of Fish and Game (ADF&G) made significant changes in the species and numbers of game fish stocked in Birch, Quartz, Chena, and Harding lakes. These changes were based on Fishery Management Plans (FMP) (ADF&G 1993) for each of these fisheries. Objectives in the FMPs such as providing annual mean catch rates and limiting stocking costs serve to guide ADF&G in management of these fisheries. Studies in 1993 were intended to provide fishery managers with information to assess how well ADF&G is progressing toward achieving these management objectives. Results from studies in 1992 for these lakes showed the mean harvest rates ranged from 0.52 to 1.53 fish per angler day of effort, the stocking costs ranged from $41,081 to $291,198, and the costs per angler day ranged from $3.05 to $57.46.

In Birch, Quartz, and Chena lakes rainbow trout *Oncorhynchus mykiss* and coho salmon *Oncorhynchus kisutch* were stocked for several years and made up most of the harvest. Under the new stocking strategy Arctic char *Salvelinus alpinus* and Arctic grayling *Thymallus arcticus* were recent additions to Birch and Quartz lakes to increase species diversity. Also, the numbers of rainbow trout and coho salmon stocked in these lakes were decreased to reduce the stocking costs. Samples of each species were collected from each lake to estimate the size and catch composition of the age 1 fish. These data were used to determine if the new stocking strategy was having the desired effect.

Brood tables were developed that projected the annual and total contribution to the harvest of stocking cohorts of rainbow trout and coho salmon in Birch, Quartz, and Chena lakes. Rainbow trout stocked as fingerlings provided an estimated average return to the creel of 3.3%. Rainbow trout stocked as subcatchables provided an estimated 31.2% return and those stocked as catchables provided an estimated 55.0% return to the creel. In Birch Lake, an estimated 12.2% of the rainbow trout stocked were harvested. The percent return to the creel in Quartz and Chena lakes for rainbow trout was 4.9% and 23.4% respectively. Coho salmon stocked as fingerlings provided a 14.8% return in Birch Lake, a 21.0% return in Quartz Lake and an 8.0% return in Chena Lake.

Since 1990, in Harding Lake, ADF&G has monitored populations of stocked Arctic char *Salvelinus alpinus*, Arctic grayling *Thymallus arcticus*, rainbow trout *Oncorhynchus mykiss*, and kokanee *Oncorhynchus nerka*. Results from this program indicated that stocking small kokanee, rainbow trout, and Arctic grayling would not maintain a fishery due to poor survival. Stocking catchable size rainbow trout to maintain a fishery would cost much more per

angler day of effort compared to the costs per angler day of effort for other lakes. The stocking of Arctic char did result in a successful fishery and stocking small Arctic char would maintain the fishery. After 1992, ADF&G stopped stocking Arctic grayling, kokanee, and rainbow trout.

KEY WORDS: Birch Lake, Chena Lake, Quartz Lake, Harding Lake, stocking evaluation, Arctic char, *Salvelinus alpinus*, rainbow trout, *Oncorhynchus mykiss*, Arctic grayling, *Thymallus arcticus*, northern pike, *Esox lucius*, burbot, *Lota lota*, least cisco, *Coregonus sardinella*, lake trout, *Salvelinus namaycush*, kokanee, *Oncorhynchus nerka*, catch per unit effort, growth, cost per angler day, stocking cost.

INTRODUCTION

The Alaska Department of Fish and Game (ADF&G) stocks game fish in lakes in the Tanana River valley (a portion of interior Alaska) to provide diverse angling opportunities and reduce the harvest of native fish stocks. This stocking program provides year-round sport fishing for rainbow trout *Oncorhynchus mykiss*, coho salmon *Oncorhynchus kisutch*, Arctic grayling *Thymallus arcticus*, lake trout *Salvelinus namaycush*, and Arctic char *Salvelinus alpinus*. The stocking program began in the early 1960's, when lakes along the road system were stocked with rainbow trout or coho salmon. Some lakes were treated with rotenone prior to stocking to remove undesired species. Today, stocked fish comprise more than half of the harvest of game fish in interior Alaska and stocked rainbow trout and coho salmon in Birch Lake, Chena Lake, and Quartz Lake provide the majority of this harvest.

In 1991, the Alaska Department of Fish and Game (ADF&G) made significant changes in the species and numbers of game fish stocked in Birch, Quartz, Chena, and Harding lakes. These changes were based on Fishery Management Plans (FMP; ADF&G 1993) for each of these fisheries. The FMPs were developed from fishery studies, angler surveys, and creel surveys conducted since the 1970's. Objectives in the FMPs, such as providing annual mean catch rates and limiting stocking costs serve to guide ADF&G in management of these fisheries. The studies summarized in this report are intended to provide fishery managers with information to assess how well ADF&G is progressing toward achieving these management objectives.

Birch, Quartz, Chena, and Harding lakes are important to anglers in interior Alaska because they are large (from 100 to 1,000 ha), near population centers, and are on the road system (Figures 1, 2, 3, and 4). As a group, these four lakes supported more than 29% of the effort and 49% of the harvest of all game fish in the Tanana River drainage in 1992 (Mills 1993). In 1992, in response to the FMPs, Birch, Quartz, and Chena lakes were stocked with different combinations of Arctic char, Arctic grayling, coho salmon, and rainbow trout. Harding Lake was stocked with only Arctic char (it has self-sustaining populations of lake trout, northern pike, burbot, and least cisco). ADF&G uses this stocking strategy to provide a diversity of fishing opportunity along the road system to attract anglers and divert fishing pressure from wild stocks which may have conservation problems.

The objectives of the studies were:

Birch Lake, Quartz Lake, and Chena Lake

(1) Estimate the mean lengths (mid-eye to fork-of-tail, FL) at age 1 for all stocked species present such that the error of the estimates is less than 10 mm with a probability of 0.95.

(2) Estimate the harvest of rainbow trout and coho salmon by stocking cohort and year for Birch Lake, Quartz Lake, and Chena Lake from the historical database. (This objective was from Project F-10-8, Study E, Job 3-1.)

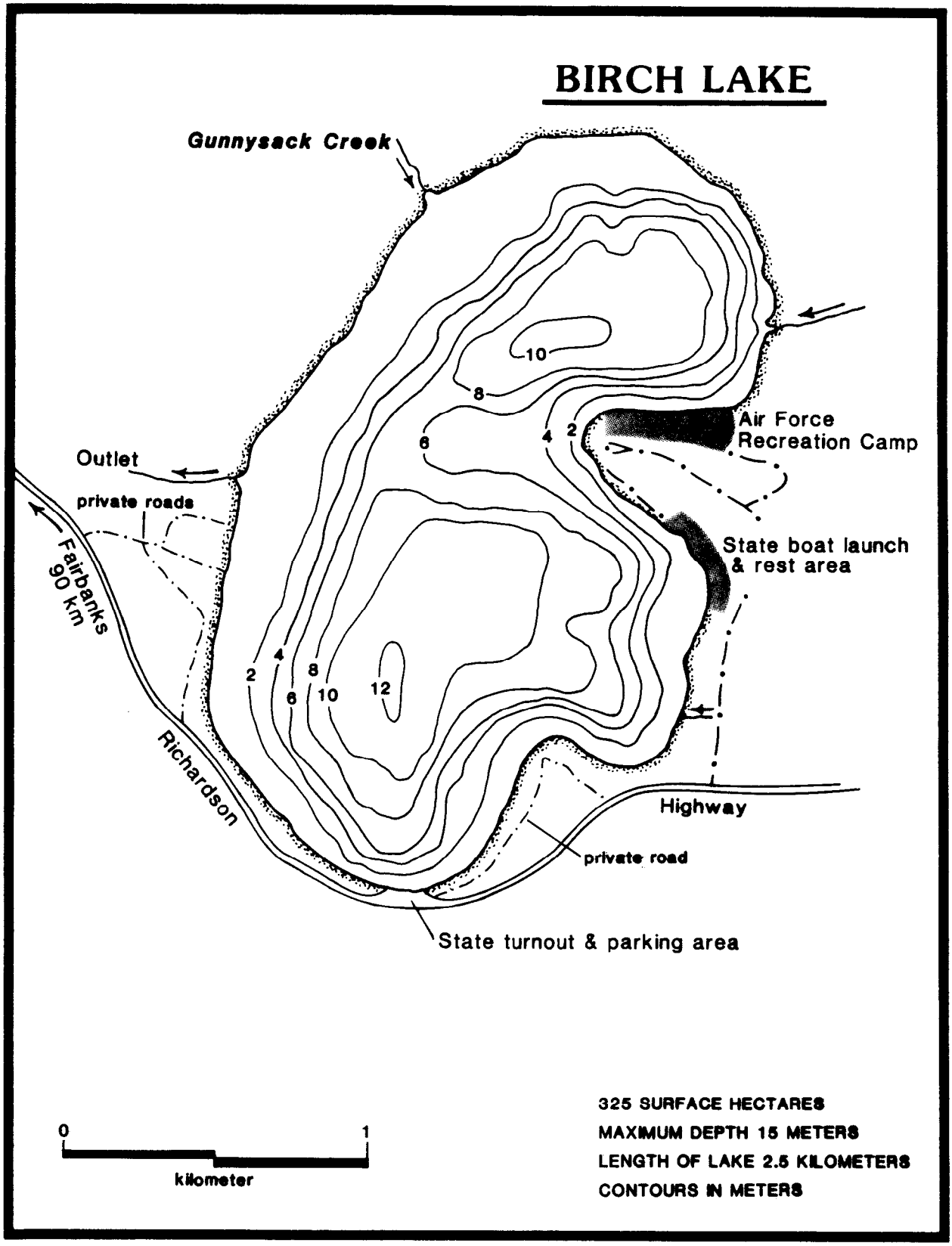


Figure 1. Study area, Birch Lake.

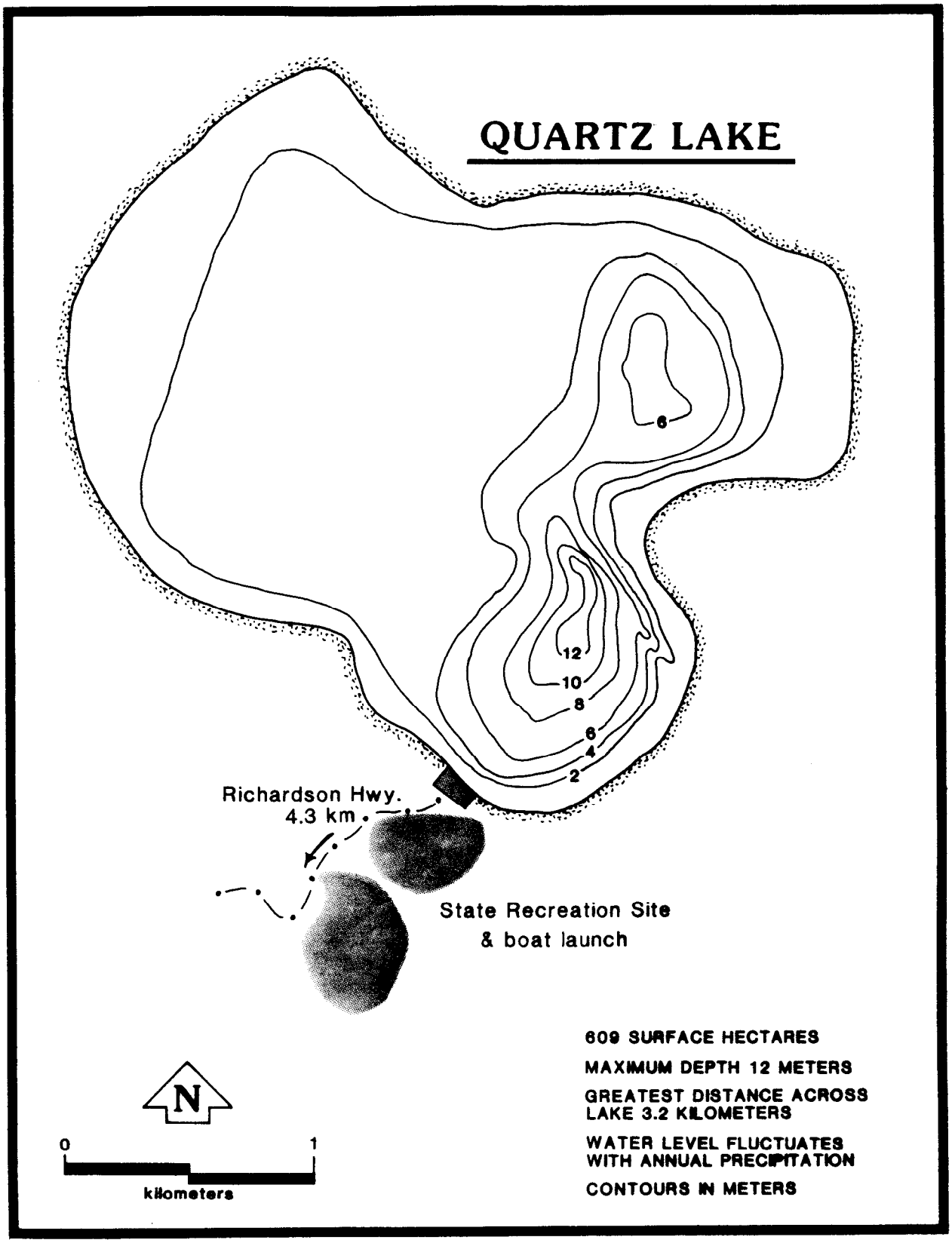


Figure 2. Study area, Quartz Lake.

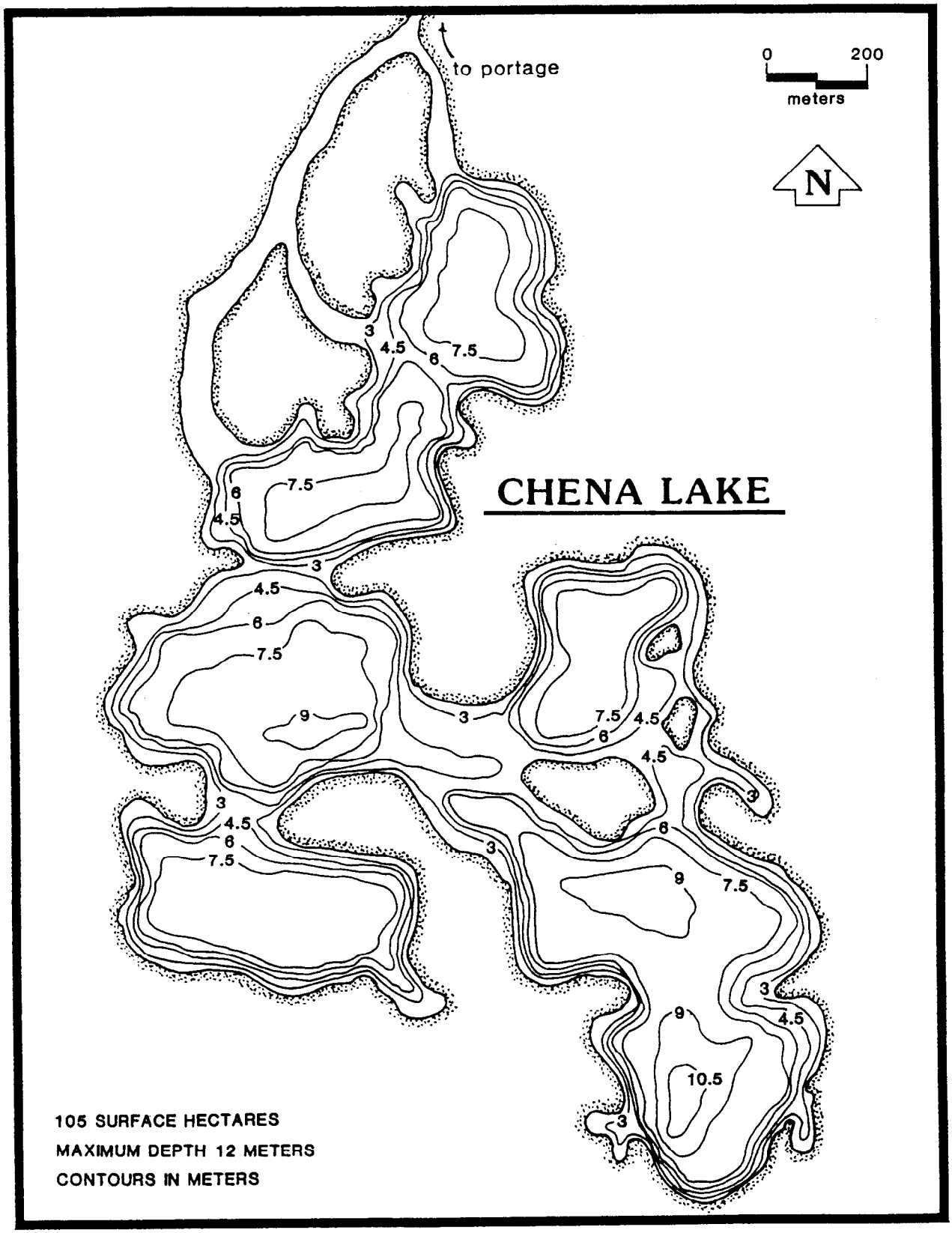


Figure 3. Study area, Chena Lake.

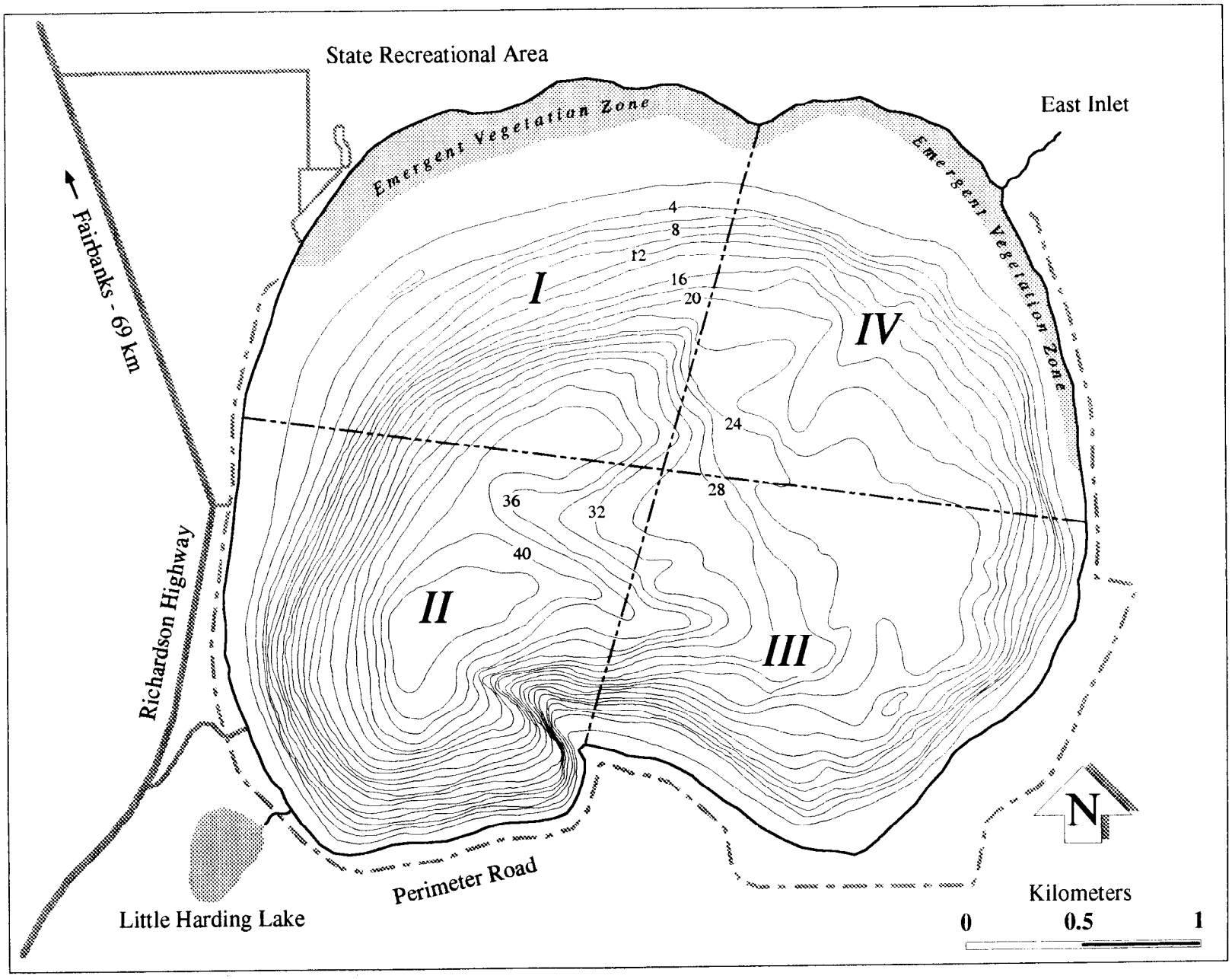


Figure 4. Study area, Harding Lake.

Harding Lake

(3) Estimate the median catch-per-unit-effort (CPUE) for Arctic char by zone during late August such that the error of the estimates is less than four fish with a probability of 0.90.

BIRCH, QUARTZ, AND CHENA LAKES

Usually, rainbow trout larger than 20 g were stocked in Birch and Chena lakes and rainbow trout smaller than 4 g were stocked in Quartz Lake. The large fish (subcatchables) were age 1 when stocked and the smaller fish (fingerlings) were age 0. This stocking method was used because cost-per-survivor to a catchable size (~180 mm) was less when subcatchable rainbow trout were stocked in Birch and Chena lakes and was less when fingerling rainbow trout were stocked in Quartz Lake. The rainbow trout fingerlings were stocked at age 0 in 1992 and the rainbow trout subcatchables were stocked at age 1 in 1993. Both size groups of rainbow trout were from the same brood year (1992). The subcatchables were from a portion of the brood that was not stocked at age 0 but were kept in the hatchery and reared to subcatchable size and stocked the following spring. The Arctic grayling, coho salmon, and Arctic char were age 0 when stocked (Appendix A).

Methods

Populations of stocked game fish in each lake were sampled in one or two capture events. Six Fyke nets were set in each lake and sampling was without replacement. Fyke nets were set in Birch Lake on 21 September and the captured fish were measured and marked on 23 September. Fyke nets were set in Quartz Lake on 27 September and the captured fish were measured and marked on 28 and 30 September. Fyke nets were set in Chena Lake on 24 September and the captured fish were measured and marked on 30 September. Sampling occurred in late September and early October because previous studies showed catch-per-unit-of-effort was highest during this period and water temperatures were cooler which reduced stress for captured fish (Doxey 1980-1991). All captured fish 140 mm and longer were marked by cutting off the left ventral fin next to where it joined the body. In previous studies most age 0 rainbow trout, coho salmon, and Arctic grayling were less than 140 mm when fish samples were collected in September and October (Doxey 1991, Skaugstad 1991). The mark identified fish captured in a previous event. Recaptured fish and age 0 fish stocked in 1993 were not used in further analysis.

Fyke net openings were 1.2 m sq., mesh size was 9 mm sq., wings were 7.5 m long, and the center lead was 30 m long. The Fyke nets were distributed roughly equal distance around the lake perimeter. Four Fyke nets were set with the center leads perpendicular to shore and the wings parallel to shore. The end of the center lead opposite the Fyke net was anchored to shore and a weight was attached to the cod end to prevent the Fyke net from collapsing. Two Fyke nets were set with the body of the net parallel to shore and the wings forming a "V". One wing was anchored to shore. A weight was attached to the other wing and positioned off shore.

Captured fish were assigned to age 1 or age 2+ (age 2 and older) cohorts by examining the distribution of length frequencies for each species. The analysis was based on histograms of length data separated into 10 mm intervals where interval *i* was from length *i* to length *i*+9.99. The length interval between modes for age 1 and age 2+ with the lowest frequency was the critical interval for separating age cohorts. The critical interval was assigned to the age 1 category. Previous studies using marked fish showed that the majority of small fish were age 1 (Doxey 1989). Mean lengths of the age 1 cohorts were calculated as the sample mean and its variance (Zar 1982 pp. 19 and 86). Because the larger age 1 fish could be misclassified as age 2, the number of age 1 fish in the sample was a minimum estimate. Mean lengths for older cohorts were not estimated because length frequency analysis can not be used to reliably determine the age of rainbow trout older than age 1 due to increasing overlap of length distributions for older fish.

For each lake, the species composition of age-1 fish was calculated using:

$$\hat{p}_s = \frac{n_s}{n} \tag{1}$$

$$V(\hat{p}_s) = \frac{\hat{p}_s(1 - \hat{p}_s)}{n - 1} \tag{2}$$

where:

$\hat{p}_s$ = proportion of age 1 fish of species *s* in a lake;

n_s = number of age 1 individuals of species *s* in a sample;

n = number of age-1 fish in the sample; and,

$V(\hat{p}_s)$ = variance of $\hat{p}_s$.

These estimates represent the population proportions only if each species was captured in proportion to the their abundance in the lake.

Results

In Birch Lake, 414 age 1 rainbow trout, 17 age 1 Arctic char, and 117 age 1 Arctic grayling were captured (Table 1). The proportions, by species, in the sample were: Rainbow trout 0.75 (SE = 0.018); Arctic char 0.031 (SE = 0.007); and Arctic grayling 0.21 (SE = 0.018) (Table 1). In Quartz Lake, 138 age 1 rainbow trout and six age 1 Arctic char were captured (Table 1). The proportions by species, in the sample were: Rainbow trout 0.96 (SE = 0.017) and Arctic char 0.042 (SE = 0.017) (Table 1). In Chena Lake, 376 age 1 rainbow trout, 129 age 1 coho salmon, 78 age 1 Arctic char, and 54 age 1 Arctic grayling were captured (Table 1). The proportions, by species in the sample were: Rainbow trout 0.59 (SE = 0.020); coho salmon 0.20 (SE = 0.016);

Table 1. Numbers of fish captured by species and species composition for Birch Lake, Quartz Lake and Chena Lake, 1993.

Species	Birch Lake			Quartz Lake			Chena Lake		
	n[a]	p[b]	se[c]	n[a]	p[b]	se[c]	n[a]	p[b]	se[c]
Rainbow trout	414	0.76	0.018	138	0.96	0.017	376	0.59	0.020
Coho Salmon	NS[d]			NS			129	0.20	0.016
Arctic char	17	0.031	0.007	6	0.042	0.017	78	0.12	0.013
Arctic grayling	117	0.21	0.018	NS			54	0.085	0.011
Total	548			144			637		

[a] Number of each species in the sample.
[b] Proportion of each species in the sample.
[c] Standard error of the estimated proportion.
[d] There were no age 1 fish of this species in the lake because no age 0 fish were stocked the previous year.

Arctic char 0.12 (SE = 0.013); and Arctic grayling 0.085 (SE = 0.011) (Table 1).

The frequency distributions of lengths of captured fish were usually multimodal (Figures 5, 6, 7, and 8). The age 1 cohorts were usually easily distinguished from age 0 and age 2+ cohorts. Generally, age 0 rainbow trout, coho salmon, and Arctic grayling stocked in 1993 were less than 140 mm when samples of fish were captured in Birch, Quartz, and Chena lakes. For each species, the frequency distributions for the age 0 and age 1 cohorts did not overlap but there was some overlap of the frequency distributions for the age 1 and age 2+ cohorts. Age 0 Arctic char, however, were stocked at more than 200 mm in 1993 and were not distinguishable from age 1 Arctic char. Only a portion of the captured age 0 fish were measured but all were counted.

Rainbow Trout:

Lengths for age 1 rainbow trout in all lakes ranged from 152 to 300 mm (Figure 5). Mean lengths for rainbow trout were 232 mm (SE = 1.1) in Birch Lake, 236 mm (SE = 2.6) in Quartz Lake, and 235 mm (SE = 1.4) in Chena Lake (Table 2).

Coho Salmon:

Lengths for age 1 coho salmon in Chena Lake ranged from 152 to 231 mm (Figure 6). Mean length at age 1 was 231 mm (SE = 1.5; Table 2). There were no age 1 coho salmon in Quartz or Birch lakes because no age 0 coho salmon were stocked in these lakes in 1992.

Arctic Char:

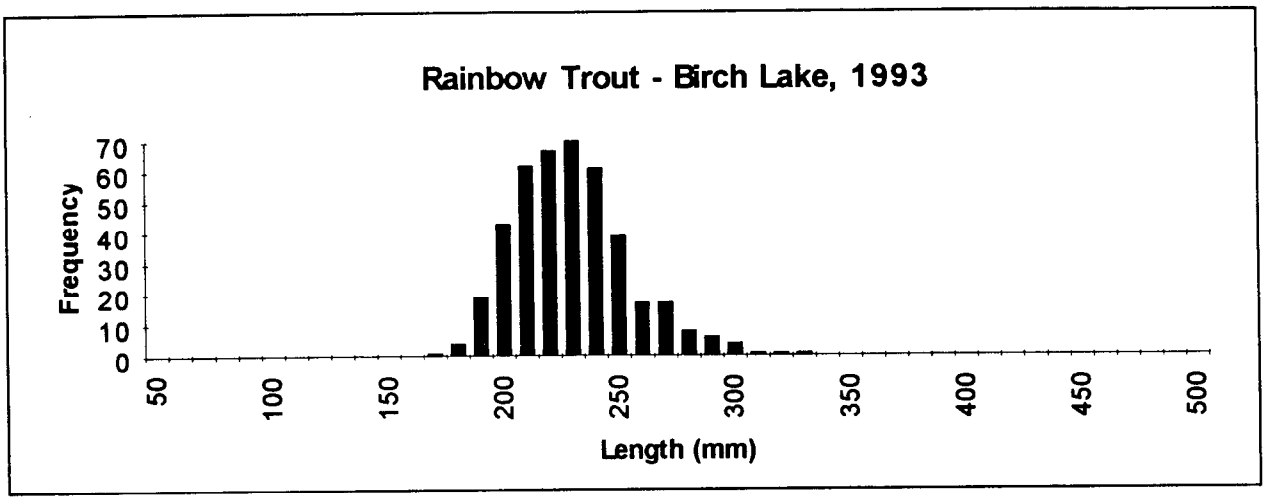
Lengths for age 1 Arctic char in all lakes ranged from 160 to 336 mm (Figure 7). Mean lengths for age 1 Arctic char were 214 mm (SE = 3.3) in Birch Lake, 310 mm (SE = 10.9) in Quartz Lake, and 240 mm (SE = 2.8) in Chena Lake (Table 2).

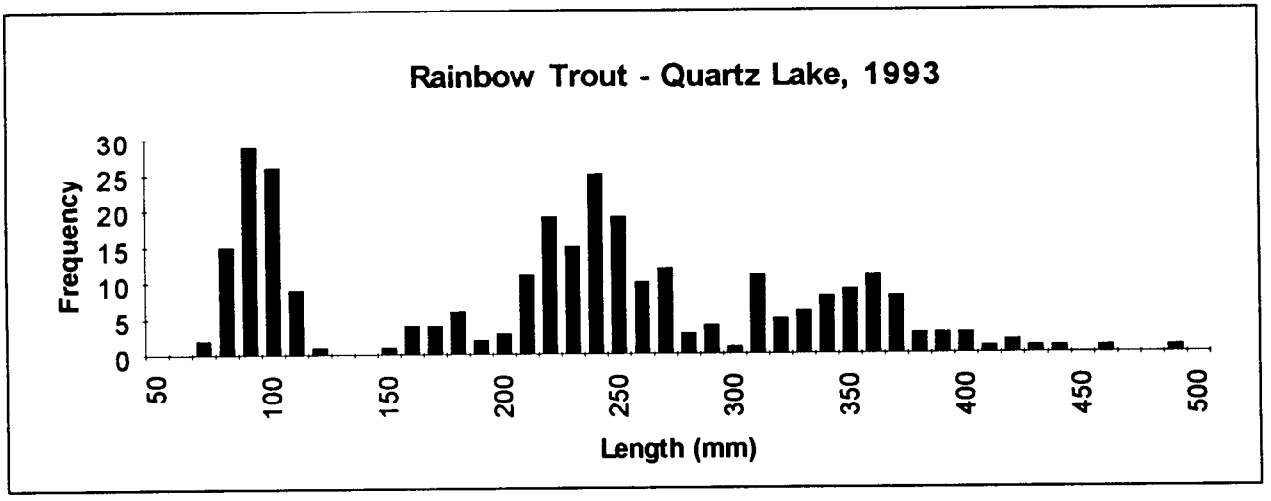
The sample of Arctic char captured in Chena Lake included age 0 Arctic char that were stocked about two weeks before the sample was collected. The age 0 Arctic char were about 106 g and 215 mm when stocked (Table 2). It was not possible to separate these fish from those stocked in 1992 using length frequency analysis (Figure 7).

Arctic Grayling:

Lengths for age 1 Arctic grayling in Birch and Chena lakes ranged from 118 to 244 mm (Figure 8). Mean lengths for age 1 Arctic grayling were 188 mm (SE = 2.2) in Birch Lake and 213 mm (SE = 2.8) in Chena Lake (Table 2). No Arctic grayling were stocked in Quartz Lake.

The sample of Arctic grayling captured in Birch Lake included large fish (>300 mm) that were not stocked by ADF&G (Figure 8). Anglers reported





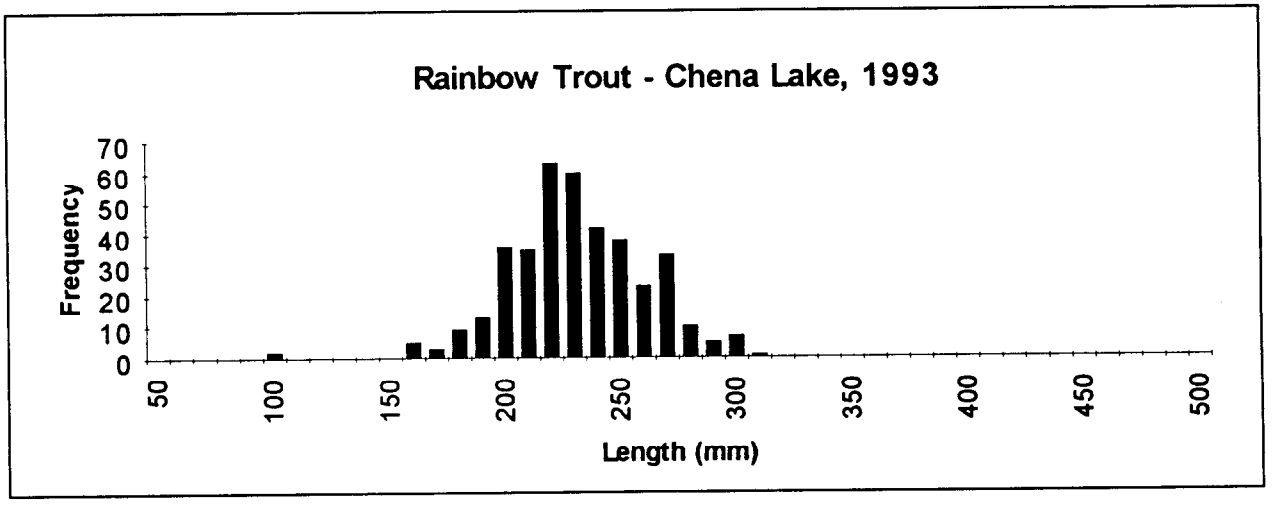
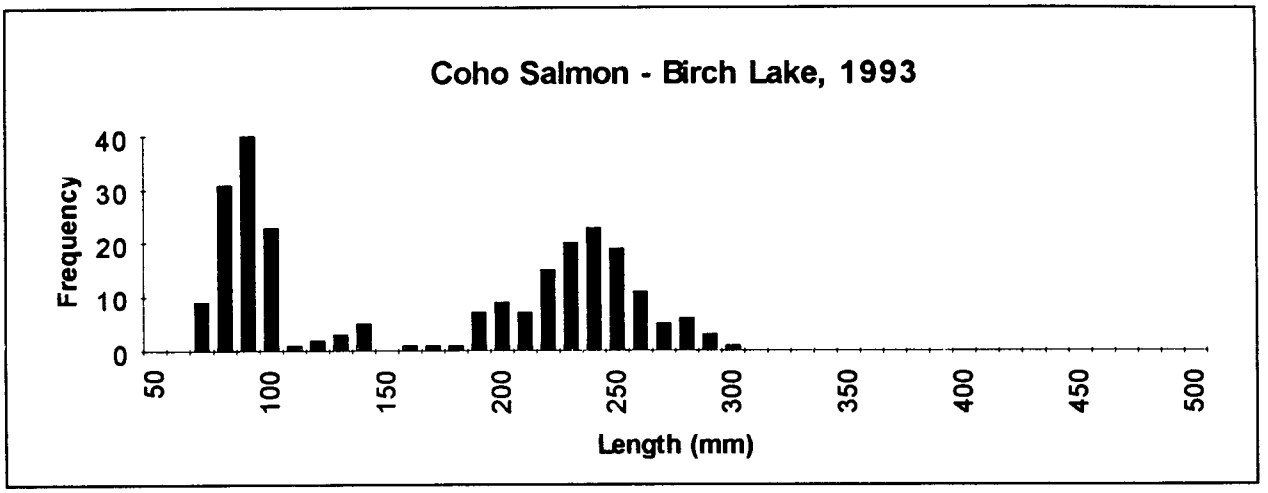
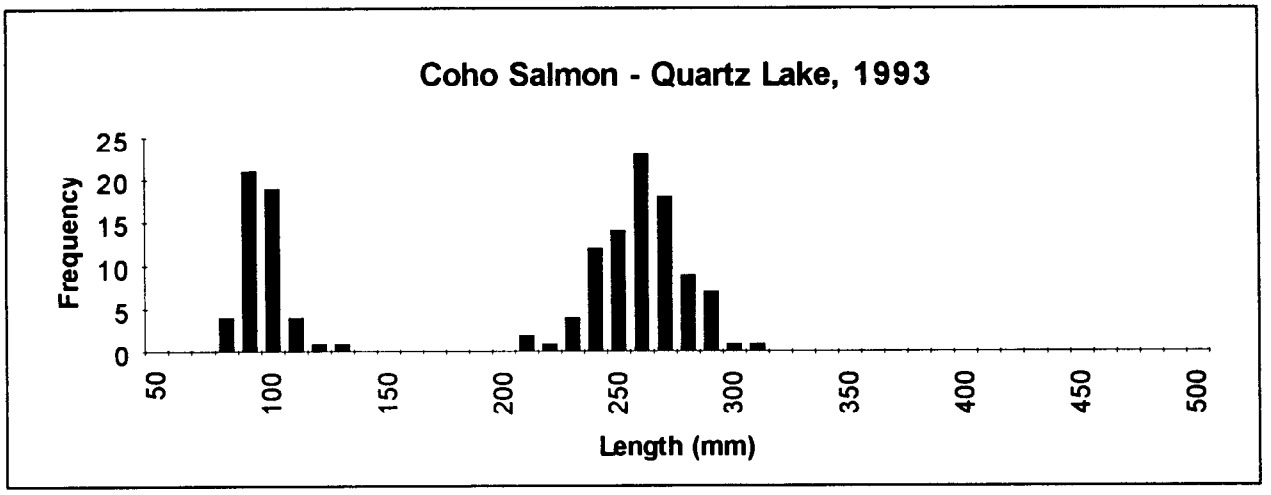


Figure 5. Length frequency histograms of rainbow trout captured in Birch Lake, Quartz Lake, and Chena Lake, 1993.





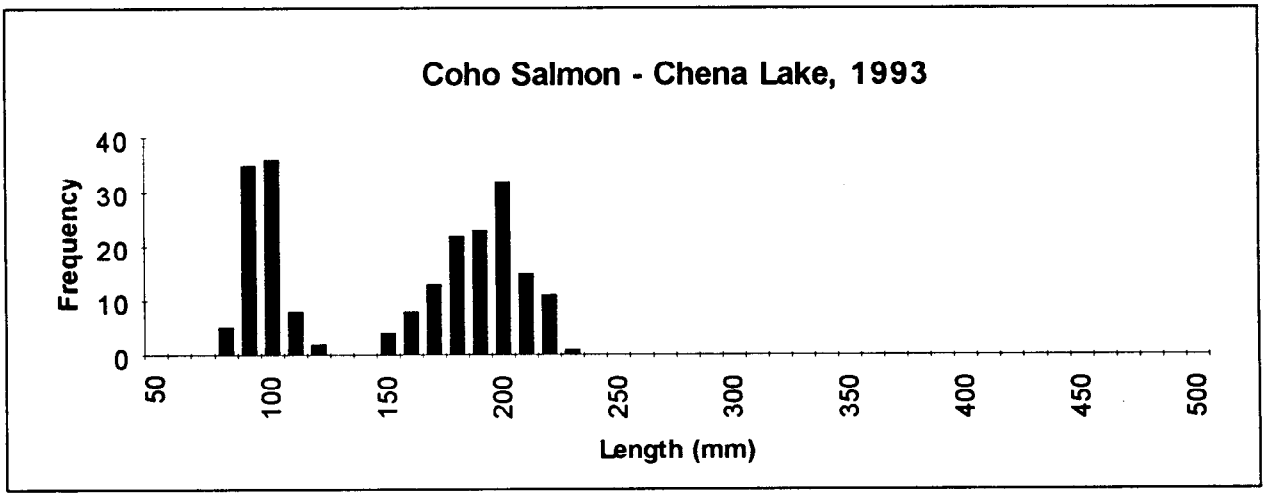
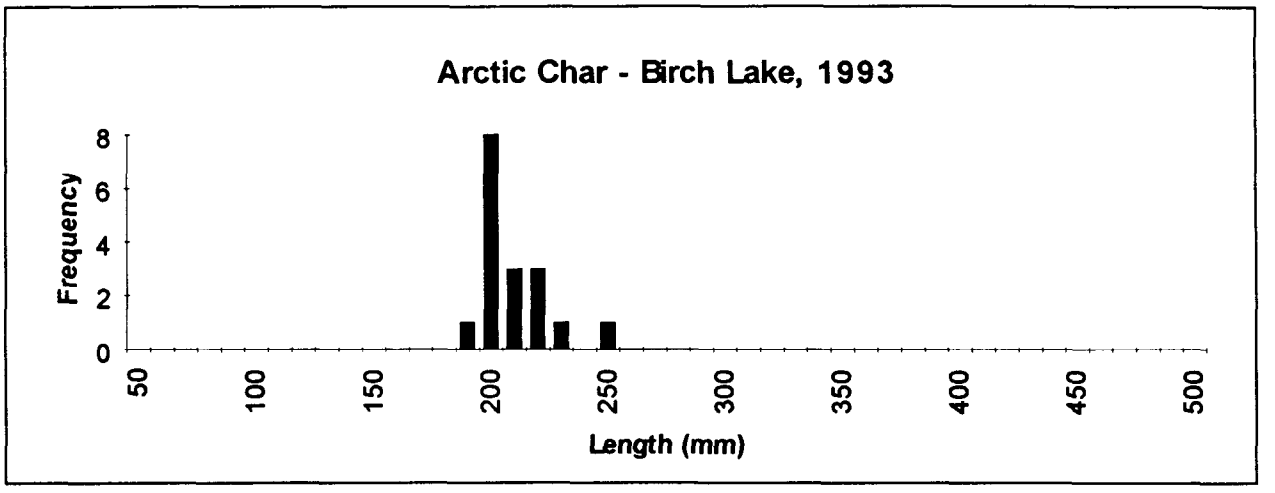
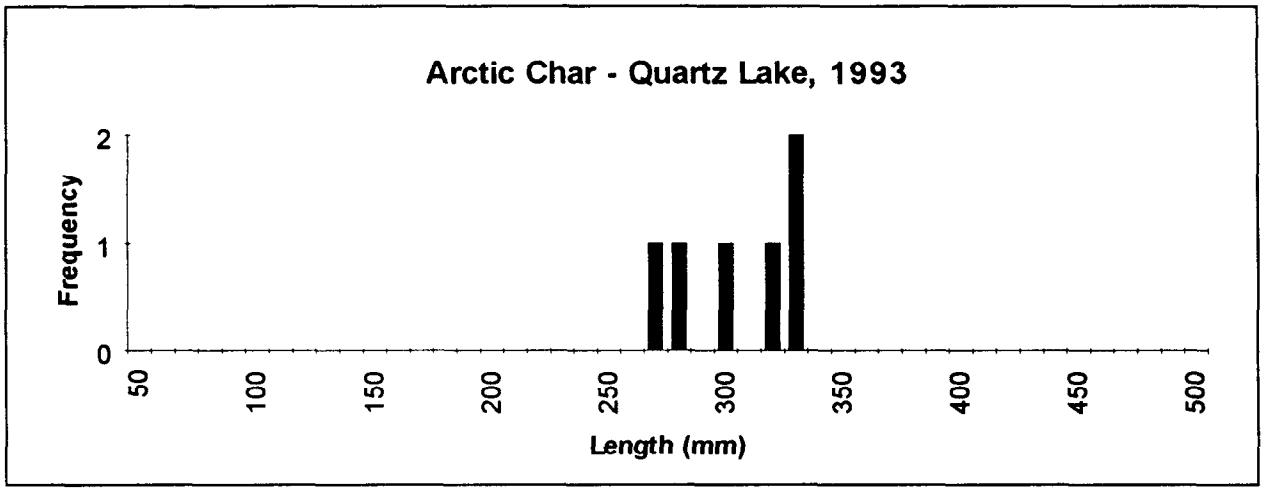


Figure 6. Length frequency histograms of coho salmon captured in Birch Lake, Quartz Lake, and Chena Lake, 1993.





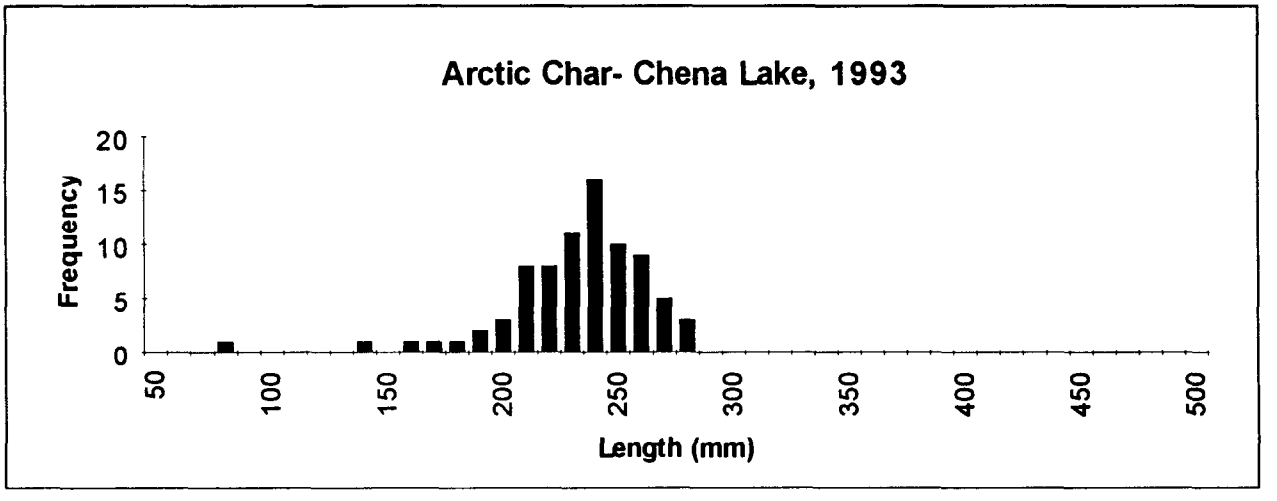
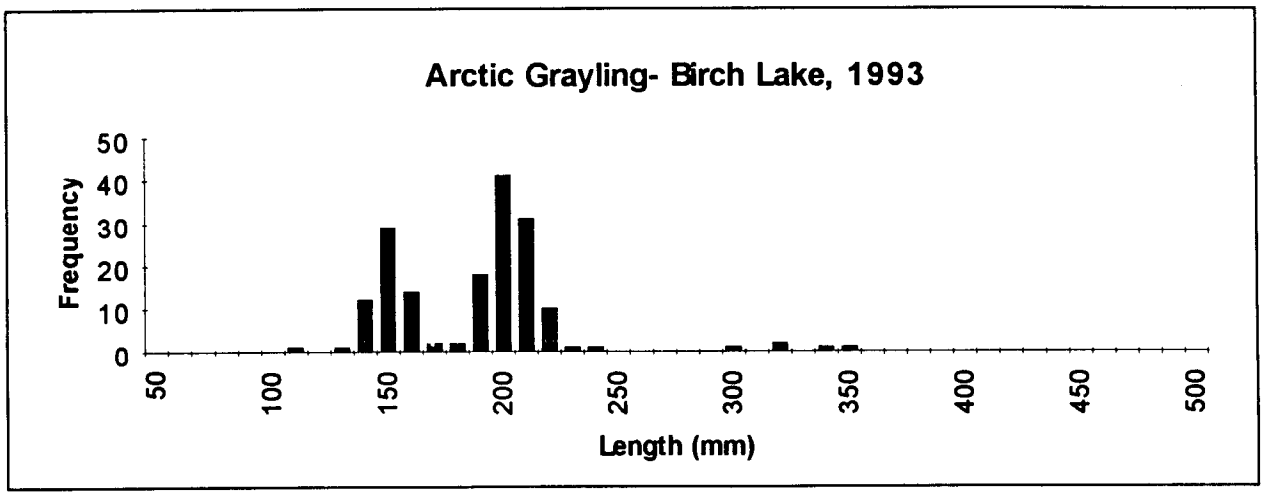


Figure 7. Length frequency histograms of Arctic char captured in Birch Lake, Quartz Lake, and Chena Lake, 1993.



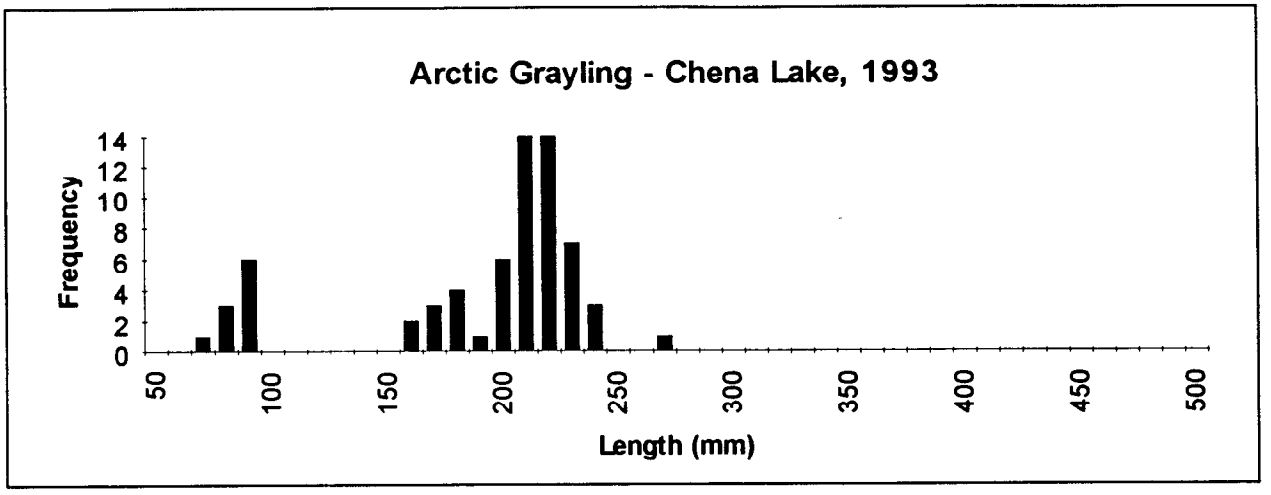


Figure 8. Length frequency histograms of Arctic grayling captured in Birch Lake and Chena Lake, 1993.

Table 2. Statistics for age 1 rainbow trout, coho salmon, Arctic char, and Arctic grayling captured in Birch Lake, Quartz Lake, and Chena Lake, 1993.

Species	Lake	n	Mean Length (mm)	se	Minimum Length (mm)	Maximum Length (mm)
Rainbow trout	Birch Lake	414	232	1.1	175	298
	Quartz Lake	138	236	2.6	152	299
	Chena Lake	376	235	1.4	162	300
Coho salmon	Birch Lake[a]	129	240	2.3	161	301
	Quartz Lake[a]	92	265	2.0	210	312
	Chena Lake	129	195	1.5	152	231
Arctic char	Birch Lake	17	214	3.3	199	250
	Quartz Lake	6	310	10.9	276	336
	Chena Lake[b]	78	240	2.8	160	286
Arctic grayling	Birch Lake	117	188	2.2	118	242
	Quartz Lake[c]					
	Chena Lake	54	213	2.8	160	244

[a] These fish were age 2. There were no age 1 fish present in 1993 because no age 0 fish were stocked in 1992.

[b] The sample was made up of age 1 and age 0 Arctic char. The age 0 Arctic char were stocked at about 106 g (mean length was 215 mm) about two weeks before samples were collected in 1993. Age 1 Arctic char could not be distinguished from age 0 Arctic char using length frequency analysis.

[c] Arctic grayling were not stocked in Quartz Lake.

catching large Arctic grayling in Birch Lake prior to 1991 when Arctic grayling were first stocked by ADF&G.

Discussion

Few Arctic char were captured in Birch, Quartz, and Chena lakes. The sampling design used in this study makes an assumption that each species is captured in proportion to their abundance. However, this assumption cannot be evaluated with this study design. If catches were proportional to abundance then these data indicate few Arctic char were present in the littoral zone where the Fyke nets were set. There may be two reasons why few Arctic char were captured in Fyke nets: 1) The abundance of Arctic char was very low, or 2) If Arctic char were abundant most of the population was not in the littoral zone. Previous studies suggest that Arctic char may be found in littoral or pelagic zones depending on the size of a lake. In small lakes (less than 20 ha) Arctic char were captured in Fyke nets set in the littoral zone (Skaugstad 1991). However, in Harding Lake (1,000 ha) most Arctic char were captured away from shore (pelagic) in gill nets rather than near shore (littoral) in Fyke nets (Skaugstad 1992). In Harding Lake, the capture rates also may have been an artifact of the type of gear used in the littoral and pelagic zones. Catch rates in the littoral zone may have been higher if gill nets had been used. If Arctic char were less likely to be captured with Fyke nets in the littoral zone of a large lake such as Harding Lake then the same result may occur in Birch Lake (324 ha), Quartz Lake (602 ha), and Chena Lake (104 ha).

The success of the new stocking strategy for Birch, Quartz, and Chena lakes will depend on whether or not Arctic char and Arctic grayling contribute to these fisheries. Harvest estimates used by ADF&G are obtained through a mail survey and harvest estimates for 1993 will not be available until late 1994 or early 1995. Currently, the new species make up only a small portion of the total number of fish available to anglers. The proportion of age 1 Arctic grayling in the sample from Birch Lake (0.21) was high only because there were no age 1 coho salmon present (age 0 coho salmon were not stocked in Birch Lake in 1992). However, size data indicate that age 1 Arctic char and Arctic grayling have entered the fisheries.

The new stocking strategy does not appear to have effected the growth of rainbow trout or coho salmon. The mean lengths of age 1 rainbow trout and coho salmon in 1993 were comparable to mean lengths at age 1 for the same species captured before 1993. Data used for these comparisons were from Doxey (1991). Mean lengths of age 1 rainbow trout captured before 1993 ranged from 176-231 mm in Birch Lake and 186-218 mm in Quartz Lake. Mean lengths of age 1 coho salmon captured before 1993 ranged from 179-213 mm in Birch Lake, 192-254 mm in Quartz Lake, and 152-186 mm in Chena Lake. However, the number of rainbow trout and coho salmon available to anglers may decrease because fewer and sometimes smaller rainbow trout and coho salmon were stocked into these lakes in 1992 and 1993 than were stocked before 1992. Although fewer rainbow trout and coho salmon may be available, ADF&G has increased the number of species available to anglers by stocking Arctic grayling and Arctic char in these lakes. This stocking strategy was designed to make more species available to anglers while maintaining or increasing the total number of fish

available. Because different species are better at using different niches (habitat partitioning) this stocking strategy should result in greater species diversity and more fish for anglers (Sekulich 1974, Manzer 1976, Northcote 1970).

BROOD TABLES

Methods

The rainbow trout and coho salmon stocking programs for Birch, Chena and Quartz lakes were evaluated using brood tables to estimate the annual and total contribution to the harvest of each stocking cohort. Each brood table was based on the following five types of information:

1. Number, size, and stocking date of each cohort.
   The number of fish stocked, size at stocking, and date of stocking was known for all years and is presented in Tables 3, 4, and 5.

2. Estimated recruitment to the fishery.
   Rainbow trout were considered fully recruited to the fishery at 180 mm FL (Doxey 1990). Abundance estimates were available for rainbow trout in recent years and were used to estimate survival rate from stocking to catchable size and the recruitment into the fishery (Doxey 1980-1991; Hallberg 1984-1985; Kramer 1977; Kramer and Hallberg 1982; Appendix B).

3. Total annual harvest estimates.
   A mail survey, Alaska Statewide Harvest Survey (SWHS) (Mills, 1978-1991) estimated the annual harvest of rainbow trout and coho salmon in each lake beginning in 1977. These harvest estimates could not be used to assign harvest to specific stocking cohorts, but they represent an overall estimate of the annual contribution for all stocking cohorts.

4. Average annual natural mortality estimates.
   The average natural mortality rate was calculated as:

$$n_{i+1} = n_i + r_{i+1} - h_i - m_i \qquad (3)$$

where:

n_{i+1} = number of fish in year i+1,
n_i = number of fish in year i,
r_{i+1} = recruitment in year i,
h_i = harvest in year i; and,
m_i = natural mortality in year i.

Table 3. Fish stocked into Birch Lake, 1966-1990.

Year	Rainbow Trout	Broodstock	Size (g)	Coho Salmon	Size (g)
1966	193,500	Winthrop	2.2-2.8		
1967	352,300	Winthrop	0.5-1.1		
1968	464,400	Winthrop	Fingerling		
1969	411,200	Winthrop	Fingerling		
1970	189,200	Winthrop	Fingerling		
1971	297,800	Roaring R.	Fingerling		
1972	297,800	Winthrop	Fingerling		
1973					
1974	9,800	Naknek	Fingerling	55,700	Fingerling
				18,567	Smolt
1975				5,907	Age II
				95,000	1.2
1976	766	Talarik & Swanson	80	54,900	2.0
1977	104,249	Ennis-Alaska	3.0-3.8		
1978	95,079	Ennis-Alaska & Talarik	2.8-3.1		
1979	101,314	Ennis-Alaska	25		
1980	55,074	Swanson R.	25	59,850	2.8
1981	50,654	Swanson R.	23	30,000	1.3
1982	97,261	Swanson R.	8.1		
	98,500	Swanson R.	1.3		
1983	19,482	Big Lake	45		
	25,218	Swanson R.	1.8		
1984	269,963	Swanson R.	1.7-2.7	50,000	3.7
1985				55,539	3.6
1986	83,368	Swanson R.	21	40,000	3.9
1987	34,039	Swanson R.	23-30	40,000	4.8
1988	54,723	Swanson R.	25-32	40,000	3.3
1989	50,000	Swanson R.	16	40,000	4.2
	4,045	Swanson R.	112		
1990	48,345	Swanson R.	23 131,000	2.7	
1991	25,153	Swanson R.	23	40,303	1.0

Table 4. Fish stocked into Chena Lake, 1982-1990.

Year	Rainbow Trout	Broodstock	Size (g)	Coho Salmon	Size (g)
1982	7,134	Swanson R.	57	27,607	1.5-2.0
	20,417	Swanson R.	7.7		
1983	30,691	Swanson R.	1.7		
1984	18,579	Big Lake	25	30,000	3.8
	47,529	Swanson R.	1.7		
1985	15,800	Anchor R.	44-56	30,000	3.7
1986	29,102	Big Lake	57-76	30,000	3.8
1987	25,406	Swanson R.	113-151	30,000	5.2
1988	30,091	Big Lake & Swanson R.	63-100	47,885	3.4-8.6
1989	30,481	Swanson R.	78-103	15,000	4.0
1990	31,251	Swanson R.	97-107		
1991	26,976	Swanson R.	97-109	16,364	1.0

Table 5. Fish stocked into Quartz Lake, 1971-1990.

Year	Rainbow Trout	Broodstock	Size (g)	Coho Salmon	Size (g)
1971	810,000	Winthrop	Fry		
1972	306,726	Ennis	Fingerling		
1973	354,400	Winthrop	Fingerling		
1974	185,100	Winthrop	Fingerling		
1975	209,900	Ennis	2.4-2.6		
1976	155,300	Willamette	0.7-4.5		
		Crooked Creek			
1977	110,500	Ennis Alaska	1.4	197,400	1.1-2.7
	3,301	Ennis Alaska	39		
1978	55,549	3.1-3.5			
1979	32,858	Swanson R.	1.6	150,095	8.0
1980	87,559	Swanson R.	1.2		
1981	150,114	Swanson R.	1.2-1.5		
1982	226,600	Swanson R.	1.3		
1983	233,272	Swanson R.	1.3	46,543	2.7
1984	273,567	Swanson R.	2.0-2.4	155,718	1.8-4.3
1985	287,376	Swanson R.	1.6-1.7	149,976	3.6
1986	301,877	Swanson R.	1.4-1.8	168,500	4.1
1987	10,000	Swanson R.	28	168,489	2.3-4.9
	407,917	Swanson R.	2.2-2.4		
1988	48,094	Swanson R.	25	150,000	3-4
	150,000	Swanson R.	1.0		
1989	47,323	Swanson R.	17-36	150,000	4.0
	150,000	Swanson R.	1.2		
1990	33,843	Swanson R.	23	150,000	2.7
	150,632	Swanson R.	1.2		
	52,914	Swanson R.	2.4		
1991	42,716	Swanson R.	20-25	151,785	1.1
	152,000	Swanson R.	2.0		

With estimates of abundance, harvest and recruitment, the number of fish that died naturally can be easily calculated algebraically. The natural mortality rate is then expressed as a proportion of the number of fish in year *i*. The average natural mortality rate was then used in the brood tables.

5. Estimated angler preferences for size.
Creel surveys at Birch and Quartz lakes were used to determine anglers' preference for various sizes of fish and apportion the harvest among the cohorts. Creel data showed that the proportion of larger fish in the harvest was greater than what was estimated for the size composition of the population (Table 6). One possible explanation as to why larger fish were more likely to be harvested was that anglers are more likely to keep larger fish and release smaller fish. The angler preference is a correction factor which minimizes absolute difference between the creel data and the population data (Baker 1988; Clark and Ridder 1987; Appendix C).

The following assumptions also were made:

1. The estimated annual natural mortality was constant across years.

2. The angler preference was the same for all lakes and years.

The brood tables work in the following way:

1. A cohort was stocked into a lake and the survival to catchable size was estimated and this number was then the first entry in the brood table.

2. The number of fish which survived to catchable size was then discounted for natural mortality and timing (fish unavailable for capture due to size or time of stocking) in the following manner:

    a. Fingerlings and subcatchable sized rainbow trout did not reach catchable size until the eighth month of the calendar year. Therefore, the first year harvest and annual mortality of these cohorts were reduced by a factor of 0.67.

    b. Rainbow trout of catchable size were not stocked until the sixth month of the calendar year. Therefore the first year of harvest and annual mortality were reduced by a factor of 0.50 prior to estimating proportions.

    c. Age 3 coho salmon near the end of their life tend to not eat and are not attracted to lures or bait so the number of harvestable age 3 salmon was reduced by 10%.

Table 6. Brood tables for rainbow trout stocked into Birch Lake with an annual mortality rate of 0.25.

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Abundance in Year of Age	Natural Mortality	Not Available Due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest	Estimated Number in Creel
1977	1,850	1974	fing	157	3	39	0	118	0.014	1.5	0.014	27	
		1976	catch	766	1	192	0	575	0.070	1.5	0.070	130	
		other			2	0	0	7,500	0.915	1.5	0.915	1,694	
								8,192				1,850	
1978	5,126	1977	fing	10,425	1	2,606	6,985	834	0.151	0.8	0.087	444	
		1976	catch	445	2	111	0	334	0.060	1.5	0.065	333	
		other		5,806	2	1,452	0	4,355	0.789	1.5	0.848	4,349	
								5,522				5,126	
1979	4,190	1978	fing	9.508	1	2,377	6,370	761	0.064	0.8	0.046	191	
		1977	fing	7,375	2	1,844	0	5,531	0.466	1.5	0.621	2,602	
		1979	sub[a]	22,492	0	1,856	15,070	5,567	0.469	0.8	0.333	1.397	
								11,858				4,190	
1980	18,727	1978	fing	6,940	2	1,735	0	5,205	0.176	1.5	0.246	4,607	2,027
		1977	fing	2,929	3	732	0	2,196	0.074	1.5	0.104	1,944	
		1980	sub	31,337	0	2,585	20,996	7,756	0.262	0.8	0.196	3,661	1,697
		1979	sub	19,240	1	4,810	0	14,430	0.488	1	0.455	8,515	14,236
								29,587				18,727	17,960
1981	21,622	1978	fing	598	3	150	0	449	0.015	1.5	0.020	439	241
		1981	sub	27,708	0	2,286	18,564	6,858	0.224	0.2	0.041	894	4,811
		1980	sub	25,090	1	6,273	0	18,818	0.616	1.3	0.738	15,950	13,081
		1979	sub	5,915	2	1,479	0	4,436	0.145	1.5	0.201	4,339	2,682
								30,560				21,622	20,815

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Table 6. (Page 2 of 3).

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Abundance in Year of Age	Natural Mortality	Not available due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest	Estimated Number in Creel
1982	18,385	1982	sub	26,260	0	2,166	26,260	0	0.000	0.8	0.000	0	0
		1981	sub	24,528	1	6,132	0	18,396	0.895	1.5	0.895	16,461	15,645
		1980	sub	2,868	2	717	0	2,151	0.105	1.5	0.105	1,924	2,640
								20,547				18,385	18,285
1983	16,963	1982	fing	3,582	1	896	2,400	287	0.020	1.2	0.022	287	38
		1983	sub	15,586	0	1,286	10,443	3,858	0.275	1.2	0.297	3,858	1,440
		1982	sub	24,094	1	6,023	9,637	8,433	0.601	1	0.541	8,433	8,752
		1981	sub	1,935	2	484	0	1,451	0.103	1.5	0.140	1,451	4,711
								14,028				14,028	14,941
1984	12,123	1983	fing	2,755	1	689	1,846	220	0.013	0.8	0.008	99	
		1982	fing	2,400	2	600	0	1,800	0.105	1.5	0.125	1,519	
		1983	sub	10,443	1	2,611	0	7,832	0.459	1	0.363	4,406	
		1982	sub	9,637	2	2,409	0	7,228	0.423	1.5	0.503	6,099	
								17,080				12,123	
1985	10,161	1984	fing	3,779	1	945	2,532	302	0.066	0.8	0.037	302	
		1983	fing	1,967	2	492	0	1,475	0.324	1.5	0.334	1,475	
		1982	fing	281	3	70	0	211	0.046	1.5	0.048	211	
		1983	sub	3,426	2	857	0	2,570	0.564	1.5	0.582	2,570	
								4,558				4,558	
1986	8,723	1984	fing	2,532	2	633	0	1,899	0.120	1.5	0.204	1,778	
		1983	fing	0	3	0	0	0	0.000	1.5	0.000	0	
		1986	suh	56,190	0	4,636	37,647	13,907	0.880	0.8	0.796	6,945	
								15,806				8,723	

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Table 6. (Page 3 of 3).

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Age	Natural Mortality	Not available due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest	Estimated Number in Creel
1987	9,981	1984	fing	121	3	30	0	91	0.002	1.5	0.004	36	
		1987	sub	18,585	0	1,533	12,452	4,600	0.121	0.8	0.099	985	
		1986	sub	44,609	1	11,152	0	33,457	0.877	1	0.898	8,959	
								38,147				9,981	
1988	18,390	1988	sub	26,869	0	2,217	18,002	6,650	0.179	0.8	0.118	2,178	
		1987	sub	16,066	1	4,017	0	12,050	0.325	1	0.268	4,932	
		1986	sub	24,498	2	6,124	0	18,373	0.496	1.5	0.613	11,280	
								37,073				18,390	
1989	16,420	1989	sub	14,150	0	1,167	9,481	3,502	0.129	0.8	0.096	1,576	
		1988	sub	22,475	1	5,619	0	16,856	0.619	1	0.578	9,484	
		1987	sub	7,118	2	1,779	0	5,338	0.196	1.5	0.274	4,506	
		1989	catch	4,045	0	506	2,023	1,517	0.056	1	0.052	854	
								27,213				16,420	
1990	15,901	1990	sub	25,236	0	6,309	0	18,927	0.646	0.8	0.517	8,223	
		1989	sub	11,406	1	941	7,642	2,823	0.096	1	0.096	1,533	
		1988	sub	7,372	2	1,843	0	5,529	0.189	1.5	0.283	4,504	
		1989	catch	2,686	1	671	0	2,014	0.069	1.5	0.283	1,641	
								29,293				15,903	
1991	17,625	1991	sub	13,130	0	3,282	0	9,847	0.493	2	0.558	9,842	
		1990	sub	10,704	1	883	7,172	2,649	0.133	1	0.075	1,324	
		1989	sub	8,932	2	2,233	0	6,699	0.336	1.7	0.323	5,691	
		1989	catch	1,025	2	256	0	769	0.039	2	0.044	768	
								19.964				17,625	

[a] Sub = sub catchable.

Those fish unavailable for capture due to timing were added back into the available number the second year (except age 3 coho).

3. The proportion of the total abundance represented by each cohort was then calculated.

4. The proportion of the cohort in the population was then corrected for angler preference.

5. The adjusted proportion was used to divide the harvest of that year among the various cohorts. If there were not enough fish of the preferred size more fish of the next preferred cohort were harvested.

Results

An annual natural mortality rate of 25% was used in the rainbow trout brood tables for Birch and Quartz lakes (Tables 6 and 7). The annual mortality rate was only 20% in Chena Lake (Table 8). Coho salmon had an estimated annual mortality rate of 45% in Birch and Chena lakes and only 40% in Quartz Lake (Tables 9, 10, and 11).

The harvest predicted by the brood tables was less than the harvest reported in the SWHS 14% of the time (Table 12). Abundances predicted by the brood tables were generally greater than abundance estimated through mark-recapture experiments (Table 13).

The brood tables indicated that cohorts of rainbow trout stocked as fingerlings provided the majority of their contribution to the harvest during the second year after they were stocked. Harvest of rainbow trout stocked as subcatchables peaked during the first year after stocking, as did that of catchables.

Estimated percent return to the creel from cohorts of rainbow trout stocked as fingerlings in Birch Lake ranged from 0.8% in 1984 to 5.5% in 1977 (Table 14). The estimated return to the creel of rainbow trout stocked as fingerlings at Chena Lake ranged from 1.1% to 6.6% (Table 15). Returns to the creel of rainbow trout stocked as fingerlings at Quartz Lake ranged from 0.2% in 1977 to 5.6% in 1988 (Table 16). Estimated contribution of subcatchable rainbow trout ranged from 14.1% to 55.6% at Birch Lake (Table 14); from 32.0% to 45.7% at Chena Lake (Table 15); and from 7.0% to 54.5% at Quartz Lake (Table 16). Catchables were estimated to have contributed 80.7% of the stocking to the creel in Birch Lake. In Chena Lake between 14.9% (1987) and 38.3% (1988) of catchable-sized stocked rainbow trout were returned to the creel (Table 15).

Peak harvest (66.9%) from cohorts of coho salmon occurred in the second year after stocking (Tables 17, 18, and 19). The first year after stocking provided a 12.0% return to the creel and the third year provided a 20.6% return. Estimated coho salmon return to the creel at Birch Lake ranged from

Table 7. Brood tables for rainbow trout stocked into Quartz Lake with an annual mortality rate of 0.20.

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Age	Natural Mortality	Not Available Due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest
1977	2,634	1976	fing	2,330	1	154	1,561	615	0.233	1.5	0.233	614
		1975	fing	630	2	126	0	504	0.191	1.5	0.191	503
		1974	fing	111	3	22	0	89	0.034	1.5	0.034	89
		1977	sub catch	3,301	0	218	1,651	1,433	0.543	1.5	0.543	1,429
								2,640				2,634
1978	512	1977	fing	1,658	1	109	1,111	438	0.145	0.8	0.083	43
		1976	fing	1,562	2	312	0	1,250	0.415	1.5	0.445	228
		1975	fing	1	3	0	0	1	0.000	1.5	0.000	0
		1977	sub catch	1,654	1	331	0	1,323	0.439	1.5	0.471	241
								3,011				512
1979	273	1977	fing	1,506	2	301	0	1,204	0.417	1.5	0.417	114
		1976	fing	1,022	3	204	0	817	0.283	1.5	0.283	77
		1975	fing	1	4	0	0	1	0.000	1.5	0.000	0
		1977	sub catch	1,082	2	216	0	865	0.300	1.5	0.300	82
								2,888				273
1980	129	1979	fing	2,300	1	152	1,541	607	0.288	0.8	0.178	23
		1977	fing	1,091	3	218	0	872	0.414	1.5	0.479	62
		1977	sub catch	784	3	157	0	627	0.298	1.5	0.344	44
								2,107				129
1981	1,869	1980	fing	6,129	1	405	4,106	1,618	0.488	0.8	0.337	629
		1979	fing	2,125	2	425	0	1,700	0.512	1.5	0.663	1,240
								3,318				1,869
1982	5,003	1980	fing	5,095	2	1,019	0	4,076	0.917	1.5	0.917	4,076
		1979	fing	460	3	92	0	368	0.083	1.5	0.083	368
								4,445				4,445

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Table 7. (Page 2 of 3).

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Age	Natural Mortality	Not Available Due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest
1983	1,547	1982	fing	15,862	1	1,047	10,628	4,188	1.000	0.8	1.000	1,547
		1980	fing	0	3	0	0	0	0.000	1.5	0.000	0
								4,188				1,547
1984	5,491	1983	fing	16,329	1	1,078	10,940	4,311	0.289	0.8	0.178	978
		1982	fing	13,268	2	2,654	0	10,614	0.711	1.5	0.822	4,513
								14,925				5,491
1985	12,398	1984	fing	19,150	1	1,264	12,831	5,056	0.237	0.8	0.142	1,760
		1983	fing	14,274	2	2,855	0	11,419	0.535	1.5	0.601	7,453
		1982	fing	6,101	3	1,220	0	4,881	0.229	1.5	0.257	3,186
								21,355				12,398
1986	14,778	1985	fing	20,116	1	1,328	13,478	5,311	0.248	1.3	0.223	3,290
		1984	fing	16,126	2	3,225	0	12,901	0.603	1.5	0.624	9,221
		1983	fing	3,966	3	793	0	3,173	0.148	1.5	0.153	2,268
								21,385				14,778
1987	10,106	1986	fing	21,131	1	1,395	14,158	5,579	0.262	0.8	0.161	1,624
		1985	fing	15,499	2	3,100	0	12,399	0.582	1.5	0.670	6,766
		1984	fing	3,680	3	736	0	2,944	0.138	1.5	0.159	1,607
		1987	sub catch	1,420	0	94	951	375	0.018	0.8	0.011	109
								21,297				10,106
1988	25,175	1987	fing	28,554	1	1,885	19,131	7,538	0.243	1.5	0.243	6,109
		1986	fing	18,113	2	3,623	0	14,490	0.466	1.5	0.466	11,743
		1985	fing	5,633	3	1,127	0	4,506	0.145	1.5	0.145	3,652
		1988	sub catch	13,466	0	889	9,022	3,555	0.114	1.5	0.114	2,881
		1987	sub catch	1,217	1	243	0	974	0.031	1.5	0.031	789
								31,063				25,175
1989	27,356	1988	fing	10,500	1	693	7,035	2,772	0.091	1.5	0.094	2,559
		1987	fing	20,560	2	4,112	0	16,448	0.540	1.5	0.555	15,187
		1986	fing	2,747	3	549	0	2,197	0.072	1.5	0.074	2,029
		1989	sub catch	4,354	0	287	2,917	1,149	0.038	0.4	0.010	283
		1988	sub catch	9,696	1	1,939	0	7,757	0.255	1.5	0.262	7,162
		1987	sub catch	185	2	37	0	148	0.005	1.5	0.005	136
								30,471				27,356

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Table 7. (Page 3 of 3).

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Age	Natural Mortality	Not Available Due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest
1990	20,847	1989	fing	10,500	1	693	7,035	2,772	0.137	1.5	0.137	2,772
		1988	fing	7,248	2	1,450	0	5,798	0.287	1.5	0.287	5,798
		1987	fing	1,262	3	252	0	1,009	0.050	1.5	0.050	1,009
		1990	sub catch	5,787	0	382	3,877	1,528	0.076	1.5	0.076	1,528
		1989	sub catch	3,784	1	757	0	3,027	0.150	1.5	0.150	3,027
		1988	sub catch	7,621	2	1,524	0	6,096	0.301	1.5	0.301	6,096
								20,230				20,230
1991	28,238	1990	fing	14,248	1	940	9,546	3,762	0.261	1.5	0.261	3,762
		1989	fing	7,035	2	1,407	0	5,628	0.390	1.5	0.390	5,628
		1988	fing	0	3	0	0	0	0.000	1.5	0.000	0
		1991	sub catch	7,304	0	482	4,894	1,928	0.134	1.5	0.134	1,928
		1990	sub catch	3,877	1	775	0	3,102	0.215	1.5	0.215	3,102
		1989	sub catch	0	2	0	0	0	0.000	1.5	0.000	0
								14,420				14,420

Table 8. Brood tables for rainbow trout stocked into Chena Lake with an annual mortality rate of 0.25.

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Age	Natural Mortality	Not Available Due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest
1982	0	1982	fing	14,904	0	3,726	14,904	0	0.000	0	0.000	0
		1982	sub catch	6,421	0	530	4,302	1,589	0.000	0.8	0.000	0
								1,589				0
1983	0	1983	fing	3,069	0	767	3,069	0	0.000	0	0.000	0
		1982	fing	14,904	1	1,230	9,986	3,689	0.000	0.8	0.000	0
		1982	sub catch	5,891	1	1,473	0	4,418	0.000	1.2	0.000	0
								8,107				0
1984	12,032	1983	fing	3,069	1	253	2,056	760	0.046	1.5	0.046	554
		1982	fing	13,674	2	3,419	0	10,256	0.617	1.5	0.621	7,476
		1984	sub catch	9,290	0	766	6,224	2,299	0.138	1.4	0.132	1,587
		1982	sub catch	4,418	2	1,105	0	3,314	0.199	1.5	0.201	2,416
								16,629				12,032
1985	9,990	1984	fing	950	1	78	637	235	0.018	1.5	0.018	175
		1983	fing	2,262	2	566	0	1,697	0.126	1.5	0.126	1,264
		1982	fing	2,780	3	695	0	2,085	0.155	1.5	0.155	1,553
		1985	sub catch	14,220	0	1,173	9,527	3,519	0.262	1.5	0.262	2,621
		1984	sub catch	6,937	1	1,734	0	5,203	0.388	1.5	0.388	3,875
		1982	sub catch	898	3	225	0	674	0.050	1.5	0.050	502
								13,412				9,990
1986	7,001	1984	fing	696	2	174	0	522	0.032	1.5	0.045	316
		1983	fing	433	3	108	0	325	0.020	1.5	0.028	197
		1986	sub catch	26,192	0	2,161	17,549	6,483	0.402	0.8	0.299	2,095
		1985	sub catch	10,425	1	2,606	0	7,819	0.484	1.2	0.541	3,790
		1984	sub catch	1,328	2	332	0	996	0.062	1.5	0.086	603
								16,144				7,001
1987	5,220	1984	fing	206	3	51	0	154	0.007	1.5	0.008	42
		1986	sub catch	21,936	1	5,484	0	16,452	0.703	1.2	0.678	3,538
		1985	sub catch	4,029	2	1,007	0	3,022	0.129	1.5	0.156	812
		1984	sub catch	392	3	98	0	294	0.013	1.5	0.015	79
		1987	catch	9,290	0	1,161	4,645	3,484	0.149	1.2	0.144	749
								23,407				5,220

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Table 8. (Page 2 of 2).

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Age	Natural Mortality	Not Available Due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest
1988	9,877	1985	sub catch	2,210	3	552	0	1,657	0.059	1.5	0.064	632
		1986	sub catch	12,914	2	3,229	0	9,686	0.344	1.5	0.374	3,693
		1988	catch	30,091	0	3,761	15,046	11,284	0.401	1.2	0.348	3,442
		1987	catch	7,380	1	1,845	0	5,535	0.197	1.5	0.214	2,110
								28,162				9,877
1989	11,966	1986	sub catch	5,993	3	1,498	0	4,495	0.126	1.5	0.135	1,612
		1989	catch	30,481	0	3,810	15,241	11,430	0.321	1.2	0.274	3,279
		1988	catch	22,888	1	5,722	0	17,166	0.481	1.5	0.514	6,155
		1987	catch	3,424	2	856	0	2,568	0.072	1.5	0.077	921
								35,659				11,966
1990	8,558	1990	catch	31,251	0	3,906	15,626	11,719	0.302	1.2	0.257	2,203
		1989	catch	23,392	1	5,848	0	17,544	0.453	1.5	0.482	4,123
		1988	catch	11,011	2	2,753	0	8,258	0.213	1.5	0.227	1,941
		1987	catch	1,647	3	412	0	1,236	0.032	1.5	0.034	290
								38,757				8,558
1991	12,196	1991	catch	26,976	0	3,372	13,488	10,116	0.231	1.2	0.194	2,364
		1990	catch	25,141	1	6,285	0	18,856	0.431	1.5	0.452	5,508
		1989	catch	13,421	2	3,355	0	10,066	0.230	1.5	0.241	2,940
		1988	catch	6,317	3	1,579	0	4,738	0.108	1.5	0.113	1,384
								43,776				12,196

Table 9. Brood tables for coho salmon stocked in Birch Lake with an annual mortality rate of 0.45.

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Age	Natural Mortality	Not Available Due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest
1977	5,687	1977	fing	0	0	0	0	0	0.000	0	0.000	0
		1976	fing	23,401	1	10,531	11,701	1,170	0.099	0.5	0.035	200
		1975	fing	0	2	0	0	0	0.000	1.5	0.000	0
		1974	fing	23,742	3	10,684	2,374	10,684	0.901	1.5	0.965	5,487
								11,854				5,687
1978	6,354	1978	fing	0	0	0	0	0	0.000	0	0.000	0
		1977	fing	0	1	0	0	0	0.000	0.5	0.000	0
		1976	fing	12,670	2	5,702	0	6,969	1.000	1.5	1.000	6,354
		1975	fing	0	3	0	0	0	0.000	1.5	0.000	0
								6,969				6,354
1979	132	1979	fing	0	0	0	0	0	0.000	0	0.000	0
		1978	fing	0	1	0	0	0	0.000	0.5	0.000	0
		1977	fing	0	2	0	0	0	0.000	1.5	0.000	0
		1976	fing	615	3	277	61	277	1.000	1.5	1.000	132
								277				132
1980	0	1980	fing	59,850	0	6,733	59,850	0	0.000	0	0.000	0
		1979	fing	0	1	0	0	0	0.000	0.5	0.000	0
		1978	fing	0	2	0	0	0	0.000	1.5	0.000	0
		1977	fing	0	3	0	0	0	0.000	1.5	0.000	0
								0				0
1981	2,549	1981	fing	30,000	0	3,375	30,000	0	0.000	0	0.000	0
		1980	fing	53,117	1	23,903	26,558	2,656	1.000	0.5	1.000	2,549
		1979	fing	0	2	0	0	0	0.000	1.5	0.000	0
		1978	fing	0	3	0	0	0	0.000	1.5	0.000	0
								2,656				2,549
1982	6,275	1982	fing	0	0	0	0	0	0.000	0	0.000	0
		1981	fing	26,625	1	11,981	13,313	1,331	0.083	0.5	0.029	184
		1980	fing	26,665	2	11,999	0	14,666	0.917	1.5	0.971	6,091
		1979	fing	0	3	0	0	0	0.000	1.5	0.000	0
								15,997				6,275
1983	8,686	1983	fing	0	0	0	0	0	0.000	0	0.000	0
		1982	fing	0	1	0	0	0	0.000	0.5	0.000	0
		1981	fing	14,459	2	6,507	0	7,953	0.673	1.5	0.673	5,848
		1980	fing	8,575	3	3,859	858	3,859	0.327	1.5	0.327	2,838
								11,812				8,686

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Table 9. (Page 2 of 3)

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Abundance in Year of Age	Natural Mortality	Not Available Due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest
1984	6,049	1984	fing	50,000	0	5,625	50,000	0	0.000	0	0.000	0
		1983	fing	0	1	0	0	0	0.000	0.5	0.000	0
		1982	fing	0	2	0	0	0	0.000	1.5	0.000	0
		1981	fing	2,104	3	947	210	947	1.000	1.5	1.000	947
								947				947
1985	4,672	1985	fing	55,539	0	6,248	55,539	0	0.000	0	0.000	0
		1984	fing	44,375	1	19,969	22,188	2,219	1.000	1.5	1.000	2,219
		1983	fing	0	2	0	0	0	0.000	1.5	0.000	0
		1982	fing	0	3	0	0	0	0.000	1.5	0.000	0
								2,219				2,219
1986	4,950	1986	fing	40,000	0	4,500	40,000	0	0.000	0	0.000	0
		1985	fing	49,291	1	22,181	24,645	2,465	0.168	0.5	0.063	312
		1984	fing	22,188	2	9,984	0	12,203	0.832	1.5	0.937	4,638
		1983	fing	0	3	0	0	0	0.000	1.5	0.000	0
								14,668				4,950
1987	6,719	1987	fing	40,000	0	4,500	40,000	0	0.000	0	0.000	0
		1986	fing	35,500	1	15,975	17,750	1,775	0.089	0.5	0.032	212
		1985	fing	26,798	2	12,059	0	14,739	0.740	1.5	0.787	5,286
		1984	fing	7,565	3	3,404	757	3,404	0.171	1.5	0.182	1,221
								19,918				6,719
1988	5,548	1988	fing	40,000	0	4,500	40,000	0	0.000	0	0.000	0
		1987	fing	35,500	1	15,975	17,750	1,775	0.107	0.5	0.038	212
		1986	fing	19,313	2	8,691	0	10,622	0.638	1.5	0.687	3,810
		1985	fing	9,453	3	4,254	945	4,254	0.255	1.5	0.275	1,526
								16,651				5,548
1989	4,982	1989	fing	40,000	0	4,500	40,000	0	0.000	0	0.000	0
		1988	fing	35,500	1	15,975	17,750	1,775	0.115	0.5	0.041	206
		1987	fing	19,313	2	8,691	0	10,622	0.687	1.5	0.744	3,706
		1986	fing	6,812	3	3,065	681	3,065	0.198	1.5	0.215	1,070
								15,462				4,982
1990	3,308	1990	fing	131,000	0	14,738	131,000	0	0.000	0	0.000	0
		1989	fing	35,500	1	15,975	17,750	1,775	0.114	0.5	0.041	137
		1988	fing	19,319	2	8,693	0	10,625	0.685	1.5	0.742	2,453
		1987	fing	6,916	3	3,112	692	3,112	0.201	1.5	0.217	718
								15,512				3,308

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Table 9. (Page 3 of 3).

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Age	Natural Mortality	Not Available Due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest
1991	6,098	1991	fing	40,303	0	4,5334	40,303	0	0.000	0	0.000	0
		1990	fing	116,263	1	52,318	58,131	5,813	0.288	0.5	0.119	726
		1989	fing	19,388	2	8,725	0	10,664	0.529	1.5	0.655	3,995
		1988	fing	8,172	3	3,678	817	3,678	0.182	1.5	0.226	1,378
								20,154				6,098

Table 10. Brood tables for coho salmon stocked into Chena Lake with an annual mortality rate of 0.45.

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Abundance in Year of Age	Natural Mortality	Not Available Due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest
1982	0	1982	fing	27,607	0	3,106	27,607	0	0.000	0	0.000	0
		1981	fing	0	1	0	0	0	0.000	0.5	0.000	0
		1980	fing	0	2	0	0	0	0.000	1.5	0.000	0
		1979	fing	0	3	0	0	0	0.000	1.5	0.000	0
								0				0
1983	0	1983	fing	0	0	0	0	0	0.000	0	0.000	0
		1982	fing	24,501	1	11,026	12,251	1,225	1.000	0.5	1.000	0
		1981	fing	0	2	0	0	0	0.000	1.5	0.000	0
		1980	fing	0	3	0	0	0	0.000	1.5	0.000	0
								1,225				0
1984	5,036	1984	fing	30,000	0	3,375	30,000	0	0.000	0	0.000	0
		1983	fing	0	1	0	0	0	0.000	0.5	0.000	0
		1982	fing	13,476	2	6,064	0	7,412	1.000	1.5	1.000	5,036
		1981	fing	0	3	0	0	0	0.000	1.5	0.000	0
								7,412				5,036
1985	9,485	1985	fing	30,000	0	3,375	30,000	0	0.000	0	0.000	0
		1984	fing	26,625	1	11,981	13,313	1,331	0.555	0.5	0.293	1,331
		1983	fing	0	2	0	0	0	0.000	1.5	0.000	0
		1982	fing	2,376	3	1,069	238	1,069	0.445	1.5	0.707	1,069
								2,400				2,400
1986	1,778	1986	fing	30,000	0	3,375	30,000	0	0.000	0	0.000	0
		1985	fing	26,625	1	11,981	13,313	1,331	0.154	0.5	0.057	102
		1984	fing	13,313	2	5,991	0	7,322	0.846	1.5	0.943	1,676
		1983	fing	0	3	0	0	0	0.000	1.5	0.000	0
								8,653				1,778
1987	1,398	1987	fing	30,000	0	3,375	30,000	0	0.000	0	0.000	0
		1986	fing	26,625	1	11,981	13,313	1,331	0.112	0.5	0.040	56
		1985	fing	14,542	2	6,544	0	7,998	0.674	1.5	0.728	1,018
		1984	fing	5,645	3	2,540	565	2,540	0.214	1.5	0.231	323
								11,870				1,398

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Table 10. (Page 2 of 2).

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Age	Natural Mortality	Not Available Due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest
1988	2,401	1988	fing	47,885	0	5,387	47,885	0	0.000	0	0.000	0
		1987	fing	26,625	1	11,981	13,313	1,331	0.107	0.5	0.038	92
		1986	fing	14,587	2	6,564	0	8,023	0.642	1.5	0.691	1,660
		1985	fing	6,980	3	3,141	698	3,141	0.251	1.5	0.271	650
								12,495				2,401
1989	2,468	1989	fing	15,000	0	1,688	15,000	0	0.000	0	0.000	0
		1988	fing	42,498	1	19,124	21,249	2,125	0.164	0.5	0.061	151
		1987	fing	14,552	2	6,548	0	8,004	0.616	1.5	0.691	1,706
		1986	fing	6,363	3	2,864	636	2,864	0.220	1.5	0.247	611
								12,992				2,468
1990	2,313	1990	fing	0	0	0	0	0	0.000	0	0.000	0
		1989	fing	13,313	1	5,991	6,656	666	0.041	0.5	0.014	32
		1988	fing	23,223	2	10,450	0	12,773	0.785	1.5	0.807	1,866
		1987	fing	6,297	3	2,834	630	2,834	0.174	1.5	0.179	414
								16,272				2,313
1991	3,058	1991	fing	16,364	0	1,841	16,364	0	0.000	0	0.000	0
		1990	fing	0	1	0	0	0	0.000	0.5	0.000	0
		1989	fing	7,289	2	3,280	0	4,009	0.450	1.5	0.450	1,375
		1988	fing	10,906	3	4,908	1,091	4,908	0.550	1.5	0.550	1,683
								8,917				3,058

Table 11. Brood tables for coho salmon stocked in Quartz Lake with a annual natural mortality rate of 0.40.

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Abundance in Year of Age	Natural Mortality	Not available due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest
1977	0	1977	fing	197,400	0	19,740	197,400	0	0.000	0	0.000	0
		1976	fing	0	1	0	0	0	0.000	0.5	0.000	0
		1975	fing	0	2	0	0	0	0.000	1.5	0.000	0
		1974	fing	0	3	0	0	0	0.000	1.5	0.000	0
								0				0
1978	14,892	1978	fing	55,549	0	5,555	55,549	0	0.000	0	0.000	0
		1977	fing	177,660	1	71,064	88,830	17,766	1.000	0.5	1.000	14,892
		1976	fing	0	2	0	0	0	0.000	1.5	0.000	0
		1975	fing	0	3	0	0	0	0.000	1.5	0.000	0
								17,766				14,892
1979	34,787	1979	fing	150,095	0	15,010	150,095	0	0.000	0	0.000	0
		1978	fing	49,994	1	19,998	24,997	4,999	0.083	0.5	0.029	1,023
		1977	fing	91,704	2	36,682	0	55,022	0.917	1.5	0.971	33,764
		1976	fing	0	3	0	0	0	0.000	1.5	0.000	0
								60,022				34,787
1980	23,316	1980	fing	0	0	0	0	0	0.000	0	0.000	0
		1979	fing	135,086	1	54,034	67,543	13,509	0.000	0.5	0.138	3,229
		1978	fing	28,974	2	11,590	0	17,384	0.000	1.5	0.535	12,466
		1977	fing	21,258	3	8,503	2,126	10,629	0.000	1.5	0.327	7,622
								41,522				23,316
1981	50,965	1981	fing	150,114	0	15,011	150,114	0	0.000	0	0.000	0
		1980	fing	0	1	0	0	0	0.000	0.5	0.000	0
		1979	fing	77,822	2	31,129	0	46,693	0.950	1.5	0.950	46,693
		1978	fing	4,919	3	1,967	492	2,459	0.050	1.5	0.050	2,459
								49,153				49,153

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Table 11. (Page 2 of 3).

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Abundance in Age	Natural Mortality	Not available due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest
1982	35,380	1982	fing	0	0	0	0	0	0.000	0	0.000	0
		1981	fing	135,103	1	54,041	67,551	13,510	1.000	0.5	1.000	13,510
		1980	fing	0	2	0	0	0	0.000	1.5	0.000	0
		1979	fing	0	3	0	0	0	0.000	1.5	0.000	0
								13,510				13,510
1983	24,042	1983	fing	46,543	0	4,654	46,543	0	0.000	0	0.000	0
		1982	fing	0	1	0	0	0	0.000	0.5	0.000	0
		1981	fing	67,551	2	27,021	0	40,531	1.000	1.5	1.000	24,042
		1980	fing	0	3	0	0	0	0.000	1.5	0.000	0
								40,531				24,042
1984	17,069	1984	fing	155,718	0	15,572	155,718	0	0.000	0	0.000	0
		1983	fing	41,889	1	16,755	20,944	4,189	0.337	1.5	0.337	4,189
		1982	fing	0	2	0	0	0	0.000	1.5	0.000	0
		1981	fing	16,489	3	6,596	1,649	8,244	0.663	1.5	0.663	8,244
								12,433				12,433
1985	26,312	1985	fing	149,976	0	14,998	149,976	0	0.000	0	0.000	0
		1984	fing	140,146	1	56,058	70,073	14,015	0.527	1.5	0.527	13,873
		1983	fing	20,944	2	8,378	0	12,567	0.473	1.5	0.473	12,439
		1982	fing	0	3	0	0	0	0.000	1.5	0.000	0
								26,581				26,312
1986	16,613	1986	fing	168,500	0	16,850	168,500	0	0.000	0	0.000	0
		1985	fing	134,978	1	53,991	67,489	13,498	0.242	0.5	0.096	1,601
		1984	fing	70,215	2	28,086	0	42,129	0.756	1.5	0.902	14,990
		1983	fing	127	3	51	13	64	0.001	1.5	0.001	23
								55,691				16,613

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Page 11. (Page 3 of 3).

Year of Harvest	SWHS Harvest Estimates	Stocking Year	Stocking Size	Abundance in Year of Harvest	Age	Natural Mortality	Not available due to Timing	Number Available	Proportion of Cohort in Population	Angler Preference	Adjusted Proportion	Number of Cohort in Harvest
1987	15,449	1987	fing	168,489	0	16,849	168,489	0	0.000	0	0.000	0
		1986	fing	151,650	1	60,660	75,825	15,165	0.199	0.5	0.076	1,179
		1985	fing	79,386	2	31,754	0	47,632	0.624	1.5	0.719	11,106
		1984	fing	27,140	3	10,856	2,714	13,570	0.178	1.5	0.205	3,164
								76,366				15,449
1988	19,009	1988	fing	150,000	0	15,000	150,000	0	0.000	0	0.000	0
		1987	fing	151,640	1	60,656	75,820	15,164	0.174	0.5	0.065	1,245
		1986	fing	89,811	2	35,925	0	53,887	0.617	1.5	0.698	13,268
		1985	fing	36,525	3	14,610	3,653	18,263	0.209	1.5	0.237	4,497
								87,314				19,009
1989	9,593	1989	fing	150,000	0	15,000	150,000	0	0.000	0	0.000	0
		1988	fing	135,000	1	54,000	67,500	13,500	0.154	0.5	0.057	549
		1987	fing	89,740	2	35,896	0	53,844	0.614	1.5	0.685	6,567
		1986	fing	40,619	3	16,248	4,062	20,309	0.232	1.5	0.258	2,477
								87,653				9,593
1990	7,309	1990	fing	150,000	0	15,000	150,000	0	0.000	0	0.000	0
		1989	fing	135,000	1	54,000	67,500	13,500	0.158	0.5	0.059	430
		1988	fing	80,451	2	32,180	0	48,271	0.565	1.5	0.632	4,617
		1987	fing	47,277	3	18,911	4,728	23,638	0.277	1.5	0.309	2,261
								85,409				7,309
1991	11,054	1991	fing	151,785	0	15,179	151,785	0	0.000	0	0.000	0
		1990	fing	135,000	1	54,000	67,500	13,500	0.161	0.5	0.060	666
		1989	fing	80,570	2	32,228	0	48,342	0.578	1.5	0.647	7,157
		1988	fing	43,653	3	17,461	4,365	21,827	0.261	1.5	0.292	3,231
								83,668				11,054

Table 12. Comparison of harvest estimates between Alaska Statewide Harvest Survey and Brood Tables.

RAINBOW TROUT

	Birch Lake			Chena Lake			Quartz Lake		
Year	SWHS	Brood	D[a]	SWHS	Brood	D[a]	SWHS	Brood	D[a]
1977	1,850	1,850	0				2,634	2,634	0
1978	5,126	5,126	0				512	512	0
1979	4,190	4,190	0				273	273	0
1980	18,727	18,727	0				129	129	0
1981	21,622	21,622	0				1,869	1,869	0
1982	18,385	18,385	0				5,003	4,445	558
1983	16,963	14,028	2,935				1,547	1,547	0
1984	12,123	12,123	0	12,032	12,032	0	5,491	5,491	0
1985	10,161	4,558	5,603	9,990	9,990	0	12,398	12,398	0
1986	8,723	8,723	0	7001	7,001	0	14,778	14,778	0
1987	9,981	9,981	0	5,220	5,220	0	10,106	10,106	0
1988	18,390	18,390	0	9,877	9,877	0	25,175	25,175	0
1989	16,420	16,420	0	11,966	11,966	0	27,356	27,356	0
1990	15901	15,901	0	8,558	8,558	0	20,847	20,230	617
1991	17625	17,625	0	12,196	12,196	0	28,238	14,420	13,818

COHO SALMON

	Birch Lake			Chena Lake			Quartz Lake		
Year	SWHS	Brood	D[a]	SWHS	Brood	D[a]	SWHS	Brood	D[a]
1977	5,687	5,687	0				0	0	0
1978	6,354	6,354	0				14,892	14,892	0
1979	132	132	0				34,787	34,787	0
1980	0	0	0				23,316	23,316	0
1981	2,549	2,549	0				50,965	49,153	1,812
1982	6,275	6,275	0				35,380	13,510	21,870
1983	8,686	8,686	0				24,042	24,042	0
1984	6,049	947	5,102	5,036	5,036	0	17,069	12,433	4,636
1985	4,672	2,219	2,453	9,485	2,400	7,085	26,312	26,312	0
1986	4,950	4,950	0	1,778	1,778	0	16,613	16,613	0
1987	6,719	6,719	0	1,398	1,398	0	15,449	15,449	0
1988	5,548	5,548	0	2,401	2,401	0	19,009	19,009	0
1989	4,982	4,982	0	2,468	2,468	0	9,593	9,593	0
1990	3,308	3,308	0	2,313	2,313	0	7,309	7,309	0
1991	6,098	6,098	0	3,058	3,058	0	11,054	11,054	0

[a] D is the difference between estimates from the SWHS and brood tables.

Table 13. Comparison of abundance estimates between brood tables and mark-recapture experiments.

	BIRCH LAKE			QUARTZ LAKE		
Year	Brood	M-R	SE [a]	Brood	M-R	SE
1986	15,806	58,269	2,404	21,385	10,497	2,649
1987	38,147	26,556	4,791	21,297	9,489	455
1988	37,073	25,766	2,858	31,063	43,251	5,320
1989	27,213	19,551	2,019	30,471	24,713	3,273

[a] Standard error (SE) of the abundance estimate from the mark-recapture (M-R) experiment.

Table 14. Total harvest and percent return to the creel of rainbow trout at Birch Lake, by stocking cohort.[a]

STOCKING			HARVEST									
			AGE 1			AGE 2			AGE 3			Total	
Year	Size	Number	Year	Number	%	Year	Number	%	Year	Number	%	Number	%
1974	F	9,800	1975			1976			1977	27		27	
1977	F	104,249	1978	444	9	1979	2,602	52	1980	1,944	39	4,991	5
1978	F	95,079	1979	191	4	1980	4,607	88	1981	439	8	5,237	6
1982	F	298,500	1983	287	14	1984	1,519	75	1985	211	10	2,016	1
1983	F	125,218	1984	99	6	1985	1,475	94	1986	0	0	1,574	1
1984	F	269,963	1985	302	14	1986	1,778	84	1987	36	2	2,117	1
			AVERAGE		9			79			12		3
1979	S	101,314	1979	1,397	10	1980	8,515	60	1981	4,339	30	14,250	14
1980	S	55,074	1980	3,661	17	1981	15,950	74	1982	1,924	9	21,536	39
1981	S	50,654	1981	894	5	1982	16,461	88	1983	1,451	8	18,806	37
1982	S	97,261	1982	0	0	1983	8,433	58	1984	6,099	42	14,532	15
1983	S	19,482	1983	3,858	36	1984	4,406	41	1985	2,570	24	10,833	56
1986	S	83,368	1986	6,945	26	1987	8,959	33	1988	11,280	41	27,185	33
1987	S	34,039	1987	985	9	1988	4,932	47	1989	4,506	43	10,423	31
1988	S	54,723	1988	2,178	13	1989	9,484	59	1990	4,504	28	16,166	30
1989	S	50,000	1989	1,576	18	1990	1,533	17	1991	5,691	65	8,801	18
1990	S	48,345	1990	8,223		1991	1,324					9,547	
1991	S	25,153	1991	9,842								9,842	
			AVERAGE		15			53			32		30
1976	C	766	1976			1977	130		1978	333		463	
1989	C	4,045	1989	854	26	1990	1,641	50	1991	768	24	3,263	81
			AVERAGE		26			50			24		81
TOTAL		1,442,969										176,309	12

[a] Only those cohorts with complete capture histories were used in the calculations of averages and total.

Table 15. Total harvest and percent return to the creel of rainbow trout at Chena Lake, by stocking cohort.[a]

STOCKING			HARVEST									
			AGE 1			AGE 2			AGE 3			Total	
Year	Size	Number	Year	Number	%	Year	Number	%	Year	Number	%	Number	%
1982	F	20,417	1983	0		1984	7,476		1985	1,553		9,029	
1983	F	30,691	1984	554	27	1985	1,264	63	1986	197	10	2,014	7
1984	F	47,529	1985	175	33	1986	316	59	1987	42	8	533	1
			AVERAGE		30			61			9		4
1982	S	7,134	1982	0		1983	0	75	1984	2,416		2,416	
1984	S	18,579	1984	1,587	26	1985	3,875	64	1986	603	10	6,065	33
1985	S	15,800	1985	2,621	36	1986	3,790	52	1987	812	11	7,224	46
			AVERAGE		28			51			20		37
1987	C	25,406	1987	749	20	1988	2,110	56	1989	921	24	3,780	15
1988	C	30,091	1988	3,442	30	1989	6,155	53	1990	1,941	17	11,538	38
1989	C	30,481	1989	3,279	32	1990	4,123	40	1991	2,940	28	10,342	34
1990	C	31,251	1990	2,203		1991	5,508						
1991	C	26,976	1991	2,364									
			AVERAGE		27			50			23		29
TOTAL		227,679										53,237	23

[a] Only those cohorts with complete capture histories were used in calculations of averages and totals.

Table 16. Total harvest and percent return to the creel of rainbow trout at Quartz Lake, by stocking cohort.[a]

STOCKING			HARVEST									
			AGE 1			AGE 2			AGE 3			Total	
Year	Size	Number	Year	Number	%	Year	Number	%	Year	Number	%	Number	%
1974	F	185,100							1977	89		89	
1975	F	209,900				1977	503		1978	0		503	
1976	F	155,300	1977	614	67	1978	228	25	1979	77	8	919	1
1977	F	110,500	1978	43	20	1979	114	52	1980	62	28	218	0
1979	F	32,858	1980	23	1	1981	1,240	76	1982	368	23	1,631	5
1980	F	87,559	1981	629	13	1982	4,076	87	1983	0	0	4,705	5
1982	F	226,600	1983	1,547	17	1984	4,513	49	1985	3,186	34	9,246	4
1983	F	233,272	1984	978	9	1985	7,453	70	1986	2,268	21	10,698	5
1984	F	273,567	1985	1,760	14	1986	9,221	73	1987	1,607	13	12,587	5
1985	F	287,376	1986	3,290	24	1987	6,766	49	1988	3,652	27	13,708	5
1986	F	301,877	1987	1,624	11	1988	11,743	76	1989	2,029	13	15,396	5
1987	F	407,917	1988	6,109	27	1989	15,187	68	1990	1,009	5	22,305	5
1988	F	150,000	1989	2,559	31	1990	5,798	69	1991	0	0	8,357	6
1989	F	150,000	1990	2,772		1991	5,628					8,400	
1990	F	203,546	1991	3,762								3,762	
			AVERAGE		21			63			16		4
1977	S	3,301	1977	1,429	79	1978	241	13	1979	129	7	1,800	55
1987	S	10,000	1987	109	11	1988	789	76	1989	136	13	1,035	10
1988	S	48,094	1988	2,881	18	1989	7,162	44	1990	6,096	38	16,140	34
1989	S	47,323	1989	283	9	1990	3,027	91	1991	0	0	3,310	7
1990	S	33,843	1990	1,528		1991	3,102		1992			4,630	14
			AVERAGE		29			56					24
Total		2,729,090										134,216	5

[a] Only those cohorts with complete capture histories were used in calculations of averages and totals.

Table 17. Total harvest and percent return to the creel of coho salmon at Birch Lake, by stocking cohort.[a]

STOCKING			HARVEST									
			AGE 1			AGE 2			AGE 3			Total	
Year	Size	Number	Year	Number	%	Year	Number	%	Year	Number	%	Number	%
1974	F	55,700	1975			1976			1977	5,487		5,487	
1975	F	95,000	1976			1977	0		1978	0		0	
1976	F	54,900	1977	200	3	1978	6,354	95	1979	132	2	6,686	12
1980	F	59,850	1981	2,549	22	1982	6,091	53	1983	2,838	25	11,477	19
1981	F	30,000	1982	184	3	1983	5,848	84	1984	947	14	6,980	23
1984	F	50,000	1985	2,219	27	1986	4,638	57	1987	1,221	15	8,077	16
1985	F	55,539	1986	312	4	1987	5,286	74	1988	1,526	21	7,124	13
1986	F	40,000	1987	212	4	1988	3,810	75	1989	1,070	21	5,092	13
1987	F	40,000	1988	212	5	1989	3,706	80	1990	718	15	4,637	12
1988	F	40,000	1989	206	5	1990	2,453	61	1991	1,378	34	4,037	10
1989	F	40,000	1990	137	3	1991	3,995					4,131	
1990	F	131,000	1991	726									
1991	F	40,303											
				AVERAGE	9			72			18		15
TOTAL		370,289										54,110	15

[a] Only those cohorts with complete capture histories were used in the calculations of averages and total.

Table 18. Total harvest and percent return tothe creel of coho salmon at Chena Lake, by stocking cohort.[a]

STOCKING			HARVEST									
			AGE 1			AGE 2			AGE 3			Total	
Year	Size	Number	Year	Number	%	Year	Number	%	Year	Number	%	Number	%
1982	F	27,607	1983	0		1984	5,036		1985	1,069		6,105	
1984	F	30,000	1985	1,331	40	1986	1,676	50	1987	323	10	3,331	11
1985	F	30,000	1986	102	6	1987	1,018	58	1988	650	37	1,769	6
1986	F	30,000	1987	56	2	1988	1,660	71	1989	611	26	2,327	8
1987	F	30,000	1988	92	4	1989	1,706	77	1990	414	19	2,212	7
1988	F	47,885	1989	151	4	1990	1,866	50	1991	1,683	45	3,701	8
1989	F	15,000	1990	32		1991	1,375					1,407	
				AVERAGE	11			61			27		8
TOTAL		167,885										13,340	

[a] Only those cohorts with complete capture histories were used in calculations of averages and totals.

Table 19. Total harvest and percent return to the creel of coho salmon at Quartz Lake, by stocking cohort.[a]

STOCKING			HARVEST									
			AGE 1			AGE 2			AGE 3			Total	
Year	Size	Number	Year	Number	%	Year	Number	%	Year	Number	%	Number	%
1977	F	197,400	1978	14,892	26	1979	33,764	60	1980	7,622	14	56,278	29
1978	F	55,549	1979	1,023	6	1980	12,466	78	1981	2,459	15	15,948	29
1979	F	150,095	1980	3,229	6	1981	46,693	94	1982	0	0	49,922	33
1981	F	150,114	1982	13,510	30	1983	24,042	52	1984	8,244	18	45,797	31
1983	F	46,543	1984	4,189	25	1985	12,439	75	1986	23	0	16,651	36
1984	F	155,718	1985	13,873	43	1986	14,990	47	1987	3,164	10	32,026	21
1985	F	149,976	1986	1,601	9	1987	11,106	65	1988	4,497	26	17,204	11
1986	F	168,500	1987	1,179	7	1988	13,268	78	1989	2,477	15	16,924	10
1987	F	168,489	1988	1,245	12	1989	6,567	65	1990	2,261	22	10,073	6
1988	F	150,000	1989	549	7	1990	4,617	55	1991	3,231	38	8,397	6
1989	F	150,000	1990	430		1991	7,157					7,587	
1990	F	150,000	1991	666								666	
1991	F	151,785											
				AVERAGE	17			67			16		21
TOTAL		1,542,384										276,806	18

[a] Only those cohorts with complete capture histories were used in calculations of averages and totals.

10.1% to 23.3% (Table 17); at Chena Lake ranged from 5.9% to 11.1% (Table 18); and, at Quartz Lake ranged from 5.6% to 35.8% (Table 19).

Discussion

While there was not complete agreement between the brood tables and the five sources of information, the estimates were comparable for most situations. The largest discrepancies were between abundance estimates from the brood tables and those from mark-recapture experiments. Part of this discrepancy could be attributed to biased estimates of abundance from mark-recapture experiments and using an average to estimate annual mortality rates. Mark-recapture experiments require that several assumptions not be violated during an experiment. If any one of these assumptions were violated then the estimates of abundance would be biased (Bernard and Hansen 1992). Average annual mortality rates were used in the brood tables which in some years probably resulted in biased estimates.

Nevertheless, fishery managers will use the brood table data along with results from the 1993 mail survey (when available) to model the fisheries in Birch, Quartz, and Chena lakes under different stocking strategies. Results from these models will be used to make changes to the stocking program to reduce stocking costs.

HARDING LAKE

Methods

Harding Lake was divided into quadrants and three limnological zones to distribute sampling effort (Figure 4 and Table 20). The littoral zone was near-shore in water less than 10 m deep. The benthic zone was within 2 m of the bottom at depths ranging from 10 to 36 m. The benthic zone was further subdivided into four depth categories to spread sampling effort (10 to <15, 15 to <21, 21 to <27, and 27 to <37 m; Table 20). The pelagic zone was the entire water column in water more than 30 m deep.

The littoral zone in each quadrant was fished for eight 24-hour periods with Fyke traps. The Fyke traps had a 25 m center lead and 7.5 m wings. The four depth categories within the benthic zone in each quadrant were fished for two 24-hour periods with a 40 m x 2 m, variable mesh, monofilament, sinking gill-net. The pelagic zone of each quadrant was fished for two 24-hour periods with six vertical gill-nets. Each net was 3 m x 30 m, mono-filament or multi-filament, and had a different mesh size which ranged from 12.7 mm to 63.5 mm (bar measure). All sampling took place from 25 August to 4 September 1992. All net locations in each quadrant were randomly chosen within each limnological zone. Sample design in 1993 was similar to that of test netting conducted during 1989, 1990, and 1991 (Viavant and Clark 1991a; Viavant 1992a). All captured fish were measured to the nearest millimeter FL and examined for fin clips and Floy tags.

Table 20. Zones, depths, and gear types used to sample fish in Harding Lake during August-September 1993.

Limnological Zone	Water Depth (m)	Gear Type	Number of Periods Fished[a]
Littoral	0 - <10	Fyke trap	32
Benthic	10 - <15	Sinking Gill-net	8
Benthic	15 - <21	Sinking Gill-net	8
Benthic	21 - <27	Sinking Gill-net	8
Benthic	27 - <37	Sinking Gill-net	8
Pelagic	>30	Vertical Gill-net	48

[a] A period is defined as 24 hours.

In addition to catches during this study, other sources of data (Appendix D) included incidental captures during spring assessment of the northern pike *Esox lucius* population (Skaugstad and Burkholder 1992), tag returns from anglers, data gathered during a winter creel survey at Harding Lake (Merritt et al. 1990), and data taken during experimental hook and line fishing at Harding Lake (Viavant and Clark 1991b). The stocking history of Harding Lake since 1988 is provided in Appendix E. Fishing effort and harvest of wild and stocked fish from 1986 through 1992 are provided in Appendix G.

Relative Abundance:

Relative abundance was defined as the median catch per net or trap in a 24-hour period or CPUE. The 95% confidence interval for the median CPUE was calculated as:

$$P(X_k \leq median \leq X_m) \geq 1 - \alpha \qquad (4)$$

where: $k = (C_{\alpha(2),n}) + 1$

$m = n - C_{\alpha(2),n}$; and,

$C_{\alpha(2}$ = critical values of the binomial distribution with $p = 0.5$ and X_k and X_m being the k^{th} and m^{th} ranked observations (Zar 1984).

The median CPUE of a species in a zone was classified as abundant, moderately abundant, or sparse, based on the numerical criteria for each species as provided in Appendix F. These abundance criteria were developed by polling biologists regarding their opinions of what catch levels they would categorize as abundant, moderately abundant, or sparse for each species for a 24-hour period, and averaging the results (Viavant and Clark 1991a). These abundance criteria were used only as a consistent basis for categorizing relative catch levels.

Growth of Arctic Char:

Prior to stocking, different cohorts of Arctic char were measured and marked with fin clips and Floy anchor tags at Clear Hatchery. Because growth rates of Arctic char were shown to be dependent on the length of the fish at marking (Buklis 1978), growth data were grouped into 25 mm length categories based on fork-length at time of marking. Growth was subsequently estimated as follows:

$$G_{ji} = \frac{L(t_{rji}) - L(t_{mji})}{(t_{rji} - t_{mji})} \qquad (5)$$

where: G_{ji} = growth in mm/day of the i^{th} fish in the j^{th} length category;

$L(t_{rji})$ = fork length at time of recapture of the i^{th} fish in the j^{th} length class;

$L(t_{mji})$ = fork length at time of marking of the i^{th} fish in the j^{th} length class;

t_{mji} = time of marking in days, and of the i^{th} fish in the j^{th} length category;

t_{rji} = time of recapture in days of the i^{th} fish in the j^{th} length category.

Results

Catches of stocked species in 1993 were: 63 Arctic char, 1 rainbow trout, 0 Arctic grayling, and 3 kokanee (Table 21; Figure 9). Catches of naturally reproducing species were: 92 northern pike, 15 burbot, 29 lake trout, and 289 least cisco. Fishing effort totaled 32, 24-hour periods with Fyke nets in the littoral zone, 32, 24-hour periods with gill nets in the benthic zone, and 48, 24-hour periods with gill nets in the pelagic zone. For stocked and resident species combined, 69 fish were captured in the littoral zone, 64 fish were captured in the benthic zone, and 383 fish were captured in the pelagic zone (Table 21). Length frequency distributions of captured fish are shown in Figure 10a and 10b.

Arctic Char:

One Arctic char was captured in the littoral zone, 43 were caught in the benthic zone, and 9 were caught in the pelagic zone (Table 21). The median CPUE (and range) for: (1) the littoral zone was 0 (0 to 1); (2) the benthic zone was 1 (0 to 6); and, (3) the pelagic zone was 0 (0 to 2; Table 22). Relative abundance in the littoral, benthic, and pelagic zones were rated sparse for all zones (Table 22; Appendix F).

During 1993, two of the captured Arctic char were missing the adipose fin (Table 23, Appendix D). Arctic char released in 1988 and 1990 were marked by removing the adipose fin prior to stocking.

Rainbow Trout:

One rainbow trout was captured in the littoral zone (Table 21). The stocking cohort was not determined because the fish had no marks. The length was 305 mm. Relative abundance was rated sparse (Table 22; Appendix F).

Arctic Grayling:

No Arctic grayling were captured during this study or any other study in Harding Lake in 1993 (Table 21).

Northern Pike:

Fifty one northern pike were captured in the littoral zone, 39 were captured in the benthic zone, and 2 were captured in the pelagic zone (Table 21). The median CPUE (and range) for: (1) the littoral zone was 0 (0 to 8); (2) the

Table 21. Total catch by species, size, and zone while test netting Harding Lake during August-September 1993.

Species	Fork Length (mm)	Number of Fish Caught						
		Zone[a]						
			Benthic					
		Littoral	10 m	15 m	21 m	27 m	Pelagic	Total
Arctic char	< 200	0	0	0	0	2	1	3
	≥ 200	1	3	10	11	17	8	50
Arctic grayling	< 200	0	0	0	0	0	0	0
	≥ 200	0	0	0	0	0	0	0
Lake trout	< 300	0	1	5	1	7	0	14
	≥ 300	0	2	0	7	6	0	15
Least cisco	All	0	3	5	26	230	25	289
Northern pike	< 300	14	1	0	0	0	0	15
	≥ 300	37	34	4	0	0	2	77
Rainbow trout	< 200	0	0	0	0	0	0	0
	≥ 200	1	0	0	0	0	0	1
Burbot	< 300	1	0	0	0	0	1	2
	≥ 300	0	0	0	0	6	7	13
Kokanee	< 200	0	0	0	0	0	0	0
	≥ 200	2	1	0	0	0	0	3
Zone Total		58	43	24	45	268	44	482
Number of net-nights		32	8	8	8	8	48	112

[a] The littoral zone consisted of near-shore water less than 10 m deep and fishing gear was Fyke trap; the benthic zone consisted of water within 2 m of the bottom at depths listed and fishing gear was 40 m by 2 m, variable mesh, sinking gill-net; and, the pelagic zone consisted of the entire water column at depths over 30 m and fishing gear were six vertical gill-nets composed of 3 m by 30 m panels, each of a different mesh size.

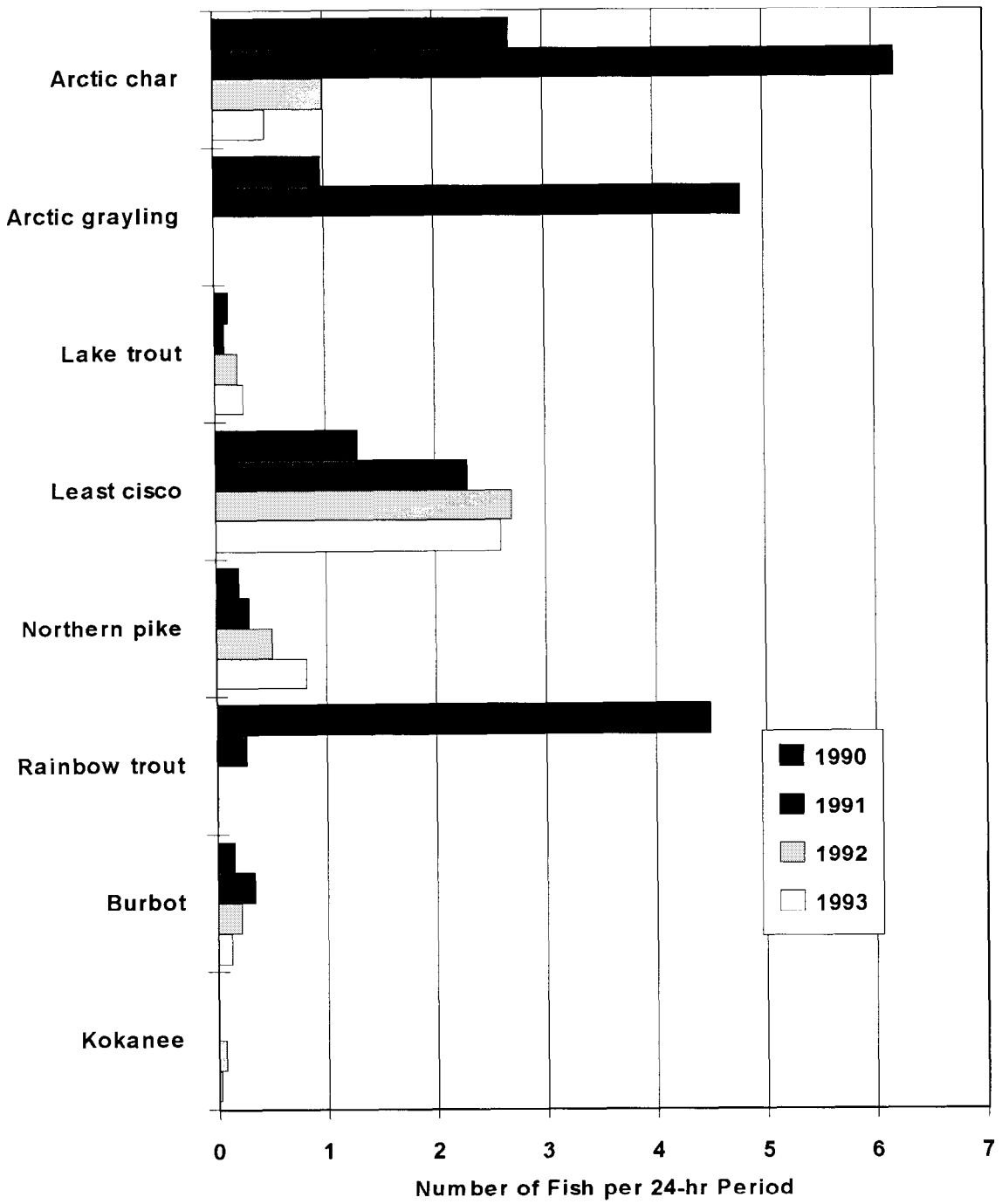
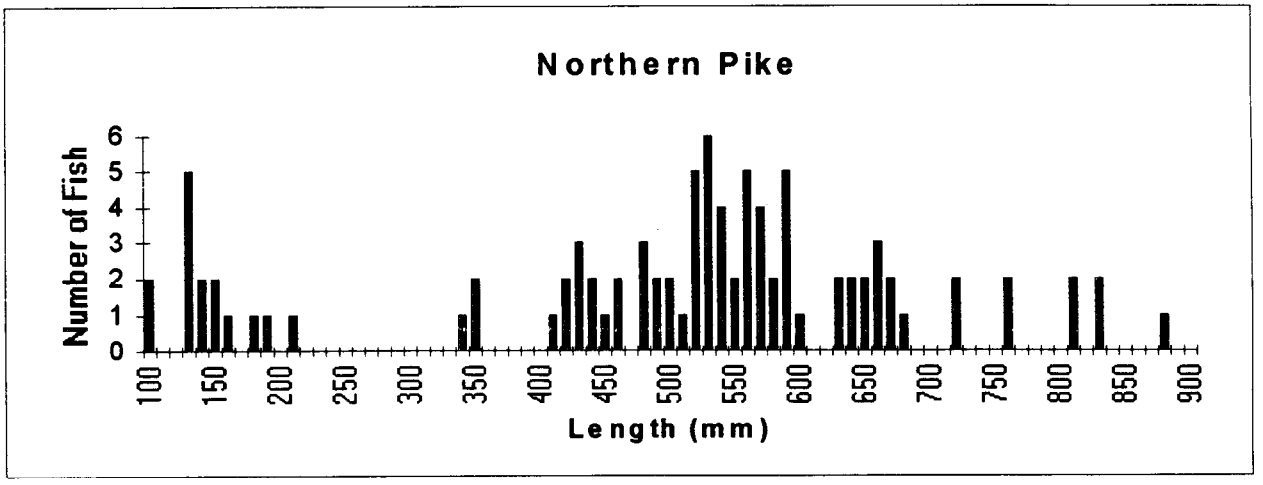
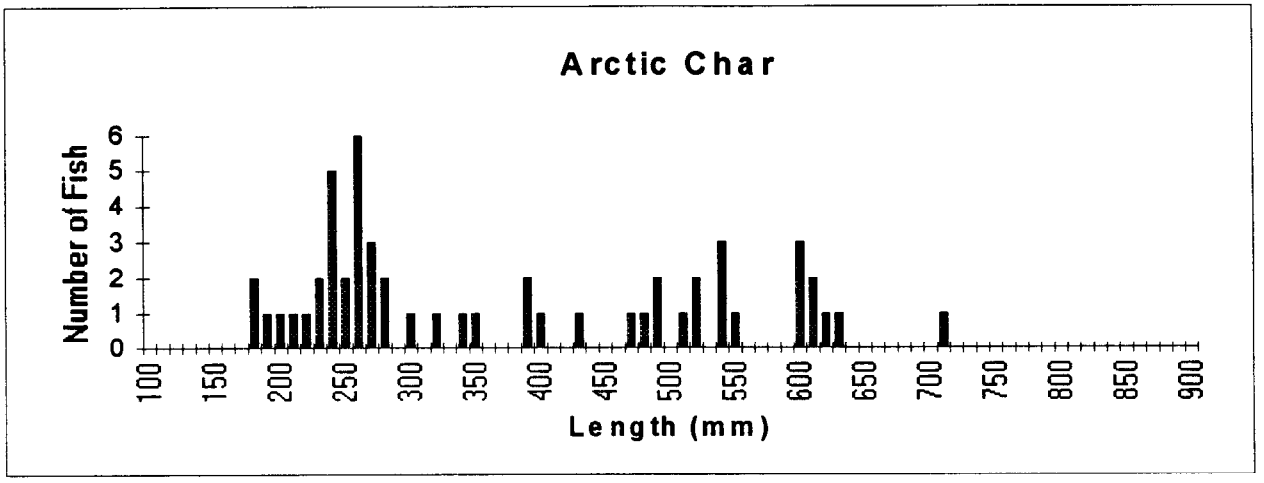


Figure 9. Catch per unit effort from all zones and gear types for each species caught while test netting Harding Lake during September 1990, September 1991, August-September 1992, and August-September 1993. Effort in 1990 was 56 periods, 1991 was 112 periods, 1992 was 112 periods, and 1993 was 112 periods.





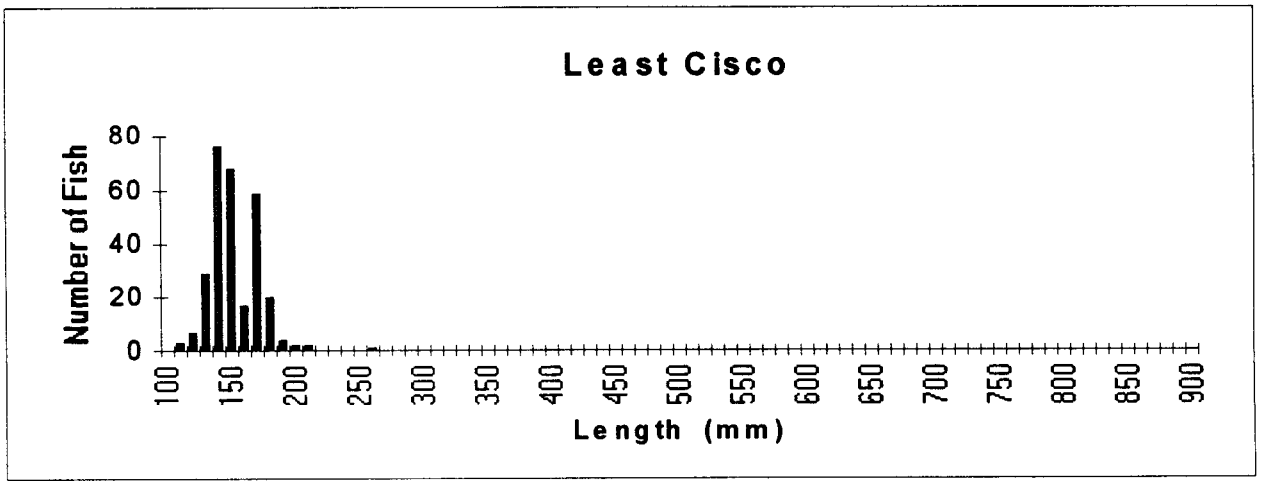
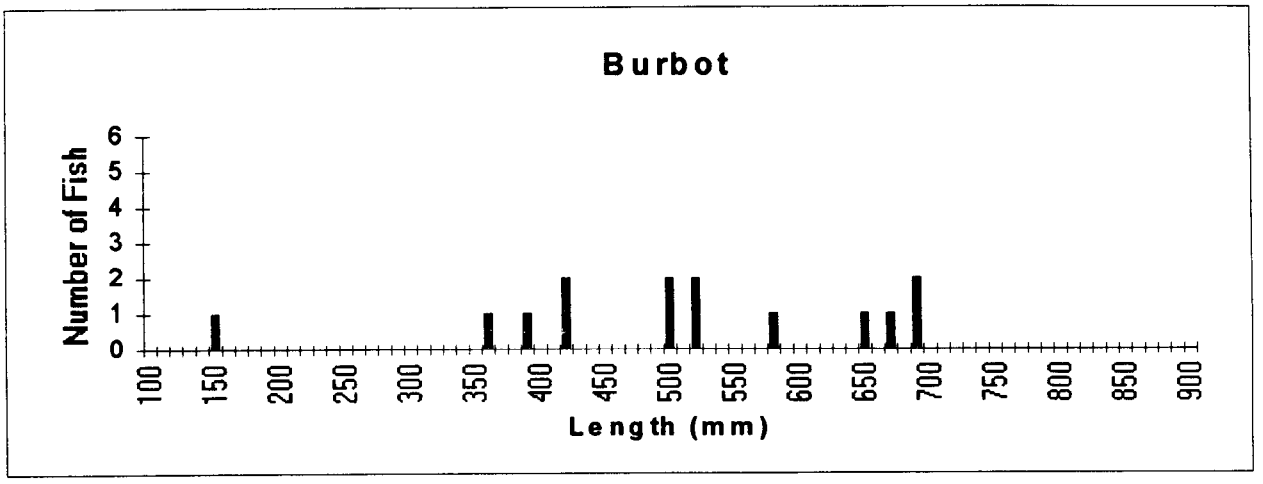
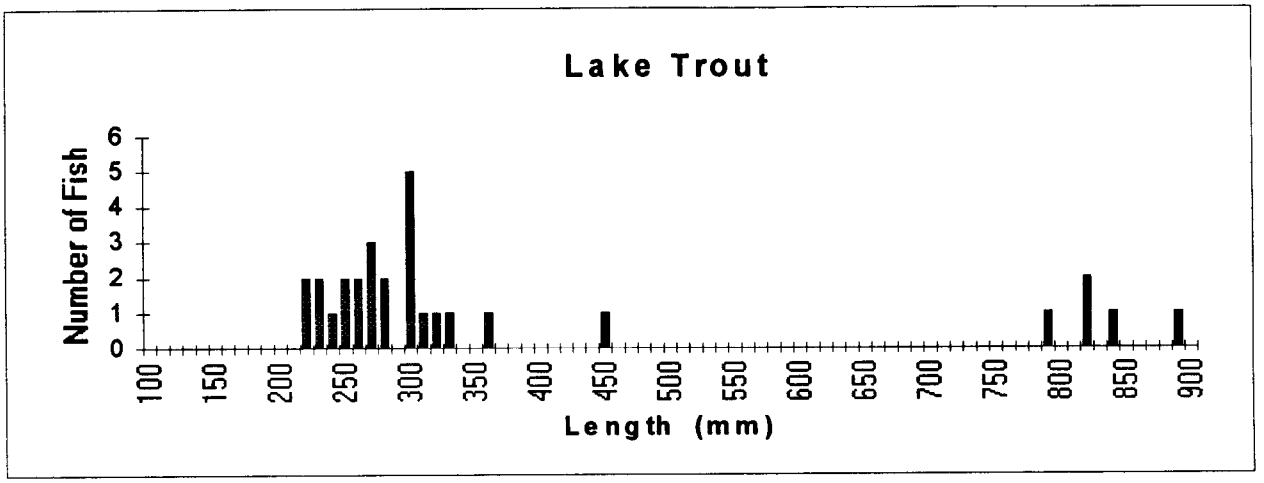


Figure 10a. Number of fish captured by length category, Harding Lake, 1993.





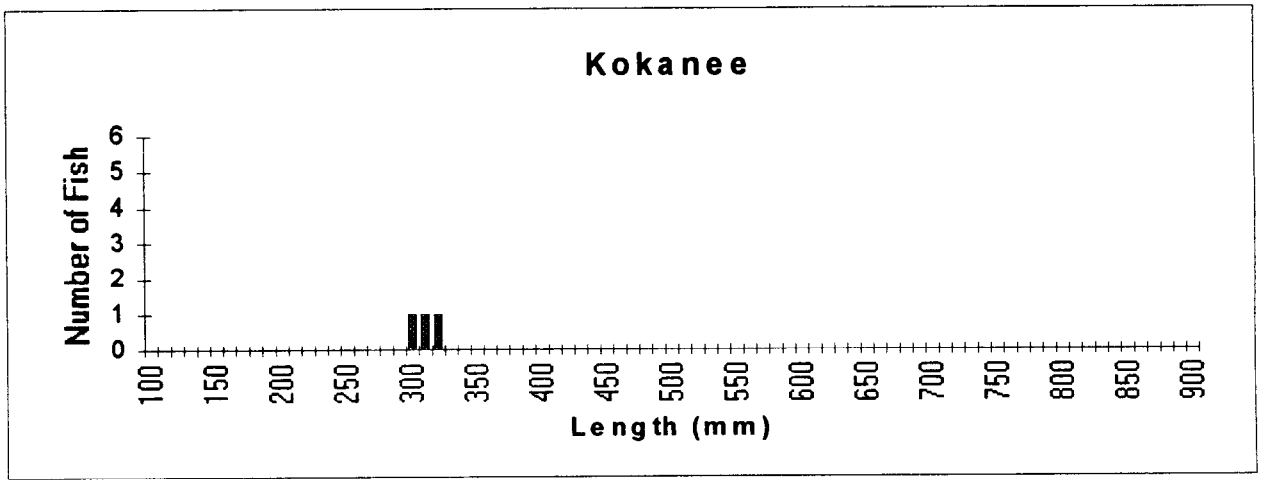


Figure 10b. Number of fish captured by length category, Harding Lake, 1993.

Table 22. Minimum, maximum, and median catches of fish per 24-hour period by zone and designated level of abundance, Harding Lake, August-September 1993.

Species	Zone[a]	Catch per period				Designated Abundance[b]
		Minimum	Maximum	Median	95% C.I.	
Arctic Char	Littoral	0	1	0	0 - 0	Sparse
	Benthic	0	6	1	0 - 2	Sparse
	Pelagic	0	2	0	0 - 0	Sparse
Arctic Grayling	Littoral	0	0	0	0 - 0	
	Benthic	0	0	0	0 - 0	
	Pelagic	0	0	0	0 - 0	
Lake Trout	Littoral	0	0	0	0 - 0	Sparse
	Benthic	0	5	1	0 - 1	Sparse
	Pelagic	0	0	0	0 - 0	Sparse
Least Cisco	Littoral	0	0	0	0 - 0	Sparse
	Benthic	0	48	3	0 - 7	Sparse
	Pelagic	0	5	0	0 - 0	Moderate
Northern Pike	Littoral	0	8	1	0 - 1	Sparse
	Benthic	0	9	0	0 - 2	Sparse
	Pelagic	0	1	0	0 - 0	Sparse
Rainbow Trout	Littoral	0	1	0	0 - 0	
	Benthic	0	0	0	0 - 0	
	Pelagic	0	0	0	0 - 0	
Burbot	Littoral	0	1	0	0 - 0	Sparse
	Benthic	0	2	0	0 - 0	Sparse
	Pelagic	0	1	0	0 - 0	Sparse
Kokanee	Littoral	0	1	0	0 - 0	Sparse
	Benthic	0	1	0	0 - 0	Sparse
	Pelagic	0	0	0	0 - 0	Sparse

[a] The littoral zone consisted of near-shore water less than 10 m deep and fishing gear was Fyke traps; the benthic zone consisted of water within 2 m of the bottom at depths listed and fishing gear was 40 m by 2 m, variable mesh, sinking gill-nets; and, the pelagic zone consisted of the entire water column at depths over 30 m and fishing gear was six vertical gill-nets composed of 3 m by 30 m panels, each of a different mesh size.

[b] Criteria used to develop these abundance designations are in Appendix C.

Table 23. Summary of fish captured from each marked cohort of Arctic char stocked into Harding Lake, 1988-1993.

	Mean Length when Marked (Prior to Stocking)					
Stocking Date:	11/1/88	02/8/89	5/22/89	3/22/90	8/23/90	5/30/91
Mean Length:	165 mm	210 mm	322 mm	339 mm	121 mm	369 mm
Number Stocked:	10,799	8,391	1,909	1,304	7,500/50,000	1,556
Type of Mark:	AD Clip	RV Clip	Green Tag	Blue Tag	AD Clip	Blue Tag
Sampling Event:						
1989						
Summer Netting	3	14 (253 mm)	6 (352 mm)	0	0	0
Hook & Line	2 (256 mm)	14 (266 mm)	44 (363 mm)	0	0	0
1990						
Winter Creel	0	8 (286 mm)	0	0	0	0
Summer Netting	3 (327 mm)	4 (350 mm)	10 (395 mm)	8 (382 mm)	2 (119 mm)	0
Hook & Line	0	1 (375 mm)	5 (392 mm)	2 (422 mm)	2 (146 mm)	0
1991						
Spring Netting	2 (360 mm)	1 (392 mm)	1 (452 mm)	0	0	1 (350 mm)
Summer Netting	7 (382 mm)	3 (402 mm)	3 (473 mm)	1 (374 mm)	0	27 (383 mm)
Hook & Line	0	0	7 (466 mm)	0	0	100
1992						
Spring Netting	1 (443 mm)	0	0	0	0	0
Summer Netting	2 (449 mm)	3 (514 mm)	4 (532 mm)	0	0	0
Hook & Line	0	0	0	0	0	4 (388 mm)
1993						
Spring Netting	0	0	0	0	0	0
Summer Netting	2 (567 mm)	0	0	0	0	0
Hook & Line	0	0	0	0	0	0

AD = Adipose fin clip, RV = Right ventral fin clip.

benthic zone was 0 (0 to 9); and, (3) the pelagic zone was 0 (0 to 1; Table 22). Relative abundance was rated sparse in all zones (Table 22; Appendix F).

Burbot:

One burbot was captured in the littoral zone, 6 were captured in the benthic zone, and 8 were captured in the pelagic zone (Table 21). The median CPUE (and range) for: (1) the littoral zone was 0 (0 to 1); (2) the benthic zone was 0 (0 to 2); and, (3) the pelagic zone was 0 (0 to 1; Table 22). Relative abundance was rated sparse in all zones (Table 22; Appendix F).

Lake Trout:

No lake trout were captured in the littoral zone, 29 were captured in the benthic zone, and none were captured in the pelagic zone (Table 21). The median CPUE (and range) for: (1) the littoral zone was 0 (0 to 0); (2) the benthic zone was 1 (0 to 5); and, (3) the pelagic zone was 0 (0 to 0; Table 22). Relative abundance was rated sparse in all zones (Table 22; Appendix F).

Least Cisco:

No least cisco were captured in the littoral zone, 289 were captured in the benthic zone, and 25 were captured in the pelagic zone (Table 21). Catches generally increased with depth in the benthic zone. The median CPUE (and range) for: (1) the littoral zone was 0 (0 to 0); (2) the benthic zone was 3 (0 to 48); and, (3) the pelagic zone was 0 (0 to 5; Table 22). Relative abundance was rated sparse in all zones (Table 22; Appendix F).

Kokanee:

Two kokanee were captured in the littoral zone, 1 was captured in the benthic zone, and none were captured in the pelagic zone (Table 21). The median CPUE (and range) for: (1) the littoral zone was 0 (0 to 1); and, (2) the benthic zone was 0 (0 to 1; Table 22). Relative abundance was rated sparse in all zones (Table 22; Appendix F using criteria for Arctic char). The kokanee were from the same size cohort (Figure 10b).

Growth of Arctic Char:

Lengths of Arctic char captured at Harding Lake during August-September 1993 ranged from 184 to 710 mm (4.9 kg). The length frequency distribution was bi-modal; the mode for the larger fish was between 520 to 600 mm and the mode for the smaller fish was about 260 mm (Figure 10a).

Growth and growth rate were determined for four Arctic char that were captured in 1992 and again in 1993 and for two Arctic char that were stocked in 1988 and captured in 1993 (Tables 23 and 24). The fish captured in 1992 were marked with yellow Floy tags and could be individually identified. Three hundred sixty-two to 365 days had passed from the time of tagging in 1992 to

Table 24. Growth and growth rate of Arctic char captured in Harding Lake, 1993.

Tag Number	Sex	Color	Date Stocked	Length (mm)	Date Captured	Length (mm)	Days	Growth (mm)	Growth Rate
3	F	Green	9-Mar-89	304	25-Aug-92	508	1,265	204	0.16
933	F	Green	9-Mar-89	325	28-Aug-92	545	1,268	220	0.17
88660	F	Green	9-Mar-89	320	4-Sep-92	505	1,275	185	0.15
89552	M	Green	9-Mar-89	300	25-Aug-92	546	1,265	246	0.19
69411	ND[b]	Blue	30-May-91	375	15-Nov-92	405	535	30	0.056
68312	ND[b]	Blue	30-May-91	320	15-Nov-92	370	535	50	0.093
Adipose fin clip:									
	ND[b]		11-Jan-88	165[c]	24-Aug-93	610	2,052	445	0.22
	ND[b]		11-Jan-88	165[c]	31-Aug-93	524	2,059	359	0.17
Marked during a prior study:[e]									
924	ND	Yellow	27-Aug-92	495[d]	24-Aug-93	550	362	55	0.15
903	ND	Yellow	25-Aug-92	451[d]	24-Aug-93	485	364	34	0.093
917	ND	Yellow	26-Aug-92	525[d]	25-Aug-93	625	364	100	0.27
951	ND	Yellow	2-Sep-92	512[d]	2-Sep-93	540	365	28	0.077

[a] Growth rate = mm/day.
[b] Sex could not be determined.
[c] Mean length of the cohort when stocked.
[d] Size when first captured and marked.
[e] The date stocked is the date these fish were captured and marked during a prior study.

recapture in 1993. Growth ranged from 28 to 100 mm and the growth rate ranged from 0.08 to 0.27 mm per day. The two Arctic char captured in 1993 that were marked with adipose fin clips could not be individually identified. The cohort that these two fish were from was stocked on 1 November 1988. The average length of the cohort was 165 mm when stocked. When captured in gill nets in August-September 1993 these fish were 524 and 610 mm and had spent 2,059 and 2,052 days, respectively, in the lake. The respective growths (determined from the average size when stocked) were 359 and 445 mm and the growth rates were 0.17 and 0.22 mm per day.

Discussion

Catches of each stocked and resident species were usually highest in one or two of the limnological zones. Arctic char, burbot, and least cisco were captured in greatest numbers in the pelagic and benthic zones. Northern pike and kokanee were captured most often in the littoral and shallow benthic zones. Lake trout were captured only in the benthic zone. Catch rates in the different limnological zones were probably an indicator of habitat preference of each species during August-September.

This is the second year that kokanee older than age 2 were captured. Kokanee were stocked in Harding Lake in 1988, 1989, and 1990 (Appendix E). Juvenile kokanee were captured in a tow-net in 1988, 1989, and 1990 (Clark and Doxey 1988; Clark 1991). During the same period no kokanee were captured in gill nets or Fyke nets (Viavant and Clark 1991a; Viavant 1992). The kokanee captured this year were probably attempting to spawn. The kokanee is usually a pelagic, plankton feeder and is not usually found in shallow near-shore water except when spawning. In Canadian lakes, kokanee spawn in the fall and on gravel beds along shore. Generally, kokanee spawn at age 4. Kokanee stocked in 1989 were age 4 in 1993. These fish did not produce eggs or milt when squeezed slightly.

The CPUE for Arctic char was less in 1993 compared to the CPUEs in 1990, 1991 and 1992 (Figure 9). The larger CPUEs in 1990 and 1991 were probably due to stocking Arctic char within a few weeks of starting the study. These stockings were reflected in the size composition of the catch in 1991 (Viavant 1992). Small Arctic char were stocked in the fall of 1990 and 1991 and small Arctic char comprised a large proportion of the catch in 1990 and 1991. In 1992 and 1993 Arctic char were stocked after the study ended and small Arctic char made up a smaller portion of the catch.

The number of Arctic char that were marked at Clear Hatchery with Floy tags and released as adults (> 200 mm) and then captured in gill nets has continued to decrease each year. Compared to other stocking cohorts, few of these large fish were stocked and their decreasing contribution to catches in gill nets was probably the result of harvest by anglers. When stocking was initiated, large and small Arctic char were stocked but the small Arctic char were probably too small to initially contribute to the fishery.

The largest Arctic char captured in gill nets in 1992 were not marked and did not have deformed fins. The same was true in 1993 except two of the large

Arctic char were marked with adipose fin clips. A portion of the fish stocked in 1988 were marked by removing the adipose fin. All of these fish were probably stocked at less than 200 mm in 1988 or 1989. The presence of these large unmarked Arctic char in gill nets indicates that the cohorts of Arctic char that were stocked at less than 200 mm have grown and entered the fishery.

Arctic grayling and rainbow trout were captured in nets in 1990 and 1991 but no Arctic grayling were captured and only three rainbow trout were captured in 1992 during another study and only one rainbow trout was captured in 1993. Catches in 1990 and 1991 were probably influenced by stocking both species within a few weeks of starting the study. Size at the time of stocking for both species ranged from fingerlings to adults. These results indicate that survival of stocked Arctic grayling and rainbow trout was probably very low and size at the time of stocking probably did not influence survival because survival was poor for all size cohorts. In the statewide harvest survey more rainbow trout than Arctic char, lake trout, or burbot were estimated to have been harvested in prior years (Mills 1987-1993). However, catches of these species in nets from 1990 to 1992 and catches during a hook and line study (Viavant and Clark 1991b) indicate that the relative abundance and harvest of rainbow trout is less than the other species. Anglers probably caught rainbow trout immediately after stocking but few rainbow trout survived to the second year.

Catches of resident northern pike and lake trout increased slightly compared to catches for 1990 through 1992. Catches of least cisco were slightly lower compared to 1992. Catches of burbot were the lowest reported for 1990 through 1992. In spring 1992, Skaugstad and Burkholder (1992) found that the abundance of northern pike in Harding Lake had increased and the increase was due mainly to more small fish in the population. The increased catch of northern pike may be the result of an increase in the number of northern pike in the lake.

The number of lake trout and least cisco captured for 1990-1993 suggest that the abundances of both species have been increasing. However, the abundance of lake trout has never been estimated so there are no data to compare with. From 1988-1990 the catches of least cisco in gillnets generally increased (Clark and Doxey 1988; Clark 1991). These two studies suggest that the abundance of least cisco was probably increasing during 1988-1993.

ASSESSMENT OF FISHERY MANAGEMENT OBJECTIVES

Methods

Fishery management objectives were obtained from the Fishery Management Plans (FMP) for Birch, Quartz, Chena, and Harding lakes (ADF&G 1993). The number of annual angler days (a measure of fishing effort) and the total catch of game fish from each lake were obtained from an annual mail survey to estimate sport fishing participation and harvests in Alaska (Mills 1993).

Stocking costs were obtained from an audit of production and financial records from Clear Hatchery, Ft. Richardson Hatchery, and Big Lake Hatchery. Data requested from the hatcheries were: total operating budget (by hatchery), total weight of fish produced (by hatchery), the average weight of each released cohort (by hatchery and species), and the number of fish of a given cohort stocked (by hatchery, species, and stocking location). Annual stocking costs were then calculated for each lake, species, and size cohort (*i.e.* sac fry, fingerlings, subcatchables, and catchables) as:

$$c_i = \frac{c_t(n_i \overline{w}_i)}{\sum_{i=1}^{t} n_i \overline{w}_i} \qquad (6)$$

where:

c_t = annual hatchery operating cost;

n_i = number of fish stocked in size cohort i;

$\overline{w}_i$ = average weight of fish stocked in size cohort i; and,

c_i = cost of fish stocked in size cohort i.

Fish stockings were based on a calendar year (CY 1992 = 1 January 1992 through 31 December 1992). Operating budgets were based on a fiscal year (FY 1992 = 1 July 1991 through 30 June 1992). To estimate stocking costs for CY 1992, the operating budget for Clear Hatchery during CY 1992 was calculated as the average of the operating budgets for FY 1992 and FY 1993. The stocking cost for each lake in 1992 was then calculated as the sum of costs for all size cohorts for all species stocked in each lake. These statistics were then compared to the fishery management objectives.

Results

The relevant fishery statistics (angler-days and harvest) and stocking costs for 1992 that were used to evaluate the progress toward achieving the management objectives are summarized in Table 25. Stocking records and stocking costs by species and lake are listed in Appendix A and these data are summarized in Table 26. Hatchery operation costs, total weight of fish produced, and cost per kilogram of fish produced are summarized in Table 27.

Birch Lake:

In 1992 there were 10,072 angler days of fishing effort and 12,855 fish (all species) harvested at Birch Lake (Table 25). The mean harvest rate was 1.28 fish per angler day of effort, the stocking cost was $48,140, and the cost per angler day was $4.78 (Tables 25 and 26). The management objectives for Birch Lake are 15,000 angler days of fishing effort, a mean harvest rate of two fish per angler day, and a cost per angler day of no more than $2.00 (Table 25).

Table 25. Summary of objectives from the Fishery Management Plans and statistics from the fisheries in 1992.

Management Plan	Actual	Objective
Birch Lake:		
Angler days	10,072	15,000
Harvest	12,855	
Mean harvest rate	1.28	2
Stocking cost	$48,155	
Cost per angler day	$4.78	$2.00
Quartz Lake:		
Angler days	13,486	20,000
Harvest	20,597	
Mean harvest rate	1.53	2
Stocking cost	$41,085	
Cost per angler day	$3.05	$2.50
Chena Lake:		
Angler days	6,007	10,000
Harvest	5,829	
Mean harvest rate	0.97	2
Stocking cost	$73,585	
Cost per angler day	$12.25	$2.00
Harding Lake:		
Angler days	5,068	maintain current level
Harvest	2,643	
Mean harvest rate	0.52	maintain current level
Stocking cost	$291,245	
Cost per angler day	$57.47	$3.00

Table 26. Cost of stocking game fish in Birch Lake, Quartz Lake, Chena Lake, and Harding Lake by hatchery, 1992.

Lake	Number Stocked	Total Weigh (k)	Cost per Kilogram	Stocking Cost
Birch Lake:				
Clear Hatchery	380,788	1,082	$28.61	$30,973
Ft. Richardson Hatchery	24,494	735	$23.38	$17,182
				$48,155
Quartz Lake:				
Clear Hatchery	30,000	300	$28.61	$8,584
Ft. Richardson Hatchery	426,576	1,390	$23.38	$32,501
				$41,085
Chena Lake:				
Clear Hatchery	25,000	674	$28.61	$19,286
Ft. Richardson Hatchery	20,391	1,525	$23.38	$35,653
Big Lake	10,428	188	$99.34	$18,646
				$73,585
Harding Lake:				
Clear Hatchery	920,188	8,583	$28.61	$245,609
Ft. Richardson Hatchery	19,517	1,952	$23.38	$45,636
				$291,245

Table 27. Summary of operation costs, total weight of fish produced, and cost per kilogram of fish produced by Clear Hatchery, Ft. Richardson Hatchery, and Big Lake Hatchery, 1992.

Hatchery	Statistics
Clear Hatchery:	
Operation Cost (FY 1992)[1]	$442,331
Operation Cost (FY 1993)[2]	$453,126
Operation Cost (CY 1992)	$447,728
Production weight (CY 1992)[1]	15,647 kg
Cost per kilogram	$28.61
Ft. Richardson Hatchery:	
Operation Cost (FY 92)[1]	$1,203,930
Operation Cost (FY 93)[2]	$1,135,601
Operation Cost (CY 1992)	$1,169,765
Production weight (CY 92)[1]	50,027 kg
Cost per kilogram	$23.38
Big Lake Hatchery:	
Operation Cost (FY 92)[1]	$364,935
Operation Cost (FY 93)[2]	$375,344
Operation Cost (CY 1992)	$370,139
Production weight (CY 92)[1]	3,726 kg
Cost per kilogram	$99.34

[1] *Data from* Recreational Fishery Program Maintenance of Effort 1992: FRED Division. Alaska Department of Fish and Game, P.O. Box 25526, Juneau, Alaska 99802-5526.

[2] *Data from* Recreational Fishery Program Maintenance of Effort 1993: CFMD Division. Regional Information Report No. 5J94-03. Alaska Department of Fish and Game, P.O. Box 25526, Juneau, Alaska 99802-5526.

Quartz Lake:

In 1992 there were 13,486 angler days of fishing effort and 20,597 fish (all species) harvested at Quartz Lake (Table 25). The mean harvest rate was 1.53 fish per angler day of effort, the stocking cost was $41,081, and the cost per angler day was $3.05 (Tables 25 and 26). The management objectives for Quartz Lake are 20,000 angler days of fishing effort, a mean harvest rate of two fish per angler day, and a cost per angler day of no more than $2.50 (Table 25).

Chena Lake:

In 1992 there were 6,007 angler days of fishing effort and 5,829 fish (all species) harvested at Chena Lake (Table 25). The mean harvest rate was 0.97 fish per angler day of effort, the stocking cost was $73,613, and the cost per angler day was $12.25 (Tables 25 and 26). The management objectives for Chena Lake are 10,000 angler days of fishing effort, a mean harvest rate of two fish per angler day, and a cost per angler day of no more than $2.00 (Table 25).

Harding Lake:

In 1992 there were 5,068 angler days of fishing effort and 2,643 fish (all species) harvested at Harding Lake (Table 25). The harvest includes resident lake trout. burbot, and northern pike. The mean harvest rate was 0.52 fish per angler day of effort, the stocking cost was $291,198, and the cost per angler day was $57.46 (Tables 25 and 26). The management objectives for Harding Lake are to maintain the current level of angler days of fishing effort and mean harvest rate, and a cost per angler day of no more than $2.00 (Table 25).

Discussion

None of the management objectives were achieved for any of the fisheries in these four lakes in 1992. ADF&G did not anticipate meeting these objectives in just one year. Changes made to the stocking program in 1993, such as reducing the number of fish stocked, should reduce stocking costs and in turn reduce the cost per angler day of fishing effort. The high stocking costs for Harding Lake in 1992 was the result of ADF&G's effort to develop fisheries for rainbow trout, Arctic char, and Arctic grayling in the lake. ADF&G conducted experiments to determine if fish survival was dependent on the size of the fish when stocked. Prior to 1992, ADF&G adopted a strategy for Harding Lake of stocking different sizes of each species to: 1) create an instant fishery by stocking catchable size fish, and 2) determine if these fisheries could be maintained using smaller fish which cost less to produce. ADF&G evaluated these fisheries and determined that stocking small rainbow trout and Arctic grayling would not maintain a fishery due to poor survival. Stocking catchable size rainbow trout to maintain a fishery would cost much more per angler day of effort compared to costs for other lakes. ADF&G stopped stocking rainbow trout and Arctic grayling after 1992. The stocking of Arctic char did result in a successful fishery. An instant fishery was started by stocking catchable size Arctic char. Evaluation of the stocking strategy suggested that the rate of survival for Arctic char stocked at a smaller size

was sufficient to maintain the fishery. Most of the Arctic char stocked at a small size were not marked and growth rate could not be estimated for individuals. However, unmarked Arctic char captured during sampling in 1992 and 1993 indicates that these fish have grown to catchable size. As a result, ADF&G stopped stocking the more expensive catchable size Arctic char and reduced the number of smaller Arctic char stocked in Harding Lake. In 1993, only 10,000 Arctic char were stocked and the total stocking cost for Harding Lake was $1,060. These actions will greatly reduce the cost per angler day.

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APPENDIX A

Appendix A. Stocking histories for Birch Lake, Chena Lake, Quartz Lake, and Harding Lake, 1990-1993.

Stocking Location	Species	Date	Number Stocked	Average Weight (g)	Stocking Cost
Birch Lake:	Arctic char	19-Jul-91	13,365	11.03	$4,249
	Arctic char	23-Jul-91	5,235	11.06	$1,669
	Arctic char	1-Sep-92	15,327	58	$25,437
	Arctic grayling	16-Sep-91	40,000	4.93	$5,684
	Arctic grayling	17-Jun-92	318,000	0.02	$182
	Arctic grayling	18-Sep-92	20,000	4	$2,289
	Arctic grayling	22-Sep-92	23,936	3.9	$2,671
	Arctic grayling	25-Sep-92	3,525	3.9	$393
	Arctic grayling	16-Sep-93	20,000	4.15	$2,405
	Chinook Salmon	7-Oct-93	12,861	67.6	$19,735
	Coho salmon	16-Jul-90	26,000	2.7	$1,805
	Coho salmon	19-Jul-90	105,000	2.7	$7,290
	Coho salmon	11-Jul-91	40,303	0.99	$3,878
	Coho salmon	24-Jun-93	79,800	0.823	$6,616
	Rainbow trout	7-Jun-90	48,345	22.9	$18,681
	Rainbow trout	4-Jun-91	25,153	22.9	$13,875
	Rainbow trout	10-Jun-92	24,494	30	$17,182
	Rainbow trout	17-May-93	12,256	72.4	$20,142
	Rainbow trout	20-May-93	15,956	59	$21,370
Chena Lake:	Arctic char	30-May-91	330	738	$7,020
	Arctic char	30-May-91	250	761	$5,484
	Arctic char	3-Jun-91	364	761	$7,984
	Arctic char	3-Jun-91	36	2,134	$2,214
	Arctic char	10-Sep-91	16,900	35.6	$17,341
	Arctic char	2-Sep-92	10,000	62	$17,741
	Arctic char	16-Sep-93	6,000	106	$18,426
	Arctic grayling	16-Sep-91	13,000	4.93	$1,847
	Arctic grayling	20-Sep-92	15,000	3.6	$1,545
	Arctic grayling	15-Sep-93	15,000	4.15	$1,803
	Chinook Salmon	4-Oct-93	2,584	67.6	$3,965
	Chinook Salmon	7-Oct-93	2,625	67.6	$4,028
	Coho salmon	11-Jul-91	16,364	0.99	$1,575
	Coho salmon	18-Sep-92	10,428	18	$18,646
	Coho salmon	24-Jun-93	30,000	0.887	$2,681
	Rainbow trout	4-Jun-90	23,092	97.1	$37,836
	Rainbow trout	12-Jul-90	8,159	107	$14,731
	Rainbow trout	17-Jun-91	16,010	96.8	$37,331
	Rainbow trout	15-Jul-91	10,966	109	$28,792
	Rainbow trout	10-Jun-92	10,367	30	$7,272
	Rainbow trout	17-Jun-92	9,424	123	$27,104
	Rainbow trout	25-Jun-92	600	91	$1,277
	Rainbow trout	20-May-93	14,639	79.2	$26,318
	Rainbow trout	2-Sep-93	1,500	107	$3,643

-continued-

Appendix A. (Page 2 of 3).

Stocking Location	Species	Date	Number Stocked	Average Weight (g)	Stocking Cost
Quartz Lake:	Arctic char	16-Jul-91	75,000	10.55	$22,807
	Arctic char	19-Jun-92	30,000	10	$8,584
	Chinook Salmon	4-Oct-93	12,568	67.6	$19,286
	Coho salmon	16-Jul-90	52,000	2.7	$3,610
	Coho salmon	17-Jul-90	98,000	2.7	$6,804
	Coho salmon	8-Jul-91	105,825	1.03	$10,594
	Coho salmon	11-Jul-91	45,960	0.99	$4,422
	Coho salmon	24-Jun-93	160,600	0.803	$12,991
	Rainbow trout	7-Jun-90	33,843	22.9	$13,078
	Rainbow trout	19-Jul-90	150,632	1.2	$3,050
	Rainbow trout	12-Sep-90	52,914	2.4	$2,143
	Rainbow trout	17-May-91	25,005	20.3	$12,227
	Rainbow trout	17-Jun-91	17,711	24.9	$10,623
	Rainbow trout	31-Jul-91	152,000	2	$7,323
	Rainbow trout	10-Jun-92	25,967	30	$18,215
	Rainbow trout	16-Jul-92	325,563	1.6	$12,180
	Rainbow trout	22-Jul-92	75,046	1.2	$2,106
	Rainbow trout	22-Jul-93	203,858	1.37	$6,340
	Rainbow trout	27-Jul-93	217,043	1.3	$6,405
Harding Lake:	Arctic char	21-Mar-90	437	653.5	$21,882
	Arctic char	22-Mar-90	438	653.5	$21,932
	Arctic char	23-Mar-90	437	653.5	$21,882
	Arctic char	18-Jun-90	40,000	6.05	$18,543
	Arctic char	21-Jun-90	10,000	5.66	$4,337
	Arctic char	28-Aug-90	49,900	20.08	$76,775
	Arctic char	29-Aug-90	20,614	35.2	$55,598
	Arctic char	31-Aug-90	15,159	35.9	$41,699
	Arctic char	19-Sep-90	11,230	56.6	$48,703
	Arctic char	20-Sep-90	7,331	50.1	$28,142
	Arctic char	29-May-91	1,044	761	$22,900
	Arctic char	30-May-91	522	761	$11,450
	Arctic char	18-Jul-91	49,296	11.06	$15,715
	Arctic char	19-Jul-91	49,095	11.03	$15,608
	Arctic char	23-Jul-91	7,659	11.06	$2,442
	Arctic char	21-Aug-91	22,967	31.59	$20,912
	Arctic char	22-Aug-91	24,030	34.6	$23,965
	Arctic char	23-Aug-91	20,452	35.36	$20,845
	Arctic char	3-Sep-91	22,888	43.6	$28,764
	Arctic char	4-Sep-91	23,386	42.67	$28,762
	Arctic char	5-Sep-91	7,992	42	$9,675
	Arctic char	9-Sep-91	29,967	33.3	$28,763
	Arctic char	10-Sep-91	7,010	35.6	$7,193
	Arctic char	11-Sep-91	12,684	40.73	$14,891
	Arctic char	16-Jun-92	60,603	9	$15,607
	Arctic char	17-Jun-92	60,603	9	$15,607
	Arctic char	18-Jun-92	60,000	9	$15,452

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Appendix A. (Page 3 of 3).

Stocking Location	Species	Date	Number Stocked	Average Weight (g)	Stocking Cost
Harding Lake:	Arctic char	19-Jun-92	8,928	10	$2,555
	Arctic char	23-Jun-92	11,190	9	$2,882
	Arctic char	8-Sep-92	17,836	56	$28,580
	Arctic char	9-Sep-92	16,012	63	$28,865
	Arctic char	10-Sep-92	18,412	56	$29,503
	Arctic char	11-Sep-92	17,627	54	$27,237
	Arctic char	29-Sep-92	17,408	60	$29,887
	Arctic char	30-Sep-92	16,614	64	$30,426
	Arctic char	1-Oct-92	10,692	61	$18,663
	Arctic char	15-Sep-93	7,500	106	$23,033
	Arctic char	16-Sep-93	2,500	106	$7,678
	Arctic grayling	7-Jun-90	54,200	0.017	$71
	Arctic grayling	3-Jul-90	30,000	0.246	$565
	Arctic grayling	1-Aug-90	30,000	1.78	$4,092
	Arctic grayling	26-Aug-90	2,400	3.21	$590
	Arctic grayling	27-Aug-90	29,972	5.21	$11,965
	Arctic grayling	28-May-91	160	117	$540
	Arctic grayling	7-Jun-91	322,178	0.016	$149
	Arctic grayling	10-Jun-91	375,000	0.016	$173
	Arctic grayling	16-Sep-91	20,000	4.93	$2,842
	Arctic grayling	23-Sep-91	23,397	5.63	$3,797
	Arctic grayling	19-Jun-92	400,000	0.02	$229
	Arctic grayling	24-Jun-92	204,263	0.02	$117
	Lake trout	14-Jun-90	30,000	4.6	$10,574
	Lake trout	21-Jun-90	43,700	4.6	$15,403
	Lake trout	26-Aug-90	71,446	10.28	$56,277
	Rainbow trout	7-Jun-90	10,061	22.9	$3,888
	Rainbow trout	27-Jun-90	103,312	1.2	$2,092
	Rainbow trout	27-Jun-90	100,000	1.29	$2,177
	Rainbow trout	19-Jul-90	2,019	105	$3,577
	Rainbow trout	24-Jul-90	150,000	1.7	$4,303
	Rainbow trout	24-Jul-90	50,000	1.7	$1,434
	Rainbow trout	24-Jul-90	50,000	1.7	$1,434
	Rainbow trout	24-Aug-90	15,000	6.89	$1,744
	Rainbow trout	24-Aug-90	84,000	6.89	$9,766
	Rainbow trout	24-Aug-90	9,961	120.6	$20,271
	Rainbow trout	26-Aug-90	7,500	3.21	$406
	Rainbow trout	26-Aug-90	42,000	3.21	$2,275
	Rainbow trout	27-Aug-90	1,019	105	$1,805
	Rainbow trout	27-Aug-90	1,000	185	$3,122
	Rainbow trout	11-Jun-91	10,530	20	$5,073
	Rainbow trout	24-Jul-91	173,800	1.7	$7,117
	Rainbow trout	19-Jun-92	19,517	100	$45,636
	Sockeye salmon	7-Jun-90	400,000	0.16	$2,502
	Sockeye salmon	7-Jun-90	505,305	0.16	$3,160
	Sockeye salmon	2-Aug-90	289	1.64	$19

APPENDIX B

Appendix B. Abundance and percent survival of rainbow trout in Quartz Lake 1986-1990. Estimates are from the date of stocking to the fall of that year.

Stocking	Abundance		Percent Survival		Stocking	
Date	$\hat{N}$	SE	$\hat{S}$	SE	Size Cohort	Size (g)
5/27/87	1,419	91	14.2	1.0	Subcatchable	28
8/26/87	28,718	3,596	7.0	2.0	Fingerling	2.3
6/02/88	13,871	1,915	28.0	4.0	Subcatchable	25
8/12/88	Combined				Fingerling	1
5/31/89	15,935	3,358			Subcatchable	26
4/24/89	2,116	754	9.2	2.0	Subcatchable	17-36
8/7/89	Combined				Fingerling	1.2
6/7/90	23,425	3,886			Subcatchable	23

[a] Standard error (SE) of the abundance estimate from the mark-recapture (M-R) experiment.

APPENDIX C

Appendix C. Comparison of differences between estimates of harvest from creel surveys of Birch Lake and brood tables for rainbow trout by cohort.

	Difference				
Age Cohort	1980	1981	1982	1983	Average
Age 0	-1,892	4,103	0	-2,505	-74
Age 1	6,329	-2,362	-730	-466	693
Age 2	-2,494	-1,553	730	2,972	-86
Age 3	-1,944	-188	0	0	-533

APPENDIX D

Appendix D. Number of Arctic char, rainbow trout, Arctic grayling, and kokanee caught, date and method of capture, and type of mark for fish captured at Harding Lake from 1990 through 1992.

Species	Date of Capture	Capture Method[a]	Number Caught	Type of Mark[b]	Size Cohort When Captured
Arctic char	6/89	TR	1	GT	
Arctic char	7/89	TN	97	N	
Arctic char	7/89	TN	14	RV	
Arctic char	7/89	TN	3	AD	
Arctic char	7/89	TN	16	GT	
Arctic char	11/89	TR	29	GT	
Arctic char	12/89	HL	141	N	
Arctic char	12/89	HL	14	RV	
Arctic char	12/89	HL	2	AD	
Arctic char	12/89	HL	1	GT/AD	
Arctic char	12/89	HL	3	GT/LV	
Arctic char	12/89	HL	5	GT/LP	
Arctic char	12/89	HL	1	GT/UC	
Arctic char	12/89	HL	4	GT/NC	
Arctic char	1-2/90	CC	23	N	
Arctic char	1-2/90	CC	8	RV	
Arctic char	6-9/90	TN	14	N	> 299 mm
Arctic char	6-9/90	TN	57	N	200 to 299 mm
Arctic char	6-9/90	TN	104	N	< 200 mm
Arctic char	6-9/90	TN	4	RV	
Arctic char	6-9/90	TN	3	AD	> 300 mm
Arctic char	6-9/90	TN	2	AD	< 200 mm
Arctic char	6-9/90	TN	3	GT/AD	
Arctic char	6-9/90	TN	3	GT/NC	
Arctic char	6-9/90	TN	1	GT/RV	
Arctic char	6-9/90	TN	2	GT/LV	
Arctic char	6-9/90	TN	1	GT/UC	
Arctic char	6-9/90	TN	8	BT/AD	
Arctic char	11/90	TR	4	GT	

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Appendix D. (Page 2 of 3).

Species	Date of Capture	Capture Method[a]	Number Caught	Type of Mark[b]	Size Cohort When Captured
Arctic char	12/90	HL	41	N	
Arctic char	12/90	HL	1	GT	
Arctic char	12/90	HL	1	RV	
Arctic char	12/90	HL	2	AD	< 200 mm
Arctic char	5/91	TN	2	N	
Arctic char	5/91	TN	1	RV	
Arctic char	5/91	TN	1	AD	
Arctic char	5/91	TN	1	GT/LP	
Arctic char	5/91	TN	1	BT/AD	
Arctic char	6-8/91	TR	100	BT	
Arctic char	6-8/91	TR	7	GT	
Arctic char	9/91	TN	25	N	⊥ 300 mm
Arctic char	9/91	TN	634	N	< 300 mm
Arctic char	9/91	TN	3	RV	
Arctic char	9/91	TN	7	AD	⊥ 300 mm
Arctic char	9/91	TN	3	GT/NC	
Arctic char	9/91	TN	28	BT/AD	
Arctic char	8-9/92	TN	39	N	< 200 mm
Arctic char	8-9/92	TN	68	N	200 to 299 mm
Arctic char	8-9/92	TN	3	AD	≥ 300 mm
Arctic char	8-9/92	TN	3	RV	≥ 300 mm
Arctic char	8-9/92	TN	4	GT/NC	≥ 300 mm
Arctic char	8-9/92	TR	4	BT/NC	≥ 300 mm
Arctic char	8-9/93	TN	3	N	< 200 mm
Arctic char	8-9/93	TN	23	N	200 to 299 mm
Arctic char	8-9/93	TN	2	AD	≥ 300 mm
Arctic char	8-9/93	TN	4	YT/NC	≥ 300 mm
Arctic char	8-9/93	TN	21	N	≥ 300 mm
Arctic char	8-9/93	TR	5	N	≥ 300 mm

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Appendix D. (Page 3 of 3).

Species	Date of Capture	Capture Method[a]	Number Caught	Type of Mark[b]	Size Cohort When Captured
Rainbow trout	6-9/90	TN	64	BT/AD	
Rainbow trout	6-9/90	TN	177	N	≥ 150 mm
Rainbow trout	6-9/90	TN	12	N	< 150 mm
Rainbow trout	5/91	TN	9	N	
Rainbow trout	5/91	TN	5	AD	
Rainbow trout	5/91	TN	1	BT/AD	
Rainbow trout	6-8/91	TR	1	BT/AD	
Rainbow trout	9/91	TN	10	RV	
Rainbow trout	9/91	TN	20	N	
Rainbow trout	6/92	TN	3	N	> 200 mm
Rainbow trout	8/93	TN	1	N	> 200 mm
Arctic grayling	6-9/90	TN	55	N	< 150 mm
Arctic grayling	9/91	TN	1	GT	
Arctic grayling	9/91	TN	534	N	< 150 mm
Kokanee	8-9/92	TN	4	N	> 200 mm
Kokanee	8-9/93	TN	3	N	> 200 mm

[a] TN = test netting, HL = experimental hook and line sampling, TR = tag return (from anglers), CC = creel census sampling

[b] N = no mark, AD = adipose clip, RV = right ventral clip, LV = left ventral clip, LP = left pectoral clip, TC = top caudal clip, BT/__ = blue tag with fin clip, GT/__ = green tag with fin clip, GT/NC = green tag with no fin clip, GT = Green tag with unknown clip, YT/NC = yellow tag from 1992 sampling with no fin clip.

APPENDIX E

Appendix E. Number of Arctic char, rainbow trout, Arctic grayling, and kokanee stocked, size at stocking, type of mark, and number marked, Harding Lake, 1988 - 1992.

Species	Stocking Date	Number Stocked	Size at Stocking (g)	Number Marked	Type of Mark[a]	Pen Reared
Arctic char	10/1/88	20,021	50.0	0		No
Arctic char	11/1/88	10,799	53.0	All	AD	No
Arctic char	2/8/89	8,391	122.0	All	RV	No
Arctic char	5/22/89	380	739.0	All	GT/AD	No
Arctic char	5/22/89	389	739.0	All	GT/LV	No
Arctic char	5/22/89	389	739.0	All	GT/LP	No
Arctic char	5/22/89	389	739.0	All	GT/TC	No
Arctic char	5/22/89	362	739.0	All	GT/NC	No
Arctic char	7/18/89	12,365	20.0	0		No
Arctic char	10/17/89	38,696	108.0	0		No
Arctic char	3/22/90	1,304	654.0	All	BT/AD	No
Arctic char	8/23/90	50,000	20.0	7,500	AD	Yes
Arctic char	8/30/90	32,733	35.5	0		No
Arctic char	9/14/90	18,561	54.0	0		No
Arctic char	5/30/91	1,556	761.0	ALL	BT/AD	No
Arctic char	7/19/91	106,050	11.0	0		No
Arctic char	8/30/91	171,376	37.7	0		No
Arctic char	6/16/92	60,603	9.0	0		No
Arctic char	6/17/92	60,603	9.0	0		No
Arctic char	6/18/92	60,000	9.0	0		No
Arctic char	6/19/92	8,928	9.0	0		No
Arctic char	6/23/92	11,190	9.0	0		No

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Appendix E. (Page 2 of 3).

Species	Stocking Date	Number Stocked	Size at Stocking (g)	Number Marked	Type of Mark[a]	Pen Reared
Arctic char	9/8/92	17,836	56.0	0		No
Arctic char	9/11/92	17,627	54.0	0		No
Arctic char	9/9/92	16,012	63.0	0		No
Arctic char	9/10/92	18,412	56.0	0		No
Arctic char	9/29/92	17,408	60.0	0		No
Arctic char	9/30/92	16,614	64.0	0		No
Arctic char	10/1/92	10,692	61.0	0		No
Arctic char	10/15-16/93	10,000	106.0	0		No
Rainbow trout	8/20/88	248,658	1.3	0		No
Rainbow trout	8/2/89	148,836	1.4	0		No
Rainbow trout	8/14/89	44,921	1.0	0		No
Rainbow trout	7/19/90	1,019	110.0	0		No
Rainbow trout	7/24/90	100,000	1.7	0		No
Rainbow trout	8/26/90	9,970	125.5	4,000	BT/AD	Yes
Rainbow trout	8/26/90	49,912	3.2	12,500	LV	Yes
Rainbow trout	8/28/90	99,907	6.9	25,000	LV	Yes
Rainbow trout	8/28/90	1,000	177.0	All	BT/AD	Yes
Rainbow trout	7/24/91	173,800	1.8	0		No
Rainbow trout	8/1/91	9,406	90.6	4,406	RV	Yes
Rainbow trout	6/19/92	19,517	100.0	0		No
Arctic grayling	6/17/88	1,169,806	0.02	0		No
Arctic grayling	6/7/90	54,200	0.02	0		No
Arctic grayling	8/28/90	2,400	3.9	0		Yes
Arctic grayling	8/29/90	29,972	5.2	0		Yes

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Appendix E. (Page 3 of 3).

Species	Stocking Date	Number Stocked	Size at Stocking (g)	Number Marked	Type of Mark[a]	Pen Reared
Arctic grayling	6/8/91	697,178	0.02	0		No
Arctic grayling	8/25/91	71	100.0	All	GT	Yes
Arctic grayling	8/27/91	186,800	3.9	0		Yes
Arctic grayling	8/28/91	150,200	2.6	0		Yes
Arctic grayling	9/20/91	43,397	5.3	0		No
Arctic grayling	6/19/92	400,000	0.02	0		No
Arctic grayling	6/24/92	204,263	0.02	0		No
Kokanee	5/23/88	503,000	0.16	0		No
Kokanee	5/22/89	515,000	0.16	0		No
Kokanee	6/7/90	505,305	0.16	0		No

[a] N = no mark, AD = adipose clip, RV = right ventral clip, LV = left ventral clip, LP = left pectoral clip, TC = top caudal clip, BT/AD = blue tag with adipose fin clip, GT/__ = green tag with fin clip (AD, LV, LP, TC), GT/NC = green tag with no fin clip.

APPENDIX F

Appendix F. Abundance criteria by species for Harding Lake used to categorize estimates of catch-per-24-hour-period.

Species	Abundance Criteria for Average Catch Per Net-Night Data[a]		
	Sparse	Moderate	Abundant
Arctic char	0 to 1	2 to 6	more than 6
Arctic grayling	0 to 5	5 to 20	more than 20
Burbot	0 to 1	2 to 6	more than 6
Lake trout	0 to 1	2 to 6	more than 6
Least cisco	0 to 6	7 to 30	more than 30
Northern Pike	0 to 4	5 to 10	more than 10
Rainbow trout	0 to 5	6 to 20	more than 20

[a] These criteria represent the arithmetic average of values given by regional sport fish biologists for catches from a standard experimental gill-net.

APPENDIX G

Appendix G. Fishing effort and harvests of wild and stocked fish, Harding Lake, 1986-1991[a].

	Year						
	1986	1987	1988	1989	1990[b]	1991[b]	1992
Number of Days Fished	2,064	5,125	3,256	4,935	3,895	5,155	2,830
Number of Anglers	1,590	3,371	2,599	2,976	2,650	3,241	5,068
Number of Fish Harvested (Caught):							
Arctic char	0	0	0	141	304 (996)	450 (2,076)	508 (1,401)
Arctic grayling	0	79	0	0	17 (84)	86 (147)	8 (16)
Burbot	0	53	73	10	17 (17)	45 (45)	17 (17)
Lake trout	24	0	55	119	51 (186)	133 (148)	200 (517)
Northern pike	673	1,886	2,092	1,764	591 (3,629)	1,888 (4,595)	341 (3,400)
Rainbow trout	0	118	73	456	354 (1,182)	246 (277)	1,385 (3,253)
Sheefish	0	0	73	0	0 (68)	0 (0)	0 (0)
Kokanee	0	0	0	0	0	185 (454)	184 (303)

[a] Data from Mills (1987, 1988, 1989, 1990, 1991, 1992).
[b] Catches in parenthesis.

APPENDIX H

Appendix H. Data files for information collected from fish populations in Birch Lake, Quartz Lake, Chena Lake, and Harding Lake, 1993.

Data File	Description
BQC93.DTA	Data file of catches by species with lengths and fi clips for fish captured in Birch Lake, Quartz Lak and Chena Lake, 1993
U1890LB3.DTA	Data file of catches by species, location, depth gear type, and biological information for fis captured in Harding Lake, 1993.

[a] Data files have been archived at and are available from the Alaska Department of Fish and Game, Sport Fish Division, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska, 99518-1599.