ROSS LAKE RAINBOW TROUT STUDY

1991-92 PROGRESS REPORT

by

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ABSTRACT

The Washington Department of Wildlife conducted a rainbow trout study on Ross Reservoir from June 1, 1991 to May 31, 1992. This investigation was the second year of a proposed 5-year study to evaluate the effect of special sport fishing 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 1992 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 36,108 hours during the 1991 fishing season, or 8,777 angler days. The total seasonal rainbow trout <u>harvest</u> estimate was 3,833 fish, with a mean seasonal harvest rate of 0.103 fish per hour. Total <u>catch</u> (harvested + released) was estimated at 13,162 rainbow trout, with a mean catch rate of 0.366 fish per hour. The total seasonal dolly varden char, brook trout (char), and cutthroat trout <u>harvest</u> estimates were 13, 19, and 4 fish, respectively. Total <u>catch</u> was estimated at 25 dolly varden char, 29 brook trout (char), and 11 cutthroat trout.

The new angling regulations continue to have significant impacts on angler effort, harvest rates and harvest at Ross Reservoir. Total estimated 1990 and 1991 seasonal angler effort declined approximately 50 percent from the mid-1980's and early 1970's. Mean overall harvest rates declined approximately 400 percent from studies conducted prior to 1990, while total estimated rainbow trout harvests are ten and five times smaller than harvests obtained in the early 1970's and mid-1980's, respectively.

Five hydroacoustic surveys were conducted on the lower portion of Ross Lake from March through May of 1992. These surveys were used to establish index counts and estimate the total size of the reservoir's fish population (fish larger than six inches). A total combined species population estimate of 37,263 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 37,082 fish. Even though the 1992 rainbow trout population estimate increased approximately 81 percent over the 1991 estimate, large confidence intervals associated with the estimates preclude definitive conclusions about recovery.

Seven spawning surveys conducted on each of five U.S. tributaries to Ross Lake between May and July of 1992 resulted in a total enumeration of 2,400 rainbow trout. Peak spawning occurred on most tributaries during

the first two weeks of June, with Lightning Creek recording the largest number of spawning fish. Roland Creek and Dry Creek continue to be the most important index tributaries due to fish accessibility, flow, spawner use, availability of spawning habitat, and visibility and accessibility by survey personnel. Observations of spawning rainbow trout in 1992 indicate that numbers are much reduced from the mid-1980's, but are substantially higher than in 1991.

Data collected from the 1990-91 and 1991-92 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 still considerably below 1970's levels. 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 1, 1991 to May 31, 1992. This is the second year of an ongoing 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, Looff 1991, Looff 1992a). 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 (with the exception of 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 fish to spawn at least once before entering the fishery (increased minimum size limit). A bait restriction was necessary to reduce mortality of released fish, and a later season opener was enacted to permit spawning fish more time to ascend tributary streams before the fishery opened, and also 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). A number of 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 <u>Resident Fisheries Study for Ross, Diablo and Gorge Lakes</u> (Seattle City Light 1989).

Study Area

Ross Lake is an oligotrophic reservoir located at 49°N latitude and 121°W 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

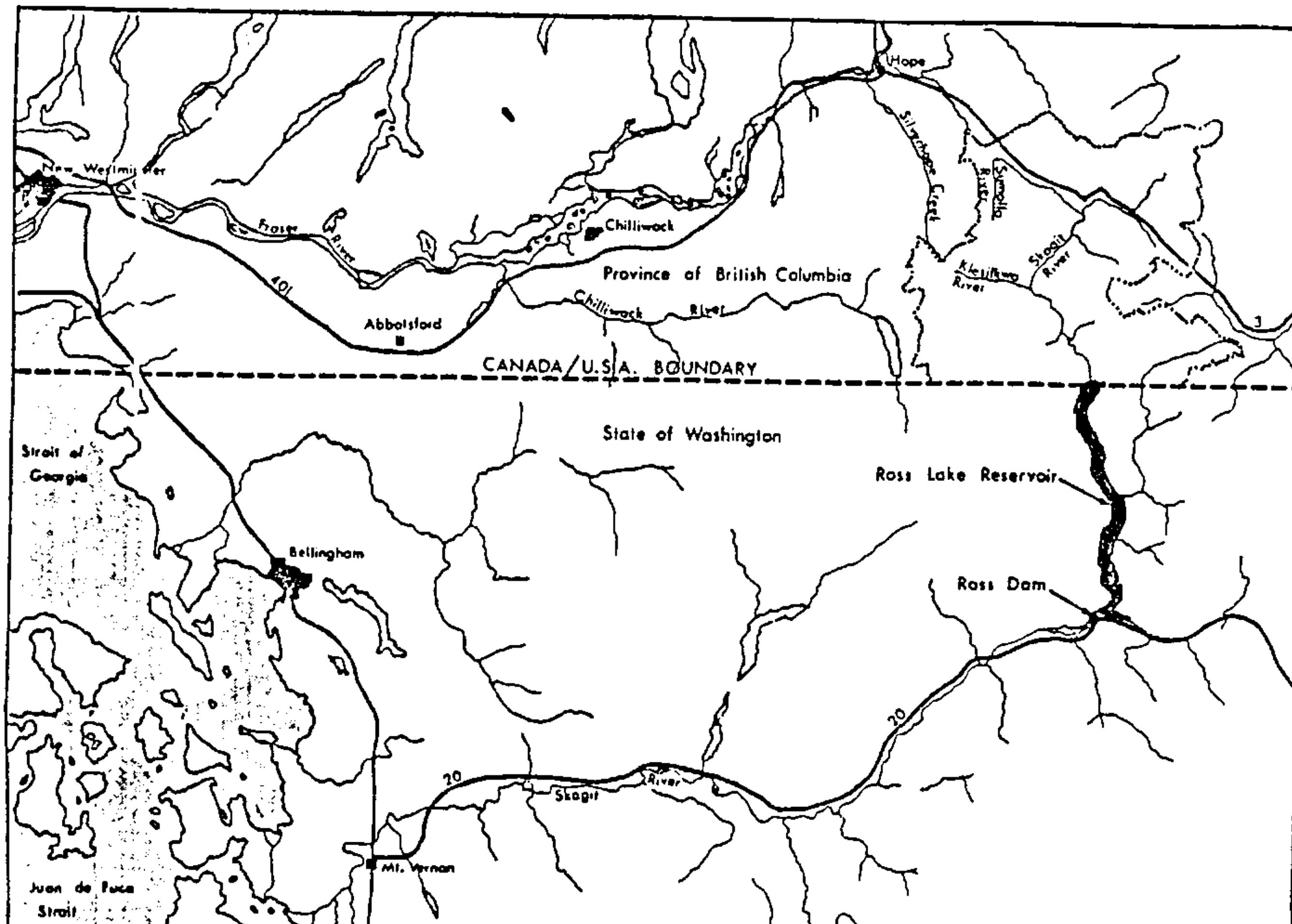


FIGURE 1. Geographic location of Ross Lake in NW Washington and SW British Columbia.

the Skagit River 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 given 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 ft near the base of the dam and mean reservoir depth is 123 ft. 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). Numerous 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 1991-92 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

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	---	---
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

[a]Based on 1953-69 flushing rates.
[b]Skagit River drainage upstream of Ross dam.
[c]Shoreline development (SD) = $S/(2*((Pi*A)^{.5}))$, where S = shore length and A = lake area.

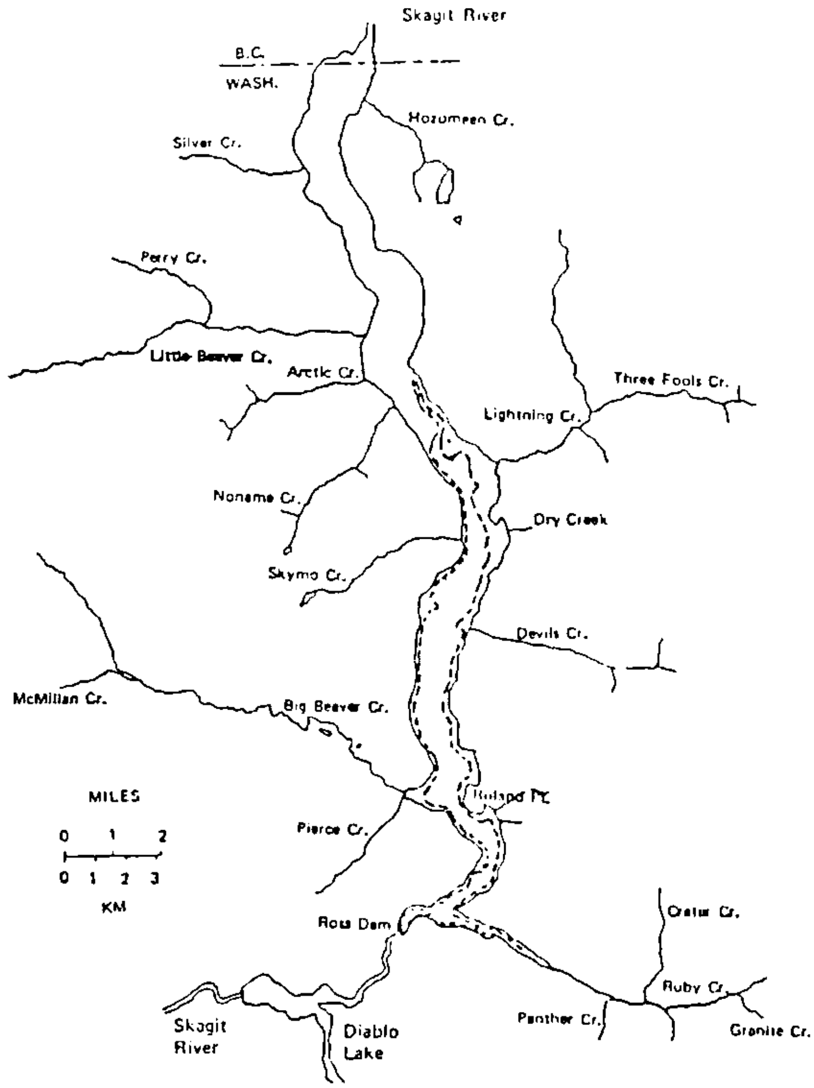


FIGURE 2. Ross Lake and major tributaries. The perimeter of the lake at full pool (1602.5 feet msl) is shown as a solid line, and the maximum drawdown contour (1475 feet msl) is depicted as a dotted line.

trout sampled from the angler sport catch.

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 1991-92 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

Sampling methods and procedures for the 1991-92 rainbow trout study on Ross Reservoir are identical to the 1990-91 study. Statistical comparisons of data are primarily limited to the first two years of the present study, since different fishing regulations and/or sampling regimes were in effect for studies conducted in the mid-1980's and early 1970's.

1991-92 Studies

The 1991-92 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, 1991 to determine angler harvest and harvest-related information. A second study involved collection of hydroacoustic transect data from four lake surveys performed from March through May of 1992. The purpose of these surveys was to establish index counts of fish density for use in annual monitoring of population size fluctuations, and to estimate the size of the 1991-92 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 were used to establish index counts of spawner density for use in annual monitoring of spawning population fluctuations in each index stream.

Personnel consisted of one full-time biologist and one part-time technician that assisted in the collection of angler creel survey data at the north end of the lake. The biologist was responsible for the angler creel survey at the south end of the reservoir, as well as all other project-related work.

1991 Creel Survey

The 1991 angler creel census was based on a stratified random design that was identical to that used during the 1990 creel census (Looff 1992a). 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 prior to 1990) is treated as a separate strata, since a considerably higher degree of angler effort is generated at this time than at any other time during the fishing season.

Sample days were randomly selected by microcomputer using a Microsoft QuickBASIC program written by the author. 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 1991 fishing season (*Table 2*). Logistical and budgetary constraints travelling to and from the lake necessitated the use of continuous

TABLE 2. Number of days censused per day type strata during the 1991 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%

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 1991 sport fishing season are listed in *Appendix 2*.

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 (described above) 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), rather than on 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 in order to develop effort estimates. The design 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 access to the reservoir permitted most anglers to be interviewed during the course of any work day (except for a very 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, 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 in 1990 were considered to be a single access area, 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 in some cases, especially at the north end of the lake where it was impossible for the interviewer to survey the Canadian and Hozeem access sites at the same time, information was frequently collected later in the day. Information was collected from

TABLE 3. Number of daylight hours assumed available to anglers during the 1991 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

all anglers contacted, regardless of whether they had finished fishing for the day. Two primary reasons for checking incomplete anglers was that a large proportion of 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:

- 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 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

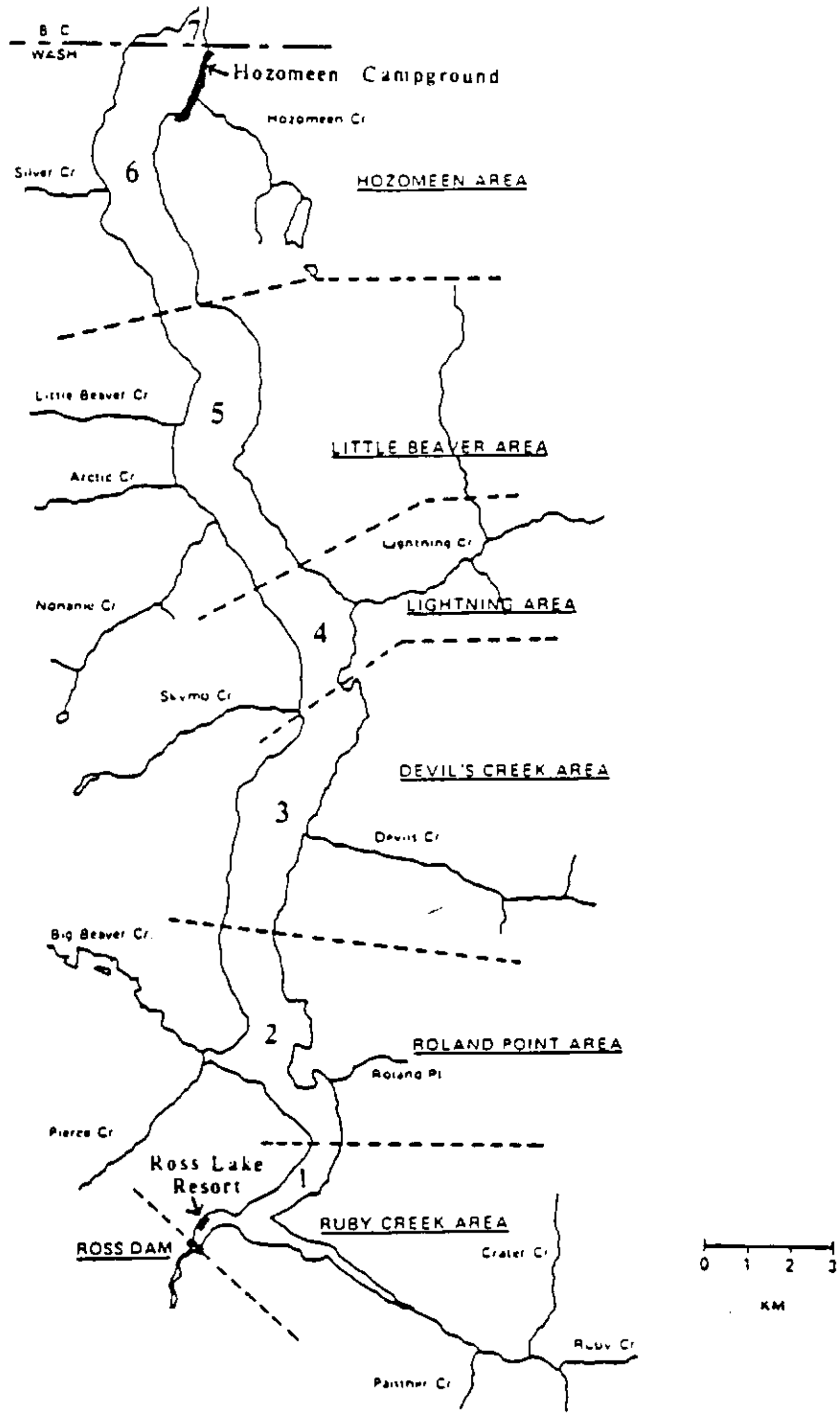


FIGURE 3. Ross Lake survey zones.

samples containing at least two good scales that did not exhibit regenerated areas were used. After aging all of the samples once to determine 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 final result of this third reading was considered to be the age of the sample.

A subset of rainbow trout that were sampled for scale analysis were also examined for sexual maturity on the basis of gonadal development. Sexual maturity information was only collected from trout sampled during the month of 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, served 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) [(0.629 * branchiostegal ray number) + (0.178 * anal fin number) + (37.310 * (maxillary length/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 2*) 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 actually fishing in each zone of the lake (*Figure 3*). Counts during July and August involved two separate round trips up and down the reservoir, but the additional expenses of lost interview time and extra cost of boat operation necessitated 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 daytypes, lake zones, and access areas. 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 utilized 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 strata within any monthly time block. Missing hourly effort within a specific strata was estimated using the following proportion:

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

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 actually 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) $r = c / t$

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. Even though 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) $c = e * Q1$

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) $sQ12 = Q12 * ((sc2/c2) + (st2/t2) - ((2*sct)/ct))$

where,

c = catch,
t = time (hours),
$Q_1 = c/t$, and
s_{ct} = covariance(c,t)

(6) $sQ22 = Q22 * ((se2/e2) + (sr2/r2) + ((2*sct)/ct))$

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 March, April, and May of 1992 to estimate the total number of fish (all species) greater than six inches 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 is 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.

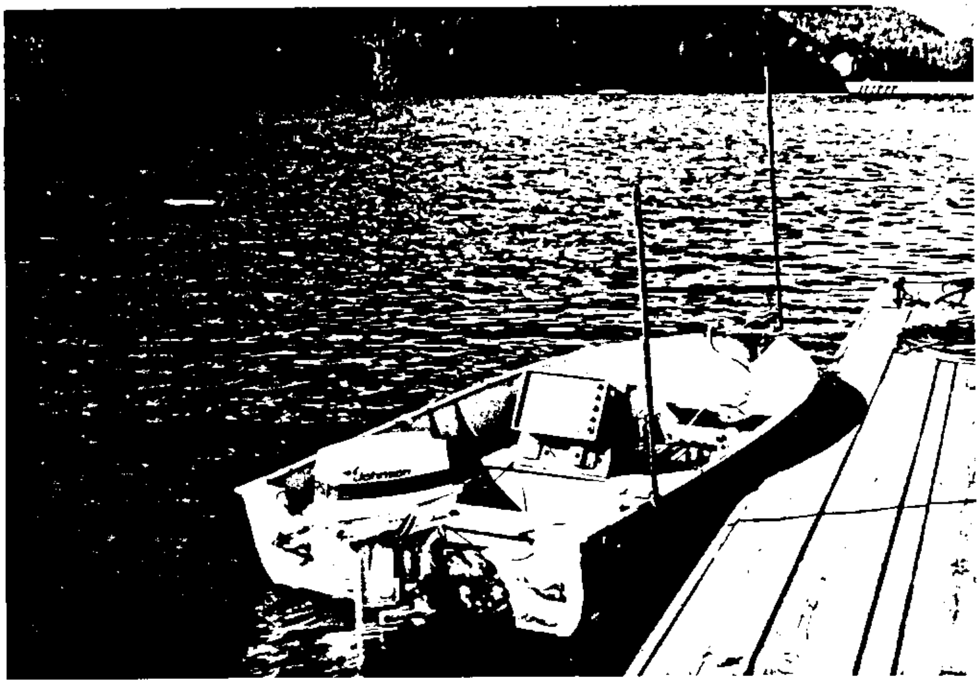


FIGURE 4. Hydroacoustic equipment used in reservoir trout population estimates and index counts.

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.

Five estimates were conducted on March 25-26, April 19, and May 4-5. Three estimates (March 26, April 19 and May 5) were conducted in the morning between 0800 and 1200 hours, and the remaining two estimates (March 25 and May 4) 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 indicate 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 the 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 the methods and procedures for determining 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 strata.

Spawning Surveys

Seven rainbow trout spawning surveys were conducted from May through mid-July on each of five index streams. Streams were selected for annual enumeration of spawning fish on the basis of size, flow, availability of spawning habitat, historic spawner usage, and accessability by personnel. Streams surveyed included Dry, Lightning, Pierce, Roland, and Thursday Creeks (*Figure 2*). Canyon Creek was not surveyed in 1992 due to persistent high water flows, and will be discontinued from any future surveys.

Each stream was surveyed from the mouth upstream to either the first total migration barrier, or the limit of adequate spawning habitat. It was not possible to survey 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 eleven days during peak spawning.

RESULTS

1991-92 Lake Levels

The opening day lake elevation was 1592.54 feet msl on July 1, 1991. The reservoir reached a maximum elevation of 1602.51 feet msl on August 1, 1991, and a minimum elevation of 1533.30 feet msl on April 2, 1992.

1991 Opening Day Creel Survey - (post-1990 regulation change)

A total of 49 anglers were checked at Ross Lake on opening day, July 1, 1991 (*Table 4*). These anglers fished a total of 301.00 hours and caught 215 rainbow trout (harvested and released) for a catch per unit effort (CPUE) of 0.714 fish per hour. Catch per unit effort was slightly higher at the north end of the lake (0.750 fish per hour) than at the south end (0.708 fish per hour). The fish per angler average was 4.4 for a combination of complete and incomplete anglers, while completed trip anglers caught an average of 4.5 fish per person. No other species of trout or char were reported by anglers on opening day.

1991 Opening Day - Harvest

Opening day harvest totalled 46 rainbow trout for interviewed anglers (*Table 4*). A total of 169 fish (79%) were released. Harvest per unit effort (HPUE) was 0.153 fish per hour, and was slightly higher at the north end of the lake (0.182 fish per hour) than at the south end (0.148 fish per hour). The fish per angler average was 0.9 for a combination of complete and incomplete anglers, while completed trip anglers harvested an average of 1.3 fish per person.

1991 Opening Day - Methods and Gear

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

1991 Opening Day - Age

Twelve rainbow trout were randomly sampled from the angler harvest on opening day, 1991 for age determination. (All opening day rainbow trout biological data was collected from the angler harvest at Ross Lake Resort. Boat problems precluded collection of life history data at the north end of the lake on opening day.) The majority of the sample was composed of age 4 fish (58%), while age 5 (25%) and age 3 fish (17%) comprised the remainder of the sample.

1991 Opening Day - Length

The average fork length of rainbow trout kept by anglers on opening day

TABLE 4. Comparison of 1991 opening day rainbow trout catch statistics between different access areas at Ross Reservoir.

			Rainbow Trout					
						Fork Length (mm)		
Access	Anglers	Hours	Catch	CPUE[a]	F/A[b]	Min	Max	Avg
COMBINED TRIPS[c] - Harvest Only								
Hozomeen	12	44	8	0.182	0.7	---	---	---
Resort	37	257	38	0.148	1.0	300	360	325
Total	49	301	46	0.153	0.9	300	360	325
COMBINED TRIPS[c] - Harvest + Released								
Hozomeen	12	44	33	0.750	2.8			
Resort	37	257	182	0.708	4.9			
Total	49	301	215	0.714	4.4			
COMPLETE TRIPS - Harvest Only								
Hozomeen	3	18	1	0.056	0.3	---	---	---
Resort	5	37	9	0.243	1.8	305	350	323
Total	8	55	10	0.182	1.3	305	350	323
COMPLETE TRIPS - Harvest + Released								
Hozomeen	3	18	5	0.278	1.7			
Resort	5	37	31	0.838	6.2			
Total	8	55	36	0.655	4.5			

[a]Catch per unit effort (fish/hour).

[b]Fish per angler.

[c]Includes data from fishermen that were not finished fishing for the day (complete + incomplete trips).

was 325 mm (*Table 4*). These trout ranged in length from 300 to 360 mm. *Figure 5* depicts a length-frequency histogram of the opening day harvest of rainbow trout sampled at the south end of Ross Lake. From a sample of 23 rainbow trout, the most numerous number of fish (n=7) were in the 300-310 mm size group. This size interval is slightly smaller than the approximate minimum legal <u>fork length</u> size limit of 317 mm (12.5 inches) permitted under the new regulations.

<u>1991 Opening Day - Sex</u>

On July 1, 1991, a sub-sample of fifteen rainbow trout were examined internally for sex determination. Nine fish (60%) were males and six fish (40%) were females.

<u>1991 Opening Day - Sexual Maturity</u>

The sub-sample of rainbow trout that were examined for sex determination were also checked for sexual maturity (*Table 5*). Four mature fish comprised 31 percent of the sample (all males), while immature fish made up 69 percent of the sample (3 males and 6 females). The average length of mature males was 346 mm, while immature fish averaged 312 mm, and 331 mm for males and females, respectively.

Age and length information of the opening day sexual maturity sub-sample, grouped by access, sex, and maturity, is given in *Table 6*. Mature fish (all males) were four and five years old, while immature males were age 3 and age 4. Immature females ranged from three to five years of age.

A complete list of the 1991 opening day creel data for Ross Lake is given in *Appendix 1* of the <u>Ross Lake Rainbow Trout Study: 1991-92 Data Appendix</u> (Looff 1992b).

1991 Season Creel Survey

A total of 1,548 anglers were interviewed during the July 1 to October 31, 1991 creel census at Ross Reservoir. During the interviews 335 rainbow trout were sampled for life history information.

<u>1991 Season - Angler Effort</u>

From July 1, 1991 to October 31, 1991 anglers fished an estimated 36,108 ± 1,118 hours, or 8,777 angler days (*Table 7*, daytype estimate). The standard error of the estimated total effort was small (± 1.5 percent), indicating good precision. Most angler effort occurred in July (40%), primarily during the first week of the season (*Figure 6* and *Appendix 3*). Angling effort decreased throughout the rest of the season, with 24 percent of the effort occurring in August, 21 percent in September, and 15 percent in October.

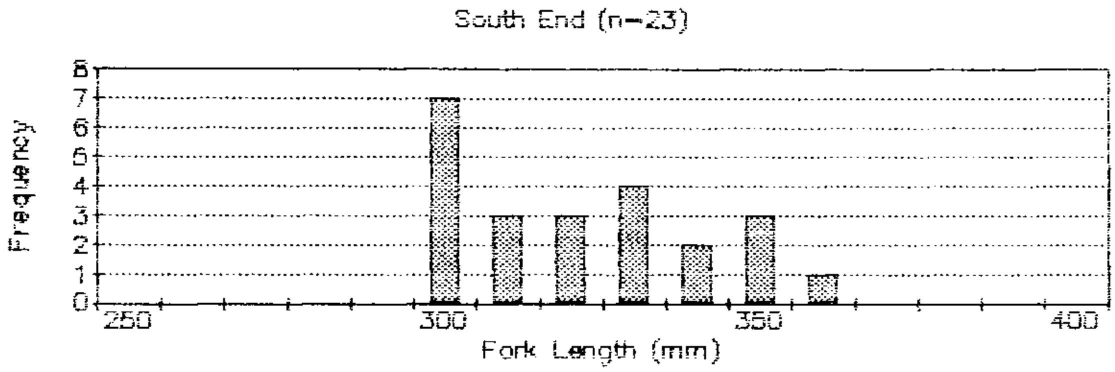


FIGURE 5. Length-frequency distribution of rainbow trout sampled from the Ross Lake sport harvest (south end only) on opening day, 1991. Minimum legal size limit is approximately 317 mm fork length. Abscissa values indicate lower limit of length interval.

TABLE 5. Rainbow trout length information, grouped by sex and maturity, from the opening day, 1991 sport harvest at Ross Reservoir.

			Fork Length (mm)		
Sex	Maturity	N	Avg	Min	Max
Male	Mature	4	346	337	356
	Immature	3	312	300	330
Female	Mature				
	Immature	6	331	302	353

TABLE 6. Rainbow trout age and length information, grouped by access area, sex and maturity, from the opening day, 1991 sport harvest at Ross Reservoir.

					Fork Length (mm)		
Access	Sex	Maturity	Age	N	Avg	Min	Max
Resort	Male	Mature	4	2	347	337	356
			5	2	346	342	350
		Immature	3	1	300	300	300
			4	1	305	305	305
	Female	Immature	3	1	302	302	302
			4	3	329	326	334
			5	1	353	353	353

TABLE 7. Estimated total seasonal angler effort in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

Type[a]	Strata	Angler Hours[b]		Mean Hours Fished per Day[c]	Total Angler Days[d]
Daytype	Opener	744	(0)	6.14	121
	Weekday	19508	(475)	4.18	4673
	Weekend	15856	(296)	3.98	3983
	Total	36108	(559)	4.11	8777
Zone[e]	1 Rby	4687	(329)	3.67	1279
	2 Bbv	8386	(533)	4.29	1957
	3 Dev	3812	(300)	5.43	702
	4 Lit	3062	(312)	5.49	558
	5 Lbv	2963	(289)	3.83	773
	6 Hoz	10350	(573)	3.69	2807
	7 Can	3845	(260)	2.79	1379
	Total	37104	(1029)	3.92	9456
Access	Resort	19947	(875)	4.40	4529
	Hozomeen	13313	(660)	3.78	3526
	Canada	3845	(260)	2.79	1379
	Total	37104	(1127)	3.93	9434

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

[b]Standard 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.

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

[d]Total angler days = angler hours/mean hours fished per day.

[e]See *Figure 3* for location of lake survey zones.

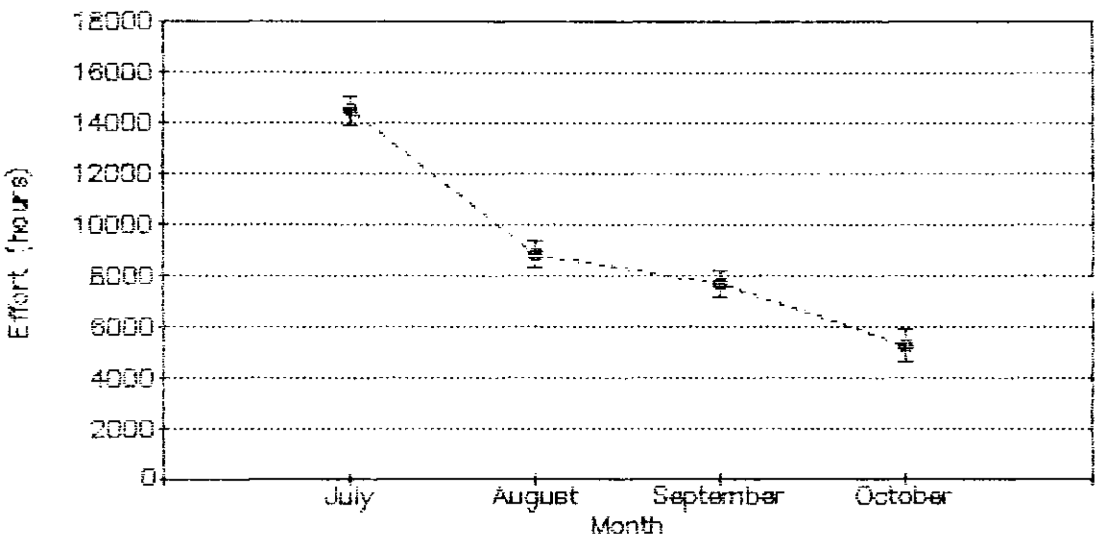


FIGURE 6. Monthly distribution of seasonal angler effort (daytype estimate) during the 1991 Ross Reservoir sport fishery.

A total seasonal estimate of 37,104 ± 2,058 hours was calculated for effort data that was separated into zones (*Table 7* and *Appendix 4*). From *Figure 7*, it can be seen that most effort was expended in zones 6-Hozomeen (28%), 2-Big Beaver (23%), 1-Ruby (13%) and 7-Canada (10%). The three access areas were either located within or immediately adjacent to these four zones. Zones 3-Devils (10%), 4-Lightning (8%), and 5-Little Beaver (8%) comprised the remaining effort.

A total seasonal effort estimate of 37,104 ± 2,254 hours was calculated for effort data that was separated into access areas (*Table 7* and *Appendix 5*). An estimated total of 19,947 hours (54%) was calculated for anglers utilizing the resort, 13,313 hours (36%) for anglers at Hozomeen, and 3845 hours (10%) for anglers in Canada.

<u>1991 Season - Angler Catch and Harvest Rates</u>

The mean seasonal <u>catch rate</u> (combination of harvested and released) for rainbow trout was 0.366 ± <0.001 fish per hour (*Table 8*, daytype estimate). The standard error of the estimated mean catch rate was very small (+/- 0.08 percent), indicating excellent precision. Catch rates varied throughout the season (*Figure 8* and *Appendix 6*), declining from a seasonal high in July (0.418 CPUE) to a seasonal low in August (0.314 CPUE), and gradually increasing in September (0.339 CPUE) and October (0.377 CPUE).

The mean seasonal <u>harvest rate</u> for rainbow trout was 0.103 ± <0.001 fish per hour (*Table 8*, daytype estimate). The standard error of the estimated mean harvest rate was very small (± 0.1 percent), indicating excellent precision. As shown in *Figure 8*, harvest rates for rainbow trout progressively decreased from a seasonal high in July (0.124 HPUE) to a seasonal low in September (0.086 HPUE), then increased in October (0.100 HPUE).

Mean seasonal catch and harvest rates for zone and access area estimates are identical to daytype estimates (*Table 8*), since all three estimates were calculated from the same creel data. As shown in *Table 8* and *Figure 9*, the highest seasonal <u>catch rates</u> for rainbow trout (zone estimate) occurred at the south end of the lake in zones 3-Devils (0.433 CPUE) and 2-Big Beaver (0.395 CPUE). The lowest seasonal catch rates occurred at the north end of the lake in zones 7-Canada (0.215 CPUE) and 6-Hozomeen (0.324 CPUE). Intermediate catch rates occurred in 5-Little Beaver (0.357 CPUE), 4-Lightning (0.355 CPUE), and 1-Ruby (0.346 CPUE). Rainbow trout <u>harvest rates</u> were fairly constant over the entire lake (approximately one fish per ten hours of fishing effort), but were slightly higher in zones 6-Hozomeen (0.118 HPUE) and 2-Big Beaver (0.110 HPUE), and somewhat lower in zones 1-Ruby (0.070 HPUE) and 7-Canada (0.081 HPUE). Monthly and seasonal catch and harvest rate estimates for the different zone strata are listed in *Appendix 7*.

As shown in *Table 8*, resort anglers had the highest seasonal <u>catch rate</u> (access area estimate) for rainbow trout (0.389 CPUE). An intermediate

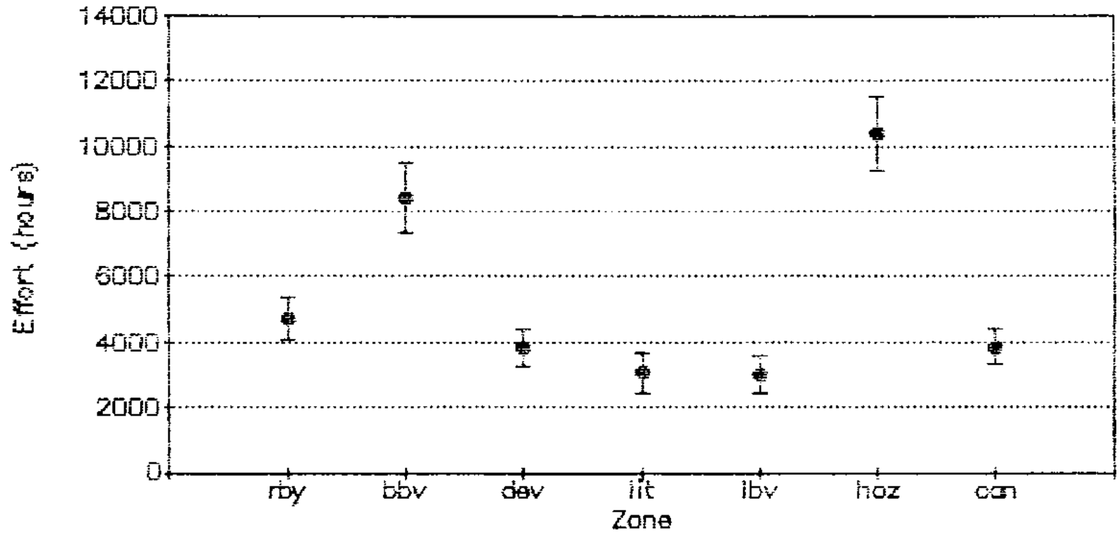


FIGURE 7. Distribution of seasonal angler effort (zone estimate) among lake zones during the 1991 Ross Reservoir sport fishery. Zone abbreviations are as follows: rby = ruby (zone 1); bbv = big beaver (zone 2); dev = devils (zone 3); lit = lightning (zone 4); lbv = little beaver (zone 5); hoz = hozomeen (zone 6); and can = canada (zone 7).

TABLE 8. Estimated mean seasonal catch and harvest rates for rainbow trout in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

			Rainbow Trout Catch per Hour[a]					
Type[b]	Strata	N[c]	Harvested		Released		Total	
Daytype	Opener	49	.153	(.0032)	.561	(.0137)	.714	(.0138)
	Weekday	673	.105	(.0003)	.286	(.0006)	.391	(.0007)
	Weekend	826	.097	(.0002)	.216	(.0004)	.313	(.0005)
	Mean		.103	(.0001)	.263	(.0003)	.366	(.0003)
Zone[d]	1 Rby	273	.070	(.0006)	.276	(.0022)	.346	(.0022)
	2 Bbv	433	.110	(.0004)	.286	(.0009)	.395	(.0011)
	3 Dev	166	.103	(.0009)	.330	(.0025)	.433	(.0029)
	4 Lit	66	.101	(.0023)	.253	(.0047)	.355	(.0060)
	5 Lbv	115	.100	(.0014)	.256	(.0027)	.357	(.0034)
	6 Hoz	453	.118	(.0004)	.205	(.0007)	.324	(.0009)
	7 Can	42	.081	(.0042)	.134	(.0060)	.215	(.0088)
	Mean		.103	(.0001)	.263	(.0003)	.366	(.0003)
Access	Resort	929	.099	(.0002)	.290	(.0005)	.389	(.0005)
	Hozomeen	577	.113	(.0003)	.218	(.0006)	.331	(.0007)
	Canada	42	.081	(.0042)	.134	(.0060)	.215	(.0088)
	Mean		.103	(.0001)	.263	(.0003)	.366	(.0003)

[a]Standard 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.

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

[c]Number of anglers surveyed.

[d]See *Figure 3* for location of lake survey zones.

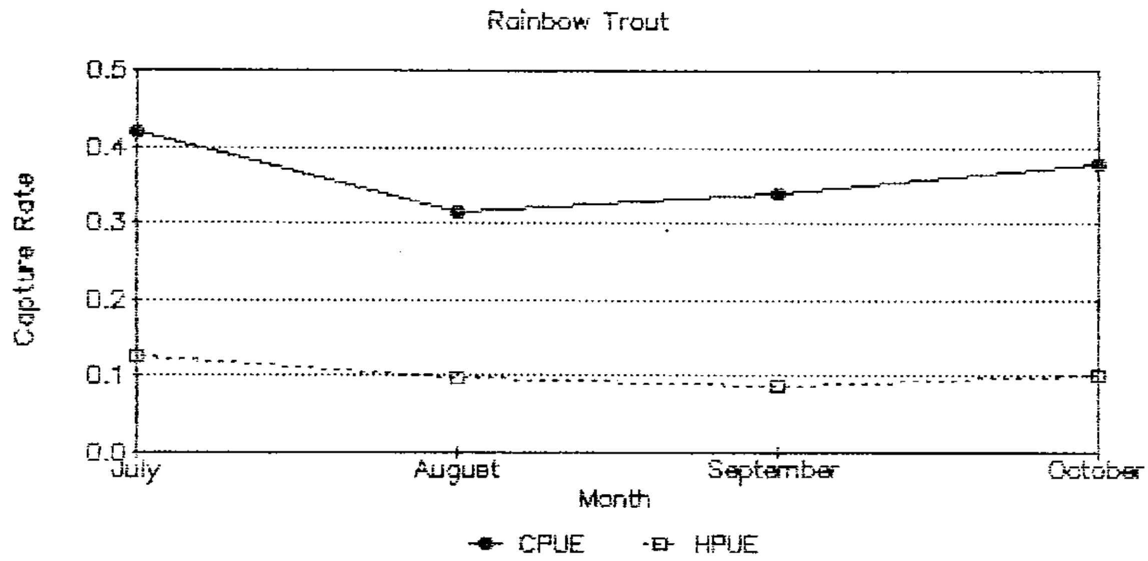


FIGURE 8. Monthly distribution of seasonal rainbow trout catch and harvest rates (daytype estimate) during the 1991 Ross Reservoir sport fishery.

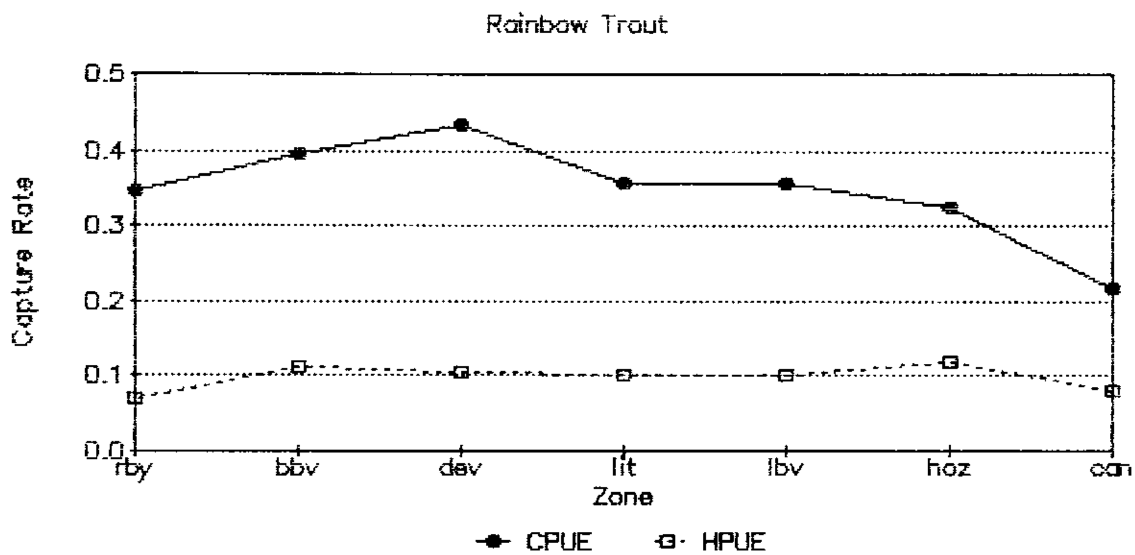


FIGURE 9. Distribution of seasonal rainbow trout catch and harvest rates (zone estimate) among lake zones during the 1991 Ross Reservoir sport fishery. Zone abbreviations are as follows: rby = ruby (zone 1); bbv = big beaver (zone 2); dev = devils (zone 3); lit = lightning (zone 4); lbv = little beaver (zone 5); hoz = hozomeen (zone 6); and can = canada (zone 7).

catch rate was returned by anglers utilizing the Hozomeen access (0.331 CPUE), while anglers fishing in Canada experienced the lowest catch rate (0.215 CPUE). The highest rainbow trout harvest rates were returned by anglers utilizing the Hozomeen access (0.113 HPUE), and the lowest from anglers fishing in Canada (0.081 HPUE). Resort anglers had an intermediate harvest rate of 0.099 fish per hour. Monthly and seasonal catch and harvest rate estimates for the different access area strata can be found in *Appendix 8*.

Angler catch and harvest rate estimates for dolly varden char/bull trout, cutthroat trout, and eastern brook trout (char) were low during the 1991 sport fishing season at Ross Lake (*Table 9* and *Appendix 9-11*). Mean seasonal catch rates for the two char species (dolly varden/bull trout and eastern brook trout were 0.001 ± <<0.001 fish per hour, while catch rates for cutthroat trout were less than 0.001 fish per hour (daytype estimates).

Mean seasonal catch and harvest rate estimates for all species of trout and char combined are given in *Table 9* and *Appendix 12*. The mean seasonal catch rate of all species combined was 0.367 ± 0.001 fish per hour, while the seasonal harvest rate was 0.104 ± <0.001 fish per hour (daytype estimates).

1991 Season - Angler Catch and Harvest

The total seasonal catch (combination of harvested and released) of rainbow trout was 13,162 ± 387 fish (*Table 10*, daytype estimate). The standard error of the estimated seasonal catch was small (± 1.5 percent), indicating good precision. Total catch dropped sharply from a seasonal high of 5,735 fish in July to 2,750 in August, then declined more slowly to 2,636 fish in September and 2,041 in October (*Figure 10* and *Appendix 13*).

The total seasonal harvest of rainbow trout was 3,833 ± 130 fish (*Table 10*, daytype estimate). The standard error of the estimated seasonal harvest was small (± 1.7 percent), indicating good precision. As shown in *Figure 10*, harvest of rainbow trout also decreased throughout the season. Total harvest was highest in July (47%), moderate in August (22%) and September (17%), and lowest in October (14%).

A total seasonal catch estimate of 13,497 ± 658 rainbow trout were calculated for data that was separated into zones (*Table 10* and *Appendix 14*). As shown in *Figure 11*, the greatest catch of rainbow trout was caught at the north end of the lake in zone 6-Hozomeen (27%), and at the south end of the lake in zone 2-Big Beaver (24%). Intermediate catch totals occured in zones 3-Devils (12%), 1-Ruby (12%), and 5-Little Beaver (11%), while lowest catch totals occurred in zones 4-Lightning (7%) and 7-Canada (7%). A total seasonal harvest estimate of 4,074 ± 280 rainbow trout was distributed similar to catch for the different zones. The greatest numbers were harvested in zones 6-Hozomeen (33%) and 2-Big Beaver (23%), while lower numbers were harvested in zones

TABLE 9. Estimated mean seasonal catch and harvest rates for all trout and char species in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

Species	Strata*	Harvest	Release	Total
Rainbow	Opener	0.153	0.561	0.714
	Weekday	0.105	0.286	0.391
	Weekend	0.097	0.216	0.313
	Mean	0.103	0.263	0.366
Dolly Varden	Opener	0	0	0
	Weekday	<0.001	<0.001	0.001
	Weekend	<0.001	<0.001	0.001
	Mean	<0.001	<0.001	0.001
Cutthroat	Opener	0	0	0
	Weekday	0	<0.001	<0.001
	Weekend	<0.001	0	<0.001
	Mean	<0.001	<0.001	<0.001
Eastern Brook	Opener	0	0	0
	Weekday	0.001	<0.001	0.001
	Weekend	0	<0.001	<0.001
	Mean	<0.001	<0.001	0.001
All Species	Opener	0.153	0.561	0.714
	Weekday	0.106	0.287	0.393
	Weekend	0.098	0.216	0.314
	Mean	0.104	0.263	0.367

*Daytype estimate.

TABLE 10. Estimated total seasonal catch and harvest of rainbow trout in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

			Rainbow Trout Catch[a]					
Type[b]	Strata	N[c]	Harvested		Released		Total	
Daytype	Opener	49	114	(2.4)	418	(10.2)	531	(10.5)
	Weekday	673	2181	(54.9)	5479	(164.8)	7660	(173.7)
	Weekend	826	1539	(34.3)	3431	(77.2)	4970	(84.5)
	Total		3833	(64.8)	9328	(182.3)	13162	(193.4)
Zone[d]	1 Rby	273	328	(22.9)	1274	(88.4)	1602	(91.3)
	2 Bbv	433	931	(60.4)	2298	(144.3)	3229	(156.4)
	3 Dev	166	389	(32.1)	1221	(104.3)	1610	(109.1)
	4 Lit	66	288	(34.7)	731	(89.3)	1018	(95.8)
	5 Lbv	115	422	(75.6)	1025	(148.0)	1447	(166.2)
	6 Hoz	453	1341	(67.1)	2288	(114.0)	3629	(132.3)
	7 Can	42	374	(54.6)	586	(78.4)	960	(95.5)
	Total		4074	(140.0)	9423	(297.5)	13497	(328.8)
Acccess	Resort	929	1977	(87.2)	5697	(249.8)	7674	(264.6)
	Hozomeen	577	1616	(73.9)	3110	(140.8)	4726	(159.0)
	Canada	42	374	(54.6)	586	(78.4)	960	(95.5)
	Total		3967	(126.7)	9393	(297.3)	13359	(323.1)

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

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

[c]Number of anglers surveyed.

[d]See *Figure 3* for location of lake survey zones.

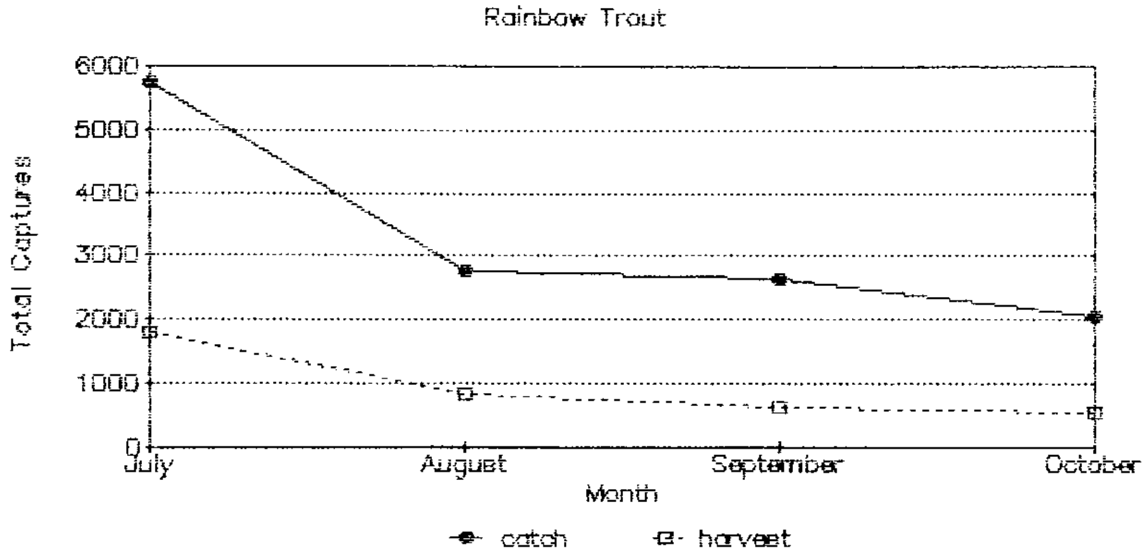


FIGURE 10. Monthly distribution of seasonal rainbow trout catch and harvest (daytype estimate) during the 1991 Ross Reservoir sport fishery.

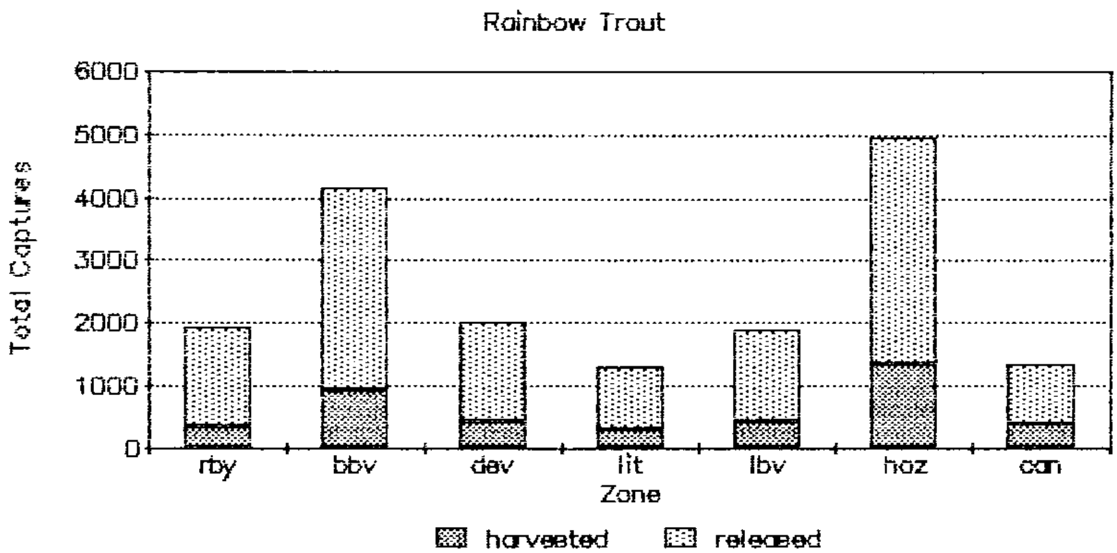


FIGURE 11. Distribution of seasonal rainbow trout catch and harvest (zone estimate) among lake zones during the 1991 Ross Reservoir sport fishery. Zone abbreviations are as follows: rby = ruby (zone 1); bbv = big beaver (zone 2); dev = devils (zone 3); lit = lightning (zone 4); lbv = little beaver (zone 5); hoz = hozomeen (zone 6); and can = canada (zone 7).

5-Little Beaver(10%), 3-Devils (10%), 7-Canada (9%), 1-Ruby (8%), and 4-Lightning (7%).

A total seasonal <u>catch</u> estimate of 13,359 ± 646 rainbow trout were calculated for data that was separated into access areas (*Table 10* and *Appendix 15*). Anglers originating from Ross Lake Resort caught the largest numbers of rainbow trout (58%). Anglers utilizing the Hozomeen access also caught a large proportion of the catch (35%), while anglers using the Canadian access caught the fewest fish (7%). A total seasonal <u>harvest</u> estimate of 3,967 ± 253 rainbow trout followed the same distributional pattern as catch. More fish were harvested by anglers utilizing the resort (50%), than by anglers originating from either Hozomeen (41%) or Canada (9%).

Catch and harvest estimates for dolly varden/bull trout char, cutthroat trout, and eastern brook trout (char) were low during the 1991 sport fishing season at Ross Lake (*Table 11* and *Appendix 16-18*). Total seasonal <u>catch</u> of the two char species were 25 ± 2 dolly varden/bull trout and 29 ± 3 eastern brook trout, while the total catch of cutthroat trout was 11 ± 2 fish (daytype estimate).

Total seasonal catch and harvest estimates for all species of trout and char combined are given in *Table 11* and *Appendix 19*. The total seasonal <u>catch</u> of all species combined was 13,226 ± 388 fish, while the seasonal <u>harvest</u> was 3,870 ± 131 fish (daytype estimate).

<u>1991 Season - Angling Methods and Gear</u>

The majority (99.9%) of anglers at Ross Lake used boats in 1991 (*Table 12*). Only one shore angler (0.1%) was interviewed the entire season. The most popular angling method was trolling with flashers and lures (93.6%), followed by trolling with flies (6.3%), and casting lures from shore (0.1%). Bait fishing is no longer permitted under the new regulations (implemented at the beginning of the 1990 sport fishing season).

Anglers trolling lures caught 95.8 percent of the total harvest, and had a HPUE of 0.104 fish per hour (*Table 12*). Anglers trolling flies caught 4.1 percent of the catch, and had a HPUE of 0.080 fish per hour. One fish was harvested at the Hozomeen access by an angler casting lures from shore.

<u>1991 Season - Age</u>

A total of 321 rainbow trout scale samples from the 1991 angler sport harvest were read for age determination. Age 4 fish were the most abundant age class, comprising sixty percent of the total sample (*Table 13*). The remaining fish were age 3 (15%), age 5 (23%), and age 6 (2%). Age 4 fish were the dominant age class throughout the entire season.

TABLE 11. 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*	Harvest	Release	Total
Rainbow	Opener	114	418	531
	Weekday	2181	5479	7660
	Weekend	1539	3431	4970
	Total	3833	9328	13162
Dolly Varden	Opener	0	0	0
	Weekday	10	6	16
	Weekend	4	5	9
	Total	13	11	25
Cutthroat	Opener	0	0	0
	Weekday	0	6	6
	Weekend	4	0	4
	Total	4	6	11
Eastern Brook	Opener	0	0	0
	Weekday	19	5	24
	Weekend	0	5	5
	Total	19	10	29
All Species	Opener	114	418	531
	Weekday	2210	5497	7706
	Weekend	1547	3442	4989
	Total	3870	9356	13226

*Daytype estimate.

TABLE 12. Harvest, harvest rates, and number of anglers fishing for rainbow trout using different types of gear and methods during the 1991 sport fishing season[a].

Geartype[b]	Resort	Hozomeen	Canada	Total	Percent
ANGLERS					
bl	895	531	23	1449	93.6
bf	34	45	19	98	6.3
sl	0	1	0	1	0.1
Total	929	577	42	1548	100.0
HARVEST					
bl	397	235	5	637	95.8
bf	9	14	4	27	4.1
sl	0	1	0	1	0.2
Total	406	250	9	665	100.0
HPUE					
bl	0.100	0.114	0.078	0.104	
bf	0.069	0.087	0.083	0.080	
sl	0	4.000	0	4.000	
Mean	0.099	0.113	0.081	0.103	

[a]Data compiled from combined (complete + incomplete) trip anglers.

[b]bl = boat, trolling lure
bf = boat, trolling fly
sl = shore, casting lure

TABLE 13. Percent age composition of rainbow trout sampled from the 1991 sport harvest at Ross Reservoir.

	MONTH									
	Jul		Aug		Sep		Oct		Total	
AGE	n	%	n	%	n	%	n	%	n	%
THREE:	24	20	11	13	4	5	8	20	47	15
FOUR:	62	53	51	61	59	75	21	51	193	60
FIVE:	28	24	20	24	15	19	11	27	74	23
SIX:	4	3	1	1	1	1	1	2	7	2
TOTAL:	118	100	83	100	79	100	41	100	321	100

Occurrence of age 3 fish decreased over the first three months of the season, then increased to July levels in October (*Table 13*). Conversely, age 4 fish increased from July to September, then declined to July levels in October. Both age 5 and age 6 fish exhibited relatively constant occurrence in the harvest throughout the season.

1991 Season - Length

A total of 445 rainbow trout were measured during the 1991 fishing season (*Table 14*). 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 1991 season was 335 mm. Sizes ranged from a low of 292 mm (illegally harvested) to a high of 411 mm. Average size slowly declined as the season progressed. 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 15.* As expected, average fork length increases with each successive age class. Age 3 fish averaged 302 mm, age 4 fish averaged 329 mm, age 5 fish averaged 359 mm, and age 6 fish averaged 383 mm.

Table 16 and *Figure 12* show the summer growth of rainbow trout in Ross Lake, as reflected by the size of fish in the angler sport harvest. Age 3 fish showed a slight increase in average size as the season progressed, increasing from 294 mm in July to 312 mm in October. Growth of age 4 and age 5 fish remained relatively constant throughout the season, varying little from seasonal averages of 329 mm and 359 mm, respectively. A small sample size (n=7) precluded any definitive growth analysis of age 6 fish. As mentioned earlier in this section, factors that may be responsible for static and/or negative temporal growth of specific age classes of fish will be presented in a later section of this report.

Monthly and seasonal length-frequency histograms of angler harvested rainbow trout at Ross Reservoir are shown in *Figure 13.* 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 around 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.

1991 Season - Sex

A total of 297 rainbow trout were sampled from the seasonal sport harvest for sex determination. Males constituted 41 percent of the total sample (n=123), while females accounted for 59 percent (n=174).

TABLE 14. Trout and char length information, by month, from the 1991 sport fishing season at Ross Reservoir.

			Fork Length (mm)		
Month	Number	Percent	Average	Minimum	Maximum
RAINBOW					
July	154	35	336	295	385
August	96	21	336	292	396
September	132	30	335	294	396
October	63	14	333	302	411
Season	445	100	335	292	411
DOLLY VARDEN					
July	1	50	738	738	738
August					
September	1	50	384	384	384
October					
Season	2	100	561	384	738
CUTTHROAT					
July					
August					
September					
October	1	100	407	407	407
Season	1	100	407	407	407
BROOK					
July	2	100	333	331	335
August					
September					
October					
Season	2	100	333	331	335

TABLE 15. Rainbow trout length information, by age, from the 1991 sport harvest at Ross Reservoir.

Age	Number	Percent	Fork Length (mm) Average	Minimum	Maximum
3	47	15	302	292	371
4	193	60	329	305	370
5	74	23	359	335	396
6	7	2	383	360	411

TABLE 16. Average fork length (mm) of rainbow trout, grouped by month and age class, from the 1991 sport harvest at Ross Reservoir.

AGE		JUL	AUG	SEP	OCT	SEASON
THREE:	n	24	11	4	8	47
	avg	294	308	309	312	302
FOUR:	n	62	51	59	21	193
	avg	329	326	333	326	329
FIVE:	n	28	20	15	11	74
	avg	358	358	361	359	359
SIX:	n	4	1	1	1	7
	avg	371	396	392	411	383

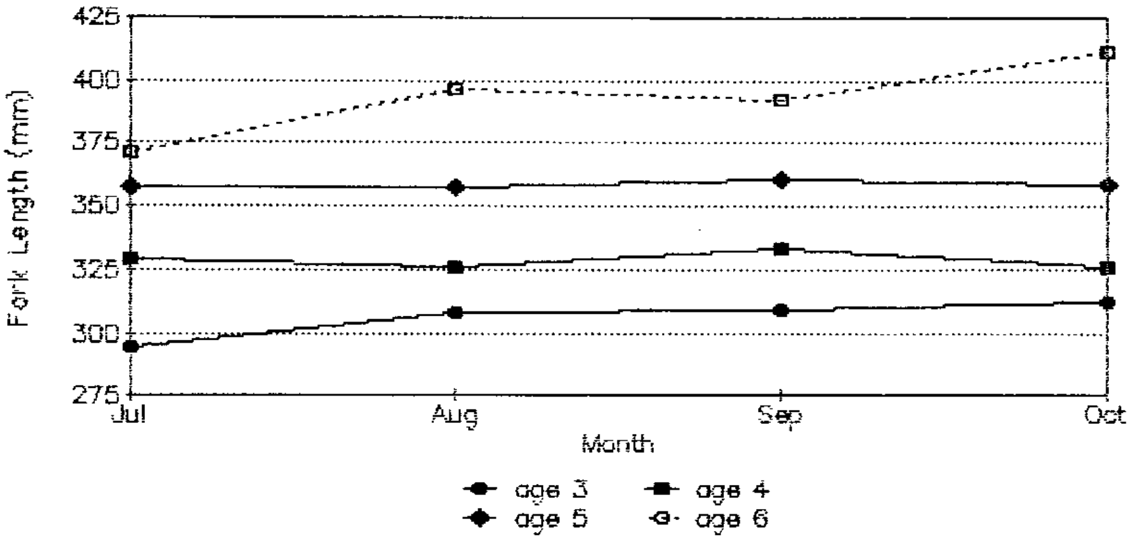


FIGURE 12. Average lengths of age 3 - age 6 rainbow trout, by month, from the 1991 Ross Lake sport harvest.

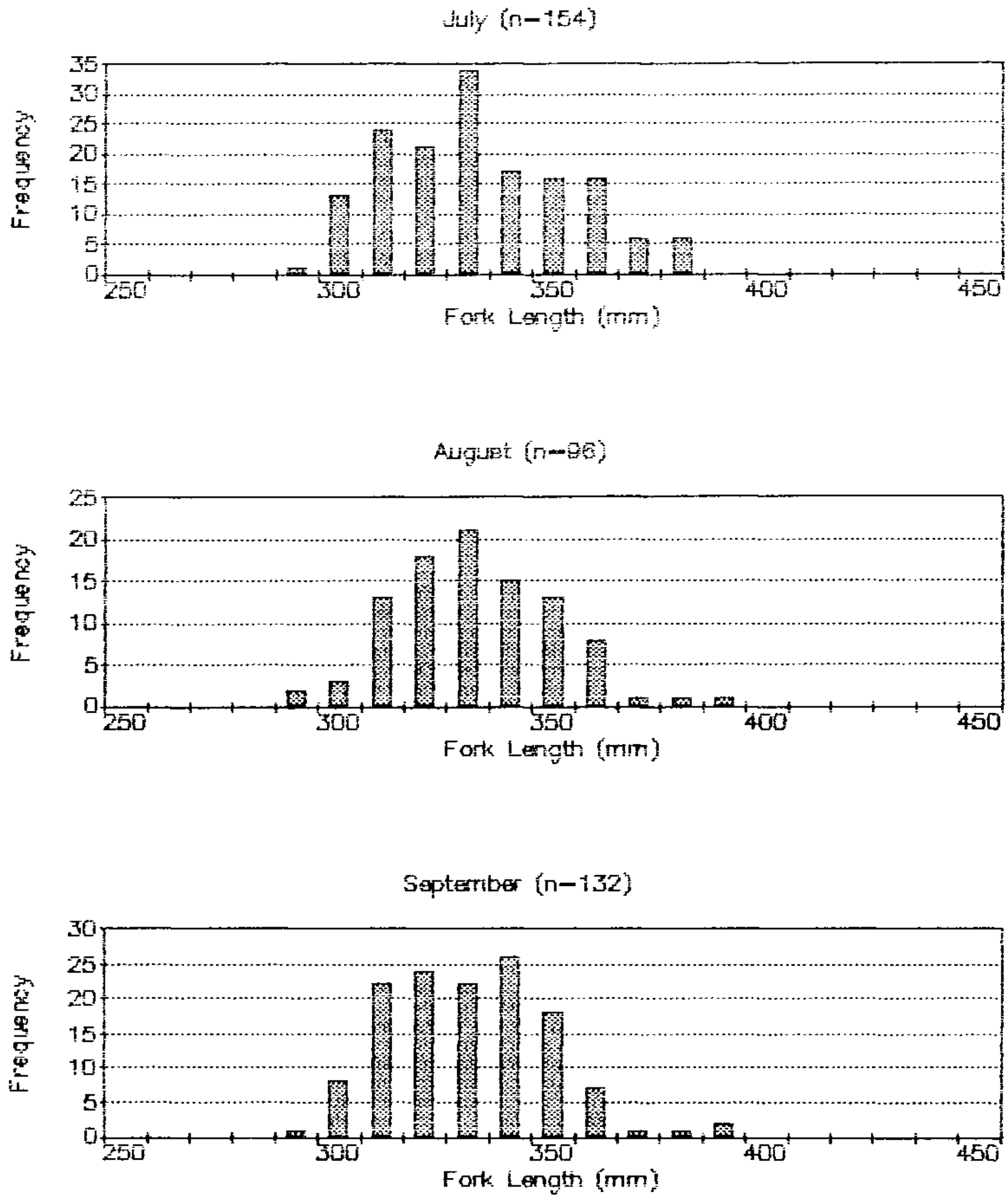
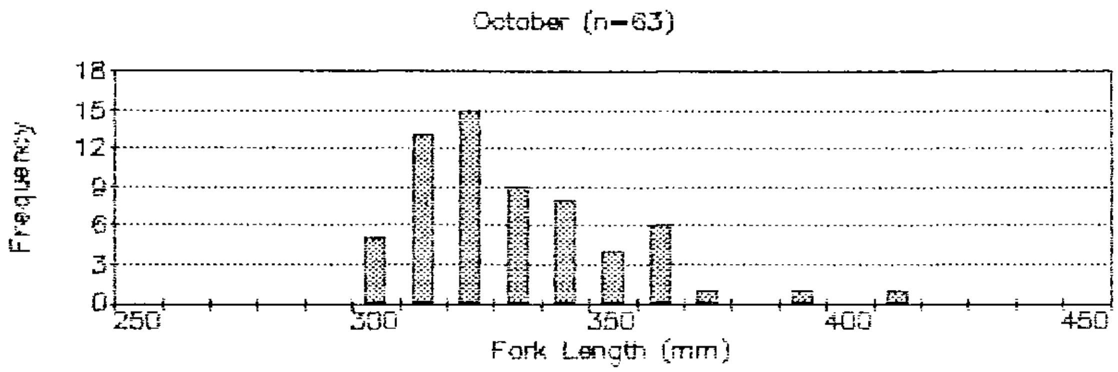


FIGURE 13. Length-frequency distribution of rainbow trout sampled from the 1991 Ross Lake sport harvest. Minimum legal size limit is approximately 317 mm fork length. Abscissa values indicate lower limit of length interval.



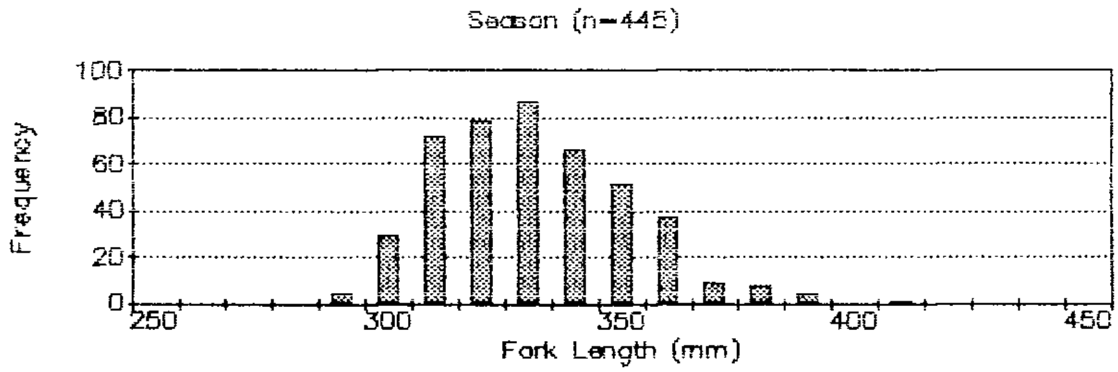


FIGURE 13. (Continued).

The north end sample (n=128) was comprised of 40 percent males and 60 percent females, while the south end sample (n=169) was composed of 43 percent males and 57 percent females.

1991 Season - Sexual Maturity

A random sample of 97 rainbow trout from the seasonal sport harvest were checked for gonadal development (*Table 17*). Immature fish comprised 51 percent of the sample, while the remaining 49 percent were mature. Males were composed of 59 percent mature and 41 percent immature fish, while females were comprised of 43 percent mature and 57 percent immature fish.

Table 18 shows the average fork length and size range of a random sample of 85 rainbow trout from the seasonal sport harvest, separated by access, sex, sexual maturity, and age. The north end sample (n=32) was comprised of 81 percent immature fish, while only 19 percent were mature. The male sample was composed of 80 percent immature (average length = 342 mm), and 20 percent mature fish (average length = 350 mm). Eighty-two percent of the female sample were immature fish (average length = 318 mm), while 18 percent were mature (average length = 367 mm).

The south end sample (n=53) was comprised of thirty-six percent immature fish, while 64 percent were mature (*Table 18*). The male sample was composed of 21 percent immature (average length = 312 mm), and 79 percent mature fish (average length = 346 mm). Fourty-eight percent of the female sample were immature fish (average length = 322 mm), while 52 percent were mature (average length = 339 mm).

1991 Season - Additional Data

Forty-three percent of the interviewed anglers that were fishing for rainbow trout during the 1991 sport fishing season at Ross Reservoir were unsuccessful at catching a fish (*Figure 14*). The remaining anglers (57%) were successful at catching from one to twenty-five fish. Seventy percent of the anglers were unsuccessful in harvesting a legal rainbow trout, while the remaining anglers harvested one (20%), two (7%), and three (3%) fish.

Very few of the remaining species of trout and char were caught and/or harvested by interviewed anglers during the season (*Figure 15*). Four anglers each reported catching one dolly varden char, two of which were harvested. Similarly, four anglers caught one brook trout (char) each, two of the anglers harvesting their catch. Only two anglers reported catching a cutthroat trout, one of which was harvested.

1991 Season - Dolly Varden Char/Bull Trout

Four dolly varden and/or bull trout char were measured for (possible future) species classification during the 1991-92 study at Ross Lake.

TABLE 17. Rainbow trout length information, grouped by sex and maturity, from the 1991 sport harvest at Ross Reservoir.

			Fork Length (mm)		
Sex	Maturity	N	Avg	Min	Max
Male	Mature	22	347	313	380
	Immature	15	333	300	382
Female	Mature	26	345	313	385
	Immature	34	321	295	365

TABLE 18. Rainbow trout age and length information, grouped by access area, sex and maturity, from the 1991 sport harvest at Ross Reservoir.

					Fork Length (mm)		
Access	Sex	Maturity	Age	N	Avg	Min	Max
Hozomeen	Male	Mature	4	1	335	335	335
			5	1	365	365	365
		Immature	3	2	320	310	330
			4	4	340	320	350
			5	2	369	356	382
	Female	Mature	4	2	357	350	364
			5	2	378	370	385
		Immature	3	4	321	310	330
			4	11	304	308	362
			5	3	362	355	365
Resort	Male	Mature	3	2	319	313	325
			4	10	342	318	366
			5	6	358	342	380
			6	1	362	362	362
		Immature	3	2	315	300	330
			4	3	311	305	319
	Female	Mature	4	8	328	313	348
			5	7	352	335	385
		Immature	3	5	307	295	315
			4	8	328	318	335
			5	1	353	353	353

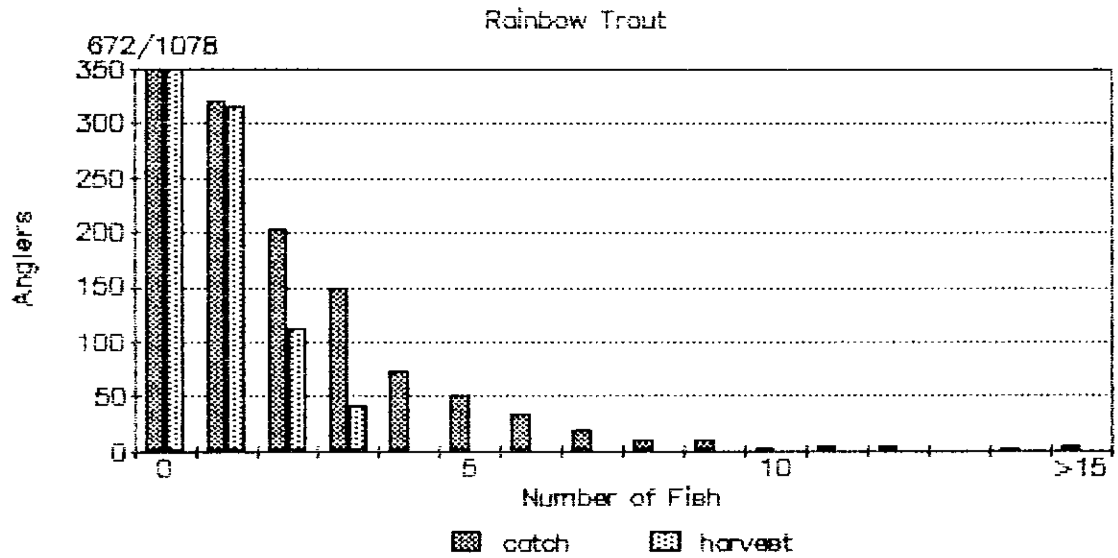


FIGURE 14. Reported angler success at catching rainbow trout during the 1991 sport fishing season at Ross Reservoir.

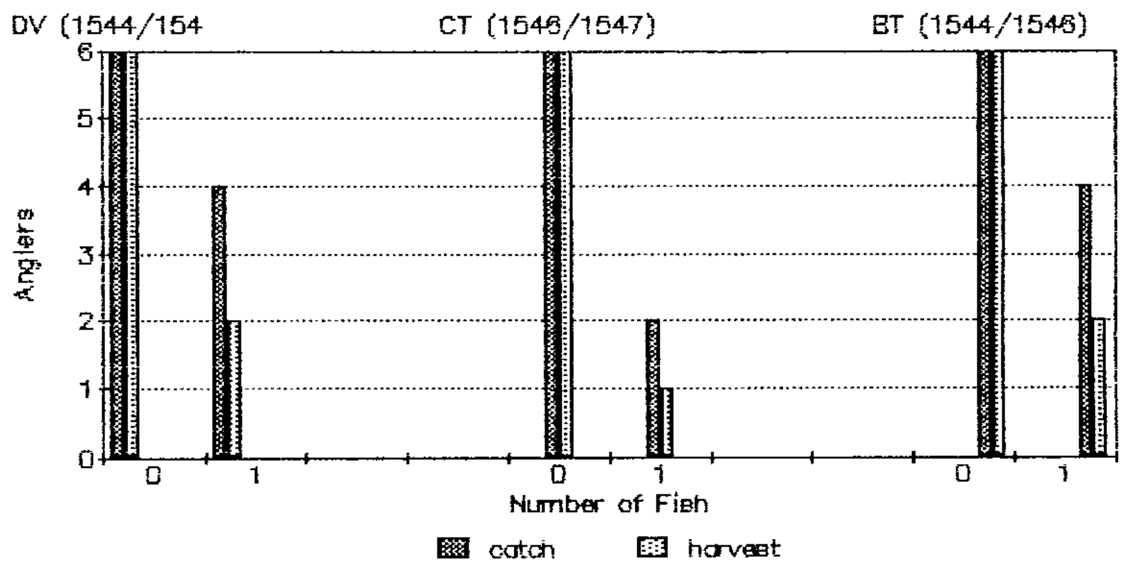


FIGURE 15. Reported angler success at catching dolly varden/bull trout char, cutthroat trout, and brook trout (char) during the 1991 sport fishing season at Ross Reservoir.

Three fish were sampled during the 1991 fishing season, while the fourth was caught off the mouth of Ruby Creek in May 1992 by the author (*Table 19*). All four fish keyed out as bull trout when classified according to the linear discriminant function developed by Haas (1988).

Hydroacoustic Surveys

Five hydroacoustic surveys were conducted on Ross Lake between March 25 and May 5, 1992. A total of 139 fish were recorded for the five surveys, resulting in an average of 27.8 fish per survey (*Table 20*). Index counts varied as much as 50 percent between surveys, ranging from 18 to 36 fish per survey. There was no appreciable difference in the average number of fish recorded between morning and afternoon surveys (AM average = 27.7, PM average = 28.0).

Population estimates for the five hydroacoustic surveys are given in *Table 21*. Based on the assumption that percent species occurrence in the sport catch reflects species occurrence in the reservoir, rainbow trout population estimates for the five surveys ranged from a high of 51,145 fish to a low of 19,475. The total reservoir rainbow trout population was estimated at 37,082 ± 23,808, while the total combined species (trout and char) population was estimated at 37,263 ± 23,923. Standard errors of the rainbow trout and combined species population estimates are large, ± 31.9 percent for both estimates, 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

Seven rainbow trout spawning surveys were conducted on Dry, Lightning, Pierce, Roland, and Thursday Creeks between May 3 and July 17, 1992 (*Table 22*). High water flows precluded surveys of Lightning Creek above the full pool elevation (1602 ft) on all survey dates. In addition, Dry Creek was not surveyed on May 3, and Thursday Creek was not surveyed on June 23 due to inclement weather.

Survey results are summarized in *Table 23*. A total of 2,400 rainbow trout were counted during the seven spawning surveys. Spawning fish were first observed on May 16, and all subsequent survey dates. The largest numbers of rainbow trout were counted on June 5, when a total of 1,382 fish were recorded on the five tributaries. Lightning Creek recorded the largest spawner total for the season (1,554 fish), although the vast majority of these fish were observed adjacent to the stream

TABLE 19. Dolly varden/bull trout char physical data and linear discriminant function values[a] from samples collected at Ross Reservoir between 06/01/91 and 05/31/92.

				Linear Discrimanant Function (LDF) Variables						
Y	M	D	Sex	SL[b]	B-L[c]	B-R[d]	Max[e]	AFR[f]	LDF[g]	Type
07	21	91		505	15	15	63	10	3.5	Bull trout
07	29	91	M	662	17	15	83	11	5.0	Bull trout
09	02	91		437	15	15	48	11	3.1	Bull trout
05	21	92	M	672	14	14	82	12	2.5	Bull trout

[a]See Haas (1988).

[b]Standard length (mm).

[c]Number of branchiostegal rays (left side).

[d]Number of branchiostegal rays (right side).

[e]Maxillary length (mm).

[f]Number of anal fin rays.

[g]LDF<0 = dolly varden, LDF>0 = bull trout.

TABLE 20. Hydroacoustic index counts of trout and char[a] from the lower end of Ross Lake (Ross Dam to Rainbow Point) from five surveys conducted between March 25 and May 5, 1992.

		Transect											
Date[b]	Elev	1	2	3	4	5	6	7	8	9	10	11	Total
03/25	1535	1	1	1	0	1	0	2	1	8	3	5	23
03/26	1534	0	0	0	0	7	0	3	0	4	0	4	18
04/19	1533	5	0	0	6	3	3	3	1	3	0	5	29
05/04	1548	3	2	3	3	2	3	1	8	2	3	3	33
05/05	1549	6	1	3	2	1	2	2	6	2	5	6	36
Mean		3	1	1	2	3	2	2	3	4	2	5	28

[a]Fish larger than 152 mm (6 in).

[b]AM (0800-1200) counts = 03/26, 04/19, and 05/05
PM (1200-1600) counts = 03/25 and 05/04

TABLE 21. Population estimates of Ross-Skagit system trout and char[a] from five hydroacoustic surveys conducted between March 25 and May 5, 1992.

	Trout and Char		Rainbow Trout[b]	
Date[c]	Estimate	95% C.I.	Estimate	95% C.I.
03/25	22,516	± 11,912	22,407	± 11,855
03/26	19,570	± 17,699	19,475	± 17,613
04/19	42,602	± 34,295	42,396	± 34,129
05/04	50,231	± 22,593	49,988	± 22,484
05/05	51,394	± 26,830	51,145	± 26,701
Mean	37,263	± 23,923	37,082	± 23,808

[a]Fish larger than 152 mm (6 in).

[b]Estimates using proportion of rainbow trout in 1991 sport harvest (0.9952).

[c]AM (0800-1200) counts = 03/26, 04/19, and 05/05
PM (1200-1600) counts = 03/25 and 05/04

TABLE 22. Elevations and distances surveyed* on Ross Reservoir index tributaries during rainbow trout spawning surveys from May 3 to July 17, 1991.

Tributary Name	Distance (ft)	Elevation (ft) Minimum	Elevation (ft) Maximum
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

*Baseline elevations and distances are measured from full pool upstream, and do not include drawdown elevations and distances surveyed.

TABLE 23. Number of spawning rainbow trout observed in selected tributaries of Ross Reservoir from May 3 to July 17, 1992.

	Number of Rainbow Trout							
	May			Jun		Jul		
Tributary	03	16	30	05	23	03	17	Total
Dry	–	3[a]	20	66	56	7	3	155
Lightning[b]	–	500	–	1006	30	18	0	1554
Pierce	0	0	6	12	8	3	1	30
Roland	0	102	220	275	0	0	0	597
Thursday	0	3[a]	8	23	–	3	27	64
Total	0	608	254	1382	94	31	31	2400

[a]Temporary migration barrier in drawdown.

[b]High water flows prevented surveys of one or more areas of stream (ie. mouth, drawdown and/or upstream of full pool) on all dates.

mouth. Roland Creek recorded the second highest spawner total (597 fish), and because of size, accessibility, and available spawning habitat, is the best spawning indicator stream of those surveyed.

Peak spawning probably occurred during the first two weeks of June on most of the tributaries surveyed. Spawning counts gradually declined on most survey streams after June 5, and surveys concluded on July 17 when thirty-one fish were observed in Dry, Pierce and Thursday Creeks. Four of these fish were spawning in the drawdown, while the remaining twenty-seven fish were milling off the mouth of Thursday Creek, and were probably kelts that had recently completed spawning.

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, HPUE, CPUE, 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 1991 seasonal angler effort remained markedly less than previous years as a result of the new restrictive fishing regulations. The 1991 estimated angler effort was 36,108 hours, while estimated angler effort was 74,098, 65,673, and 65,797 hours in 1971, 1985 and 1986, respectively (*Table 24*). This represents an effort decline of approximately 50 percent from the mid-1980's, and 55 percent from the early 1970's. Total 1991 estimated angler effort increased

TABLE 24. Estimated seasonal angler effort[a] at Ross Reservoir in 1971, 1985, 1986, 1990 and 1991.

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	Looff (1992)
1991	36,108[f]	559	

[a]Season length approximately two weeks shorter in 1990 and 1991 than in previous years. See Johnston (1989) and *Appendix 1*.

[b]Standard error of estimated total angler-hours.

[c]Effort estimated from interview data and boat rental information (south end), and vehicle counts (north end).

[d]Effort estimated from reservoir boat counts.

[e]Effort estimated from interview data.

[f]Effort estimated from reservoir pole counts.

approximately 9 percent over the 1990 estimate of 33,216 hours.

The new regulations appear to be more of a deterrent to anglers using 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. In 1991, 54 percent of the seasonal effort total (19,947 hours) was contributed by south end anglers, while 46 percent (17,158 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 remained considerably lower than previous years due to the 1990 regulation changes. The mean seasonal HPUE in 1990 and 1991 was 0.12 and 0.10, respectively, while HPUE was 0.48 in 1971, 0.52 in 1972, 0.33 in 1985, and 0.41 in 1986 (*Table 25*). The observed 1990 and 1991 harvest rate declines are 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 16*). 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 10°C (Slaney and Godin 1989; Rosenau and Slaney 1991). Summer growth of previously undersized fish also recruits new numbers into the fishery. Very little increase in HPUE occurred in 1991 at the end of the season, with HPUE remaining relatively constant from July through October.

Mean seasonal harvest rates for the different lake zones show contrasting patterns between the 1971-74, 1986, and 1990-91 fishing seasons (*Table 26*). 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

TABLE 25. Mean overall (all species combined) opening day, monthly, and seasonal harvest rates for the 1971, 1972, 1985, 1986, 1990, and 1991 fishing seasons[a] at Ross Reservoir.

	Trout and Char HPUE						
Year	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
1991[b]	0.15	----	0.13	0.10	0.09	0.10	0.10

[a]Fishing regulations differed between 1971-72, 1985-86 and 1990-91. See Johnston (1989) and *Appendix 1.*

[b]Opening day of the 1990 and 1991 fishing seasons was July 1.

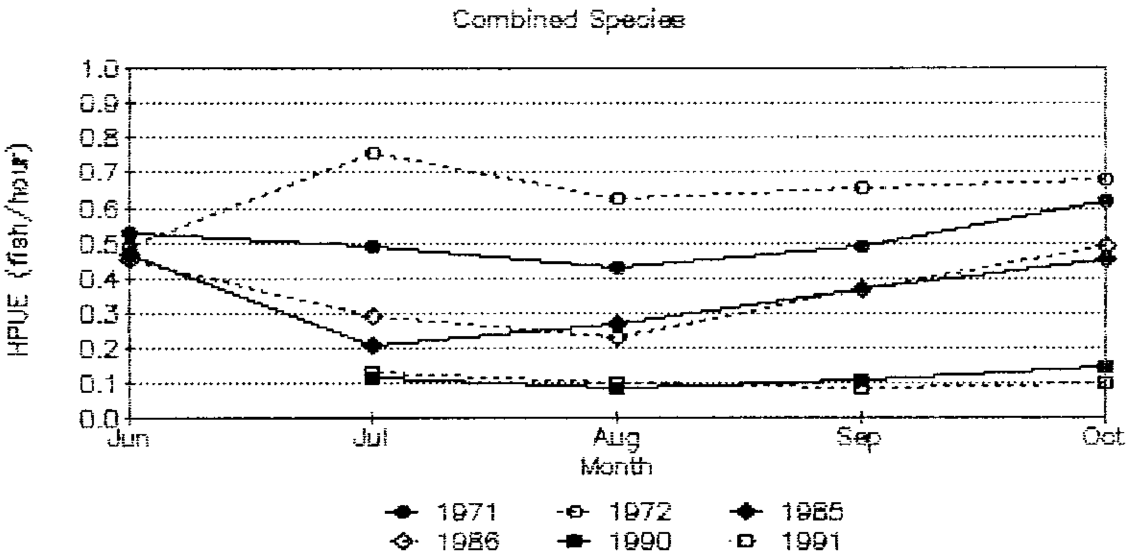


FIGURE 16. Mean overall (all species combined) monthly harvest rates for the 1971, 1972, 1985, 1986, 1990, and 1991 fishing seasons at Ross Reservoir.

TABLE 26. Mean overall (all species combined) seasonal harvest rates[a] for zones 1 through 7 on Ross Reservoir in 1971, 1972, 1973, 1974, 1986, 1990, and 1991.

	Trout and Char HPUE						
Lake Zone[b]	1971	1972	1973	1974	1986	1990[c]	1991[c]
1 (Ruby)	0.50	0.57	0.54	0.53	0.29	0.06	0.07
2 (B. Beaver)	0.47	0.70	0.45	0.50	0.42	0.08	0.11
3 (Devils)	0.49	0.72	0.45	0.49	0.48	0.10	0.10
4 (Lightning)	0.44	0.43	0.36	0.48	0.45	0.09	0.10
5 (L. Beaver)	0.43	0.52	0.43	0.39	0.46	0.12	0.10
6 (Hozomeen)	0.53	0.46	0.36	0.39	0.35	0.24	0.12
7 (Canada)	0.46	0.53	0.35	0.44	0.28	0.15	0.08

[a]Fishing regulations differed between 1971-74, 1986 and 1990-91. See Johnston (1989) and *Appendix 1*.

[b]See *Figure 3* for location of lake zones.

[c]Zone estimates for rainbow trout only.

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 rates in 1991 were roughly similar for zones 2-6, but were slightly less in zones 1 and 2. Of particular interest is the marked decrease (50%) in HPUE at the north end of the lake from 1990 to 1991. This suggests that older rainbow trout age classes are still suffering the effects of overharvest at the north end, since angling effort was similar both years.

Harvest

The 1990 and 1991 overall (all species combined) and rainbow trout harvest estimates are greatly reduced from previous years (*Table 27*). Rainbow 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 (3,774) and 1991 (3,833) totals. 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 small harvest increase (2%) in 1991 compared to 1990 is due primarily to increased effort on the reservoir in 1991.

The greater proportion of rainbow trout in the overall 1990 and 1991 harvests (99.5% and 99.0%, respectively) 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 and 1991 harvests than in previous studies (*Table 28*). Most of the 1990 harvest was composed of age 3 (47 percent) and age 4 (32 percent) fish, while the 1991 harvest was comprised primarily of age 4 (60 percent) and age 5 (23 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

TABLE 27. Combined species and rainbow trout harvest[a] estimates for the 1971-74, 1985-86, and 1990-91 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
1991	3,870	99.0	3,833

[a]Fishing regulations differed between 1971-74, 1985-86 and 1990-91. See Johnston (1989) and *Appendix 1.*

TABLE 28. Percent age class contribution* of rainbow trout to the 1971-73, 1985-86, and 1990-91 seasonal sport harvest at Ross Reservoir.

Age	Percent of Season Harvest						
	1971	1972	1973	1985	1986	1990	1991
2	55	49	62	36	28	10	0
3	26	39	29	29	40	47	15
4	7	8	6	13	19	32	60
5	1	2	1	4	4	10	23
6	0	0	0	1	1	1	2
7	0	0	0	0	0	<1	0

*Fishing regulations differed between 1971-73, 1985-86 and 1990-91. See Johnston (1989) and *Appendix 1.*

brightest rainbow trout (predominantly age 3, immature females).

The ratio of age 4 to age 3 rainbow trout also increased in 1990 and 1991 from previous years (*Table 28*). The 1990 and 1991 age 4:age 3 harvest ratios were 68 and 400 percent, respectively, 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. This appears to have happened in 1991, when eighty-five percent of the harvest was age 4 and older fish, compared to fourty-three percent in 1991. 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.

Length

The average size of age 4 and age 5 rainbow trout age classes were roughly similar (within each age class) in 1985, 1986, 1990, and 1991 (*Table 29*). The maximum average size difference was 10 mm for both age 4 and age 5 fish during all four years. The much larger average size differences between age 2 (56 mm) and age 3 (24 mm) fish in 1990 and 1991, 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 smaller 1990 and 1991 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 1991 rainbow trout harvest was composed of immature age 3 and age 4 fish (*Table 18*). Of a total sample of fifteen age 3 and forty-seven age 4 fish sampled from the 1991 harvest, 87 percent (n=13) and 55 percent (n=26) were immature, respectively. Thus, the 13-inch minimum size restriction did not completely protect immature fish in 1991. This was also the case in 1990 (Looff 1992), when a much larger proportion of immature age 3 fish were harvested than in 1991. 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 in 1990 and 1991 (*Table 29*).

Population Size

Ross Lake rainbow trout mark-recapture and hydroacoustic population

TABLE 29. Seasonal rainbow trout age and length data* from the 1985, 1986, 1990, and 1991 sport harvests at Ross Reservoir.

			Fork Length (mm)		
Year	Age	N	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	328
	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	330
	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
1991	2	0	---	---	---
	3	47	302	292	371
	4	193	329	305	370
	5	74	359	335	396
	6	7	383	360	411
	7	0	---	---	---

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

estimates from the early 1970's are substantially higher than the 1990 and 1991 hydroacoustic estimates (*Table 30*). 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 and 1992 estimates of 20,513 and 37,082 fish, respectively. 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 almost all larger, but considerably closer to, the 1990 and 1991 estimates than the mark-recapture estimates. The 1973 hydroacoustic estimate of 31,000 rainbow trout in *Table 30* is the only year that a specific date and estimate were reported (Thorne 1976).

The 1991 and 1992 population estimates suggest 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) fish, while the 1992 estimate of 37,082 (n=5) is roughly 76 percent of the 1970's average (*Table 30*). This decline is further supported by annual catch and harvest rate estimates for the different years. The 1990 overall seasonal CPUE estimate of 0.39 is approximately 81 percent and 75 percent, respectively, of the 1971 (0.48) and 1972 (0.52) HPUE estimates (Looff 1992), while the 1991 overall seasonal CPUE of 0.37 (*Table 9*) is roughly 77 percent and 71 percent, respectively, of the 1970's estimates. (The 1990-91 overall CPUE estimates are used for comparison with the overall 1971-72 HPUE estimates, since 1990-91 <u>catch</u> would be roughly equivalent to 1971-72 <u>harvest</u>).

Even though the reservoir trout population appears to be lower than in the 1970's, the mean 1992 hydroacoustic population estimate is approximately 81 percent larger than in 1991. This suggests that the reservoir trout population is on the increase, and in the absence of increased CPUE, is probably due to larger numbers of younger age classes (age 2 and age 3) of fish in the lake. However, the large confidence intervals associated with the estimates should be treated with caution, and it is desirable to base future measurements on a larger number of sample transects to reduce variance associated with the estimate.

Spawning Surveys

Spawning survey data conducted on selected tributary streams in 1992 showed a marked increase in the number of spawning rainbow trout over the previous year. A total of 174 fish were counted during eight surveys in 1991, while 2,400 fish were enumerated from seven surveys in 1992. However, this is still well below a single estimate of 2,500 to 3,000 fish that were observed spawning in Roland Creek by a National

TABLE 30. Population estimates of Ross-Skagit system rainbow trout in 1971, 1972, 1973, 1991, and 1992.

Year	Estimate	95% C.I.	Method	Source
1971	153,580	± 33,317	Mark-Recapture	Johnston (1989)
1972	206,185	± 31,685	Mark-Recapture	Johnston (1989)
1973	191,480	± 20,729	Mark-Recapture	Johnston (1989)
1973	31,000[a]	------	Hydroacoustic	Thorne (1976)
1991	20,513	± 15,324	Hydroacoustic	Looff (1992)
1992	37,082	± 23,808	Hydroacoustic	

[a]One estimate. See text for explanation.

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 1991 surveys.

Lightning Creek recorded the largest number of spawners (1,554 fish) of the five tributaries surveyed, although most of these fish were observed off the stream mouth. Spawner use increased from 107 fish in 1991 to 597 fish in 1992 on Roland Creek, which is the best index stream based on spawner use, flow, available spawning habitat, and accessibility. Spawner use on Dry Creek incresed from eight fish in 1991 to 155 in 1992, and is another excellent index stream that should continue to be included in future surveys. Pierce Creek and Thursday Creek also recorded marked increases in numbers of spawning rainbow trout in 1992. From 1991 to 1992, spawning counts increased from 5 to 30 fish on Pierce Creek, and from 3 to 64 fish on Thursday Creek.

Continuation of 1990-91 and 1991-92 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 1989-1991 Ross Lake fishing regulations.

	1990-1991	
	Washington State	British Columbia
Season:	07/01 - 10/31	
Catch limit:	three	
Size limit[a]*:*	13 inch minimum size for rainbow trout, 20 inch minimum size for char	same as Washington State
Possession limit:	six	
Gear restriction:	no bait	

	1989	
	Washington State	British Columbia
Season:	06/17 - 10/31	07/01 - 10/31
Catch limit:	eight	four
Size limit[b]*:*	no more than three over 14 inches	
Possession limit:	eight	four
Gear restriction:	none	none

[a]Size limits were measured using total length in both Washington State and British Columbia.

[b]Size limits were measured using total length in Washington State, and fork length in British Columbia.

APPENDIX 2. Creel and effort sampling schedule for the 1991 sport fishing season at Ross Reservoir.

Month	Day[a]	Daytype[b]	Work Period Start	Work Period Finish	Effort Count[c] 1	Effort Count[c] 2
July	1	OD	1000	1800	1000	1700
	2	WD	1300	2100	1300	2000
	4	WE	0900	1700	0900	1600
	17	WD	1100	1900	1100	1800
	18	WD	0900	1700	0900	1600
	19	WD	0800	1600	0800	1500
	20	WE	0800	1600	0800	1500
	21	WE	1000	1800	1000	1700
	22	WD	0800	1600	0800	1500
	27	WE	1000	1800	1100	1700
	28	WE	0900	1700	1500	1600
	29	WD	0600	1400	0700	1200
August	10	WE	1000	1800	1300	1600
	11	WE	0900	1700	0900	1600
	12	WD	0800	1600	0800	1300
	16	WD	1100	1900	1100	1800
	17	WE	1200	2000	1100	1800
	18	WE	0700	1500	0700	1300
	21	WD	1000	1800	1000	1700
	22	WD	0900	1700	1000	1600
	23	WD	0700	1500	1100	1300
	27	WD	1000	1800	1000	1700
	28	WD	0800	1600	0800	1500
	29	WD	0700	1500	0700	1400
September	1	WE	1000	1800	1000	1700
	2	WE	1100	1900	1100	1800
	3	WD	0800	1600	0800	1200
	15	WE	0800	1600	0800	1500
	16	WD	1000	1800	1000	1700
	17	WD	0800	1600	0800	1500
	20	WD	0900	1700	0900	1600
	21	WE	0800	1600	0800	1500
	22	WE	0900	1700	0900	1400
	25	WD	1000	1800	1000	1700
	26	WD	1100	1900	1100	1800
	27	WD	0900	1700	0900	1500

APPENDIX 2. (Continued)

Month	Day[a]	Daytype[b]	Work Period Start	Work Period Finish	Effort Count[c] 1	Effort Count[c] 2
October	1	WD	1000	1800	1300	1500
	2	WD	0900	1700	1000	1200
	3	WD	1000	1800	1100	1300
	12	WE	1000	1800	1200	1400
	13	WE	0900	1700	0900	1100
	14	WD	0900	1700	0900	1100
	21	WD	1000	1800	0900	1100
	22	WD	1000	1800	1100	1300
	23	WD	0900	1700	1200	1300
	26	WE	1000	1800	1200	1400
	27	WE	0900	1700	1000	1100
	28	WD	0900	1700	0900	1100

aTwo holidays, July 4 (Independence Day) and September 2 (Labor Day), were treated as weekend days, even though they were observed during midweek in 1991 (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 2* of the Ross Lake Rainbow Trout Study: 1991-92 Data Appendix (Looff 1992a).

APPENDIX 3. Estimated monthly and seasonal angler effort by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

Month	Daytype	Angler Hours[a]		Mean Hours Fished per Day[b]	Total Angler Days[c]
Jul	Opener	744	(0)	6.14	121
	Weekday	8593	(246)	4.30	1998
	Weekend	5143	(153)	3.97	1297
	Total	14480	(290)	4.24	3416
Aug	Weekday	4302	(258)	3.45	1248
	Weekend	4463	(28)	3.70	1206
	Total	8764	(259)	3.57	2454
Sep	Weekday	3600	(239)	4.63	777
	Weekend	4043	(127)	4.31	939
	Total	7643	(271)	4.45	1716
Oct	Weekday	3013	(203)	4.64	649
	Weekend	2208	(217)	4.08	541
	Total	5221	(297)	4.38	1191
Ssn	Opener	744	(0)	6.14	121
	Weekday	19508	(475)	4.18	4673
	Weekend	15856	(296)	3.98	3983
	Total	36108	(559)	4.11	8777

[a]Standard 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.

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

[c]Total angler days = angler hours/mean hours fished per day.

APPENDIX 4. Estimated monthly and seasonal angler effort by lake zone[a] in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

Month	Daytype	Angler Hours[b]		Mean Hours Fished per Day[c]	Total Angler Days[d]
Jul	1 Rby	1978	(177)	4.32	458
	2 Bbv	3159	(325)	4.30	734
	3 Dev	1026	(137)	5.42	189
	4 Lit	1103	(164)	4.62	239
	5 Lbv	1505	(191)	4.45	339
	6 Hoz	4688	(292)	3.92	1194
	7 Can	2023	(128)	2.95	686
	Total	15482	(566)	4.03	3839
Aug	1 Rby	960	(182)	2.83	339
	2 Bbv	2558	(340)	3.97	644
	3 Dev	927	(123)	4.52	205
	4 Lit	615	(138)	6.73	91
	5 Lbv	664	(115)	3.26	204
	6 Hoz	2081	(203)	3.19	653
	7 Can	1279	(198)	2.67	480
	Total	9084	(526)	3.47	2616
Sep	1 Rby	843	(176)	3.66	230
	2 Bbv	1653	(219)	4.53	365
	3 Dev	1227	(175)	6.03	203
	4 Lit	774	(158)	5.52	140
	5 Lbv	381	(93)	5.17	74
	6 Hoz	2148	(364)	3.87	555
	7 Can	264	(72)	2.18	121
	Total	7290	(530)	4.32	1689
Oct	1 Rby	906	(113)	3.61	251
	2 Bbv	1017	(122)	4.76	214
	3 Dev	631	(159)	6.06	104
	4 Lit	569	(162)	6.52	87
	5 Lbv	413	(158)	2.63	157
	6 Hoz	1433	(263)	3.54	405
	7 Can	278	(84)	3.00	93
	Total	5248	(425)	4.00	1311
Ssn	1 Rby	4687	(329)	3.67	1279
	2 Bbv	8386	(533)	4.29	1957
	3 Dev	3812	(300)	5.43	702
	4 Lit	3062	(312)	5.49	558
	5 Lbv	2963	(289)	3.83	773
	6 Hoz	10350	(573)	3.69	2807
	7 Can	3845	(260)	2.79	1379
	Total	37104	(1029)	3.92	9456

[a]See *Figure 3* for location of lake survey zones.
[b]Standard 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.
[c]Mean hours calculated using data from all anglers, including those that indicated they had not finished fishing for the day (see text).
[d]Total angler days = angler hours/mean hours fished per day.

APPENDIX 5. Estimated monthly and seasonal angler effort by access area[a] in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

Month	Daytype	Angler Hours[b]		Mean Hours Fished per Day[c]	Total Angler Days[d]
Jul	Resort	7266	(526)	4.50	1613
	Hozomeen	6193	(338)	4.08	1519
	Canada	2023	(128)	2.95	686
	Total	15482	(638)	4.06	3818
Aug	Resort	5060	(481)	3.88	1303
	Hozomeen	2745	(272)	3.20	859
	Canada	1279	(198)	2.67	480
	Total	9084	(587)	3.44	2642
Sep	Resort	4497	(401)	4.73	951
	Hozomeen	2529	(415)	4.11	615
	Canada	264	(72)	2.18	121
	Total	7290	(581)	4.32	1687
Oct	Resort	3124	(311)	4.72	662
	Hozomeen	1846	(276)	3.46	534
	Canada	278	(84)	3.00	93
	Total	5248	(425)	4.07	1288
Ssn	Resort	19947	(875)	4.40	4529
	Hozomeen	13313	(660)	3.78	3526
	Canada	3845	(260)	2.79	1379
	Total	37104	(1127)	3.93	9434

[a]See *Figure 3* for location of access areas.

[b]Standard 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.

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

[d]Total angler days = angler hours/mean hours fished per day.

APPENDIX 6. Estimated monthly and seasonal mean catch per hour for rainbow trout by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

			Rainbow Trout Catch per Hour[a]					
Month	Daytype	N[b]	Harvested		Released		Total	
Jul	Opener	49	.153	(.0032)	.561	(.0137)	.714	(.0138)
	Weekday	206	.134	(.0009)	.266	(.0014)	.401	(.0017)
	Weekend	249	.106	(.0007)	.236	(.0013)	.342	(.0017)
	Mean		.124	(.0004)	.293	(.0009)	.418	(.0010)
Aug	Weekday	199	.102	(.0009)	.230	(.0017)	.332	(.0020)
	Weekend	190	.091	(.0009)	.205	(.0016)	.296	(.0021)
	Mean		.096	(.0005)	.217	(.0008)	.314	(.0010)
Sep	Weekday	163	.064	(.0008)	.326	(.0032)	.389	(.0035)
	Weekend	264	.100	(.0007)	.205	(.0013)	.305	(.0016)
	Mean		.086	(.0004)	.253	(.0010)	.339	(.0012)
Oct	Weekday	105	.119	(.0015)	.341	(.0038)	.460	(.0044)
	Weekend	123	.082	(.0012)	.215	(.0026)	.297	(.0031)
	Mean		.100	(.0007)	.277	(.0016)	.377	(.0019)
Ssn	Opener	49	.153	(.0032)	.561	(.0137)	.714	(.0138)
	Weekday	673	.105	(.0003)	.286	(.0006)	.391	(.0007)
	Weekend	826	.097	(.0002)	.216	(.0004)	.313	(.0005)
	Mean		.103	(.0001)	.263	(.0003)	.366	(.0003)

[a]Standard 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.

[b]Number of anglers surveyed.

APPENDIX 7. 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, 1991.

			Rainbow Trout Catch per Hour[b]					
Month	Zone	N[c]	Harvested		Released		Total	
Jul	1 Rby	97	.074	(.0017)	.363	(.0075)	.437	(.0075)
	2 Bbv	143	.137	(.0013)	.241	(.0023)	.377	(.0029)
	3 Dev	49	.132	(.0030)	.414	(.0071)	.546	(.0085)
	4 Lit	17	.064	(.0070)	.140	(.0157)	.204	(.0213)
	5 Lbv	55	.102	(.0028)	.282	(.0048)	.384	(.0061)
	6 Hoz	133	.165	(.0014)	.272	(.0025)	.437	(.0032)
	7 Can	10	.136	(.0241)	.203	(.0339)	.339	(.0523)
	Mean		.124	(.0004)	.293	(.0009)	.418	(.0010)
Aug	1 Rby	62	.057	(.0023)	.114	(.0042)	.171	(.0051)
	2 Bbv	118	.092	(.0014)	.239	(.0028)	.331	(.0033)
	3 Dev	41	.092	(.0048)	.151	(.0052)	.243	(.0081)
	4 Lit	10	.104	(.0109)	.357	(.0224)	.461	(.0311)
	5 Lbv	21	.088	(.0089)	.307	(.0190)	.394	(.0228)
	6 Hoz	113	.128	(.0018)	.250	(.0031)	.378	(.0039)
	7 Can	24	.078	(.0065)	.109	(.0089)	.188	(.0126)
	Mean		.096	(.0005)	.217	(.0008)	.314	(.0010)
Sep	1 Rby	57	.067	(.0025)	.263	(.0066)	.331	(.0073)
	2 Bbv	111	.107	(.0015)	.366	(.0045)	.473	(.0051)
	3 Dev	49	.078	(.0023)	.352	(.0100)	.430	(.0109)
	4 Lit	25	.101	(.0074)	.203	(.0128)	.304	(.0163)
	5 Lbv	33	.070	(.0040)	.147	(.0085)	.217	(.0109)
	6 Hoz	145	.080	(.0013)	.144	(.0023)	.224	(.0027)
	7 Can	7	0		.131	(.0297)	.131	(.0297)
	Mean		.086	(.0004)	.253	(.0010)	.339	(.0012)
Oct	1 Rby	57	.078	(.0027)	.248	(.0071)	.326	(.0082)
	2 Bbv	61	.086	(.0021)	.317	(.0057)	.403	(.0063)
	3 Dev	27	.116	(.0058)	.355	(.0154)	.471	(.0180)
	4 Lit	14	.132	(.0112)	.351	(.0238)	.482	(.0293)
	5 Lbv	6	.444	(.0328)	.825	(.0404)	1.270	(.0609)
	6 Hoz	62	.091	(.0026)	.128	(.0029)	.219	(.0044)
	7 Can	1	0		0		0	
	Mean		.100	(.0007)	.277	(.0016)	.377	(.0019)
Ssn	1 Rby	273	.070	(.0006)	.276	(.0022)	.346	(.0022)
	2 Bbv	433	.110	(.0004)	.286	(.0009)	.395	(.0011)
	3 Dev	166	.103	(.0009)	.330	(.0025)	.433	(.0029)
	4 Lit	66	.101	(.0023)	.253	(.0047)	.355	(.0060)
	5 Lbv	115	.100	(.0014)	.256	(.0027)	.357	(.0034)
	6 Hoz	453	.118	(.0004)	.205	(.0007)	.324	(.0009)
	7 Can	42	.081	(.0042)	.134	(.0060)	.215	(.0088)
	Mean		.103	(.0001)	.263	(.0003)	.366	(.0003)

[a]See *Figure 3* for location of lake survey zones.
[b]Standard 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.
[c]Number of anglers surveyed.

APPENDIX 8. 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, 1991.

			Rainbow Trout Catch per Hour[b]					
Month	Access	N[c]	Harvested		Released		Total	
Jul	Resort	300	.113	(.0006)	.306	(.0017)	.419	(.0018)
	Hozomeen	194	.142	(.0009)	.276	(.0016)	.418	(.0020)
	Canada	10	.136	(.0241)	.203	(.0339)	.339	(.0523)
	Mean		.124	(.0004)	.293	(.0009)	.418	(.0010)
Aug	Resort	233	.086	(.0007)	.205	(.0013)	.291	(.0016)
	Hozomeen	132	.121	(.0015)	.260	(.0027)	.380	(.0033)
	Canada	24	.078	(.0065)	.109	(.0089)	.188	(.0126)
	Mean		.096	(.0005)	.217	(.0008)	.314	(.0010)
Sep	Resort	237	.093	(.0006)	.326	(.0020)	.420	(.0022)
	Hozomeen	183	.076	(.0010)	.145	(.0017)	.221	(.0021)
	Canada	7	0		.131	(.0297)	.131	(.0297)
	Mean		.086	(.0004)	.253	(.0010)	.339	(.0012)
Oct	Resort	159	.096	(.0009)	.310	(.0024)	.406	(.0028)
	Hozomeen	68	.115	(.0026)	.174	(.0035)	.289	(.0052)
	Canada	1	0		0		0	
	Mean		.100	(.0007)	.277	(.0016)	.377	(.0019)
Ssn	Resort	929	.099	(.0002)	.290	(.0005)	.389	(.0005)
	Hozomeen	577	.113	(.0003)	.218	(.0006)	.331	(.0007)
	Canada	42	.081	(.0042)	.134	(.0060)	.215	(.0088)
	Mean		.103	(.0001)	.263	(.0003)	.366	(.0003)

[a]See *Figure 3* for location of access areas.

[b]Standard 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.

[c]Number of anglers surveyed.

APPENDIX 9. 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, 1991.

			Dolly Varden Char Catch per Hour[a]					
Month	Daytype	N[b]	Harvested		Released		Total	
Jul	Opener	49	0		0		0	
	Weekday	206	.001	(.0001)	0		.001	(.0001)
	Weekend	249	0		.001	(.0001)	.001	(.0001)
	Mean		<.001	(.0000)	<.001	(.0000)	.001	(.0000)
Aug	Weekday	199	0		.001	(.0001)	.001	(.0001)
	Weekend	190	0		0		0	
	Mean		0		.001	(.0000)	.001	(.0000)
Sep	Weekday	163	0		0		0	
	Weekend	264	.001	(.0001)	0		.001	(.0001)
	Mean		.001	(.0000)	0		.001	(.0000)
Oct	Weekday	105	0		0		0	
	Weekend	123	0		0		0	
	Mean		0		0		0	
Ssn	Opener	49	0		0		0	
	Weekday	673	<.001	(.0000)	<.001	(.0000)	.001	(.0000)
	Weekend	826	<.001	(.0000)	<.001	(.0000)	.001	(.0000)
	Mean		<.001	(.0000)	<.001	(.0000)	.001	(.0000)

[a]Standard 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.

[b]Number of anglers surveyed.

APPENDIX 10. Estimated monthly and seasonal mean catch per hour for cutthroat trout by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

			Cutthroat Trout Catch per Hour[a]					
Month	Daytype	N[b]	Harvested		Released		Total	
Jul	Opener	49	0		0		0	
	Weekday	206	0		0		0	
	Weekend	249	0		0		0	
	Mean		0		0		0	
Aug	Weekday	199	0		.001	(.0001)	.001	(.0001)
	Weekend	190	0		0		0	
	Mean		0		.001	(.0000)	.001	(.0000)
Sep	Weekday	163	0		0		0	
	Weekend	264	0		0		0	
	Mean		0		0		0	
Oct	Weekday	105	0		0		0	
	Weekend	123	.002	(.0002)	0		.002	(.0002)
	Mean		.001	(.0001)	0		.001	(.0001)
Ssn	Opener	49	0		0		0	
	Weekday	673	0		<.001	(.0000)	<.001	(.0000)
	Weekend	826	<.001	(.0000)	0		<.001	(.0000)
	Mean		<.001	(.0000)	<.001	(.0000)	<.001	(.0000)

[a]Standard 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.

[b]Number of anglers surveyed.

APPENDIX 11. Estimated monthly and seasonal mean catch per hour for eastern brook trout by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

			Eastern Brook Trout Catch per Hour[a]					
Month	Daytype	N[b]	Harvested		Released		Total	
Jul	Opener	49	0		0		0	
	Weekday	206	.002	(.0001)	0		.002	(.0001)
	Weekend	249	0		.001	(.0001)	.001	(.0001)
	Mean		<.001	(.0000)	<.001	(.0000)	.001	(.0000)
Aug	Weekday	199	0		0		0	
	Weekend	190	0		0		0	
	Mean		0		0		0	
Sep	Weekday	163	0		.001	(.0001)	.001	(.0001)
	Weekend	264	0		0		0	
	Mean		0		.001	(.0000)	.001	(.0000)
Oct	Weekday	105	0		0		0	
	Weekend	123	0		0		0	
	Mean		0		0		0	
Ssn	Opener	49	0		0		0	
	Weekday	673	.001	(.0000)	<.001	(.0000)	.001	(.0000)
	Weekend	826	0		<.001	(.0000)	<.001	(.0000)
	Mean		<.001	(.0000)	<.001	(.0000)	.001	(.0000)

[a]Standard 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.

[b]Number of anglers surveyed.

APPENDIX 12. 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, 1991.

			Trout and Char Catch per Hour[a]					
Month	Daytype	N[b]	Harvested		Released		Total	
Jul	Opener	49	.153	(.0032)	.561	(.0137)	.714	(.0138)
	Weekday	206	.138	(.0009)	.266	(.0014)	.404	(.0017)
	Weekend	249	.106	(.0007)	.238	(.0013)	.344	(.0017)
	Mean		.126	(.0004)	.294	(.0009)	.420	(.0010)
Aug	Weekday	199	.102	(.0009)	.233	(.0017)	.335	(.0020)
	Weekend	190	.091	(.0009)	.205	(.0016)	.296	(.0021)
	Mean		.096	(.0005)	.219	(.0008)	.315	(.0010)
Sep	Weekday	163	.064	(.0008)	.327	(.0032)	.391	(.0035)
	Weekend	264	.101	(.0007)	.205	(.0013)	.306	(.0016)
	Mean		.086	(.0004)	.254	(.0010)	.340	(.0012)
Oct	Weekday	105	.119	(.0015)	.341	(.0038)	.460	(.0044)
	Weekend	123	.084	(.0012)	.215	(.0026)	.299	(.0031)
	Mean		.101	(.0007)	.277	(.0016)	.378	(.0019)
Ssn	Opener	49	.153	(.0032)	.561	(.0137)	.714	(.0138)
	Weekday	673	.106	(.0003)	.287	(.0006)	.393	(.0007)
	Weekend	826	.098	(.0002)	.216	(.0004)	.314	(.0005)
	Mean		.104	(.0001)	.263	(.0003)	.367	(.0003)

[a]Standard 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.

[b]Number of anglers surveyed.

APPENDIX 13. Monthly and seasonal estimates of rainbow trout captured by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

		Rainbow Trout Catch*					
Month	Daytype	Harvested		Released		Total	
Jul	Opener	114	(2.4)	418	(10.2)	531	(10.5)
	Weekday	1154	(34.0)	2289	(66.7)	3443	(74.8)
	Weekend	547	(16.7)	1214	(36.8)	1761	(40.4)
	Total	1815	(38.0)	3920	(76.9)	5735	(85.7)
Aug	Weekday	439	(26.6)	991	(59.9)	1430	(65.5)
	Weekend	406	(4.9)	914	(9.1)	1320	(10.3)
	Total	845	(27.0)	1905	(60.6)	2750	(66.3)
Sep	Weekday	229	(23.4)	1173	(119.3)	1402	(121.6)
	Weekend	405	(23.5)	828	(48.0)	1234	(53.5)
	Total	634	(33.1)	2001	(128.6)	2636	(132.8)
Oct	Weekday	359	(24.6)	1026	(70.0)	1385	(74.2)
	Weekend	180	(17.9)	475	(47.0)	656	(50.3)
	Total	539	(30.4)	1502	(84.3)	2041	(89.7)
Ssn	Opener	114	(2.4)	418	(10.2)	531	(10.5)
	Weekday	2181	(54.9)	5479	(164.8)	7660	(173.7)
	Weekend	1539	(34.3)	3431	(77.2)	4970	(84.5)
	Total	3833	(64.8)	9328	(182.3)	13162	(193.4)

*Standard 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 lake zone[a] in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

		Rainbow Trout Catch[b]					
Month	Zone	Harvested		Released		Total	
Jul	1 Rby	146	(13.5)	718	(65.9)	864	(67.3)
	2 Bbv	431	(44.5)	760	(78.4)	1191	(90.2)
	3 Dev	135	(18.3)	425	(57.1)	560	(60.0)
	4 Lit	70	(13.0)	155	(28.8)	225	(31.6)
	5 Lbv	154	(20.0)	425	(54.4)	579	(58.0)
	6 Hoz	772	(48.6)	1275	(80.3)	2048	(93.9)
	7 Can	274	(51.7)	412	(73.5)	686	(89.9)
	Total	1984	(90.0)	4169	(171.5)	6152	(193.7)
Aug	1 Rby	55	(10.6)	109	(21.2)	164	(23.7)
	2 Bbv	235	(31.4)	611	(81.6)	846	(87.4)
	3 Dev	85	(12.1)	140	(19.2)	225	(22.7)
	4 Lit	64	(15.9)	219	(51.2)	283	(53.6)
	5 Lbv	58	(11.7)	204	(37.5)	262	(39.3)
	6 Hoz	266	(26.2)	520	(51.2)	786	(57.6)
	7 Can	100	(17.5)	140	(24.4)	240	(30.1)
	Total	862	(51.3)	1944	(121.3)	2806	(131.7)
Sep	1 Rby	57	(12.0)	222	(46.7)	279	(48.2)
	2 Bbv	178	(23.6)	605	(80.4)	783	(83.8)
	3 Dev	96	(13.9)	432	(62.9)	527	(64.4)
	4 Lit	79	(17.0)	157	(33.5)	236	(37.6)
	5 Lbv	27	(6.7)	56	(14.0)	83	(15.5)
	6 Hoz	172	(29.3)	310	(52.8)	482	(60.4)
	7 Can	0		35	(12.2)	35	(12.2)
	Total	607	(45.7)	1817	(129.8)	2424	(137.6)
Oct	1 Rby	71	(9.1)	225	(28.9)	295	(30.3)
	2 Bbv	88	(10.8)	322	(39.2)	410	(40.6)
	3 Dev	73	(18.9)	224	(57.4)	297	(60.4)
	4 Lit	75	(22.2)	200	(58.3)	275	(62.4)
	5 Lbv	183	(71.6)	341	(131.7)	524	(149.9)
	6 Hoz	131	(24.3)	183	(33.8)	313	(41.6)
	7 Can	0		0		0	
	Total	620	(82.3)	1494	(166.0)	2114	(185.2)
Ssn	1 Rby	328	(22.9)	1274	(88.4)	1602	(91.3)
	2 Bbv	931	(60.4)	2298	(144.3)	3229	(156.4)
	3 Dev	389	(32.1)	1221	(104.3)	1610	(109.1)
	4 Lit	288	(34.7)	731	(89.3)	1018	(95.8)
	5 Lbv	422	(75.6)	1025	(148.0)	1447	(166.2)
	6 Hoz	1341	(67.1)	2288	(114.0)	3629	(132.3)
	7 Can	374	(54.6)	586	(78.4)	960	(95.5)
	Total	4074	(140.0)	9423	(297.5)	13497	(328.8)

[a]See *Figure 1* for location of lake survey zones.

[b]Standard 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 rainbow trout captured by access area[a] in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

		Rainbow Trout Catch[b]					
Month	Access	Harvested		Released		Total	
Jul	Resort	822	(59.7)	2223	(161.4)	3045	(172.0)
	Hozomeen	881	(48.4)	1708	(93.7)	2588	(105.5)
	Canada	274	(51.7)	412	(73.5)	686	(89.9)
	Total	1977	(92.6)	4342	(200.5)	6320	(220.9)
Aug	Resort	436	(41.6)	1036	(98.7)	1472	(107.2)
	Hozomeen	331	(33.0)	713	(70.9)	1043	(78.2)
	Canada	100	(17.5)	140	(24.4)	240	(30.1)
	Total	867	(55.9)	1889	(124.0)	2755	(136.0)
Sep	Resort	419	(37.5)	1468	(131.3)	1887	(136.6)
	Hozomeen	192	(31.6)	368	(60.4)	560	(68.2)
	Canada	0		35	(12.2)	35	(12.2)
	Total	611	(49.0)	1871	(145.1)	2482	(153.1)
Oct	Resort	300	(30.0)	969	(96.9)	1269	(101.5)
	Hozomeen	212	(32.1)	322	(48.6)	534	(58.2)
	Canada	0		0		0	
	Total	511	(43.9)	1291	(108.4)	1803	(117.0)
Ssn	Resort	1977	(87.2)	5697	(249.8)	7674	(264.6)
	Hozomeen	1616	(73.9)	3110	(140.8)	4726	(159.0)
	Canada	374	(54.6)	586	(78.4)	960	(95.5)
	Total	3967	(126.7)	9393	(297.3)	13359	(323.1)

[a]See *Figure 1* for location of access areas.

[b]Standard 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 dolly varden char captured by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

		Dolly Varden Char Catch[a]					
Month	Daytype	Harvested		Released		Total	
Jul	Opener	0		0		0	
	Weekday	10	(0.7)	0		10	(0.7)
	Weekend	0		5	(0.4)	5	(0.4)
	Total	10	(0.7)	5	(0.4)	15	(0.8)
Aug	Weekday	0		6	(0.6)	6	(0.6)
	Weekend	0		0		0	
	Total	0		6	(0.6)	6	(0.6)
Sep	Weekday	0		0		0	
	Weekend	4	(0.3)	0		4	(0.3)
	Total	4	(0.3)	0		4	(0.3)
Oct	Weekday	0		0		0	
	Weekend	0		0		0	
	Total	0		0		0	
Ssn	Opener	0		0		0	
	Weekday	10	(0.7)	6	(0.6)	16	(0.9)
	Weekend	4	(0.3)	5	(0.4)	9	(0.5)
	Total	13	(0.8)	11	(0.7)	25	(1.0)

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

APPENDIX 17. Monthly and seasonal estimates of cutthroat trout captured by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

		Cutthroat Trout Catch*					
Month	Daytype	Harvested		Released		Total	
Jul	Opener	0		0		0	
	Weekday	0		0		0	
	Weekend	0		0		0	
	Total	0		0		0	
Aug	Weekday	0		6	(0.6)	6	(0.6)
	Weekend	0		0		0	
	Total	0		6	(0.6)	6	(0.6)
Sep	Weekday	0		0		0	
	Weekend	0		0		0	
	Total	0		0		0	
Oct	Weekday	0		0		0	
	Weekend	4	(0.6)	0		4	(0.6)
	Total	4	(0.6)	0		4	(0.6)
Ssn	Opener	0		0		0	
	Weekday	0		6	(0.6)	6	(0.6)
	Weekend	4	(0.6)	0		4	(0.6)
	Total	4	(0.6)	6	(0.6)	11	(0.8)

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

APPENDIX 18. Monthly and seasonal estimates of eastern brook trout captured by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

		Eastern Brook Trout Catch*					
Month	Daytype	Harvested		Released		Total	
Jul	Opener	0		0		0	
	Weekday	19	(1.1)	0		19	(1.1)
	Weekend	0		5	(0.4)	5	(0.4)
	Total	19	(1.1)	5	(0.4)	25	(1.2)
Aug	Weekday	0		0		0	
	Weekend	0		0		0	
	Total	0		0		0	
Sep	Weekday	0		5	(0.6)	5	(0.6)
	Weekend	0		0		0	
	Total	0		5	(0.6)	5	(0.6)
Oct	Weekday	0		0		0	
	Weekend	0		0		0	
	Total	0		0		0	
Ssn	Opener	0		0		0	
	Weekday	19	(1.1)	5	(0.6)	24	(1.3)
	Weekend	0		5	(0.4)	5	(0.4)
	Total	19	(1.1)	10	(0.7)	29	(1.3)

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

APPENDIX 19. Monthly and seasonal estimates of trout and char captured by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1991.

		Trout and Char Catch*					
Month	Daytype	Harvested		Released		Total	
Jul	Opener	114	(2.4)	418	(10.2)	531	(10.5)
	Weekday	1183	(34.8)	2289	(66.7)	3472	(75.2)
	Weekend	547	(16.7)	1224	(37.1)	1771	(40.7)
	Total	1844	(38.7)	3931	(77.0)	5775	(86.2)
Aug	Weekday	439	(26.6)	1003	(60.6)	1442	(66.2)
	Weekend	406	(4.9)	914	(9.1)	1320	(10.3)
	Total	845	(27.0)	1917	(61.3)	2762	(67.0)
Sep	Weekday	229	(23.4)	1178	(119.8)	1407	(122.0)
	Weekend	409	(23.7)	828	(48.0)	1237	(53.6)
	Total	638	(33.3)	2006	(129.0)	2644	(133.3)
Oct	Weekday	359	(24.6)	1026	(70.0)	1385	(74.2)
	Weekend	185	(18.4)	475	(47.0)	660	(50.5)
	Total	543	(30.7)	1502	(84.3)	2045	(89.7)
Ssn	Opener	114	(2.4)	418	(10.2)	531	(10.5)
	Weekday	2210	(55.4)	5497	(165.4)	7706	(174.4)
	Weekend	1547	(34.7)	3442	(77.3)	4989	(84.8)
	Total	3870	(65.4)	9356	(182.9)	13226	(194.2)

*Standard 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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