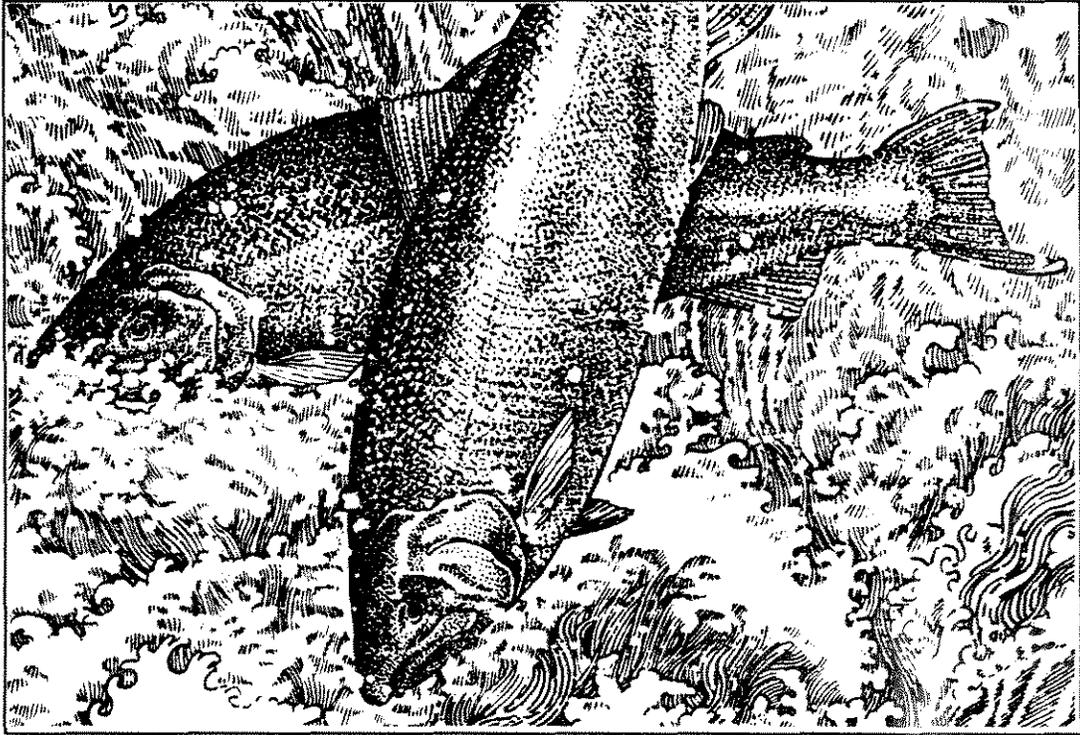


W DEPARTMENT OF WILDLIFE Washington

AUGUST 1992



ROSS LAKE RAINBOW TROUT STUDY
1990 - 91 PROGRESS REPORT Report #: 92-15
FISHERIES MANAGEMENT DIVISION
BY: ALAN C. LOOFF

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ROSS LAKE RAINBOW TROUT STUDY

1990-91 PROGRESS REPORT

by

Alan C. Looff

August 1992

Fisheries Management Division
Washington Department of Wildlife
600 Capitol Way North
Olympia, Washington 98501

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Skagit Environmental Endowment Commission
(SEEC Project No. 90-13)

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ABSTRACT

The Washington Department of Wildlife conducted a rainbow trout study on Ross Reservoir from June 15, 1990 to June 1, 1991. This investigation was the first year of a proposed 5-year study to evaluate the effect of special sport fishery regulations (implemented at the beginning of the 1990 fishing season) on reversing a historic decline in size and numbers of rainbow trout at Ross Lake. Study objectives included estimation of harvest and catch statistics for all species of trout and char, analysis of rainbow trout life history information, estimation of the total size of the 1991 overwintering fish population, and evaluation of rainbow trout spawning timing and success in selected tributaries of Ross Lake. A stratified random sampling design was used to develop all effort, catch and harvest estimates.

Ross Lake anglers fished a total of 33,216 hours during the 1990 fishing season, or 8,218 angler days. The total seasonal rainbow trout harvest estimate was 3,774 fish, with a mean seasonal harvest rate of 0.118 fish per hour. Total catch (harvested + released) was estimated at 12,484 rainbow trout, with a mean catch rate of 0.386 fish per hour. The total seasonal dolly varden char harvest estimate was 18 fish, with a mean seasonal catch rate of 0.001 fish per hour. Total catch was 153 dolly varden char, with a mean seasonal catch rate of 0.004 fish per hour. No other species were sampled and/or reported during the season.

The new restrictive angling regulations had significant impacts on the 1990 angler effort, harvest rates and harvest. Total 1990 seasonal angler effort declined approximately 50 and 55 percent, respectively, from mid-1980's and early 1970's levels. Mean overall 1990 seasonal harvest rates were approximately 25 percent of earlier studies, and the total estimated rainbow trout harvest in the early 1970's and mid-1980's, were ten and five times larger than 1990 levels, respectively.

The 1990 rainbow trout harvest was composed primarily of age 3 and age 4 fish. The 13-inch minimum size restriction caused a shift toward a greater percentage of these two age classes in 1990, since fewer age 2 and age 3 fish were legally available for harvest. Rainbow trout age and sexual maturity data also indicates that a large proportion of the 1990 harvest was composed of immature age 3 fish. The larger than normal average size of harvested fish in 1990, compared to 1985 and 1986, may indicate increased food availability as a result of low population density.

Four hydroacoustic surveys conducted on the lower portion of Ross Lake during April 1991 were used to establish baseline index counts and estimate total size of the reservoir's fish population (fish larger than six inches). A total combined species population estimate of 20,789 fish was calculated for the reservoir from the index count data. Assuming

catch data reflects relative species abundance, the total rainbow trout population was estimated at 20,513 fish. Comparison of the 1991 estimate with hydroacoustic estimates conducted in the early 1970's suggests the present reservoir fish population is roughly half as large.

Eight spawning surveys conducted on each of six U.S. tributaries to Ross Lake between May and August of 1991 resulted in a total enumeration of 174 rainbow trout. Peak spawning occurred on most tributaries between the last week of June and the first week of July. Roland Creek recorded the largest numbers of spawning fish observed and, along with Dry Creek, is an important index tributary due to fish accessibility, flow, spawner use, availability of spawning habitat, and visibility and accessibility by survey personnel. Observations from the mid-1980's show that 1991 spawning numbers are much reduced from previous years.

Data collected from the 1990-91 rainbow trout study on Ross Reservoir show the fish population is still suffering from the effects of past overharvest. These studies suggest the present rainbow trout population is roughly half as large as in the early 1970's. Continued evaluation and monitoring of the fish and fishery in response to the new regulations are necessary to promote recovery of rainbow trout stocks in Ross Reservoir.

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INTRODUCTION

This report summarizes the results of an angler harvest and rainbow trout study conducted on Ross Reservoir from June 15, 1990 to May 31, 1991. This is the first year of a five-year study by the Washington State Department of Wildlife (WDW) to evaluate the effect of special fishery regulations designed to reverse the decline in size and numbers of rainbow trout in Ross Lake (Johnston 1989). These regulations were implemented at the beginning of the 1990 sport fishing season by both the WDW and the British Columbia Division of Fish and Wildlife (BCF&W), and (excepting dolly varden char/bull trout) are identical for both agencies (*Appendix 1*).

The new fishery regulations are more restrictive than earlier regulations, and are expected to reduce angler harvest (reduced catch limit) and allow rainbow trout to spawn at least once before entering the fishery (increased minimum size limit). A bait restriction was necessary to reduce mortality of released fish, which can sometimes reach levels as high as 50 percent. A later season opener was enacted to permit spawning rainbow trout more time to ascend tributary streams, and to allow both Canadian and American anglers equal access to the lake on opening day. Johnston (1989) gives a complete list of all Washington State fishing regulations on the reservoir since 1933.

This study was funded by the Skagit Environmental Endowment Commission (SEEC). The SEEC solicits, approves, and funds projects from a special fund using money set aside by Seattle City Light as part of a U.S. Federal Energy Regulatory Commission (FERC) permit requirement.

Previous Studies

The present study is a continuation of fisheries studies conducted on Ross Reservoir by the WDW and BCF&W in 1985 and 1986 (Scott and Peterson 1986; Johnston 1989). Earlier in-depth fisheries studies were also conducted on Ross Lake by the University of Washington Fisheries Research Institute (FRI) at the time Seattle City Light (SCL) proposed to proceed with the third and final construction phase of Ross dam (High Ross). Several studies have also been conducted on the upper Skagit River by BCF&W. A complete list of all major fisheries studies related to Ross Reservoir is given in Resident Fisheries Study for Ross, Diablo and Gorge Lakes (Seattle City Light 1989).

Study Area

Ross Lake is an oligotrophic reservoir located at 49N latitude and 121W longitude in the northeastern portion of Whatcom County, Washington and the southeastern portion of Fraser Cheam Regional District, British Columbia (*Figure 1*). The reservoir is located within the Skagit River

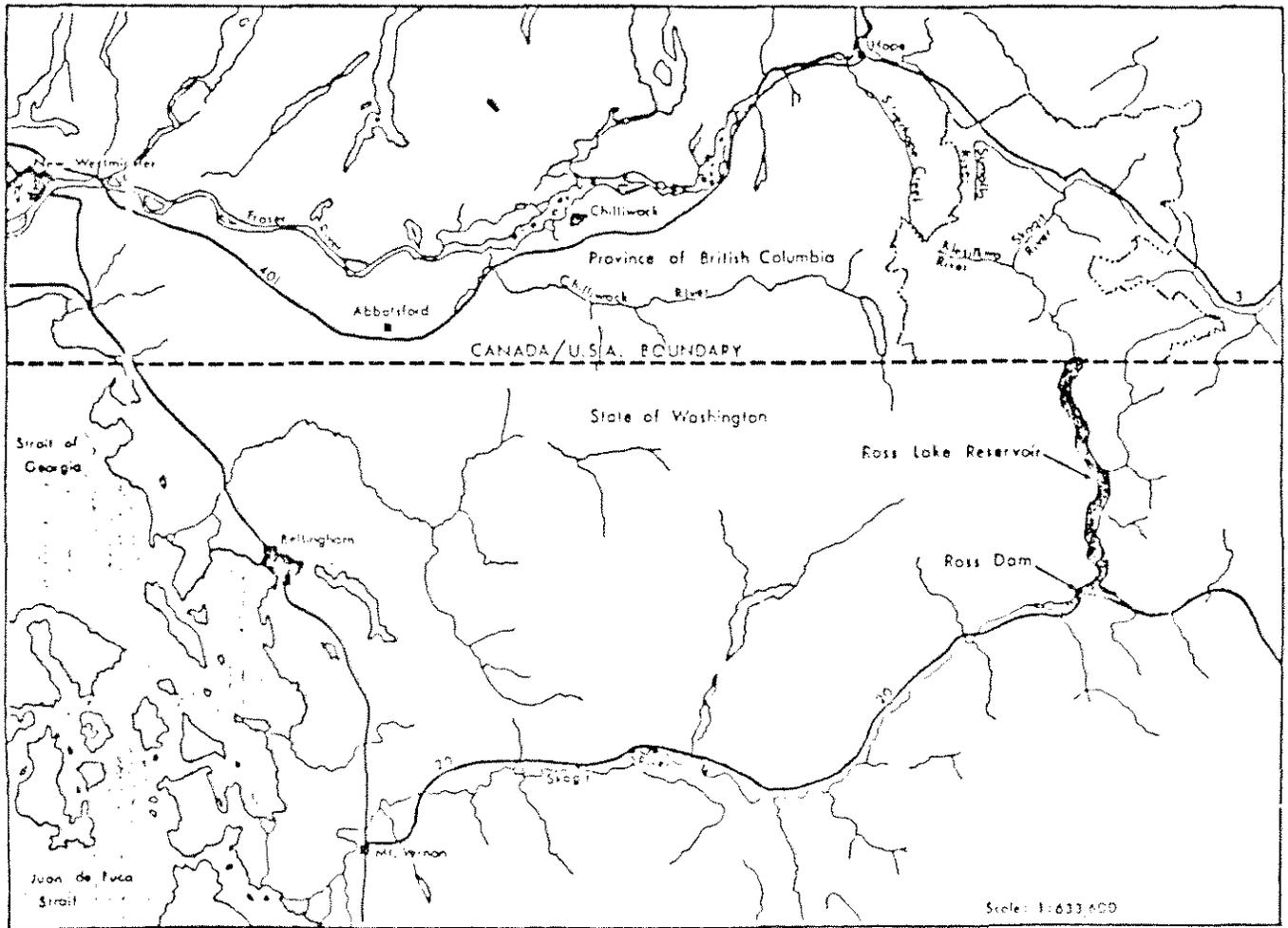


FIGURE 1. Geographic location of Ross Lake in NW Washington and SW British Columbia.

watershed, and was formed by the construction of Ross Dam (1937-49) on the Skagit River. The lake drains approximately 999 square miles of the watershed upstream from the dam. Surface elevation of the lake is 1602.5 feet mean sea level (msl) at full pool and 1475 feet msl at maximum drawdown.

Physical characteristics of the reservoir vary seasonally due to winter drawdown by Seattle City Light for power and flood control purposes. Therefore, the following measurements are for full pool elevations only. The reservoir is approximately 22 miles long, with the northernmost mile extending into Canada. Average width is approximately one mile, and maximum width is two miles. The long axis of the reservoir is oriented in a north-south direction, and is perpendicular to the direction of prevailing winds. Total surface acreage is 11,680 acres, of which 480 acres is located in British Columbia. Total lake volume is estimated at 770,000 acre-ft. The lake basin is predominantly deep and steep-sided, although the northern portion of the lake is relatively shallow. Maximum depth is 400 feet near the base of the dam and mean reservoir depth is 123 feet. A summary of the physical characteristics of Ross Lake is given in *Table 1*.

Ross Reservoir is fed by the upper Skagit River in Canada and several large, perennial streams on the U.S. side of the reservoir (*Figure 2*). Ruby Creek, Lightning Creek, and Big Beaver Creek are the largest American tributaries, followed by Little Beaver, Devils, Silver, Arctic, No Name, Hozomeen, Dry, Pierce, and Roland Creeks. Physical characteristics and spawning habitat summaries of the major tributaries to Ross Lake are summarized in the *Ross Lake Tributary Stream Catalog* (Seattle City Light 1989). Many small, intermittent streams also drain into the lake. The Skagit River is the only outflow channel present.

Rainbow trout (*Oncorhynchus gairdneri*) are the predominate sport fish in Ross Lake. A seasonal sport fishery exists on this species from July through October. Also present in the lake are dolly varden char (*Salvelinus malma*)/bull trout (*Salvelinus confluentus*), cutthroat trout (*Oncorhynchus clarkii*), and brook trout (*Salvelinus fontinalis*).

Objectives

The specific objectives of the 1990-91 Ross Lake study were as follows:

1. Determine angler effort and distribution on the reservoir.
2. Determine angler catch (kept and released), harvest (kept only), catch per unit effort (CPUE), harvest per unit effort (HPUE), and angler distribution on the reservoir.
3. Determine age distribution, age class strength, age versus length, age versus sexual maturity, and length at sexual maturity of rainbow trout sampled from the angler sport catch.

TABLE 1. Ross Lake physical data. From *The Aquatic Environment, Fishes and Fishery: Ross Lake and the Canadian Skagit River* (City of Seattle 1972).

Reservoir Water Levels			
	Max.	Min.	Mean
Annual Flushing Rate ^a	1.84	---	2.35
Drainage Area (mi ²) ^b	999	999	999
Elevation (feet)	1,602.5	1,475	1,575
Length (miles)	22	---	---
Maximum depth (feet)	400	---	---
Mean depth (feet)	122.5	93.6	---
Shoreline development ^c	4.26	4.01	4.07
Shoreline length (miles)	64.5	37.4	51.0
Surface area (acres)	11,680	4,400	10,300
Volume (acre-feet)	1,435,000	412,000	---

Lake Elevation (feet)	Shoreline length (miles)	Area (acres)	Lake Volume (acre-feet)
1602.5	64.5	11,680	1,435,000
1600	64.3	11,600	1,390,000
1575	58.8	10,280	1,125,000
1550	53.3	9,040	890,000
1525	50.3	7,600	680,000
1500	43.7	5,840	520,000
1475	37.4	4,400	412,000
1450	29.1	3,400	285,000
1425	26.9	2,820	210,000
1400	24.3	2,300	140,000
1375	21.2	1,850	90,000
1350	19.4	1,400	60,000
1325	16.7	900	25,000
1300	13.4	420	10,000

^aBased on 1953-69 flushing rates.

^bSkagit River drainage upstream of Ross dam.

^cShoreline development (SD) = $S / (2 * ((\pi * A)^{0.5}))$, where S = shore length and A = lake area.

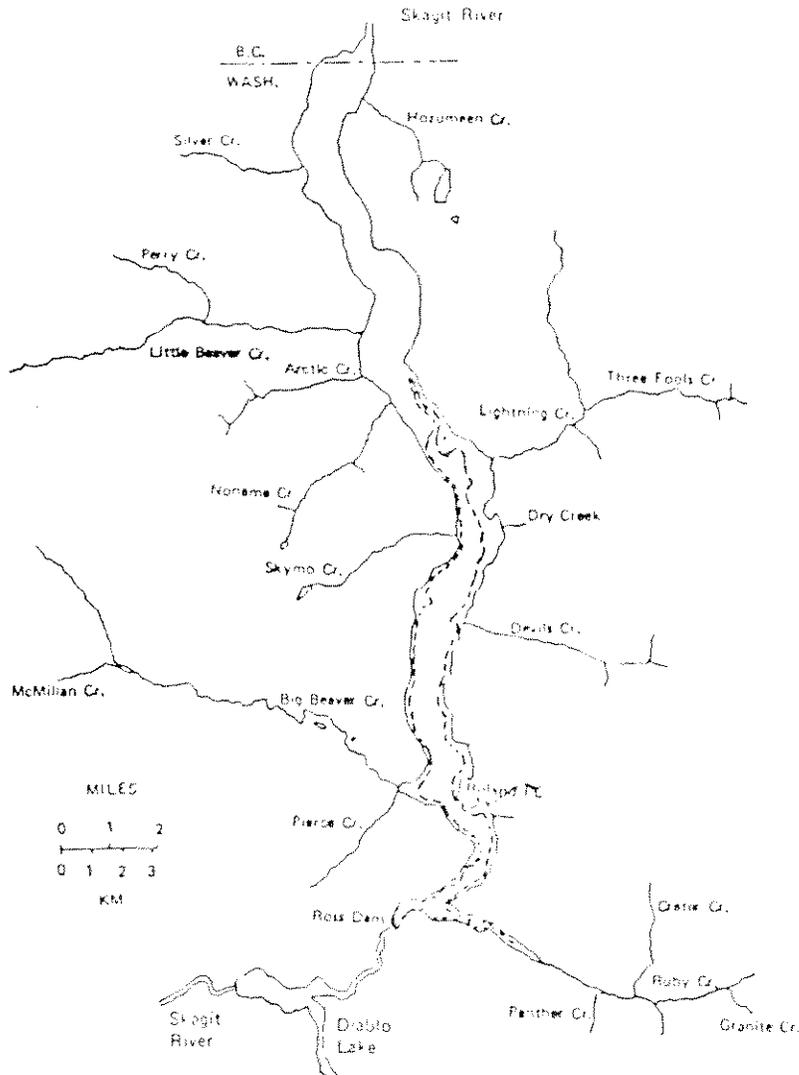


FIGURE 2. Ross Lake and major tributaries. The perimeter of the lake at full pool (1602.5 feet msl) is shown as a solid line, and the maximum drawdown contour (1475 feet msl) is depicted as a dotted line.

4. Develop estimates of the reservoir fish population size and conduct index counts from fixed hydroacoustic transects to monitor annual population status.
5. Conduct annual spawner surveys on index streams to determine time of spawning, spawning locations, and effectiveness of (minimum size) catch limits on increasing numbers of spawning fish.
6. Compare results of the 1990-91 study with previous studies.
7. Identify additional data requirements for future studies.
8. Continue development of a long-term management plan for Ross Reservoir in coordination with federal (National Park Service) and international (British Columbia Ministry of Environment) management agencies.

METHODS

Creel data from the 1989 opening day of fishing season at Ross Reservoir is included in this progress report as a continuation of opening day data collected and documented from previous years (see Johnston 1989). This data is important to our knowledge of trends in angler use and harvest at Ross Reservoir, and is the last data available under the older, less restrictive fishing regulations.

1989 Opening Day Creel Survey

An opening day creel census was conducted on June 17, 1989 to collect angler catch and harvest information on Ross Reservoir. Data was collected by the WDW Area Fisheries Biologist at the U.S. National Park Service (NPS) Hozomeen campground (one of two access sites at the north end of the lake), and by a volunteer stationed at the privately-owned and operated Ross Lake Resort (the only south end access). Interview questions were the same for the 1989 opening day and 1990 seasonal creel surveys, and are discussed under the 1990 creel survey methods below. The only biological information collected in 1989 was fork length measurement (mm) from a random sample of fish selected from the opening day angler harvest.

1990-91 Studies

The 1990-91 sampling program consisted of data and information collected from three different studies. A four-month angler creel survey was conducted from July 1 to October 31, 1990 to determine angler harvest and harvest-related information. A second study involved collection of hydroacoustic transect data from four lake surveys during April 1991. The purpose of these surveys was to establish baseline index counts of fish density for use in annual monitoring of population size fluctuations, and to estimate the size of the 1990-91 overwintering reservoir fish population (all species combined). The third study involved enumeration of spawning rainbow trout on selected tributaries of Ross Lake from May to mid-August. These surveys will be used to establish baseline index counts of spawner density for use in annual monitoring of spawning population fluctuations in each index stream. All three studies were designed to parallel earlier studies as much as possible, but were modified in some instances due to knowledge gained from earlier work.

Personnel consisted of one full-time biologist and one part-time technician that assisted in the collection of angler creel survey data. Two technicians were initially hired to collect data at the north end of the lake, but a significant reduction in angler effort on the reservoir (due to the new restrictive angling regulations) resulted in a personnel cutback to one technician beginning in August. The biologist was

responsible for the angler creel survey at the south end of the reservoir, as well as all other project-related work.

1990 Creel Survey

The angler creel census was based on a stratified random design that was similar to the design used during the 1985 study on Ross Reservoir (Scott and Peterson 1986). Strata were divided into three day-types that reflected intensity of angler use on the reservoir. These day-types included opening day, weekdays, and weekends. Opening day (opening weekend in previous years) on the reservoir typically supports a substantially higher degree of angler effort than the other two types of strata. Holidays (Independence Day and Labor Day) were classified as weekend days during the current study, differing from the 1985 and 1986 designs when these two holidays and opening day were classified as a single stratum. Angler use during these holidays in 1990 resembled weekend days during the season, and did not have a significantly higher degree of effort over weekends as observed in previous studies.

Sample days were randomly selected by microcomputer using a Microsoft QuickBASIC program written by the author (*Appendix 2*). This program randomly selected four, three-day (continuous) time blocks for each month from July through October, for a total of forty-eight sample days for the 1990 fishing season (*Table 2*). Logistical and budgetary constraints traveling to and from the lake required the use of continuous three-day time blocks. Two additional constraints on the selection process were that four weekend days and eight weekdays had to be sampled each month, and that opening day (July 1), Independence Day (July 4), and Labor Day (September 1) had to be included as sample days. The latter restriction modified the number of (effective) weekend days and weekdays sampled during the months of July and September (*Table 2*). Sampling dates for the 1990 sport fishing season are listed in *Appendix 3*.

A continuous eight-hour work day was scheduled for each sample day throughout the creel census. The starting time and subsequent eight-hour work period for each sample day was randomly selected by computer (*Appendix 3*) according to the number of daylight hours available each month (*Table 3*). This work schedule was based on the same design as that used in 1985 (Scott and Peterson 1986), instead of the 1986 design, which required sampling over the entire daylight period (Lewynsky 1986). The latter design required continuous sampling of *all* anglers from dawn to dusk to develop effort estimates. The designs used in the 1985 and 1990 studies required a *random* sampling of returning anglers (although an attempt was made to survey as many anglers as possible).

Restricted angler access to the reservoir permitted most anglers to be interviewed during the course of any work day (except for a few heavy use periods such as opening day and holidays). Scott and Peterson (1986) classified five access areas where anglers were intercepted for interviews and biological sampling of catch. These included Canada,

TABLE 2. Number of days sampled per day type strata during the 1990 sport fishing season at Ross Reservoir.

Month	Daytype	Total Days	Days Censused	% Total
Jul	Opener	1	1	100%
	Weekday	21	6	29%
	Weekend	9	5	56%
	Total	31	12	39%
Aug	Weekday	23	8	35%
	Weekend	8	4	50%
	Total	31	12	39%
Sep	Weekday	19	7	37%
	Weekend	11	5	45%
	Total	30	12	40%
Oct	Weekday	23	8	35%
	Weekend	8	4	50%
	Total	31	12	39%
Season	Opener	1	1	100%
	Weekday	86	29	34%
	Weekend	36	18	50%
	Total	123	48	39%

TABLE 3. Number of daylight hours assumed available to anglers during the 1990 sport fishing season at Ross Reservoir.

Month	Hours	Start	Finish
July	15	0600	2100
August	13	0700	2000
September	11	0800	1900
October	9	0900	1800

three sites on the American portion of the reservoir at the north end of the lake (Winnebago Flats, government dock, and lower launch), and Ross Lake Resort at the south end of the lake. Only three access areas were designated for the present study. These sites included Canada, Hozomeen campground, and Ross Lake Resort. The three launch sites at Hozomeen campground were classified as a single access area in 1990, since seasonal angler use was significantly lower than in previous years, and the lower launch site was inundated by water during the entire fishing season. (When late-season drawdown by Seattle City Light does permit use of the lower launch site, the remaining sites at the north end of the lake are not normally accessible due to receding water levels). From August through October, when only one interviewer was employed at the north end of the lake, roving interviews were conducted between the Canadian and Hozomeen access areas each working day.

Angler Interviews

Angler interviews at Ross Reservoir were conducted by contacting anglers returning to the three primary access areas. All anglers were asked to volunteer the same information. Anglers were generally interviewed immediately upon returning, but occasionally, especially at the north end of the lake where it was impossible for the interviewer to survey the Canadian and Hozomeen access sites simultaneously, information was sometimes collected later in the day. Information was collected from all anglers contacted, regardless of whether they had finished fishing for the day. Two primary reasons for checking incomplete anglers were that many anglers did not continue fishing after indicating they were going to, and information would be lost from anglers that continued fishing but did not return before the work day ended.

Interviews consisted of the collection of angler catch and profile data. The following catch information was recorded for each species of trout and char captured by anglers:

- time of interview
- time angler started fishing (to the nearest 15 minutes)
- whether angler had finished fishing for the day
- species
- number of fish harvested
- number of fish released
- size range of fish released
- capture location (discussed below)

As in the 1970's, 1985, and 1986 studies, the reservoir was arbitrarily divided into seven zones for purposes of determining distribution of angler effort, CPUE (catch per unit effort), HPUE (harvest per unit effort), and catch and harvest information. The location of each of these zones is shown in *Figure 3*. These zones are numbered the same as shown in the 1989 report (Johnston 1989).

The following angler profile information was collected for each angler

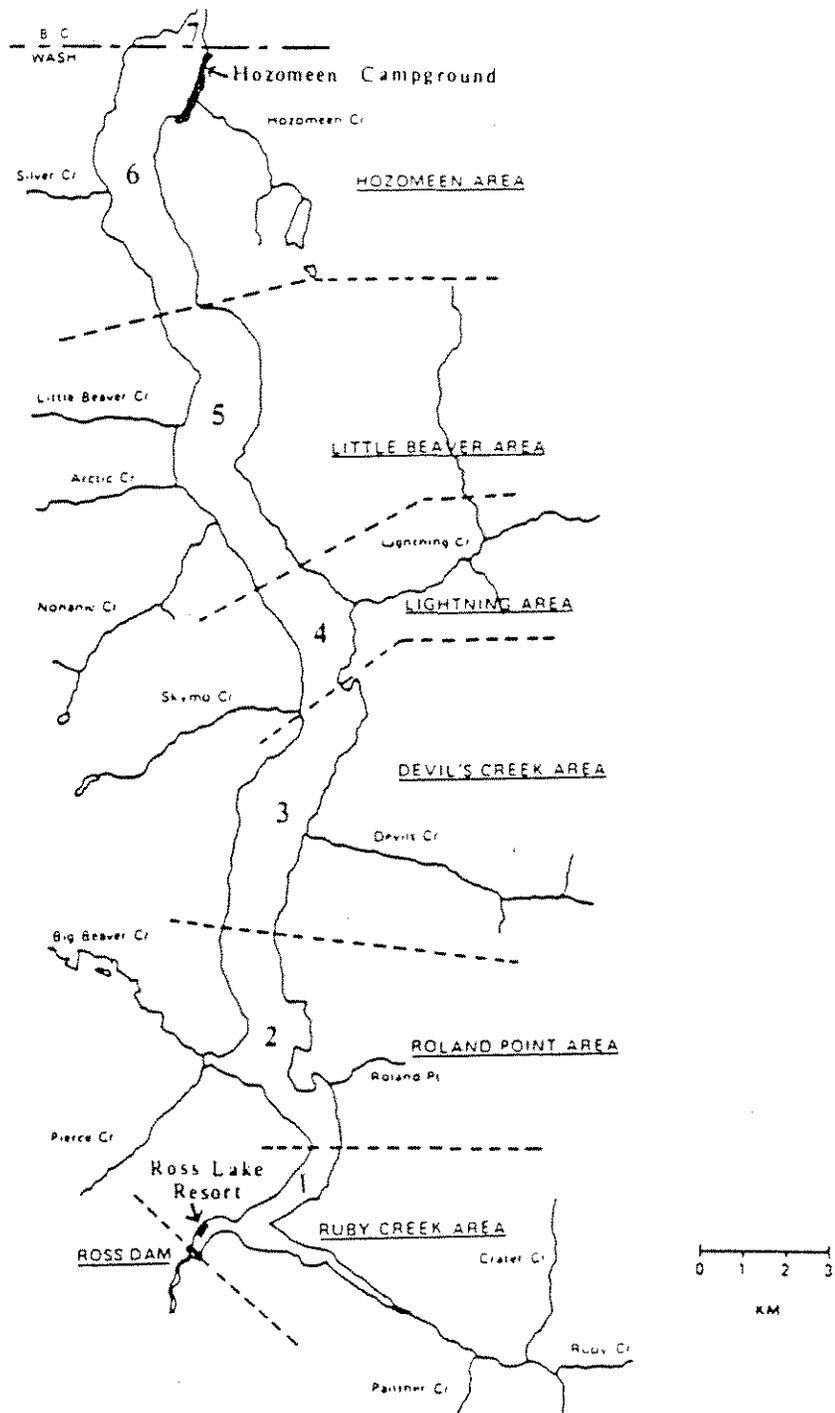


FIGURE 3. Ross Lake survey zones.

interviewed:

- age category (adult, juvenile)
- fishing method (boat, shore, float tube)
- angling gear (lure, fly)

The following biological information was collected from a random sample of the angler harvest for rainbow trout only:

- nose to fork length of harvested fish (mm)
- sex
- scales for aging (discussed below)
- sexual maturity (discussed below)

Approximately 20-30 scales were collected from each rainbow trout sampled. Scales were removed from an area formed by an imaginary line drawn from the rear insertion of the dorsal fin and front insertion of the anal fin approximately 3-5 scale rows above the lateral line. Scales were then placed in scale envelopes and the date, capture area, species, fork length (mm), sex and sexual maturity (if collected) recorded on the outside. Five scales from each sample were later cleaned and mounted on a glass slide using a cover slip and transparent tape. A microfiche reader (35X) was then used to age each sample. Only samples containing at least two good scales that did not exhibit regenerated areas were used. After aging all of the samples once to find growth patterns and other characteristics, the scales were aged a second time. If the two readings did not agree, a third reading was done. The result of this third reading was considered the age of the sample.

A subset of rainbow trout that was sampled for scale analysis was also examined for sexual maturity based on gonadal development. Sexual maturity information was only collected from trout sampled during July, since newly developing egg skeins and sperm sacs of recently spawned fish appear identical (very small size) to those of immature fish after this time. In addition, sexual maturity determinations are further hindered by the rapid disappearance of secondary external sexual characteristics, and resorption of unspawned gametes following spawning.

Fish were classified as mature if testes were enlarged or contained sperm in males, and if eggs were in an advanced stage of development or freely flowing in females. External spawning characteristics, such as dark color, emaciated condition, and enhanced color of the red side stripe, were used as secondary aids to classification of mature fish of both sexes. Fish were classified as immature if male testes and female egg skeins were small and poorly developed.

Separate measurements were collected for dolly varden char/bull trout to assist current WDW studies aimed at delineating the geographic ranges of these two species whose external physical characteristics are visually almost identical. A special linear discriminant function developed by

Haas (1988) at the University of British Columbia was used to distinguish between the two species. This equation requires the collection of the following four external physical measurements:

- number of branchiostegal rays (slender bones in the gill membranes) on both right and left sides
- maxillary length
- number of principal anal fin rays
- standard length (nose to last vertebra) in millimeters

The function for species identification is as follows (Haas and McPhail 1991):

$$1) \quad [(0.629 * \text{branchiostegal ray number}) + (0.178 * \text{anal fin number}) + (37.310 * (\text{maxillary length}/\text{standard length}))] - 21.8$$

where, dolly varden <0 and bull trout >0.

Char fork length (mm) was also measured to compare with data collected from earlier studies at Ross Reservoir.

Effort

Effort estimates were generated separate from the angler creel survey. This precluded personnel from having to work over the entire daylight period of each sample day, as previously mentioned. Effort sampling times were randomly selected by computer (*Appendix 3*) to correspond with sample days and work schedules (*Table 2*).

Instantaneous effort counts were conducted at least twice daily by running a boat the length of the reservoir and counting the number of anglers fishing in each zone of the lake (*Figure 3*). Counts during July and August involved two separate round trips up and down the reservoir. However, the additional expenses of lost interview time and extra cost of boat operation required a reduction to only one round trip during September and October. An angler was not counted unless a line was visually observed in the water. (This sampling method differed from the 1985 effort survey design in that boats, and not anglers, were counted during the 1985 study. These counts were later expanded to angler counts using average number of anglers per boat data collected by National Park Service personnel during the 1985 season.) On average, it required from 40-50 minutes to conduct a single count using an 18' Olympic with a 140 hp inboard/outboard motor, depending on weather conditions and number of anglers fishing. The second count was made on the return trip back, after waiting approximately 10-20 minutes for the beginning of the next hour. On some days, one or more additional hours was waited before conducting counts on the return trip.

Three separate effort estimates (and associated variances) for 1990 were derived by organizing strata into daytype, lake zone, and access area. For reasons outlined below and in later portions of the methods section,

daytype estimates for all variables (effort, CPUE, HPUE, catch, and harvest) generate the most accurate estimates based on the sampling design used in this study, and will be the actual results reported. Zone and access area estimates, which do not accurately reflect one or more of the above variables, are used for comparative purposes only.

Accurate access area effort estimates were not possible using the effort sampling design of the current study (it was not practical to stop and ask each angler where he launched from while conducting effort counts). However, it was assumed that anglers fishing in zone 7 used the Canadian access, anglers fishing in zones 4-6 utilized the Hozomeen access, and anglers fishing in zones 1-3 came from Ross Lake Resort. The small size and low horsepower engines on the resort boats made it difficult for most anglers using these craft to fish north of Ten-Mile Island (zone 3), which was verified both through visual observations during effort counts, and during angler interviews at the resort. Conversely, very few boats originating from Hozomeen fished farther south on the reservoir than Lightning Creek (zone 4). Lastly, very few anglers from either country purchased a second license to fish on the opposite side of the international boundary (zones 6 and 7).

Effort counts for each of the three estimates were converted to monthly and total estimates using simple expansion techniques. However, due to the random sampling of hourly daylight time periods, not all hours were sampled for a particular stratum within any monthly time block. Missing hourly effort within a specific stratum was estimated using the following proportion:

$$2) \quad e = e_h * (n/h)$$

where, in any particular strata,

e = total effort,

e_h = sum of the hourly effort counts in a particular strata,

n = total number of available survey hours, and

h = number of hours surveyed

The same technique was applied to variance estimates, using the appropriate equation for multiplication of a variance by a constant (Freese 1962).

Catch Rate and Harvest Rate

Catch rate (and harvest rate) estimates and associated variances were generated by expanding data from the creel surveys. The general formula for the catch rate (CPUE) of any particular strata-type is:

$$3) \quad r = c / t$$

where, in any particular strata,

r = catch rate (CPUE)
c = catch, and
t = time (hours)

The harvest rate (HPUE) of any particular strata-type is found by substituting harvest (**h**) for catch (**c**) in (3).

Three separate rainbow trout catch rate (and harvest rate) estimates for daytype, zone, and access areas were generated using the two formulas. Although the total monthly and seasonal catch (and harvest) rates are identical for the three types of estimates, strata estimates are more accurate for **daytype** calculations. The primary reason for this is that interviewed anglers were asked to identify which one zone they caught and harvested most fish in. Thus, each fish captured or harvested was not traced to the exact zone of capture. Access area catch (and harvest) rate estimates were calculated by arbitrarily dividing the catch identified by zone using the method outlined earlier in the effort section. Daytype estimates consider only the number of fish caught and/or harvested. Thus, zone and access area estimates imply more accuracy than is acceptable, and are given for comparative purposes only. Dolly Varden char and cutthroat trout catch rate (and harvest rate) estimates were produced using daytype information only.

Catch and Harvest

Catch (and harvest) estimates and associated variances were generated by expanding data from the two separate creel and effort surveys. The general formula for total catch of any particular strata-type is:

$$4) \quad c = e * Q_1$$

where, in any particular strata,

c = total catch
e = total effort, and
 $Q_1 = c/t$

The total harvest of any particular strata-type is found by substituting harvest (**h**) for catch (**c**) in (4).

Three separate rainbow trout catch (and harvest) estimates for daytype, zone, and access area were generated using this formula. As discussed previously, **daytype** estimates produce the most accurate results, while zone and access area estimates are given for comparative purposes only. Dolly Varden char and cutthroat trout catch (and harvest) estimates were produced using daytype information only.

Variance Estimators

Variance estimators were used to generate standard errors for all effort, CPUE, HPUE, catch, and harvest estimates (Freese 1962). The following

estimators were used to compute the variance of a ratio (CPUE and HPUE), and product (catch and harvest) of any particular strata type:

$$(5) s_{Q1}^2 = Q_1^2 * ((s_c^2/c^2) + (s_t^2/t^2) - ((2*s_{ct})/ct))$$

where,

c = catch,

t = time (hours),

$Q_1 = c/t$, and

s_{ct} = covariance(c,t)

$$(6) s_{Q2}^2 = Q_2^2 * ((s_e^2/e^2) + (s_r^2/r^2) + ((2*s_{ct})/ct))$$

where,

e = effort,

r = c/t, and

$Q_2 = e*r$.

Since effort and catch rate were determined from separate surveys, they were assumed to be independent and the covariance set equal to zero in (6). Thus, the quantity $((2*s_{ct})/ct)$ equaled zero and was dropped from the second equation.

The variance of a harvest rate (HPUE) and total harvest of any particular strata-type is found by substituting harvest (h) for catch (c) in (5) and (6), respectively.

Hydroacoustic Surveys

Hydroacoustic surveys were conducted during April 1991 to estimate the total number of fish (all species) greater than six inches of length in the reservoir. Late winter and early spring is the optimal time to conduct these surveys for several reasons. Both the number and length of hydroacoustic transects are reduced at this time of year due to winter reservoir drawdown by Seattle City Light and subsequent decrease in reservoir size (*Figure 2*). The reservoir fish population is also at a maximum, since fish have not yet ascended tributary streams to spawn and/or feed. Environmental conditions at this time of the year result in more calm, windless days, which are required to keep the sonic cone perpendicular to the lake surface and also eliminate noise interference from boat waves. Lastly, reservoir and environmental conditions also result in less debris in the water column that can create transducer interference.

A modified Ross 600C Straight Line Recorder with a revolving chart recorder was used to collect population data. Power was supplied to the echosounder using two 12-volt DC deep cycle batteries connected in-line to produce 24 volts. One down- and one side-scanning transducer were

mounted on a 14' aluminum boat powered by a 25 horsepower outboard motor (*Figure 4*). Transducer calibration, equipment operation, and development of estimates and associated variances followed echo counting procedures developed by Johnston (1981). However, sampling design was based on fixed transect counts, instead of random selection of transects for each survey, as explained below.

Preliminary hydroacoustic surveys conducted on March 29-30, 1991, indicated that the upper portion of the reservoir north of Rainbow Point was unsuitable for echosounding due to the presence of large numbers of trees just below the lake surface. The reservoir was only partially logged prior to inundation in the late 1940's and early 1950's, with most of the logging having occurred north of Lightning Creek (Pitzer 1978). Both fish and tree parts trace identically on the chart recorder, making it impossible to conduct population estimates in this portion of the lake. Furthermore, other areas south of Rainbow Point, including areas adjacent to May Creek, Big Beaver Creek, and Roland Point, also have large numbers of standing trees close to the surface.

Based on the above information, eleven fixed transects south of Rainbow Point were selected for annual index counts and subsequent calculation of reservoir population density. Transects were almost or entirely devoid of standing trees, and were selected to encompass as many geographic features of the lake as possible. Each transect was surveyed with the down-scanning transducer using a 0-100 foot setting. It was not necessary to scan deeper than 100 feet, since very few fish were present below 60 feet. Additionally, three of the eleven transects were randomly selected for sampling with the side-scanning transducer (transects 1, 6, and 8). Approximately four hours were required to survey all eleven transects.

Four estimates were conducted on April 11-12, and April 16-17. Two estimates (April 12 and 17) were conducted in the morning between 0800 and 1200 hours. The remaining two estimates (April 11 and 16) were conducted in the afternoon between 1200 and 1600 hours.

Population estimates were calculated from index count data, and are based on the assumption that fish are randomly distributed in the reservoir during early spring. Visual inspection of transect data did not show clumping of fish in any of the areas surveyed. Relatively rapid water level fluctuations probably inhibit establishment of territories along shallow littoral areas of the lake, possibly enhancing random dispersion into pelagic zones. Also, the absence of terrestrial and aquatic invertebrates due to seasonal timing and/or reservoir fluctuations, probably entice fish to disperse and feed on zooplankton throughout the upper water column of the lake.

The development of reservoir population estimates required calculation of lake strata volumes. Lake volumes were estimated at (even) 25-foot contour intervals from 1600 feet down to 1375 feet using a set of 1933 topographic maps supplied by Seattle City Light. Johnston (1981) lists

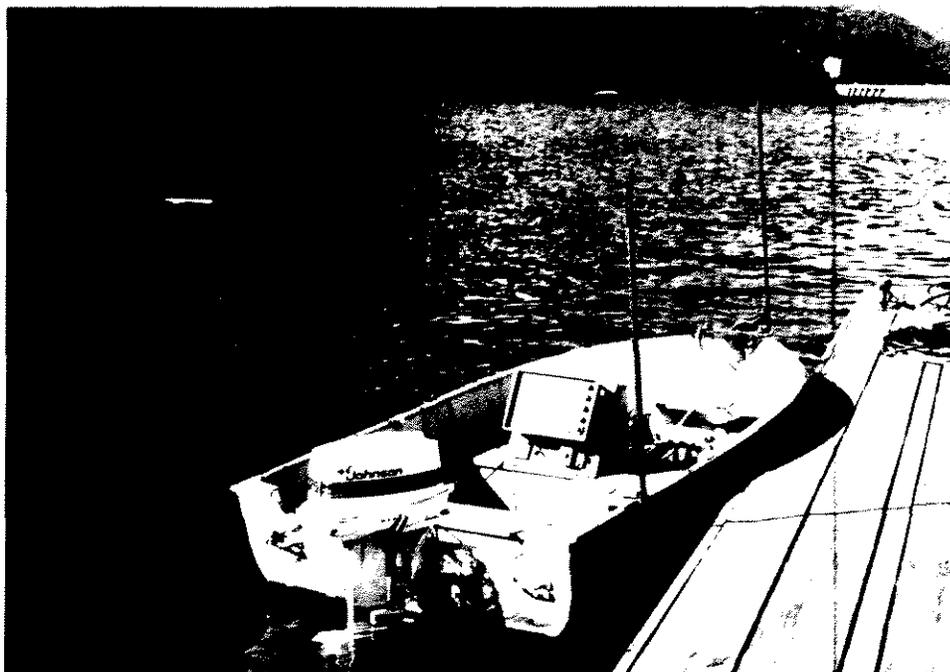


FIGURE 4. Hydroacoustic equipment used in reservoir trout population estimates and index counts.

the methods and procedures for finding lake strata volumes from topographic maps. It was necessary to first locate the appropriate 25-foot contour intervals used in the lake volume estimates on the down-scan transect echograms before making any initial fish counts. This was necessary since the reservoir was at a different elevation on each survey date. Fish counts were then made between these intervals. Volume adjustments (linear interpolation) were necessary for the upper and lower portion of each echogram, since the echogram did not precisely match the 25-foot volume contour intervals.

Population estimates and variances for each of the four surveys were calculated using statistical procedures developed by Johnston (1981). These procedures utilize simple expansion techniques to estimate density within each 25-foot depth stratum.

Spawning Surveys

Eight rainbow trout spawning surveys were conducted from May through mid-August on each of six index streams. Streams were selected for annual enumeration of spawning fish based on size, flow, availability of spawning habitat, historic spawner usage, and accessibility by personnel. Streams surveyed included Canyon, Dry, Lightning, Pierce, Roland, and Thursday Creeks (*Figure 2*).

Each stream was surveyed from the mouth upstream to either the first total migration barrier, or the limit of adequate spawning habitat. The only exception was Canyon Creek, which was surveyed from the confluence with Ruby Creek to 0.5 mile upstream. It was not possible to survey Canyon Creek and Lightning Creek during high water flows, due to the turbid condition and dangerous nature of the water. Survey frequency varied throughout the spawning period, but averaged five days during peak spawning.

RESULTS

1989-90 Lake Levels

The opening day lake elevation on June 17, 1989 was 1595.53 feet msl. A maximum reservoir elevation of 1602.48 feet msl occurred on July 15, 1989, and a minimum reservoir elevation of 1513.55 feet msl was recorded on April 1, 1990.

1989 Opening Day - Creel Survey (pre-1990 regulation changes)

A total of 134 anglers were interviewed at Ross Lake on opening day, June 17, 1989. The anglers fished a total of 589.25 hours and caught 582 fish (combination of harvested and released) for a catch per unit effort (CPUE) of 0.988 fish per hour. The catch was composed of 578 rainbow trout and four dolly varden char for a CPUE of 0.981 and 0.007, respectively. The fish per angler average (harvested and released) was 4.3 for a combination of complete and incomplete anglers. Completed trip anglers averaged 6.3 fish (harvested and released) per person.

1989 Opening Day - Harvest

The opening day harvest totaled 543 fish for interviewed anglers. Species composition of the harvest was 541 rainbow trout (99.6%) and two dolly varden char (0.4%). A total of 39 fish (6.7%) were released. *Table 4* compares various creel data from the north, south, and combined ends of the lake.

1989 Opening Day - Methods and Gear

All anglers checked at Ross Lake fished from boats on opening day (*Table 5*). The most popular angling method was trolling with flashers and bait (44.8%), followed by trolling with flashers and lures (31.3%), and still fishing with bait (23.9%).

Anglers trolling with bait harvested 44.8% of the fish reported and had a CPUE of 0.825 fish per hour. Anglers trolling with lures harvested 26.6% of the fish and had a CPUE of 0.975, while anglers still fishing with bait harvested 28.5% of the fish and had a CPUE of 1.407. These data suggest a direct correlation between percent gear type chosen and percent capture by gear type, and an inverse correlation between percent gear type and CPUE. Johnston (1989) discusses the significance between access and/or the physical characteristics of the reservoir and the types of tackle and fishing methods chosen by anglers.

1989 Opening Day - Length

The average fork length of rainbow trout harvested by anglers was 281 mm (*Table 4*). These trout ranged from 178 to 355 mm in length. *Figure 5*

TABLE 4. Comparison of 1989 opening day rainbow trout catch statistics between different access areas at Ross Reservoir.

Access	Anglers	Hours	Catch	CPUE ^b	F/A ^c	Rainbow Trout Catch ^a		
						Fork Length (mm)		
						Max	Min	Avg
COMBINED TRIPS ^d								
Resort	52	290	252	0.869	4.8	355	220	284
Hozomeen	82	299	326	1.089	4.0	273	178	231
Combined	134	589	578	0.981	4.3	355	178	281
COMPLETE TRIPS								
Resort	31	193	177	0.917	5.7	---	---	---
Hozomeen	17	72	123	1.714	7.2	---	---	---
Combined	48	265	300	1.133	6.3	---	---	---

^aCatch, catch per unit effort, and fish per angler data are summarized from total number of rainbow trout caught (harvested + released).

^bCatch per unit effort (fish/hour).

^cFish per angler.

^dIncludes data from anglers that were not finished fishing for the day (complete + incomplete trips).

TABLE 5. Angler catch, catch rates, and number of anglers fishing for rainbow trout using different types of gear and fishing methods on opening day, 1989^a.

Gear type ^b	Resort	Hozomeen	Total	Percent
ANGLERS				
bl	26	16	42	31.3
bb	26	34	60	44.8
bs	--	32	32	23.9
Total	52	82	134	100.0
CATCH ^c				
bl	100	54	154	26.6
bb	152	107	259	44.8
bs	---	165	165	28.5
Total	252	326	578	100.0
CPUE ^c				
bl	1.020	0.900	0.975	
bb	0.792	0.877	0.825	
bs	-----	1.407	1.407	
Mean	0.869	1.089	0.981	

^aData is from combined (complete + incomplete) trip anglers.

^bbl = boat, trolling lure
 bb = boat, trolling bait
 bs = boat, still-fishing bait

^cCombination of harvested and released.

depicts length-frequency histograms of the opening day harvest of rainbow trout from the north, south, and combined ends of Ross Lake. The sample size of fish measured at the north end of the lake in 1989 was too small (n=9) for comparison with other data. However, the length-frequency diagram for the south end of the reservoir shows that the most numerous fish in any one size group were between 270 and 290 mm. This situation is very similar to the 1987 and 1988 opening days at the south end of the lake (Johnston 1989). No dolly varden char were measured from the angler harvest.

A complete list of the 1989 opening day creel data for Ross Lake is given in *Appendix 1* of the Ross Lake Rainbow Trout Study: 1990-91 Data Appendix (Looff 1991).

1990-91 Lake Levels

The opening day lake elevation was 1599.23 feet msl on July 1, 1990. The reservoir reached a maximum elevation of 1601.98 feet msl on November 12, 1990, and a minimum elevation of 1512.93 feet msl on April 21, 1991.

1990 Opening Day Creel Survey - (post-1990 regulation change)

A total of 93 anglers were checked at Ross Lake on opening day, July 1, 1990. These anglers fished a total of 340.50 hours and caught 297 fish (combination of harvested and released) for a catch per unit effort (CPUE) of 0.872 fish per hour. The catch was composed of 295 rainbow trout and two dolly varden char comprising a CPUE of 0.866 and 0.006, respectively. The fish per angler average (harvested and released) was 3.2 for a combination of complete and incomplete anglers. Completed trip anglers caught (harvested and released) an average of 3.4 fish per person.

The 1990 opening day CPUE and number of fish per angler were less than 1989 opening day values (*Tables 4 and 6*). Opening day CPUE was 0.981 in 1989 and 0.866 in 1990, while fish per angler dropped from 4.3 to 3.2, respectively.

1990 Opening Day - Harvest

Opening day harvest totaled 52 rainbow trout for interviewed anglers. No dolly varden char were harvested from the catch. A total of 245 fish (82.5%) were released. *Table 6* compares various creel data from the north, south, and composite ends of the lake.

1990 Opening Day - Methods and Gear

All anglers checked at Ross Lake fished from boats on opening day. The only angling method used by these anglers, under the new regulations, was trolling with flashers and lures.

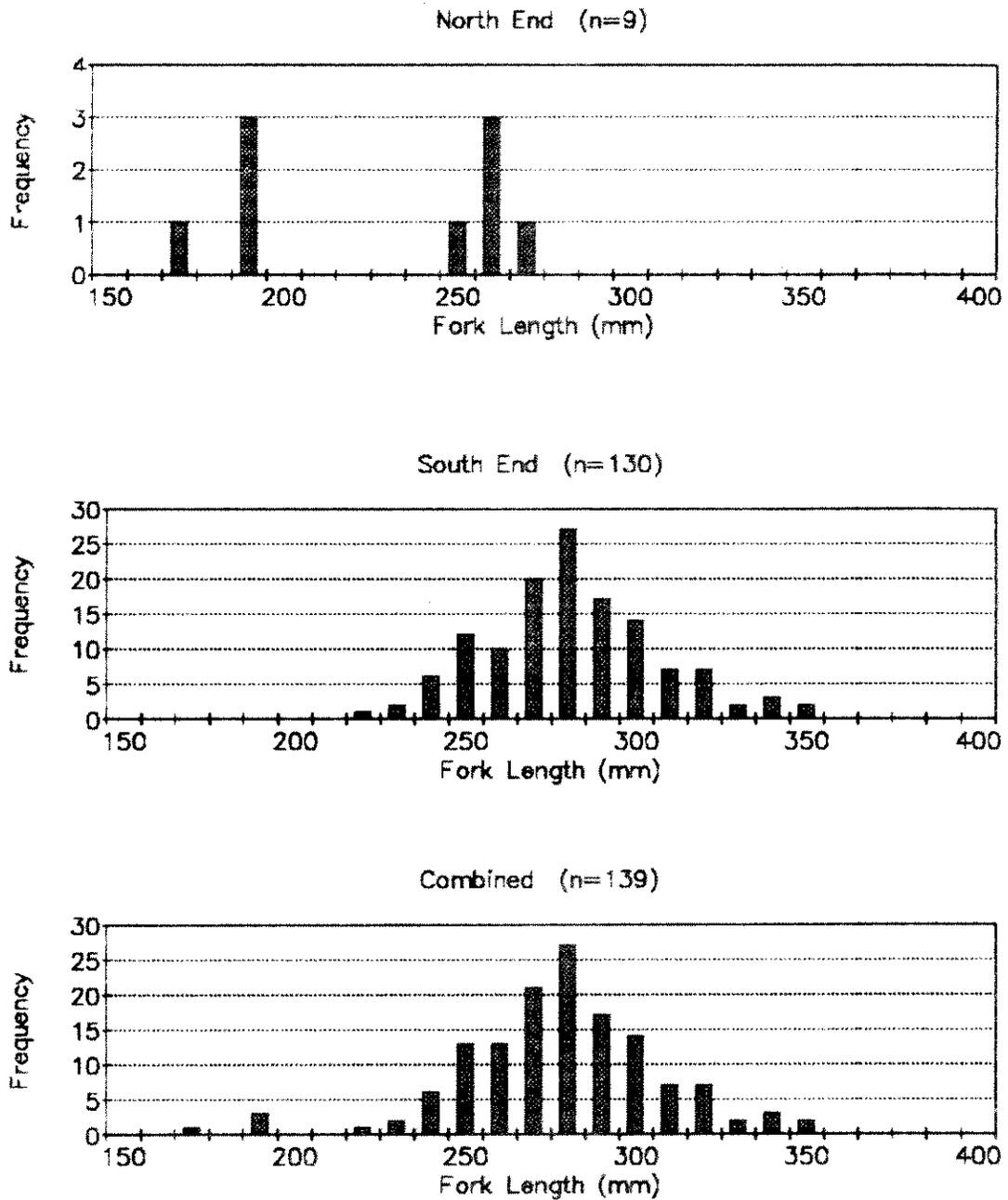


FIGURE 5. Length-frequency distributions of rainbow trout sampled from the Ross Lake sport harvest on opening day, 1989. Minimum legal size limit is approximately 317 mm fork length. Abscissa values indicate lower limit of length interval.

TABLE 6. Comparison of 1990 opening day rainbow trout catch statistics between different access areas at Ross Reservoir.

Access	Anglers	Hours	Catch	CPUE ^b	F/A ^c	Rainbow Trout Catch ^a		
						Fork Length (mm)		
						Max	Min	Avg
COMBINED TRIPS^d								
Resort	27	137	129	0.945	4.8	373	320	338
Hozomeen	20	61	86	1.416	4.3	405	330	338
Canada	46	143	80	0.558	1.7	370	270	330
Combined	93	341	295	0.866	3.2	405	270	336
COMPLETE TRIPS								
Resort	2	12	12	1.000	6.0	---	---	---
Hozomeen	4	21	30	1.446	7.5	---	---	---
Canada	25	88	61	0.691	2.4	---	---	---
Combined	31	121	103	0.851	3.3	---	---	---

^aCatch, catch per unit effort, and fish per angler data are summarized from total number of rainbow trout caught (harvested + released).

^bCatch per unit effort (fish/hour).

^cFish per angler.

^dIncludes data from anglers that were not finished fishing for the day (complete + incomplete trips).

1990 Opening Day - Age

Out of 46 rainbow trout randomly sampled from the opening day harvest in 1990, the majority were age 3 (43%) and age 4 (39%). Fifteen percent were age 2, and one fish (2%) was age 5. A marked difference in age composition of fish sampled from the north and south ends of the lake is probably due to the small sample size (n=12) at the south end. North end rainbow trout (n=34) were primarily age 3 (53%), while south end rainbow trout were predominantly age 4 (67%). The remainder of the north end sample comprised age 2 (18%) and age 4 (29%) fish, while the balance of the south end sample included age 2 (8%), age 3 (17%), and age 5 (8%) fish.

1990 Opening Day - Length

The average fork length of rainbow trout harvested by anglers was 336 mm (Table 6). These trout ranged in length from 270 to 405 mm. Figure 6 depicts length-frequency histograms of the opening day harvest of rainbow trout from the north, south, and combined ends of Ross Lake. The most numerous number of fish were in the 330-340 mm size group, which is slightly larger than the approximate minimum legal fork length size limit (317 mm, or 12.5 inches) permitted under the new regulations. No dolly varden char were measured in the angler harvest.

1990 Opening Day - Sex

On July 1, 1990, a sub-sample of fifteen rainbow trout were examined internally for sex determination. A larger sample size was precluded by anglers cleaning their catch before returning to shore. Seven fish (47%) were males and eight fish (53%) were females. The sample size was too small to further subdivide the sex information by lake access.

1990 Opening Day - Sexual Maturity

The sub-sample of fifteen rainbow trout that were examined for sex determination were also checked for sexual maturity (Table 7). Mature fish comprised 33 percent of the sample (3 males and 2 females), while immature fish made up 67 percent of the sample (4 males and 6 females). The average lengths of mature fish were 358 mm for males, and 354 mm for females. Immature males averaged 334 mm, while immature females averaged 330 mm.

Age and length information of the opening day sexual maturity sub-sample, grouped by access, sex and maturity, is given in Table 8. All mature fish (both sexes) were four years old. Immature males were either age 3 or age 4, while immature females were more variable in age, ranging from two to five years old.

A complete list of the 1990 opening day creel data for Ross Lake is given in Appendix 2 of the Ross Lake Rainbow Trout Study: 1990-91 Data Appendix (Looff 1991).

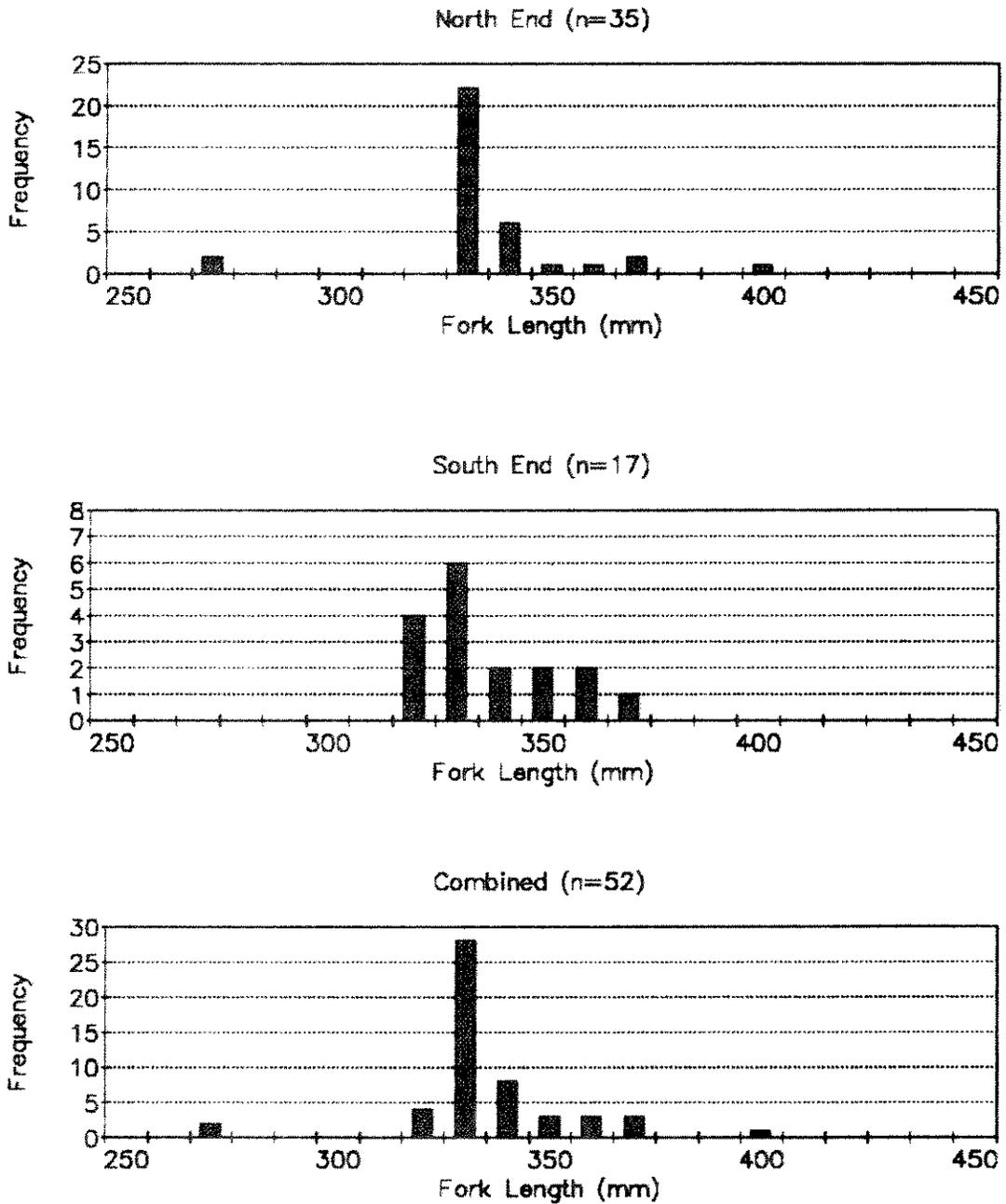


FIGURE 6. Length-frequency distributions of rainbow trout sampled from the Ross Lake sport harvest on opening day, 1990. Minimum legal size limit is approximately 317 mm fork length. Abscissa values indicate lower limit of length interval.

TABLE 7. Rainbow trout length information, grouped by sex and maturity, from the opening day, 1990 sport harvest at Ross Reservoir.

Sex	Maturity	N	Fork Length (mm)		
			Avg	Min	Max
Male	Mature	3	357.7	340	373
	Immature	4	333.8	320	355
Female	Mature	2	353.5	345	362
	Immature	6	329.5	320	352

TABLE 8. Rainbow trout age and length information, grouped by access area, sex and maturity, from the opening day, 1990 sport harvest at Ross Reservoir.

Access	Sex	Maturity	Age	N	Fork Length (mm)		
					Avg	Min	Max
Hozomeen	Male	Mature	4	1	340.0	340	340
		Immature	3	1	320.0	320	320
	Female	Immature	4	1	320.0	320	320
Resort	Male	Mature	4	2	366.5	373	360
		Immature	3	1	330.0	330	330
			4	2	342.5	355	330
	Female	Mature	4	2	353.5	362	345
		Immature	2	1	323.0	323	323
			3	1	330.0	330	330
			4	2	326.0	330	322
		5	1	352.0	352	352	

1990 Season Creel Survey

A total of 1562 anglers were interviewed during the July 1 to October 31, 1990 creel census at Ross Reservoir. During the interviews 594 rainbow trout were sampled for life history information.

1990 Season - Angler Effort

From July 1, 1990 to October 31, 1990 anglers fished an estimated 33,216 +/- 2,330 hours, or 8,218 angler days (*Table 9, daytype* estimate). The standard error of the estimated total effort was small (+/- 3.5 percent), indicating good precision. Most angler effort occurred in July (36%), primarily during the first week of the season (*Figure 7* and *Appendix 4*). Angling generally decreased as the season progressed, although effort in August (24%) was slightly lower than in September (25%). October sustained only 14% of the total angler effort.

A total seasonal estimate of 36,820 +/- 3,008 hours was calculated for effort data that was separated into **zones** (*Table 9* and *Appendix 5*). From *Figure 8*, it can be seen that most effort was expended in zones 2-Big Beaver (24%), 6-Hozomeen (19%), 1-Ruby (16%) and 7-Canada (14%). The three access areas were either located within or immediately adjacent to these four zones. Zones 3-Devils (12%), 5-Little Beaver (8%), and 4-Lightning (6%), comprised the remaining effort.

A total seasonal effort estimate of 36,820 +/- 3,440 hours was calculated for effort data that was separated into **access areas** (*Table 9* and *Appendix 6*). Effort totals of 21,509 hours (58%) were calculated for anglers utilizing the resort, 10,001 hours (27%) for anglers at Hozomeen, and 5,310 hours (14%) for anglers in Canada.

1990 Season - Angler Catch and Harvest Rates

The mean seasonal catch rate (combination of harvested and released) for rainbow trout was 0.386 +/- 0.001 fish per hour (*Table 10, daytype* estimate). The standard error of the estimated mean catch rate was very small (+/- 0.01 percent), indicating excellent precision. Except for a CPUE increase in October, rainbow trout catch rates declined throughout the season (*Figure 9* and *Appendix 7*). Catch rates were highest in July (0.512 CPUE) and October (0.385 CPUE), and lowest in August (0.336 CPUE) and September (0.289 CPUE).

The mean seasonal harvest rate for rainbow trout was 0.118 +/- <0.001 fish per hour (*Table 10, daytype* estimate). The standard error of the estimated mean harvest rate was very small (+/- 0.01 percent), indicating excellent precision. As shown in *Figure 9*, harvest rates for rainbow trout decreased from July (0.122 HPUE) to a seasonal low in August (0.088 HPUE), then increased in September (0.113 HPUE) to a seasonal high in October (0.152 HPUE).

TABLE 9. Estimated total seasonal angler effort in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Type ^a	Strata	Angler Hours ^b		Mean Hours Fished per Day ^c	Total Angler Days ^d
Daytype	Opener	885	(0)	3.66	242
	Weekday	20135	(1094)	3.93	5128
	Weekend	12195	(400)	4.28	2848
	Total	33216	(1165)	4.04	8218
Zone ^e	1 Rby	5902	(578)	3.92	1507
	2 Bbv	8934	(845)	4.59	1948
	3 Dev	4519	(505)	5.58	809
	4 Lit	2154	(250)	6.15	350
	5 Lbv	3026	(320)	3.82	793
	6 Hoz	6974	(691)	3.26	2137
	7 Can	5310	(563)	2.75	1934
	Total	36820	(1504)	3.88	9478
Access	Resort	21509	(1363)	4.69	4582
	Hozomeen	10001	(885)	3.63	2755
	Canada	5310	(563)	2.75	1934
	Total	36820	(1720)	3.97	9270

^aType of estimate. Daytype estimates are the most accurate based on sample design, and are the values reported for this study (see text).

^bStandard error of estimated total angler-hours given in parentheses. Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

^cMean hours calculated using data from all anglers, including those that indicated they had not finished fishing for the day (see text).

^dTotal angler days = angler hours/mean hours fished per day.

^eSee Figure 3 for location of lake survey zones.

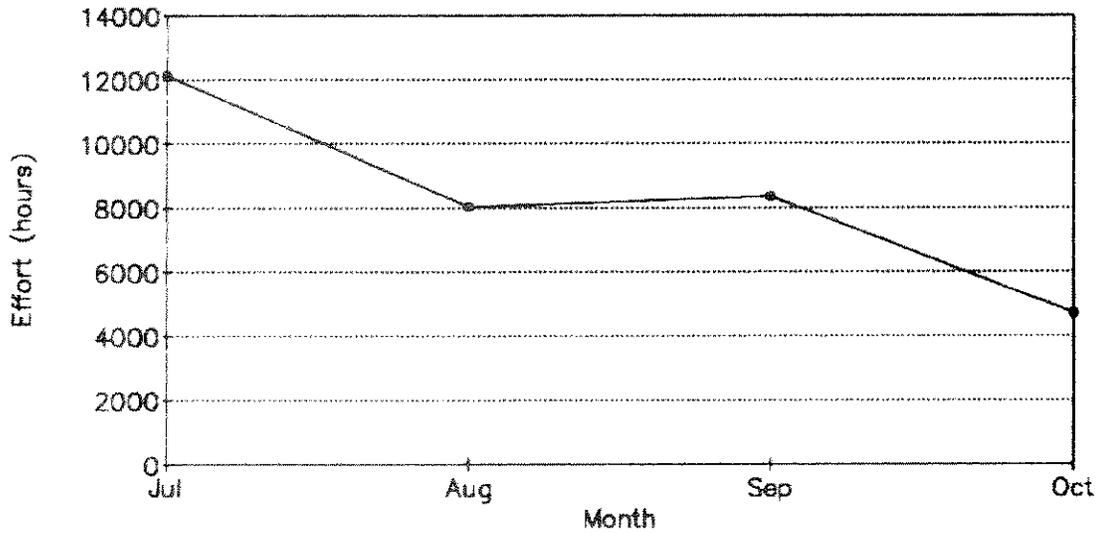


FIGURE 7. Monthly distribution of seasonal angler effort (daytype estimate) during the 1990 Ross Reservoir sport fishery.

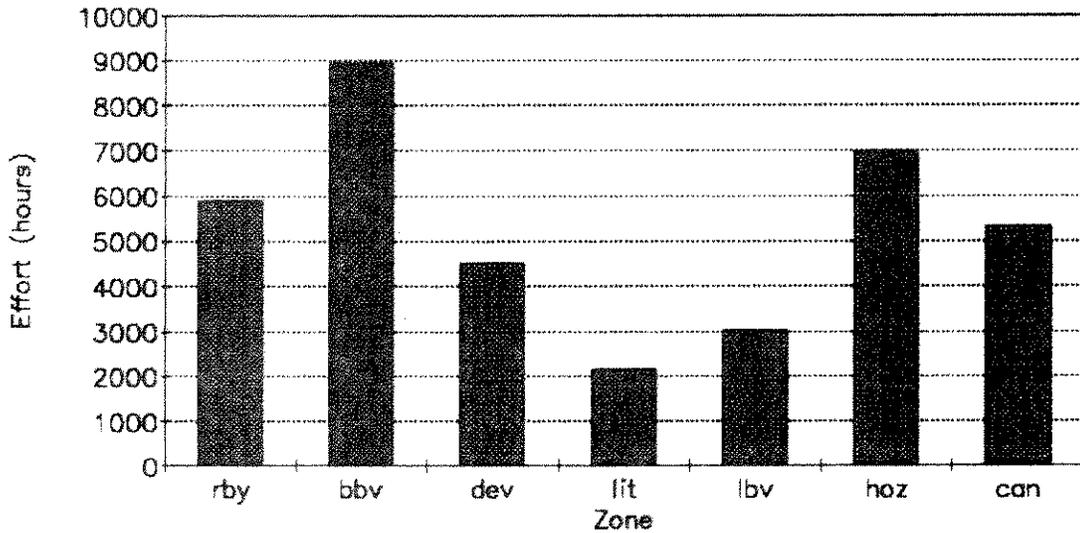


FIGURE 8. Distribution of seasonal angler effort (zone estimate) among lake zones during the 1990 Ross Reservoir sport fishery. Zone abbreviations are as follows: rby = ruby (zone 1), bbv = big beaver (zone 2); dev = devils (zone 3); lit = lightning (zone 4); lbv = little beaver (zone 5); hoz = hozomeen (zone 6); and can = canada (zone 7).

TABLE 10. Estimated mean seasonal catch and harvest rates for rainbow trout in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Rainbow Trout Catch per Hour ^a								
Type ^b	Strata	N ^c	Harvested		Released		Total	
Day	Opener	93	.153	(.0023)	.714	(.0067)	.866	(.0075)
	Weekday	736	.109	(.0002)	.247	(.0005)	.356	(.0006)
	Weekend	733	.122	(.0003)	.241	(.0005)	.363	(.0006)
	Mean		.118	(.0001)	.268	(.0002)	.386	(.0003)
Zon ^d	1 Rby	265	.060	(.0005)	.292	(.0017)	.351	(.0019)
	2 Bbv	395	.081	(.0004)	.210	(.0008)	.291	(.0010)
	3 Dev	150	.101	(.0011)	.217	(.0021)	.319	(.0027)
	4 Lit	73	.093	(.0018)	.284	(.0042)	.377	(.0050)
	5 Lbv	105	.122	(.0016)	.254	(.0031)	.376	(.0044)
	6 Hoz	306	.239	(.0008)	.321	(.0012)	.559	(.0015)
	7 Can	268	.145	(.0009)	.362	(.0019)	.507	(.0022)
Mean		.118	(.0001)	.268	(.0002)	.386	(.0003)	
Acc	Resort	900	.078	(.0002)	.228	(.0004)	.306	(.0004)
	Hozomeen	405	.226	(.0006)	.346	(.0010)	.572	(.0013)
	Canada	257	.142	(.0010)	.354	(.0020)	.496	(.0023)
	Mean		.118	(.0001)	.268	(.0002)	.386	(.0003)

^aStandard error of estimated mean catch per hour given in parentheses. Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

^bType of estimate. Daytype estimates are the most accurate based on sample design, and are the values reported for this study (see text). Day = daytype estimate, Zon = zone estimate, and Acc = access area estimate.

^cNumber of anglers surveyed.

^dSee Figure 3 for location of lake survey zones.

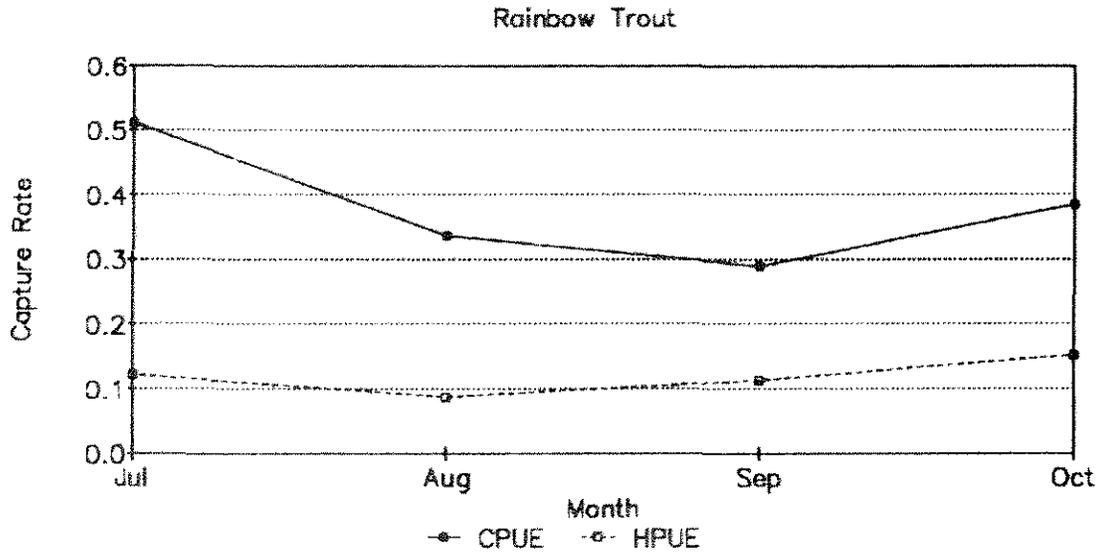


FIGURE 9. Monthly distribution of seasonal rainbow trout catch and harvest rates (daytype estimate) during the 1990 Ross Reservoir sport fishery.

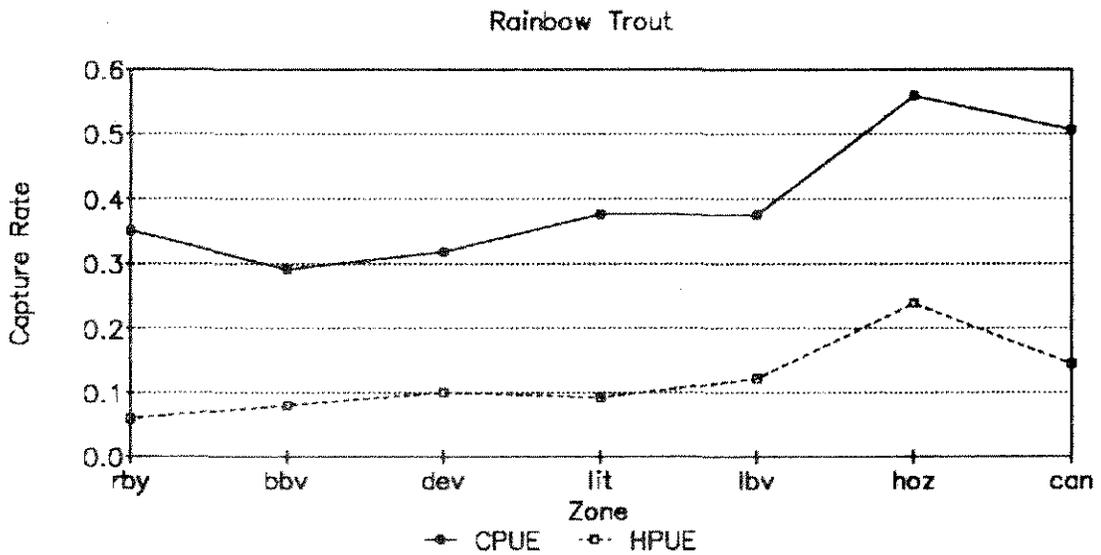


FIGURE 10. Distribution of seasonal rainbow trout catch and harvest rates (zone estimate) among lake zones during the 1990 Ross Reservoir sport fishery. Zone abbreviations are as follows: rby = ruby (zone 1), bbv = big beaver (zone 2); dev = devils (zone 3); lit = lightning (zone 4); lbv = little beaver (zone 5); hoz = hozomeen (zone 6); and can = canada (zone 7).

Mean seasonal catch and harvest rates for zone and access area estimates are identical to daytype estimates (*Table 10*), since all three estimates were calculated from the same creel data. As shown in *Table 10* and *Figure 10*, the highest seasonal catch rates for rainbow trout (zone estimate) occurred at the north end of the lake in zones 6-Hozomeen (0.559 CPUE) and 7-Canada (0.507 CPUE). The lowest seasonal catch rates occurred in zones 2-Big Beaver (0.291 CPUE), 3-Devils (0.319 CPUE) and 1-Ruby (0.351 CPUE). Rainbow trout harvest rates followed a similar pattern as catch rates for the different zones, being highest at the north end of the lake, and lowest at the south end. *Appendix 8* lists monthly and seasonal catch and harvest rate estimates for the different zone strata.

Table 10 shows that anglers using the Hozomeen access had the highest seasonal catch rate (access area estimate) for rainbow trout (0.572 CPUE). An intermediate catch rate was returned by anglers utilizing the Canadian access (0.496 CPUE), while resort anglers experienced the lowest catch rate (0.306 CPUE). Rainbow trout harvest rates followed the same pattern as catch rates for the different access areas, being highest at the north end of the lake, and lowest at the south end. *Appendix 9* lists monthly and seasonal catch and harvest rate estimates for the different access area strata.

Angler catch and harvest rate estimates for dolly varden char were low during the 1990 sport fishery at Ross Lake (*Table 11* and *Appendix 10*). The mean seasonal catch rate for dolly varden char was 0.004 fish per hour, while the mean seasonal harvest rate was 0.001 fish per hour (daytype estimate). Monthly dolly varden char catch rates were highest in August (0.012 CPUE), while harvest rates remained very low throughout the season (0.001 CPUE).

Mean seasonal catch and harvest rate estimates for all species of trout and char combined are given in *Table 11* and *Appendix 11*. The mean seasonal catch rate of all species combined was 0.391 fish per hour, while the seasonal harvest rate was 0.118 fish per hour (daytype estimate).

1990 Season - Angler Catch and Harvest

The total seasonal catch (combination of harvested and released) of rainbow trout was 12,484 +/- 741 fish (*Table 12*, daytype estimate). The standard error of the estimated seasonal catch was small (+/- 3.0 percent), indicating good precision. Total catch declined steadily throughout the season, from a high of 5,598 fish in July to a low of 1,792 fish in October (*Figure 11* and *Appendix 12*).

The total seasonal harvest of rainbow trout was 3,774 +/- 283 fish (*Table 12*, daytype estimate). The standard error of the estimated seasonal harvest was small (+/- 3.7 percent), indicating good precision. As shown in *Figure 11*, harvest of rainbow trout decreased from July (39%) to August (19%), increased in September (24%), and declined to a seasonal

TABLE 11. Estimated mean seasonal catch and harvest rates for all trout and char species in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Species	Strata ^a	Harvest	Release	Total
Rainbow	Opener	0.153	0.714	0.866
	Weekday	0.109	0.247	0.356
	Weekend	0.122	0.241	0.363
	Mean	0.118	0.268	0.386
Dolly Varden	Opener	0	0.003	0.003
	Weekday	0.001	0.003	0.004
	Weekend	0.001	0.004	0.005
	Mean	0.001	0.004	0.004
All Species	Opener	0.153	0.717	0.869
	Weekday	0.110	0.251	0.361
	Weekend	0.123	0.245	0.367
	Mean	0.118	0.272	0.391

^aDaytype estimate.

TABLE 12. Estimated total seasonal catch and harvest of rainbow trout in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

		Rainbow Trout Catch ^a					
Type ^b	Strata	Harvested		Released		Total	
Day	Opener	135	(2.1)	632	(5.9)	768	(6.3)
	Weekday	2236	(131.9)	5163	(318.0)	7399	(344.3)
	Weekend	1403	(50.6)	2914	(127.4)	4317	(137.1)
	Total	3774	(141.3)	8709	(342.7)	12484	(370.6)
Zon ^c	1 Rby	362	(39.9)	1823	(210.8)	2185	(214.6)
	2 Bbv	729	(70.9)	1928	(186.0)	2657	(199.0)
	3 Dev	475	(52.3)	944	(112.3)	1419	(123.9)
	4 Lit	197	(23.8)	658	(80.1)	855	(83.6)
	5 Lbv	381	(45.4)	998	(114.8)	1379	(123.5)
	6 Hoz	1626	(176.8)	2329	(255.6)	3955	(310.8)
	7 Can	734	(86.5)	1800	(214.8)	2533	(231.6)
	Total	4503	(225.2)	10479	(471.9)	14982	(522.9)
Acc	Resort	1680	(108.8)	5114	(374.4)	6794	(389.8)
	Hozomeen	2195	(208.1)	3540	(321.4)	5736	(382.9)
	Canada	720	(84.4)	1770	(209.9)	2490	(226.3)
	Total	4595	(249.5)	10424	(536.2)	15019	(591.4)

^aStandard error of estimated total catch given in parentheses. Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

^bType of estimate. Daytype estimates are the most accurate based on sample design, and are the values reported for this study (see text). Day = daytype estimate, Zon = zone estimate, and Acc = access area estimate.

^cSee *Figure 3* for location of lake survey zones.

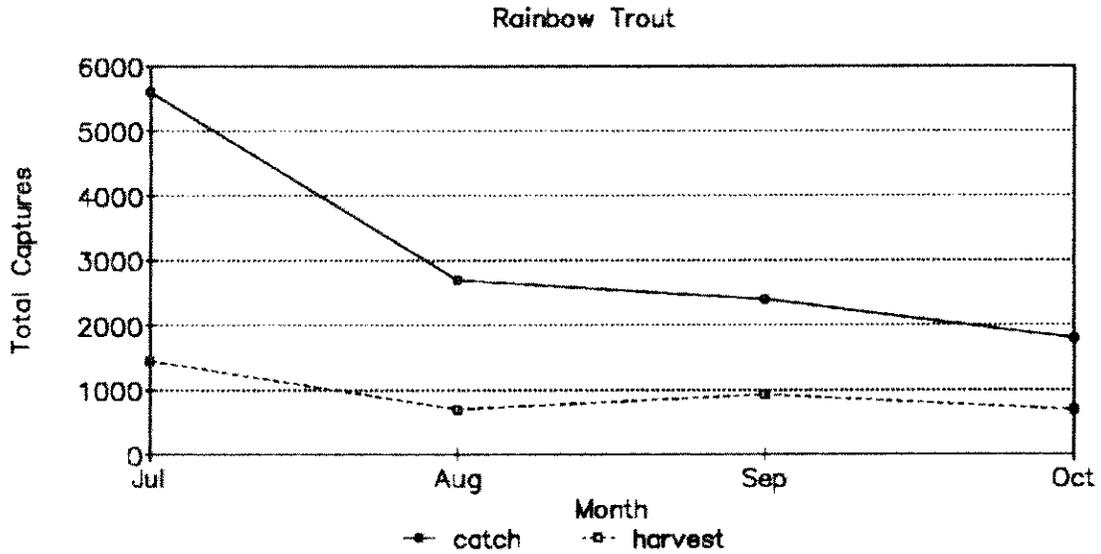


FIGURE 11. Monthly distribution of seasonal rainbow trout catch and harvest (daytype estimate) during the 1990 Ross Reservoir sport fishery.

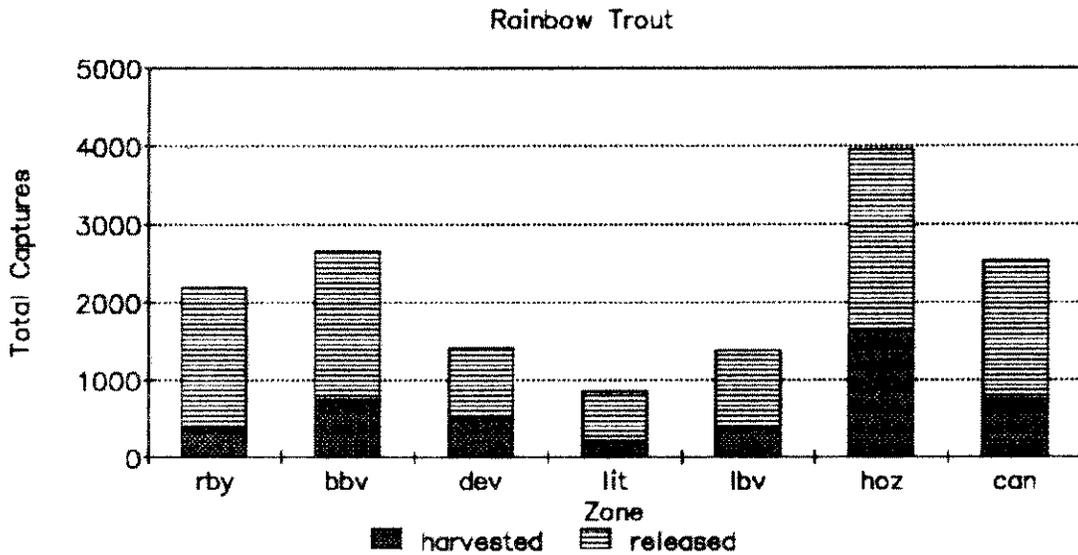


FIGURE 12. Distribution of seasonal rainbow trout catch and harvest (zone estimate) among lake zones during the 1990 Ross Reservoir sport fishery. Zone abbreviations are as follows: rby = ruby (zone 1), bbv = big beaver (zone 2); dev = devils (zone 3); lit = lightning (zone 4); lbv = little beaver (zone 5); hoz = hozomeen (zone 6); and can = canada (zone 7).

low in October (18%).

A total seasonal catch estimate of 14,982 +/- 1,046 rainbow trout were calculated for data that was separated into **zones** (*Table 12* and *Appendix 13*). As shown in *Figure 12*, the greatest catch of rainbow trout was caught at the north end of the lake in zones 6-Hozomeen (26%) and 7-Canada (17%), and at the south end of the lake in zone 2-Big Beaver (18%). Lowest catch totals occurred in zones 4-Lightning (6%), 5-Little Beaver (9%), 3-Devils (9%), and 1-Ruby (15%). A total seasonal harvest estimate of 4,503 +/- 450 rainbow trout was distributed similar to catch for the different zones. The greatest numbers were harvested in zones 6-Hozomeen (36%), 7-Canada (16%), and 2-Big Beaver (16%), while lower numbers were harvested in zones 4-Lightning (4%), 1-Ruby (8%), 5-Little Beaver (9%), and 3-Devils (11%).

A total seasonal catch estimate of 15,019 +/- 1,183 rainbow trout were calculated for data that was separated into **access areas** (*Table 12* and *Appendix 14*). Anglers originating from Ross Lake Resort caught the largest numbers of rainbow trout (45%). Anglers utilizing the Hozomeen access also caught a substantial proportion of the catch (38%), while anglers using the Canadian access caught the fewest fish (17%). A total seasonal harvest estimate of 4,595 +/- 499 rainbow trout, did not follow the same distribution pattern as catch. More fish were harvested by Hozomeen anglers (48%) than either resort (36%) or Canadian (16%) anglers.

Total dolly varden char catch estimates were low for the 1990 sport fishing season at Ross Lake (*Table 13* and *Appendix 15*). The total seasonal catch of dolly varden char was 153 +/- 12 fish, while the total seasonal harvest was 18 +/- 2 fish (**daytype** estimate). Monthly catch ranged from a high of 100 char in August to a low of six char in October, while monthly harvest ranged from three fish in July to six fish in October.

Total seasonal catch for all species of trout and char combined are given in *Table 13* and *Appendix 16*. The total seasonal catch of all species combined was 12,652 +/- 748 fish, while the total seasonal harvest was estimated at 3,793 +/- 283 fish (**daytype** estimate).

1990 Season - Angling Gear and Methods

The majority (99.9%) of anglers at Ross Lake used boats in 1990 (*Table 14*). Only two shore anglers (0.1%) were interviewed the entire season. The most popular angling method was trolling with flashers and lures (96.4%), followed by trolling with flies (3.5%), and casting flies from shore (0.1%). Bait fishing is no longer permitted under the new fishing regulations.

Anglers trolling lures caught 97.3 percent of the total catch (combination of harvested and released), and had a CPUE of 0.371 fish per hour (*Table 14*). Anglers trolling flies caught 2.7 percent of the catch,

TABLE 13. Estimated total seasonal catch and harvest of all species of trout and char in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

Species	Strata ^a	Harvest	Release	Total
Rainbow	Opener	135	632	768
	Weekday	2236	5163	7399
	Weekend	1403	2914	4317
	Total	3774	8709	12484
Dolly Varden	Opener	0	3	3
	Weekday	11	62	73
	Weekend	7	70	77
	Total	18	135	153
All Species	Opener	135	635	770
	Weekday	2247	5241	7487
	Weekend	1410	2984	4394
	Total	3793	8859	12652

^aDaytype estimate.

TABLE 14. Angler catch, catch rates, and number of anglers fishing for rainbow trout using different types of gear and fishing methods during the 1990 sport fishing season^a.

Geartype ^b	Resort	Hozomeen	Canada	Total	Percent
ANGLERS					
bl	786	320	217	1323	96.4
bf	30	2	16	48	3.5
sf	0	0	2	2	0.1
Total	816	322	235	1373	100.0
CATCH ^c					
bl	1228	587	296	2111	97.3
bf	15	3	40	58	2.7
sf	0	0	0	0	0.0
Total	1243	590	336	2169	100.0
CPUE ^c					
bl	0.317	0.489	0.490	0.371	
bf	0.137	1.000	0.851	0.364	
sf	0	0	<0.000	<0.000	
Mean	0.312	0.490	0.511	0.371	

^aData are from combined (complete + incomplete) trip anglers.

^bbl = boat, trolling lure
 bf = boat, trolling fly
 sf = shore, casting fly

^cCombination of harvested and released.

and had a CPUE of 0.364 fish per hour. The two anglers casting flies from shore were unsuccessful.

1990 Season - Age

A total of 365 rainbow trout scale samples from the 1990 angler sport harvest were read for age determination. Age 3 fish were the most abundant age class, comprising 47.1 percent of the total sample (*Table 15*). The remaining fish were age 2 (9.9%), age 4 (31.5%), age 5 (9.9%), age 6 (1.4%), and age 7 (0.3%). Age 3 fish were the dominant age class throughout the season.

Occurrence of age 2 fish increased over the first three months of the season, but were absent from the harvest in October (*Table 15*). Percent contribution of age 3 fish was relatively constant each month, except for a moderate decline in August. Both age 4 and age 5 fish increased in August, decreased in September, and then increased again slightly in October. One age 6 fish was harvested in July, two in September, and two in October. Only one age 7 rainbow (harvested in August) was sampled the entire season.

1990 Season - Length

A total of 594 rainbow trout were measured from the 1990 angler sport harvest (*Table 16*). The minimum size regulations restrict angler harvest to fish longer than 13 inches (330 mm) total length. A fork length of 317 mm is an approximate equivalent to the 330 mm total length minimum size restriction. The average fork length of angler harvested rainbow trout during the 1990 season was 332 mm. Sizes ranged from a low of 270 mm (illegally harvested) to a high of 405 mm. Average size declined from July through September, then increased slightly in October. Life history characteristics that may be responsible for the apparent temporal decrease in average size of specific age classes will be presented in a later section of this report.

Length at age information for the rainbow trout harvest is shown in *Table 17*. As expected, average fork length increases with each successive age class. Age 2 fish averaged 313 mm, age 3 fish averaged 326 mm, age 4 fish averaged 339 mm, age 5 fish averaged 352 mm, age 6 fish averaged 368 mm, and the one age 7 fish measured 380 mm.

Table 18 and *Figure 13* show the summer growth of rainbow trout in Ross Lake, as reflected by the size of fish in the angler sport harvest. Age 2 fish showed an increase in average size as the summer progressed, while age 3 and age 4 fish showed a decrease in average size. Average length of age 5 fish increased from July to August, then declined in size during September and October. Small sample sizes for age 6 (n=5) and age 7 (n=1) fish preclude definitive growth analyses for these two age classes. As mentioned earlier in this section, factors that may be responsible for negative temporal growth of specific age classes of fish will be presented in a later section of this report.

TABLE 15. Percent age composition of rainbow trout sampled from the 1990 sport harvest at Ross Reservoir.

AGE	MONTH									
	Jul		Aug		Sep		Oct		Total	
	n	%	n	%	n	%	n	%	n	%
TWO:	14	7.6	9	10.2	13	16.5	--	--	36	9.9
THREE:	92	50.0	34	38.6	39	49.4	7	50.0	172	47.1
FOUR:	60	32.6	31	35.2	20	25.3	4	28.6	115	31.5
FIVE:	17	9.2	13	14.8	5	6.3	1	7.1	36	9.9
SIX:	1	0.5	--	--	2	2.5	2	14.3	5	1.4
SEVEN:	--	--	1	1.1	--	--	--	--	1	0.3
TOTAL:	184		88		79		14		365	100.0

TABLE 16. Rainbow trout length information, by month, from the 1990 sport harvest at Ross Reservoir.

Month	Number	Percent	Fork Length (mm)		
			Average	Maximum	Minimum
July	214	36.0	333.5	270	405
August	90	15.2	332.5	298	400
September	150	25.3	329.0	278	370
October	140	23.6	331.5	299	395
Season	594	100.0	331.7	270	405

TABLE 17. Rainbow trout length information, by age, from the 1990 sport harvest at Ross Reservoir.

Age	Number	Percent	Fork Length (mm)		
			Average	Minimum	Maximum
2	36	9.9	313.3	270	330
3	172	47.1	325.8	271	370
4	115	31.5	338.9	300	460
5	36	9.9	352.2	300	400
6	5	1.4	368.0	350	395
7	1	0.3	380.0	380	380

TABLE 18. Average fork length (mm) of rainbow trout, grouped by month and age class, from the 1990 sport harvest at Ross Reservoir.

Age		JUL	AUG	SEP	OCT	SEASON
TWO:	n	14	9	13	-----	36
	avg	312.5	313.3	314.2	-----	313.3
THREE:	n	92	34	39	7	172
	avg	328.3	324.0	322.4	319.4	325.8
FOUR:	n	60	31	20	4	115
	avg	343.4	334.9	333.6	330.8	338.9
FIVE:	n	17	13	5	1	36
	avg	345.3	360.1	355.6	350.0	352.2
SIX:	n	1	-----	2	2	5
	avg	350.0	-----	362.5	382.5	368.0
SEVEN:	n	-----	1	-----	-----	1
	avg	-----	380.0	-----	-----	380.0

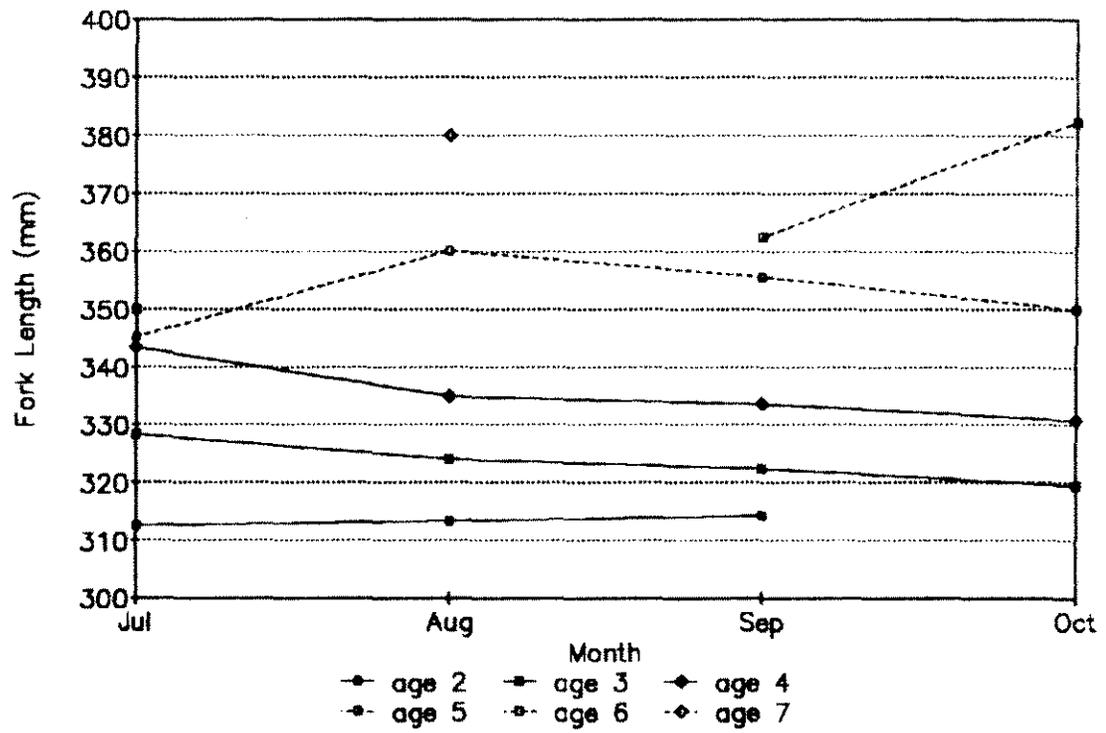


FIGURE 13. Average lengths of age 2 - age 7 rainbow trout, by month, from the 1990 Ross Lake sport harvest.

Monthly and seasonal length-frequency histograms of angler harvested rainbow trout at Ross Reservoir are shown in *Figure 14*. The abscissa scale values are standardized to facilitate comparison. All five histograms (monthly and seasonal) closely resemble the standard normal curve, and are predominantly centered on the 330-340 mm fork length interval. The legal size limit is 330 mm total length or approximately 317 mm fork length. The August and September histograms are vertically compressed compared to the July and October histograms.

1990 Season - Sex

A total of 254 rainbow trout were sampled from the seasonal sport harvest for sex determination. Males constituted 42 percent of the total sample (n=107), while females accounted for 58 percent (n=147). The north end sample (n=99) comprised 45 percent males and 55 percent females, while the south end sample (n=155) was composed of 40 percent males and 60 percent females.

1990 Season - Sexual Maturity

A random sample of 113 rainbow trout from the seasonal sport harvest were checked for gonadal development (*Table 19*). Immature fish comprised 70 percent of the sample, while the remaining 30 percent were mature. Males were composed of 60 percent immature and 40 percent mature fish, while females comprised 78 percent immature and 22 percent mature fish.

Table 20 shows the average fork length and size range of a random sample of 111 rainbow trout from the seasonal sport harvest, separated by access, sex, sexual maturity, and age. The north end sample (n=57) comprised 63 percent immature fish, while only 37 percent were mature. The male sample was composed of 52 percent immature (average length = 326 mm), and 48 percent mature fish (average length = 342 mm). Seventy-two percent of the female sample were immature fish (average length = 331 mm), while 28 percent were mature (average length = 334 mm).

The south end sample (n=54) comprised 79 percent immature fish, while only 21 percent were mature (*Table 20*). The male sample was composed of 71 percent immature (average length = 330 mm), and 29 percent mature fish (average length = 353 mm). Eighty-three percent of the female sample were immature fish (average length = 325 mm), while 17 percent were mature (average length = 347 mm).

1990 Season - Additional Data

Forty-two percent of the interviewed anglers that were fishing for rainbow trout during the 1990 sport fishing season at Ross Reservoir were unsuccessful (*Figure 15*). The remaining anglers (58%) were successful at catching from one to thirteen fish. Sixty-eight percent of the anglers were unsuccessful in harvesting a legal rainbow trout, while the remaining anglers harvested one (20%), two (7%), and three (5%) fish.

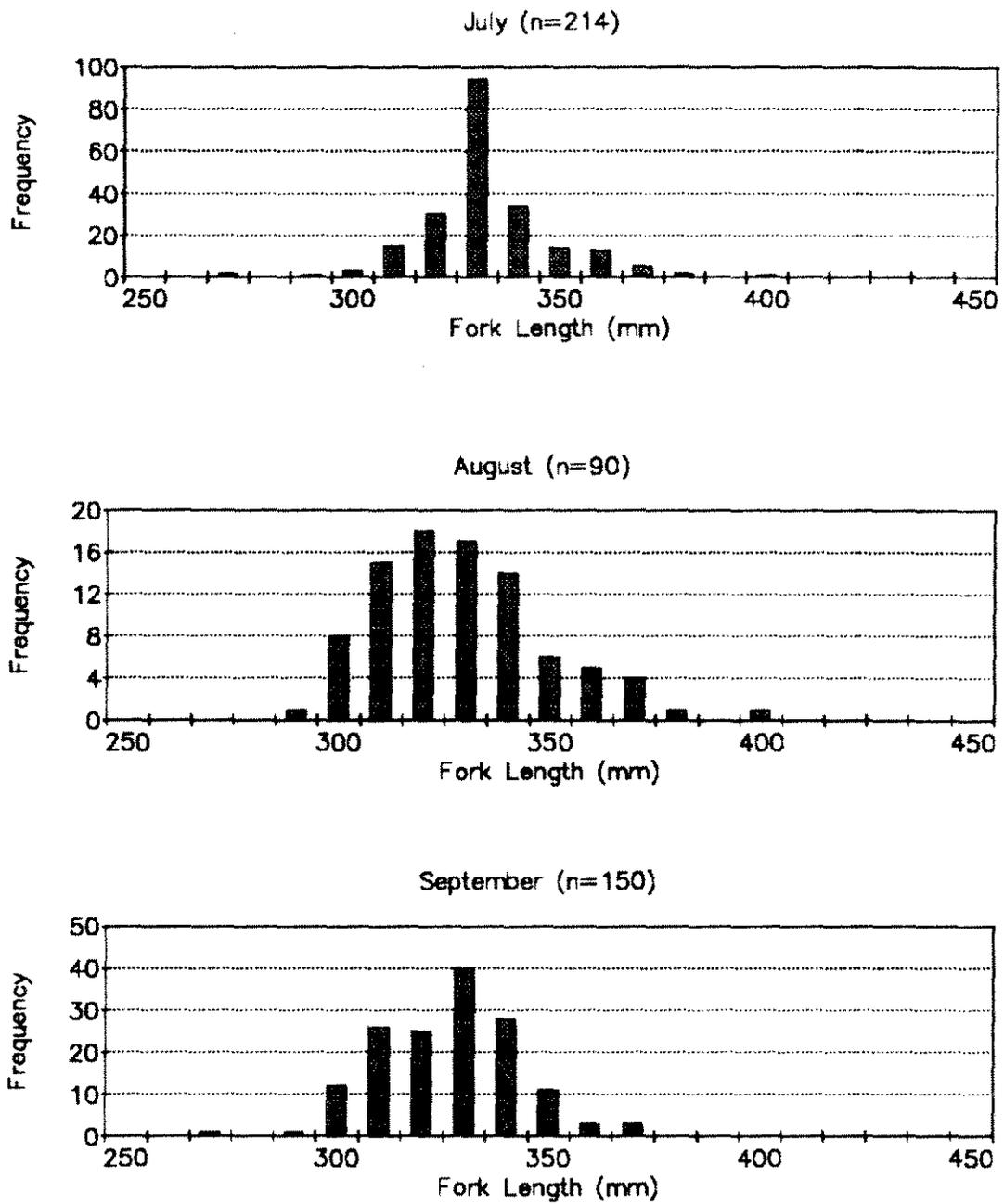


FIGURE 14. Length-frequency distribution of rainbow trout sampled from the 1990 Ross Lake sport harvest. Minimum legal size limit is approximately 317 mm fork length. Abscissa values indicate lower limit of length interval.

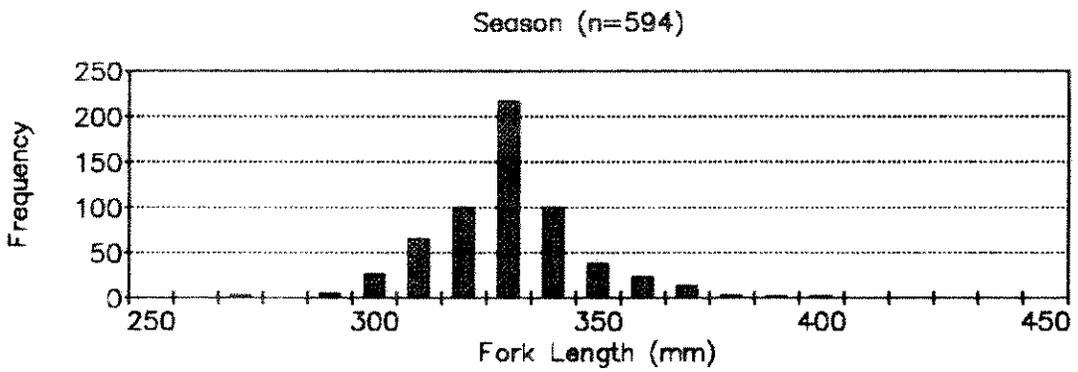
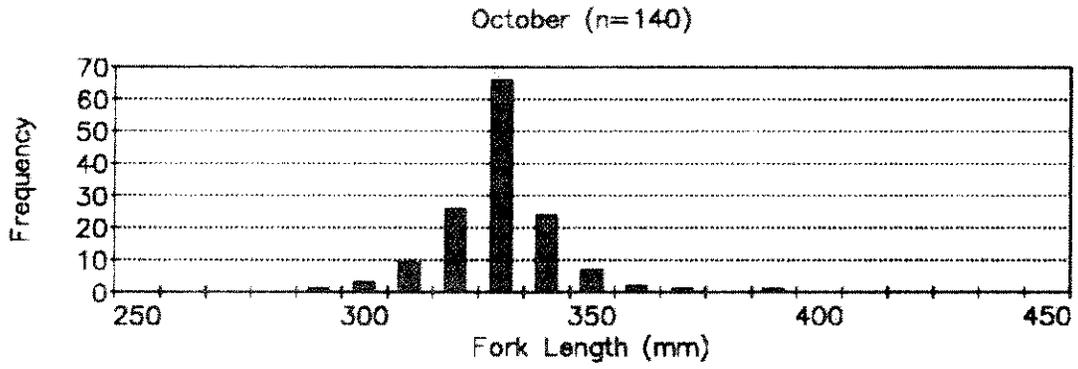


FIGURE 14. (Continued).

TABLE 19. Rainbow trout length information, grouped by sex and maturity, from the 1990 sport harvest at Ross Reservoir.

Sex	Maturity	N	Fork Length (mm)		
			Avg	Min	Max
Male	Mature	20	346.9	325	375
	Immature	30	328.1	300	355
Female	Mature	14	338.7	318	370
	Immature	49	327.7	290	360

TABLE 20. Rainbow trout age and length information, grouped by access area, sex and maturity, from the 1990 sport harvest at Ross Reservoir.

Access	Sex	Maturity	Age	N	Fork Length (mm)		
					Avg	Min	Max
Hozomeen	Male	Mature	3	3	325.0	325	325
			4	4	347.5	330	360
			5	4	347.5	340	360
			6	1	350.0	350	350
		Immature	3	8	327.8	320	340
			4	4	329.5	318	340
			5	1	300.0	300	300
	Female	Mature	2	1	320.0	320	320
			3	4	319.5	318	320
			4	3	345.7	330	355
			5	1	370.0	370	370
		Immature	2	1	325.0	325	325
			3	15	328.7	320	340
4			6	336.7	320	360	
5			1	340.0	340	340	
Resort	Male	Mature	3	2	337.5	330	345
			4	2	366.5	360	373
			5	3	353.3	340	375
		Immature	2	3	308.0	300	314
			3	5	323.0	315	335
			4	8	340.6	330	355
			5	1	340.0	340	340
	Female	Mature	4	5	347.4	330	362
		Immature	2	2	306.5	290	323
			3	16	322.4	300	350

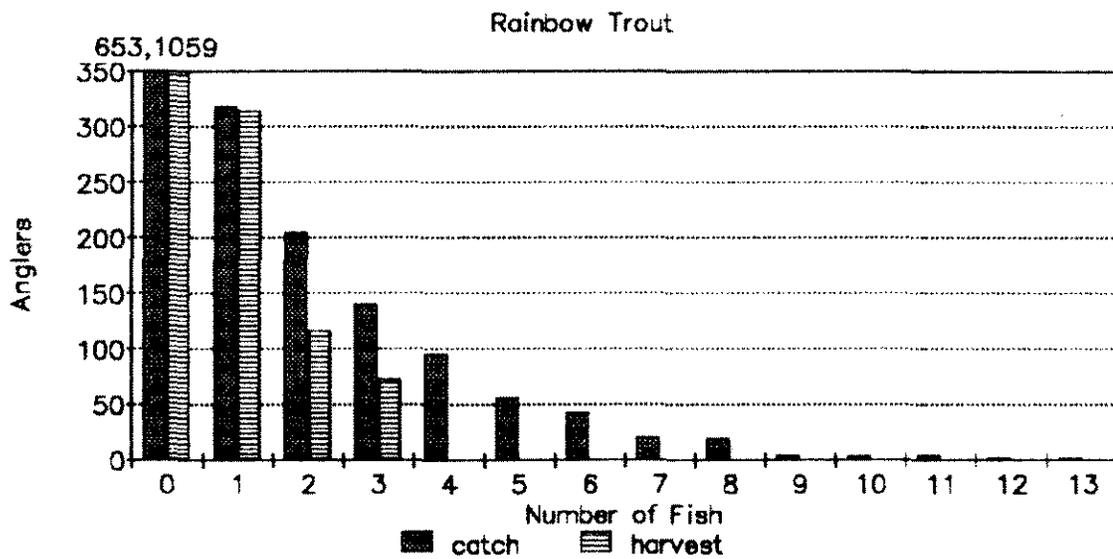


FIGURE 15. Reported angler success at catching rainbow trout during the 1990 sport fishing season at Ross Reservoir.

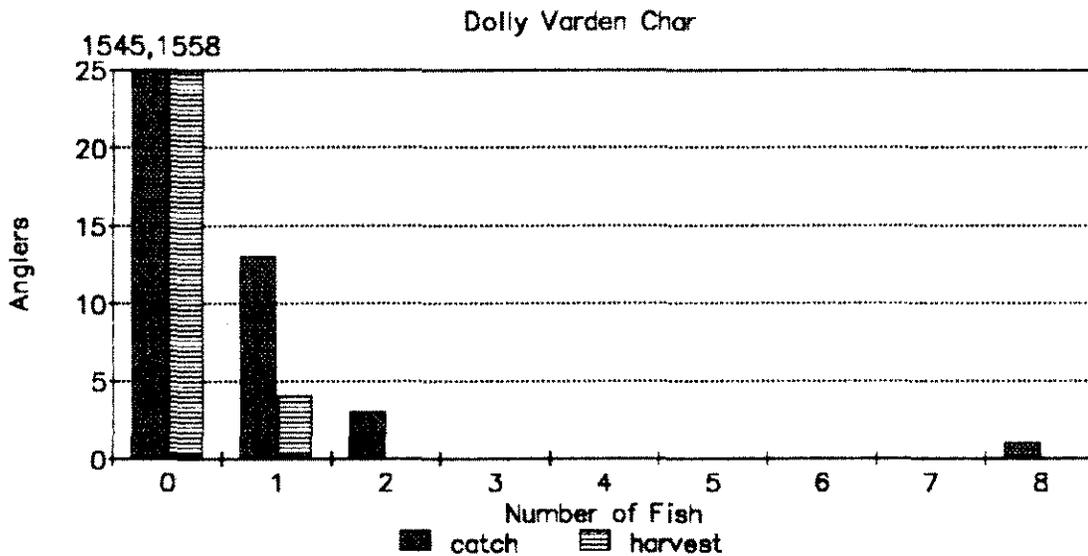


FIGURE 16. Reported angler success at catching dolly varden char during the 1990 sport fishing season at Ross Reservoir.

Ninety-nine percent of the interviewed anglers fishing at Ross Lake did not catch a dolly varden char (*Figure 16*). The remaining anglers (1%) caught one, two, or eight char. Only four dolly varden were harvested by interviewed anglers during the season, with four anglers harvesting one fish each.

1990 Season - Dolly Varden Char/Bull Trout

No dolly varden and/or bull trout char were classified for species identification during the 1990 fishing season at Ross Lake.

Hydroacoustic Surveys

Four hydroacoustic surveys were conducted on Ross Lake between April 11 and 17, 1991. A total of 91 fish were recorded for the four surveys, resulting in an average of 22.8 fish per survey (*Table 21*). Index counts varied as much as 43 percent between surveys, ranging from 16 to 28 fish per survey. There was no appreciable difference in the average number of fish recorded between morning and afternoon surveys (AM average = 22.0, PM average = 23.5).

Population estimates for the four hydroacoustic surveys are given in *Table 22*. Based on the assumption that percent species occurrence in the sport catch reflects species occurrence in the reservoir, rainbow trout population estimates for the four surveys ranged from a high of 26,826 fish to a low of 12,536. The total reservoir rainbow trout population was estimated at 20,513 +/- 15,324, while the total combined species (trout and char) population was estimated at 20,789 +/- 15,530. Standard errors of the rainbow trout and combined species population estimates are large, +/- 37.1 percent, indicating poor precision.

The values shown may eventually be modified for the final completion report, since an accurate bottom contour map of sufficiently large scale has not yet been obtained from Seattle City Light. An accurate, large-scale map is needed for precise calculation of lake strata volumes and transect lengths. Estimates should also be viewed with caution for reasons outlined earlier in the methods section of this report.

Spawning Surveys

Eight rainbow trout spawning surveys were conducted on Roland, Pierce, Dry, Lightning, Thursday and Canyon Creeks between May 1 and August 17, 1991 (*Table 23*). High water flows (resulting from large snow packs in the North Cascades) precluded surveys of Canyon Creek on all survey dates, and on Lightning Creek until July 28. In addition, high water flows may have adversely affected counting accuracy on most tributaries through the end of July.

A total of 174 rainbow trout were counted during the eight spawning

TABLE 21. Hydroacoustic index counts of trout and char^a from the lower end of Ross Lake (Ross Dam to Rainbow Point) from four surveys conducted April 11-17, 1991.

Date ^b	Elev	Transect											Tot
		1	2	3	4	5	6	7	8	9	10	11	
04/11	1518	3	0	1	1	0	2	5	2	2	3	2	21
04/12	1518	0	2	2	2	4	1	0	0	2	2	1	16
04/16	1516	2	3	3	0	1	0	10	0	2	2	3	26
04/17	1515	2	0	1	5	0	1	9	3	3	3	1	28

^aFish larger than 152 mm (6 in).

^bAM (0800-1200) counts = 04/12 and 04/17
 PM (1200-1600) counts = 04/11 and 04/16

TABLE 22. Population estimates of Ross-Skagit system trout and char^a from four hydroacoustic surveys conducted April 11-17, 1991.

Date ^c	Trout and Char		Rainbow Trout ^b	
	Estimate	95% C.I.	Estimate	95% C.I.
04/11	18,367	+/- 14,039	18,123	+/- 13,852
04/12	12,705	+/- 7,947	12,536	+/- 7,841
04/16	27,187	+/- 20,583	26,826	+/- 20,310
04/17	24,896	+/- 16,757	24,565	+/- 16,535
MEAN	20,789	+/- 15,530	20,513	+/- 15,324

^aFish larger than 152 mm (6 in).

^bEstimates using proportion of rainbow trout in 1990 sport catch (0.9867).

^cAM (0800-1200) counts = 04/12 and 04/17
 PM (1200-1600) counts = 04/11 and 04/16

TABLE 23. Elevations and distances surveyed^a on Ross Reservoir index tributaries during rainbow trout spawning surveys from May 1 to August 17, 1991.

Tributary Name	Distance (ft)	Elevation (ft)	
		Minimum	Maximum
Canyon Creek	1000	1920	2000
Dry Creek	1200	1602	1800
Lightning Creek	1000	1602	1675
Pierce Creek	85	1602	1615
Roland Creek	1500	1602	1835
Thursday Creek	25	1602	1610

^aWith the exception of Canyon Creek (a tributary of Ruby Creek), baseline elevations and distances are measured from full pool upstream, and do not include drawdown elevations and distances surveyed.

surveys. The first fish was observed in Roland Creek on June 8, and at least one trout was observed on all subsequent survey dates. The largest numbers of rainbow trout were counted on June 28, when a total of 55 fish were recorded for four tributaries. Roland Creek recorded the largest spawner total for the season (107 fish), and because of size, accessibility, and available spawning habitat, is the best spawning indicator stream of those surveyed. Survey results are summarized in *Table 24*.

Peak spawning probably occurred between the last week of June and first week of July on most of the tributaries surveyed. Spawning counts gradually declined on most survey streams after June 28, and surveys concluded on August 17 when only two fish were observed in Pierce and Roland Creeks. The 50 fish recorded in Lightning Creek on August 17 were all observed milling off the stream mouth, and were probably kelts that had recently completed spawning.

An additional eleven rainbow trout were caught with hook and line off the mouths of Roland and Dry Creeks on June 28-29 (*Table 25*). These fish were sampled for length, sex, and sexual maturity information before being released back into their respective streams. Five were identified as mature (average length = 312 mm), while the remainder comprised smaller fish of unknown maturity (average length = 249 mm).

TABLE 24. Number of spawning rainbow trout observed in selected tributaries of Ross Reservoir from May 1 to August 17, 1991.

Tributary	Number of Rainbow Trout								TOT
	May		Jun		Jul			Aug	
	01	22	08	28	18	22	28	17	
Canyon ^a	-	-	-	-	-	-	-	-	--
Dry	0	0	0	2 ^c	0	5	1	0	8
Lightning ^b	-	-	-	-	-	-	1	50	51
Pierce	0	0	0	0	0	1	3	1	5
Roland	0	0	1	51 ^d	23	19	12	1	107
Thursday	0	0	0	2	0	0	1	0	3
TOTAL	0	0	1	55	23	25	18	52	174

^aHigh water flows prevented surveys on all dates.

^bHigh water flows prevented surveys on all dates except those listed.

^cFour fish were captured off tributary mouth with hook and line on 07/29/91. Fish were examined for sex, length and sexual maturity information and released back into the stream (*Table 25*).

^dSeven fish were captured off tributary mouth with hook and line on 07/28/91 and 07/29/91. Fish were examined for sex, length and sexual maturity information and released back into the stream (*Table 25*).

TABLE 25. Rainbow trout length, sex, and sexual maturity information from fish caught off the mouths of selected Ross Reservoir tributary streams during the 1991 rainbow trout spawning season.

Tributary	Date	Elev	Sex	N	Maturity	Fork Length (mm)		
						Min	Max	Avg
Roland	06/28	1586	Male	2	Unknown	256	260	258
				1	Mature	311	311	311
	06/29	1588	Female	2	Unknown	240	252	246
				1	Mature	270	270	270
				Total	7		240	320
Dry	06/29	1588	Male	2	Unknown	230	256	243
				1	Mature	346	346	346
	Total	4	Female	1	Mature	313	313	313
				230	346	286		
TOTAL				11		230	346	278

DISCUSSION

The fish and fishery of Ross Lake (and the Canadian Skagit River) are dependent upon wild, naturally produced trout and char. No hatchery fish are planted directly into the lake or upper Skagit River, although two fish plants have recently been conducted in the Sumallo River (tributary to the upper Skagit River) by BCF&W. A resident strain of wild-origin Skagit River rainbow trout and a strain of Blackwater River rainbow trout were introduced into the Sumallo River in 1987 and 1988, respectively, in an attempt to increase fish production in that section of the Canadian Skagit River drainage (Slaney and Godin 1989; Rosenau and Slaney 1991). These introductions were determined by BCF&W to be unsuccessful, and plans for further plants have been canceled.

Stability of the Ross Reservoir and Skagit River fish population appears, from analysis of historic data (Johnston 1989), to be largely dependent upon restricting the harvest to only surplus fish above that required to maintain the population. This surplus is not a static number, since annual variability in environmental conditions, production, survival, and other factors can cause this number to change from year to year. It is desirable, therefore, to establish and implement a harvestable surplus value that represents a realistic worst case scenario.

Johnston (1989) discusses the factors affecting optimum population numbers and angler harvest levels at Ross Reservoir, and discusses the importance of monitoring annual harvest levels to help evaluate fluctuations in the lake fish population. However, it is difficult to estimate optimum harvest levels unless the annual variability in size of the fish population is also known. Annual fluctuations in total population size can be used to find total annual mortality rates, and depending on annual recruitment and survival rates, used to establish optimum harvest rates. Regulations can then be adjusted to achieve harvest and spawning escapement goals.

Through comparisons of current effort, CPUE, HPUE, harvest, catch, population size, and spawner numbers with data collected in previous years, it is possible to determine the effectiveness of the new regulations in achieving current management goals.

Effort

Total estimated seasonal angler effort dropped markedly from previous years as a result of the new restrictive fishing regulations. The 1990 estimated angler effort was 33,216 hours, while estimated angler effort was 74,098, 65,673, and 65,797 hours in 1971, 1985 and 1986, respectively (*Table 26*). This represents an effort decline of approximately 50 percent from the mid-1980's, and 55 percent from the early 1970's.

The new regulations appeared to be more of a deterrent to anglers using

TABLE 26. Estimated seasonal angler effort^a at Ross Reservoir in 1971, 1985, 1986 and 1990.

Year	Effort (hours)	SE ^b	Source
1971	74,098 ^c	----	City of Seattle (1972) City of Seattle (1973)
1985	65,673 ^d	----	Scott and Peterson (1986)
1986	65,797 ^e	----	Johnston (1989)
1990	33,216 ^f	1165	

^aSeason length approximately two weeks shorter in 1990 than in previous years. See Johnston (1989) and *Appendix 1*.

^bStandard error of estimated total angler-hours.

^cEffort estimated from interview data and boat rental information (south end), and vehicle counts (north end).

^dEffort estimated from reservoir boat counts.

^eEffort estimated from interview data.

^fEffort estimated from reservoir pole counts.

the north end of the lake than to anglers fishing from the south end. In 1971, anglers from the south end accounted for 22 percent of the total seasonal effort (16,572 hours), while north end anglers accounted for 78 percent (57,526 hours). In 1990, 58 percent of the seasonal effort total (21,509 hours) was contributed by south end anglers, while 42 percent (15,311 hours) came from north end anglers. Effort estimates for the different access areas are not available for the 1985 and 1986 study years.

Harvest Rates

Mean overall (all species combined) harvest rates also declined considerably from previous years due to the 1990 regulation changes. The mean seasonal HPUE in 1990 was 0.12, while HPUE was 0.48 in 1971, 0.52 in 1972, 0.33 in 1985, and 0.41 in 1986 (*Table 27*). The observed 1990 harvest rate decline is due primarily to the 13-inch minimum size limit imposed at the beginning of the 1990 season. However, the decline may also be influenced by decreasing numbers of fish in the reservoir (as indicated by the HPUE decline from the early 1970's to the mid-1980's).

Mean overall monthly harvest rates tend to decline and then increase as the season progresses (*Figure 17*). Harvest rates generally decline from the beginning of the season to August, and then increase in September and October to levels higher than at the start of the season. The initial HPUE decline is probably due to mature rainbow trout ascending tributary streams to spawn. In addition, some fish may also be removed from the fishery when they enter streams on midsummer feeding runs (Johnston 1989). Subsequent HPUE increases in September and October may be due to migration patterns and/or recruitment. Studies of rainbow trout migration patterns in the Sumallo River suggest that trout may migrate to the lake when water temperatures drop below 10C (Slaney and Godin 1989; Rosenau and Slaney 1991). Summer growth of previously undersized fish also recruits new numbers into the fishery.

Mean seasonal harvest rates for the different lake zones show contrasting patterns between the 1971-74, 1986, and 1990 fishing seasons (*Table 28*). Overall harvest rates remained relatively high throughout the different lake zones in the early 1970's, but were lower at the north end (zones 5 and 6) and south end (zone 1) of the lake in 1986. Johnston (1989) attributes the latter declines to excessive fishing mortality in zones adjacent to the two major access areas. In contrast, 1990 rainbow trout harvest rates were markedly higher at the north end of the lake (zones 5-7) than at the south end (zones 1-4), due primarily to the marked decrease in angler effort at the north end.

Harvest

The 1990 overall (all species combined) and rainbow trout harvest estimates are greatly reduced from previous years (*Table 29*). Rainbow

TABLE 27. Mean overall (all species combined) opening day, monthly, and seasonal harvest rates for the 1971, 1972, 1985, 1986 and 1990 fishing seasons^a at Ross Reservoir.

Year	Trout and Char HPUE						
	Opener	Jun	Jul	Aug	Sep	Oct	Season
1971	0.56	0.53	0.49	0.43	0.49	0.62	0.48
1972	0.52	0.49	0.76	0.63	0.66	0.68	0.52
1985	0.83	0.47	0.21	0.27	0.37	0.45	0.33
1986	0.81	0.45	0.29	0.23	0.37	0.49	0.41
1990 ^b	0.15	----	0.12	0.09	0.11	0.15	0.12

^aFishing regulations differed between 1971-72, 1985-86 and 1990. See Johnston (1989) and *Appendix 1*.

^bOpening day of the 1990 fishing season was July 1.

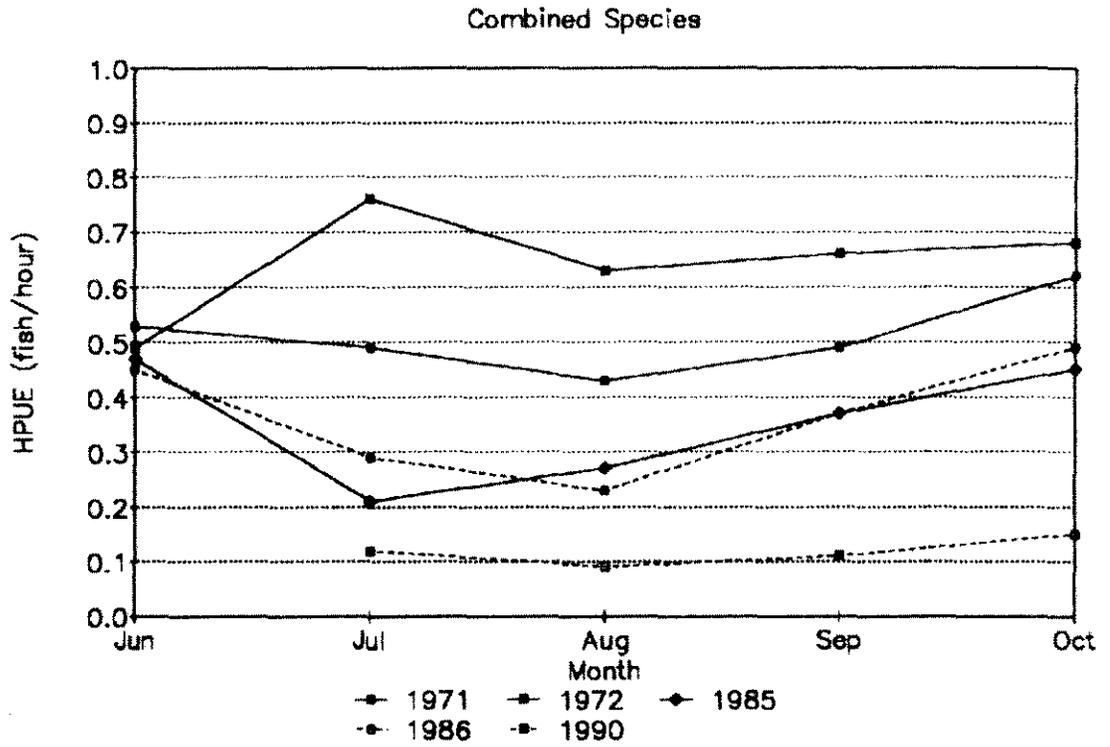


FIGURE 17. Mean overall (all species combined) monthly harvest rates for the 1971, 1972, 1985, 1986 and 1990 fishing seasons at Ross Reservoir.

TABLE 28. Mean overall (all species combined) seasonal harvest rates^a for zones 1 through 7 on Ross Reservoir in 1971, 1972, 1973, 1986 and 1990.

Lake Zone ^b	Trout and Char HPUE					
	1971	1972	1973	1974	1986	1990 ^c
1 (Ruby)	0.50	0.57	0.54	0.53	0.29	0.06
2 (B. Beaver)	0.47	0.70	0.45	0.50	0.42	0.08
3 (Devils)	0.49	0.72	0.45	0.49	0.48	0.10
4 (Lightning)	0.44	0.43	0.36	0.48	0.45	0.09
5 (L. Beaver)	0.43	0.52	0.43	0.39	0.46	0.12
6 (Hozomeen)	0.53	0.46	0.36	0.39	0.35	0.24
7 (Canada)	0.46	0.53	0.35	0.44	0.28	0.15

^aFishing regulations differed between 1971-72, 1985-86 and 1990. See Johnston (1989) and *Appendix 1*.

^bSee *Figure 3* for location of lake zones.

^cZone estimate for rainbow trout only (*Appendix 8*).

TABLE 29. Combined species and rainbow trout harvest^a estimates for the 1971-74, 1985-86, and 1990 fishing seasons at Ross Reservoir.

Year	Combined	% Rb	Rainbow
1971	36,552	97.9	35,784
1972	37,380	94.0	35,137
1973	38,937	91.8	35,744
1974	41,700	91.0	37,947
1985	21,007	88.1	18,503
1986	23,054	97.7	22,524
1990	3,793	99.5	3,774

^aFishing regulations differed between 1971-74, 1985-86 and 1990. See Johnston (1989) and *Appendix 1*.

trout harvest levels in the early 1970's (average = 36,153) and mid-1980's (average = 20,514) were approximately ten and five times larger, respectively, than the 1990 total (3,774). The dramatic reduction in harvest is due primarily to the reduced daily catch limit (eight fish reduced to three), minimum size restriction (no size limit changed to 13-inch minimum size), shorter season (mid-June opener changed to July 1 opener) and reduced reservoir fishing effort. In addition, an apparent continued reduction of the reservoir fish population can be expected to contribute to the decline.

The greater proportion of rainbow trout (99.5 percent) in the overall 1990 harvest is due to fewer numbers of dolly varden char/bull trout being caught. The 1990 bait fishing restriction coupled with a resultant decrease in anglers fishing with live and/or scented bait off stream mouths is probably responsible for the dolly varden char/bull trout harvest reduction.

Age

The 13-inch (317 mm fork length) minimum size restriction resulted in a greater percentage of older rainbow trout in the 1990 harvest than in previous studies (*Table 30*). Most of the 1990 harvest was composed of age 3 (47 percent) and age 4 (32 percent) fish. This is in contrast to earlier years, when small numbers of age 1 and large numbers of age 2 fish were present in the harvest. Except for 1986, when age 3 fish comprised the majority of the harvest, age 2 fish were the age class harvested in greatest numbers by anglers prior to 1990. Johnston (1989) attributes the increase in percentage of older age classes (age 3 and age 4) in the harvest from the early 1970's to the mid-1980's to anglers targeting older Canadian Skagit River rainbow trout (that enter the reservoir fishery in June and again in September and October) at the north end of the lake, and to selectively "high-grading" their catch to retain the largest and brightest rainbow trout (predominantly age 3, immature females).

The ratio of age 4 to age 3 rainbow trout also increased in 1990 from previous years (*Table 30*). The 1990 age 4:age 3 harvest ratio was 68 percent, compared to 27 percent in 1971, 21 percent in 1972, 21 percent in 1973, 45 percent in 1985, and 48 percent in 1986. The 13-inch minimum size restriction is designed to increase the percentage of age 4 and older age classes of rainbow trout harvested. Sexual maturity and spawning or post-spawning of Ross Lake rainbow trout occurs primarily at age 4 for females (age 3 for males), generally before opening day of the fishing season (July 1). Theoretically, fish can then spawn at least once before becoming available for harvest.

TABLE 30. Percent age class contribution^a of rainbow trout to the 1971-73, 1985-86, and 1990 seasonal sport harvest at Ross Reservoir.

Age	Percent of Season Harvest					
	1971	1972	1973	1985	1986	1990
2	55	49	62	36	28	10
3	26	39	29	29	40	47
4	7	8	6	13	19	32
5	1	2	1	4	4	10
6	0	0	0	1	1	1
7	0	0	0	0	0	<1

^aFishing regulations differed between 1971-73, 1985-86 and 1990. See Johnston (1989) and *Appendix 1*.

Length

The average size of age 4 and age 5 rainbow trout age classes were slightly larger in 1990 than in 1985 and 1986 (*Table 31*). Age 4 rainbow trout averaged 339 mm in 1990, 333 mm in 1986, and 334 mm in 1985, while age 5 fish averaged 352 mm in 1990, 349 mm in 1986, and 347 mm in 1985. The much larger average size differences between age 2 and age 3 fish in 1990, as compared to similar age classes in 1985 and 1986, are due primarily to the 13-inch minimum size restriction, which selects for larger fish from the two age groups. Nevertheless, the increase in average size of the 1990 age classes may reflect increased growth rates through food availability, and can also be an indicator that fewer fish are competing for available food resources in the reservoir.

Sexual Maturity

A substantial proportion of the 1990 rainbow trout harvest was composed of immature age 3 fish (*Table 20*). Of a total sample of fifty-three age 3 fish sampled from the 1990 harvest, 83 percent (n=44) were immature. In addition, almost all age 2 rainbow trout were immature, illegal fish. Thus, the 13-inch minimum size restriction did not completely protect immature fish in 1990. Exceptionally good growth conditions during the winter and early spring of 1990 may have resulted in larger size at age of rainbow trout compared to earlier years, resulting in a large proportion of immature fish available for harvest (*Table 31*).

Population Size

Ross Lake rainbow trout mark-recapture and hydroacoustic population estimates from the early 1970's are substantially higher than the 1991 hydroacoustic estimate (*Table 32*). Mark-recapture studies estimated reservoir rainbow trout population sizes of 153,580, 206,185, and 191,480 fish in 1971, 1972, and 1973, respectively. These estimates are much larger than the 1991 estimate of 20,513 fish. A possible explanation for this large discrepancy is that mark-recapture efforts in the early 1970's may have been concentrated at stream mouths, where fish concentrations are high. Hydroacoustic surveys conducted on the reservoir between December 1970 and June 1973 are much closer in magnitude to the 1991 hydroacoustic estimate, ranging in size from 26,000-90,000 fish with a mean of 49,000 (Thorne 1976). The latter estimates are all larger, but considerably closer to, the 1991 estimate. The 1973 hydroacoustic estimate of 31,000 rainbow trout in *Table 32* is the only year that a specific date and estimate were reported (Thorne 1976).

The 1991 population estimate suggests that the reservoir trout population may be substantially lower than in the early 1970's. The mean 1991 hydroacoustic estimate of 20,513 (n=4) is approximately 42 percent of the mean 1970-73 hydroacoustic estimate of 49,000 (n=7). Even with the large variance associated with the 1991 estimate (+/- 15,530, *Table 32*), the

TABLE 31. Seasonal rainbow trout age and length data^a from the 1985, 1986 and 1990 sport harvests at Ross Reservoir.

Year	Age	N	Fork Length (mm)		
			Avg	Min	Max
1985	2	216	260	183	337
	3	169	302	207	369
	4	76	334	275	378
	5	23	347	307	384
	6	5	394	374	424
	7	0	---	---	---
	1986	2	207	257	157
3		251	302	218	380
4		146	333	286	403
5		32	349	295	395
6		3	380	365	409
7		0	---	---	---
1990		2	36	313	270
	3	172	326	271	370
	4	115	339	300	460
	5	36	352	300	400
	6	5	368	350	395
	7	1	380	380	380

^aFishing regulations differed between 1971-73, 1985-86 and 1990. See Johnston (1989) and *Appendix 1*.

TABLE 32. Population estimates of Ross-Skagit system rainbow trout in 1971, 1972, 1973 and 1991.

Year	Estimate	95% C.I.	Method ^a	Source
1971	153,580	+/- 33,317	Mark-R	Johnston (1989)
1972	206,185	+/- 31,685	Mark-R	Johnston (1989)
1973	191,480	+/- 20,729	Mark-R	Johnston (1989)
1973	31,000	-----	Acoustic	Thorne (1976)
1991	20,513	+/- 15,324	Acoustic	

^aMark-R = Mark-recapture
 Acoustic = Hydroacoustic

upper range of the estimate is still considerably below the 1970's average. This decline is further supported by annual catch and harvest rate estimates for the different years. The 1991 overall seasonal CPUE estimate of 0.39 (Table 11) is approximately 81 percent and 75 percent, respectively, of the 1971 (0.48) and 1972 (0.52) HPUE estimates (Table 27). (The 1991 overall CPUE estimate is used for comparison with the overall 1971-72 HPUE estimates, since 1991 catch would be roughly equivalent to 1971-72 harvest). However, the primary value of the 1991 index counts and population estimates will be in comparison to future measurements of population size on Ross Lake the next four years. In addition, it is desirable to base these measurements on a larger number of sample transects to reduce variance associated with the estimate.

Spawning Surveys

Spawning survey data on selected tributary streams did not show an abundance of spawning rainbow trout in 1991. A total of 174 fish were counted on six U.S. tributaries during eight surveys from May to August. This is well below a single estimate of 2,500 to 3,000 fish that were observed spawning in Roland Creek by a National Park Service employee on June 13, 1986 (National Park Service letter from Gary Mason to Washington Department of Wildlife area fisheries biologist Jim Johnston). Excessive and prolonged spring and early summer runoff in 1991 may have prevented most fish from spawning in tributaries, as well as reducing survival of any eggs that may have been deposited. However, fish should have been observed milling off stream mouths at this time, which was not observed during any of the surveys.

Roland Creek recorded the largest number of spawners (107 fish) of the six tributaries surveyed, and is the best index stream based on spawner use, flow, available spawning habitat, and accessibility. Although spawner use was low in 1991 (eight fish), Dry Creek is another excellent index stream that should continue to be included in future surveys.

Continuation of 1990-91 reservoir studies, as well as concurrent monitoring of the Canadian Skagit River, are necessary to evaluate the effectiveness of the new restrictive angling regulations. With adequate data and analysis, appropriate management responses can be used to promote recovery of the Ross Lake rainbow trout population from the effects of past overharvest.



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APPENDIX 1. Summary of 1989 and 1990 Ross Lake fishing regulations.

	1990	
	<u>Washington State</u>	<u>British Columbia</u>
<i>Season:</i>	07/01/90 - 10/31/90	
<i>Catch limit:</i>	three	
<i>Size limit^a:</i>	13 inch minimum size for rainbow trout, 20 inch minimum size for dolly varden char	same as Washington State
<i>Possession limit:</i>	six	
<i>Gear restriction:</i>	no bait	

	1989	
	<u>Washington State</u>	<u>British Columbia</u>
<i>Season:</i>	06/17/89 - 10/31/89	07/01/89 - 10/31/89
<i>Catch limit:</i>	eight	four
<i>Size limit^b:</i>	no more than three over 14 inches	200mm (8 inches); no more than two over 500mm (20 inches)
<i>Possession limit:</i>	eight	eight
<i>Gear restriction:</i>	none	none

^aSize limits were measured using total length in both Washington State and British Columbia.

^bSize limits were measured using total length in Washington State, and fork length in British Columbia.

APPENDIX 2. QuickBASIC program to generate creel and effort sampling schedules.

ROSS LAKE RAINBOW TROUT RANDOM SAMPLING PROGRAM

by

Alan Loeff (WDW Fisheries Research Biologist 2)

The following program is written in Microsoft QuickBASIC. The file LAKE.EXE must be located on the current directory OR accessible by a previous DOS <Path> command to run the program. Type

LAKE -->

to begin the program. A random number seed must first be entered prior to data input. Follow remaining program instructions to enter data for generating one or more monthly creel sample schedules.

After a sample schedule is displayed, *PRESS* one of the following keys to continue:

- L Load previously saved disk file
- N Create new schedule using new data
- P Print schedule displayed on screen
- Q Quit
- S Save current schedule to disk file
- > Create new schedule using same data

* *Reset* *

```
CLS
KEY OFF
CLEAR
ON ERROR GOTO 190
COLOR 12, 1, 1
CLS
RANDOMIZE
COLOR 15
```

```

10 ' * Sample Day Input *
'
COLOR 15, 1, 1
CLS
LOCATE 5, 10
PRINT "MONTH ";
COLOR 14
INPUT "", m$
IF m$ = "1" OR m$ = "L" THEN LET a = 1: GOTO 20
COLOR 15
LOCATE 7, 10
PRINT "Number of DAYS in month ";
COLOR 14
INPUT "", d
LET wd = 8
LET we = 4
LET l = 3
COLOR 15
LOCATE 9, 10
PRINT "DAY NUMBER for first day of month (ie. 1=Su, 2=Mo, etc.) ";
COLOR 14
INPUT "", dn
PRINT
'
20 ' * *
'
DIM c(1, 42), d(1, 42), sd(1, 12), ss(1, 42), s$(1, 42)
IF a = 1 THEN GOTO 90
'
' * day number calendar *
'
LET co = 1
FOR x = dn TO dn + d - 1
LET c(1, x) = co
LET co = co + 1
NEXT x
'
' * weekday and weekend calendar *
'
LET dx = dn
FOR x = dn TO (dn + d) - 1
IF dx = 1 OR dx = 7 THEN LET v = 1
IF dx > 1 AND dx < 7 THEN LET v = 2
LET d(1, x) = v
LET dx = dx + 1
IF dx > 7 THEN LET dx = 1
NEXT x
'
' * sample day *

```

```

COLOR 14
LET ct = 0
FOR y = 1 TO (we + wd) / 1
30 LET r = INT(d * RND(1) + 1)
  IF r + 2 > d THEN GOTO 30
  LET sd = (r + dn) - 1
  LET sc = sd
  FOR x = 1 TO 1
    IF s$(1, sd) = "x" THEN GOTO 30
    LET sd = sd + 1
  NEXT x
  LET ct = ct + 1
  IF ct > 25 THEN ERASE c, d, ss, s$: LET w1 = 0: LET w2 = 0
  IF ct > 25 THEN LET ct = 0: GOTO 20
  LET ce = 0
  LET cd = 0
  LET sd = sc
  FOR x = 1 TO 1
    IF d(1, sd) = 1 THEN LET ce = ce + 1: LET w1 = w1 + 1
    IF d(1, sd) = 2 THEN LET cd = cd + 1: LET w2 = w2 + 1
    IF w2 = wd AND we - w1 > 2 THEN GOTO 40
  GOTO 50
40 LET w1 = w1 - ce: LET w2 = w2 - cd: GOTO 30
50 IF w1 > we THEN LET w1 = w1 - ce: LET w2 = w2 - cd: GOTO 30
  IF w2 > wd THEN LET w2 = w2 - cd: LET w1 = w1 - ce: GOTO 30
  LET sd = sd + 1
  NEXT x
  LET sd = sc
  FOR x = 1 TO 1 + 2
    LET s$(1, sd) = "x"
    IF x = 1 THEN LET s$(1, sd - 1) = "x"
    IF sd < 2 THEN GOTO 60
    IF x = 1 THEN LET s$(1, sd - 2) = "x"
60 IF x > 1 THEN GOTO 70
  LET ss(1, sd) = (sd - dn) + 1
70 LET sd = sd + 1
  NEXT x
  NEXT y
  LET w1 = 0
  LET w2 = 0
  '
  ' * *
  '
  LET x1 = 1
  FOR x = 1 TO 42
    IF ss(1, x) = 0 THEN GOTO 80
    LET sd(1, x1) = ss(1, x)
    LET x1 = x1 + 1
80 NEXT x

```

```

'
' * Work Input *
'
'
IF z = 1 THEN GOTO 90
COLOR 15
LOCATE 15, 10
PRINT "Starting TIME interval (1-24 hours) ";
COLOR 14
INPUT "", st
COLOR 15
LOCATE 17, 10
PRINT "Ending TIME interval (1-24 hours) ";
COLOR 14
INPUT "", et
'
90 ' * *
'
DIM t(1, 24)
IF a = 1 THEN GOTO 130
LET tt = (we + wd) * 2
LET co = 0
FOR x = 1 TO tt
IF co = 1 THEN GOTO 110
100 LET t(1, x) = INT((et - 8) * RND(1) + 1)
IF t(1, x) < st THEN GOTO 100
IF co = 0 THEN LET co = 1: LET t1 = t(1, x): GOTO 120
110 LET t(1, x) = t1 + 8
LET co = 0
120 NEXT x
'
'
' * Boat Input *
'
'
IF z = 1 THEN LET z = 0: GOTO 130
LET b = 2
130 DIM b(1, 24)
IF a = 1 THEN GOTO 170
LET bb = (we + wd) * b
FOR x = 1 TO bb
IF co = 0 THEN LET bx = t(1, x + 1) - 2
IF co = 0 THEN LET by = t(1, x)
140 LET b(1, x) = INT(bx * RND(1) + 1)
IF b(1, x) < by THEN GOTO 140
LET b(1, x + 1) = b(1, x) + 1
LET x = x + 1
NEXT x
'
'
150 ' * Display Sample Schedule *

```

```

'
'
LET y1 = 1
COLOR 12
CLS
PRINT SPC(37); m$
PRINT
PRINT
IF p = 1 THEN LPRINT : LPRINT : LPRINT SPC(38); m$: LPRINT : LPRINT
COLOR 14
PRINT SPC(21); "Date"; SPC(11); "Time"; SPC(11); "Boat"
PRINT
IF p = 1 THEN LPRINT SPC(21); "Date"; SPC(11); "Time";
IF p = 1 THEN LPRINT SPC(11); "Boat": LPRINT
COLOR 15
LET co = 1
FOR x = 1 TO 12
IF sd(1, x) < 10 THEN LET s1 = 22 ELSE LET s1 = 21
PRINT SPC(s1); sd(1, x);
IF p = 1 THEN LPRINT SPC(s1); sd(1, x);
IF t(1, y1) < 10 THEN LET s2 = 9 ELSE LET s2 = 8
IF t(1, y1 + 1) < 10 THEN LET s3 = 3 ELSE LET s3 = 2
PRINT SPC(s2); t(1, y1); SPC(s3); t(1, y1 + 1);
IF p = 1 THEN LPRINT SPC(s2); t(1, y1); SPC(s3); t(1, y1 + 1);
IF b(1, y1) < 10 THEN LET s4 = 6 ELSE LET s4 = 5
IF b(1, y1 + 1) < 10 THEN LET s5 = 3 ELSE LET s5 = 2
PRINT SPC(s4); b(1, y1); SPC(s5); b(1, y1 + 1)
IF p = 1 THEN LPRINT SPC(s4); b(1, y1); SPC(s5); b(1, y1 + 1)
LET co = co + 1
IF p = 1 AND co > 3 THEN LPRINT
IF co > 3 THEN LET co = 1: PRINT
LET y1 = y1 + 2
NEXT x
IF p = 1 THEN LET p = 0
'
'
' * Input *
'
'
q$ = INPUT$(1)
IF q$ = "l" OR q$ = "L" THEN GOTO 170
IF q$ = "n" OR q$ = "N" THEN CLS : CLEAR : GOTO 10
IF q$ = "p" OR q$ = "P" THEN GOTO 160
IF q$ = "q" OR q$ = "Q" THEN CLS : SYSTEM
IF q$ = "s" OR q$ = "S" THEN GOTO 180
ERASE b, c, d, t, ss, s$
CLS
IF a = 1 THEN LET a = 0: GOTO 10
LET z = 1
GOTO 20
'

```

```
'  
160 ' * Print Sample Schedule *  
'
```

```
LET p = 1  
GOTO 150  
'
```

```
'  
170 ' * Load *  
'
```

```
LET o = 1  
CLS  
LOCATE 5, 20  
COLOR 14  
PRINT "FILE NAME ";  
COLOR 15  
INPUT "", i$  
OPEN i$ FOR INPUT AS 1  
LET x1 = 1  
INPUT #1, m$  
FOR x = 1 TO 12  
INPUT #1, sd(1, x)  
INPUT #1, t(1, x1)  
INPUT #1, t(1, x1 + 1)  
INPUT #1, b(1, x1)  
INPUT #1, b(1, x1 + 1)  
LET x1 = x1 + 2  
NEXT x  
CLOSE  
LET o = 0  
GOTO 150  
'
```

```
'  
180 ' * Save *  
'
```

```
LET s = 1  
CLS  
LOCATE 5, 20  
COLOR 14  
PRINT "FILE NAME ";  
COLOR 15  
INPUT "", s$  
OPEN s$ FOR OUTPUT AS 1  
LET x1 = 1  
PRINT #1, m$  
FOR x = 1 TO 12  
PRINT #1, sd(1, x)  
PRINT #1, t(1, x1)  
PRINT #1, t(1, x1 + 1)  
PRINT #1, b(1, x1)
```

```
PRINT #1, b(1, x1 + 1)
LET x1 = x1 + 2
NEXT x
CLOSE
LET s = 0
GOTO 150
'
'
190 ' * *
'
'
IF o = 1 THEN PRINT CHR$(7): RESUME 170
IF p = 1 THEN LET p = 0: PRINT CHR$(7): CLS : RESUME 150
IF s = 1 THEN LET s = 0: PRINT CHR$(7): RESUME 180
'
'
END
```

APPENDIX 3. Creel and effort sampling schedule for the 1990 sport fishery season at Ross Reservoir.

Month	Day ^a	Daytype ^b	Work Period		Effort Count ^c	
			Start	Finish	1	2
July	1	OD	0800	1600	0700	1400
	2	WD	0800	1600	0900	1500
	4	WE	0800	1600	0700	1200
	8	WE	0600	1400	1600	1700
	9	WD	0700	1500	1000	1500
	10	WD	0800	1600	1000	1400
	14	WE	1100	1900	1400	1600
	15	WE	0900	1700	1000	1200
	16	WD	1100	1900	1300	1600
	26	WD	0700	1500	1000	1100
	27	WD	1200	2000	1200	1800
	28	WE	1200	2000	1300	1600
	August	2	WD	0900	1700	1100
3		WD	1200	2000	1200	1700
4		WE	0700	1500	1100	1200
9		WD	1100	1900	1500	1600
10		WD	1000	1800	1200	1300
11		WE	0900	1700	0900	1000
19		WE	1200	2000	1200	1300
20		WD	0700	1500	0900	1000
21		WD	0900	1700	1300	1500
26		WE	1200	2000	1500	1600
27		WD	1200	2000	1200	1300
28		WD	1100	1900	1200	1400
September		2	WE	1100	1900	1800
	3	WE	0800	1600	0900	1000
	4	WD	1000	1800	1200	1400
	9	WE	1100	1900	1100	1200
	10	WD	1100	1900	1400	1500
	11	WD	1000	1800	1100	1200
	20	WD	0800	1600	1200	1300
	21	WD	0800	1600	1000	1200
	22	WE	1100	1900	1500	1600
	27	WD	0900	1700	1100	1200
	28	WD	0800	1600	1400	1500
29	WE	1000	1800	1300	1400	

APPENDIX 3. (Continued)

Month	Day ^a	Daytype ^b	Work Period		Effort Count ^c	
			Start	Finish	1	2
October	4	WD	1000	1800	1300	1400
	5	WD	1000	1800	1100	1200
	6	WE	0900	1700	1300	1400
	10	WD	0900	1700	1400	1500
	11	WD	0900	1700	1400	1600
	12	WD	0900	1700	1000	1100
	21	WE	0900	1700	1500	1600
	22	WD	1000	1800	1300	1400
	23	WD	0900	1700	1400	1500
	26	WD	0900	1700	1500	1600
	27	WE	1000	1800	1200	1300
	28	WE	1000	1800	1000	1100

^aTwo holidays, July 4 (Independence Day) and September 3 (Labor Day), were treated as weekend days, even though they were observed during midweek in 1990 (see text).

^bOD=opening day, WD=weekday, WE=weekend day.

^cAdditional effort counts were made on opening day to reduce variance for this daytype. See *Appendix 3 of the Ross Lake Rainbow Trout Study: 1990-91 Data Appendix* (Looff 1991).

APPENDIX 4. Estimated monthly and seasonal angler effort by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Month	Daytype	Angler Hours ^a		Mean Hours Fished per Day ^b	Total Angler Days ^c
Jul	Opener	885	(0)	3.66	242
	Weekday	8244	(976)	3.61	2287
	Weekend	2986	(360)	4.24	705
	Total	12116	(1040)	3.75	3234
Aug	Weekday	4916	(109)	3.81	1291
	Weekend	3120	(28)	3.58	873
	Total	8036	(112)	3.71	2163
Sep	Weekday	3980	(245)	4.21	946
	Weekend	4369	(0)	4.94	885
	Total	8349	(245)	4.56	1831
Oct	Weekday	2994	(415)	4.96	604
	Weekend	1720	(173)	4.46	385
	Total	4714	(450)	4.76	990
Ssn	Opener	885	(0)	3.66	242
	Weekday	20135	(1094)	3.93	5128
	Weekend	12195	(400)	4.28	2848
	Total	33216	(1165)	4.04	8218

^aStandard error of estimated total angler-hours given in parentheses. Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

^bMean hours calculated using data from all anglers, including those that indicated they had not finished fishing for the day (see text).

^cTotal angler days = angler hours/mean hours fished per day.

APPENDIX 5. Estimated monthly and seasonal angler effort by lake zone^a in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Month	Daytype	Angler Hours ^b	Mean Hours Fished per Day ^c	Total Angler Days ^d
Jul	1 Rby	2913 (513)	4.24	687
	2 Bbv	3522 (465)	4.79	736
	3 Dev	619 (195)	5.64	110
	4 Lit	513 (100)	7.30	70
	5 Lbv	1001 (137)	3.78	265
	6 Hoz	1730 (282)	2.66	650
	7 Can	2734 (494)	2.88	951
	Total	13030 (933)	3.76	3468
Aug	1 Rby	1218 (144)	3.70	329
	2 Bbv	2636 (573)	4.46	591
	3 Dev	1017 (235)	4.52	225
	4 Lit	482 (140)	4.90	98
	5 Lbv	591 (153)	1.88	315
	6 Hoz	1214 (170)	2.70	450
	7 Can	1447 (212)	2.89	500
	Total	8604 (722)	3.43	2507
Sep	1 Rby	1071 (154)	3.49	307
	2 Bbv	1392 (206)	4.51	309
	3 Dev	2109 (287)	6.06	348
	4 Lit	864 (140)	6.99	124
	5 Lbv	1014 (114)	7.03	144
	6 Hoz	2049 (269)	3.47	591
	7 Can	1074 (156)	2.32	462
	Total	9573 (527)	4.19	2285
Oct	1 Rby	701 (161)	3.82	183
	2 Bbv	1384 (357)	4.42	313
	3 Dev	775 (281)	6.11	127
	4 Lit	295 (117)	5.09	58
	5 Lbv	421 (217)	6.14	69
	6 Hoz	1982 (545)	4.44	446
	7 Can	55 (52)	2.60	21
	Total	5613 (770)	4.61	1217
Ssn	1 Rby	5902 (578)	3.92	1507
	2 Bbv	8934 (845)	4.59	1948
	3 Dev	4519 (505)	5.58	809
	4 Lit	2154 (250)	6.15	350
	5 Lbv	3026 (320)	3.82	793
	6 Hoz	6974 (691)	3.26	2137
	7 Can	5310 (563)	2.75	1934
	Total	36820 (1504)	3.88	9478

^aSee Figure 3 for location of lake survey zones.

^bStandard error of estimated total angler-hours given in parentheses.

Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

^cMean hours calculated using data from all anglers, including those that indicated they had not finished fishing for the day (see text).

^dTotal angler days = angler hours/mean hours fished per day.

APPENDIX 6. Estimated monthly and seasonal angler effort by access area^a in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Month	Daytype	Angler Hours ^b		Mean Hours Fished per Day ^c	Total Angler Days ^d
Jul	Resort	7565	(1041)	4.81	1572
	Hozomeen	2731	(339)	3.05	894
	Canada	2734	(494)	2.88	951
	Total	13030	(1201)	3.81	3417
Aug	Resort	5353	(577)	4.26	1256
	Hozomeen	1804	(216)	2.60	695
	Canada	1447	(212)	2.89	500
	Total	8604	(652)	3.51	2451
Sep	Resort	5436	(185)	5.01	1086
	Hozomeen	3063	(354)	4.67	656
	Canada	1074	(156)	2.32	462
	Total	9573	(429)	4.34	2204
Oct	Resort	3155	(638)	4.73	667
	Hozomeen	2403	(705)	4.72	509
	Canada	55	(52)	2.60	21
	Total	5613	(952)	4.69	1198
Ssn	Resort	21509	(1363)	4.69	4582
	Hozomeen	10001	(885)	3.63	2755
	Canada	5310	(563)	2.75	1934
	Total	36820	(1720)	3.97	9270

^aSee Figure 3 for location of access areas.

^bStandard error of estimated total angler-hours given in parentheses. Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

^cMean hours calculated using data from all anglers, including those that indicated they had not finished fishing for the day (see text).

^dTotal angler days = angler hours/mean hours fished per day.

APPENDIX 7. Estimated monthly and seasonal mean catch per hour for rainbow trout by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Rainbow Trout Catch per Hour ^a								
Month	Daytype	N ^b	Harvested		Released		Total	
Jul	Opener	93	.153	(.0023)	.714	(.0067)	.866	(.0075)
	Weekday	208	.119	(.0010)	.305	(.0021)	.424	(.0026)
	Weekend	196	.113	(.0010)	.334	(.0021)	.447	(.0026)
	Mean		.122	(.0004)	.390	(.0010)	.512	(.0012)
Aug	Weekday	252	.090	(.0007)	.254	(.0015)	.344	(.0018)
	Weekend	159	.084	(.0011)	.239	(.0027)	.324	(.0032)
	Mean		.088	(.0004)	.249	(.0010)	.336	(.0011)
Sep	Weekday	144	.104	(.0012)	.175	(.0018)	.279	(.0024)
	Weekend	221	.117	(.0008)	.177	(.0011)	.294	(.0016)
	Mean		.113	(.0005)	.176	(.0007)	.289	(.0010)
Oct	Weekday	132	.133	(.0013)	.235	(.0020)	.368	(.0027)
	Weekend	157	.170	(.0014)	.231	(.0015)	.401	(.0023)
	Mean		.152	(.0007)	.233	(.0009)	.385	(.0012)
Ssn	Opener	93	.153	(.0023)	.714	(.0067)	.866	(.0075)
	Weekday	736	.109	(.0002)	.247	(.0005)	.356	(.0006)
	Weekend	733	.122	(.0003)	.241	(.0005)	.363	(.0006)
	Mean		.118	(.0001)	.268	(.0002)	.386	(.0003)

^aStandard error of mean catch per hour given in parentheses. Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

^bNumber of anglers surveyed.

APPENDIX 8. Estimated monthly and seasonal mean catch per hour for rainbow trout by lake zone^a in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Rainbow Trout Catch per Hour ^b								
Month	Zone	N ^c	Harvested		Released		Total	
Jul	1 Rby	88	.072	(.0016)	.386	(.0061)	.458	(.0069)
	2 Bbv	112	.082	(.0013)	.254	(.0036)	.336	(.0040)
	3 Dev	34	.083	(.0040)	.334	(.0141)	.417	(.0170)
	4 Lit	10	.096	(.0125)	.548	(.0432)	.644	(.0416)
	5 Lbv	38	.209	(.0064)	.571	(.0148)	.780	(.0201)
	6 Hoz	70	.263	(.0047)	.628	(.0084)	.891	(.0102)
	7 Can	145	.149	(.0018)	.398	(.0029)	.547	(.0036)
	Mean			.122	(.0004)	.390	(.0010)	.512
Aug	1 Rby	83	.062	(.0015)	.215	(.0045)	.277	(.0050)
	2 Bbv	135	.083	(.0012)	.226	(.0024)	.309	(.0029)
	3 Dev	24	.065	(.0066)	.240	(.0106)	.304	(.0120)
	4 Lit	20	.051	(.0045)	.265	(.0193)	.316	(.0214)
	5 Lbv	8	.067	(.0237)	.400	(.0561)	.467	(.0726)
	6 Hoz	57	.137	(.0035)	.176	(.0060)	.312	(.0083)
	7 Can	84	.127	(.0024)	.382	(.0077)	.510	(.0087)
	Mean			.088	(.0004)	.249	(.0010)	.336
Sep	1 Rby	52	.039	(.0019)	.188	(.0055)	.226	(.0061)
	2 Bbv	79	.067	(.0018)	.182	(.0032)	.250	(.0038)
	3 Dev	52	.140	(.0034)	.168	(.0052)	.308	(.0078)
	4 Lit	32	.112	(.0045)	.246	(.0072)	.358	(.0105)
	5 Lbv	39	.077	(.0028)	.106	(.0026)	.182	(.0041)
	6 Hoz	77	.232	(.0030)	.195	(.0028)	.427	(.0048)
	7 Can	34	.101	(.0052)	.139	(.0083)	.241	(.0101)
	Mean			.113	(.0005)	.176	(.0007)	.289
Oct	1 Rby	42	.050	(.0024)	.336	(.0089)	.386	(.0098)
	2 Bbv	69	.092	(.0026)	.134	(.0028)	.226	(.0045)
	3 Dev	40	.082	(.0036)	.180	(.0039)	.262	(.0060)
	4 Lit	11	.089	(.0104)	.125	(.0143)	.214	(.0212)
	5 Lbv	20	.130	(.0086)	.196	(.0077)	.326	(.0148)
	6 Hoz	102	.267	(.0019)	.318	(.0027)	.585	(.0033)
	7 Can	5	.615	(.0863)	.154	(.0743)	.769	(.0599)
	Mean			.152	(.0007)	.233	(.0009)	.385
Ssn	1 Rby	265	.060	(.0005)	.292	(.0017)	.351	(.0019)
	2 Bbv	395	.081	(.0004)	.210	(.0008)	.291	(.0010)
	3 Dev	150	.101	(.0011)	.217	(.0021)	.319	(.0027)
	4 Lit	73	.093	(.0018)	.284	(.0042)	.377	(.0050)
	5 Lbv	105	.122	(.0016)	.254	(.0031)	.376	(.0044)
	6 Hoz	306	.239	(.0008)	.321	(.0012)	.559	(.0015)
	7 Can	268	.145	(.0009)	.362	(.0019)	.507	(.0022)
	Mean			.118	(.0001)	.268	(.0002)	.386

^aSee Figure 3 for location of lake survey zones.

^bStandard error of mean catch per hour given in parentheses. Multiply the standard error by 2 to estimate the 95% confidence interval.

^cNumber of anglers surveyed.

APPENDIX 9. Estimated monthly and seasonal mean catch per hour for rainbow trout by access area^a in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Rainbow Trout Catch per Hour ^b							
Month	Access	N ^c	Harvested	Released	Total		
Jul	Resort	247	.081 (.0006)	.314 (.0018)	.396	(.0021)	
	Hozomeen	116	.249 (.0026)	.674 (.0056)	.924	(.0069)	
	Canada	134	.144 (.0019)	.387 (.0030)	.531	(.0038)	
	Mean		.122 (.0004)	.390 (.0010)	.512	(.0012)	
Aug	Resort	261	.072 (.0006)	.227 (.0013)	.299	(.0015)	
	Hozomeen	66	.133 (.0030)	.197 (.0053)	.330	(.0072)	
	Canada	84	.127 (.0024)	.382 (.0077)	.510	(.0087)	
	Mean		.088 (.0004)	.249 (.0010)	.336	(.0011)	
Sep	Resort	228	.078 (.0006)	.169 (.0010)	.247	(.0014)	
	Hozomeen	103	.227 (.0022)	.207 (.0025)	.434	(.0041)	
	Canada	34	.101 (.0052)	.139 (.0083)	.241	(.0101)	
	Mean		.113 (.0005)	.176 (.0007)	.289	(.0010)	
Oct	Resort	164	.082 (.0009)	.190 (.0014)	.272	(.0019)	
	Hozomeen	120	.240 (.0017)	.296 (.0022)	.536	(.0030)	
	Canada	5	.615 (.0863)	.154 (.0743)	.769	(.0599)	
	Mean		.152 (.0007)	.233 (.0009)	.385	(.0012)	
Ssn	Resort	900	.078 (.0002)	.228 (.0004)	.306	(.0004)	
	Hozomeen	405	.226 (.0006)	.346 (.0010)	.572	(.0013)	
	Canada	257	.142 (.0010)	.354 (.0020)	.496	(.0023)	
	Mean		.118 (.0001)	.268 (.0002)	.386	(.0003)	

^aSee Figure 3 for location of access areas.

^bStandard error of mean catch per hour given in parentheses. Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

^cNumber of anglers surveyed.

APPENDIX 10. Estimated monthly and seasonal mean catch per hour for dolly varden char by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Dolly Varden Char Catch per Hour ^a							
Month	Daytype	N ^b	Harvested	Released	Total		
Jul	Opener	93	0	.003 (.0003)	.003	(.0003)	
	Weekday	208	0	.004 (.0002)	.004	(.0002)	
	Weekend	196	.001 (.0001)	0	.001	(.0001)	
	Mean		.001 (.0000)	.002 (.0000)	.003	(.0001)	
Aug	Weekday	252	.001 (.0001)	.006 (.0002)	.007	(.0002)	
	Weekend	159	0	.021 (.0012)	.021	(.0012)	
	Mean		.001 (.0000)	.012 (.0003)	.012	(.0003)	
Sep	Weekday	144	0	0	0		
	Weekend	221	.001 (.0001)	.001 (.0001)	.002	(.0001)	
	Mean		.001 (.0000)	.001 (.0000)	.001	(.0000)	
Oct	Weekday	132	.002 (.0001)	0	.002	(.0001)	
	Weekend	157	0	0	0		
	Mean		.001 (.0000)	0	.001	(.0000)	
Ssn	Opener	93	0	.003 (.0003)	.003	(.0003)	
	Weekday	736	.001 (.0000)	.003 (.0000)	.004	(.0000)	
	Weekend	733	.001 (.0000)	.004 (.0001)	.005	(.0001)	
	Mean		.001 (.0000)	.004 (.0000)	.004	(.0000)	

^aStandard error of mean catch per hour given in parentheses. Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

^bNumber of anglers surveyed.

APPENDIX 11. Estimated monthly and seasonal mean catch per hour for all trout and char species by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Trout and Char Catch per Hour ^a							
Month	Daytype	N ^b	Harvested	Released	Total		
Jul	Opener	93	.153 (.0023)	.717 (.0067)	.869 (.0075)		
	Weekday	208	.119 (.0010)	.309 (.0021)	.428 (.0026)		
	Weekend	196	.114 (.0010)	.334 (.0021)	.448 (.0026)		
	Mean		.123 (.0004)	.392 (.0010)	.515 (.0012)		
Aug	Weekday	252	.091 (.0007)	.263 (.0015)	.353 (.0018)		
	Weekend	159	.084 (.0011)	.260 (.0035)	.345 (.0039)		
	Mean		.088 (.0004)	.262 (.0011)	.350 (.0012)		
Sep	Weekday	144	.104 (.0012)	.175 (.0018)	.279 (.0024)		
	Weekend	221	.118 (.0008)	.178 (.0011)	.296 (.0016)		
	Mean		.113 (.0005)	.177 (.0007)	.290 (.0010)		
Oct	Weekday	132	.135 (.0014)	.235 (.0020)	.370 (.0027)		
	Weekend	157	.170 (.0014)	.231 (.0015)	.401 (.0023)		
	Mean		.153 (.0007)	.233 (.0009)	.386 (.0012)		
Ssn	Opener	93	.153 (.0023)	.717 (.0067)	.869 (.0075)		
	Weekday	736	.110 (.0002)	.251 (.0005)	.361 (.0006)		
	Weekend	733	.123 (.0003)	.245 (.0005)	.367 (.0006)		
	Mean		.118 (.0001)	.272 (.0002)	.391 (.0003)		

^aStandard error of mean catch per hour given in parentheses. Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

^bNumber of anglers surveyed.

APPENDIX 12. Monthly and seasonal estimates of rainbow trout captured by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Rainbow Trout Catch ^a							
Month	Daytype	Harvested		Released		Total	
Jul	Opener	135	(2.1)	632	(5.9)	768	(6.3)
	Weekday	981	(116.4)	2515	(298.1)	3496	(320.0)
	Weekend	337	(40.8)	997	(120.3)	1335	(127.0)
	Total	1454	(123.4)	4144	(321.5)	5598	(344.4)
Aug	Weekday	442	(10.3)	1249	(28.6)	1691	(30.4)
	Weekend	262	(4.1)	746	(10.8)	1008	(11.6)
	Total	705	(11.1)	1994	(30.6)	2699	(32.6)
Sep	Weekday	414	(25.9)	696	(43.5)	1110	(50.6)
	Weekend	511	(3.5)	773	(4.7)	1285	(5.8)
	Total	925	(26.1)	1470	(43.7)	2395	(51.0)
Oct	Weekday	398	(55.4)	704	(97.8)	1102	(112.4)
	Weekend	292	(29.5)	397	(40.1)	690	(49.8)
	Total	691	(62.8)	1101	(105.7)	1792	(122.9)
Ssn	Opener	135	(2.1)	632	(5.9)	768	(6.3)
	Weekday	2236	(131.9)	5163	(318.0)	7399	(344.3)
	Weekend	1403	(50.6)	2914	(127.4)	4317	(137.1)
	Total	3774	(141.3)	8709	(342.7)	12484	(370.6)

^aStandard error of estimate given in parentheses. Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

APPENDIX 13. Monthly and seasonal estimates of rainbow trout captured by lake zone^a in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Rainbow Trout Catch ^b							
Month	Zone	Harvested		Released		Total	
Jul	1 Rby	211	(37.5)	1124	(199.0)	1335	(202.5)
	2 Bbv	289	(38.4)	893	(118.5)	1182	(124.5)
	3 Dev	52	(16.5)	206	(65.7)	258	(67.7)
	4 Lit	49	(11.5)	281	(59.3)	330	(60.4)
	5 Lbv	209	(29.4)	572	(79.9)	781	(85.1)
	6 Hoz	455	(74.7)	1087	(177.8)	1542	(192.8)
	7 Can	406	(73.7)	1088	(197.0)	1495	(210.3)
	Total	1671	(123.1)	5251	(371.8)	6923	(391.7)
Aug	1 Rby	75	(9.1)	261	(31.5)	337	(32.8)
	2 Bbv	219	(47.7)	595	(129.6)	814	(138.1)
	3 Dev	66	(16.6)	244	(57.4)	309	(59.7)
	4 Lit	25	(7.4)	128	(38.2)	153	(38.9)
	5 Lbv	39	(17.3)	236	(69.5)	276	(71.6)
	6 Hoz	166	(23.7)	213	(30.8)	379	(38.8)
	7 Can	184	(27.3)	553	(82.0)	738	(86.4)
	Total	774	(65.5)	2231	(187.2)	3005	(198.3)
Sep	1 Rby	41	(6.3)	201	(29.5)	242	(30.1)
	2 Bbv	94	(14.1)	254	(37.9)	348	(40.4)
	3 Dev	294	(40.6)	355	(49.4)	649	(64.0)
	4 Lit	97	(16.1)	212	(35.0)	309	(38.5)
	5 Lbv	78	(9.2)	107	(12.4)	185	(15.4)
	6 Hoz	476	(62.7)	399	(52.7)	875	(81.9)
	7 Can	109	(16.8)	150	(23.5)	258	(28.9)
	Total	1188	(80.3)	1678	(97.2)	2866	(126.1)
Oct	1 Rby	35	(8.2)	236	(54.5)	271	(55.1)
	2 Bbv	127	(32.9)	186	(48.1)	313	(58.3)
	3 Dev	63	(23.2)	139	(50.7)	203	(55.8)
	4 Lit	26	(10.8)	37	(15.2)	63	(18.6)
	5 Lbv	55	(28.6)	82	(42.6)	137	(51.3)
	6 Hoz	529	(145.5)	630	(173.2)	1159	(226.2)
	7 Can	34	(32.1)	9	(8.9)	43	(33.4)
	Total	870	(157.6)	1319	(200.0)	2189	(254.6)
Ssn	1 Rby	362	(39.9)	1823	(210.8)	2185	(214.6)
	2 Bbv	729	(70.9)	1928	(186.0)	2657	(199.0)
	3 Dev	475	(52.3)	944	(112.3)	1419	(123.9)
	4 Lit	197	(23.8)	658	(80.1)	855	(83.6)
	5 Lbv	381	(45.4)	998	(114.8)	1379	(123.5)
	6 Hoz	1626	(176.8)	2329	(255.6)	3955	(310.8)
	7 Can	734	(86.5)	1800	(214.8)	2533	(231.6)
	Total	4503	(225.2)	10479	(471.9)	14982	(522.9)

^aSee Figure 1 for location of lake survey zones.

^bStandard error of estimate given in parentheses. Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

APPENDIX 14. Monthly and seasonal estimates of rainbow trout captured by access area^a in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

		Rainbow Trout Catch ^b					
Month	Access	Harvested		Released		Total	
Jul	Resort	615	(84.7)	2378	(327.3)	2992	(338.1)
	Hozomeen	681	(84.9)	1841	(229.1)	2522	(244.3)
	Canada	393	(71.2)	1058	(191.6)	1451	(204.4)
	Total	1688	(139.4)	5277	(443.1)	6965	(464.5)
Aug	Resort	385	(41.6)	1217	(131.4)	1602	(137.8)
	Hozomeen	241	(29.3)	356	(43.6)	596	(52.5)
	Canada	184	(27.3)	553	(82.0)	738	(86.4)
	Total	810	(57.7)	2126	(160.9)	2936	(170.9)
Sep	Resort	422	(14.8)	920	(31.8)	1342	(35.1)
	Hozomeen	697	(80.7)	633	(73.4)	1329	(109.1)
	Canada	109	(16.8)	150	(23.5)	258	(28.9)
	Total	1228	(83.7)	1702	(83.4)	2930	(118.2)
Oct	Resort	258	(52.2)	600	(121.3)	857	(132.1)
	Hozomeen	577	(169.5)	711	(208.7)	1288	(268.8)
	Canada	34	(32.1)	9	(8.9)	43	(33.4)
	Total	869	(180.2)	1319	(241.6)	2188	(301.4)
Ssn	Resort	1680	(108.8)	5114	(374.4)	6794	(389.8)
	Hozomeen	2195	(208.1)	3540	(321.4)	5736	(382.9)
	Canada	720	(84.4)	1770	(209.9)	2490	(226.3)
	Total	4595	(249.5)	10424	(536.2)	15019	(591.4)

^aSee *Figure 1* for location of access areas.

^bStandard error of estimate given in parentheses. Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

APPENDIX 15. Monthly and seasonal estimates of dolly varden char captured by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Dolly Varden Char Catch ^a					
Month	Daytype	Harvested	Released	Total	
Jul	Opener	0	3 (0.3)	3	(0.3)
	Weekday	0	33 (4.1)	33	(4.1)
	Weekend	3 (0.4)	0	3	(0.4)
	Total	3 (0.4)	36 (4.1)	39	(4.2)
Aug	Weekday	5 (0.3)	29 (1.2)	34	(1.3)
	Weekend	0	66 (3.7)	66	(3.7)
	Total	5 (0.3)	95 (3.9)	100	(3.9)
Sep	Weekday	0	0	0	
	Weekend	4 (0.3)	4 (0.3)	9	(0.4)
	Total	4 (0.3)	4 (0.3)	9	(0.4)
Oct	Weekday	6 (0.9)	0	6	(0.9)
	Weekend	0	0	0	
	Total	6 (0.9)	0	6	(0.9)
Ssn	Opener	0	3 (0.3)	3	(0.3)
	Weekday	11 (1.0)	62 (4.3)	73	(4.4)
	Weekend	7 (0.5)	70 (3.7)	77	(3.7)
	Total	18 (1.1)	135 (5.7)	153	(5.8)

^aStandard error of estimate given in parentheses. Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

APPENDIX 16. Monthly and seasonal estimates of trout and char captured by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1990.

Trout and Char Catch^a

Month	Daytype	Harvested		Released		Total	
Jul	Opener	135	(2.1)	635	(5.9)	770	(6.3)
	Weekday	981	(116.4)	2548	(302.0)	3529	(323.7)
	Weekend	340	(41.1)	997	(120.3)	1338	(127.2)
	Total	1457	(123.5)	4180	(325.2)	5637	(347.8)
Aug	Weekday	447	(10.4)	1293	(29.6)	1740	(31.4)
	Weekend	262	(4.1)	811	(13.1)	1073	(13.7)
	Total	709	(11.2)	2104	(32.3)	2814	(34.2)
Sep	Weekday	414	(25.9)	696	(43.5)	1110	(50.6)
	Weekend	516	(3.5)	778	(4.7)	1293	(5.8)
	Total	929	(26.1)	1474	(43.7)	2404	(51.0)
Oct	Weekday	404	(56.2)	704	(97.8)	1108	(112.8)
	Weekend	292	(29.5)	397	(40.1)	690	(49.8)
	Total	697	(63.5)	1101	(105.7)	1798	(123.3)
Ssn	Opener	135	(2.1)	635	(5.9)	770	(6.3)
	Weekday	2247	(132.2)	5241	(321.8)	7487	(347.9)
	Weekend	1410	(50.9)	2984	(127.6)	4394	(137.4)
	Total	3793	(141.7)	8859	(346.2)	12652	(374.1)

^aStandard error of estimate given in parentheses. Multiply the standard error by 2 to obtain a rough estimate of the 95% confidence interval.

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