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Evaluation of Rainbow Trout and Coho Salmon Stocking Programs in Birch, Chena, and Quartz Lakes, Alaska

by

Michael Doxey

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Alaska Department of Fish and Game

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ABSTRACT

This report presents a history of the rainbow trout *Oncorhynchus mykiss* and coho salmon *Oncorhynchus kisutch* stocking programs through 1990 in Birch, Chena, and Quartz lakes in the Tanana Valley near Fairbanks, Alaska. Data are summarized from creel surveys, test netting, and mark-recapture experiments, and include estimates of harvest, survival, and growth for rainbow trout and coho salmon that were stocked at different sizes and densities. Data collected during 1989 and 1990 are presented for the first time in this report. Abundance of rainbow trout in Birch Lake in 1989 and 1990 was estimated at 19,551 (SE = 2,019) and 27,022 (SE = 3,903), respectively. Abundance of rainbow trout in Quartz Lake in 1989 and 1990 was estimated at 24,713 (SE = 3,723) and 27,887 (SE = 4,615), respectively. Lengths of predominant rainbow trout cohorts sampled in Birch and Quartz lakes overlapped so cohort composition of the total population was not estimated for Birch and Quartz lakes in 1989 and for Quartz Lake in 1990. Mean lengths of some cohorts which could be distinguished are presented. In 1990, the largest proportion of coho salmon in the sample consisted of 1989 fingerlings in Quartz Lake and 1990 fingerlings in Birch Lake. Insufficient numbers of coho salmon were captured at Chena Lake in 1990 to assess cohort composition. 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. Catchable rainbow trout entered the fishery immediately.

Peak harvests from cohorts of coho salmon occurred in the second year after stocking.

KEY WORDS: Rainbow trout *Oncorhynchus mykiss*, coho salmon *Oncorhynchus kisutch*, stocking, evaluation, Birch Lake, Chena Lake, Quartz Lake, interior Alaska.

INTRODUCTION

To provide diverse angling opportunities and reduce the harvest of native fish stocks, the Alaska Department of Fish and Game (ADFG) has undertaken a lake stocking program providing 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* in interior Alaska. The stocking program in the Interior began in the early 1960's, when barren lakes along the road system were stocked with rainbow trout or coho salmon. Some lakes were chemically rehabilitated prior to stocking. Today, stocked fish comprise more than half of the harvest of game fish in interior Alaska. This report summarizes the results of the rainbow trout and coho salmon enhancement programs in Birch, Chena, and Quartz lakes from the beginnings of enhancement through 1990.

Project objectives addressed in this report for the 1989 (F-10-5) Federal Aid contract were to estimate:

1) abundance, mean length, and cohort composition of populations of rainbow trout in Quartz and Birch lakes.

Project objectives addressed in this report for the 1990 (F-10-6) Federal Aid contract were to:

1) estimate the abundance, length composition and cohort composition of populations of rainbow trout in Quartz and Birch lakes;

2) estimate the length composition, and cohort composition of populations of coho salmon in Birch, Chena and Quartz lakes; and,

3) develop brood year contribution estimates for rainbow trout and coho salmon harvested in Birch, Chena and Quartz lakes.

AREA DESCRIPTION

Birch, Chena, and Quartz lakes are located along the road system between Fairbanks and Delta Junction in the Tanana Valley of central Alaska (Figure 1). The area is subarctic, and lakes are ice-covered for six to seven months from freeze-up in mid-October until breakup (the day the last of the ice disappears in spring) in mid-May. Maximum ice thickness is generally from 90 to 110 cm. Thermal stratification occurs in all three lakes during the summer, and surface water temperatures can reach 23.5° C (Doxey 1980-1985).

Birch Lake

Birch Lake (Figure 2) is a 325 ha lake located adjacent to the Richardson Highway 90 km (by road) southeast of Fairbanks. The lake is generally oval shaped, with 8 km of shoreline. The surface elevation is 251 m. There are four small inlets and one outlet. A structure operated and maintained by ADFG on the outlet controls flow, regulates lake level, and prevents fish passage. Maximum depth is 12 m, and there are three major habitat zones (nearshore,

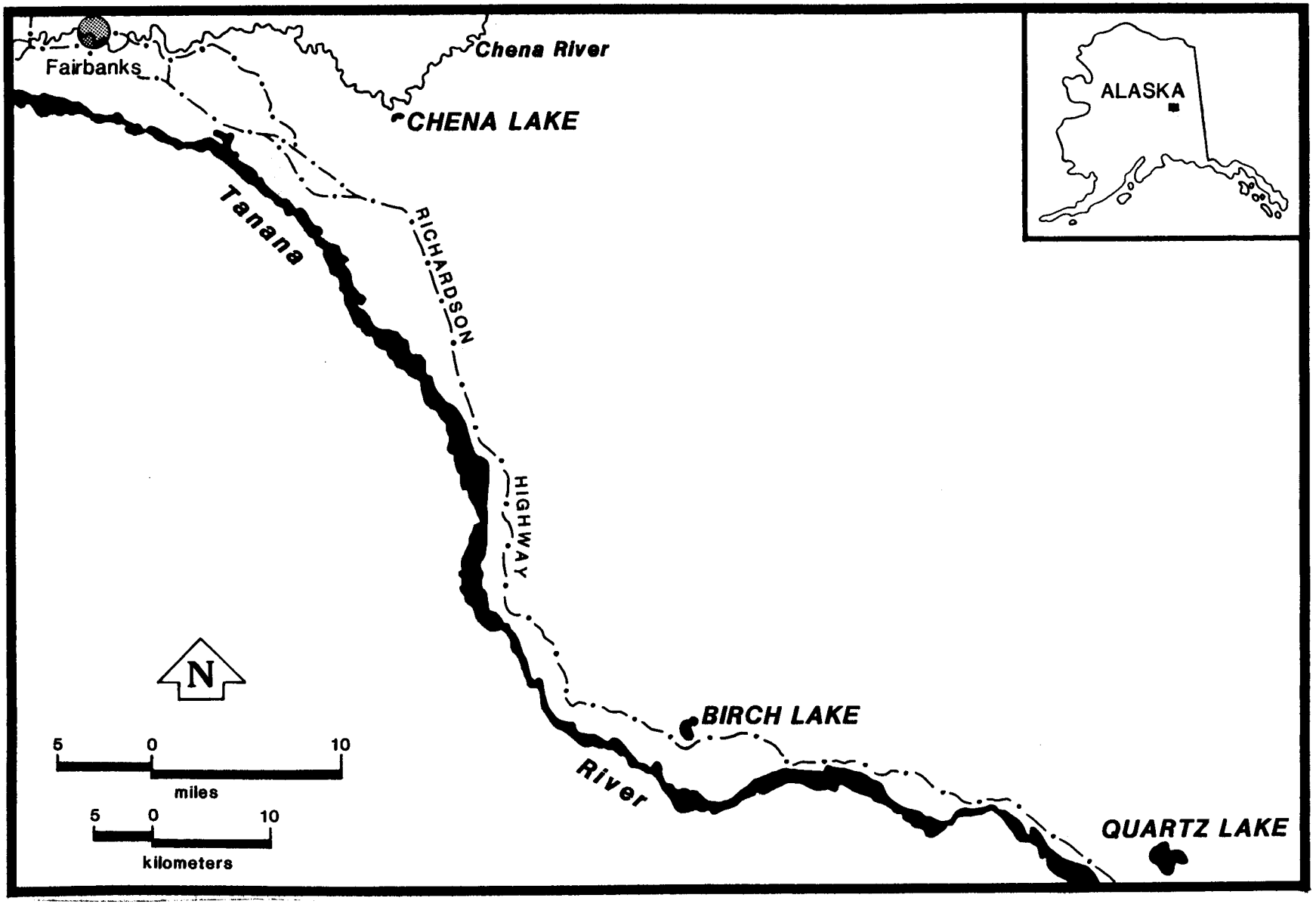

Figure 1. Area map.

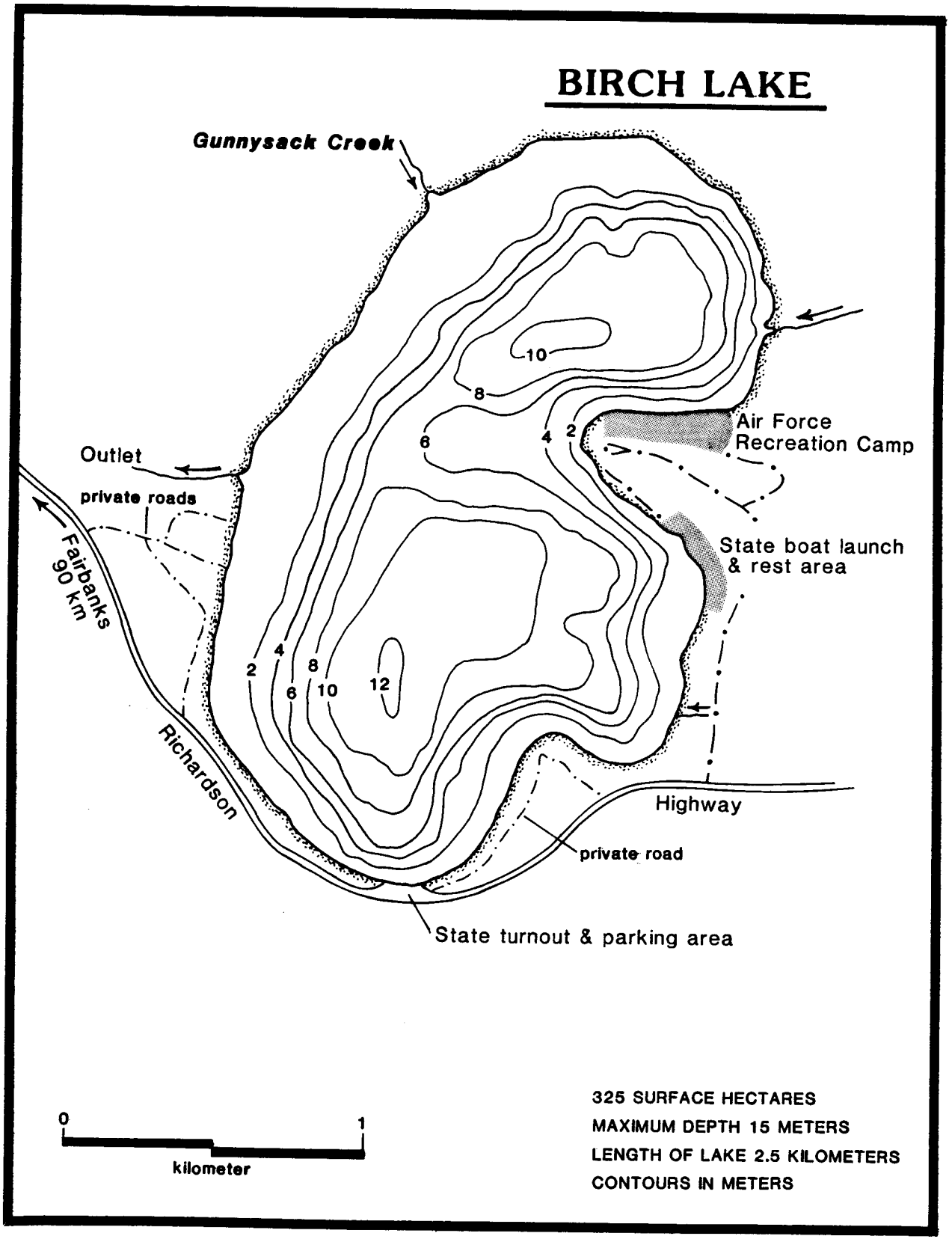

Figure 2. Depth contour map of Birch Lake.

deep littoral, and profundal). The littoral zone (as defined by the outer edge of the deep weed-beds at approximately 4 m depth) comprises about 40% of the surface area of the lake and consists primarily of two vegetative zones. Beds of lily pads near shore extend in a broad band along much of the perimeter of the lake to a depth of about 3 m. There is a relatively narrow band of deep weed-beds (*Potamageton* sp.) along the outer edge of the lily pads from a depth of about 3 m to 5 m. The remainder of the lake is deep water without aquatic vegetation. In some areas, the unvegetated zone extends almost to shore, where there may be some reeds and emergent vegetation. The lily pads appear shortly after the lake becomes ice-free, reach their peak density in late July and early August, and begin to die and thin out by mid-August. Most of the lake bottom is overlain by decaying organic matter, but there are some sand beds composed primarily of decomposed granite.

Developed recreational areas include a U.S. Air Force recreation camp and a State boat launch and camping area. About half of the shoreline is private land with cabins. The remaining shoreline is undeveloped.

Chena Lake

Chena Lake is centrally located in the North Pole area, southeast of Fairbanks between Fort Wainwright and Eielson Air Force Base (Figure 3). The lake was created in 1979 when the U.S. Army Corps of Engineers restructured a cluster of seven borrow pits to form a single 105 ha lake near the river control structure of the Chena River Lakes Flood Control Project. In preparation for a planned stocking program, the Corps cooperated closely with the ADFG to develop the structure of the lake so that fish habitat was optimized. Overburden was pushed back into the lake, the littoral zone was restructured and improved, and the outlet to the Chena River was blocked (Kramer and Hallberg 1982). The result is an attractive lake with five islands, seven deep basins, channels in back of some of the islands, and numerous bays and points. Maximum depth is 12 m and littoral zone comprises about 25% of the surface area. Thin bands of emergent and submerged aquatic vegetation occur along the shoreline. The lake is part of a Fairbanks North Star Borough recreation area, with the southeastern part of the lake developed with campsites, concessions, a boat launch (no motors are allowed) and a swimming beach.

Quartz Lake

Quartz Lake (Figure 4) is a 607 ha lake located near the Richardson Highway 26 km (by road) north of Delta Junction (138 km by road southeast of Fairbanks). Maximum depth is 12 m, and there is 10 km of shoreline. The surface elevation is 292 m. The water is lightly tannic stained. Littoral zone (defined as ending at about 5 m depth) comprises 82% of the surface area, and the profundal zone consists of two deep basins in the southeastern portion of the lake. The shoreline is broken by one prominent point and two smaller points. There are no outlets or inlets and water level is dependent on springs, runoff from surrounding hillsides, and the water table. Habitat types are similar to those in Birch Lake, but because much more of the lake has water depths less than 5 m, a large part of the surface area has emergent aquatic vegetation or dense areas of lily pads.

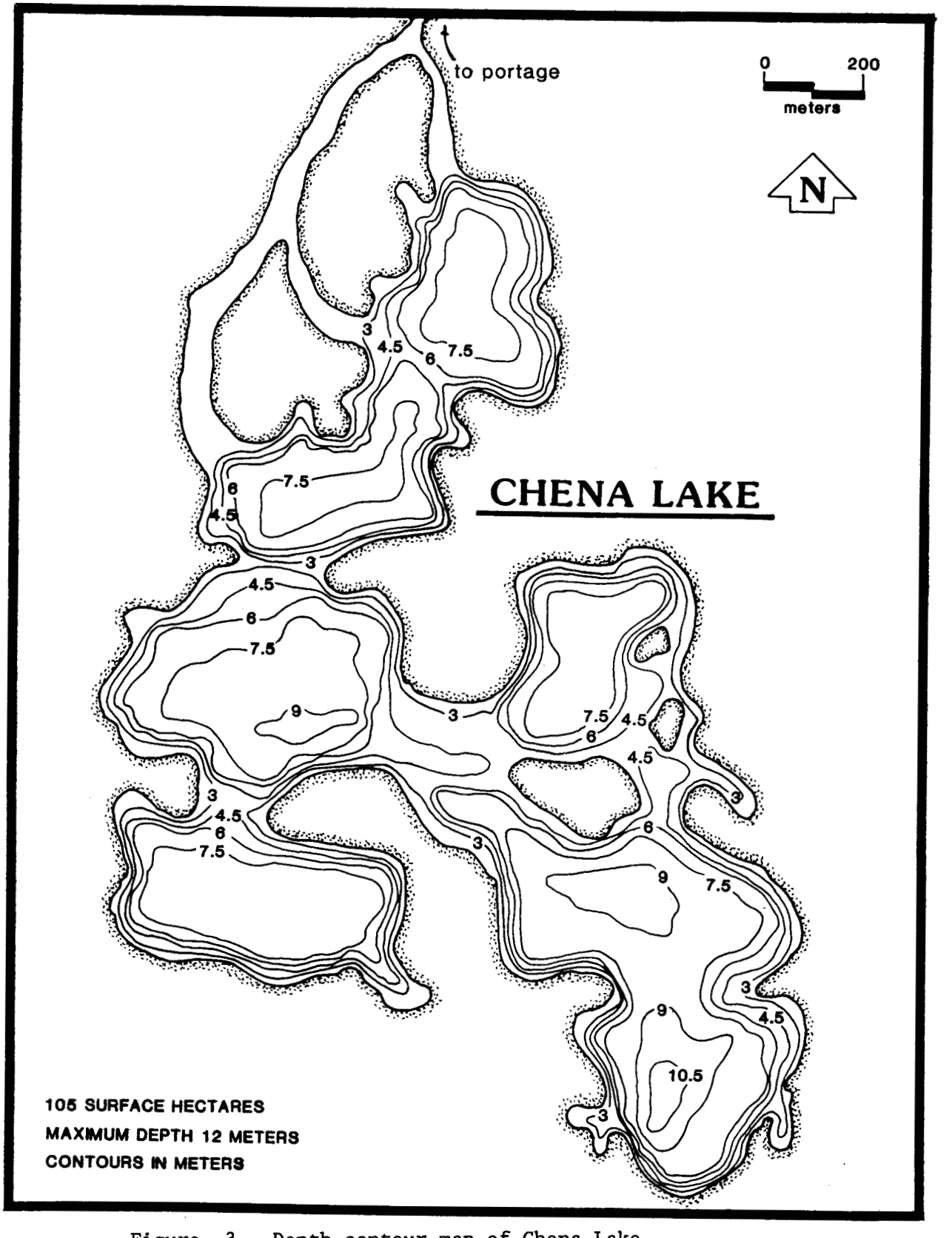

Figure 3 Depth contour map of Chena Lake.

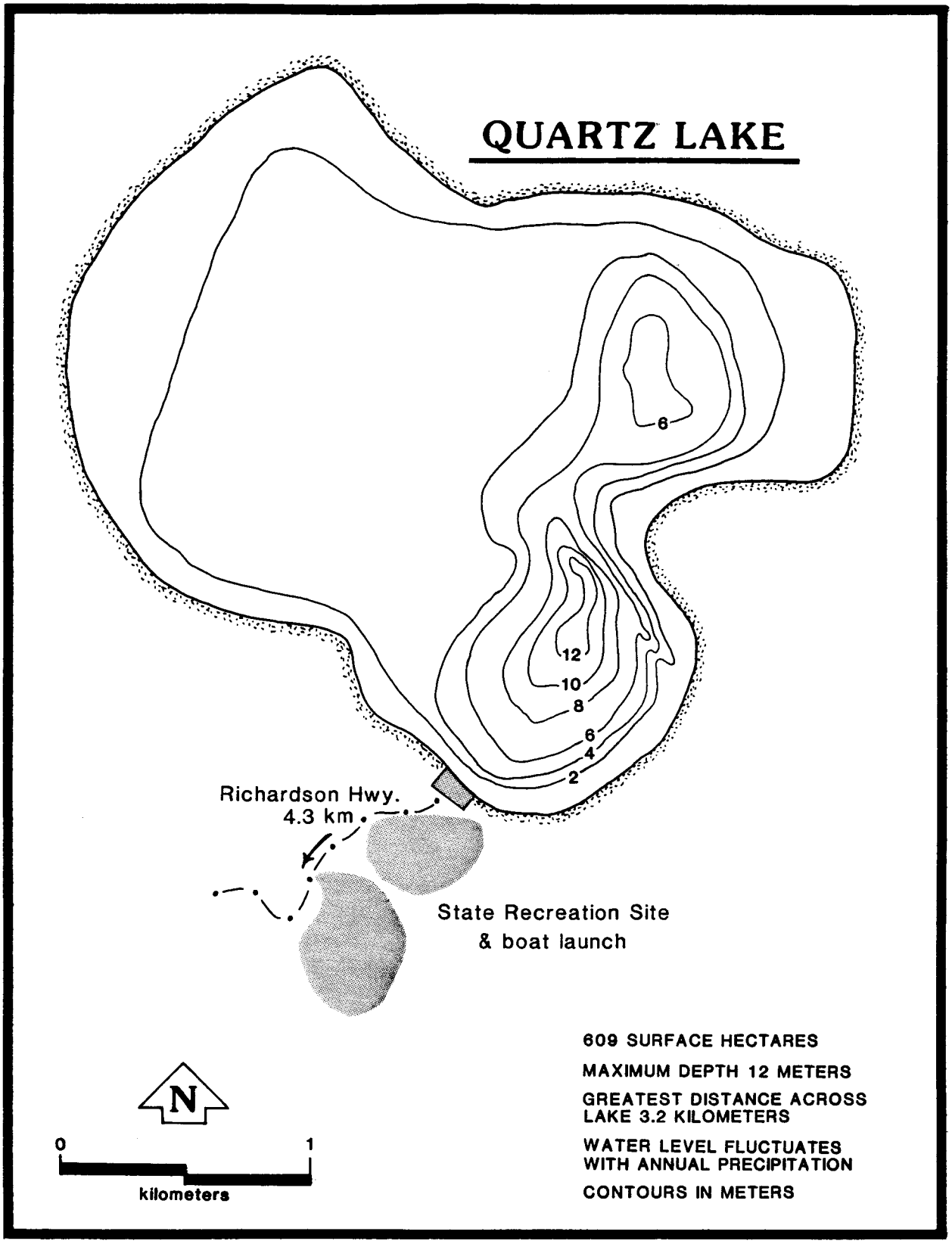

Figure 4. Depth contour map of Quartz Lake.

The only access is a single road from the Richardson Highway ending at the Quartz Lake State campground. There are two boat launches at the campground, one of which was completed in 1990 as part of a cooperative project funded by the ADFG to improve angler access. A commercial lodge on the eastern shore rents out cabins and boats. Private cabins are scattered sparsely along the southern and eastern shoreline. About half of the land along the shoreline is undeveloped. There is no road access beyond the campground, but in winter the lodge owner sometimes plows an ice road around the southern perimeter of the lake.

HISTORICAL REVIEW OF STOCKING EFFORTS

Birch Lake

Birch Lake was the first large roadside lake to be chemically rehabilitated - it was treated with powdered rotenone in July, 1966. The indigenous species residing in the lake at that time included least cisco *Coregonus sardinella*, humpback whitefish *Coregonus pidschian*, burbot *Lota lota*, northern pike *Esox lucius*, and slimy sculpin *Cottus cognatus*. The northern pike fishery had supported little effort and harvest. During the summer of 1965 a total of 228 anglers caught 288 northern pike. Mean length of the northern pike harvested was 440 mm (Heckart 1966). Since chemical rehabilitation, lake chubs *Couesius plumbeus* and slimy sculpins have become established in Birch Lake, either as a result of vandalization of the outlet structure in 1967, or their illegal use as live bait. Small numbers of Arctic grayling and northern pike have also been illegally introduced into the lake by individuals. There is as yet no evidence of spawning by northern pike.

Birch Lake was first stocked by ADFG with rainbow trout fingerlings in fall, 1966, and rainbow trout stocking has continued to the present (Table 1). From 1972 through about 1980 the State hatcheries had difficulty meeting the needs of the statewide rainbow trout stocking program. In some years very few rainbow trout were available to the Fairbanks area, and sometimes the quality of the rainbow trout was poor, resulting in high mortalities at the time of stocking. This trend can be seen in the reduced numbers of rainbow trout stocked between 1973 and 1976. During that period the State hatcheries were developing an Alaskan rainbow trout brood stock in order to phase out and replace exotic brood stocks. Rainbow trout strains stocked were from a mix of experimental Alaskan strains (Swanson River, Talarik, and Naknek) and from two strains originating outside of Alaska (Winthrop, Washington and Ennis, Montana). With one very minor exception in 1976 (the stocking of a total of 766 rainbow trout weighing on average 80 g) rainbow trout were stocked into Birch Lake as fingerlings (at 0.5 to 4.0 g) from 1966 through 1978. In the late 1970's, some quantities of larger rainbow trout became available as the State rainbow trout production capacity began increasing. These "subcatchables" were held in the hatchery through the winter and stocked in the spring (instead of being stocked in the fall as fingerlings). Average weight was about 25 g, and they were stocked into Birch Lake periodically beginning in 1979. The rainbow trout stocked in 1979 were from the Ennis strain, reared in an Alaskan hatchery. Thereafter, the native Alaskan Swanson

Table 1. 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	Naknck	Fingerling	55,700 18,567	Fingerling Smolt
1975				5,907 95,000	Age II 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	97,261 298,500	Swanson R. Swanson R.	8.1 1.3		
1983	19,482 125,218	Big Lake Swanson R.	45 1.8		
1984	269,963	Swanson R.	1.7-2.7	50,000	3.7

- continued -

Table 1. (Page 2 of 2).

Year	Rainbow Trout	Broodstock	Size (g)	Coho Salmon	Size (g)
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

River strain fish was chosen as the primary brood stock for the State rainbow trout hatchery program, along with the Alaskan Big Lake strain fish for some applications.

From 1979 through 1982 the rationale for stocking subcatchables was to improve the sport fishery and to evaluate the performance of stocking larger rainbow trout in the spring. In 1982, stockings of less expensive fingerlings were resumed and carried on through 1984. Rainbow trout fingerlings are generally available from the hatcheries in late July and early August. No rainbow trout were stocked into Birch Lake in 1985 because the fingerlings were being held in the hatchery to be stocked as subcatchables. In 1986, subcatchable rainbow trout stockings resumed and continue to the present. Subcatchable rainbow trout are available from the hatchery from late October through early June. Most subcatchable stockings took place in late May or early June (after breakup). The exceptions were in 1988, when 10,000 subcatchables were experimentally stocked through the ice in March, and again in 1989, when 50,000 were stocked through the ice in late March and early April. The annual planned stocking rate for Birch Lake rainbow trout has been 50,000 subcatchable rainbow trout with an average weight of 20 g. In August, 1989, 4,045 catchable sized rainbow trout (100 g) were stocked into Birch Lake.

Coho salmon were periodically stocked into Birch Lake as fingerlings beginning in 1974 and stocking has occurred regularly from 1984 to present. The first introductions were in response to the shortage of rainbow trout and in conjunction with coho salmon rearing experiments in other lakes (Kramer 1977). By 1984 coho salmon had become an established part of the sport fishery and have been stocked annually since (Table 1). The planned annual coho salmon stocking rate at Birch Lake is 40,000 fish. Coho salmon fingerlings are stocked in early summer.

Chena Lake

During construction of Chena Lake by the U.S. Army Corps of Engineers, the connection to the Chena River allowed colonization by indigenous species. At the completion of lake construction, seven species were present in the lake in a population structure numerically dominated by longnose suckers *Catostomus Catostomus* (Kramer and Hallberg 1982). Other species present included least cisco, Arctic grayling, humpback whitefish, round whitefish *Prosopium cylindraceum*, northern pike, and burbot. Chena Lake was treated with liquid rotenone in September of 1981, and has since been stocked with rainbow trout, Arctic char, and coho salmon.

Rainbow trout were introduced into Chena Lake in 1982 when 57 g subcatchables and 7.7 g fingerlings were stocked (Table 2). Rainbow trout have been stocked annually since. In 1984, evidence of slow growth of stocked fingerlings resulted in the decision to stock the largest rainbow trout available (Hallberg 1985). The requested size for rainbow trout at stocking was 100 g, and from 1987 to 1989 that goal was met. The present annual rainbow trout stocking rate for Chena Lake is 30,000 catchable sized fish (100 g).

Coho salmon fingerlings were stocked in 1982 and have been stocked annually since 1984 (Table 2). After 1988, the stocking rate of coho salmon in Chena

Table 2. Fish stocked into Chena Lake, 1982 - 1990.

Year	Rainbow Trout	Broodstock	Size (g)	Coho Salmon	Size (g)	Arctic Char	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	2,498	144
1990	31,251	Swanson R.	97-107				

Lake was reduced to 15,000 annually in order to increase growth rates of fish after stocking.

Arctic char were stocked through the ice into Chena Lake in February, 1989 in an experiment designed to assess their potential to increase angling opportunity. A total of 2,498 fish with a mean weight of 144 g was stocked.

Quartz Lake

Quartz Lake was rehabilitated with powdered rotenone in 1970, eradicating populations of northern pike and least cisco. No harvest estimates are available for the Quartz Lake northern pike fishery occurring prior to 1970. Mean length of 23 northern pike obtained through test-netting in 1964 was 350 mm (Heckart 1965).

Rainbow trout were first introduced into Quartz Lake when 810,000 fry were stocked in 1971 (Table 3). Rainbow trout stockings have continued to present, with some exceptions when hatchery production was low. Brood strains included Willamette, Oregon; Ennis, Montana; and Alaskan Ship Creek and Swanson River stocks. In 1987, fingerling stockings were supplemented with an experimental stocking of 10,000 subcatchables at 28 g. Combined stockings of subcatchable and fingerling rainbow trout continued through 1990. At present the annual planned rainbow trout stocking rate for Quartz Lake is 150,000 fingerlings at 1 g and 50,000 subcatchables at 20-25 g.

Coho salmon were first stocked in Quartz Lake to supplement the sport fishery in years when rainbow trout availability was low. While sufficient numbers of rainbow trout are now available, coho salmon continue to be stocked in Quartz Lake. Coho salmon increase angling diversity and provide angling opportunity during periods when rainbow trout are less available to the angler, particularly in the winter. Coho salmon strengthen the stocking program by ensuring the availability of fish to anglers if there is a shortfall of rainbow trout production. The planned annual coho salmon stocking rate is 150,000 fish annually, at 3 - 4 g (Table 3).

METHODS

The stocking programs for Birch, Chena and Quartz lakes were evaluated using test netting to assess cohort composition and growth; mark-recapture experiments to estimate abundance and survival; and, creel surveys to estimate harvest and cohort contribution to the harvest.

Cohort Composition and Growth

Presence and growth of stocked fish in Birch Lake has been documented intermittently beginning in 1969 (Namvedt 1970), and in Quartz Lake beginning in 1972 (Peckham 1973).

Before 1979, fish in Birch and Quartz lakes were collected with variable mesh gill nets for growth analysis. Length-at-age was determined, or all cohorts were combined and the result expressed as mean length and length range of

Table 3. 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 & Crooked Creek	0.7-4.5		
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	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		

rainbow trout and coho salmon populations. After 1979 in Birch Lake and 1984 in Quartz Lake, fish were collected with fyke nets. The use of fyke nets greatly reduced sampling mortality, and this resulted in larger sample sizes. Most length data was collected during population estimates. Fish harvested by anglers were measured during on-site creel surveys.

While rainbow trout in Birch and Quartz lakes can weigh up to 4,000 g, sampling in recent years has concentrated on growth to the point at which a cohort recruits to the sport fishery. As a consequence, sampling has emphasized age 1 and age 2 fish. Based upon creel interviews, the minimum length at which anglers retain rainbow trout is 180 mm (Doxey 1980).

Periodic sampling of rainbow trout and coho salmon in Chena Lake began in 1983 (Hallberg 1984). Methods included sampling with gill-nets and fyke-nets, electrofishing, and interviewing anglers while test fishing.

Age and stocking cohort were determined from visual observation of length frequency plots. There is error associated with age determination due to overlap of length frequencies. The magnitude of the error has not been measured.

Abundance Estimates

Abundance of rainbow trout in Birch and Quartz lakes has been estimated. No abundance estimates for rainbow trout in Chena Lake have been conducted. Efforts to estimate coho salmon abundance in Birch and Quartz lakes have been attempted but have been unsuccessful due to low capture rates (Doxey 1980, 1986, 1988).

Birch Lake:

The first abundance estimate was attempted at Birch Lake in early summer, 1979 (Doxey 1980), shortly after the first major stocking of subcatchable rainbow trout (Table 1). Fish were captured with seines and fyke nets and marked by removal of a portion of the caudal fin. It became apparent during recapture efforts that the marked fish were not mixing with the unmarked population. Efforts continued throughout the summer, and in September, 1979, the first rainbow trout abundance estimate in Birch Lake was achieved by collecting fish with fyke nets and a boat mounted electrofishing unit. Electrofishing was abandoned after 1985, primarily due to low catch rates during the middle 1980's when the rainbow trout population was supported by stockings of fingerlings. Until 1986 the abundance estimates targeted yearling rainbow trout - those that had been stocked as fingerlings the previous fall or as subcatchables that spring. The abundance of residuals (those trout that had been in the lake for more than one summer) was not estimated, but presence of those fish was documented in the creel census. Since 1986, total population abundance of rainbow trout present in the lake in August (exclusive of very recently stocked fingerlings) has been estimated and individual cohort abundance calculated from the population abundance estimate.

The present method of estimating abundance of rainbow trout in Birch Lake is through the use of mark-recapture experiments. The lake is bisected into two

sampling zones along an approximate north - south axis and several fyke nets are set in each half. The sampling sites are located approximately across the lake from each other and away from the boundary. During the marking event in August, fish are captured, measured and given a partial fin clip (upper or lower caudal clip depending upon capture location). Recapture sampling begins in late September. Mixing was evaluated using Chi-square tests, and length bias was examined by visual examination of cumulative length frequency plots. The population abundance estimator used was the Chapman modification of the Petersen mark - recapture technique (Seber 1982).

$$\hat{N}_k = \frac{(n_1 + 1)(n_2 + 1)}{(m+1)} \quad ; \text{ and,} \qquad (1)$$

$$\hat{V}[N] = \frac{(n_1+1)\ (n_2+1)\ (n_1-m)\ (n_2-m)}{(m+1)^2\ (m+2)} - 1 \quad ; \qquad (2)$$

where:

$\hat{N}$ = abundance estimate of population;

n_1 = size of the first sample;

n_2 = size of the second sample; and,

m = number of marked individuals in n_2.

Quartz Lake:

Abundance estimates and stocking cohort analysis of Quartz Lake rainbow trout populations began in 1986, and have been continued annually (Doxey 1987-1989). Methods used at Quartz Lake are similar to those outlined for Birch Lake.

Survival Estimates

Presence of rainbow trout and coho salmon in Birch, Chena and Quartz lakes has historically been determined by test netting. Periodic, overnight sets with variable mesh gill nets usually produced samples of fish of each species. Samples were also obtained during creel surveys. Abundance estimates from mark-recapture experiments in Birch and Quartz lakes are used to estimate survival of stocked rainbow trout in those lakes. Survival rates of cohorts from time of stocking to the time of the marking event are estimated.

Birch Lake:

Beginning in 1979, abundance estimates were used to estimate survival rates to catchable size of cohorts of rainbow trout stocked as subcatchables. Mean

length of subcatchable cohorts approached or exceeded 180 mm and began to enter the sport fishery in the first fall after stocking (Doxey 1980). The abundance of older fish in the lake (residuals) was not estimated. In 1982 and 1983, abundance estimates monitored the performance of rainbow trout fingerlings, which were stocked in early August. The abundance of fingerling cohorts was estimated in the fall of the following year, after they had spent a winter and full summer in the lake and had grown to catchable size. Survival rates to catchable size of stocked fingerlings and subcatchable rainbow trout were thus compared. Survival rates of subcatchable rainbow trout were again estimated when stockings of fish of that size resumed in 1986. Also, the technique of stocking subcatchable rainbow trout through the ice was evaluated in 1988 and 1989. After 1985, total abundance of the rainbow trout population was estimated and the survival rates of identifiable cohorts was calculated based on their proportion within the population.

Survival rates were calculated as follows:

$$\hat{S} = \frac{\hat{N}}{M} \text{ ; and,} \tag{3}$$

$$V[\hat{S}] = \frac{V[\hat{N}]}{M^2} \text{ ;} \tag{4}$$

where:

$\hat{S}$ = the estimated survival rate to age 1; and,

M = the number of fish stocked.

For each cohort, the mean lengths and variances were calculated as follows:

$$\bar{x} = \frac{\Sigma\, x_i}{n} \text{ ; and,} \tag{5}$$

$$V[\bar{x}] = \frac{\Sigma\, (x_i - \bar{x})^2}{n\,(n - 1)} \text{ ;}$$

where:

x_i = an individual length measurement; and,

$\bar{x}$ = the average length of the sample.

The proportions of each category were estimated with the following formulas (Cochran 1977):

$$\hat{P}_j = \frac{n_j}{n}; \text{ and,} \quad (6)$$

$$V[P_j] = \frac{\hat{P}_j\ (1-\hat{P}_j)}{n - 1}; \quad (7)$$

where:

n_j = the number in the sample from group j;

n = the sample size; and,

$\hat{P}_j$ = the estimated fraction of the population that is made up of group j.

$\hat{V}[P_j]$ is a minimum estimate because it assumes that fish were correctly classified to cohort based on length frequency.

The abundance of survivors in each stocking cohort is the product of the estimated fraction and abundance of the population:

$$\hat{N}_j = \hat{N}\ \hat{P}_j. \quad (8)$$

The variance of Eq. 8 is the product of two variances (Goodman 1960):

$$\hat{V}[N] = \hat{N}^2\ \hat{V}[P_j] + \hat{V}[N]\ \hat{P}_j^2 - \hat{V}[P_j]\ \hat{V}[N]. \quad (9)$$

Quartz Lake:

Until the mid-1980's, no quantitative survival data was gathered at Quartz Lake. Comparison of 1985 and 1986 Statewide Harvest Survey (SWHS) data (Mills 1986, 1987) with rainbow trout fingerling stocking densities in 1983 and 1984 indicated an approximate 5% return to the creel. This type of comparison is not sound for other years when harvest from subcatchable stocking cohorts overlapped the harvest from fingerling cohort stockings. Further, Peckham (1978) reported "moderate winterkills" during the winters of 1974 - 1975 and 1975 - 1976.

Abundance of the Quartz Lake rainbow trout population resulting from fingerling stockings was estimated in 1986. Beginning in 1987, estimates of survival rates of cohorts of subcatchable rainbow trout were calculated. Methodology paralleled that used for Birch Lake.

During length frequency analysis of data collected in 1989, it became apparent that the two predominant cohorts of rainbow trout in Quartz Lake (age 1 fish stocked as fingerlings in 1988, and as subcatchables in May, 1989) had overlapping size ranges, had no finclips or other cohort identification marks, and were again indistinguishable from one another. Consequently they were combined as a single cohort. Rainbow trout stocked as subcatchables through the ice in April, 1989 had adipose clips, as did all trout stocked as subcatchables in previous years. Examination of the length frequency data and review of length ranges defined for similar cohorts in previous years allowed definition of those cohorts, as well as separation of residuals from previous fingerling stockings.

During length frequency analysis of data collected in 1990, it was apparent that the two predominant cohorts of rainbow trout in the lake (Age 1 fish stocked as fingerlings in 1989, and as subcatchables in May, 1990) had overlapping size ranges, had no finclips or other cohort identification marks, and were indistinguishable from one another. Consequently they were combined as a single cohort. Similarly, most cohorts of rainbow trout stocked as subcatchables in previous years had been marked with adipose fin clips but were indistinguishable from one another, and those without adipose fin clips were indistinguishable from unmarked fish stocked as fingerlings.

Harvest Estimates

The most consistent gauge of fishing effort and harvest at the three lakes since 1977 has been the SWHS (Mills 1979 - 1990). For each of the three lakes, angler effort and the number of rainbow trout and coho salmon harvested has been estimated annually.

On-site creel surveys were conducted at Birch Lake from 1979 through 1986; at Chena Lake from 1984 through 1986 and in 1989; and at Quartz Lake from 1979 through 1987. Anglers were interviewed and fishing effort and catch by species was recorded. Fish were either visually separated by stocking cohort or length was recorded for later cohort analysis. Methods (and results) for these surveys are described for Birch Lake by Doxey (1980 - 1986); and by Clark and Ridder 1987. On-site creel survey activities at Chena Lake are detailed by Hallberg (1985); Doxey (1986); and Clark and Ridder (1987). Quartz Lake creel survey results are reported by Peckham (1980-1985); Doxey (1986); Clark and Ridder (1987); and Baker (1988).

Brood Tables

Brood tables projecting the annual and total contribution to the harvest of stocking cohorts of rainbow trout and coho salmon were developed by combining the available information for each cohort. Each brood table was based on four types of information, including known data and assumptions. These data were:

(1) number, size, and stocking date of each cohort;

(2) total annual harvest estimates from the SWHS (Mills, 1978-1990);

(3) average survivals to catchable size (180 mm) and recruitment to the fishery (from abundance estimates); and,

(4) assumptions about the proportional annual harvest of a cohort after recruitment to the fishery.

The number of fish stocked, size at stocking, and date stocked was available for all years. SWHS estimates for rainbow trout and coho salmon became available 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. Abundance estimates were available for rainbow trout in recent years, and were used to estimate survival rates to catchable size. Recruitment to the sport fishery was estimated from these survival rates.

The rainbow trout brood tables were based on the stocking density, SWHS harvest estimates and the following assumptions:

1. the estimated contribution of each stocking cohort to the harvest was the same as the estimated proportion of catchable sized fish of that cohort in the total population;

2. the estimated proportion of catchable sized fish from a given cohort within the total population was derived by first multiplying the number originally stocked by a survival rate estimate (providing an estimated recruitment to the fishery). This was the first year number. In subsequent years, the potential number of rainbow trout from a given cohort within the total population in a given year was estimated by subtracting the number of fish in that cohort estimated to have been harvested in previous years from the original recruitment estimate (see Appendices A1-A3);

3. assumptions (1) and (2) were combined to produce an estimate of the proportion of a cohort present in the population based on harvest; and,

4. stocking dates and growth rates of rainbow trout cohorts of different sizes were used to adjust the harvestable portion of stocked fish in the following manner:

    a. Fingerling and subcatchable sized rainbow trout stocked did not reach catchable size until the eighth month of the calendar year. Therefore first year harvest of these cohorts was arbitrarily reduced by a factor of 0.33 prior to estimating proportions.

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

Natural mortality was not known, and was thus not included in calculations. Numbers of fish presented as being available to anglers are maximum estimates.

The coho salmon brood tables were based on the stocking density, SWHS harvest estimates and the following assumptions:

(1) 60% of the harvest from a cohort occurred at age 1, 30% at age 2, and 10% at age 3;

(2) the ratio of the survival rates of fingerling and subcatchable sized coho salmon to catchable size in Birch Lake was similar to that of rainbow trout (mean survival of fingerlings, 1.6%; and of subcatchables, 46%);

(3) the contribution of age 3 coho salmon to the harvests from 1977 through 1979 was proportional to the number of fingerlings stocked three years earlier; and,

(4) estimates of the harvest of age 1 fish were obtained by subtracting the age 2, age 3, or age 2 and age 3 combined portion of the annual harvest from the total harvest that took place in the given year.

Additional assumptions had to be made in order to estimate the performance of specific cohorts, and are footnoted in the brood tables.

RESULTS

Cohort Composition and Growth

Swanson strain rainbow trout cohorts stocked in late summer or fall as fingerlings (1-2 g) or in the spring as subcatchables (minimum weight 20 g) generally reach mean lengths from 186 to 233 mm in fall after their first summer in Quartz Lake (Peckham 1983) and from 166 to 212 mm in Birch Lake (Doxey 1984, 1989). Subcatchable and fingerling cohort length ranges overlap and means are similar by the end of their first summer in these lakes. These cohorts are the same age at this time (age 1) and they are from the same hatchery stock. The subcatchables are fingerlings held in the hatchery through the winter and reared to 20 g for spring releases. The undersized subcatchables released into Birch Lake at 8 g in spring, 1982 grew to an average size of 154 mm by fall of that year (Doxey 1983). When subcatchable rainbow trout were graded at the hatchery and the largest 10,000 fish in the raceway (mean weight 32 g) were stocked into Birch Lake in March, 1988, mean length in October, 1988 was 231 mm and the length range of 189 to 272 mm put the entire cohort over the 180 mm threshold and into the "catchable" size range.

Ennis-Alaska strain rainbow trout stocked as subcatchables into Birch Lake in 1979 grew to a mean length of 225 mm by fall (Doxey 1980). Peckham (1985) documented mean lengths in Quartz Lake at age 1 from 1973 to 1979 for cohorts of the various brood strains used prior to the Swanson strain. Mean lengths ranged from 264 to 335 mm.

Length frequency data collected in the creel is influenced by angler size preferences for larger fish. As a consequence, angler pressure can decrease

size ranges and mean lengths of stocking cohorts when exploitation is high. In late September and early October, age 2 cohorts of Swanson rainbow trout in Quartz Lake can have mean lengths ranging from 252 to 418 mm and an overall length range from 208 to 460 mm (Peckham 1985). Mean lengths of age 2 Swanson strain rainbow trout cohorts in Birch Lake have ranged from 227 to 321 mm with an overall length range of 198 to 367 mm.

In 1989, lengths of predominant rainbow trout cohorts sampled in Birch and Quartz lakes overlapped and were indistinguishable (Tables 4 and 5). However, in Birch Lake, March 1988 subcatchables were marked and could be distinguished from all other rainbow trout. Similar to Birch Lake, in Quartz Lake a small portion of the total rainbow trout population was comprised of distinguishable cohorts. These were 1989 fingerlings and April 1989 subcatchables (Table 5). In 1990, the lengths of predominant cohorts again overlapped in Quartz Lake (Table 6). As in 1989, the distinguishable cohort consisted of 1990 fingerlings. In 1990 at Birch Lake, 1990 subcatchables were distinguished from older rainbow trout. Mean length of subcatchable rainbow trout stocked into Birch Lake in May 1990 was 206 mm by 26 September, 1990 (Table 7). As mentioned earlier, rainbow trout in Chena, Birch, and Quartz lakes can reach large sizes. Lengths of rainbow trout weighing up to 4,000 g are over 600 mm.

Growth of rainbow trout was assessed at Chena Lake by intermittent test netting and from data collected during on-site creel surveys. Assessments conducted in 1984 and 1985 evaluated growth of cohorts of smaller fish stocked from 1982 through 1984 (Table 2). Growth of fingerlings was poor. A sample of 46 age 2 rainbow trout that had been stocked as fingerlings in 1983 had a length range of 126 to 172 mm, with a mean length of only 149 mm. Similarly, rainbow trout stocked as fingerlings in 1984 had a mean length of 127 mm by August, 1985 at age 1 (Doxey 1986). Overlapping length distributions among cohorts made it difficult to assess the growth of some cohorts of smaller fish (Hallberg 1985). Stockings of fingerlings and subcatchables were discontinued after 1984, and only 100 g rainbow trout were requested. There was some difficulty obtaining fish of this size from the hatchery, but in 1987, 1988, and 1989 most of the rainbow trout were near the specified size (Table 2).

Coho salmon have been captured and sampled for length in all three lakes in late summer and fall (Table 8). Mean length at age (and thus growth) of coho salmon stocked into Chena Lake has been less than mean length and growth of coho salmon stocked into Birch and Quartz lakes. The documented slow growth of coho salmon stocked in Chena Lake was the impetus leading to the decision to reduce the stocking density to 15,000 fish annually.

The majority of unharvested coho salmon become sexually mature and die at age 3. When length data from the three lakes is compared, coho salmon growth appears to be fastest in Quartz Lake. Growth rates of stocked coho salmon vary. For example, age 0 coho salmon stocked in Birch Lake in 1980 and 1981 grew to respective mean lengths of 112 and 118 mm by fall (Doxey 1982). In contrast, age 0 coho salmon grew to a mean length of 181 mm by fall 1984, entering the sport fishery after only one summer in the lake (Doxey 1985). In 1989, coho salmon lengths at age 0 were at the upper end of the historical spectrum in Quartz Lake (Table 9) and for age 1 were in the lower end of the historical ranges in both Birch and Quartz lakes (Tables 9, 10). In 1990, all

Table 4. Range and mean length of rainbow trout cohorts sampled from Birch Lake, 1989.

Date	Stocking Cohort	Number Sampled	Length Range(mm)	Mean Length(mm)	Standard Error
25 Aug	March 1988[a] Subcatchables	15	243 - 339	291	24
25 Aug	All other Rainbow Trout	1,104	87 - 590	203	42
25 Sept	March, 1988 Subcatchables	14	282 - 367	321	21
25 Sept	All other Rainbow Trout	1,523	110 - 381	226	32

[a] These fish were marked so they were distinguishable as a cohort.

Table 5. Range and mean length of rainbow trout cohorts sampled from Quartz Lake, 1989.

Date	Stocking Cohort	Number Sampled	Length Range (mm)	Mean Length (mm)	Standard Error
25 Aug	1989 Fingerling	53	53 - 94	62	-7
25 Aug[a]	1988 Fingerling & 5/89 Subcatchable	471	121 - 263	196	27
25 Aug	April 1989 Subcatchable	73	126 - 262	214	33
25 Aug	1987 & Earlier Fingerling	127	267 - 451	316	38
25 Aug	1988 & Earlier Subcatchable	60	267 - 432	303	28
04 Oct	1989 Fingerling	40	62 - 98	83	7
04 Oct[a]	1988 Fingerling & 5/89 Subcatchable	911	141 - 279	218	28
04 Oct	April 1989 Subcatchable	111	171 - 264	225	21
04 Oct	1987 & Earlier Fingerling	305	280 - 402	324	31
04 Oct	1988 & Earlier Subcatchable	90	265 - 396	308	31

[a] Cohorts overlapped in length but all are age 1 fish.

Table 6. Range and mean length of rainbow trout cohorts sampled from Quartz Lake, 1990.

Date	Stocking Cohort	Number Sampled	Length Range (mm)	Mean Length (mm)	Standard Error
23 Aug	1990 Fingerling	129	58 - 91	75	7
23 Aug	1989 Fingerling & 1990 Subcatchable	675	124 - 262	193	26
23 Aug	Older Rainbow Trout	95	267 - 431	347	39
27 Sept	1990 Fingerling	78	76 - 113	95	9
27 Sept	1989 Fingerling & 1990 Subcatchable	491	131 - 272	208	25
27 Sept	Older Rainbow Trout	86	282 - 462	359	38

Table 7. Range and mean length of rainbow trout cohorts sampled from Birch Lake, 1990.

Date	Stocking Cohort	Number Sampled	Length Range(mm)	Mean Length(mm)	Standard Error
23 Aug	1990 Subcatchables	1,188	103 - 234	183	19
25 Aug	Older Rainbow Trout	90	238 - 353	280	25
26 Sept	1990 Subcatchables	2,065	83 - 249	206	18
26 Sept	Older Rainbow Trout	156	250 - 436	298	35

Table 8. Historical summary of mean lengths (mm) of coho salmon sampled from Birch, Chena, and Quartz lakes.[a]

Age		Birch Lake	Chena Lake	Quartz Lake
0	Range of Mean Lengths[b]	106-209 mm	-----	106-140 mm
	Overall Length Range[c]	85-210 mm	-----	82-178 mm
1	Range of Mean Lengths[b]	179-213 mm	152-186 mm	192-254 mm
	Overall Length Range[c]	140-237 mm	162-200 mm	145-285 mm
2	Range of Mean Length[sb]	254-282 mm	207-221 mm	254-275 mm
	Overall Length Range[c]	229-294 mm	192-249 mm	233-322 mm
3	Range of Mean Length[sb]	289-412 mm	263 mm	289-358 mm
	Overall Length Range[c]	245-443 mm	253-275 mm	267-358 mm

[a] Sampling occurred primarily from August to October.

[b] Range of annual mean lengths over the years.

[c] Minimum and maximum length of fish for this year class from the combined length ranges reported over the years.

Table 9. Range and mean length of coho salmon cohorts sampled from Quartz Lake, 1989.

Date	Stocking Cohort	Age	Number Sampled	Length Range (mm)	Mean Length (mm)	Standard Error
25 Aug	1989 Fingerling	0	74	84 - 165	129	18
25 Aug	1988 Fingerling	1	21	167 - 211	182	11
25 Aug	1987 Fingerling	2	2	236 & 240	---	---
28 Sep	1989 Fingerling	0	133	94 - 178	140	17
28 Sep	1988 Fingerling	1	13	187 - 214	198	9
28 Sep	1987 Fingerling	2	1	254	---	---

Table 10. Range and mean length of coho salmon cohorts sampled from Birch Lake, 1989.

Date	Stocking Cohort	Age	Number Sampled	Length Range (mm)	Mean Length (mm)	Standard Error
21 Aug.	1989 Fingerling	0	85	81 - 120	100	1
21 Aug.	1988 Fingerling	1	26	143 - 197	175	3
25 Sept.	1989 Fingerling	2	49	101 - 134	117	1
22 Sept.	1988 Fingerling	3	51	140 - 217	179	3

coho salmon lengths were at the lower end of the historical ranges, but the smaller age 0 fish were at least partially the result of a change in hatchery methodology (Tables 11, 12). Coho salmon were stocked later in the season at a smaller size (Tables 1, 3).

Sampling efforts with fyke nets along the shoreline of Chena Lake in August, 1990 produced six coho salmon (and 416 rainbow trout). Length range of the coho salmon was 147 - 196 mm. A gill net set for one night at 8 m depth captured 12 coho salmon (length range 218 - 275 mm). Sampling with fyke nets in October produced 39 coho salmon (and 637 rainbow trout). Length range of the coho salmon was 162 - 249 mm. The coho salmon sample size in 1990 was insufficient to precisely define cohort composition or mean cohort length in 1990.

Abundance and Survival Estimates

Abundance and survival estimates for rainbow trout are presented for Birch and Quartz lakes. Although presence of stocked fish as indicated through test netting at Chena Lake has been documented, no abundance and survival estimates are available.

Birch Lake:

Abundance estimates for rainbow trout at Birch Lake have ranged from 19,551 (SE = 2,109) in 1989 to 58,269 (SE = 2,404) in 1986 (Table 13). In 1989, a total of 4,039 rainbow trout was captured during the mark-recapture experiment at Birch Lake. A total of 1,119 was marked in August (Table 14). In September, 1,507 rainbow trout were sampled, however this event was not used to estimate abundance as mixing was incomplete. The estimate was completed in early October where a total of 1,413 rainbow trout was examined for marks. Eighty were recaptures. Marked fish mixed with unmarked fish ($\chi^2 = 0.12$, DF = 2, P = 0.94) and as in previous years (Doxey 1988, 1989) cumulative length frequency distributions showed similarity between sampling events. The total abundance of rainbow trout in Birch Lake in late August, 1989, was estimated at 19,551 (SE = 2,019). Examination of length frequency analysis indicated that the population was comprised of four distinct cohorts. These cohorts were: (1) subcatchables stocked in March, 1988, 178 fish (SE = 51); (2) other large rainbow trout, 1,347 (SE = 932); (3) 100 g fish stocked in August, 1989, 4,045 (known abundance); and, (4) subcatchable rainbow trout stocked in March, 1989, 14,159 (SE = 2,075). The length frequency distribution of the 100 g trout stocked in August overlapped the modes of the distributions of the other cohorts, including unmarked large rainbow trout. However, an abundance estimate of the unmarked large rainbow trout cohort was developed based on the proportion of large rainbow trout with adipose clips. Those rainbow trout with adipose fin clips comprised 13.2% of the total rainbow trout population in 1988 (Doxey 1988). Assuming that survival rates to August 1989 of marked and unmarked fish present in the lake in August, 1988 were similar, the estimated abundance of 178 adipose clipped rainbow trout present in the lake in August 1989 represents 13.2% of the large rainbow trout population, which can then be calculated at 1,348 fish. The abundances of the adipose clipped fish, other large rainbow trout, and 100 g fish stocked in August subtracted from the total estimated abundance of 19,551 rainbow trout leave an estimate

Table 11. Range and mean length of coho salmon cohorts sampled from Birch Lake, 1990.

Date	Stocking Cohort	Age	Number Sampled	Length Range (mm)	Mean Length (mm)	Standard Error
22 Aug	1990 Fingerling	0	65	69 - 91	78	5
26 Sept	1990 Fingerling	0	102	85 - 121	105	8
26 Sept	1988 & 1989 Fingerling	1 & 2	33	178 - 263	231	20
26 Sept	1987 Fingerling	3	1	293		

Table 12. Range and mean length of coho salmon cohorts sampled from Quartz Lake, 1990.

Date	Stocking Cohort	Age	Number Sampled	Length Range (mm)	Mean Length (mm)	Standard Error
23 Aug	1990 Fingerling	0	90	73 - 101	86	5
23 Aug	1989 Fingerling	1	114	145 - 230	192	14
23 Aug	1987 & 1988 Fingerling	2 & 3	19	231 - 305	257	20
03 Oct	1990 Fingerling	0	119	85 - 128	106	8
03 Oct	1989 Fingerling	1	125	171 - 237	210	15
03 Oct	1988 Fingerling	2	19	241 - 263	254	8
03 Oct	1987 Fingerling	3	8	267 - 310	289	16

Table 13. Abundance estimates of rainbow trout in Birch Lake, 1986 - 1990.[a]

Year	Number Marked	Number Examined	Number Recaptured	Estimated Abundance	Standard Error
1986	4,324	6,610	478	58,269	2,404
1987	1,970	2,718	313	26,556	4,791
1988	1,090	3,135	110	25,766	2,858
1989	1,119	1,413	80	19,551	2,019
1990	1,279	949	44	27,022	3,903

[a] Exclusive of those year's fingerling stockings.

Table 14. Numbers of rainbow trout sampled and estimated abundance, Birch Lake, August 1989.

Cohort	Number Marked	Number Examined	Number Recaptured	Estimated Abundance	Standard Error
Total Population	1,119	1,413	80	19,551[a]	2,019[a]
1988 March Subcatchables				178[b]	51[b]
1989 August Lg. Subcatchables				4,045[c]	
Residual Rainbow Trout				1,348[d]	932[b]
1989 March Subcatchables				14,158[e]	2,075

[a] Total abundance estimate and standard error of combined cohorts was calculated using equations 1 and 2 from Doxey, 1989.

[b] Cohort abundance estimates and standard errors were derived from proportions of each cohort in the total sample, using equations 3 and 4 from Doxey (1989).

[c] Absolute number (stocked immediately before estimate).

[d] Based on proportion of 1988 March subcatchables present in total population in August, 1988 (Doxey 1988).

[e] Estimated by subtraction (after 1988 March subcatchables, 1989 August catchables, and residual rainbow trout were subtracted from the estimate of total abundance of 19,551).

of 14,158 survivors of the March 1989 stocking. This represents a survival rate to October of 28.3% (SE = 4.0) for rainbow trout stocked in March, 1989.

In 1990, a total of 2,228 rainbow trout was captured during the mark-recapture experiment at Birch Lake. A total of 1,279 was marked in August (Table 15). September sampling indicated that mixing of marked and unmarked fish was incomplete. The estimate was completed in early October when a total of 949 rainbow trout was examined for marks. Forty-four were recaptures. The rates of capture by area were not significantly different in the first event (χ^2 = 0.76, DF = 1, P = 0.38) or in the second event (χ^2 = 0.07, DF = 1, P = 0.79) and as in previous years (Doxey 1988, 1989) cumulative length frequency distributions showed similarity between sampling events. However, marked fish did not mix with unmarked fish (χ^2 = 9.3, DF = 2, P = 0.01). The total abundance of rainbow trout in Birch Lake in late August, 1990, was estimated to be 27,022 (SE = 3,903). The population was composed of two discernible cohorts, based on length frequency analysis. These cohorts were: (1) subcatchables stocked in May, 1990, 25,129 fish (SE = 3,631), and (2) large rainbow trout stocked in previous years, 1,347 (SE = 146). This represents a survival rate to fall of 52.0% (SE = 6.0) of the rainbow trout stocked in May, 1990.

The first survival rate to fall (to catchable size, generally a mean cohort length of 180 mm or larger) of Ennis-Alaska strain rainbow trout stocked as subcatchables in early June, 1979 was estimated from the abundance estimate. Survival rate was 22.2% (Table 16). Survival rates of Swanson strain subcatchable rainbow trout stocked in subsequent years ranged from 27% in 1982 to 80% in 1983 and appeared to be related to size at stocking and timing of stocking (Table 16). The estimates are referenced to the year in which the fish were stocked, which in the case of fingerlings is the year before the estimate was done. These abundance estimates represent recruitment to the fishery. The abundance of rainbow trout present in the lake from older cohorts was also estimated after 1985. These fish represented a smaller increment of the population. Percent survival of subcatchables in 1989 was estimated at 28.3%, and in 1990 was estimated to be 52.0% (Table 16).

Quartz Lake:

Abundance estimates for rainbow trout at Quartz Lake have ranged from 9,489 (SE = 455) in 1987 to 43,251 (SE = 5,320) in 1988 (Table 17). In 1986, Quartz Lake coho salmon abundance was estimated at 21,503 (SE = 4,379). Mixing of marked with unmarked fish was not evaluated. In other years, attempts to estimate abundance of coho salmon in Quartz Lake during rainbow trout abundance estimates produced unsuccessful results, because insufficient numbers of coho salmon were captured.

In 1989, a total of 2,148 rainbow trout was captured during the mark-recapture experiment at Quartz Lake. A total of 731 fish were marked in August (Table 18). The estimate was completed in early October when 1,417 rainbow trout were examined for marks, of which 41 were recaptures. Marked fish mixed with unmarked fish (χ^2 = 1.27, DF = 2, P = 0.53) and cumulative length frequency distributions showed similarity between sampling events. The total abundance (exclusive of the 1 g fingerlings stocked in August, 1989) of Quartz Lake

Table 15. Numbers of rainbow trout sampled and estimated abundance, Birch Lake, August 1990.

Cohort	Number Marked	Number Examined	Number Recaptured	Estimated Abundance	Standard Error
Total Population	1,279	949	44	27,022[a]	2,019[a]
1990 May Subcatchables				25,129[b]	3,631[b]
Residual Rainbow Trout				1,891[b]	146[b]

[a] Total abundance estimate and standard error of combined cohorts was calculated using equations 1 and 2 from Doxey, 1989.

[b] Cohort abundance estimates and standard errors were derived from proportions of each cohort in the total sample, using equations 3 and 4 from Doxey (1989).

Table 16. Estimated abundance and percent survival of rainbow trout (approximately 180 mm (TL) in Birch Lake, 1979 - 1990. Estimates are from the date of stocking to the fall of that year.

Stocking Date	Abundance Estimate	SE	Percent Survival	SE	Stocking Size Cohort	Size at Stocking (g)
5/24/79	22,533	2,815	22.2	3.0	Subcatchable	25
5/22/80	31,259	1,927	56.9	1.0	Subcatchable	25
5/19/81	22,560	3,636	54.7	7.0	Subcatchable	23
6/08/82	28,191[a]	983	27.0	1.0	Small Subcatchable	8
8/23/82	3,565	291	1.2	0.1	1982 Fingerling	1.3
6/17/83	15,585	---	80.0[b]	---	Subcatchable	45
8/29/83	2,727	122	2.2	0.1	1983 Fingerling	1.9
7/25/84	3,971	248	1.4	0.1	1984 Fingerling	1.7
1985	None Stocked in 1985					
6/11/86	56,191	2,372	67.4	3.0	Subcatchable	21
5/29/87	18,589	786	54.6	2.0	Subcatchable	25
3/17/88	4,068	947	40.6	9.0	Subcatchable	32
5/25/88	25,766	2,200	57.6	5.0	Subcatchable	25
4/03/89	14,159	2,075	28.3	4.0	Subcatchable	16
8/02/89	4,045[c]	---	100.0[b]	---	Catchable Subcatchable	113
6/7/90	25,129	3,631	52.0	0.6	Subcatchable	23

[a] These undersize subcatchables did not grow to 180 mm by fall, 1982.

[b] No survival estimate was attempted for these large fish. Size at stocking of appropriate other rainbow trout cohorts in the table was plotted against survival rate, and by interpolation survival of this cohort of 45 g fish was estimated to be 80%. Harvest of this cohort was consistent with this estimate.

[c] Fish stocked at this size have attained an average cohort length in excess of 180 mm in the hatchery and by default have 100% survival to catchable size in the lake.

Table 17. Abundance estimates of rainbow trout in Quartz Lake, 1986 - 1990.[a]

Year	Number Marked	Number Examined	Number Recaptured	Estimated Abundance	Standard Error
1986	786	131	20	10,497	2,649
1987	1,595	1,747	293	9,489	455
1988	1,372	1,985	62	43,251	5,320
1989	731	1,417	41	24,713	3,273
1990	807	1,138	32	27,887	4,615

[a] Exclusive of those year's fingerling stockings.

Table 18. Numbers of rainbow trout sampled and estimated abundance from the mark-recapture experiment at Quartz Lake, August, 1989.

Cohort	Number Marked	Number Examined	Number Recaptured	Estimated Abundance	Standard Error
All Rainbow Trout	731	1,417	41	24,713[a]	3,723[a]
1988 Fingerlings and May 1989 Subcatchables				15,935[b]	2,358[b]
April 1989 Subcatchables				2,116[b]	764[b]
Older Trout Stocked as Subcatchables				1,726[b]	288[b]
Older Trout Stocked as Fingerlings				4,970[b]	765[b]

[a] Total abundance estimate and standard error of combined cohorts was calculated using equations 1 and 2 from Doxey, (1989).

[b] Cohort abundance estimates and standard errors were derived from proportions of each cohort in the total sample, using equations 3 and 4 in Doxey (1989).

rainbow trout during late August, 1989 was estimated to have been 24,713 fish (SE = 3,723). The abundance estimate for fish stocked in April, 1989 as subcatchables represents a survival rate to October of 9.2% (SE = 2.0).

In 1990, a total of 2,822 rainbow trout was captured during the mark-recapture experiment at Quartz Lake. A total of 807 was marked in August (Table 19). Sampling of 877 rainbow trout in September indicated that mixing of marked and unmarked fish was incomplete. The estimate was completed in early October when a total of 1,138 rainbow trout was examined for marks, of which 32 were recaptures. Marked fish mixed (χ^2 = 1.84, DF = 2, P = 0.40) and cumulative length frequency distributions showed similarity between sampling events. The total abundance (exclusive of the 1 and 2 g fingerlings stocked in July and August, 1990) of Quartz Lake rainbow trout during late August, 1990 was estimated to have been 27,887 fish (SE = 4,615). Survival rates of rainbow trout to October of the first full summer in Quartz Lake ranged from 9.2% to 28.0% for subcatchables and was 7% for fingerlings (Table 20).

Estimated Harvest of Introduced Species

The SWHS (Mills 1979-1990) has provided annual estimates of harvest since 1977 (Tables 21 and 22). Statewide harvest survey estimates are for a calendar year, dividing the winter fishery into two portions between December and January. Thus the annual estimate includes the last portion of one ice fishing season (from January 1 to when the ice is unsafe in April), the summer fishery, and the first part of the next ice fishing season (from freeze-up in October to December 31). Periodic on-site creel surveys have been undertaken at the three lakes. These surveys have tended to confirm harvests reported in the SWHS. They provided season-specific harvest and effort information and allowed sampling of harvested fish, crucial to cohort identification. Some demographic and angler opinion information has also been obtained.

Birch Lake:

Estimated rainbow trout harvest at Birch Lake ranged from 1,850 in 1977 (from 1973-1976 virtually no rainbow trout stockings occurred) to 21,622 in 1981 (from 1978-1980 subcatchable rainbow trout were stocked in early summer). From 1981 to 1986, harvests declined from 21,622 to 8,723 rainbow trout and the fishery was largely based on fingerling stockings (Table 16). The fishery began to rebound after 1986, and was largely supported by stockings of subcatchable sized rainbow trout. Coho salmon harvest has ranged from none in 1980 to 8,686 in 1983 (Table 22).

Angler effort ranged from 7,804 days fished in 1979 to 17,036 in 1981 (Table 23). From 1979 through 1986 on-site summer creel surveys were conducted at Birch Lake, and on-site winter creel surveys were conducted from the winter of 1979-1980 through the winter of 1984-1985 and during the winter of 1986-1987. Harvest and effort was described as catch in fish per hour (CPUE). CPUE for rainbow trout in summer (Table 24) ranged from 0.55 in 1981 (Doxey 1982) to 0.16 in 1985 (Doxey 1986) and 1986 (Baker 1987). CPUE for rainbow trout in winter ranged from 0.20 during the winter of 1984-1985 to 0.99 during the winter of 1986-1987 (Baker 1987), and for coho salmon ranged from 0 during the winter of 1979-1980 (Doxey 1981) to 0.68 during the winter of 1984-1985 (Doxey

Table 19. Numbers of rainbow trout sampled and estimated abundance from the mark-recapture experiment at Quartz Lake, August, 1990.

Cohort	Number Marked	Number Examined	Number Recaptured	Estimated Abundance	Standard Error
All Rainbow Trout	807	1,138	32	27,887[a]	4,615[a]
1989 Fingerlings and May 1990 Subcatchables				23,425[b]	3,886[b]
Older Trout				4,449[b]	786[b]

[a] Total abundance estimate and standard error of combined cohorts was calculated using equations 1 and 2 from Doxey, 1989.

[b] Cohort abundance estimates and standard errors were derived from proportions of each cohort in the total sample, using equations 3 and 4 in Doxey (1989).

Table 20. Abundance and percent survival of rainbow trout in Quartz Lake 1986 - 1990.[a]

Stocking Date	Abundance Estimate	SE	Percent Survival	SE	Stocking Size Cohort	Size at Stocking (g)
5/27/87	1,419	91	14.2	1.0	Subcatchable	25
8/26/87	28,718	3,596	7.0	2.0	Fingerling	2.3
6/2/88	13,871	1,915	28.0	4.0	Subcatchable	25
8/12/88	Combined[a]				Fingerling	1
5/31/89	15,935	3,358			Subcatchable[b]	26
4/24/89	2,116	754	9.2	2.0	Subcatchable[c]	17-36
8/7/89	Combined[e]				Fingerling	1.2
6/7/90	23,425	3,886			Subcatchable	23

[a] Estimates are from the date of stocking to the fall of that year.
[b] 1988 fingerling and 1989 May subcatchable cohorts were indistinguishable by fall, 1989.
[c] Subcatchables stocked in May, 1989.
[d] Subcatchables stocked through the ice in April, 1989.
[e] 1989 fingerling and 1990 May subcatchable cohorts were indistinguishable by fall, 1990.

Table 21. Harvest of rainbow trout, Birch, Chena, and Quartz lakes.[a]

Year	Birch Lake	Quartz Lake	Chena Lake
1977	1,850	2,634	
1978	5,126	512	
1979	4,190	273	
1980	18,727	129	
1981	21,622	1,869	
1982	18,385	5,003	
1983	16,963	1,574	
1984	12,123	5,491	12,032
1985	10,161	12,398	9,660
1986	8,723	14,778	7,001
1987	9,981	10,106	5,220
1988	18,390	25,175	9,877
1989	16,420	27,356	11,968

[a] Data source is Mills (1979 - 1990).

Table 22. Harvest of coho salmon, Birch, Chena, and Quartz lakes.[a]

Year	Birch Lake	Quartz Lake	Chena Lake
1977	5,697		
1978	6,354	14,892	
1979	132	34,787	
1980	0	23,316	
1981	2,549	50,965	
1982	6,275	35,380	
1983	8,686	24,042	
1984	6,049	17,069	5,036
1985	4,672	26,312	9,485
1986	4,950	16,613	1,778
1987	6,719	15,449	1,398
1988	5,548	19,009	2,401
1989	4,892	9593	2,468

[a] Data source is Mills (1978 - 1990).

Table 23. Annual angling effort in days fished for Birch, Quartz, and Chena Lakes; 1977 - 1989.[a]

Year	Days Fished		
	Birch Lake	Quartz Lake	Chena Lake
1977	8,118	6,317	
1978	8,982	6,845	
1979	7,804	10,150	
1980	17,036	13,994	
1981	14,233	19,599	
1982	16,677	18,254	
1983	15,882	14,162	
1984	13,170	15,922	11,044
1985	14,444	16,456	11,288
1986	9,969	18,486	8,853
1987	15,375	20,410	9,472
1988	15,607	19,391	9,404
1989	14,284	18,299	16,180

[a] Data source is Mills (1978 - 1990).

Table 24. Birch Lake seasonal harvest per hour for rainbow trout and coho salmon, 1979 - 1985.

Summer			Winter[a]		
Year	Rainbow Trout	Coho Salmon	Year	Rainbow Trout	Coho Salmon
1979	0.27	0.008	1979-1980	0.82	0.00
1980	0.34	0.00	1980-1981	0.91	0.01
1981	0.55	0.15	1981-1982	0.88	0.33
1982	0.46	0.05	1982-1983	0.60	0.68
1983	0.50	0.05	1983-1984	0.57	0.02
1984	0.28	0.00	1984-1985	0.29	0.68
1985	0.16	0.12	1985-1986		
1986	0.16	0.03	1986-1987	0.99	0.48

[a] Winter creel census took place for varying lengths of time during different winters.

1986). To better assess cohort impact upon CPUE and harvest, results from Birch Lake on-site creel surveys have been described in terms of a "fishing year", from freeze-up of one year through the entire ice fishing season and summer fishery of the next year, ending again in early fall (Doxey 1985). This allows the winter fishery to be evaluated as a single event, and enables better evaluation of cohorts of rainbow trout that typically grow to catchable size (mean length 180 mm) by late summer and recruit to the ice fishery immediately following. These cohorts contribute the majority of the rainbow trout to the winter fishery, and up to half of the rainbow trout harvested during such a fishing year are caught during the winter fishery (Doxey 1982; 1983). Estimated harvests of rainbow trout during winters 1979-1980 through 1981-1982 (the highest documented winter harvests) were 10,358, 11,003, and 10,348, respectively. Rainbow trout harvest declined to 6,917 during the winter of 1982-1983 in response to the stocking of undersized subcatchables in spring of 1982 (Table 1) and to 6,763 in the winter of 1983-1984, the last winter during which harvest was estimated (Doxey 1985). By the winter of 1984-1985 the fishery was supported primarily by coho salmon (Doxey 1986).

Chena Lake:

The estimated annual harvest of rainbow trout from 1984 through 1989 at Chena Lake (Table 21) ranged from a high of 12,032 in 1984, (when the lake recreation area had just been opened to the public after having been stocked since 1982) to 5,220 in 1987. The harvest increased to 9,877 in 1988 and to 11,968 in 1989. On-site creel surveys have been conducted during two summers and two winters. Summer harvest rate for rainbow trout was 0.82 fish per hour in 1985 (Hallberg 1986) and 0.93 in 1986 (Clark and Ridder 1987). Reported winter harvest rate was 0.64 in the winter of 1986-1987 (Clark and Ridder 1987). Rainbow trout harvest rate from February to April of 1989 was 0.43 fish per hour.

Annual coho salmon harvest ranged from 1,398 in 1987 to 9,485 in 1985 (Table 21). Harvest rate was 0.70 fish per hour in summer 1985, 0.14 in summer 1987, 0.77 in winter 1986-1987, and 0.67 in February - April 1989. Angler effort at Chena Lake has ranged from 8,853 days fished in 1986 to 16,180 days in 1989 (Table 23).

Quartz Lake:

Annual rainbow trout harvest in Quartz Lake from 1977 through 1989 ranged from 129 in 1980 (during a period when insufficient numbers of rainbow trout were available for stocking) to 27,356 in 1989 (Table 21). On-site summer creel surveys began in 1973 and continued on an annual basis until 1987. Summer CPUE for rainbow trout was 0.35, 0.43, and 0.42 during the years 1973, 1974, and 1975 (Table 25). Subsequently the catch rate plunged in response to reductions in availability of rainbow trout. Although sufficient rainbow trout fingerlings had been stocked in the mid-1970's to support a higher harvest (Table 3), probable poor survivals of those rainbow trout also contributed to poor catch rates. From 1977 to 1984 CPUE ranged from 0.09 to 0.003 rainbow trout per hour. SWHS estimates for that period report correspondingly low annual rainbow trout harvests (Table 21). By 1986, the summer harvest rate had climbed to 0.30 rainbow trout per hour but it declined

Table 25. Quartz Lake seasonal harvest per hour for rainbow trout and coho salmon, 1973 - 1987.

Summer			Winter[a]		
Year	Rainbow Trout	Coho Salmon	Year	Rainbow Trout	Coho Salmon
1973	0.35		1973-1974		
1974	0.43		1974-1975		
1975	0.42		1975-1976		
1976	0.13		1976-1977	0.24	
1977	0.09		1977-1978		
1978	0.04	1.03	1978-1979		
1979	0.01	1.39	1979-1980	0.01	0.52
1980	0.003	0.93	1980-1981	0.02	0.64
1981	0.025	1.59	1981-1982	0.14	0.55
1982	0.06	0.55	1982-1983	0.03	1.38
1983	0.003	0.40	1983-1984	0.05	0.54
1984	0.05	0.11	1984-1985	0.15	0.49
1985	0.14	0.58	1985-1986		
1986	0.30	0.29	1986-1987	0.40	0.74
1987	0.16	0.52	1987-1988		

[a] Winter creel census took place for varying lengths of time during different winters.

to 0.16 fish per hour in 1987, the last year during which summer on-site creel surveys were conducted. Rainbow trout harvest data collected during winter fisheries shows similar trends (Table 25).

Coho salmon were first harvested in Quartz Lake in 1978 (Table 22) after the initial stocking in 1977 (Table 3). Annual harvest ranged from 14,892 in 1978 to a peak of 50,965 in 1981, a year during which no rainbow trout were stocked and few were present in the lake. Coho salmon harvest stabilized at a somewhat lower level from 1983 to 1988, ranging from 26,312 to 15,449. Harvest decreased in 1989 to 9,593 coho salmon. Summer harvest rates from 1980 to 1987 for coho salmon ranged from 1.59 to 0.11 fish per hour, and the range of winter harvest rates was 1.38 to 0.49 fish per hour (Table 25). Angler days at Quartz Lake has ranged from 6,317 days fished in 1977 to 20,410 days in 1987 (Table 23).

Brood Tables

Rainbow trout and coho salmon stocking densities and harvest estimates from the SWHS were combined with cohort survival and abundance estimates to provide estimates of the annual maximum number of fish from each cohort that were available for harvest. The resulting brood tables project the contribution of each cohort to the annual harvest. Since natural mortality was not known, it was omitted from the estimates.

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. Rainbow trout stocked as catchables entered the fishery immediately, but because they were stocked in mid-year they were assumed to provide only half of the harvest that such a cohort would if present in the lake for the full 12 months.

Estimated percent return to the creel from cohorts of rainbow trout stocked as fingerlings in Birch Lake ranged from 0.86% in 1984 to 11.06% in 1974 (Table 26; Part III). Return to the creel of rainbow trout stocked as fingerling at Chena Lake was estimated to have ranged from 1.29% to 2.04% (Table 27; Part III). Returns to the creel of rainbow trout stocked as fingerling at Quartz Lake were small (<0.80%; Table 28; Part III). Estimated contribution of subcatchable rainbow trout ranged from 3.5% to 66.4% at Birch Lake (Table 26); from 34.5% to 91.9% at Chena Lake (Table 22); and from 1.3% to 15.0% at Quartz Lake (Table 28). Catchables were estimated to have contributed 100% at Birch Lake (Table 26); and 30.37% at Chena Lake (Table 27). Complete harvest estimates for catchable rainbow trout were only available for years prior to 1988.

Peak harvest from cohorts of coho salmon occurred in the second year after stocking, and declined rapidly in the next two years. Estimated coho salmon return to the creel at Birch Lake ranged from 7.1% to 64.4% (Table 29; Part II); at Chena Lake ranged from 5.5% to 27.1% (Table 30; Part II); and, at Quartz Lake ranged from 4.7% to 82% (Table 31; Part II).

Table 26. Estimated sport fishery harvests of rainbow trout at Birch Lake, 1977-1989.

Part I. Estimated contributions of rainbow trout to the annual creels of Birch Lake by stocking cohort and size at stocking.[a]

Harv. Year	Number of Fish Harvested	Stocking Year and Number of Fingerlings Harvested						Stocking Year and Number of Subcatchables Harvested						Stocking Year and Number of Catchables Harvested	
		Age 1	No. Fish	Age 2	No. Fish	Age 3	No. Fish	Age 1	No. Fish	Age 2	No. Fish	Age 3	No. Fish	Age 1	No. Fish
1977	1,850					1974	1,084							1976	766
1978	5,126	1977	5,126												
1979	4,190	1978	829	1977	1,400			1979	1,961						
1980	18,727			1978	3,741	1977	1,680	1980	4,457	1979	8,849				
1981	21,622					1978	2,028	1981	3,756	1980	11,040	1979	4,798		
1982	18,385							1982	0[b]	1981	11,067	1980	7,318		
1983	16,963	1982	441					1983	1,919	1982	9,797	1981	4,806		
1984	12,123	1983	323	1982	1,114					1983	4,847	1982	5,839		
1985	10,161	1984	872	1983	1,701	1982	1,418					1983	6,170		
1986	8,723			1984	1,143	1983	287	1986	7,293						

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Table 26. (Page 2 of 4).

Part I. Estimated contributions of rainbow trout to the annual creels of Birch Lake by stocking cohort and size at stocking.[a]

Harv. Year	Number of Fish Harvested	Stocking Year and Number of Fingerlings Harvested						Stocking Year and Number of Subcatchables Harvested						Stocking Year and Number of Catchables Harvested	
		Age 1	No. Fish	Age 2	No. Fish	Age 3	No. Fish	Age 1	No. Fish	Age 2	No. Fish	Age 3	No. Fish	Age 1	No. Fish
1987	9,981					1984	310	1987	1,078	1986	8,593				
1988	18,390							1988	2,446	1987	4,828	1986	11,116		
1989	16,420							1989	1,751	1988	9,157	1987	4,754	1989	758

[a] Estimates are based upon the assumption that the proportion of each stocking cohort in the harvest each year is the same as the estimated proportion of catchable sized (180 mm +) fish of that cohort in the population. The estimated number of fish in each stocking cohort each year is based upon the number originally stocked multiplied by a survival rate estimate (see Part II) minus numbers of fish in the cohort estimated to have been harvested in earlier years. Fingerling and subcatchable sized rainbow trout in Birch Lake do not reach catchable size until the eighth month of the calender year, therefore first fishing year numbers are arbitrarily reduced by a factor of 0.33 prior to estimating proportions. Catchable rainbow trout are not stocked until the sixth month of the calender year, therefore, first fishing year numbers are arbitrarily reduced by 0.50 prior to estimating proportions.

[b] This group of age 1 rainbow trout stocked at a mean weight of 8.1 g in 1982 did not achieve catchable size until 1983; contribution to 1982 fishery was zero.

-continued-

Table 26. (Page 3 of 4).

Part II. Estimated numbers of stocked rainbow trout that survived to catchable size (80 g) in Birch Lake.

Stocking Cohorts			Estimated Survival Rate	Estimated Number of Catchable Sized Fish	1st Year When Fish Reached Catchable Size
Year	Size	Number			
1974	Fingerling	9,800	0.111[e]	1,084	1975
1977	Fingerling	114,249	0.100[d]	10,425	1978
1978	Fingerling	95,079	0.100[d]	9,508	1979
1982	Fingerling	298,500	0.012	3,582	1983
1983	Fingerling	125,218	0.022	2,755	1984
1984	Fingerling	269,963	0.014	3,779	1985
1979	Subcatchable	101,314	0.222	22,492	1979
1980	Subcatchable	55,074	0.569	31,337	1980
1981	Subcatchable	50,654	0.547	27,708	1981
1982	Subcatchable	97,261[a]	0.270	26,260	1983[a]
1983	Subcatchable	19,482	0.800[c]	15,586	1983
1986	Subcatchable	83,368	0.674	56,190	1986
1987	Subcatchable	34,039	0.546	18,585	1987
1988	Subcatchable	54,723	0.491[b]	26,869	1988
1989	Subcatchable	50,000	0.283	14,150	1989
1976	Catchable	766	1.000	766	1976
1989	Catchable	4,045	1.000	4,045	1989

[a] This group of age 1 rainbow trout stocked at a mean weight of 8.1 g in 1982 did not achieve catchable size until 1983.

[b] Mean survival of fish stocked in March and June, 1988.

[c] Estimated from plot of size at stocking versus estimated survivals.

[d] Arbitrarily estimated at 10%.

[e] Assuming all catchables stocked in 1976 survived and were caught, the remainder of the 1977 harvest was comprised of age 3 rainbow trout stocked as fingerlings in 1974. Hence survival was at least 11.06%.

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Table 26. (Page 4 of 4).

Part III. Total harvest and percent return to the creel of rainbow trout at Birch Lake, by stocking cohort.

Stocking Cohort			Year of Harvest and Number Harvested by Age						Total	Percent Return To
			Age 1		Age 2		Age 3			
Year	Size	Number	Year	No.	Year	No.	Year	No.	Harvest	Creel
1974	Fing.[a]	9,800	1975	---	1976	---	1977	1,084	1,084[d]	11.06[f]
1977	Fing.	104,249	1978	5,126	1979	1,400	1980	1,680	8,206	7.87
1978	Fing.	95,079	1979	829	1980	3,741	1981	2,028	6,598	6.94
1982	Fing.	298,500	1983	441	1984	1,114	1985	1,418	2,973	7.00
1983	Fing.	125,218	1984	323	1985	1,701	1986	287	2,311	1.85
1984	Fing.	269,963	1985	872	1986	1,143	1987	310	2,325	0.86
1979	Sub.[b]	101,314	1979	1,961	1980	8,849	1981	4,798	15,608	15.41
1980	Sub.	55,074	1980	4,457	1981	11,040	1982	7,318	22,815	41.42
1981	Sub.	50,654	1981	3,756	1982	11,067	1983	4,806	19,629	38.75
1982	Sub.	97,261	1982	0	1983	9,797	1984	5,839	15,636	16.08
1983	Sub.	19,482	1983	1,919	1984	4,847	1985	6,170	12,936	66.40
1986	Sub.	83,368	1986	7,293	1987	8,593	1988	11,116	27,002	32.39
1987	Sub.	34,039	1987	1,078	1988	4,828	1989	4,754	10,660	31.32
1988	Sub.	54,723	1988	2,446	1989	9,157	1990	---	11,603[d]	21.20[d]
1989	Sub.	50,000	1989	1,751	1990	---	1991	---	1,751[e]	3.50[e]
1976	Catch.[c]	766	1976	0	1977	766	1978	0	766	100.00
1989	Catch.	4,045								

[a] Fing. = Fingerlings.
[b] Sub. = Subcatchables.
[c] Catch. = Catchables.
[d] Minimum estimate because 1 year of harvest statistics is not included in the estimate.
[e] Minimum estimate because 2 years of harvest statistics is not inlcuded in the estimate.
[f] Partial estimate.

Table 27. Estimated sport fishery harvests of rainbow trout at Chena Lake, 1984-1989.

Part I. Estimated contributions of rainbow trout to the annual creels of Chena Lake by stocking cohort and size at stocking.[a]

Total Annual Harvest		Stocking Year and Number of Fingerlings Harvested						Stocking Year and Number of Subcatchables Harvested						Stocking Year and Number of Catchables Harvested					
		Age 1	No.	Age 2	No.	Age 3	No.	Age 1	No.	Age 2	No.	Age 3	No.	Age 1	No.	Age 2	No.	Age 3	No.
Year	No. Fish[b]		Fish		Fish		Fish		Fish		Fish		Fish		Fish		Fish		Fish
1984[c]	12,032	1983	314	1982	417			1984	4,744			1982	5,557						
1985	9,990	1984	314	1983	300	1982	0	1985	4,830	1984	4,546								
1986	7,001			1984	239	1983	0	1986	3,258	1985	3,506	1984	0						
1987	5,220					1984	62			1986	3,535	1985	907	1987	716				
1988	9,877											1986	3,240	1988	2,513	1987	4,124		
1989	11,966													1989	2,877	1988	5,206	1987	3,883

[a] Estimates are based upon the assumption that the proportion of each stocking cohort in the harvest each year is the same as the estimated proportion of catchable sized (180 mm +) fish of that cohort in the population. The estimated number of fish in each stocking cohort each year is based upon the number originally stocked multiplied by a survival rate estimate (see Part II) minus numbers of fish in the cohort estimated to have been harvested in earlier years. Fingerling and subcatchable sized rainbow trout do not reach catchable size until the eighth month of the calender year, therefore first fishing year numbers arbitrarily are reduced by 0.33 prior to estimating proportions. Catchable rainbow trout are not stocked until the sixth month of the calender year, therefore first fishing year numbers are arbitrarily reduced by 0.50 prior to estimating proportions.

[b] Data source of annual harvests is Mills 1985-1990.

[c] In 1984, the fishery first opened for public use in early summer, hence, first fishing year numbers for the 1983 fingerling and the 1984 subcatchable cohorts were reduced by 0.50.

-continued-

Table 27. (Page 2 of 3).

Part II. Estimated numbers of stocked rainbow trout that survived to catchable size (80 g) in Chena Lake.

Size At Stocking	Year Stocked	Number Stocked	Estimated Survival Rate To Catchable Size[a]	Estimated Number Surviving	Year When Fish Reached Catchable Size
Fingerling:					
	1982	20,417	0.02	408	1983
	1983	30,691	0.02	614	1984
	1984	47,529	0.02	950	1985
Subcatchable:					
	1982	7,134	0.90	6,420	1982
	1984	18,579	0.50	9,290	1984
	1985	15,800	0.80	14,220	1985
	1986	29,102	0.90	26,192	1986
Catchable:					
	1987	25,406	1.00	25,406	1987
	1988	30,091	1.00	34,091	1988
	1989	30,481	1.00	30,481	1989

[a] Survival rates are based upon the relationship between size at stocking and estimated survival to catchable size for rainbow trout stocked into Birch Lake between 1979 and 1990.

-continued-

Table 27. (Page 3 of 3).

Part III. Total harvest and percent return to the creel of rainbow trout at Chena Lake, by stocking cohort.

Stocking Cohort			Year of Harvest and Number Harvested by Age						Total	Percent Return To
			Age 1		Age 2		Age 3			
Year	Size	Number	Year	No.	Year	No.	Year	No.	Harvest	Creel
1982	Fing.[a]	20,417			1984	417	1985	06	417	2.04
1983	Fing.	30,691	1984	314	1985	300	1986	0	614	2.00
1984	Fing.	47,529	1985	314	1986	237	1987	62	613	1.29
1982	Sub.[b]	7,134					1984	6,557	6,557	91.91
1984	Sub.	18,579	1984	4,744	1985	4,546	1986	0	7,290	50.00
1985	Sub.	15,800	1985	4,830	1986	3,506	1987	907	9,243	58.50
1986	Sub.	29,102	1986	3,258	1987	3,535	1988	3,240	10,033	34.48
1987	Catch.[c]	25,406	1987	716	1988	4,124	1989	2,877	7,717	30.37
1988	Catch.	30,091	1988	2,513	1989	5,206			7,719[d]	25.65[d]
1989	Catch.	30,481	1989	2,877					2,877[e]	9.44[e]

[a] Fing. = Fingerlings.
[b] Sub. = Subcatchables.
[c] Catch. = Catchables.
[d] Minimum estimate because 1 year of harvest statistics is not included in the estimate.
[e] Minimum estimate because 2 years of harvest statistics is not included in the estimate.

Table 28. Estimated sport fishery harvests of rainbow trout at Quartz Lake, 1977-1989.

Part I. Estimated contributions of rainbow trout to the annual creels of Quartz Lake by stocking cohort and size at stocking.[a]

Total Annual Harvest		Stocking Year and Number of Fingerlings Harvested						Stocking Year and Number of Sub-catchables Harvested					
		Age	No.	Age	No.	Age	No.	Age	No.	Age	No.	Age	No.
Year	No. Fish[b]	1	Fish	2	Fish	3	Fish	1	Fish	2	Fish	3	Fish
1977	2,634	1976	301	1975	1,231	1974	1,086	1977	16				
1978	512	1977	48	1976	199	1975	254			1977	19		
1979	273			1977	113	1976	152					1977	8
1980	129	1979	12			1977	117						
1981	1,869	1980	877	1979	992								
1982	5,003			1980	4,013	1979	990						
1983	1,574	1982	1,273			1980	301						
1984	5,491	1983	1,481	1982	4,010								
1985	12,398	1984	2,468	1983	5,799	1982	4,131						
1986	14,778	1985	3,031	1984	7,616	1983	4,131						
1987	10,106	1986	2,098	1985	5,140	1984	2,727	1987	141				
1988	25,175	1987	5,143	1986	10,388	1985	6,520	1988	2,426	1987	698		
1989	27,356	1988	1,510	1987	10,205	1986	3,768	1989	6,807	1988	4,812	1987	254

[a] Estimates are based upon the assumption that the proportion of each stocking cohort in the harvest each year is the same as the estimated proportion of catchable sized (180 mm+) fish of that cohort in the population. The estimated number of fish in each stocking cohort each year is based upon the number originally stocked multiplied by a survival rate estimate (see Part II) minus numbers of fish in the cohort estimated to have been harvested in earlier years. Fingerling and subcatchable sized rainbow trout do not reach catchable size until the eighth month of the calender year, therefore first fishing year numbers are arbitrarily reduced by 0.33 prior to estimating proportions.

[b] Data source of annual harvests is Mills 1978-1990.

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Table 28. (Page 2 of 3).

Part II. Estimated numbers of stocked rainbow trout that survived to catchable size (80 g) in Quartz Lake.

Size At Stocking	Year Stocked	Number Stocked	Estimated Survival Rate To Catchable Size[a]	Estimated Number Surviving	Year When Fish Reached Catchable Size
Fingerling:					
	1974	185,100	0.07	12,957	1975
	1975	209,900	0.07	14,693	1976
	1976	155,300	0.07	10,871	1977
	1977	110,500	0.07	7,735	1978
	1978	---	---	---	---
	1979	32,858	0.07	2,300	1980
	1980	87,559	0.07	6,129	1981
	1981	---	---	---	---
	1982	226,600	0.07	15,862	1983
	1983	233,272	0.07	16,329	1984
	1984	273,567	0.07	19,150	1985
	1985	287,376	0.07	20,116	1986
	1986	301,877	0.07	21,131	1987
	1987	407,917	0.07	28,554	1988
	1988	150,000	0.07*	10,500	1989
Subcatchable:					
	1977	3,301	0.171	566	1977
	1987	10,000	0.142*	1,420	1987
	1988	48,094	0.280*	13,466	1988
	1989	47,323	0.092*	4,354	1989

[a] Estimates with * are based upon population estimates (Doxey 1988 and this report). Others are mean rates based upon population estimates.

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Table 28. (Page 3 of 3).

Part III. Total harvest and percent return to the creel of rainbow trout at Quartz Lake, by stocking cohort.

Stocking Cohort			Year of Harvest and Number Harvested by Age						Total	Percent Return To
			Age 1		Age 2		Age 3			
Year	Size	Number	Year	No.	Year	No.	Year	No.	Harvest	Creel
1974	Fing.[a]	185,100					1987	1,086	1,086	0.59
1975	Fing.	209,900			1977	1,231	1978	254	1,485	0.71
1976	Fing.	155,300	1977	301	1978	199	1979	152	652	0.42
1977	Fing.	110,500	1978	48	1979	113	1980	117	278	0.25
1978	Fing.	---								
1979	Fing.	32,854	1980	12	1981	992	1982	990	1,994	6.1
1980	Fing.	87,559	1981	877	1982	4,013	1983	301	5,191	5.9
1981	Fing.									
1982	Fing.	226,600	1983	1,273	1984	4,010	1985	4,131	9,414	4.2
1983	Fing.	233,272	1984	1,481	1985	5,799	1986	4,131	11,411	4.9
1984	Fing.	273,567	1985	2,468	1986	7,616			10,084	3.7
1985	Fing.	287,376	1986	3,031	1987	5,140	1988	6,520	14,691	5.1
1986	Fing.	301,877	1987	2,098	1988	10,388	1989	3,768	16,254	5.4
1987	Fing.	407,917	1988	5,143	1989	10,205			15,348	3.8
1988	Fing.	150,000	1989	1,510					1,510	1.0
1977	Sub.[b]	3,301	1977	16	1978	19	1979	8	43	1.3
1987	Sub.	10,000	1987	141	1988	698	1989	254	1,093	11.0
1988	Sub.	48,094	1988	2,426	1989	4,812			7,238	15.0
1989	Sub.	47,323	1989	6,807					6,807	14.0

[a] Fing. = Fingerling.
[b] Sub. = Subcatchables.

Table 29. Estimated sport fishery harvests of coho salmon at Birch Lake, 1977-1989.

Part I. Estimated contributions of coho salmon to the annual creels of Birch Lake by stocking cohort.

Total Annual Harvest		Estimated Contribution to Harvest by Stocking Cohort (Year and Size: F = fingerlings & S = subcatchables)					
		Age 1	No. of	Age 2	No. of	Age 3	No. of
Year	No. Fish[a]	Cohort	Fish	Cohort	Fish	Cohort	Fish
1977	5,687	1976 F	4,463[b]	1975 F	685[c]	1974 F	133[d]
						1975 S	406[d]
1978	6,354			1976 F	6,126[b]	1975 F	228[d]
1979	132					1976 F	132[e]
1980	0						
1981	2,549	1980 F	2,549[e]				
1982	6,275	1981 F	5,000[b]	1980 F	1,275[c]		
1983	8,686			1981 F	8,261[b]	1980 F	425[c]
1984	6,049					1981 F	6,049[e]
1985	4,672	1984 F	4,672[e]				
1986	4,950	1985 F	2,614[b]	1984 F	2,336[c]		
1987	6,719	1986 F	4,633[b]	1985 F	1,307[c]	1984 F	779[c]
1988	5,548	1987 F	2,796[b]	1986 F	2,316[c]	1985 F	436[c]
1989	4,982	1988 F	2,812[b]	1987 F	1,398[c]	1986 F	772[c]

[a] Data source of annual harvests is Mills 1978-90.

[b] These estimates are the result of the subtraction of the age 2, age 3, or age 2 and 3 combined portion of the annual harvest (obtained as described in footnotes c and d below) from the total harvest that took place in the given year.

[c] These estimates are based upon the assumption that 60% of the harvest from a cohort are harvested at age 1, 30% are harvested at age 2, and 10 % are harvested at age 3.

[d] These estimates are based upon one and/or two assumptions: (a) the ratio of the survival rates of fingerling and subcatchable sized coho salmon to catchable size is similiar to that of rainbow trout in Birch Lake (mean survival of fingerlings = 1.6%, subcatchables = 46 %, and ratio = 30:1); (b) the contribution of age 3 coho salmon to the harvests in 1977 through 1979 are proportional to the number of fingerlings stocked three years earlier.

[e] Only a single age class contributed to the harvest in these years.

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Table 29. (Page 2 of 2).

Part II. Estimated total sport harvests of stocked cohorts of coho salmon from Birch Lake.

Stocking Cohort (Year, Cohort [F=fingerling & S=subcatchable], & No. Stocked)	Year Harvested-Estimated Number of Age 1 Fish	Year Harvested-Estimated Number of Age 2 Fish	Year Harvested-Estimated Number of Age 3 Fish	Total Harvest of Cohort	Percent of Cohort Harvested
1974 F 55,700	1975-unknown	1976-unknown	1977- 133	133+	-
1975 F 95,000	1976-unknown	1977- 685	1978- 228	913+	-
1975 S 5,907	1975-unknown	1976-unknown	1977- 406	406+	-
1976 F 54,900	1977-1,094	1978-5,214	1979- 132	6,440	11.7
1980 F 59,850	1981-2,549	1982-1,275	1983- 425	4,249	7.1
1981 F 30,000	1982-5,000	1983-8,261	1984-6,049	19,310	64.4
1984 F 50,000	1985-4,672	1986-2,336	1987- 779	7,787	15.6
1985 F 55,539	1986-2,614	1987-1,307	1988- 436	4,357	7.8
1986 F 40,000	1987-4,633	1988-2,316	1989- 772	7,721	19.3
1987 F 40,000	1988-2,796	1989-1,398	1990-unknown	4,194[a]	10.5[a]
1988 F 40,000	1989-2,812	1990-unknown	1991-unknown	2,812[b]	-
1989 F 40,000	1990-unknown	1991-unknown	1992-unknown	unknown	-

[a] Minimum estimate because 1 year of harvest statistics is not included in the estimate.

[b] Minimum estimate because 2 years of harvest statistics is not included in the estimate.

Table 30. Estimated sport fishery harvests of stocked fingerling coho salmon at Chena Lake, 1984-89.

Part I. Estimated contributions of coho salmon to the annual creels by stocking cohort.

Total Annual Harvest		Estimated Contribution to Harvest by Stocking Year Cohort					
Year	No. Fish[a]	Age 1 Cohort	No. of Fish	Age 2 Cohort	No. of Fish	Age 3 Cohort	No. of Fish
1984	5,036	1983	0[b]	1982	5,036	1981	0[b]
1985	9,485	1984	7,806[c]	1983	0[b]	1982	1,679[d]
1986	1,778	1985	1,440[d]	1984	338[ce]	1983	0[b]
1987	1,398	1986	678[c]	1985	720[d]	1984	0[e]
1988	2,401	1987	1,441[d]	1986	720[d]	1985	240[d]
1989	2,468	1988	1,508[c]	1987	720[d]	1986	240[d]

[a] Data source of annual harvests is Mills 1985-90.

[b] Coho salmon of this cohort were not stocked.

[c] These estimates are the result of the subtraction of the age 2, the age 3, or the age 2 and 3 combined portion of the annual harvest (obtained as described in footnote d below) from the total harvest that took place in the given year to provide an estimate of the harvest of age 1 fish; or, are the result of the subtraction of the age 1 portion of the annual harvest (obtained as described in footnote d below) from the total harvest that took place in the given year to provide an estimate of the harvest of age 2 fish.

[d] These estimates are based upon the assumption that 60% of the harvest from a cohort are harvested at age 1, 30% are harvested at age 2, and 10 % are harvested at age 3.

[e] The 1984 stocked cohort of coho salmon was heavily exploited as age 1 fish in 1985; it is assumed that few were left to harvest as age two fish in 1986 and that none were left to harvest in 1987 as age three fish.

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Table 30. (Page 2 of 2).

Part II. Estimated total sport harvests of stocked cohorts of coho salmon from Chena Lake.

Year and Number of Fish Stocked in Cohort	Year Harvested-Estimated Number of Age 1 Fish	Year Harvested-Estimated Number of Age 2 Fish	Year Harvested-Estimated Number of Age 3 Fish	Total Harvest of Cohort	Percent of Cohort Harvested
1982 27,607	1983- 0	1984-5,036	1985-1,679	6,715	24.3
1984 30,000	1985-7,806	1986- 338	1987- 0	8,144	27.1
1985 30,000	1986-1,440	1987- 720	1988- 240	2,400	8.0
1986 30,000	1987- 678	1988- 720	1989- 240	1,638	5.5
1987 30,000	1988-1,441	1989- 720	1990-unknown	2,161[a]	7.2[a]
1988 47,885	1989-1,508	1990-unknown	1991-unknown	1,508[b]	-
1989 15,000	1990-unknown	1991-unknown	1992-unknown	unknown	-

[a] Minimum estimate because 1 year of harvest statistics is not included in the estimate.

[b] Minimum estimate because 2 years of harvest statistics is not included in the estimate.

Table 31. Estimated sport fishery harvests of stocked fingerling coho salmon at Quartz Lake, 1977-89.

Part I. Estimated contributions of coho salmon to the annual creels by stocking cohort.

Total Annual Harvest		Estimated Contribution to Harvest by Stocking Year Cohort					
Year	No. Fish[a]	Age 1 Cohort	No. of Fish	Age 2 Cohort	No. of Fish	Age 3 Cohort	No. of Fish
1977	0	1976	0	1975	0	1974	0
1978	14,892	1977	14,892	1976	0	1975	0
1979	34,787	1978	27,341[b]	1977	7,446[c]	1976	0
1980	23,316	1979	7,164[b]	1978	13,670[c]	1977	2,482[c]
1981	50,965	1980	0	1979	46,408[b]	1978	4,557[c]
1982	35,380	1981	19,911[b]	1980	0	1979	15,469[c]
1983	24,042	1982	0	1981	24,042	1980	0
1984	17,069	1983	9,055[b]	1982	0	1981	8,014[c]
1985	26,312	1984	21,784[b]	1983	4,528[c]	1982	0
1986	16,613	1985	4,212[b]	1984	10,892[c]	1983	1,509[c]
1987	15,449	1986	9,712[b]	1985	2,106[c]	1984	3,631[c]
1988	19,009	1987	13,451[b]	1986	4,856[c]	1985	702[c]
1989	9,593	1988	1,249[b]	1987	6,725[c]	1986	1,619[c]

[a] Data source of annual harvests is Mills 1979-90.

[b] These estimates are the result of the subtraction of the age 2, the age 3, or the age 2 and 3 combined portion of the annual harvest (obtained as described in footnote c below) from the total harvest that took place in the given year to provide an estimate of the harvest of age 1 fish; or, are the result of the subtraction of the age 3 portion of the annual harvest (obtained as described in footnote c below) from the total harvest that took place in the given year to provide an estimate of the harvest of age 2 fish.

[c] These estimates are based upon the assumption that 60% of the harvest from a cohort are harvested at age 1, 30% are harvested at age 2, and 10 % are harvested at age 3.

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Table 31. (Page 2 of 2).

Part II. Estimated total sport harvests of stocked cohorts of coho salmon from Quartz Lake.

Year and Number of Fish Stocked in Cohort		Year Harvested-Estimated Number of Age 1 Fish	Year Harvested-Estimated Number of Age 2 Fish	Year Harvested-Estimated Number of Age 3 Fish	Total Harvest of Cohort	Percent of Cohort Harvested
1977	197,400	1978-14,892	1979- 7,446	1980- 2,482	24,820	12.6
1978	55,549	1979-27,341	1980-13,670	1981- 4,557	45,568	82.0
1979	150,095	1980- 7,164	1981-46,408	1982-15,469	69,041	46.0
1981	150,114	1982-19,911	1983-24,042	1984- 8,014	51,967	34.6
1983	46,543	1984- 9,055	1985- 4,528	1986- 1,509	15,092	32.4
1984	155,718	1985-21,784	1986-10,892	1987- 3,631	36,307	23.3
1985	149,976	1986- 4,212	1987- 2,106	1988- 702	7,020	4.7
1986	168,500	1987- 9,712	1988- 4,856	1989- 1,619	16,187	9.6
1987	168,489	1988-13,451	1989- 6,725	1990-unknown	20,176[a]	12.0[a]
1988	150,000	1989- 1,249	1990-unknown	1991-unknown	1,249[b]	-
1989	150,000	1990-unknown	1991-unknown	1992-unknown	unknown	-

[a] Minimum estimate because 1 year of harvest statistics is not included in the estimate.

[b] Minimum estimate because 2 years of harvest statistics is not included in the estimate.

DISCUSSION

Birch, Chena, and Quartz lakes continue to play a major role in providing recreational sport fishing opportunity in the Tanana Valley. In 1989, 26% of all of the angler effort (days fished) and 39% of the sport fish harvest was provided by these three lakes (Mills 1990). Improvements in hatchery methodology and quality of fish should make greater numbers of fish available to anglers in the future.

Birch Lake has received much of the attention in the regional enhancement evaluation program over the past ten years. Swanson strain subcatchable rainbow trout stocked at a mean weight of about 25 g in 1980 and 1981 grew to catchable size by late summer and began entering the sport fishery. Harvest of these cohorts continued at a high rate through the winter and following early summer. The discontinuance of subcatchable rainbow trout stockings and the beginning of an apparently less expensive fingerling rainbow trout stocking program in 1982 resulted in a decline of the rainbow trout sport harvest. Harvest in 1986 was at only about one third the 1981 level. Harvest had rebounded by 1988 after stockings of subcatchable rainbow trout were resumed.

The low survival rates of rainbow trout fingerlings stocked in mid to late summer and of subcatchables stocked under the ice points out the failure of stocking rainbow trout prior to breakup in Birch Lake. During spring in years when heavy snow-pack and/or a late, rapid breakup produced high flows at the outlet of the lake, large numbers of fingerling rainbow trout that had been stocked the previous fall were seen attempting to move down the outlet. Many of them were not strong enough to swim against the current and died when they were forced against the screens of the outlet structure. Nothing was done about this, since the ADFG attempts to maintain high flows at the outlet in order to maintain lake level below the high water mark. Conversely, during the early 1980's when subcatchable rainbow trout were stocked after breakup, the trout that were moving into the outlet in the spring were older fish, strong enough to avoid being pushed onto the screens. Few mortalities were observed and those fish had already contributed to at least one fall and winter sport fishery. The importance of stocking subcatchable rainbow trout after peak spring flows became very apparent in 1989, when the entire complement of subcatchable rainbow trout for the year were stocked under the ice in late winter. In May, 1989, it appeared that a large number of recently stocked subcatchable rainbow trout died in the weir at the outlet, and in the fall the survival rate of that cohort was only 28.3%, far short of the 50% range that was expected based on results of previous studies. It may also help to explain the lower (40%) survival of the subcatchables stocked under the ice in March, 1988, a year of mild spring flows at the outlet. Survival to fall of the subcatchable rainbow trout stocked after breakup in June, 1990, to 52%. The practice of waiting until early summer to stock the fish will likely contribute to a higher survival of stocked fish to catchable size. However, a cost analysis will be needed to determine the stocking practice that will be most effective at maintaining the Birch Lake fishery. Coho salmon compliment rainbow trout and provide about 5,000 fish per year to the sport harvest at Birch Lake. Coho salmon growth rates may decline if the

rainbow trout population increases in abundance due to interspecific competition for food.

The increased harvest of rainbow trout in Chena Lake in 1988 and 1989 is most likely the result of the stocking of rainbow trout at or near the requested 100 g size and at the full compliment of 30,000 fish. Observations indicate that the lake is "maturing" and becoming more productive than the sterile gravel pit described by Hallberg (1985). Beavers have colonized portions of the lake, and aquatic vegetation is becoming established. However, it is unlikely that this 105 ha lake could support the high use fishery that it is presently producing (16,180 angler-days and a harvest of 11,968 rainbow trout in 1989) based on stockings of smaller rainbow trout. The reduction of stocking density for coho salmon that was instituted in 1989 may increase the size of the coho salmon available for harvest, making them more desirable to anglers and increasing the harvest rate.

Rainbow trout harvest is increasing in Quartz Lake. The dramatic increase in harvest in 1988 and 1989 is reflected in the total abundance estimates. The fishery is being improved by stocking subcatchable rainbow trout and the continued fingerling stocking program. Subcatchable rainbow trout stocked into Quartz Lake have to date exhibited lower survival to fall than those stocked into Birch Lake. The reason for this is not clear, and there have not been enough cohorts of subcatchable rainbow trout stocked into Quartz Lake in a consistent pattern to determine if this lower survival rate will be a consistent trend. The impact of angler pressure upon a cohort of subcatchable rainbow trout prior to the October survival estimate has not been assessed. Changes in stocking practices may produce differing rainbow trout survival to catchable size rates and subsequent harvest.

Both fingerling and subcatchable rainbow trout are stocked into Quartz Lake annually, and overlapping size ranges of cohorts can make evaluation of individual cohorts difficult. Cohorts of rainbow trout have been marked with adipose fin clips to enable separation and immediate and continuing evaluation, but an overall consistent marking regime has not been established. As part of the continuing evaluation of Quartz Lake rainbow trout stocking practices, a marking regime should be established allowing separation of stocking cohorts having overlapping ages and lengths. Subcatchable rainbow trout to be stocked into Quartz Lake should be given an adipose fin clip. If cohorts of subcatchable rainbow trout are given an adipose fin clip in alternating years, there will be no overlap in size ranges between identifiable cohorts and evaluation of marked cohorts will be possible. This type of marking regime can be started immediately in 1991, since none of the rainbow trout stocked into Quartz Lake in 1990 had adipose clips.

The failure to capture sufficient numbers of coho salmon to conduct mark and recapture experiments is apparently an artifact of coho salmon behavior, since reasonable numbers are harvested annually by anglers (Doxey 1982, 1984; Mills 1985-1988).

The harvest of coho salmon in Quartz Lake was exceeded by the rainbow trout harvest for the first time in 1988. Coho salmon harvests in the late 1980's were at a lower level than during the early 1980's, even though the stocking

density has been consistent at between 150,000 and 168,000 fish annually from 1984 through 1989, compared to intermittent and variable stocking levels prior to that time. Lower coho salmon harvests in the late 1980's may be a result of increasing rainbow trout abundance in Quartz Lake over the past decade. A change in coho salmon stocking procedure occurred in 1990.

This report has attempted to summarize available biological and harvest related information pertinent to the continuing rainbow trout and coho salmon stocking of Birch, Chena, and Quartz lakes. As such, this report provides much information related to stocking evaluation. Unfortunately, the success or failure of the stocking program for these three lakes cannot be determined until fishery management criteria and objectives for these three lakes are defined. For example, if the objective of the stocking program for Birch Lake is to provide an annual fishery of 10,000 man-days or more, success has been achieved since 1980. If concurrently, the objective is to produce a harvest rate of two fish per man-day, the program has failed, and if whatever the objective is, the program is to minimize cost, success cannot be judged with information summarized in this report. In conclusion, a full and meaningful evaluation of these stocking programs cannot be conducted until such time that fishery management objectives are defined, and at that time information presented herein will likely be very useful.

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LITERATURE CITED

Baker, T. 1988. Creel censuses in interior Alaska in 1987. Alaska Department of Fish and Game, Fishery Data Series No. 64. 138 pp.

Clark R. and W. Ridder. 1987. Tanana Drainage creel census and harvest surveys, 1986. Alaska Department of Fish and Game, Fishery Data Series No. 12. 91 pp.

Doxey, M. R. 1980. Population studies of game fish and evaluation of managed lakes in the Salcha District with emphasis on Birch Lake. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1979-1980, Project F-9-12, 21(G-III-K):26-47.

_____. 1981. Population studies of game fish and evaluation of managed lakes in the Salcha District with emphasis on Birch Lake. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1980-1981, Project F-9-13, 22(G-III-K):38-59.

_____. 1982. Population studies of game fish and evaluation of managed lakes in the Salcha District with emphasis on Birch Lake. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1981-1982, Project F-9-14, 23(G-III-K):30-49.

_____. 1983. Population studies of game fish and evaluation of managed lakes in the Salcha District with emphasis on Birch Lake. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1982-1983, Project F-9-15, 24(G-III-K):39-66.

_____. 1984. Population studies of game fish and evaluation of managed lakes in the Salcha District with emphasis on Birch Lake. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1983-1984, Project F-9-16, 25(G-III-K):26-51.

_____. 1985. Population studies of game fish and evaluation of Alaska waters, Salcha District. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1984-1985, Project F-19-17, 26(G-III-K):67-96.

_____. 1986. Interior landlocked trout and salmon program. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1985-1986, Project F-10-1, 27(T-8-1):1-24.

_____. 1987. Tanana Drainage lake stocking evaluations, 1986. Alaska Department of Fish and Game, Fishery Data Series No. 31. 32 pp.

_____. 1988. Evaluation of Stocked Waters in the Tanana Drainage, 1987. Alaska Department of Fish and Game, Fishery Data Series No. 73. 53 pp.

Hallberg, J. E. 1984. Evaluation of interior Alaska waters and sport fish with emphasis on managed waters, Fairbanks District. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Report of Progress, 1983-1984, Project F-9-16, 25(G-III): 50-84.

_____. 1985. Evaluation of interior Alaska waters and sport fish with emphasis on managed waters, Fairbanks District. Alaska Department of Fish and Game, Federal Aid in Fish Restoration, Annual Report of Progress, 1984-1985, Project F-9-17, 26(G-III-H): 1-26.

Heckart, Larry. 1965. Inventory and Cataloging of the Sport Fish and Sport Fish Waters in the Interior of Alaska. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1964-1965, Project F-5-R-6, 6(15A): 300.

_____. 1966. Inventory and Cataloging of the Sport Fish and Sport Fish Waters in the Interior of Alaska. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1965-1966, Project F-5-R-7, 7(15A): 227.

Kramer, M. J. 1977. Evaluation of Interior Alaska Waters and Sport Fish with Emphasis on Managed Lakes, Fairbanks District. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1976-1977, Project F-9-9, 18(G-III-H): 66-86.

Kramer, M. J. and J. Hallberg. 1982. Evaluation of Interior Alaska Waters and Sport Fish with Emphasis on Managed Waters, Fairbanks District. Alaska Department of Fish and Game, Division of Sport Fish. Federal Aid in Fish Restoration, Annual Report of Progress, 1981-1982, Project F-9-14, 23(G-III-H): 72-75.

Mills, M. J. 1979. Alaska statewide sport fish harvest studies. Alaska Department of Fish and game. Federal Aid in fish Restoration, Annual Performance Report, 1978-1979, project F-9-11, 20 (SW-I-A). 112 pp.

_____. 1980. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1979-1980. Project F-9-12, 21 (SW-1): 65 pp.

_____. 1981. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1980-1981. Project F-9-13, 22 (SW-1): 78 pp.

_____. 1982. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1981-1982. Project F-9-13, 23 (SW-1): 115 pp.

_____. 1983. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1982-1983. Project F-9-14, 24 (SW-1): 118 pp.

_____. 1984. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1983-1984. Project F-9-16, 25 (SW-1): 122 pp.

_____. 1985. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1984-1985. Project F-9-17, 26 (SW-1): 88 pp.

_____. 1986. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1985-1986. Project F-9-18, 27 (SW-1): 137 pp.

_____. 1987. Alaska statewide sport fish harvest studies. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1986-1987. Project F-9-19, 28 (SW-1): 91 pp.

_____. 1988. Alaska statewide sport fisheries harvest report 1987. Alaska Department of Fish and Game. Fishery Data Series No. 52. 95 pp.

Namvedt, T. B. 1970. Inventory and Cataloging of the Sport Fish and Sport Fish Waters in Interior Alaska. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1969-1970, Project F-9-2, 11(15-A): 263-268.

Peckham, R. D. 1973. Evaluation of Interior Alaska Waters and Sport Fish with Emphasis on Managed Lakes. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1972-1973, Project F-9-5, 14(G-III-E): 18-47.

_____. 1974. Evaluation of Interior Alaska waters and sport fish with emphasis on stocked lakes. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual report of Progress, 1973-1974, Project F-9-6, 15(G-III-E): 1-38.

_____. 1975. Evaluation of Interior Alaska waters and sport fish with emphasis on stocked lakes. Alaska Department of Fish and Game. Federal aid in Fish Restoration, Annual report of Progress, 1974-1975, Project F-9-7, 16(G-III-E): 52-77

_____. 1976. Evaluation of Interior Alaska waters and sport fish with emphasis on managed water - Delta District. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1975-1976, Project F-9-8, 18(G-III-I): 31-50

_____. 1978. Evaluation of Interior Alaska waters and sport fish with emphasis on managed water - Delta District. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1977-1978, Project F-9-10, 19(G-III-I): 63-82.

_____. 1979. Evaluation of Interior Alaska waters and sport fish with emphasis on managed water - Delta District. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1978-1979, Project F-9-11, 20(G-III-I): 87-114.

_____. 1980. Evaluation of Interior Alaska waters and sport fish with emphasis on managed water - Delta District. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1979-1980, Project F-9-12, 21(G-III-I): 1-25.

_____. 1981. Evaluation of Interior Alaska waters and sport fish with emphasis on managed water - Delta District. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1980-1981, Project F-9-13, 22(G-III-I): 1-37.

_____. 1982. Evaluation of Interior Alaska waters and sport fish with emphasis on managed water - Delta District. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1981-1982, Project F-9-14, 23(G-III-I): 1-28.

_____. 1983. Evaluation of Interior Alaska waters and sport fish with emphasis on managed water - Delta District. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1982-1983, Project F-9-15, 24(G-III-I): 1-38.

_____. 1984. Evaluation of Interior Alaska waters and sport fish with emphasis on managed water - Delta District. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1983-1984, Project F-9-16, 25(G-III-I): 1-25.

_____. 1985. Evaluation of Interior Alaska waters and sport fish with emphasis on managed water - Delta District. Alaska Department of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1984-1985, Project F-9-17, 25(G-III-I): 27-66.

Seber, G. 1982. The estimation of animal abundance and related parameters. Charles Griffin and Co., London, U.K. 654 p.

APPENDIX A

Appendix A1. Worksheet for the development of rainbow trout brood tables, Birch Lake.

Year of Harvest	Stocking Cohort Year	Size	Number	Number of Fish Assumed to be Unavailable[a]		Maximum Number of Fish Available[b]	Proportion of Cohort in Population	Number of Cohort in Harvest
1977	1974	Fing.	157			1,084		
	1976	Catch.	766			766		
Total						1,850		
1978	1977	Fing.	9,508			5,126		
1979	1978	Fing.	9,508	(0.33)	=	3,138	0.200	829
	1977	Fing.	10,425	-5,126	=	5,299	0.334	1,400
	1979	Sub.	22,492	(0.33)	=	7,422	0.468	1,961
Total						15,859		4,190
1980	1978	Fing.	9,508	- 829	=	8,679	0.199	3,741
	1977	Fing.	10,425	-5,126 - 1,400	=	3,899	0.090	1,680
	1980	Sub.	31,337	(0.33)	=	10,341	0.238	4,457
	1979	Sub.	22,492	-1,961	=	20,531	0.472	8,849
Total						43,450		18,727
1981	1978	Fing.	9,508	- 829 - 3,741	=	4,938	0.094	2,028
	1981	Sub.	27,708	(0.33)	=	9,144	0.174	3,756
	1980	Sub.	31,337	-4,457	=	26,880	0.510	11,040
	1979	Sub.	22,492	-1,961 - 8,849	=	11,682	0.222	4,798
Total						52,644		21,622
1982	1982	Sub.	0					0
	1982	Sub.	27,708	-3,756	=	23,952	0.602	11,067
	1980	Sub.	31,337	-4,457 -11,040	=	15,840	0.398	7,318
Total						39,792		18,385
1983	1982	Fing.	3,582	(0.33)	=	1,182	0.026	441
	1983	Sub.	15,586	(0.33)	=	5,143	0.113	1,919
	1982	Sub.	26,260		=	26,260	0.578	9,797
	1981	Sub.	27,708	-3,756 -11,067	=	12,885	0.283	4,807
Total						45,470		16,964
1984	1983	Fing.	2,755	(0.33)	=	909	0.027	323
	1982	Fing.	3,582	- 441	=	3,141	0.092	1,114
	1983	Sub.	15,586	-1,919	=	13,667	0.400	4,847
	1982	Sub.	26,260	-9,797	=	16,463	0.482	5,839
Total						34,180		12,123
1985	1984	Fing.	3,779	(0.33)	=	1,247	0.086	872
	1983	Fing.	2,755	- 323	=	2,432	0.167	1,701
	1982	Fing.	3,582	- 441 - 1,114	=	2,027	0.140	1,418
	1983	Sub.	15,586	-1,919 - 4,847	=	8,820	0.607	6,170
Total						14,526		10,161
1986	1984	Fing.	3,779	- 872	=	2,907	0.131	1,143
	1983	Fing.	2,755	- 323 - 1,701	=	731	0.033	287
	1986	Sub.	56,190	(0.33)	=	18,543	0.836	7,293
Total						22,181		8,723

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Year of Harvest	Stocking Cohort Year	Size	Number	Number of Fish Assumed to be Unavailable[a]	Maximum Number of Fish Available[b]	Proportion of Cohort in Population	Number of Cohort In Harvest
1987	1984	Fing.	3,779	- 872 - 1,143 =	1,764	0.031	310
	1987	Sub.	18,585	(0.33) =	6,133	0.108	1,078
	1986	Sub.	56,190	-7,293 =	48,897	0.861	8,593
Total					56,794		9,981
1988	1988	Sub.	26,869	(0.33) =	8,867	0.133	2,446
	1987	Sub.	18,585	-1,078 =	17,507	0.263	4,828
	1986	Sub.	56,190	-7,293 - 8,593 =	40,304	0.604	11,116
Total					66,678		18,390
1989	1989	Sub.	14,150	(0.33) =	4,670	0.107	1,751
	1988	Sub.	26,869	-2,446 =	24,423	0.558	9,157
	1987	Sub.	18,585	-1,078 - 4,828 =	12,679	0.280	4,754
	1989	Catch.	4,045	(0.50) =	2,023	0.046	758
Total					43,795		16,420

[a] See assumptions for the development of rainbow trout brood tables in Methods.

[b] Natural mortality is not known, and the number of fish estimated to be available is a maximum estimate.

Appendix A2. Worksheet for the development of rainbow trout brood tables, Chena Lake.

Year of Harvest	Stocking Cohort Year	Size	Number	Number of Fish Assumed to be Unavailable[a]		Maximum Number of Fish Available[b]	Proportion of Cohort in Population	Number of Cohort In Harvest
1984	1983	Fing.	614	(0.50)	=	307	0.026	314
	1982	Fing.	408		=	408	0.035	417
	1984	Sub.	9,290	(0.50)	=	4,645	0.394	4,744
	1985	Sub.	6,420		=	6,420	0.545	6,557
Total						11,780		12,032
1985	1984	Fing.	950	(0.33)	=	314		314
	1983	Fing.	614	- 314	=	300		300
	1982	Fing.	408	- 417	=	0		0
	1985	Sub.	14,220	(0.33)	=	4,693		4,830*
	1984	Sub.	9,290	- 4,744	=	4,546		4,546
Total						9,853		9,990
1986	1984	Fing.	950	- 314	=	636	0.034	237
	1983	Fing.	614	- 314 - 300	=	0	0	0
	1986	Sub.	26,192	(0.33)	=	8,722	0.465	3,258
	1985	Sub.	14,220	- 4,830	=	9,390	0.501	3,506
	1984	Sub.	9,290	- 4,744 - 4,546	=	0	0	0
Total						18,748		7,001
1987	1984	Fing.	950	- 314 - 237	=	399	0.012	62
	1986	Sub.	26,192	- 3,258	=	22,934	0.077	3,535
	1985	Sub.	14,220	- 4,830 - 3,506	=	5,884	0.174	907
	1987	Catch.	9,290	(0.50)	=	4,645	0.137	716
Total						33,862		5,220
1988	1986	Sub.	26,192	- 3,258 - 3,535	=	19,399	0.328	3,240
	1988	Catch.	30,091	(0.50)	=	15,046	0.254	2,513
	1987	Catch.	25,406	- 716	=	24,690	0.417	4,124
Total						59,135		9,877
1989	1989	Catch.	30,481	(0.50)	=	15,241	0.240	2,877
	1988	Catch.	30,091	-(2,513)	=	27,578	0.435	5,206
	1987	Catch.	25,406	- 716 - 4,124	=	20,566	0.325	3,883
Total						63,385		11,966

[a] See assumptions for the development of rainbow trout brood tables in Methods.

[b] Natural mortality is not known, and the number of fish estimated to be available is a maximum estimate.

Appendix A3. Worksheet for the development of rainbow trout brood tables, Quartz Lake.

Year of Harvest	Stocking Cohort Year	Size	Number	Number of Fish Assumed to be Unavailable[a]		Maximum Number of Fish Available[b]	Proportion of Cohort in Population	Number of Cohort in Harvest
1977	1976	Fing.	10,871	(0.33)		3,587	0.114	301
	1975	Fing.	14,693			14,693	0.468	1,231
	1975	Fing.	12,957			12,957	0.412	1,086
	1977	Catch.	566	(0.33)		187	0.006	16
Total						31,424		2,634
1978	1977	Fing.	7,735	(0.33)		2,552	0.094	48
	1976	Fing.	10,871	- 301	=	10,570	0.389	199
	1975	Fing.	14,693	-1,231	=	13,462	0.496	254
	1977	Sub.	566	- 16	=	550	0.020	19
Total						27,134		512
1979	1977	Fing.	7,735	- 48	=	7,687	0.413	113
	1976	Fing.	10,871	- 301 - 199	=	10,371	0.558	152
	1977	Sub.	566	- 16 - 11		539	0.029	8
Total						18,597		273
1980	1979	Fing.	2,300	(0.33)	=	759	0.091	12
	1977	Fing.	7,735	- 48 - 113	=	7,574	0.909	117
Total						8,333		129
1981	1980	Fing.	6,129	(0.33)	=	2,023	0.469	879
	1979	Fing.	2,300	- 12	=	2,288	0.531	992
Total						4,311		1,869
1982	1980	Fing.	6,129	- 877	=	5,252	0.802	4,013
	1979	Fing.	2,300	- 12 - 992	=	1,296	0.197	990
Total						6,548		5,003
1983	1982	Fing.	15,862	(0.33)	=	5,234	0.809	1,273
	1980	Fing.	6,129	- 877 - 4,013	=	1,239	0.191	301
Total						6,473		1,547
1984	1983	Fing.	16,329	(0.33)	=	5,389	0.270	1,481
	1982	Fing.	15,862	-1,273	=	14,589	0.730	4,010
Total						19,978		5,491

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Year of Harvest	Stocking Cohort Year	Size	Number	Number of Fish Assumed to be Unavailable[a]		Maximum Number of Fish Available[b]	Proportion of Cohort in Population	Number of Cohort in Harvest
1985	1984	Fing.	19,150	(0.33)	=	6,320	0.199	2,468
	1983	Fing.	16,329	-1,481	=	14,848	0.468	5,799
	1982	Fing.	15,862	-1,273 - 4,010	=	10,579	0.333	4,131
Total						31,747		12,398
1986	1985	Fing.	20,116	(0.33)	=	6,638	0.205	3,031
	1984	Fing.	19,150	-2,468	=	16,682	0.515	7,616
	1983	Fing.	16,329	-1,481 - 5,799	=	9,049	0.279	4,131
Total						32,369		14,778
1987	1986	Fing.	21,131	(0.33)	=	6,973	0.208	2,098
	1985	Fing.	20,116	-3,031	=	17,085	0.509	5,140
	1984	Fing.	19,150	-2,468 - 7,616	=	9,066	0.270	2,727
	1987	Sub.	1,420	(0.33)	=	469	0.014	141
Total						33,593		10,106
1988	1987	Fing.	28,554	(0.33)	=	9,423	0.204	5,143
	1987	Fing.	21,131	-2,098	=	19,033	0.413	10,388
	1985	Fing.	20,116	-3,031 - 5,140	=	11,945	0.259	6,520
	1988	Sub.	13,466	(0.33)	=	4,444	0.096	2,426
	1987	Sub.	1,420	- 141	=	1,279	0.028	698
Total						46,124		25,175
1989	1988	Fing.	10,500	(0.33)	=	3,465	0.055	1,510
	1987	Fing.	28,554	-5,143	=	23,411	0.373	10,205
	1986	Fing.	21,131	-2,098 -10,388	=	8,645	0.138	3,768
	1989	Sub.	47,323	(0.33)	=	15,617	0.249	6,807
	1988	Sub.	13,466	-2,426	=	11,040	0.176	4,812
	1987	Sub.	1,420	- 141 - 698	=	581	0.009	254
Total						62,759		27,356

[a] See assumptions for the development of rainbow trout brood tables in Methods.

[b] Natural mortality is not known, and the number of fish estimated to be available is a maximum estimate.