# ROSS LAKE RAINBOW TROUT STUDY

## 1992-93 PROGRESS REPORT

by

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## ABSTRACT

The Washington Department of Fish and Wildlife conducted a rainbow trout study on Ross Reservoir from June 1, 1992 to May 31, 1993. This investigation was the third 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 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 25,370 hours during the 1992 fishing season, or 5,918 angler days. The total seasonal rainbow trout harvest estimate was 2,326 fish, with a mean seasonal harvest rate of 0.104 fish per hour. Total catch (harvested + released) was estimated at 8,687 rainbow trout, with a mean catch rate of 0.424 fish per hour. Total seasonal dolly varden/bull trout char, cutthroat trout, and brook trout (char) harvest estimates were 6, 4, and 0 fish, respectively. Total catch was estimated at 23 dolly varden/bull trout char, 4 cutthroat trout, and 0 brook trout.

The new angling regulations continue to have significant impacts on angler effort, harvest rates, and harvest at Ross Reservoir. Estimated 1990-92 seasonal angler effort, harvest rates, and harvest remain markedly less than during the the early 1970's and mid-1980's. Total estimated 1992 seasonal angler effort and harvest also declined approximately 30 percent and 40 percent, respectively, from 1991 estimates, while harvest rates remained similar.

Two hydroacoustic surveys were conducted on the lower portion of Ross Lake during March and April of 1993. These surveys are a continuation of annual index counts that are also used to estimate the total size of the reservoir's fish population (fish larger than six inches). The total combined reservoir species population was estimated at 61,047 fish, while the rainbow trout portion of the population was estimated at 60,857 fish. Index counts and population estimates continue to increase each year, and probably reflect increasing numbers of immature age 2 and age 3 fish.

Seven spawning surveys conducted on the U.S. portion of five Ross Lake tributaries from May to July of 1993 resulted in a total enumeration of 2,464 rainbow trout. Peak spawning occurred on most tributaries during the first two weeks of June, with Roland 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 1993 indicate that numbers continue to increase each year, but remain much reduced from mid-1980's levels.

Data collected from the 1990-91, 1991-92, and 1992-93 rainbow trout studies at Ross Reservoir indicate the fish population is still suffering from the effects of past overharvest. These studies suggest the present rainbow trout population is increasing, but is still below early 1970's levels. Continued evaluation and monitoring of the fish and fishery in response to the new regulations is 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, 1992 to May 31, 1993. This is the third year of an ongoing five-year study by the Washington State Department of Fish and Wildlife (WDF&W) 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, 1992a, 1992b, 1993a). These regulations were implemented at the beginning of the 1990 sport fishing season by both the WDF&W and the British Columbia Division of Fish and Wildlife (BCF&W), and 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 WDF&W 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 Resident Fisheries Study for Ross, Diablo and Gorge Lakes (Seattle City Light 1989a).

## 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

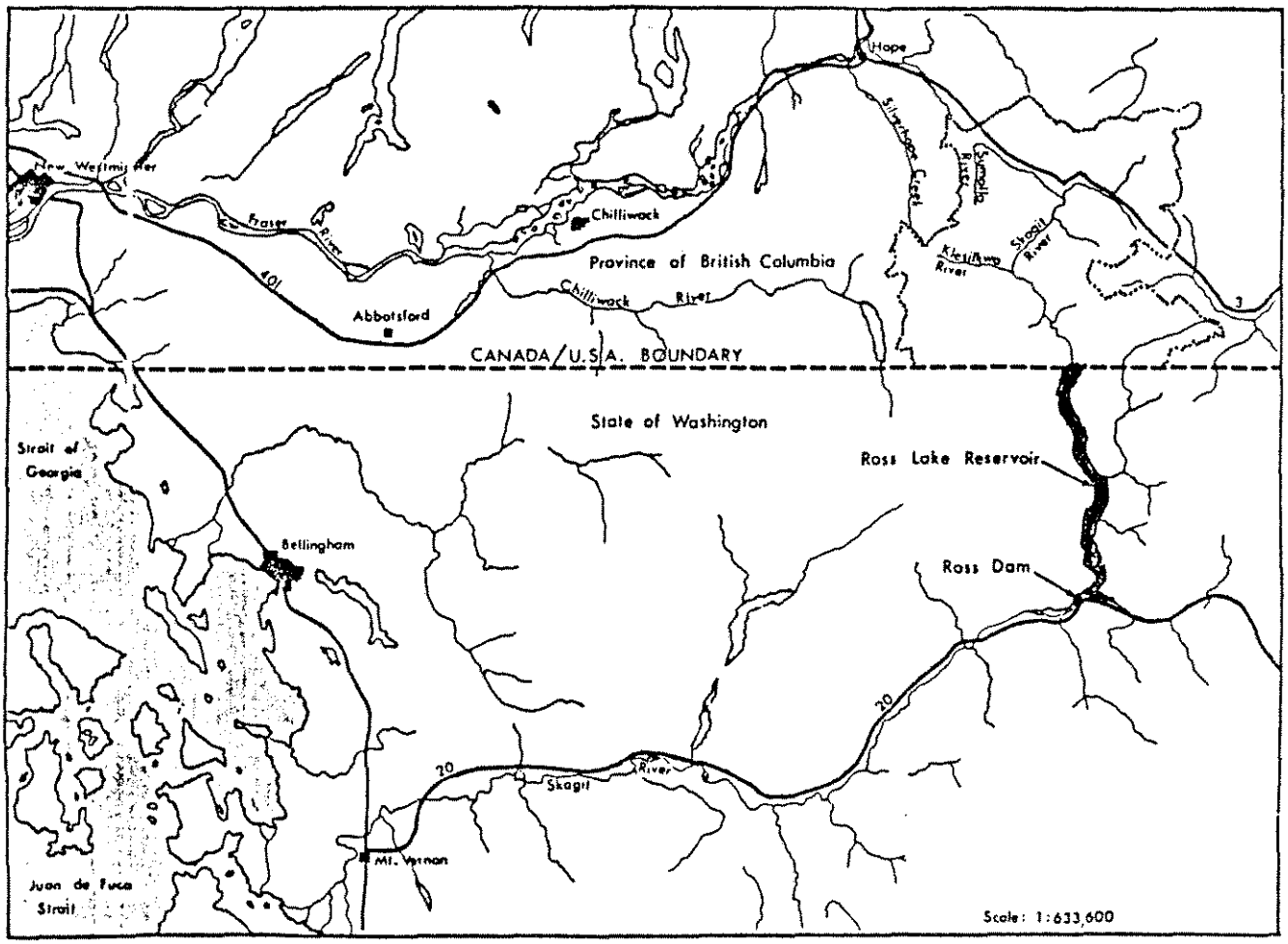


FIGURE 1. Geographic location of Ross Lake in NW Washington and SW British Columbia.

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 1,602.5 feet mean sea level (msl) at full pool and 1,475 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 elevation 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 1989b). 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 (Salvelinus malma)/bull trout (Salvelinus confluentus) char, cutthroat trout (Oncorhynchus clarkii), and brook trout (Salvelinus fontinalis) char.

## Objectives

The specific objectives of the 1992-93 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) = $S/(2*((Pi*A)\cdot^{5}))$, where S = shore length and A = lake area.

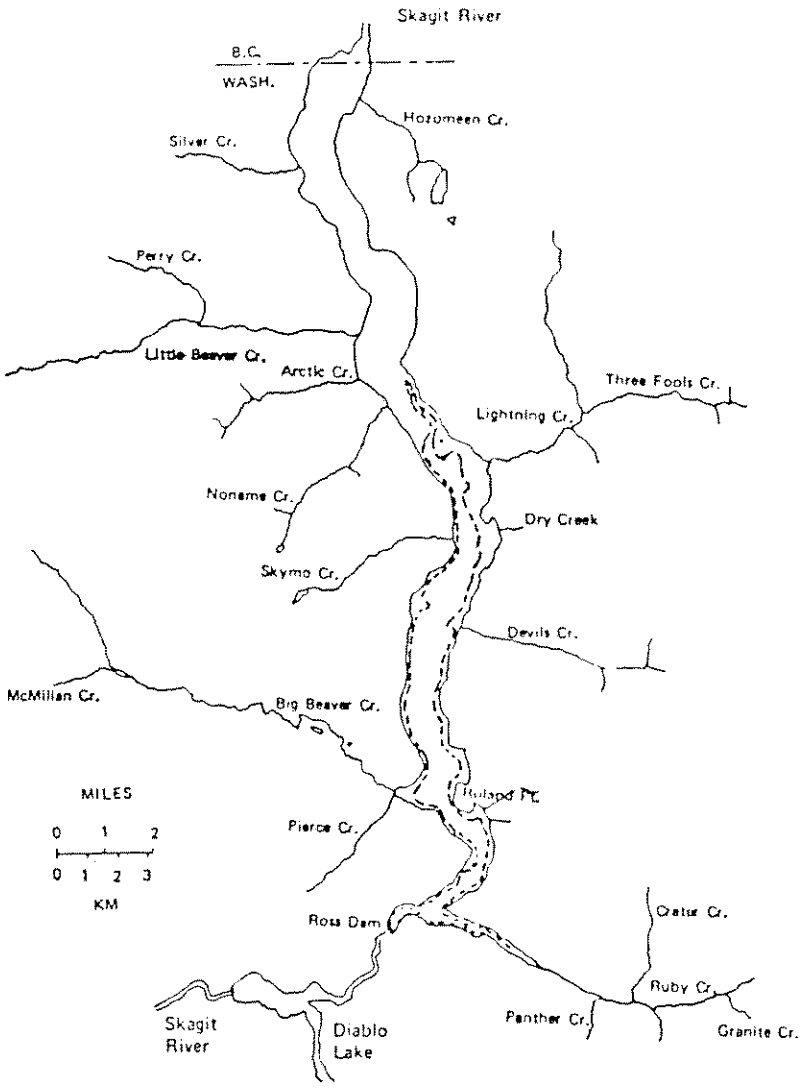


FIGURE 2. Ross Lake and major tributaries. The perimeter of the lake at full pool (1,602.5 feet msl) is shown as a solid line, and the maximum drawdown contour (1,475 feet msl) is depicted as a dotted line.

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 1992-93 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 1992-93 rainbow trout study on Ross Reservoir are identical to studies conducted during 1990-91 and 1991-92. Statistical comparisons of data are primarily limited to the first three years of the present five-year study, since different fishing regulations and/or sampling designs were in effect for studies conducted in the mid-1980's and early 1970's.

### 1992-93 Studies

The 1992-93 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, 1992 to determine angler harvest and harvest-related information. A second study involved collection of hydroacoustic transect data from two lake surveys performed during March and April of 1993. The purpose of these surveys was to provide index counts of fish density for use in annual monitoring of population size fluctuations, and to estimate the size of the 1992-93 overwintering reservoir fish population (all species combined). The third study involved enumeration of spawning rainbow trout on selected tributaries of Ross Lake from late May to mid-August of 1993. These surveys were used to provide 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 temporary technician. The technician was responsible for collecting angler creel survey data, while the biologist conducted all other project-related work, as well as assisting with the creel survey as needed.

### 1992 Creel Survey

The 1992 angler creel census was based on a stratified random design that was identical to that used during the 1990 and 1991 creel surveys (Looff 1992a, Looff 1993a). 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 (Looff 1992a). 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 1992 fishing season *(Table 2)*. Logistical and budgetary constraints travelling to and from the lake necessitated the use of continuous three-day time blocks. Two additional constraints on the

TABLE 2. Number of days censused per day type strata during the 1992 sport fishing season at Ross Reservoir.

| Month | Daytype | Total Days | Days Censused | % Total |
|---|---|---|---|---|
| Jul | Opener | 1 | 1 | 100% |
| | Weekday | 22 | 6 | 27% |
| | Weekend | 8 | 5 | 63% |
| | Total | 31 | 12 | 39% |
| Aug | Weekday | 21 | 8 | 38% |
| | Weekend | 10 | 4 | 40% |
| | Total | 31 | 12 | 39% |
| Sep | Weekday | 21 | 6 | 29% |
| | Weekend | 9 | 6 | 67% |
| | Total | 30 | 12 | 40% |
| Oct | Weekday | 22 | 8 | 36% |
| | Weekend | 9 | 4 | 44% |
| | Total | 31 | 12 | 39% |
| Season | Opener | 1 | 1 | 100% |
| | Weekday | 86 | 28 | 33% |
| | Weekend | 36 | 19 | 53% |
| | Total | 123 | 48 | 39% |

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 7) 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 1992 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 <u>all</u> anglers from dawn to dusk in order to develop effort estimates. The design used in the 1985, 1990-91, and 1991-92 studies required a <u>random</u> 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 from 1990 to 1992 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 most or all of each 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).

Only one employee conducted the angler creel survey on each sample day during 1992. (The only exception occurred on opening day, when two employees interviewed anglers concurrently at each end of the lake). This differed from the previous two study years, when both ends of the lake were sampled simultaneously. Work days were allocated equally between the north and south end of the lake during 1992, with roving interviews conducted between the Canadian and Hozomeen access areas at the north end.

<u>Angler Interviews</u>

Angler interviews at Ross Reservoir were conducted by contacting anglers

TABLE 3. Number of daylight hours assumed available to anglers during the 1992 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 |

returning to the three primary access areas. All anglers were asked to volunteer the same information. Anglers were generally interviewed immediately upon returning, but were also interviewed later in the day. To compensate for the reduction in sampling effort at each end, creel information from the previous day was also collected (assuming the angler fished the day before, no data had been collected, and the previous day was also a sample day). Information was collected from all anglers contacted, regardless of whether they had finished fishing for the day. Two primary reasons for checking incomplete anglers 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 early 1970's, 1985-86, and 1990-91 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 to the front insertion

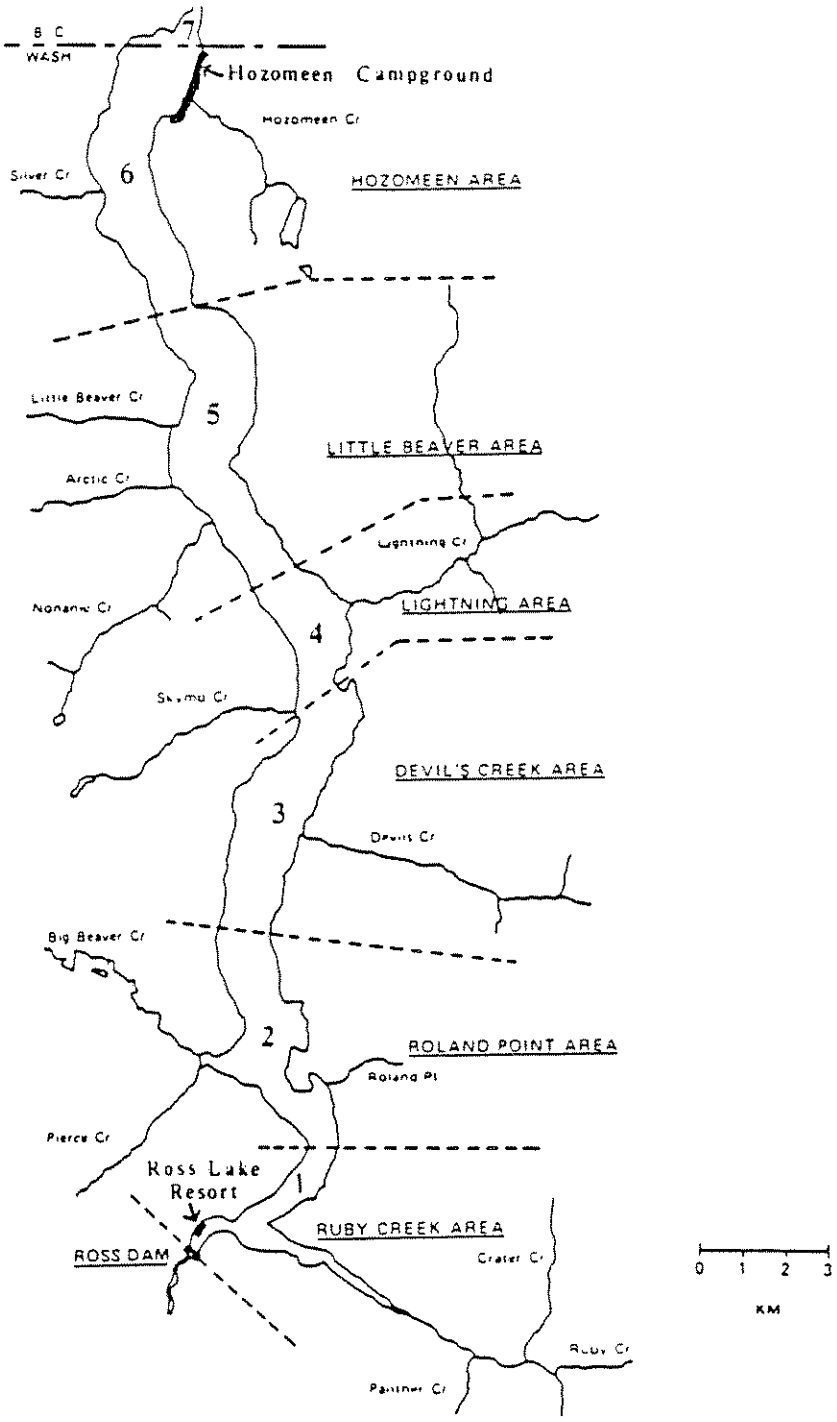


FIGURE 3. Ross Lake survey zones.

of the anal fin approximately 3-5 scale rows above the lateral line. Scales were then placed in scale envelopes and the date, capture area, species, fork length (mm), sex and sexual maturity (if collected) recorded on the outside. Five scales from each sample were later cleaned and mounted on a glass slide using a cover slip and transparent tape. A microfiche reader (35X) was then used to age each sample. Only samples containing at least two good scales that did not exhibit regenerated areas were used. After aging all of the samples once to 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/bull trout char to assist current WDF&W 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 described earlier. 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 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)*. 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 conducting angler interviews for approximately three hours. A total of twelve days in September and October were not sampled for effort data, due to mechanical breakdown of the survey boat (Looff 1993b).

Three separate effort estimates (and associated variances) for 1992 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 through both visual observations during effort counts, and during angler interviews at the resort. Conversely,

# RESULTS

## 1992-93 Lake Levels

The opening day lake elevation was 1,596.82 feet msl on July 1, 1992. The reservoir reached a maximum elevation of 1,596.92 feet msl on July 15, 1992, and a minimum elevation of 1,512.11 feet msl on March 21, 1993.

## 1992 Opening Day Creel Survey - (post-1990 regulation change)

A total of 58 anglers were checked at Ross Lake on opening day, July 1, 1992 *(Table 4)*. These anglers fished a total of 328.75 hours and caught 388 rainbow trout (harvest and release) for a catch per unit effort (CPUE) of 1.180 fish per hour. Catch per unit effort was slightly higher at the south end of the lake (1.226 fish per hour) than at the north end (1.054 fish per hour). The fish per angler average was 6.7 for a combination of complete and incomplete anglers, while completed trip anglers (south end only) caught an average of 9.5 fish per person. No other species of trout or char were reported by anglers on opening day.

### 1992 Opening Day - Harvest

Opening day harvest totalled 84 rainbow trout for interviewed anglers *(Table 4)*. A total of 304 fish (78%) were released. Harvest per unit effort (HPUE) was 0.256 fish per hour, and was higher at the south end of the lake (0.311 fish per hour) than at the north end (0.103 fish per hour). The fish per angler average was 1.4 for a combination of complete and incomplete anglers, while completed trip anglers (south end only) harvested an average of 2.5 fish per person.

### 1992 Opening Day - Methods and Gear

All anglers checked at Ross Lake used boats on opening day. The most popular angling method (n=58) was trolling with flashers and lures (97%), while the remaining anglers (n=2) utilized flies (3%).

### 1992 Opening Day - Age

Out of fifty-four rainbow trout randomly sampled from the opening day harvest in 1992, the majority were age 4 (65%). Twenty-eight percent were age 5, four percent were age 3, and the remaining three percent were age 6. A greater percentage of age 4 fish occurred in the south end sample (68%) than the north end (54%), while a larger percentage of age 5 fish occurred in the north end sample (38%) than the south end (24%). The remainder of the north end sample comprised age 3 (8%), while the balance of the south end sample included age 3 (2%), and age 6 (5%). These differences may arise from the small sample size collected

TABLE 4. Comparison of 1992 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 | 19 | 87 | 9 | 0.103 | 0.5 | 315 | 373 | 329 |
| Resort | 39 | 242 | 75 | 0.311 | 1.9 | 310 | 380 | 337 |
| Total | 58 | 329 | 84 | 0.256 | 1.4 | 310 | 380 | 336 |
| COMBINED TRIPS[c] - Harvest + Released | | | | | | | | |
| Hozomeen | 19 | 87 | 92 | 1.054 | 4.8 | | | |
| Resort | 39 | 242 | 296 | 1.226 | 7.6 | | | |
| Total | 58 | 329 | 388 | 1.180 | 6.7 | | | |
| COMPLETE TRIPS - Harvest Only | | | | | | | | |
| Hozomeen | 0 | --- | --- | --- | --- | --- | --- | --- |
| Resort | 22 | 147 | 54 | 0.369 | 2.5 | 310 | 375 | 333 |
| Total | 22 | 147 | 54 | 0.369 | 2.5 | 310 | 375 | 333 |
| COMPLETE TRIPS - Harvest + Released | | | | | | | | |
| Hozomeen | 0 | --- | --- | --- | --- | | | |
| Resort | 22 | 147 | 208 | 1.420 | 9.5 | | | |
| Total | 22 | 147 | 208 | 1.420 | 9.5 | | | |

[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).

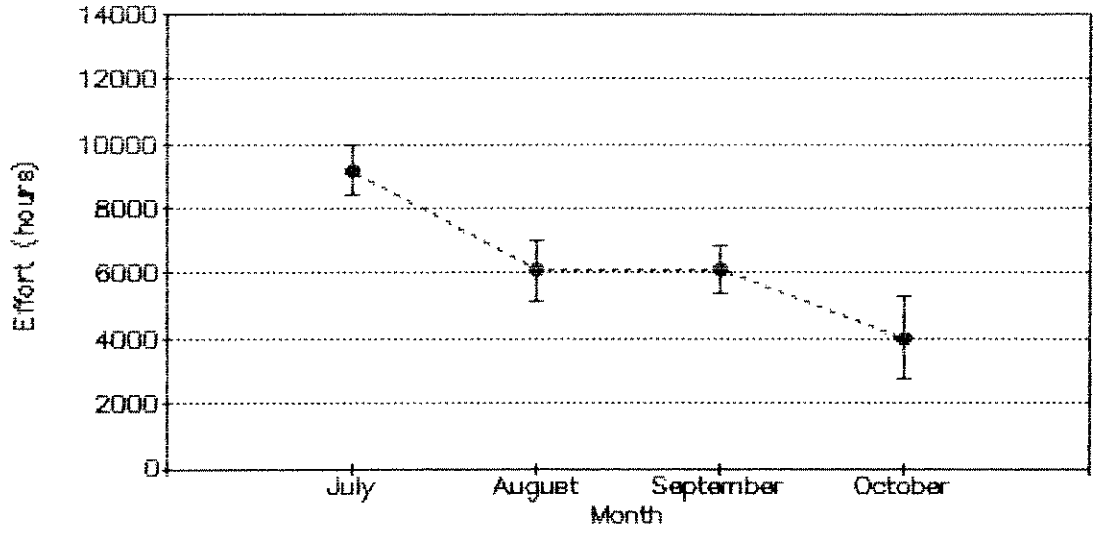


FIGURE 6. Monthly distribution of seasonal angler effort (daytype estimate) during the 1992 Ross Reservoir sport fishery. Range intervals denote 95% confidence limit of each estimate.

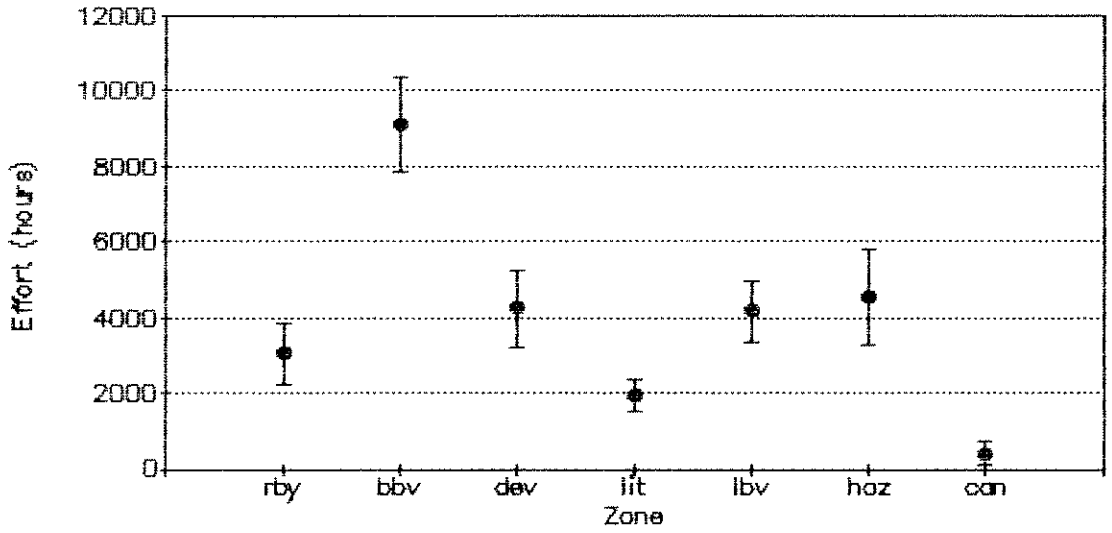


FIGURE 7. Distribution of seasonal angler effort (zone estimate) among lake zones during the 1992 Ross Reservoir sport fishery. Zone abbreviations are as follows: rby = ruby (zone 1), bbv = big beaver (zone 2); dev = devils (zone 3); lit = lightning (zone 4); lbv = little beaver (zone 5); hoz = hozomeen (zone 6); and can = canada (zone 7). Range intervals denote 95% confidence limit of each estimate.

TABLE 8. Estimated mean seasonal catch and harvest rates for rainbow trout in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| | | | Rainbow Trout Captures per Hour[a] | | |
|---|---|---|---|---|---|
| Type[b] | Strata | N[c] | Harvested | Released | Total |
| Daytype | Opener | 58 | .256 (.006) | .925 (.036) | 1.180 (.039) |
| | Weekday | 348 | .084 (.001) | .272 (.002) | .356 (.003) |
| | Weekend | 388 | .094 (.001) | .248 (.001) | .342 (.002) |
| | Mean | | .104 (.000) | .320 (.001) | .424 (.002) |
| Zone[d] | 1 Rby | 143 | .111 (.003) | .396 (.015) | .507 (.016) |
| | 2 Bbv | 354 | .107 (.001) | .315 (.002) | .423 (.003) |
| | 3 Dev | 103 | .091 (.003) | .254 (.006) | .345 (.008) |
| | 4 Lit | 59 | .101 (.006) | .250 (.011) | .351 (.014) |
| | 5 Lbv | 34 | .093 (.008) | .360 (.042) | .453 (.044) |
| | 6 Hoz | 100 | .117 (.004) | .402 (.009) | .520 (.010) |
| | 7 Can | 1 | .000 | .000 | .000 |
| | Mean | | .104 (.000) | .320 (.001) | .424 (.002) |
| Access | Resort | 663 | .104 (.001) | .308 (.001) | .411 (.002) |
| | Hozomeen | 130 | .110 (.003) | .408 (.009) | .517 (.010) |
| | Canada | 1 | .000 | .000 | .000 |
| | Mean | | .104 (.000) | .320 (.001) | .424 (.002) |

[a]Ninety-five percent confidence interval of estimated mean captures per hour given in parentheses.

[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.

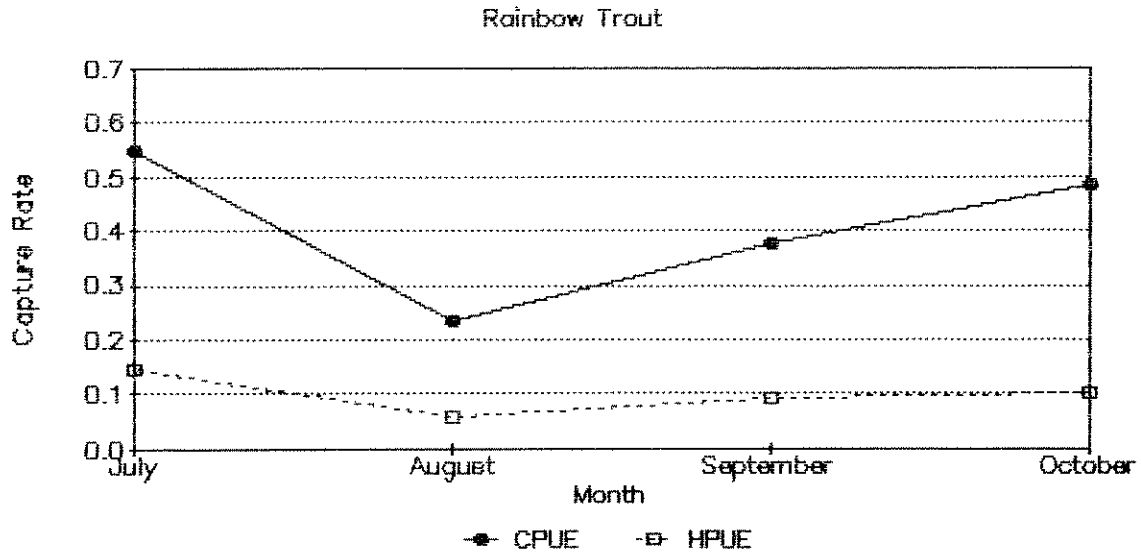


FIGURE 8. Monthly distribution of seasonal rainbow trout catch and harvest rates (daytype estimate) during the 1992 Ross Reservoir sport fishery.

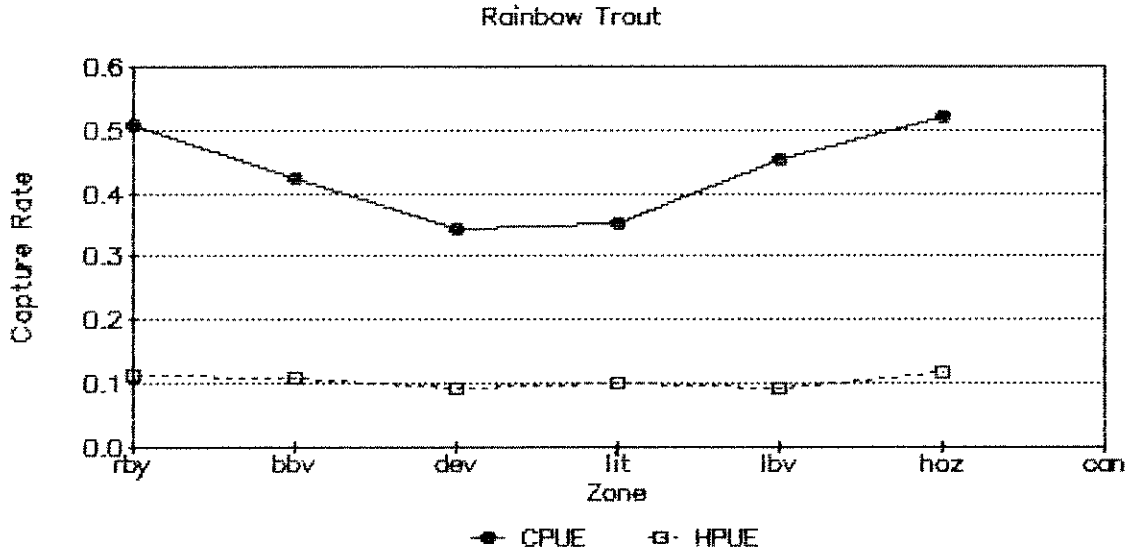


FIGURE 9. Distribution of seasonal rainbow trout catch and harvest rates (zone estimate) among lake zones during the 1992 Ross Reservoir sport fishery. Zone abbreviations are as follows: rby = ruby (zone 1), bbv = big beaver (zone 2); dev = devils (zone 3); lit = lightning (zone 4); lbv = little beaver (zone 5); hoz = hozomeen (zone 6); and can = canada (zone 7).

harvest rates varied little between the different zones, ranging from 0.117 CPUE in zone 6-Hozomeen to 0.091 CPUE in zone 3-Devils (approximately one fish per ten hours of fishing effort). Monthly and seasonal capture rate estimates for the different zone strata can be found in *Appendix 7*.

As shown in *Table 8*, Hozomeen anglers had the highest seasonal catch rate (access area estimate) for rainbow trout (0.517 CPUE). Resort anglers experienced a slightly lower catch rate (0.411 CPUE), while an extremely small sample size precluded accurate estimates of capture rates for the Canadian portion of the reservoir. Rainbow trout harvest rates followed the same pattern as catch rates, being slightly higher at the north end of the lake (0.110 HPUE) than at the south end (0.104 HPUE). Monthly and seasonal capture rate estimates for the different access area strata can be found in *Appendix 8*.

Angler catch and harvest rate estimates for dolly varden/bull trout char and cutthroat trout were low during the 1992 sport fishing season at Ross Lake *(Table 9* and *Appendix 9-10)*. Mean seasonal catch rates were 0.001 fish per hour for dolly varden/bull trout char, while catch rates for cutthroat trout were less than 0.001 fish per hour (daytype estimate). Harvest rates were less than 0.001 fish per hour for both species. No eastern brook trout (char) were reported by anglers during the 1992 season.

Mean seasonal catch and harvest rate estimates for all species of trout and char combined are given in *Table 9* and *Appendix 11*. The mean seasonal catch rate of all species combined was 0.425 fish per hour, while the seasonal harvest rate was 0.105 fish per hour (daytype estimate).

1992 Season - Angler Catch and Harvest

The total seasonal catch (combination of harvested and released) of rainbow trout was 8,687 ± 430 fish *(Table 10*, daytype estimate*)*. Total catch dropped sharply from a seasonal high of 3,322 fish in July to a seasonal low of 1,422 in August. Catch subsequently increased to 2,150 fish in September, and declined again to 1,793 in October *(Figure 10* and *Appendix 12)*.

The total seasonal harvest of rainbow trout was 2,326 ± 161 fish *(Table 10*, daytype estimate*)*. As shown in *Figure 10*, harvest of rainbow trout followed the same pattern as catch. Total harvest was highest in July (44%) and September (24%), and lowest during August (14%) and October (18%).

A total seasonal catch estimate of 10,169 ± 753 rainbow trout were calculated for data separated into zones *(Table 10* and *Appendix 13)*. As shown in *Figure 11*, the greatest catch of rainbow trout occurred near the south end of the lake in zone 2-Big Beaver (38%). Intermediate catch totals occurred in zones 1-Ruby (17%), 3-Devils (15%) and

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, 1992.

| Species | Strata* | Harvest | Release | Total |
|---|---|---|---|---|
| Rainbow | Opener | 0.256 | 0.925 | 1.180 |
| | Weekday | 0.084 | 0.272 | 0.356 |
| | Weekend | 0.094 | 0.248 | 0.342 |
| | Mean | 0.104 | 0.320 | 0.424 |
| Dolly Varden | Opener | 0 | 0 | 0 |
| | Weekday | 0 | 0.001 | 0.001 |
| | Weekend | 0.001 | 0 | 0.001 |
| | Mean | 0.000 | 0.000 | 0.001 |
| Cuttroat Trout | Opener | 0 | 0 | 0 |
| | Weekday | 0.001 | 0 | 0.001 |
| | Weekend | 0 | 0 | 0 |
| | Mean | 0.000 | 0 | 0.000 |
| All Species | Opener | 0.256 | 0.925 | 1.180 |
| | Weekday | 0.084 | 0.273 | 0.357 |
| | Weekend | 0.094 | 0.248 | 0.342 |
| | Mean | 0.105 | 0.320 | 0.425 |

*Daytype estimate.

TABLE 10. Estimated total seasonal catch and harvest of rainbow trout in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| | | Rainbow Trout Captures[a] | | | | | |
|---|---|---|---|---|---|---|---|
| Type[b] | Strata | Harvested | | Released | | Total | |
| Daytype | Opener | 157 | (4) | 570 | (23) | 727 | (23) |
| | Weekday | 1190 | (89) | 3231 | (236) | 4420 | (252) |
| | Weekend | 979 | (135) | 2560 | (322) | 3539 | (349) |
| | Total | 2326 | (161) | 6360 | (398) | 8687 | (430) |
| Zone[c] | 1 Rby | 380 | (121) | 1312 | (400) | 1692 | (418) |
| | 2 Bbv | 1015 | (121) | 2823 | (372) | 3838 | (391) |
| | 3 Dev | 396 | (96) | 1132 | (273) | 1529 | (289) |
| | 4 Lit | 213 | (43) | 524 | (104) | 737 | (113) |
| | 5 Lbv | 255 | (130) | 703 | (233) | 957 | (267) |
| | 6 Hoz | 293 | (81) | 1124 | (278) | 1416 | (289) |
| | 7 Can | 0 | | 0 | | 0 | |
| | Total | 2552 | (249) | 7617 | (711) | 10169 | (753) |
| Access | Resort | 1903 | (192) | 5580 | (646) | 7483 | (673) |
| | Hozomeen | 460 | (91) | 2405 | (350) | 2866 | (362) |
| | Canada | 0 | | 0 | | 0 | |
| | Total | 2363 | (212) | 7986 | (732) | 10349 | (762) |

[a]Ninety-five percent confidence interval of estimated captures given in parentheses.

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

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, 1992.

| Species | Strata* | Harvest | Release | Total |
|---|---|---|---|---|
| Rainbow | Opener | 157 | 570 | 727 |
| | Weekday | 1190 | 3231 | 4420 |
| | Weekend | 979 | 2560 | 3539 |
| | Total | 2326 | 6360 | 8687 |
| Dolly Varden | Opener | 0 | 0 | 0 |
| | Weekday | 0 | 16 | 16 |
| | Weekend | 6 | 0 | 6 |
| | Total | 6 | 16 | 23 |
| Cutthroat | Opener | 0 | 0 | 0 |
| | Weekday | 4 | 0 | 4 |
| | Weekend | 0 | 0 | 0 |
| | Total | 4 | 0 | 4 |
| All Species | Opener | 157 | 570 | 727 |
| | Weekday | 1194 | 3247 | 4441 |
| | Weekend | 986 | 2560 | 3546 |
| | Total | 2337 | 6377 | 8714 |

*Daytype estimate.

TABLE 12. Harvest, harvest rates, and number of anglers fishing for rainbow trout using different types of gear and methods during the 1992 sport fishing season[a].

| Geartype[b] | Resort | Hozomeen | Canada | Total | Percent |
|---|---|---|---|---|---|
| ANGLERS | | | | | |
| bl | 594 | 127 | 1 | 722 | 91 |
| bf | 69 | 3 | | 72 | 9 |
| Total | 663 | 130 | 1 | 794 | 100 |
| HARVEST | | | | | |
| bl | 295 | 50 | 0 | 345 | 92 |
| bf | 31 | 0 | | 31 | 8 |
| Total | 326 | 50 | 0 | 376 | 100 |
| HPUE | | | | | |
| bl | 0.102 | 0.112 | 0.000 | 0.103 | |
| bf | 0.121 | 0.000 | | 0.116 | |
| Mean | 0.104 | 0.110 | 0.000 | 0.104 | |

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

[b]bl = boat, trolling lure
bf = boat, trolling fly

abundant age class throughout the entire season, comprising 61 percent of the total sample *(Table 13)*. Age 5 fish also comprised a large proportion of the harvest (29%), while the remaining harvest consisted of age 6 (5%), age 3 (4%), and age 7 (<1%) fish.

Occurrence of most age classes remained relatively constant throughout the season, although age 3 and age 6 fish exhibited moderate increases in August, and age 5 fish showed a sharp decline in September *(Table 13)*. Conversely, occurrence of age 4 fish fluctuated throughout the season, declining from July to August (seaonal low), increasing markedly in September (seasonal high), and declining again slightly in October. Only one age 7 fish was sampled from the angler harvest during the season.

1992 Season - Length

A total of 315 rainbow trout were measured during the 1992 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 1992 season was 331 mm. Sizes ranged from a low of 277 mm (illegally harvested) to a high of 402 mm. Average size of fish harvested during the first half of the season was slightly larger than those harvested during the second half. 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 308 mm, age 4 fish averaged 324 mm, age 5 fish averaged 343 mm, and age 6 fish averaged 366 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. Most age classes appeared to exhibit little variation in growth throughout the summer, although small sample sizes may have caused minor fluctuations in a few age groups. Average monthly size of age 4 and age 5 fish fluctuated a maximum of 3 mm and 8 mm, respectively, throughout the summer. Except for a decrease of 20 mm in September (n=2), age 3 fish varied a maximum of 4 mm in size during the other three months of the season. Age 6 fish fluctuated a maximum of 3 mm during the first three months of the season, then increased 37 mm in October (n=1). 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

TABLE 13. Percent age composition of rainbow trout sampled from the 1992 sport harvest at Ross Reservoir.

| | MONTH | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Jul | | Aug | | Sep | | Oct | | Total | |
| AGE | n | % | n | % | n | % | n | % | n | % |
| THREE: | 3 | 2 | 5 | 14 | 2 | 3 | 2 | 6 | 12 | 4 |
| FOUR: | 84 | 59 | 16 | 43 | 44 | 76 | 23 | 66 | 167 | 61 |
| FIVE: | 47 | 33 | 12 | 32 | 10 | 17 | 9 | 26 | 78 | 29 |
| SIX: | 7 | 5 | 4 | 11 | 2 | 3 | 1 | 3 | 14 | 5 |
| SEVEN: | 1 | 1 | | | | | | | 1 | 0 |
| TOTAL: | 142 | 100 | 37 | 100 | 58 | 100 | 35 | 100 | 272 | 100 |

TABLE 14. Trout and char length information, by month, from the 1992 sport fishing season at Ross Reservoir.

| Month | Number | Percent | Fork Length (mm) | | |
|---|---|---|---|---|---|
| | | | Average | Minimum | Maximum |
| RAINBOW | | | | | |
| July | 155 | 49 | 333 | 300 | 394 |
| August | 45 | 14 | 334 | 308 | 371 |
| September | 64 | 20 | 326 | 290 | 370 |
| October | 51 | 16 | 327 | 277 | 402 |
| Season | 315 | 100 | 331 | 277 | 402 |
| DOLLY VARDEN | | | | | |
| July | | | | | |
| August | 1 | 100 | 712 | 712 | 712 |
| September | | | | | |
| October | | | | | |
| Season | 1 | 100 | 712 | 712 | 712 |

TABLE 15. Rainbow trout length information, by age, from the 1992 sport harvest at Ross Reservoir.

| | | | Fork Length (mm) | | |
|---|---|---|---|---|---|
| Age | Number | Percent | Average | Minimum | Maximum |
| 3 | 12 | 4 | 308 | 290 | 318 |
| 4 | 167 | 61 | 324 | 295 | 370 |
| 5 | 78 | 29 | 343 | 306 | 373 |
| 6 | 14 | 5 | 366 | 340 | 402 |
| 7 | 1 | 0 | 365 | 365 | 365 |

TABLE 16. Average fork length (mm) of rainbow trout, grouped by month and age class, from the 1992 sport harvest at Ross Reservoir.

| AGE | | JUL | AUG | SEP | OCT | SEASON |
|---|---|---|---|---|---|---|
| THREE: | n | 3 | 5 | 2 | 2 | 12 |
| | avg | 310 | 313 | 293 | 309 | 308 |
| FOUR: | n | 84 | 16 | 44 | 23 | 167 |
| | avg | 324 | 323 | 323 | 326 | 324 |
| FIVE: | n | 47 | 12 | 10 | 9 | 78 |
| | avg | 343 | 346 | 344 | 338 | 343 |
| SIX: | n | 7 | 4 | 2 | 1 | 14 |
| | avg | 362 | 364 | 365 | 402 | 366 |
| SEVEN: | n | 1 | --- | --- | --- | 1 |
| | avg | 365 | --- | --- | --- | 365 |

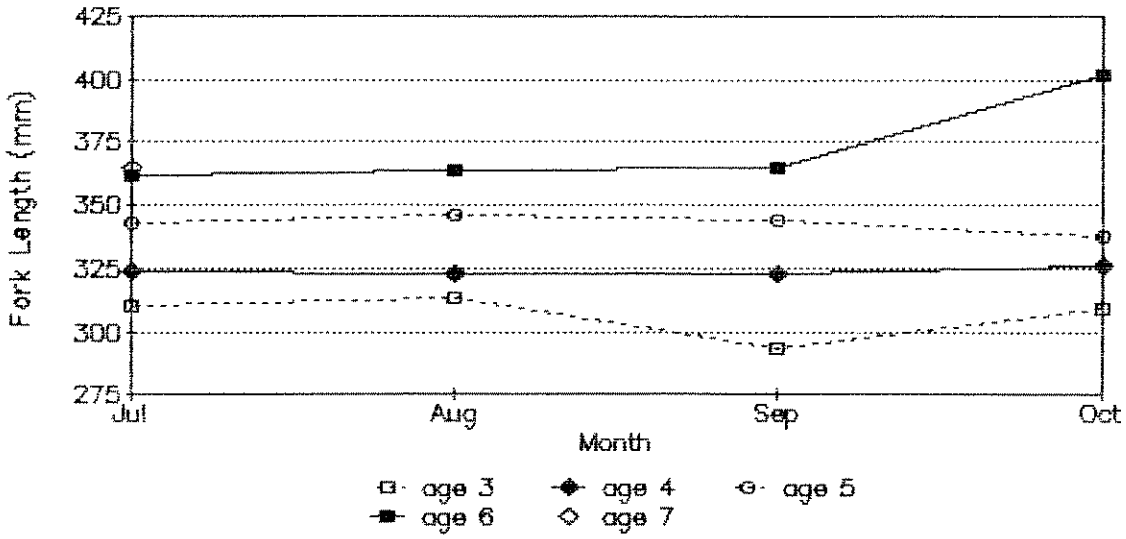


FIGURE 12. Average lengths of age 3 - age 7 rainbow trout, by month, from the 1992 Ross Lake sport harvest.

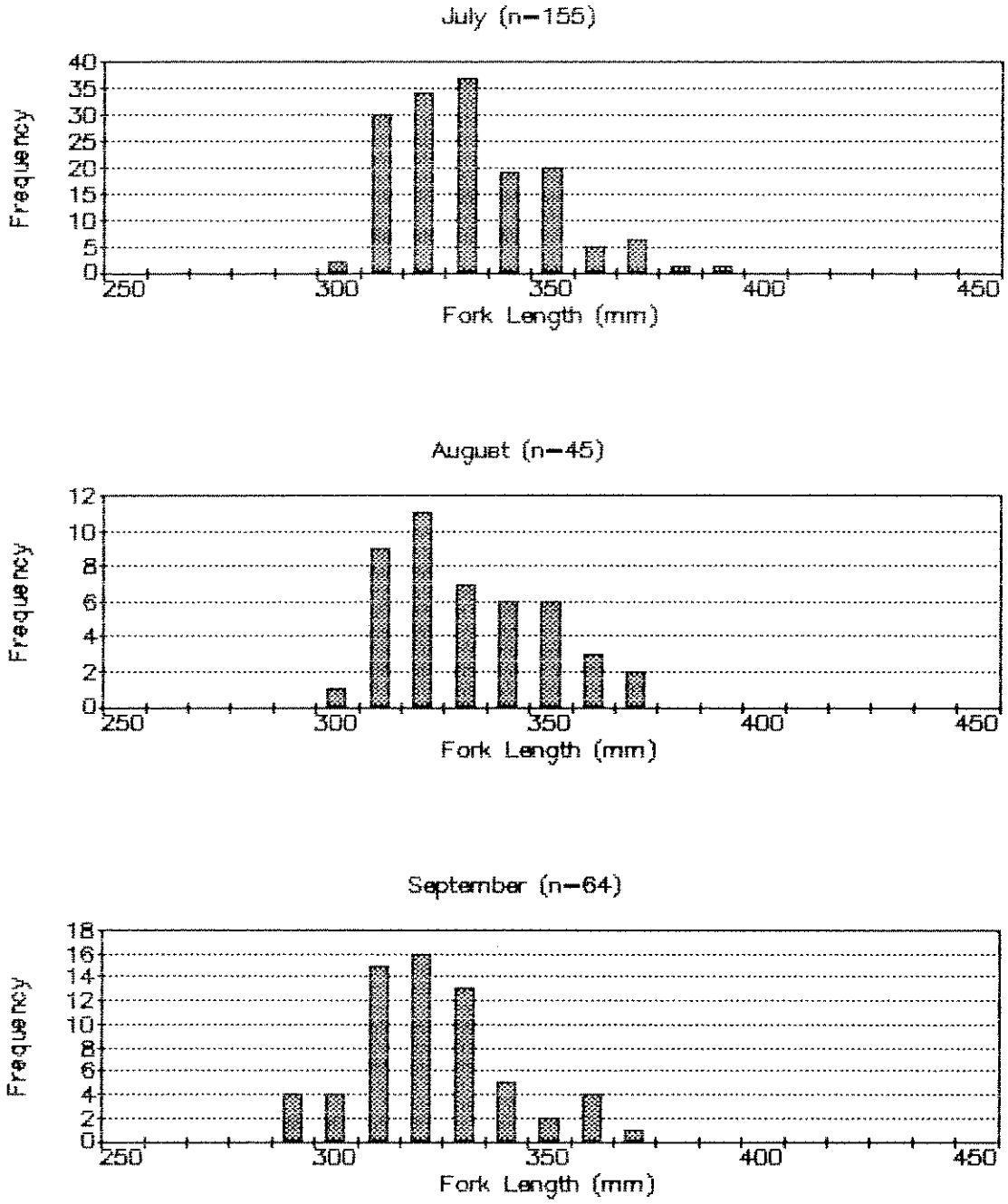


FIGURE 13. Length-frequency distribution of rainbow trout sampled from the 1992 Ross Lake sport harvest. Minimum legal size limit is approximately 317 mm fork length. Abscissa values indicate lower limit of length interval.

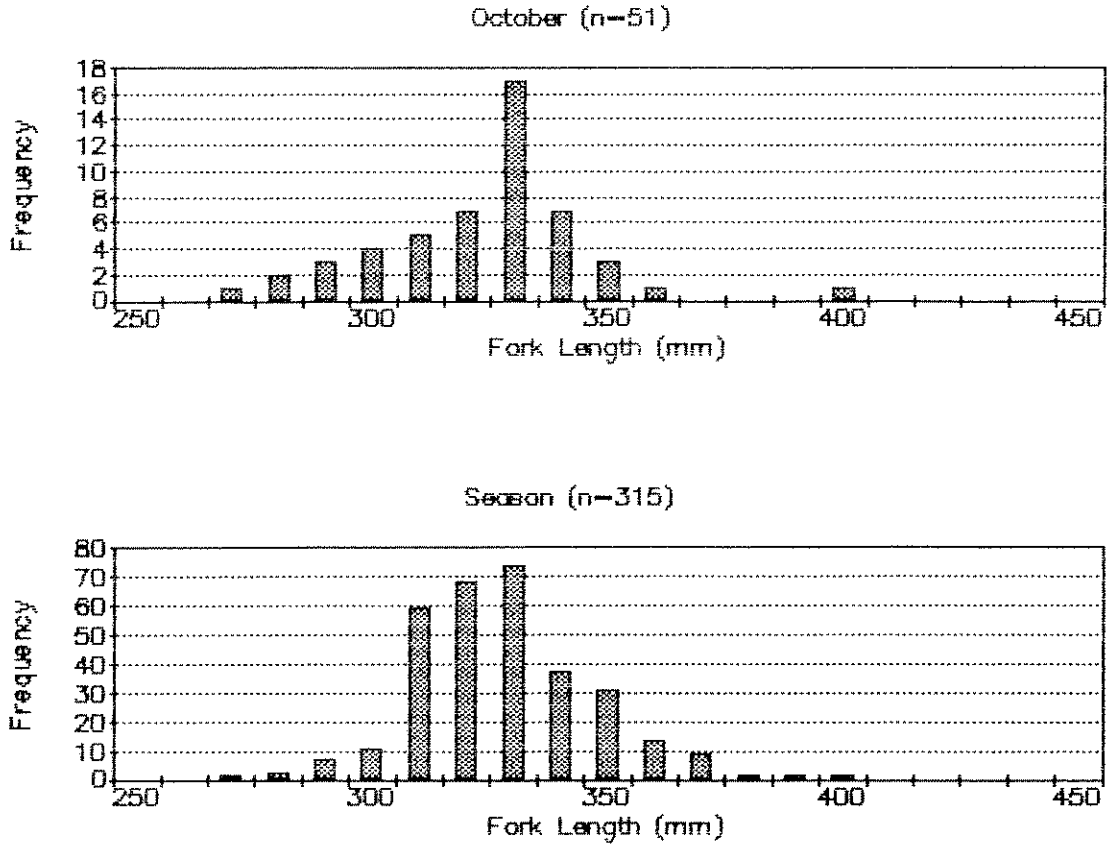


FIGURE 13. (Continued).

histograms (monthly and seasonal) closely resemble the standard normal curve, and are predominantly centered around the 330-340 mm (July and October) and 320-330 mm (August and September) fork length intervals. The legal size limit is 330 mm total length or approximately 317 mm fork length. Except for the 330-340 mm size group, the October histogram is more vertically compressed than the other histograms.

1992 Season - Sex

A total of 246 rainbow trout were sampled from the seasonal sport harvest for sex determination. Males constituted 28 percent of the total sample (n=69), while females accounted for 72 percent (n=177). The north end sample (n=82) was comprised of 33 percent males and 67 percent females, while the south end sample (n=164) was composed of 26 percent males and 74 percent females.

1992 Season - Sexual Maturity

A random sample of 105 rainbow trout from the seasonal sport harvest were checked for gonadal development *(Table 17)*. Mature fish comprised 78 percent of the sample, while the remaining 22 percent were immature. Males were composed of 82 percent mature and 18 percent immature fish, while females were comprised of 76 percent mature and 24 percent immature fish.

*Table 18* shows the average fork length and size range of a random sample of 100 rainbow trout from the seasonal sport harvest, separated by access, sex, sexual maturity, and age. The north end sample (n=56) was comprised of 79 percent mature fish, while only 21 percent were immature. The male sample was composed of 84 percent mature (average length = 344 mm), and 16 percent immature fish (average length = 338 mm). Seventy-six percent of the female sample were mature (average length = 324 mm), while 24 percent were immature (average length = 319 mm).

Sexual maturity composition of the south end sample was similar to the north end. The south end sample (n=44) comprised 75 percent mature, and 25 percent immature fish *(Table 18)*. The male sample included 77 percent mature (average length = 339 mm), and 23 percent immature (average length = 340 mm) fish. Seventy-four percent of the female sample were mature fish (average length = 326 mm), while 26 percent were immature (average length = 326 mm).

1992 Season - Additional Data

Forty-one percent of the interviewed anglers that were fishing for rainbow trout during the 1992 sport fishing season at Ross Reservoir were unsuccessful at catching a fish *(Figure 14)*. The remaining anglers (59%) were successful at catching from one to forty-three fish. Sixty-nine percent of the anglers were unsuccessful in harvesting a legal rainbow trout, while the remaining anglers harvested one (19%),

TABLE 17. Rainbow trout length information, grouped by sex and maturity, from the 1992 sport harvest at Ross Reservoir.

| | | | Fork Length (mm) | | |
|---|---|---|---|---|---|
| Sex | Maturity | N | Avg | Min | Max |
| Male | Mature | 28 | 341 | 315 | 373 |
| | Immature | 6 | 339 | 320 | 370 |
| Female | Mature | 54 | 327 | 300 | 394 |
| | Immature | 17 | 323 | 305 | 351 |

TABLE 18. Rainbow trout age and length information, grouped by access area, sex and maturity, from the 1992 sport harvest at Ross Reservoir.

| | | | | | Fork Length (mm) | | |
|---|---|---|---|---|---|---|---|
| Access | Sex | Maturity | Age | N | Avg | Min | Max |
| Hozomeen | Male | Mature | 4 | 5 | 326 | 315 | 340 |
| | | | 5 | 10 | 351 | 334 | 373 |
| | | | 6 | 1 | 360 | 360 | 360 |
| | | Immature | 4 | 2 | 330 | 322 | 337 |
| | | | 5 | 1 | 355 | 355 | 355 |
| | Female | Mature | 4 | 19 | 316 | 300 | 331 |
| | | | 5 | 7 | 340 | 322 | 355 |
| | | | 6 | 1 | 340 | 340 | 340 |
| | | | 7 | 1 | 365 | 365 | 365 |
| | | Immature | 3 | 1 | 310 | 310 | 310 |
| | | | 4 | 6 | 320 | 310 | 331 |
| | | | 5 | 2 | 324 | 315 | 332 |
| Resort | Male | Mature | 4 | 4 | 325 | 316 | 334 |
| | | | 5 | 6 | 348 | 340 | 355 |
| | | Immature | 4 | 2 | 345 | 320 | 370 |
| | | | 5 | 1 | 330 | 330 | 330 |
| | Female | Mature | 3 | 1 | 311 | 311 | 311 |
| | | | 4 | 15 | 325 | 310 | 335 |
| | | | 5 | 6 | 327 | 315 | 340 |
| | | | 6 | 1 | 351 | 351 | 351 |
| | | Immature | 4 | 5 | 321 | 305 | 335 |
| | | | 5 | 3 | 335 | 316 | 351 |

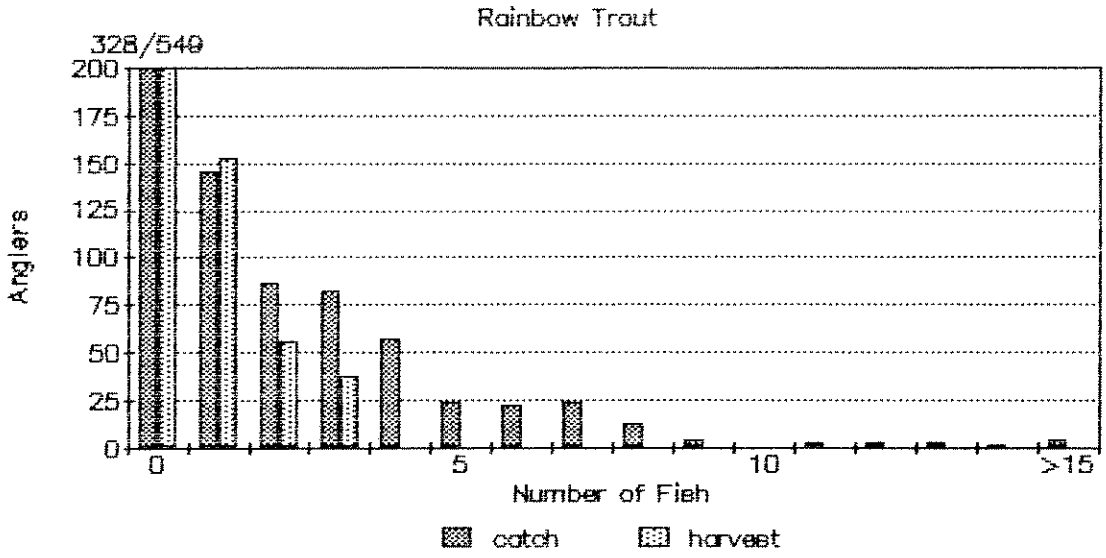


FIGURE 14. Reported angler success at catching rainbow trout during the 1992 sport fishing season at Ross Reservoir.

two (7%), and three (5%) fish.

Very few of the two remaining species of trout and char were caught and/or harvested by interviewed anglers during the season *(Figure 15)*. Two anglers each reported catching one dolly varden char, one of which was harvested. One cutthroat trout was also caught and harvested, while no brook trout captures were reported the entire season.

1992 Season - Dolly Varden/Bull Trout Char

One dolly varden/bull trout char was measured for (possible future) species classification during the 1992-93 study at Ross Lake *(Table 19)*. This fish was sampled during the 1992 angler survey, and keyed out as bull trout when classified according to the linear discriminant function developed by Haas (1988). A reduced harvest of char occurred at Ross lake in 1992 compared to previous years, due to a new 20-inch minimum size restriction *(Appendix 1)*.

Hydroacoustic Surveys

Two hydroacoustic surveys were conducted at Ross Lake on March 24 and April 2, 1993. A total of 103 fish were recorded for both surveys, resulting in an average of 51.5 fish per survey *(Table 20)*. Index counts varied only 6 percent between the two surveys, indicating little appreciable difference in the average number of fish recorded between morning and afternoon surveys (AM average = 53, PM average = 50).

Population estimates for the two 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 two surveys ranged from a high of 61,429 fish to a low of 60,286. The total reservoir rainbow trout population was estimated at 60,857 ± 12,437, while the total combined species (trout and char) population was estimated at 61,047 ± 12,476. Confidence limits are within ± 20 percent of both estimates, indicating moderate 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 24 and July 10, 1993 *(Table 22)*. A total of 2,464 rainbow trout were counted during the seven surveys *(Table 23)*. Surveys did not commence until May 24, due to

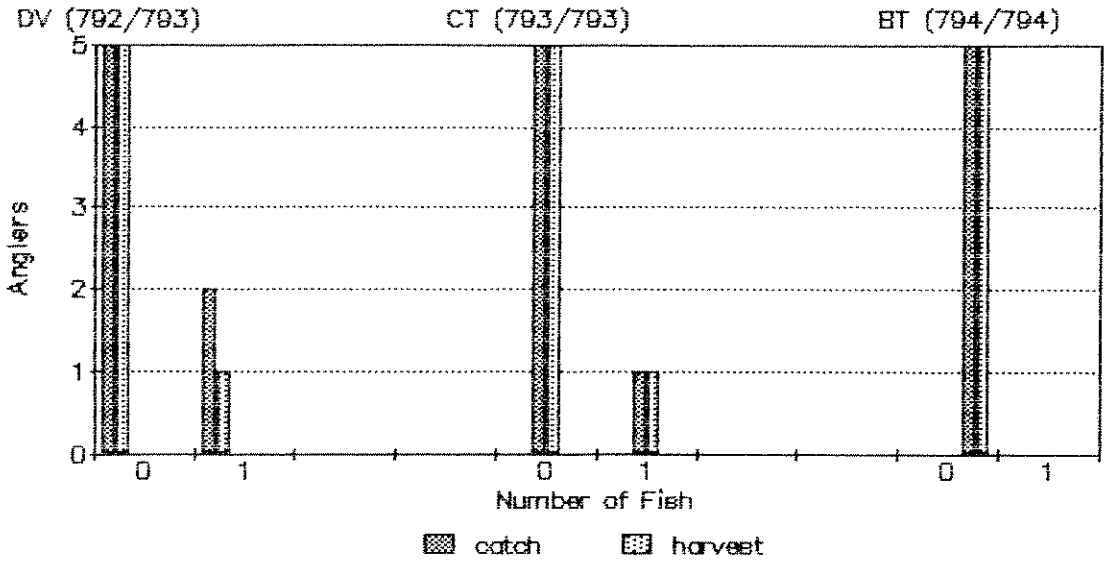


FIGURE 15. Reported angler success at catching dolly varden/bull trout char, cutthroat trout, and brook trout (char) during the 1992 sport fishing season at Ross Reservoir.

TABLE 19. Dolly varden/bull trout char physical data and linear discriminant function values[a] from samples collected at Ross Reservoir between 06/01/92 and 05/31/93.

| | | | | Linear Discrimanant Function (LDF) Variables | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Y | M | D | Sex | SL[b] | B-L[c] | B-R[d] | Max[e] | AFR[f] | LDF[g] | Type |
| 08 | 23 | 92 | M | 625 | 14 | 13 | 75 | 9 | 1.3 | 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 two surveys conducted on March 24 and April 2, 1993.

| | | Transect | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date[b] | Elev | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | Total |
| 03/24 | 1514 | 5 | 5 | 3 | 3 | 13 | 0 | 5 | 1 | 11 | 3 | 4 | 53 |
| 04/02 | 1516 | 6 | 2 | 1 | 5 | 5 | 5 | 8 | 3 | 9 | 1 | 5 | 50 |
| Mean | | 6 | 4 | 2 | 4 | 9 | 3 | 7 | 2 | 10 | 2 | 5 | 52 |

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

[b]AM (0800–1200) counts = 03/24
PM (1200–1600) counts = 04/02

TABLE 21. Population estimates of Ross-Skagit system trout and char[a] from two hydroacoustic surveys conducted on March 24 and April 2, 1993.

| | Trout and Char | | Rainbow Trout[b] | |
|---|---|---|---|---|
| Date[c] | Estimate | 95% C.I. | Estimate | 95% C.I. |
| 03/24 | 61,620 | ± 13,218 | 61,429 | ± 13,177 |
| 04/02 | 60,473 | ± 11,686 | 60,286 | ± 11,650 |
| Mean | 61,047 | ± 12,476 | 60,857 | ± 12,437 |

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

[b]Estimates using proportion of rainbow trout in 1992 sport harvest (0.9969).

[c]AM (0800-1200) count = 03/24
PM (1200-1600) count = 04/02

TABLE 22. Elevations and distances surveyed* on Ross Reservoir index tributaries during rainbow trout spawning surveys from May 24 to July 10, 1993.

| Tributary Name | Distance (ft) | Elevation (ft) | |
|---|---|---|---|
| | | Minimum | 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 elevation distances surveyed.

TABLE 23. Number of spawning rainbow trout observed in selected tributaries of Ross Reservoir from May 24 to July 10, 1993.

| | Number of Rainbow Trout | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | May | Jun | | | | Jul | | |
| Tributary | 24 | 02 | 11 | 17 | 24 | 02 | 10 | Total |
| Dry | 32 | 54 | 76 | 56 | 95 | 27 | 5 | 345 |
| Lightning* | 208 | 101 | 505 | --- | 58 | 51 | 40 | 963 |
| Pierce | 2 | 9 | 31 | 18 | 33 | 2 | 0 | 95 |
| Roland | 147 | 218 | 262 | 199 | 112 | 67 | 7 | 1012 |
| Thursday | 2 | 7 | 13 | 15 | 1 | 2 | 9 | 49 |
| Total | 391 | 389 | 887 | 288 | 299 | 149 | 61 | 2464 |

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

adverse weather conditions during the preceding several weeks. Spawning fish were observed on all survey dates, with the largest numbers of rainbow trout occurring on June 11, when a total of 887 fish were recorded on the five tributaries. Roland Creek recorded the highest spawner total (1,012 fish), and because of size, accessibility, and available spawning habitat, is the best spawning indicator stream of those surveyed. Lightning Creek recorded the second largest spawner total for the season (963 fish), although the vast majority of these fish were observed adjacent to the stream mouth.

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 11, and surveys concluded on July 10 when sixty-one fish were observed in Dry, Roland, Lightning, and Thursday Creeks. Twelve of these fish were spawning in Roland and Dry Creeks, while the remaining forty-nine fish were milling off the mouth of Lightning and Thursday Creeks, 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. Historically, direct hatchery introductions have not occurred in the reservoir and upper Skagit River, although BCF&W did conduct two plants in the Sumallo River (tributary to the upper Skagit River) in the late 1980's. 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 subsequently determined by BCF&W to be unsuccessful, and plans for further plants discontinued.

Analysis of historic data (Johnston 1989) indicates that the stability of the Ross Reservoir and Skagit River fish population appears to be largely dependent on 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 1992 seasonal angler effort remained markedly less than in years prior to the new restrictive fishing regulations implemented in 1990. The 1992 estimated angler effort was 25,370 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 61 percent from the mid-1980's, and 66 percent

TABLE 24. Estimated seasonal angler effort[a] at Ross Reservoir in 1971, 1985-86, and 1990-92.

| Year | Effort (hours) | ± CI[b] | Source |
|---|---|---|---|
| 1971 | 74,098[c] | ---- | City of Seattle (1972)<br>City of Seattle (1973) |
| 1985 | 65,673[d] | ---- | Scott and Peterson (1986) |
| 1986 | 65,797[e] | ---- | Johnston (1989) |
| 1990 | 33,216[f] | 2,330 | Looff (1992a) |
| 1991 | 36,108[f] | 1,118 | Looff (1993a) |
| 1992 | 25,370[f] | 1,735 | |

[a]Season length approximately two weeks shorter in 1990-92 than in previous years. See Johnston (1989) and *Appendix 1*.

[b]Ninety-five percent confidence interval 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.

from the early 1970's. Total 1992 estimated angler effort also declined approximately 30 percent from the 1991 estimate of 36,108 hours, and is 24 percent less than the 1990 estimate of 33,216 hours.

The new regulations appear to be more of a deterrent to anglers utilizing 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). From 1990-92, approximately 58 percent (21,509 hours), 54 percent (19,947 hours), and 67 percent (18,324 hours) of the seasonal effort totals were contributed by south end anglers, respectively. North end anglers contributed 42 percent (15,311 hours), 46 percent (17,158 hours), and 33 percent (9,119 hours) of the seasonal effort totals during the same time period. 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 in years prior to the 1990 regulation changes. The mean seasonal HPUE from 1990-92 was 0.12, 0.10, and 0.11 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 1990-92 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 (July-August) and then increase (August-October) as the season progresses *(Table 25 and Figure 16)*. Factors affecting the initial HPUE decline probably include harvest-related mortality and movement of mature rainbow trout into 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 and 1992 at the end of the season, with HPUE remaining below July levels.

Mean seasonal harvest rates for the different lake zones show contrasting patterns between the 1971-74, 1986, and 1990-92 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 6 and 7) and south end (zones 1 and 2) of the lake in 1986. Johnston (1989) attributes the latter declines to

TABLE 25. Mean overall (all species combined) opening day, monthly, and seasonal harvest rates for the 1971-72, 1985-86, and 1990-92 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 |
| 1992[b] | 0.26 | ---- | 0.15 | 0.06 | 0.09 | 0.11 | 0.11 |

[a]Fishing regulations differed between 1971-72, 1985-86, and 1990-92. See Johnston (1989) and *Appendix 1*.

[b]Opening day of the 1990-92 fishing seasons was July 1.

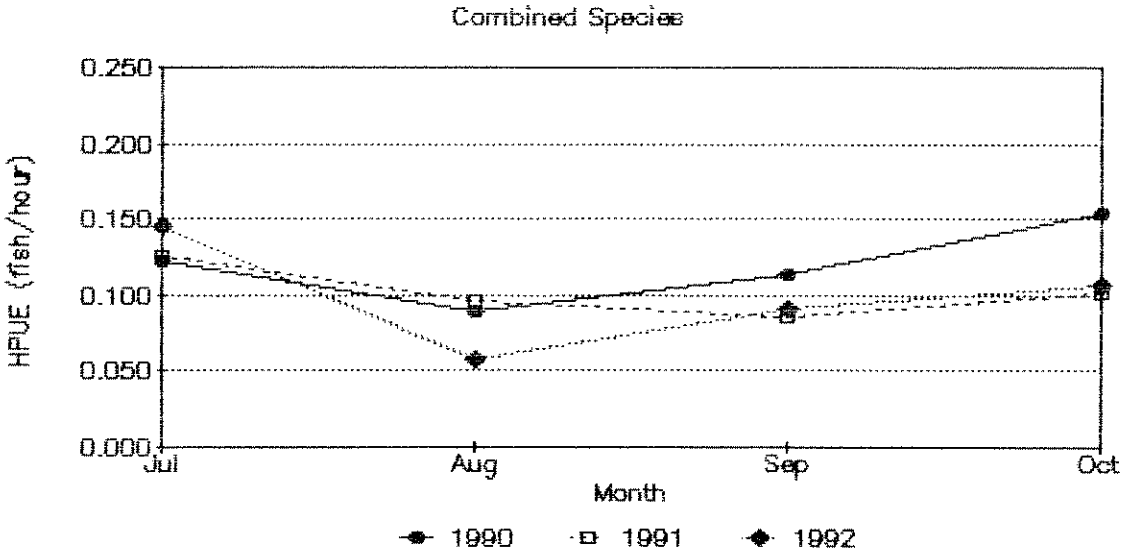


FIGURE 16. Mean overall (all species combined) monthly harvest rates for the 1990-92 fishing seasons at Ross Reservoir.

TABLE 26. Mean overall (all species combined) seasonal harvest rates[a] for zones 1 through 7 on Ross Reservoir during the 1971-74, 1986, and 1990-92 fishing seasons.

| | Trout and Char HPUE | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Zone[b] | 1971 | 1972 | 1973 | 1974 | 1986 | 1990[c] | 1991[c] | 1992[c] |
| 1 (Ru) | 0.50 | 0.57 | 0.54 | 0.53 | 0.29 | 0.06 | 0.07 | 0.11 |
| 2 (BB) | 0.47 | 0.70 | 0.45 | 0.50 | 0.42 | 0.08 | 0.11 | 0.11 |
| 3 (De) | 0.49 | 0.72 | 0.45 | 0.49 | 0.48 | 0.10 | 0.10 | 0.09 |
| 4 (Li) | 0.44 | 0.43 | 0.36 | 0.48 | 0.45 | 0.09 | 0.10 | 0.10 |
| 5 (LB) | 0.43 | 0.52 | 0.43 | 0.39 | 0.46 | 0.12 | 0.10 | 0.09 |
| 6 (Ho) | 0.53 | 0.46 | 0.36 | 0.39 | 0.35 | 0.24 | 0.12 | 0.12 |
| 7 (Ca) | 0.46 | 0.53 | 0.35 | 0.44 | 0.28 | 0.15 | 0.08 | 0.00 |

[a]Fishing regulations differed between 1971-74, 1986, and 1990-92. See Johnston (1989) and *Appendix 1.*

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

[c]Zone estimates for rainbow trout only.

excessive fishing mortality in zones adjacent to the two major access areas. In contrast, 1990 rainbow trout harvest rates were markedly higher at the north end of the lake (zones 5-7) than at the south end (zones 1-4), due primarily to the marked decrease in angler effort at the north end. Harvest rates in 1991 and 1992 were roughly similar for zones 2-6, but were generally less in zones 1 and 7. Of particular interest is the marked decrease (50 percent) 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 1990-92 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) are approximately eleven and six times larger, respectively, than the 1990-92 (average = 3,311) levels. 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, a reduction of the reservoir fish population also contributed to the decline. The small harvest increase (2 percent) in 1991 compared to 1990 is primarily the result of increased effort (9 percent) on the reservoir in 1991. Similarly, the harvest decrease (39 percent) from 1991 to 1992 is primarily due to decreased effort (30 percent) in 1992.

The greater proportion of rainbow trout in the overall 1990-92 harvests (99.5, 99.0, and 99.5 percent, respectively) is due to fewer numbers of dolly varden/bull trout char 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/bull trout char harvest reduction.

Age

The 13-inch (317 mm fork length) minimum size restriction resulted in a greater percentage of older rainbow trout in the 1990-92 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 1991-92 harvest was comprised primarily of age 4 (48 and 61 percent, respectively) and age 5 (43 and 29 percent, respectively) 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

TABLE 27. Combined species and rainbow trout harvest* estimates for the 1971-74, 1985-86, and 1990-92 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 |
| 1992 | 2,337 | 99.5 | 2,326 |

*Fishing regulations differed between 1971-74, 1985-86, and 1990-92. See Johnston (1989) and *Appendix 1.*

TABLE 28. Percent age class contribution* of rainbow trout to the 1971-73, 1985-86, and 1990-92 seasonal sport harvest at Ross Reservoir.

| | Percent of Season Harvest | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Age | 1971 | 1972 | 1973 | 1985 | 1986 | 1990 | 1991 | 1992 |
| 2 | 55 | 49 | 62 | 36 | 28 | 10 | 0 | 0 |
| 3 | 26 | 39 | 29 | 29 | 40 | 47 | 5 | 4 |
| 4 | 7 | 8 | 6 | 13 | 19 | 32 | 48 | 61 |
| 5 | 1 | 2 | 1 | 4 | 4 | 10 | 43 | 29 |
| 6 | 0 | 0 | 0 | 1 | 1 | 1 | 4 | 5 |
| 7 | 0 | 0 | 0 | 0 | 0 | <1 | 0 | <1 |

*Fishing regulations differed between 1971-73, 1985-86, and 1990-92. See Johnston (1989) and *Appendix 1*.

mid-1980's to anglers targeting older Canadian Skagit River rainbow trout (that enter the reservoir fishery in June and again in September and October) at the north end of the lake, and to selectively "high-grading" their catch to retain the largest and brightest rainbow trout (predominantly age 3, immature females).

The ratio of age 4 to age 3 rainbow trout also increased from previous years *(Table 28)*. The 1990-92 age 4:age 3 harvest ratios were 68, 960, and 1,525 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 occurred from 1990-92, with 43, 95, and 96 percent of the harvest comprising age 4 and older fish, respectively. 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 should then be able to spawn at least once before becoming available to the fishery.

## Length

The average size of age 4 and age 5 rainbow trout age classes were roughly similar (within each age class) during 1985-86, and 1990-92 *(Table 29)*. The maximum average size difference between all five years was 15 mm for age 4, and 9 mm for age 5. The much larger average size differences between age 2 (56 mm) and age 3 (24 mm) fish are primarily due 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 1990-92 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 small proportion of the 1992 rainbow trout harvest was composed of immature age 3, age 4, and age 5 fish *(Table 30)*. Of a total sample of two age 3, fifty-eight age 4, and thirty-six age 5 fish, 50 percent, 26 percent, and 19 percent were immature, respectively. Thus, the 13-inch minimum size restriction did not completely protect immature fish during 1992. This was also the case in 1990 and 1991 when a much larger proportion of immature age 3 - age 5 fish were harvested than in 1992. However, total percentage of immature fish harvested (all age classes combined) has declined markedly since 1990. Exceptionally good growth conditions during the winter and early spring of 1990 may have resulted in larger size at age of rainbow trout, resulting in a large proportion of immature fish available for harvest *(Table 29)*.

TABLE 29. Seasonal rainbow trout age and length data* from the 1985-86 and 1990-92 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 | 15 | 310 | 292 | 332 |
| | 4 | 145 | 325 | 301 | 371 |
| | 5 | 128 | 350 | 315 | 385 |
| | 6 | 13 | 378 | 325 | 411 |
| | 7 | 0 | --- | --- | --- |
| 1992 | 2 | 0 | --- | --- | --- |
| | 3 | 12 | 308 | 290 | 318 |
| | 4 | 167 | 324 | 295 | 370 |
| | 5 | 78 | 343 | 306 | 373 |
| | 6 | 14 | 366 | 340 | 402 |
| | 7 | 1 | 365 | 365 | 365 |

*Fishing regulations differed between 1985-86 and 1990-92. See Johnston (1989) and *Appendix 1*.

TABLE 30. Percent immature rainbow trout sampled, by age, from the 1990–92 sport harvests at Ross Reservoir.

| | | Percent Immature* | | | | |
|---|---|---|---|---|---|---|
| Year | N | Age 2 | Age 3 | Age 4 | Age 5 | Total |
| 1990 | 111 | 86 (6) | 83 (44) | 62 (23) | 38 (5) | 70 (78) |
| 1991 | 84 | ------ | 80 (8) | 62 (21) | 38 (15) | 52 (44) |
| 1992 | 100 | ------ | 50 (1) | 26 (15) | 19 (7) | 23 (23) |

*Sample size given in parentheses.

Population Size

Ross Lake rainbow trout mark-recapture population estimates from the early 1970's are substantially higher than hydroacoustic estimates conducted during the first three years of the current study *(Table 31)*. 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 1991-93 hydroacoustic estimates of 20,513, 37,082, and 60,857 fish, respectively. A possible explanation for this large discrepancy is that mark-recapture efforts in the early 1970's may have focused at stream mouths, where fish concentrations are typically high. In contrast, hydroacoustic surveys conducted on the reservoir between December 1970 and June 1973 ranged in size from 26,000-90,000 fish with a mean of 49,000 (Thorne 1976). These values are similar to, though range somewhat higher than, the 1991-93 hydroacoustic estimates. (The 1973 estimate of 31,000 rainbow trout listed in *Table 31* is the only year that a specific hydroacoustic date and estimate were reported).

The 1991-93 hydroacoustic estimates suggest that the reservoir trout population has increased roughly 75 percent annually over the past three years *(Table 31)*. In addition, the 1993 estimate is approximately 25 percent higher than the 1970's hydroacoustic average. (It should be noted that the fairly large confidence intervals associated with the 1991-93 hydroacoustic estimates should be treated with caution, while any future measurements should incorporate a larger number of sample transects to reduce variance associated with the estimate). However, catch and harvest rate information does not generally support an increase in the reservoir trout population. Overall HPUE shows a slight decrease from 1990-92 of 0.12, 0.10, and 0.11, respectively *(Table 25)*, while CPUE indicates a slight increase of 0.39 (Looff 1992a), 0.37 (Looff 1993a), and 0.43 *(Table 8)*. Overall 1990-92 CPUE is also less than the 1971-72 HPUE of 0.48 and 0.52, respectively, but similar to the 1985-86 HPUE of 0.33 and 0.41. (The 1990-92 overall CPUE estimates are used for comparison with the overall 1971-72 HPUE estimates, since 1990-92 <u>catch</u> would be roughly equivalent to 1971-72 <u>harvest</u>). Even though harvest and catch rates do not support a population increase, expanding numbers of younger (non-harvestable) age classes (age 2 and age 3) may be occurring in the reservoir.

Spawning Surveys

Spawning survey data conducted on selected tributary streams of Ross Reservoir from 1991 to 1993 continue to show an increase in the number of spawning rainbow trout *(Table 32)*. Spawning numbers increased from a total of 120 fish in 1991 (n=8 surveys), to a total of 660 and 1,294 fish in 1992 (n=7 surveys) and 1993 (n=7 surveys), respectively (instream counts only). 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 Park Service employee on June 13, 1986 (National Park Service letter from Gary Mason to Washington Department of

TABLE 31. Population estimates of Ross-Skagit system rainbow trout in 1971-73, and 1991-93.

| Year | Estimate | 95% CI | 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 | ± 6,846[b] | Hydroacoustic | Looff (1992a) |
| 1992 | 37,082 | ± 10,636[b] | Hydroacoustic | Looff (1993a) |
| 1993 | 60,857 | ± 12,437 | Hydroacoustic | |

[a]One estimate. See text for explanation.

[b]Confidence intervals were incorrectly reported in earlier reports.

TABLE 32. Number of spawning rainbow trout observed in selected tributaries of Ross Reservoir from 1991 to 1993.

| Tributary | Number of Rainbow Trout[a] | | | | | |
|---|---|---|---|---|---|---|
| | 1991[b] | | 1992[c] | | 1993[d] | |
| Dry | 8 | (8) | 155 | (126) | 345 | (305) |
| Lightning | 51 | (0) | 1554 | (29) | 963 | (15) |
| Pierce | 5 | (2) | 30 | (30) | 95 | (42) |
| Roland | 107 | (107) | 597 | (447) | 1012 | (897) |
| Thursday | 3 | (3) | 64 | (28) | 49 | (35) |
| Total | 174 | (120) | 2400 | (660) | 2464 | (1294) |

[a]Counts include fish observed milling in the immediate vicinity of mouth to upstream migration barrier. Counts from drawdown elevation to upstream migration barrier (instream counts only) given in parentheses.

[b]1991 = eight surveys.

[c]1992 = seven surveys

[d]1993 = seven surveys

Wildlife area fisheries biologist Jim Johnston). Excessive and prolonged spring and early summer runoff during 1991 may have prevented most fish from ascending tributary streams to spawn that year, as well as reducing survival of any eggs that may have been deposited. However, very few fish were observed milling off stream mouths during the 1991 surveys, suggesting a depressed rainbow trout spawning population.

All five tributaries recorded increases in numbers of spawning rainbow trout from 1991 to 1993 *(Table 32)*. Roland Creek recorded the largest number of (instream) spawners during all three annual surveys, and continues to be the best index stream based on spawner use, flow, available spawning habitat, and accessibility. Dry Creek is another excellent index stream that should continue to be included in future surveys. As well as recording the second highest spawner totals, Dry Creek registered the greatest percentage increase (3,800 percent) over the three year survey period. Pierce and Thursday Creeks also recorded marked spawning increases, even though total numbers remain low due to migration barriers located near the mouth of each tributary. Total (instream) numbers on Lightning Creek are difficult to determine due to stream size and flow. In addition, a substantial number of fish probably spawn in the lake immediately adjacent to the stream mouth.

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Continuation of the 1990-91, 1991-92, and 1992-93 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 1989-1992 Ross Lake fishing regulations.

1990-1992

| | Washington State | British Columbia |
|---|---|---|
| *Season:* | 07/01 - 10/31 | |
| *Catch limit:* | three | |
| *Size limit[a]:* | thirteen inch minimum size for all species[b] | 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[c]:* | no more than three over 14 inches | |
| *Possession limit:* | eight | four |
| *Gear restriction:* | none | none |

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

[b]Twenty-inch minimum size restriction for dolly varden/bull trout char in 1992.

[c]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 1992 sport fishing season at Ross Reservoir.

| Month | Day[a] | Daytype[b] | Work Period Start | Work Period Finish | Effort Count 1 | Effort Count 2 |
|---|---|---|---|---|---|---|
| July | 1 | OD | 0800 | 1600 | 0800 | 1300 |
| | 4 | WE | 0700 | 1500 | 0700 | 1200 |
| | 5 | WE | 0600 | 1400 | 0600 | 1100 |
| | 12 | WE | 0800 | 1600 | 0800 | 1300 |
| | 13 | WD | 1000 | 1800 | 1000 | 1500 |
| | 14 | WD | 0700 | 1500 | 0700 | 1200 |
| | 17 | WD | 1200 | 2000 | 1200 | 1700 |
| | 18 | WE | 0700 | 1500 | 0700 | 1200 |
| | 19 | WE | 1100 | 1900 | 1100 | 1600 |
| | 28 | WD | 0800 | 1600 | 0800 | 1200 |
| | 29 | WD | 0900 | 1700 | 0900 | 1400 |
| | 30 | WD | 0600 | 1400 | 0600 | 1000 |
| August | 4 | WD | 1000 | 1800 | 1000 | 1400 |
| | 5 | WD | 0800 | 1600 | 0800 | 1000 |
| | 6 | WD | 0800 | 1600 | 0800 | 1000 |
| | 10 | WD | 0700 | 1500 | 0700 | 0900 |
| | 11 | WD | 0900 | 1700 | 0900 | 1200 |
| | 12 | WD | 0800 | 1600 | 0800 | 1100 |
| | 14 | WD | 1000 | 1800 | 1000 | 1100 |
| | 15 | WE | 1100 | 1900 | 1100 | 1400 |
| | 16 | WE | 1100 | 1900 | 1100 | 1300 |
| | 22 | WE | 1000 | 1800 | 1000 | 1300 |
| | 23 | WE | 1000 | 1800 | 1000 | 1200 |
| | 24 | WD | 1000 | 1800 | 1000 | 1200 |
| September | 6 | WE | 0800 | 1600 | 0800 | 1100 |
| | 7 | WE | 0800 | 1600 | 0800 | 0900 |
| | 8 | WD | 0800 | 1600 | 0800 | 0900 |
| | 11 | WD | 0900 | 1700 | 0900 | 1000 |
| | 12 | WE | 1000 | 1800 | 1000 | 1100 |
| | 13 | WE | 1000 | 1800 | 1000 | 1100 |
| | 18 | WD | 0800 | 1600 | 1000 | 1100 |
| | 19 | WE | 1100 | 1900 | 1100 | 1200 |
| | 20 | WE | 0800 | 1600 | 0800 | 0900 |
| | 21 | WD | 0900 | 1700 | 0900 | 1000 |
| | 22 | WD | 0800 | 1600 | 0800 | 0900 |
| | 23 | WD | 0800 | 1600 | 0800 | 0900 |

APPENDIX 2. (Continued)

| Month | Day[a] | Daytype[b] | Work Period Start | Work Period Finish | Effort Count 1 | Effort Count 2 |
|---|---|---|---|---|---|---|
| October | 3 | WE | 0900 | 1700 | 0900 | 1000 |
| | 4 | WE | 1000 | 1800 | 1000 | 1100 |
| | 5 | WD | 1000 | 1800 | 1000 | 1100 |
| | 9 | WD | 0900 | 1700 | 0900 | 1000 |
| | 10 | WE | 1000 | 1800 | 1000 | 1100 |
| | 11 | WE | 0900 | 1700 | 0900 | 1000 |
| | 14 | WD | 1000 | 1800 | 1600 | 1700 |
| | 15 | WD | 0900 | 1700 | 0900 | 1000 |
| | 16 | WD | 1000 | 1800 | 1000 | 1100 |
| | 21 | WD | 0900 | 1700 | 0900 | 1000 |
| | 22 | WD | 1000 | 1800 | 1000 | 1100 |
| | 23 | WD | 1000 | 1800 | 1300 | 1400 |

[a]Two holidays, July 4 (Independence Day) and September 7 (Labor Day), were treated as weekend days, even though Labor Day was observed during midweek in 1992 (see text).

[b]OD=opening day
WD=weekday
WE=weekend day

APPENDIX 3. Estimated monthly and seasonal angler effort by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| Month | Daytype | Angler Hours[a] | | Mean Hours Fished per Day[b] | Total Angler Days[c] |
|---|---|---|---|---|---|
| Jul | Opener | 616 | (0) | 5.67 | 109 |
| | Weekday | 5306 | (466) | 3.88 | 1368 |
| | Weekend | 3255 | (693) | 4.79 | 679 |
| | Total | 9177 | (763) | 4.26 | 2155 |
| Aug | Weekday | 3321 | (858) | 4.06 | 817 |
| | Weekend | 2758 | (464) | 4.69 | 588 |
| | Total | 6079 | (926) | 4.33 | 1405 |
| Sep | Weekday | 3591 | (872) | 3.69 | 973 |
| | Weekend | 2511 | (87) | 4.31 | 583 |
| | Total | 6102 | (750) | 3.92 | 1555 |
| Oct | Weekday | 1980 | (0) | 5.33 | 371 |
| | Weekend | 2033 | (1305) | 4.72 | 431 |
| | Total | 4013 | (1248) | 5.00 | 802 |
| Ssn | Opener | 616 | (0) | 5.67 | 109 |
| | Weekday | 14198 | (1152) | 4.02 | 3529 |
| | Weekend | 10556 | (1346) | 4.63 | 2281 |
| | Total | 25370 | (1735) | 4.29 | 5918 |

[a]Ninety-five percent confidence interval of estimated total angler-hours given in parentheses.

[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, 1992.

| Month | Daytype | Angler Hours[b] | | Mean Hours Fished per Day[c] | Total Angler Days[d] |
|---|---|---|---|---|---|
| Jul | 1 Rby | 1488 | (579) | 3.97 | 375 |
| | 2 Bbv | 2568 | (398) | 5.62 | 457 |
| | 3 Dev | 692 | (310) | 6.97 | 99 |
| | 4 Lit | 605 | (243) | 6.73 | 90 |
| | 5 Lbv | 1514 | (324) | 4.86 | 312 |
| | 6 Hoz | 2251 | (663) | 3.39 | 664 |
| | 7 Can | 168 | (103) | 6.50 | 26 |
| | Total | 9286 | (1044) | 4.59 | 2023 |
| Aug | 1 Rby | 744 | (317) | 3.39 | 220 |
| | 2 Bbv | 2660 | (907) | 4.29 | 620 |
| | 3 Dev | 1389 | (845) | 6.19 | 224 |
| | 4 Lit | 354 | (258) | 3.65 | 97 |
| | 5 Lbv | 382 | (286) | 4.05 | 94 |
| | 6 Hoz | 266 | (202) | 2.75 | 97 |
| | 7 Can | 253 | (292) | 4.05 | 62 |
| | Total | 6048 | (1319) | 4.28 | 1415 |
| Sep | 1 Rby | 444 | (268) | 2.51 | 177 |
| | 2 Bbv | 1962 | (617) | 3.91 | 501 |
| | 3 Dev | 1260 | (470) | 5.32 | 237 |
| | 4 Lit | 888 | (200) | 4.93 | 180 |
| | 5 Lbv | 1818 | (339) | 8.38 | 217 |
| | 6 Hoz | 420 | (182) | 3.00 | 140 |
| | 7 Can | 0 | (0) | 4.67 | 0 |
| | Total | 6792 | (839) | 4.68 | 1452 |
| Oct | 1 Rby | 357 | (483) | 4.02 | 89 |
| | 2 Bbv | 1938 | (692) | 5.00 | 387 |
| | 3 Dev | 884 | (461) | 7.52 | 117 |
| | 4 Lit | 93 | (151) | 8.00 | 12 |
| | 5 Lbv | 450 | (709) | 6.14 | 73 |
| | 6 Hoz | 1597 | (1205) | 6.14 | 260 |
| | 7 Can | 0 | (0) | 6.14 | 0 |
| | Total | 5317 | (1502) | 5.67 | 938 |
| Ssn | 1 Rby | 3033 | (802) | 3.53 | 860 |
| | 2 Bbv | 9127 | (1264) | 4.64 | 1966 |
| | 3 Dev | 4224 | (1048) | 6.23 | 678 |
| | 4 Lit | 1940 | (409) | 5.12 | 379 |
| | 5 Lbv | 4164 | (811) | 5.98 | 696 |
| | 6 Hoz | 4534 | (1265) | 3.90 | 1161 |
| | 7 Can | 421 | (298) | 4.77 | 88 |
| | Total | 27442 | (2383) | 4.71 | 5828 |

[a]See *Figure 3* for location of lake survey zones.
[b]Ninety-five percent confidence interval of estimated total angler-hours given in parentheses.
[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* in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| Month | Daytype | Angler Hours[b] | | Mean Hours Fished per Day[c] | Total Angler Days[d] |
|---|---|---|---|---|---|
| Jul | Resort | 5353 | (471) | 5.42 | 988 |
| | Hozomeen | 3765 | (790) | 3.78 | 997 |
| | Canada | 168 | (103) | 6.50 | 26 |
| | Total | 9286 | (890) | 4.62 | 2011 |
| Aug | Resort | 5147 | (1575) | 4.42 | 1165 |
| | Hozomeen | 648 | (390) | 2.75 | 236 |
| | Canada | 253 | (292) | 3.74 | 68 |
| | Total | 6048 | (1589) | 4.12 | 1469 |
| Sep | Resort | 4554 | (811) | 4.05 | 1126 |
| | Hozomeen | 2238 | (419) | 5.69 | 393 |
| | Canada | 0 | (0) | 4.87 | 0 |
| | Total | 6792 | (842) | 4.47 | 1519 |
| Oct | Resort | 3271 | (1561) | 5.14 | 637 |
| | Hozomeen | 2046 | (1471) | 5.14 | 398 |
| | Canada | 0 | (0) | 5.14 | 0 |
| | Total | 5317 | (1939) | 5.14 | 1035 |
| Ssn | Resort | 18324 | (2224) | 4.68 | 3916 |
| | Hozomeen | 8698 | (1596) | 4.30 | 2025 |
| | Canada | 421 | (298) | 4.50 | 93 |
| | Total | 27442 | (2721) | 4.55 | 6034 |

*See *Figure 3* for location of access areas.

[b]Ninety-five percent confidence interval of estimated total angler-hours given in parentheses.

[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 captures per hour for rainbow trout by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| Month | Daytype | N[b] | Rainbow Trout Captures per Hour[a] Harvested | | Released | | Total | |
|---|---|---|---|---|---|---|---|---|
| Jul | Opener | 58 | .256 | (.006) | .925 | (.036) | 1.180 | (.039) |
| | Weekday | 83 | .090 | (.004) | .171 | (.006) | .261 | (.007) |
| | Weekend | 138 | .116 | (.003) | .256 | (.004) | .372 | (.006) |
| | Mean | | .145 | (.001) | .402 | (.005) | .547 | (.006) |
| Aug | Weekday | 108 | .050 | (.002) | .203 | (.006) | .253 | (.007) |
| | Weekend | 91 | .061 | (.003) | .150 | (.005) | .211 | (.008) |
| | Mean | | .055 | (.001) | .177 | (.003) | .232 | (.004) |
| Sep | Weekday | 69 | .094 | (.005) | .220 | (.010) | .314 | (.012) |
| | Weekend | 118 | .088 | (.003) | .319 | (.005) | .407 | (.007) |
| | Mean | | .090 | (.002) | .286 | (.004) | .376 | (.004) |
| Oct | Weekday | 88 | .104 | (.003) | .435 | (.010) | .539 | (.012) |
| | Weekend | 41 | .103 | (.007) | .253 | (.012) | .357 | (.016) |
| | Mean | | .104 | (.002) | .382 | (.006) | .486 | (.008) |
| Ssn | Opener | 58 | .256 | (.006) | .925 | (.036) | 1.180 | (.039) |
| | Weekday | 348 | .084 | (.001) | .272 | (.002) | .356 | (.003) |
| | Weekend | 388 | .094 | (.001) | .248 | (.001) | .342 | (.002) |
| | Mean | | .104 | (.000) | .320 | (.001) | .424 | (.002) |

[a]Ninety-five percent confidence interval of estimated mean captures per hour given in parentheses.

[b]Number of anglers surveyed.

APPENDIX 7. Estimated monthly and seasonal mean captures per hour for rainbow trout by lake zone[a] in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| Month | Zone | N[c] | Rainbow Trout Captures per Hour[b] Harvested | | Released | | Total | |
|---|---|---|---|---|---|---|---|---|
| Jul | 1 Rby | 50 | .207 | (.011) | .650 | (.059) | .856 | (.065) |
| | 2 Bbv | 66 | .186 | (.005) | .351 | (.013) | .537 | (.016) |
| | 3 Dev | 27 | .112 | (.012) | .308 | (.029) | .420 | (.038) |
| | 4 Lit | 13 | .069 | (.021) | .229 | (.032) | .297 | (.046) |
| | 5 Lbv | 32 | .096 | (.010) | .392 | (.047) | .489 | (.050) |
| | 6 Hoz | 90 | .125 | (.005) | .426 | (.010) | .551 | (.011) |
| | 7 Can | 1 | .000 | | .000 | | .000 | |
| | Mean | | .145 | (.001) | .402 | (.005) | .547 | (.006) |
| Aug | 1 Rby | 39 | .023 | (.004) | .152 | (.016) | .174 | (.017) |
| | 2 Bbv | 98 | .067 | (.003) | .207 | (.006) | .273 | (.007) |
| | 3 Dev | 37 | .057 | (.006) | .140 | (.013) | .197 | (.017) |
| | 4 Lit | 17 | .048 | (.023) | .194 | (.051) | .242 | (.066) |
| | 5 Lbv | 0 | 0 | | 0 | | 0 | |
| | 6 Hoz | 8 | .045 | (.038) | .091 | (.050) | .136 | (.079) |
| | 7 Can | 0 | 0 | | 0 | | 0 | |
| | Mean | | .055 | (.001) | .177 | (.003) | .232 | (.004) |
| Sep | 1 Rby | 28 | .071 | (.011) | .285 | (.033) | .356 | (.035) |
| | 2 Bbv | 103 | .077 | (.003) | .298 | (.006) | .375 | (.007) |
| | 3 Dev | 28 | .081 | (.010) | .228 | (.019) | .309 | (.024) |
| | 4 Lit | 24 | .169 | (.020) | .347 | (.034) | .516 | (.044) |
| | 5 Lbv | 2 | .060 | (.432) | .060 | (.640) | .119 | (.208) |
| | 6 Hoz | 2 | .000 | | .333 | (.000) | .333 | (.000) |
| | 7 Can | 0 | 0 | | 0 | | 0 | |
| | Mean | | .090 | (.002) | .286 | (.004) | .376 | (.004) |
| Oct | 1 Rby | 26 | .067 | (.011) | .297 | (.031) | .364 | (.036) |
| | 2 Bbv | 87 | .108 | (.004) | .407 | (.010) | .515 | (.012) |
| | 3 Dev | 11 | .157 | (.026) | .495 | (.061) | .653 | (.076) |
| | 4 Lit | 5 | .050 | (.036) | .100 | (.082) | .150 | (.096) |
| | 5 Lbv | 0 | 0 | | 0 | | 0 | |
| | 6 Hoz | 0 | 0 | | 0 | | 0 | |
| | 7 Can | 0 | 0 | | 0 | | 0 | |
| | Mean | | .104 | (.002) | .382 | (.006) | .486 | (.008) |
| Ssn | 1 Rby | 143 | .111 | (.003) | .396 | (.015) | .507 | (.016) |
| | 2 Bbv | 354 | .107 | (.001) | .315 | (.002) | .423 | (.003) |
| | 3 Dev | 103 | .091 | (.003) | .254 | (.006) | .345 | (.008) |
| | 4 Lit | 59 | .101 | (.006) | .250 | (.011) | .351 | (.014) |
| | 5 Lbv | 34 | .093 | (.008) | .360 | (.042) | .453 | (.044) |
| | 6 Hoz | 100 | .117 | (.004) | .402 | (.009) | .520 | (.010) |
| | 7 Can | 1 | .000 | | .000 | | .000 | |
| | Mean | | .104 | (.000) | .320 | (.001) | .424 | (.002) |

[a]See *Figure 3* for location of lake survey zones.
[b]Ninety-five percent confidence interval of estimated mean captures per hour given in parentheses.
[c]Number of anglers surveyed.

APPENDIX 8. Estimated monthly and seasonal mean captures per hour for rainbow trout by access area[a] in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| | | | Rainbow Trout Captures per Hour[b] | | | | | |
|---|---|---|---|---|---|---|---|---|
| Month | Zone | N[c] | Harvested | | Released | | Total | |
| Jul | Resort | 158 | .161 | (.002) | .394 | (.009) | .555 | (.010) |
| | Hozomeen | 120 | .114 | (.003) | .425 | (.010) | .539 | (.011) |
| | Canada | 1 | .000 | | .000 | | .000 | |
| | Mean | | .145 | (.001) | .402 | (.005) | .547 | (.006) |
| Aug | Resort | 191 | .056 | (.001) | .179 | (.003) | .235 | (.004) |
| | Hozomeen | 8 | .045 | (.038) | .091 | (.050) | .136 | (.079) |
| | Canada | 0 | 0 | | 0 | | 0 | |
| | Mean | | .055 | (.001) | .177 | (.003) | .232 | (.004) |
| Sep | Resort | 185 | .091 | (.002) | .285 | (.004) | .376 | (.004) |
| | Hozomeen | 2 | .000 | | .333 | (.000) | .333 | (.000) |
| | Canada | 0 | 0 | | 0 | | 0 | |
| | Mean | | .090 | (.002) | .286 | (.004) | .376 | (.004) |
| Oct | Resort | 129 | .104 | (.002) | .382 | (.006) | .486 | (.008) |
| | Hozomeen | 0 | 0 | | 0 | | 0 | |
| | Canada | 0 | 0 | | 0 | | 0 | |
| | Mean | | .104 | (.002) | .382 | (.006) | .486 | (.008) |
| Ssn | Resort | 663 | .104 | (.001) | .308 | (.001) | .411 | (.002) |
| | Hozomeen | 130 | .110 | (.003) | .408 | (.009) | .517 | (.010) |
| | Canada | 1 | .000 | | .000 | | .000 | |
| | Mean | | .104 | (.000) | .320 | (.001) | .424 | (.002) |

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

[b]Ninety-five percent confidence interval of estimated mean captures per hour given in parentheses.

[c]Number of anglers surveyed.

APPENDIX 9. Estimated monthly and seasonal mean captures per hour for dolly varden/bull trout char by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| | | | Dolly Varden/Bull Trout Captures per Hour[a] | | | | | |
|---|---|---|---|---|---|---|---|---|
| Month | Daytype | N[b] | Harvested | | Released | | Total | |
| Jul | Opener | 58 | 0 | | 0 | | 0 | |
| | Weekday | 83 | 0 | | .003 | (.001) | .003 | (.001) |
| | Weekend | 138 | 0 | | 0 | | 0 | |
| | Mean | | 0 | | .001 | (.000) | .001 | (.000) |
| Aug | Weekday | 108 | 0 | | 0 | | 0 | |
| | Weekend | 91 | .002 | (.000) | 0 | | .002 | (.000) |
| | Mean | | .001 | (.000) | 0 | | .001 | (.000) |
| Sep | Weekday | 69 | 0 | | 0 | | 0 | |
| | Weekend | 118 | 0 | | 0 | | 0 | |
| | Mean | | 0 | | 0 | | 0 | |
| Oct | Weekday | 88 | 0 | | 0 | | 0 | |
| | Weekend | 41 | 0 | | 0 | | 0 | |
| | Mean | | 0 | | 0 | | 0 | |
| Ssn | Opener | 58 | 0 | | 0 | | 0 | |
| | Weekday | 348 | 0 | | .001 | (.000) | .001 | (.000) |
| | Weekend | 388 | .001 | (.000) | 0 | | .001 | (.000) |
| | Mean | | .000 | (.000) | .000 | (.000) | .001 | (.000) |

[a]Ninety-five percent confidence interval of estimated mean captures per hour given in parentheses.

[b]Number of anglers surveyed.

APPENDIX 10. Estimated monthly and seasonal mean captures per hour for cutthroat trout by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| Month | Daytype | N[b] | Cutthroat Trout Captures per Hour[a] Harvested | Released | Total |
|---|---|---|---|---|---|
| Jul | Opener | 58 | 0 | 0 | 0 |
| | Weekday | 83 | 0 | 0 | 0 |
| | Weekend | 138 | 0 | 0 | 0 |
| | Mean | | 0 | 0 | 0 |
| Aug | Weekday | 108 | 0 | 0 | 0 |
| | Weekend | 91 | 0 | 0 | 0 |
| | Mean | | 0 | 0 | 0 |
| Sep | Weekday | 69 | 0 | 0 | 0 |
| | Weekend | 118 | 0 | 0 | 0 |
| | Mean | | 0 | 0 | 0 |
| Oct | Weekday | 88 | .002 (.000) | 0 | .002 (.000) |
| | Weekend | 41 | 0 | 0 | 0 |
| | Mean | | .002 (.000) | 0 | .002 (.000) |
| Ssn | Opener | 58 | 0 | 0 | 0 |
| | Weekday | 348 | .001 (.000) | 0 | .001 (.000) |
| | Weekend | 388 | 0 | 0 | 0 |
| | Mean | | .000 (.000) | 0 | .000 (.000) |

[a]Ninety-five percent confidence interval of estimated mean captures per hour given in parentheses.

[b]Number of anglers surveyed.

APPENDIX 11. Estimated monthly and seasonal mean captures per hour for all trout and char species by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| Month | Daytype | N[b] | Trout and Char Captures per Hour[a] Harvested | Released | Total |
|---|---|---|---|---|---|
| Jul | Opener | 58 | .256 (.006) | .925 (.036) | 1.180 (.039) |
| | Weekday | 83 | .090 (.004) | .174 (.006) | .264 (.008) |
| | Weekend | 138 | .116 (.003) | .256 (.004) | .372 (.006) |
| | Mean | | .145 (.001) | .403 (.005) | .548 (.006) |
| Aug | Weekday | 108 | .050 (.002) | .203 (.006) | .253 (.007) |
| | Weekend | 91 | .063 (.003) | .150 (.005) | .213 (.008) |
| | Mean | | .057 (.001) | .177 (.003) | .233 (.004) |
| Sep | Weekday | 69 | .094 (.005) | .220 (.010) | .314 (.012) |
| | Weekend | 118 | .088 (.003) | .319 (.005) | .407 (.007) |
| | Mean | | .090 (.002) | .286 (.004) | .376 (.004) |
| Oct | Weekday | 88 | .107 (.003) | .435 (.010) | .542 (.012) |
| | Weekend | 41 | .103 (.007) | .253 (.012) | .357 (.016) |
| | Mean | | .106 (.002) | .382 (.006) | .488 (.008) |
| Ssn | Opener | 58 | .256 (.006) | .925 (.036) | 1.180 (.039) |
| | Weekday | 348 | .084 (.001) | .273 (.002) | .357 (.003) |
| | Weekend | 388 | .094 (.001) | .248 (.001) | .342 (.002) |
| | Mean | | .105 (.000) | .320 (.001) | .425 (.002) |

[a]Ninety-five percent confidence interval of estimated mean captures per hour given in parentheses.

[b]Number of anglers surveyed.

APPENDIX 12. Monthly and seasonal estimates of rainbow trout captured by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| Month | Daytype | Rainbow Trout Captured* | | | | | |
|---|---|---|---|---|---|---|---|
| | | Harvested | | Released | | Total | |
| Jul | Opener | 157 | (4) | 570 | (23) | 727 | (23) |
| | Weekday | 478 | (44) | 906 | (79) | 1384 | (90) |
| | Weekend | 379 | (70) | 832 | (154) | 1211 | (169) |
| | Total | 1014 | (82) | 2308 | (172) | 3322 | (191) |
| Aug | Weekday | 167 | (41) | 674 | (164) | 840 | (169) |
| | Weekend | 168 | (25) | 414 | (61) | 582 | (66) |
| | Total | 335 | (48) | 1087 | (174) | 1422 | (180) |
| Sep | Weekday | 338 | (68) | 789 | (156) | 1128 | (170) |
| | Weekend | 222 | (9) | 800 | (25) | 1022 | (27) |
| | Total | 561 | (67) | 1589 | (154) | 2150 | (168) |
| Oct | Weekday | 207 | (7) | 861 | (20) | 1068 | (21) |
| | Weekend | 210 | (119) | 515 | (289) | 725 | (313) |
| | Total | 417 | (115) | 1376 | (281) | 1793 | (303) |
| Ssn | Opener | 157 | (4) | 570 | (23) | 727 | (23) |
| | Weekday | 1190 | (89) | 3231 | (236) | 4420 | (252) |
| | Weekend | 979 | (135) | 2560 | (322) | 3539 | (349) |
| | Total | 2326 | (161) | 6360 | (398) | 8687 | (430) |

*Ninety-five percent confidence interval of estimated captures given in parentheses.

APPENDIX 13. Monthly and seasonal estimates of rainbow trout captured by lake zone[a] in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| | | Rainbow Trout Captured[b] | | | | | |
|---|---|---|---|---|---|---|---|
| Month | Zone | Harvested | | Released | | Total | |
| Jul | 1 Rby | 307 | (118) | 967 | (379) | 1274 | (397) |
| | 2 Bbv | 478 | (73) | 901 | (139) | 1378 | (158) |
| | 3 Dev | 77 | (35) | 213 | (97) | 290 | (103) |
| | 4 Lit | 41 | (21) | 138 | (60) | 180 | (63) |
| | 5 Lbv | 146 | (34) | 594 | (144) | 740 | (148) |
| | 6 Hoz | 280 | (80) | 960 | (274) | 1240 | (285) |
| | 7 Can | 0 | | 0 | | 0 | |
| | Total | 1330 | (165) | 3772 | (507) | 5103 | (533) |
| Aug | 1 Rby | 17 | (8) | 113 | (49) | 130 | (49) |
| | 2 Bbv | 177 | (59) | 550 | (182) | 727 | (191) |
| | 3 Dev | 79 | (48) | 194 | (118) | 273 | (127) |
| | 4 Lit | 17 | (15) | 68 | (53) | 86 | (56) |
| | 5 Lbv | 0 | | 0 | | 0 | |
| | 6 Hoz | 12 | (13) | 24 | (22) | 36 | (26) |
| | 7 Can | 0 | | 0 | | 0 | |
| | Total | 302 | (77) | 950 | (225) | 1252 | (237) |
| Sep | 1 Rby | 32 | (19) | 126 | (74) | 158 | (76) |
| | 2 Bbv | 151 | (44) | 584 | (168) | 735 | (173) |
| | 3 Dev | 101 | (38) | 288 | (105) | 389 | (112) |
| | 4 Lit | 150 | (37) | 308 | (73) | 458 | (82) |
| | 5 Lbv | 109 | (153) | 109 | (225) | 217 | (272) |
| | 6 Hoz | 0 | | 140 | (67) | 140 | (67) |
| | 7 Can | 0 | | 0 | | 0 | |
| | Total | 543 | (141) | 1555 | (288) | 2097 | (321) |
| Oct | 1 Rby | 24 | (30) | 106 | (134) | 130 | (137) |
| | 2 Bbv | 209 | (67) | 788 | (251) | 997 | (260) |
| | 3 Dev | 139 | (75) | 438 | (231) | 577 | (243) |
| | 4 Lit | 5 | (8) | 9 | (17) | 14 | (19) |
| | 5 Lbv | 0 | | 0 | | 0 | |
| | 6 Hoz | 0 | | 0 | | 0 | |
| | 7 Can | 0 | | 0 | | 0 | |
| | Total | 377 | (98) | 1341 | (346) | 1717 | (360) |
| Ssn | 1 Rby | 380 | (121) | 1312 | (400) | 1692 | (418) |
| | 2 Bbv | 1015 | (121) | 2823 | (372) | 3838 | (391) |
| | 3 Dev | 396 | (96) | 1132 | (273) | 1529 | (289) |
| | 4 Lit | 213 | (43) | 524 | (104) | 737 | (113) |
| | 5 Lbv | 255 | (130) | 703 | (233) | 957 | (267) |
| | 6 Hoz | 293 | (81) | 1124 | (278) | 1416 | (289) |
| | 7 Can | 0 | | 0 | | 0 | |
| | Total | 2552 | (249) | 7617 | (711) | 10169 | (753) |

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

[b]Ninety-five percent confidence interval of estimated captures given in parentheses.

APPENDIX 14. Monthly and seasonal estimates of rainbow trout captured by access area[a] in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| | | Rainbow Trout Captured[b] | | | | | |
|---|---|---|---|---|---|---|---|
| Month | Access | Harvested | | Released | | Total | |
| Jul | Resort | 860 | (74) | 2111 | (184) | 2972 | (198) |
| | Hozomeen | 431 | (88) | 1600 | (325) | 2031 | (337) |
| | Canada | 0 | | 0 | | 0 | |
| | Total | 1291 | (114) | 3711 | (370) | 5003 | (387) |
| Aug | Resort | 287 | (84) | 921 | (270) | 1208 | (283) |
| | Hozomeen | 29 | (29) | 59 | (47) | 88 | (55) |
| | Canada | 0 | | 0 | | 0 | |
| | Total | 316 | (88) | 980 | (273) | 1297 | (287) |
| Sep | Resort | 415 | (67) | 1299 | (209) | 1714 | (220) |
| | Hozomeen | 0 | | 746 | (155) | 746 | (155) |
| | Canada | 0 | | 0 | | 0 | |
| | Total | 415 | (67) | 2045 | (244) | 2460 | (253) |
| Oct | Resort | 341 | (144) | 1249 | (526) | 1590 | (545) |
| | Hozomeen | 0 | | 0 | | 0 | |
| | Canada | 0 | | 0 | | 0 | |
| | Total | 341 | (143) | 1249 | (525) | 1590 | (544) |
| Ssn | Resort | 1903 | (192) | 5580 | (646) | 7483 | (673) |
| | Hozomeen | 460 | (91) | 2405 | (350) | 2866 | (362) |
| | Canada | 0 | | 0 | | 0 | |
| | Total | 2363 | (212) | 7986 | (732) | 10349 | (762) |

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

[b]Ninety-five percent confidence interval of estimated captures given in parentheses.

APPENDIX 15. Monthly and seasonal estimates of dolly varden/bull trout char captured by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| | | Dolly Varden/Bull Trout Captured* | | | | | |
|---|---|---|---|---|---|---|---|
| Month | Daytype | Harvested | | Released | | Total | |
| Jul | Opener | 0 | | 0 | | 0 | |
| | Weekday | 0 | | 16 | (4) | 16 | (4) |
| | Weekend | 0 | | 0 | | 0 | |
| | Total | 0 | | 16 | (4) | 16 | (4) |
| Aug | Weekday | 0 | | 0 | | 0 | |
| | Weekend | 6 | (2) | 0 | | 6 | (2) |
| | Total | 6 | (2) | 0 | | 6 | (2) |
| Sep | Weekday | 0 | | 0 | | 0 | |
| | Weekend | 0 | | 0 | | 0 | |
| | Total | 0 | | 0 | | 0 | |
| Oct | Weekday | 0 | | 0 | | 0 | |
| | Weekend | 0 | | 0 | | 0 | |
| | Total | 0 | | 0 | | 0 | |
| Ssn | Opener | 0 | | 0 | | 0 | |
| | Weekday | 0 | | 16 | (4) | 16 | (4) |
| | Weekend | 6 | (2) | 0 | | 6 | (2) |
| | Total | 6 | (2) | 16 | (4) | 23 | (4) |

*Ninety-five percent confidence interval of estimated captures given in parentheses.

APPENDIX 16. Monthly and seasonal estimates of cutthroat trout captured by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| Month | Daytype | Cutthroat Trout Captured* Harvested | | Released | Total | |
|---|---|---|---|---|---|---|
| Jul | Opener | 0 | | 0 | 0 | |
| | Weekday | 0 | | 0 | 0 | |
| | Weekend | 0 | | 0 | 0 | |
| | Total | 0 | | 0 | 0 | |
| Aug | Weekday | 0 | | 0 | 0 | |
| | Weekend | 0 | | 0 | 0 | |
| | Total | 0 | | 0 | 0 | |
| Sep | Weekday | 0 | | 0 | 0 | |
| | Weekend | 0 | | 0 | 0 | |
| | Total | 0 | | 0 | 0 | |
| Oct | Weekday | 4 | (1) | 0 | 4 | (1) |
| | Weekend | 0 | | 0 | 0 | |
| | Total | 4 | (1) | 0 | 4 | (1) |
| Ssn | Opener | 0 | | 0 | 0 | |
| | Weekday | 4 | (1) | 0 | 4 | (1) |
| | Weekend | 0 | | 0 | 0 | |
| | Total | 4 | (1) | 0 | 4 | (1) |

*Ninety-five percent confidence interval of estimated captures given in parentheses.

APPENDIX 17. Monthly and seasonal estimates of trout and char captured by daytype in the Ross Reservoir sport fishery, July 1 to October 31, 1992.

| Month | Daytype | Trout and Char Captured* | | | | | |
|---|---|---|---|---|---|---|---|
| | | Harvested | | Released | | Total | |
| Jul | Opener | 157 | (4) | 570 | (23) | 727 | (23) |
| | Weekday | 478 | (44) | 923 | (80) | 1401 | (91) |
| | Weekend | 379 | (70) | 832 | (154) | 1211 | (169) |
| | Total | 1014 | (82) | 2324 | (173) | 3339 | (191) |
| Aug | Weekday | 167 | (41) | 674 | (164) | 840 | (169) |
| | Weekend | 174 | (26) | 414 | (61) | 588 | (66) |
| | Total | 341 | (48) | 1087 | (174) | 1428 | (180) |
| Sep | Weekday | 338 | (68) | 789 | (156) | 1128 | (170) |
| | Weekend | 222 | (9) | 800 | (25) | 1022 | (27) |
| | Total | 561 | (67) | 1589 | (154) | 2150 | (168) |
| Oct | Weekday | 211 | (7) | 861 | (20) | 1072 | (21) |
| | Weekend | 210 | (119) | 515 | (289) | 725 | (313) |
| | Total | 421 | (115) | 1376 | (281) | 1797 | (303) |
| Ssn | Opener | 157 | (4) | 570 | (23) | 727 | (23) |
| | Weekday | 1194 | (89) | 3247 | (236) | 4441 | (252) |
| | Weekend | 986 | (136) | 2560 | (322) | 3546 | (349) |
| | Total | 2337 | (162) | 6377 | (399) | 8714 | (430) |

*Ninety-five percent confidence interval of estimated captures given in parentheses.

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