

ROSS LAKE RAINBOW TROUT STUDY

1991-92 PROGRESS REPORT

by

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ABSTRACT

The Washington Department of Wildlife conducted a rainbow trout study on Ross Reservoir from June 1, 1991 to May 31, 1992. This investigation was the second year of a proposed 5-year study to evaluate the effect of special sport fishing regulations (implemented at the beginning of the 1990 fishing season) on reversing a historic decline in size and numbers of rainbow trout at Ross Lake. Study objectives included estimation of harvest and catch statistics for all species of trout and char, analysis of rainbow trout life history information, estimation of the total size of the 1992 overwintering fish population, and evaluation of rainbow trout spawning timing and success in selected tributaries of Ross Lake. A stratified random sampling design was used to develop all effort, catch and harvest estimates.

Ross Lake anglers fished a total of 36,108 hours during the 1991 fishing season, or 8,777 angler days. The total seasonal rainbow trout harvest estimate was 3,833 fish, with a mean seasonal harvest rate of 0.103 fish per hour. Total catch (harvested + released) was estimated at 13,162 rainbow trout, with a mean catch rate of 0.366 fish per hour. The total seasonal dolly varden char, brook trout (char), and cutthroat trout harvest estimates were 13, 19, and 4 fish, respectively. Total catch was estimated at 25 dolly varden char, 29 brook trout (char), and 11 cutthroat trout.

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

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

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

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

Data collected from the 1990-91 and 1991-92 rainbow trout study on Ross Reservoir show the fish population is still suffering from the effects of past overharvest. These studies suggest the present rainbow trout population is still considerably below 1970's levels. Continued evaluation and monitoring of the fish and fishery in response to the new regulations are necessary to promote recovery of rainbow trout stocks in Ross Reservoir.

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INTRODUCTION

This report summarizes the results of an angler harvest and rainbow trout study conducted on Ross Reservoir from June 1, 1991 to May 31, 1992. This is the second year of an ongoing five-year study by the Washington State Department of Wildlife (WDW) to evaluate the effect of special fishery regulations designed to reverse the decline in size and numbers of rainbow trout in Ross Lake (Johnston 1989, Looff 1991, Looff 1992a). These regulations were implemented at the beginning of the 1990 sport fishing season by both the WDW and the British Columbia Division of Fish and Wildlife (BCF&W), and (with the exception of dolly varden char/bull trout) are identical for both agencies (*Appendix 1*).

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

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

Previous Studies

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

Study Area

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

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

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

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

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

Objectives

The specific objectives of the 1991-92 Ross Lake study were as follows:

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

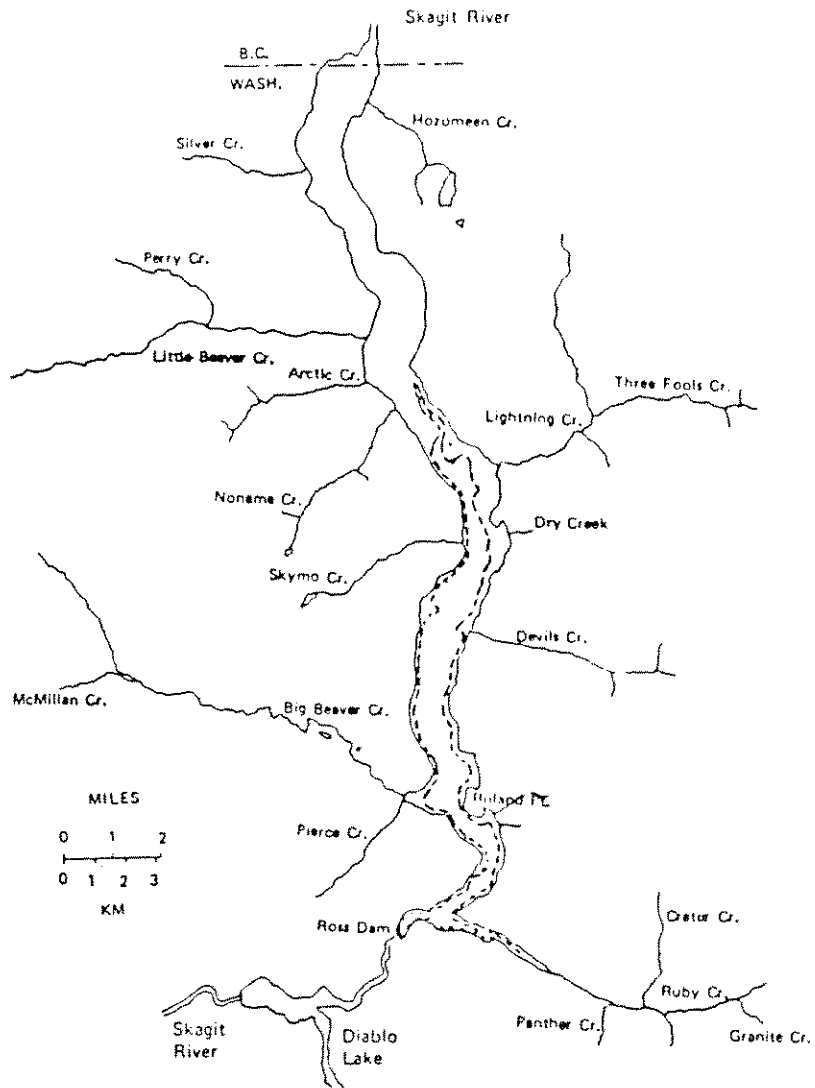


FIGURE 2. Ross Lake and major tributaries. The perimeter of the lake at full pool (1602.5 feet msl) is shown as a solid line, and the maximum drawdown contour (1475 feet msl) is depicted as a dotted line.

all anglers contacted, regardless of whether they had finished fishing for the day. Two primary reasons for checking incomplete anglers was that a large proportion of anglers did not continue fishing after indicating they were going to, and information would be lost from anglers that continued fishing but did not return before the work day ended.

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

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

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

The following angler profile information was collected for each angler interviewed:

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

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

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

Approximately 20-30 scales were collected from each rainbow trout sampled. Scales were removed from an area formed by an imaginary line drawn from the rear insertion of the dorsal fin and front insertion of the anal fin approximately 3-5 scale rows above the lateral line. Scales were then placed in scale envelopes and the date, capture area, species, fork length (mm), sex and sexual maturity (if collected) recorded on the outside. Five scales from each sample were later cleaned and mounted on a glass slide using a cover slip and transparent tape. A microfiche reader (35X) was then used to age each sample. Only

samples containing at least two good scales that did not exhibit regenerated areas were used. After aging all of the samples once to determine growth patterns and other characteristics, the scales were aged a second time. If the two readings did not agree, a third reading was done. The final result of this third reading was considered to be the age of the sample.

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

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

Separate measurements were collected for dolly varden char/bull trout to assist current WDW studies aimed at delineating the geographic ranges of these two species whose external physical characteristics are visually almost identical. A special linear discriminant function developed by Haas (1988) at the University of British Columbia was used to distinguish between the two species. This equation requires the collection of the following four external physical measurements:

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

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

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

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

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

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

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

1991 Season - Angler Catch and Harvest Rates

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

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

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

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

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

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

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

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

^cNumber of anglers surveyed.

^dSee Figure 3 for location of lake survey zones.

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

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

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

1991 Season - Angler Catch and Harvest

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

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

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

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

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

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

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

^cNumber of anglers surveyed.

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

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

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

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

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

1991 Season - Angling Methods and Gear

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

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

1991 Season - Age

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

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

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

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

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

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

1991 Season - Length

A total of 445 rainbow trout were measured during the 1991 fishing season (*Table 14*). The minimum size regulations restrict angler harvest to fish longer than 13 inches (330 mm) total length. A fork length of 317 mm is an approximate equivalent to the 330 mm (total length) minimum size restriction. The average fork length of angler harvested rainbow trout during the 1991 season was 335 mm. Sizes ranged from a low of 292 mm (illegally harvested) to a high of 411 mm. Average size slowly declined as the season progressed. Life history characteristics that may be responsible for the apparent temporal decrease in average size of specific age classes will be presented in a later section of this report.

Length at age information for the rainbow trout harvest is shown in *Table 15*. As expected, average fork length increases with each successive age class. Age 3 fish averaged 302 mm, age 4 fish averaged 329 mm, age 5 fish averaged 359 mm, and age 6 fish averaged 383 mm.

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

Monthly and seasonal length-frequency histograms of angler harvested rainbow trout at Ross Reservoir are shown in *Figure 13*. The abscissa scale values are standardized to facilitate comparison. All five histograms (monthly and seasonal) closely resemble the standard normal curve, and are predominantly centered around the 330-340 mm fork length interval. The legal size limit is 330 mm total length or approximately 317 mm fork length. The August and September histograms are vertically compressed compared to the July and October histograms.

1991 Season - Sex

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

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

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

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

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

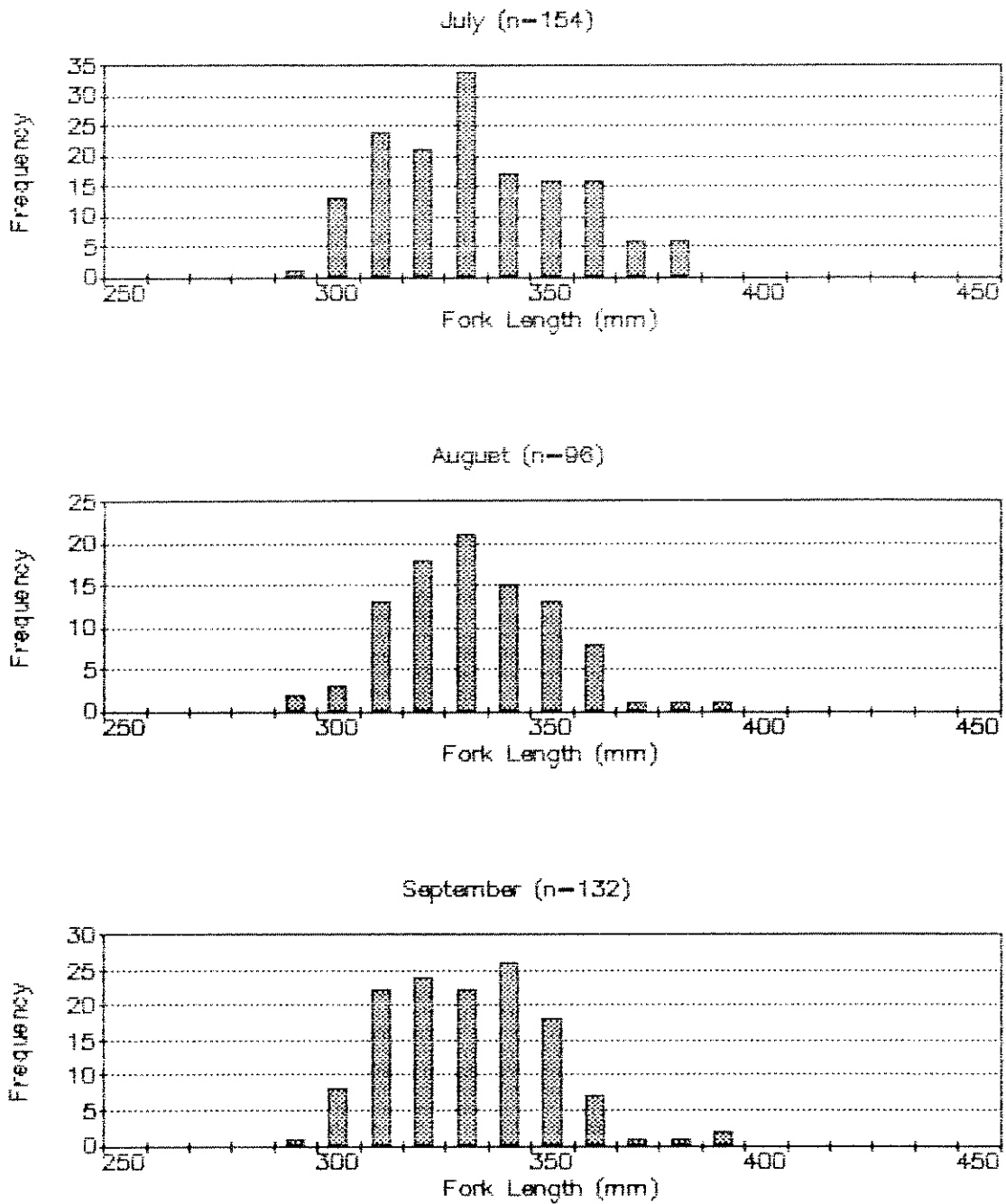


FIGURE 13. Length-frequency distribution of rainbow trout sampled from the 1991 Ross Lake sport harvest. Minimum legal size limit is approximately 317 mm fork length. Abscissa values indicate lower limit of length interval.

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

1991 Season - Sexual Maturity

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

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

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

1991 Season - Additional Data

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

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

1991 Season - Dolly Varden Char/Bull Trout

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

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

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

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

Hydroacoustic Surveys

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

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

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

Spawning Surveys

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

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

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

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

*Fish larger than 152 mm (6 in).

^PAM (0800-1200) counts = 03/26, 04/19, and 05/05

PM (1200-1600) counts = 03/25 and 05/04

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

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

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

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

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

DISCUSSION

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

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

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

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

Effort

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

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

The new regulations appear to be more of a deterrent to anglers using the north end of the lake than to anglers fishing from the south end. In 1971, anglers from the south end accounted for 22 percent of the total seasonal effort (16,572 hours), while north end anglers accounted for 78 percent (57,526 hours). In 1990, 58 percent of the seasonal effort total (21,509 hours) was contributed by south end anglers, while 42 percent (15,311 hours) came from north end anglers. In 1991, 54 percent of the seasonal effort total (19,947 hours) was contributed by south end anglers, while 46 percent (17,158 hours) came from north end anglers. Effort estimates for the different access areas are not available for the 1985 and 1986 study years.

Harvest Rates

Mean overall (all species combined) harvest rates also remained considerably lower than previous years due to the 1990 regulation changes. The mean seasonal HPUE in 1990 and 1991 was 0.12 and 0.10, respectively, while HPUE was 0.48 in 1971, 0.52 in 1972, 0.33 in 1985, and 0.41 in 1986 (*Table 25*). The observed 1990 and 1991 harvest rate declines are due primarily to the 13-inch minimum size limit imposed at the beginning of the 1990 season. However, the decline may also be influenced by decreasing numbers of fish in the reservoir (as indicated by the HPUE decline from the early 1970's to the mid-1980's).

Mean overall monthly harvest rates tend to decline and then increase as the season progresses (*Figure 16*). Harvest rates generally decline from the beginning of the season to August, and then increase in September and October to levels higher than at the start of the season. The initial HPUE decline is probably due to mature rainbow trout ascending tributary streams to spawn. In addition, some fish may also be removed from the fishery when they enter streams on midsummer feeding runs (Johnston 1989). Subsequent HPUE increases in September and October may be due to migration patterns and/or recruitment. Studies of rainbow trout migration patterns in the Sumallo River suggest that trout may migrate to the lake when water temperatures drop below 10°C (Slaney and Godin 1989; Rosenau and Slaney 1991). Summer growth of previously undersized fish also recruits new numbers into the fishery. Very little increase in HPUE occurred in 1991 at the end of the season, with HPUE remaining relatively constant from July through October.

Mean seasonal harvest rates for the different lake zones show contrasting patterns between the 1971-74, 1986, and 1990-91 fishing seasons (*Table 26*). Overall harvest rates remained relatively high throughout the different lake zones in the early 1970's, but were lower at the north end (zones 5 and 6) and south end (zone 1) of the lake in 1986. Johnston (1989) attributes the latter declines to excessive fishing mortality in zones adjacent to the two major access areas. In contrast, 1990 rainbow trout harvest rates were markedly higher at the

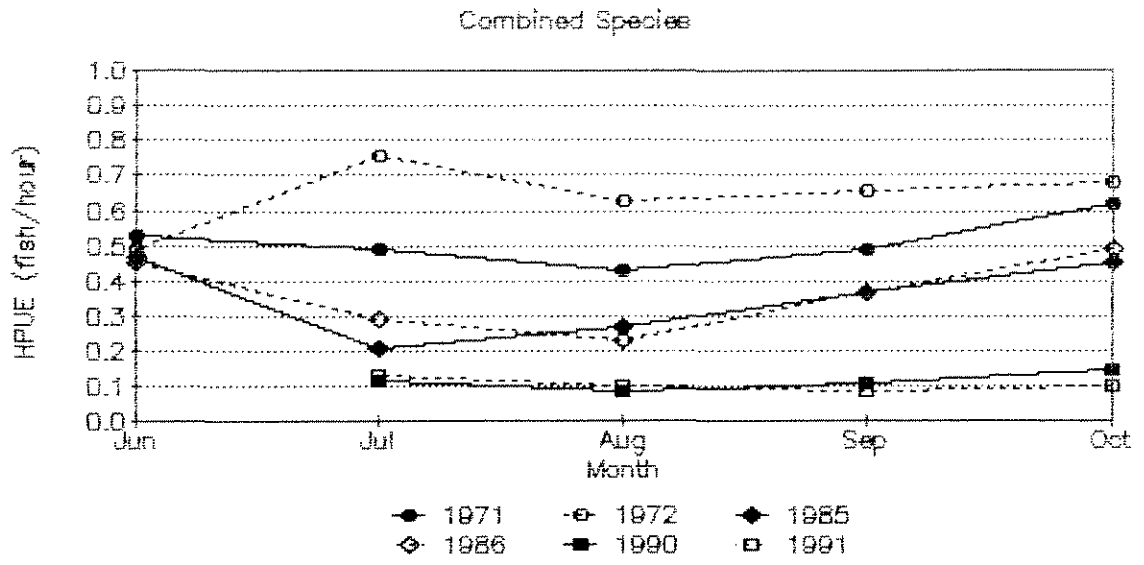


FIGURE 16. Mean overall (all species combined) monthly harvest rates for the 1971, 1972, 1985, 1986, 1990, and 1991 fishing seasons at Ross Reservoir.

north end of the lake (zones 5-7) than at the south end (zones 1-4), due primarily to the marked decrease in angler effort at the north end. Harvest rates in 1991 were roughly similar for zones 2-6, but were slightly less in zones 1 and 2. Of particular interest is the marked decrease (50%) in HPUE at the north end of the lake from 1990 to 1991. This suggests that older rainbow trout age classes are still suffering the effects of overharvest at the north end, since angling effort was similar both years.

Harvest

The 1990 and 1991 overall (all species combined) and rainbow trout harvest estimates are greatly reduced from previous years (*Table 27*). Rainbow trout harvest levels in the early 1970's (average = 36,153) and mid-1980's (average = 20,514) were approximately ten and five times larger, respectively, than the 1990 (3,774) and 1991 (3,833) totals. The dramatic reduction in harvest is due primarily to the reduced daily catch limit (eight fish reduced to three), minimum size restriction (no size limit changed to 13-inch minimum size), shorter season (mid-June opener changed to July 1 opener) and reduced reservoir fishing effort. In addition, an apparent continued reduction of the reservoir fish population can be expected to contribute to the decline. The small harvest increase (2%) in 1991 compared to 1990 is due primarily to increased effort on the reservoir in 1991.

The greater proportion of rainbow trout in the overall 1990 and 1991 harvests (99.5% and 99.0%, respectively) is due to fewer numbers of dolly varden char/bull trout being caught. The 1990 bait fishing restriction coupled with a resultant decrease in anglers fishing with live and/or scented bait off stream mouths is probably responsible for the dolly varden char/bull trout harvest reduction.

Age

The 13-inch (317 mm fork length) minimum size restriction resulted in a greater percentage of older rainbow trout in the 1990 and 1991 harvests than in previous studies (*Table 28*). Most of the 1990 harvest was composed of age 3 (47 percent) and age 4 (32 percent) fish, while the 1991 harvest was comprised primarily of age 4 (60 percent) and age 5 (23 percent) fish. This is in contrast to earlier years, when small numbers of age 1 and large numbers of age 2 fish were present in the harvest. Except for 1986, when age 3 fish comprised the majority of the harvest, age 2 fish were the age class harvested in greatest numbers by anglers prior to 1990. Johnston (1989) attributes the increase in percentage of older age classes (age 3 and age 4) in the harvest from the early 1970's to the mid-1980's to anglers targeting older Canadian Skagit River rainbow trout (that enter the reservoir fishery in June and again in September and October) at the north end of the lake, and to selectively "high-grading" their catch to retain the largest and

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

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

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

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