THE AQUATIC ENVIRONMENT, FISHES AND FISHERY
ROSS LAKE AND THE CANADIAN SKAGIT RIVER

INTERIM REPORT NO. 3

VOLUME I

JULY 1974

CITY OF SEATTLE · DEPARTMENT OF LIGHTING

THE AQUATIC ENVIRONMENT, FISHES AND FISHERY
ROSS LAKE AND THE CANADIAN SKAGIT RIVER
INTERIM REPORT NO. 3
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PART 1

INTRODUCTION

1.1 HISTORY OF ROSS LAKE

1.1.1 Original Plans

In 1918, the U. S. Department of Agriculture gave the City of Seattle permission to begin construction of power generating facilities on the Skagit River in north-central Washington State. The Lighting Department of the City proposed a staged development of three dams, called Gorge, Diablo and Ross. Long-range plans included the multi-stage construction of Ross Dam. The impounded waters forming Ross Lake, the principal storage reservoir for the three dams, were to finally reach the approximate elevation now contemplated.

1.1.2 Stages of Development

Construction began on Ross Dam in 1937 and was completed to an elevation of 1365 feet in 1940. Between 1943 and 1947 Ross Dam was raised to elevation 1550 feet. Completion of the dam to its present elevation of 1615 feet was accomplished in 1949.

Present plans include the final step of raising Ross Dam to a height of 1736 feet. The maximum elevation of Ross Lake would thereby be increased to 1725 feet from the present maximum of 1602.5 feet.

1.2 THE PRESENT STUDY

1.2.1 Objectives

An understanding of the condition of the fishes and fishery of the Ross Lake drainage area over the short and long term was the aim of this study. In order to achieve this understanding, a study of the present fish populations and fishery was designed. The results provide much of the data necessary for projections on the fishery.

1.2.2 Study Area

The study area encompasses the Skagit River-Ross Lake watershed above Ross Dam (see Maps 1 and 2). It includes Ross Lake to its maximum elevation of 1602.5 feet and the Skagit River in Canada. The study did not include areas or effects downstream from Ross Dam.

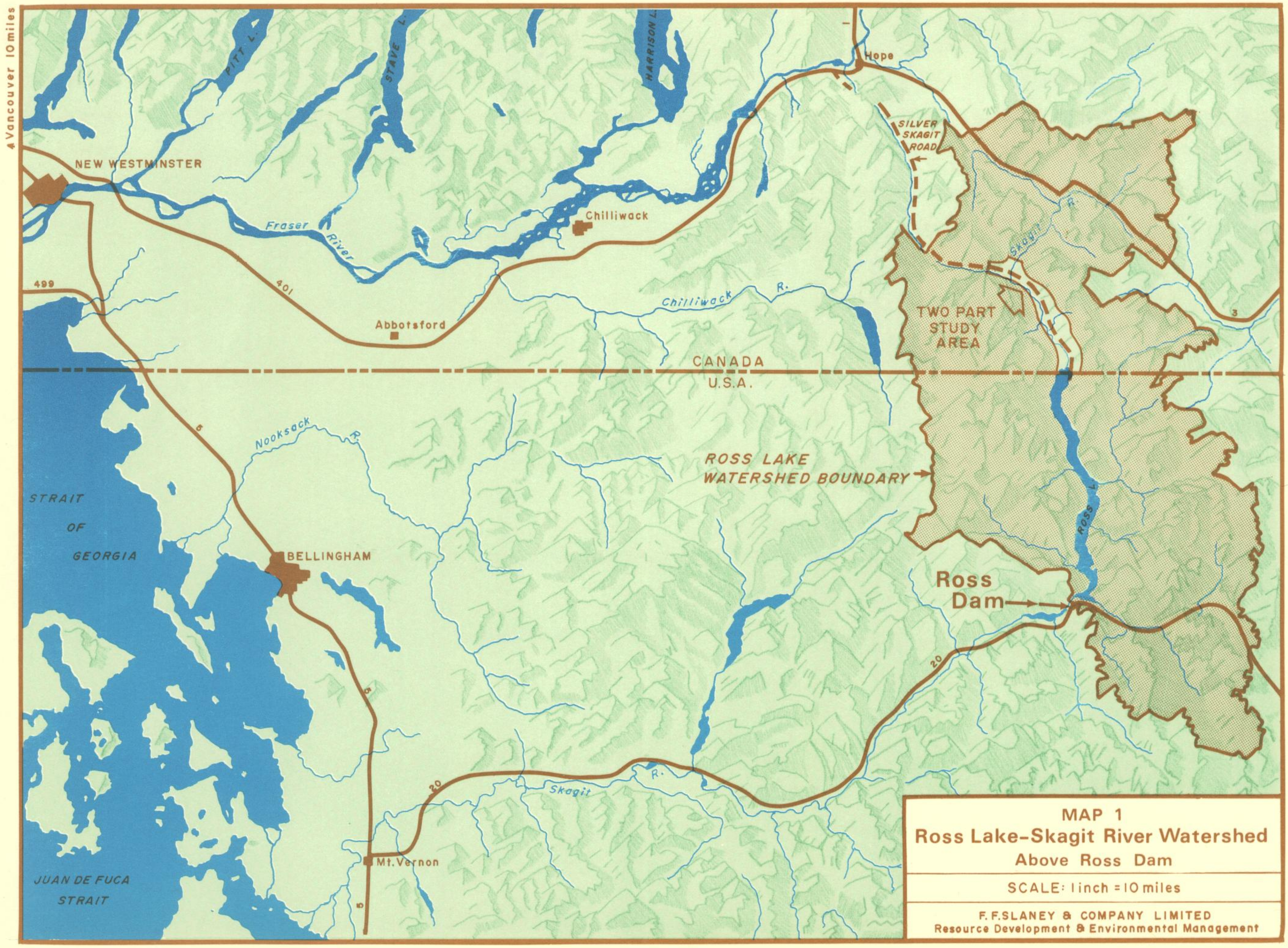
Major political jurisdictions within the watershed include the State of Washington, United States of America, and the Province of British Columbia, Canada.

1.2.3 Administration of Study

Design and co-ordination of this study were carried out under the aegis of the International Skagit-Ross Fishery Committee. Participating agencies included:

- British Columbia Fish and Wildlife Branch
- Bureau of Sports Fisheries and Wildlife (U.S.)
- F.F. Slaney and Company
- Fisheries Research Institute, University of Washington
- National Park Service (U.S.)
- Washington Department of Game

Approximately monthly meetings were held during 1971 and as necessary in 1972 and 1973 to co-ordinate the activities of the various agencies involved.



MAP 1
Ross Lake-Skagit River Watershed
Above Ross Dam

SCALE: 1 inch = 10 miles

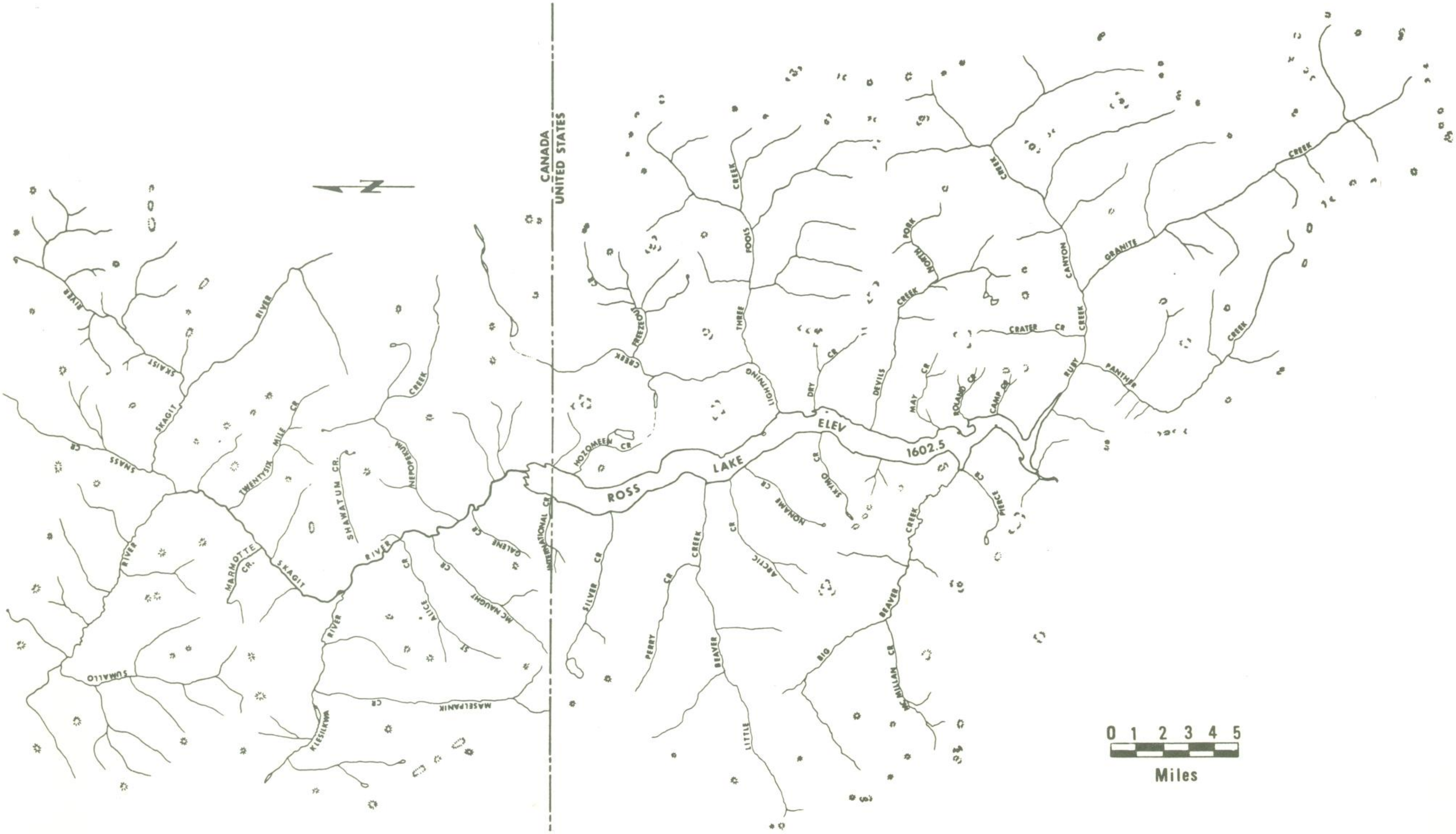
F.F.SLANEY & COMPANY LIMITED
Resource Development & Environmental Management

MAP 2

SKAGIT RIVER SYSTEM

Above Ross Dam

With Ross Lake at Elevation 1602.5 Feet



1.2.4 Funding of Study

The field, analytical and administrative work represented by this report was supported financially through agreements between Seattle City Light and:

F.F. Slaney and Company
Fisheries Research Institute, University of Washington
Washington Department of Game.

1.3 THE REPORT

1.3.1 Volumes I and II

This is the third interim report on work carried out on the fishes and fisheries of Ross Lake drainage area (above Ross Dam). Volume I presents data and results from the 1973 field work in the area. Earlier interim reports should be consulted for data from previous years. Current conclusions and projections on the impact of the project are also included in this volume.

Volume II is a supporting volume containing additional data in tabular, diagrammatic and graphical form from the 1973 work. Descriptions of methods used in analysis of the data are also included.

1.3.2 Report Preparation

The report is a result of the combined efforts of the agencies comprising The International Skagit-Ross Fishery Committee. Within the report, however, individual sections have been primarily the responsibility of one or a few agencies. In most cases, these are the agencies that had primary responsibility for implementation of the field program or analysis of the data, as well as the writing of the report, for that section. These agencies are identified by section throughout the report.

1.4 ACKNOWLEDGEMENTS

Individual participants in the deliberations of the International Skagit-Ross Fishery Committee acknowledge with thanks the assistance of colleagues in their respective agencies.

The agencies that had contractual obligations to this project extend their appreciation to the International Skagit-Ross Fishery Committee members who had no such commitment. The advice and assistance of the latter were most helpful.

The field crews were assisted greatly by employees of the National Park Service and of Seattle City Light. Mr. Wayne Dameron and his employees, of Dameron's Resort, also provided assistance.

Finally, with pleasure we thank the many anglers who graciously answered our questions, allowed their fish to be sampled, and in some cases filled out forms, for their co-operation.

PART 2

PRESENT ENVIRONMENT

2.1 ROSS LAKE 1973 (by Fisheries Research Institute)

2.1.1 Drawdown Schedule

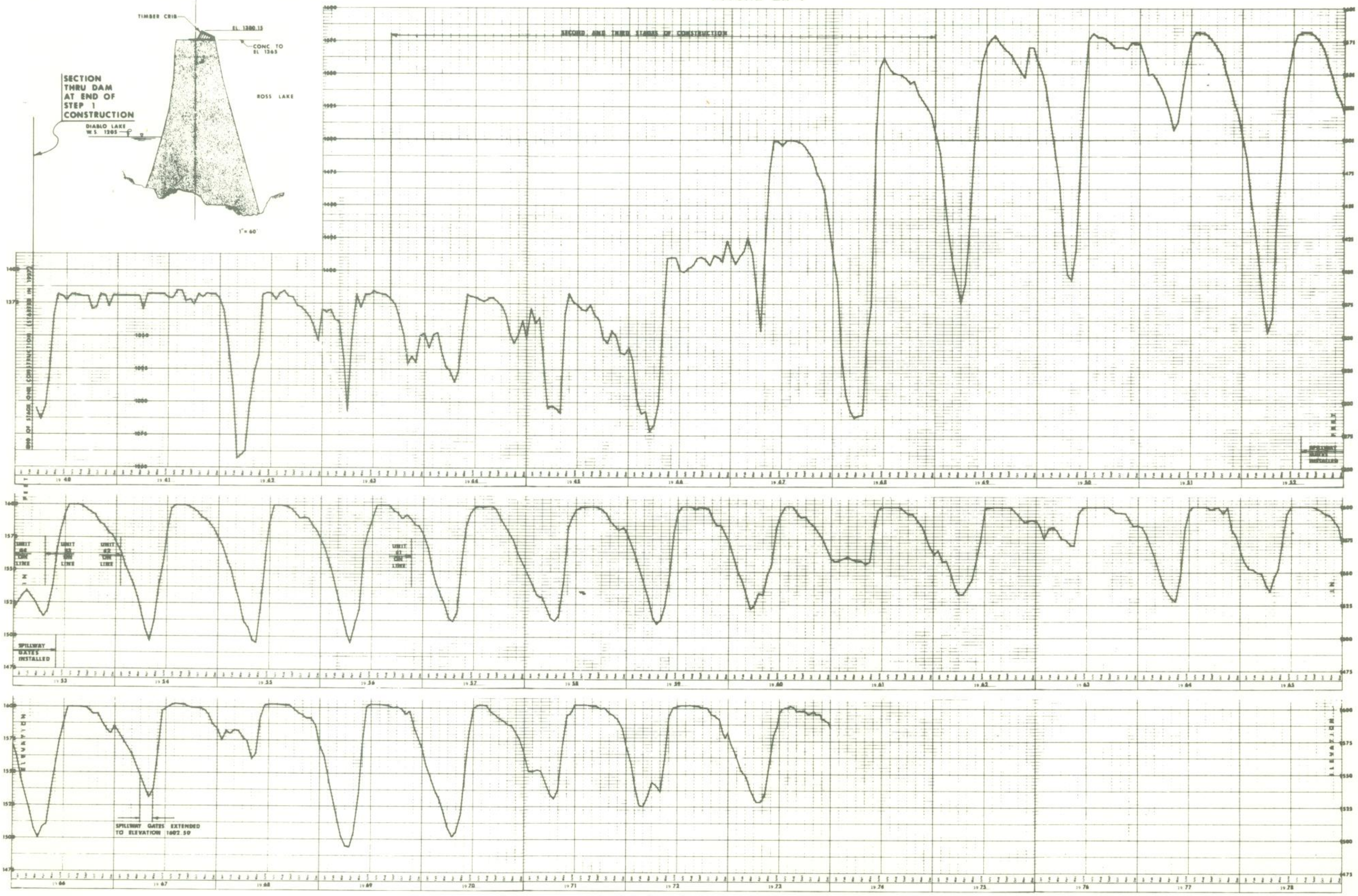
Lake level fluctuations vary from year to year depending on weather, snow pack and discharge at the dam. Generally the spring runoff begins in mid-April and continues through July. The rates of filling and drawdown of the reservoir depend on the relative amounts of runoff and water used to generate power. The drawdown schedules for previous years through 1973 are shown in Figure 2.1-1.

2.1.2 Temperature and Dissolved Oxygen

Measurements of water temperature and dissolved oxygen (D.O.) were continued in 1973 and 1974 by City Light and Institute personnel at approximately monthly intervals.

To determine precisely the time at which the overturn (homothermous conditions) occurred in the reservoir and its effects on dissolved oxygen concentrations throughout the lake, an expanded program of measurements of temperature and dissolved oxygen was begun by Institute personnel in October 1973. Sampling was conducted approximately at 2-week intervals until early January 1974 (following complete lake overturn). A bathythermograph was used to record the water temperature from surface to lake bottom every mile from the dam to the north end of the lake. D.O. concentration was determined at 10 m depth intervals from 1 m below water surface to 3 m off the lake bottom near Ross Dam (mile 0) and at 3, 6, 9, 12, 15, 18, and 21 miles from Ross Dam.

FIGURE 2.1-1



ROSS LAKE ELEVATION FLUCTUATIONS, 1940-1973

The results (Figs. 2.1-2 and 2.1-3 and Appendix 1) show the presence of a well developed thermocline during the months of summer and early fall and the rapid cooling of the epilimnion with the onset of cold weather in November. Homothermous conditions occurred at the shallower north end of the reservoir except for the extreme upper end at the mouth of the Canadian Skagit River by late November. Comparison of the graphs in Fig. 2.1-3 show that homothermous conditions progressed from the upper (shallower) end to the lower (deeper) end until complete overturn in early January 1974.

Dissolved oxygen concentrations in Ross Lake were generally lowest in the early November samples (Fig. 2.1-3). The lowest surface D.O. concentration was 9.0 ppm in July, midlake off Devils Creek. The lowest concentration, 6.7 ppm, was found 3 m off the bottom at a depth 55 m, 9 miles uplake from Ross Dam on November 7, 1973, just prior to the lake temperature overturn at this station. On November 20, just after the overturn at the 9 mile station, D.O. was 9.7 ppm at a depth 3 m off the bottom (Fig. 2.1-3).

2.1.3 Turbidity

Turbidity in Ross Lake is influenced considerably by seasonal runoff of silt and glacial flour. Secchi disk observations were made in 1973 on Ross Lake from March through December (Table 2.1-1). The results show that maximum turbidity at the south end of Ross Lake occurred in late May (Secchi depth: 11 ft. on May 22). After this time the lake at this station gradually cleared until mid-July after which Secchi depths varied from 25 to 39 ft. until December.

FIGURE 2.1-2

DISSOLVED OXYGEN AND TEMPERATURE PROFILES, ROSS LAKE
July, 1972 to December 1973

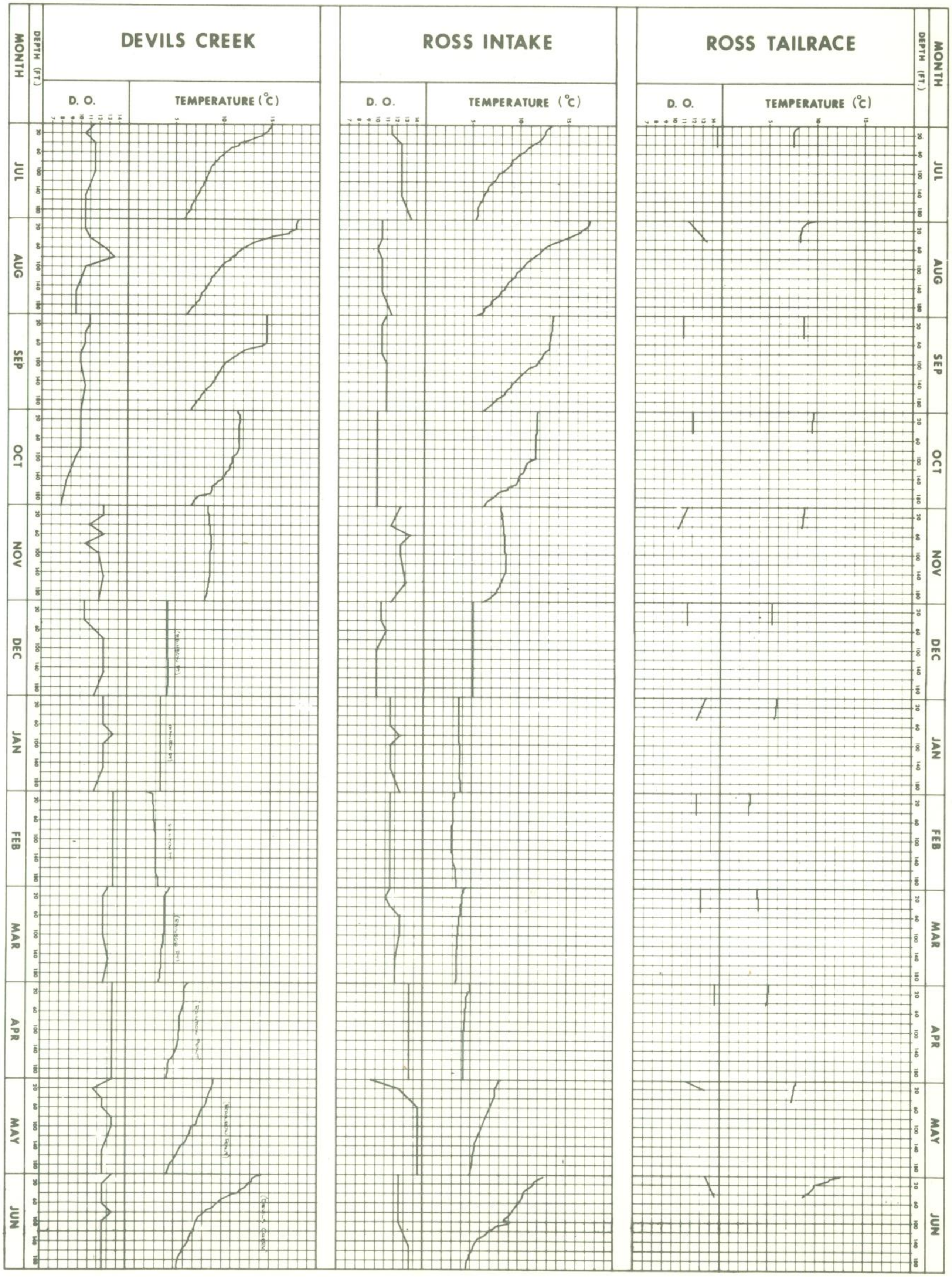


FIGURE 2.1-2 (page 2)

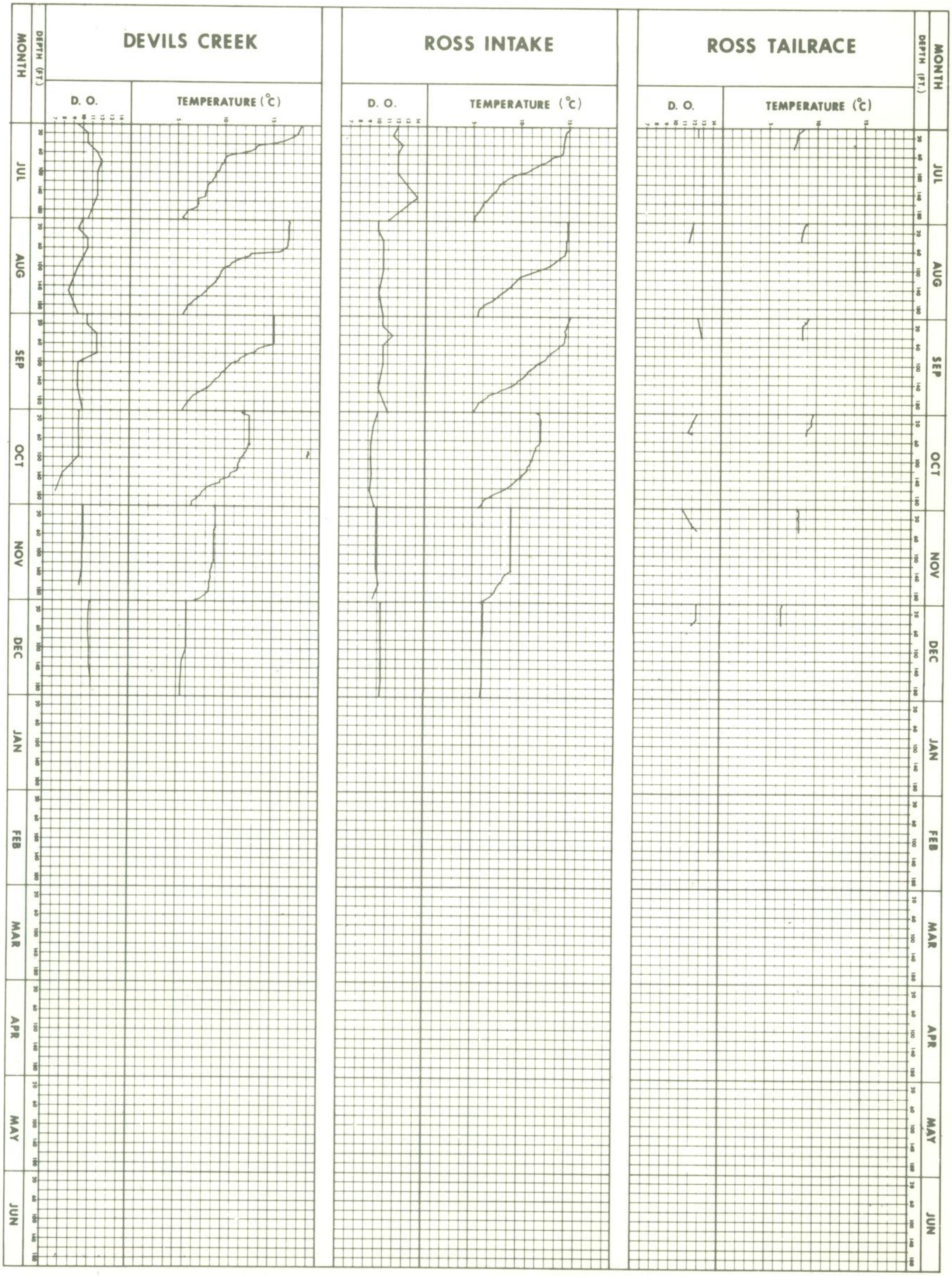


FIGURE 2.1-3

ROSS LAKE TEMPERATURE AND DISSOLVED OXYGEN

DATE: 25-26 OCTOBER, 1973

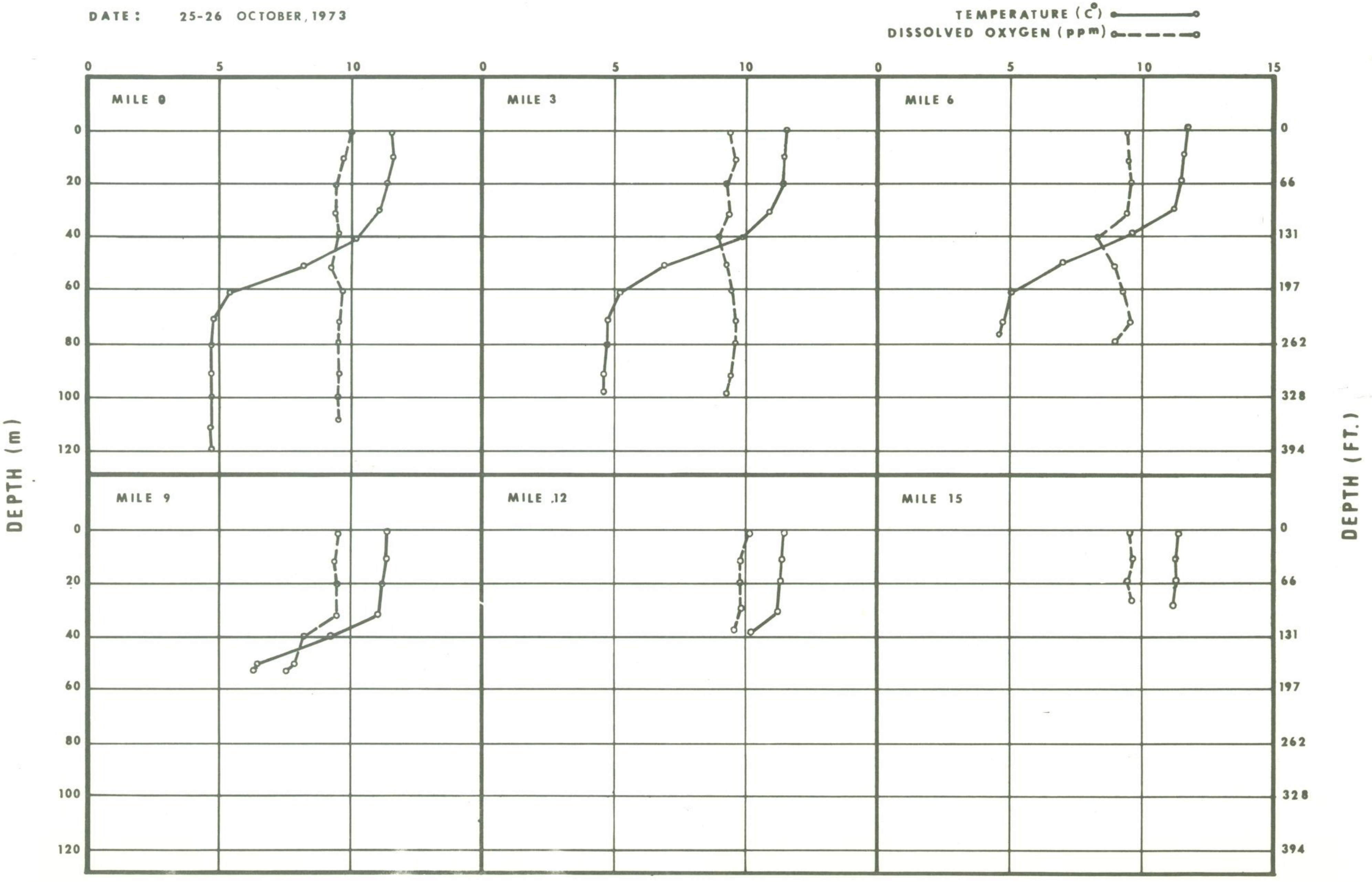


FIGURE 2.1-3 (cont'd)

ROSS LAKE TEMPERATURE AND DISSOLVED OXYGEN

DATE: 26 OCTOBER, 1973

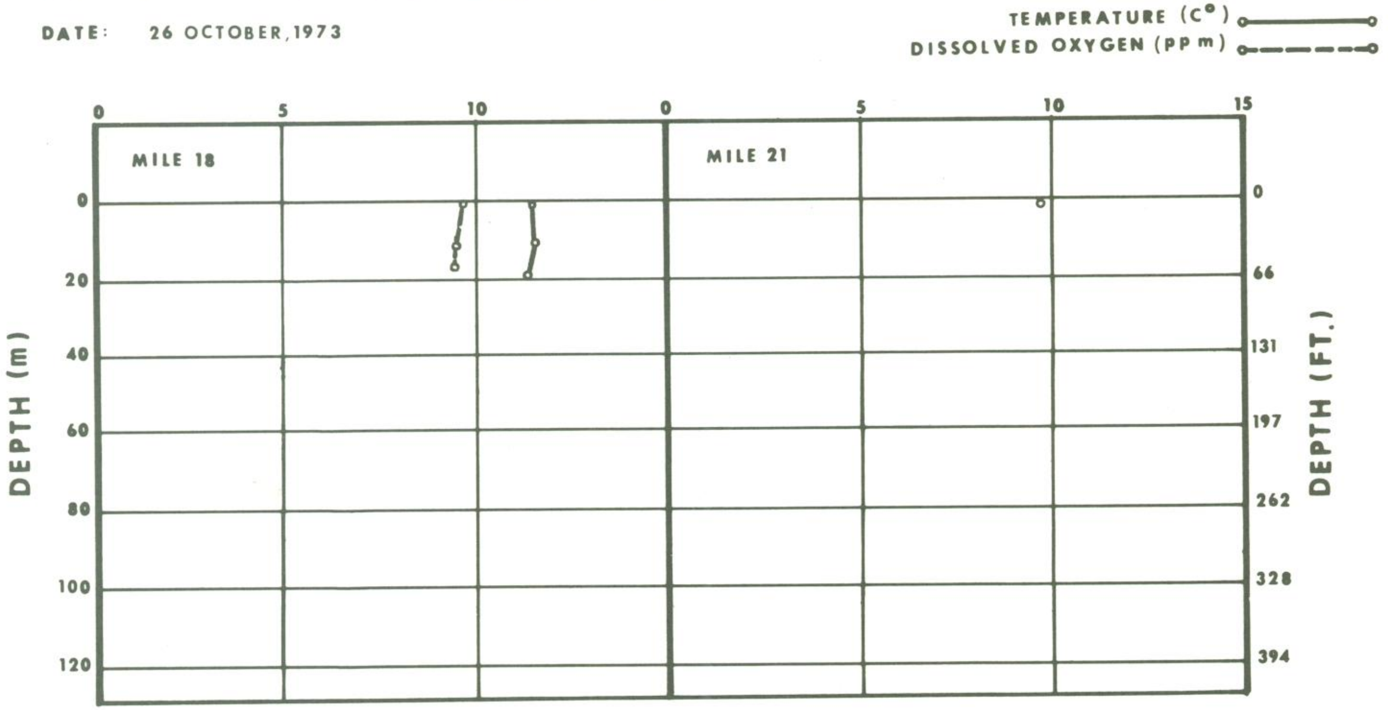


FIGURE 2.1-3 (cont'd)

ROSS LAKE TEMPERATURE AND DISSOLVED OXYGEN

DATE: 6-7 NOVEMBER, 1973

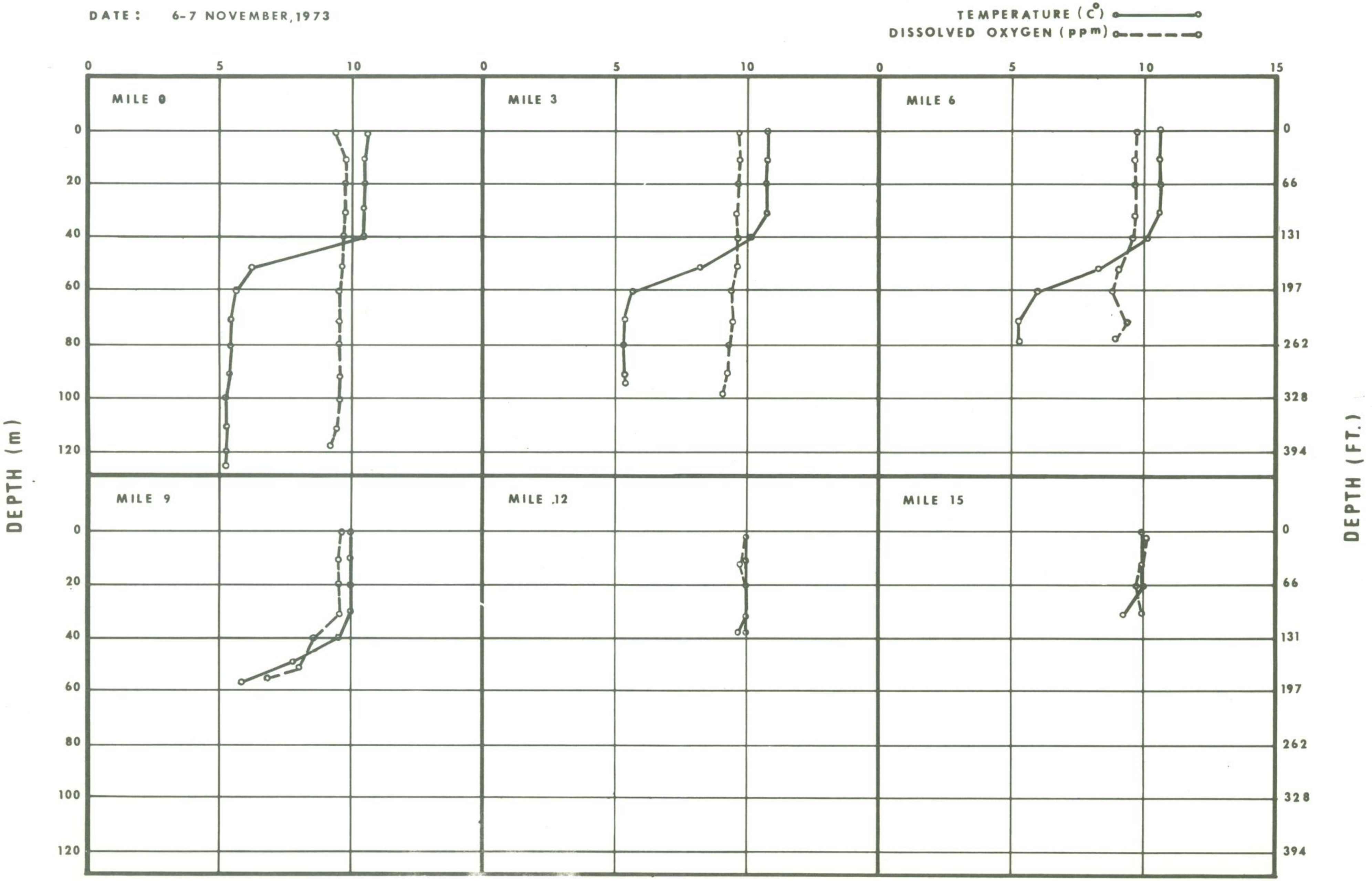
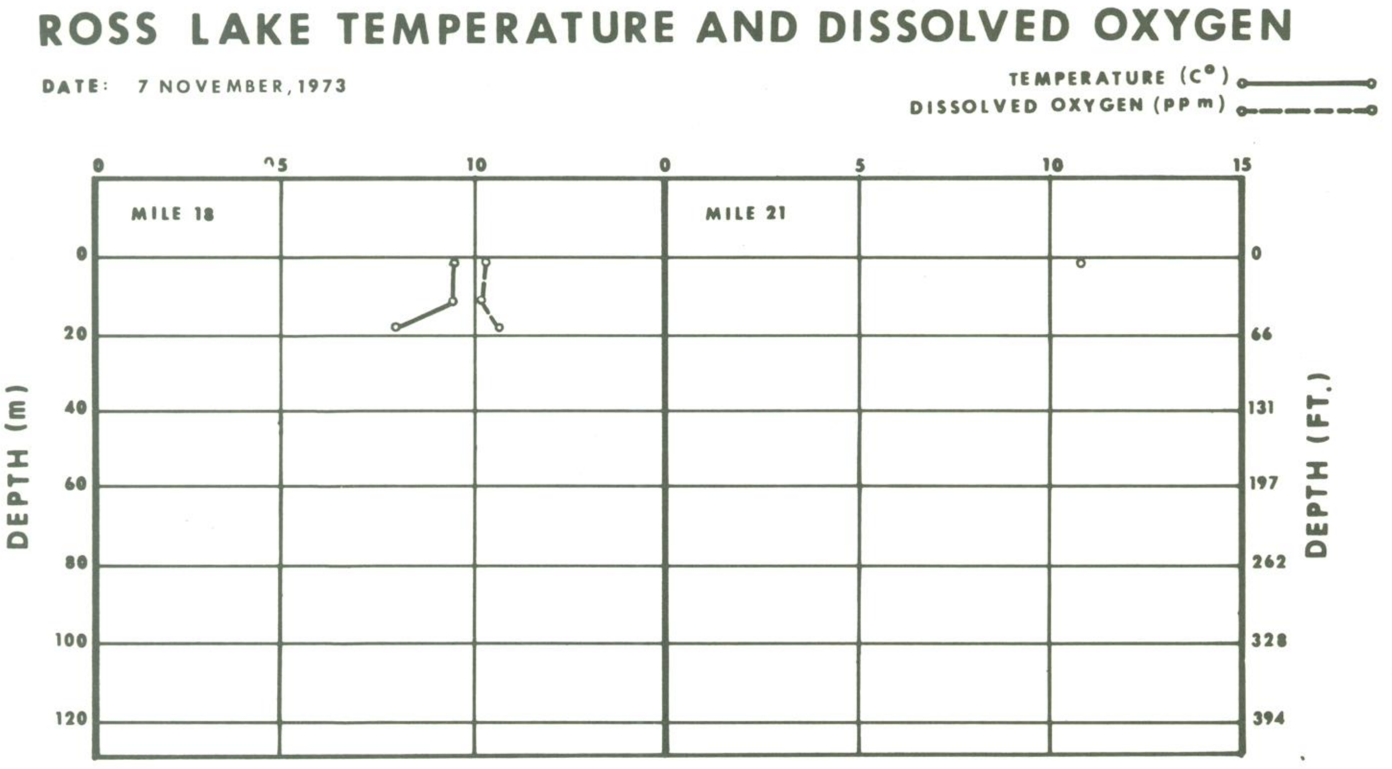


FIGURE 2.1-3 (cont'd)



ROSS LAKE TEMPERATURE AND DISSOLVED OXYGEN

DATE: 7 NOVEMBER, 1973

FIGURE 2.1-3 (cont'd)

ROSS LAKE TEMPERATURE AND DISSOLVED OXYGEN

DATE: 19-20 NOVEMBER, 1973

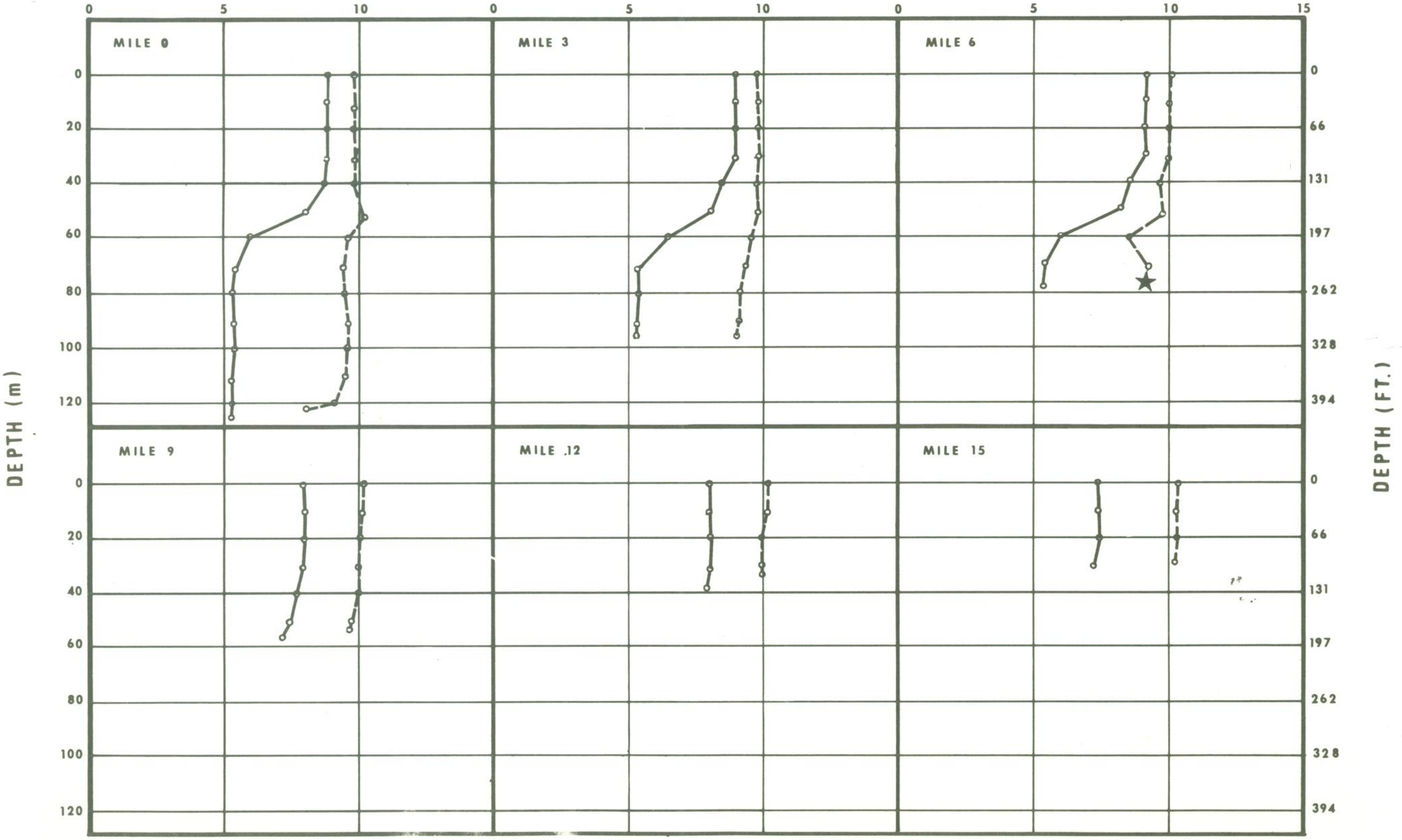


FIGURE 2.1-3 (cont'd)

ROSS LAKE TEMPERATURE AND DISSOLVED OXYGEN

DATE: 19-20 NOVEMBER, 1973

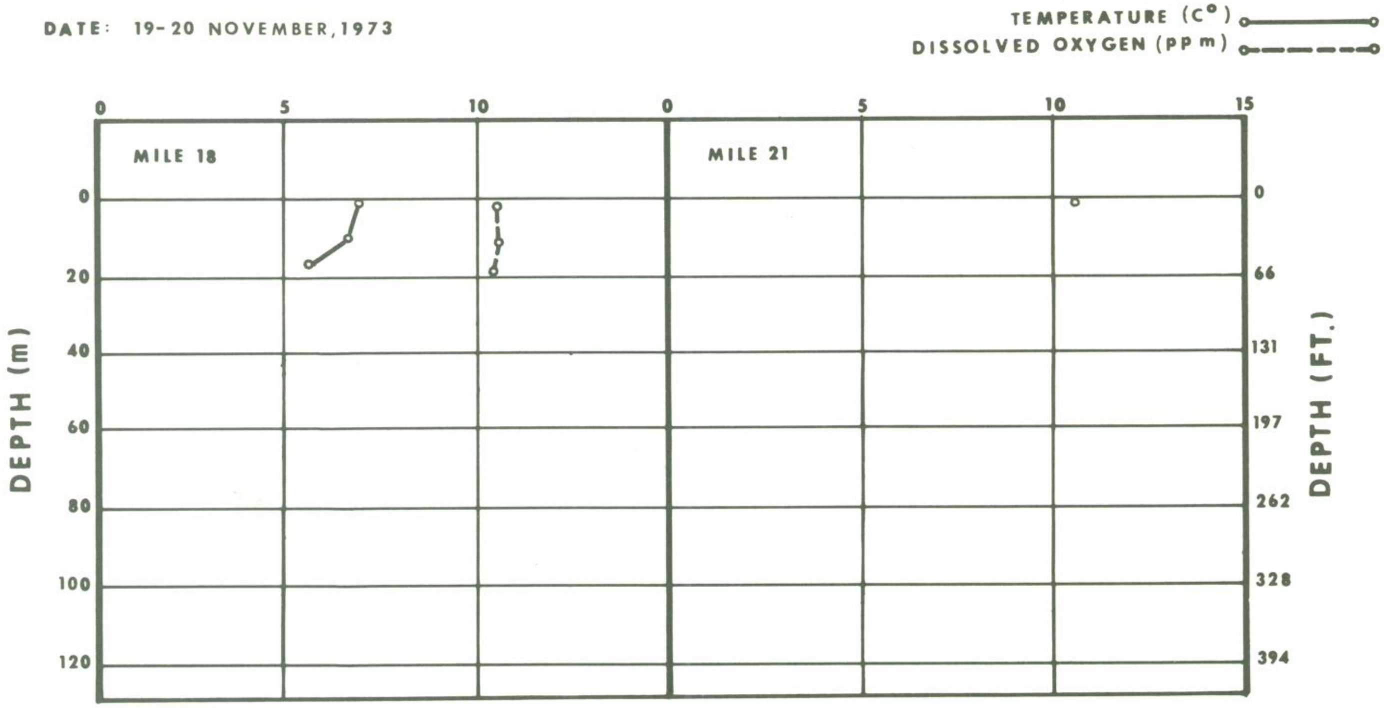


FIGURE 2.1-3 (cont'd)

ROSS LAKE TEMPERATURE AND DISSOLVED OXYGEN

DATE: 4-5 DECEMBER, 1973

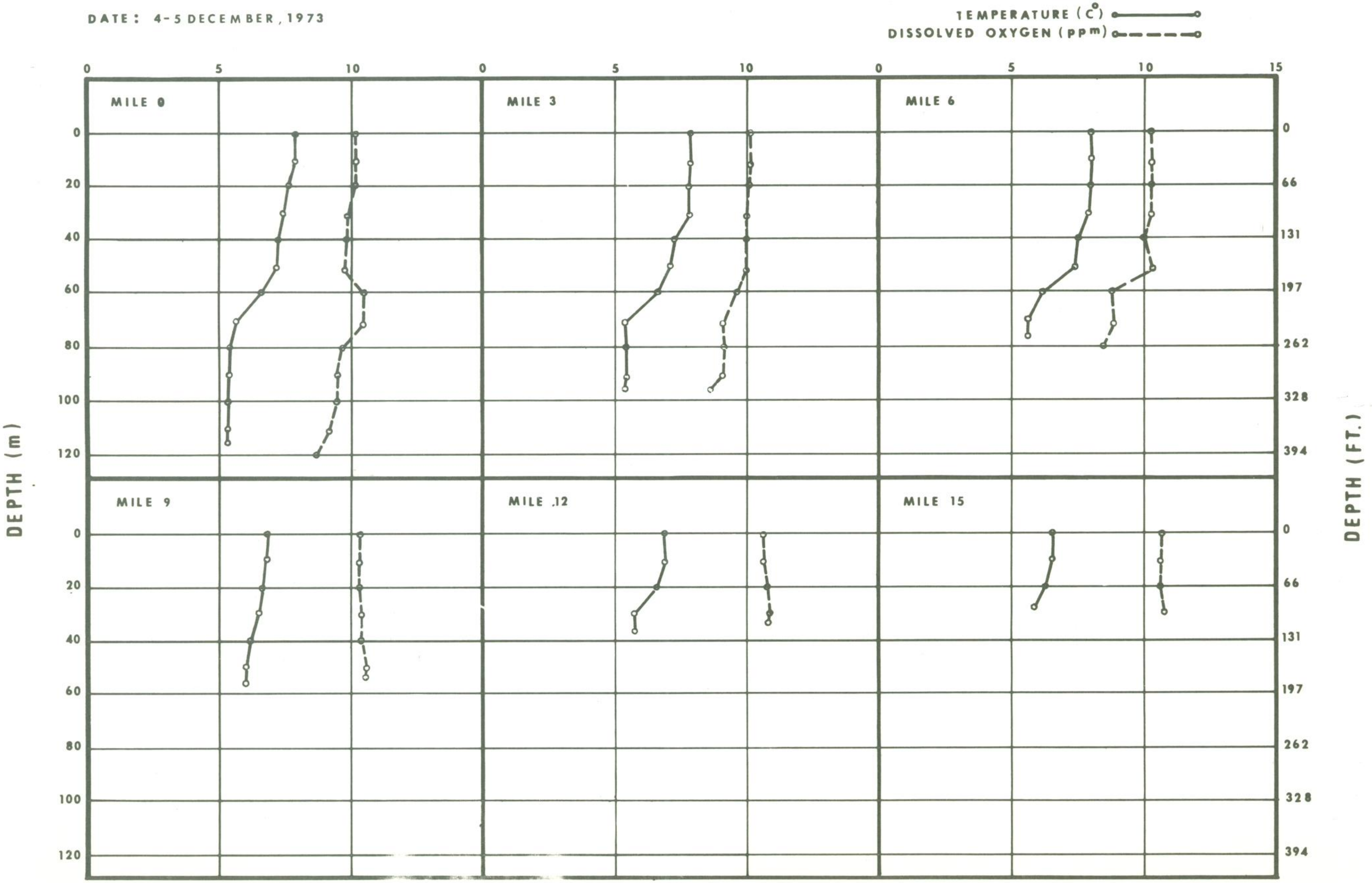


FIGURE 2.1-3(cont'd)

ROSS LAKE TEMPERATURE AND DISSOLVED OXYGEN

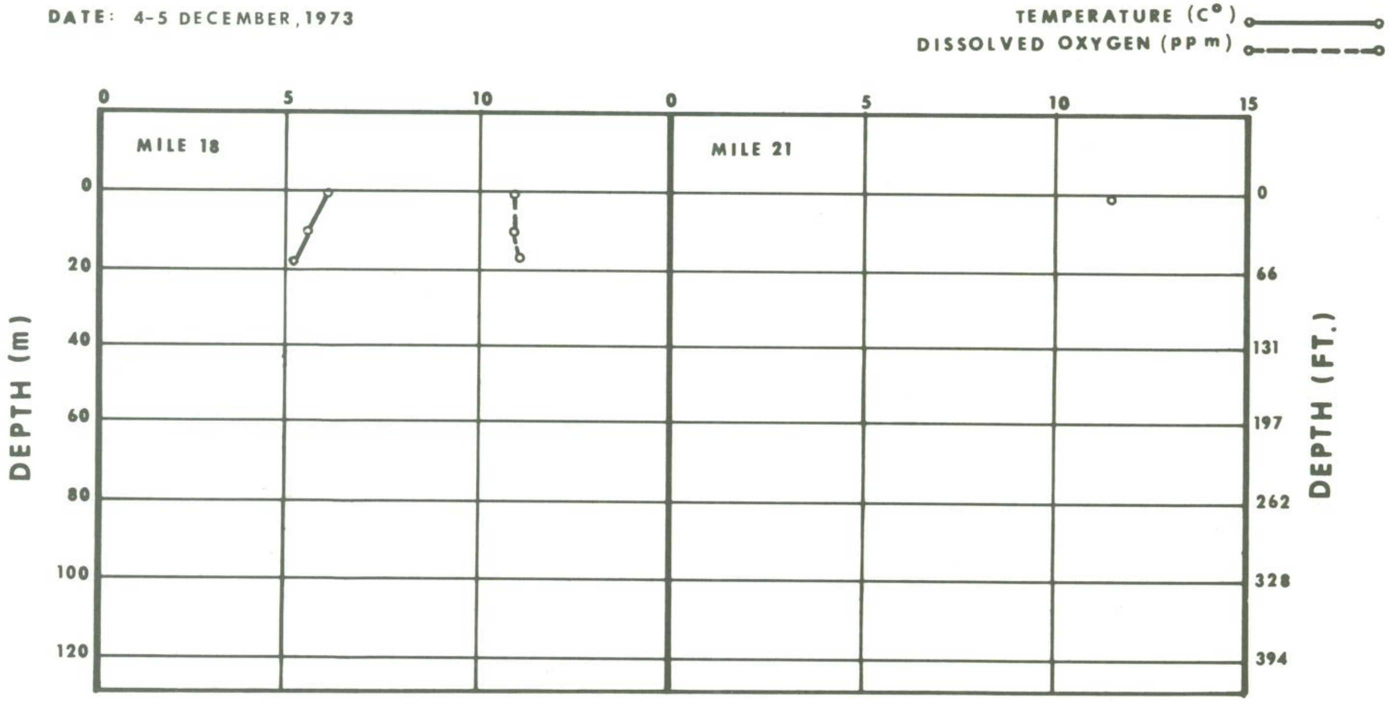


FIGURE 2.1-3 (cont'd)

ROSS LAKE TEMPERATURE AND DISSOLVED OXYGEN

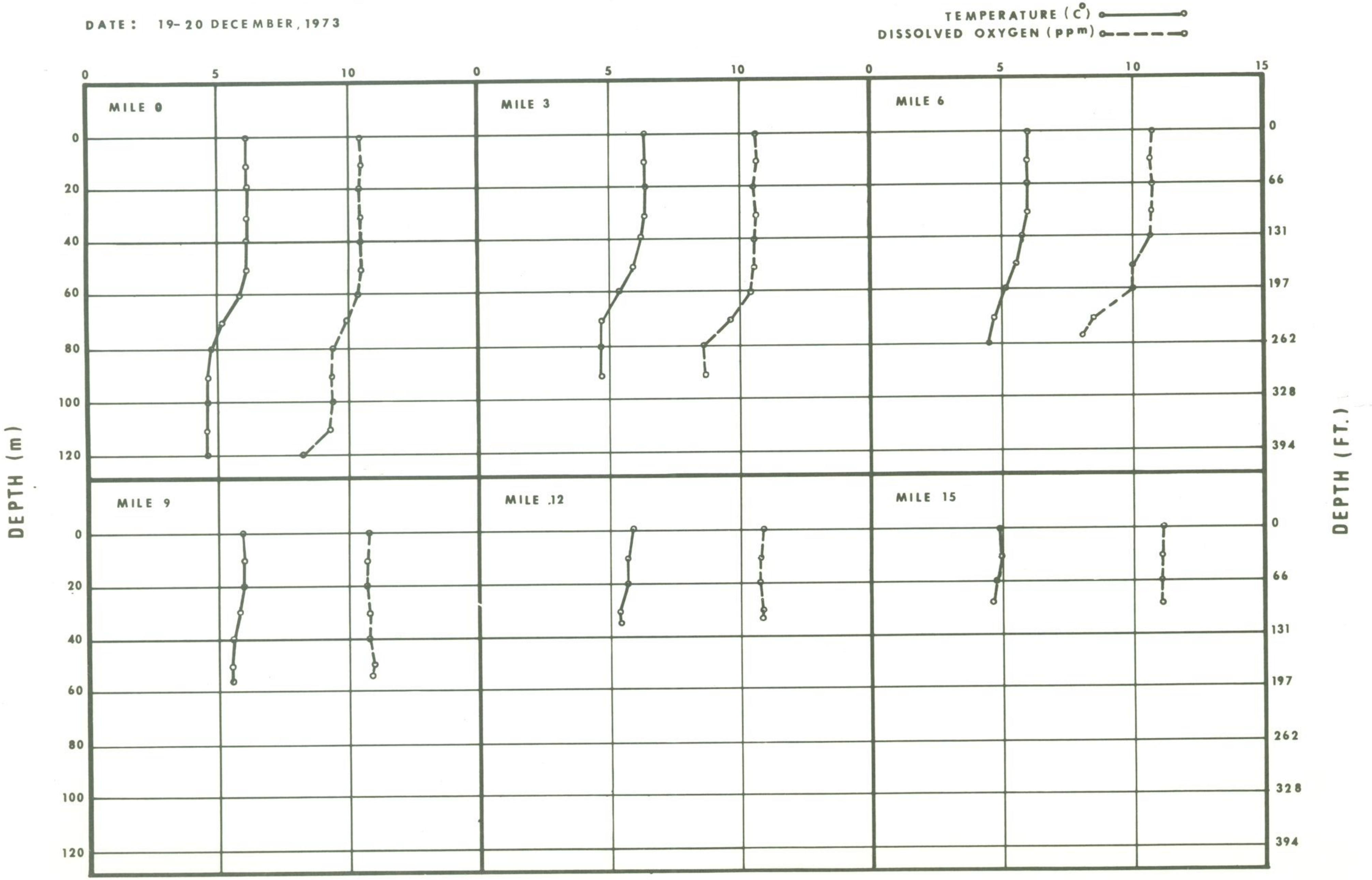


FIGURE 2.1-3 (cont'd)

ROSS LAKE TEMPERATURE AND DISSOLVED OXYGEN

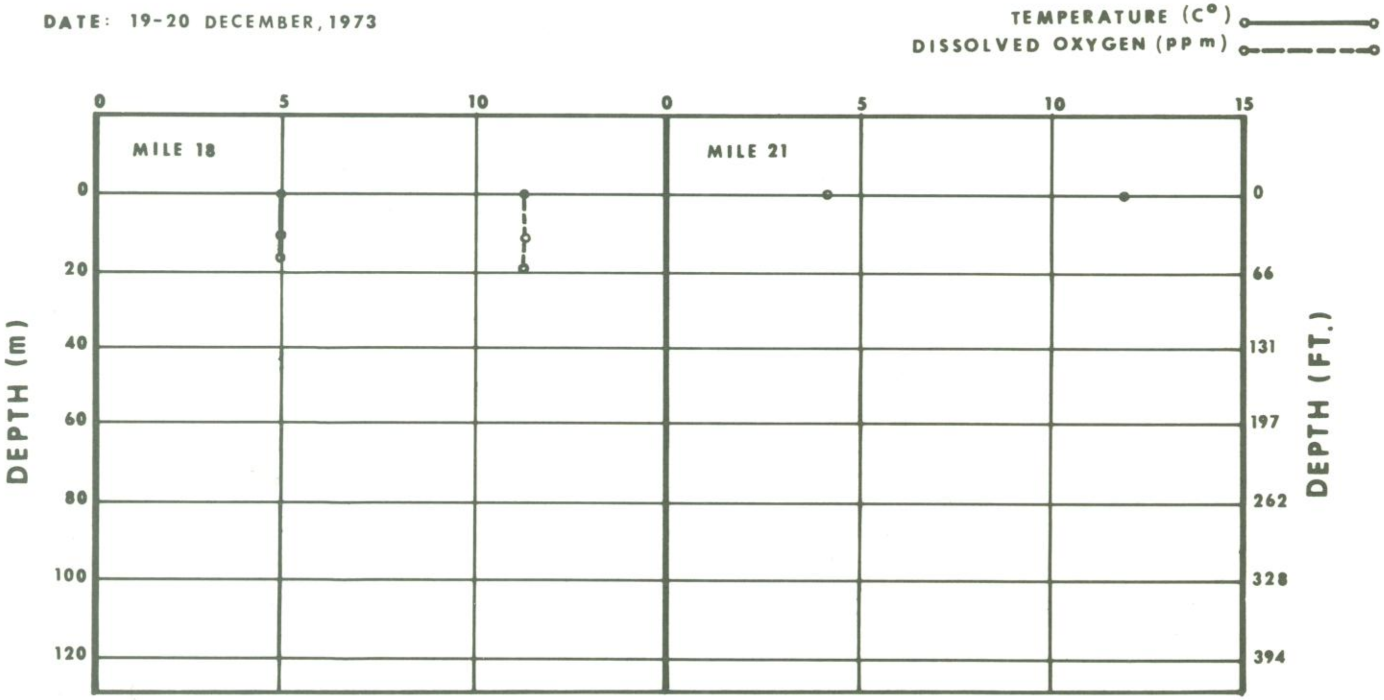
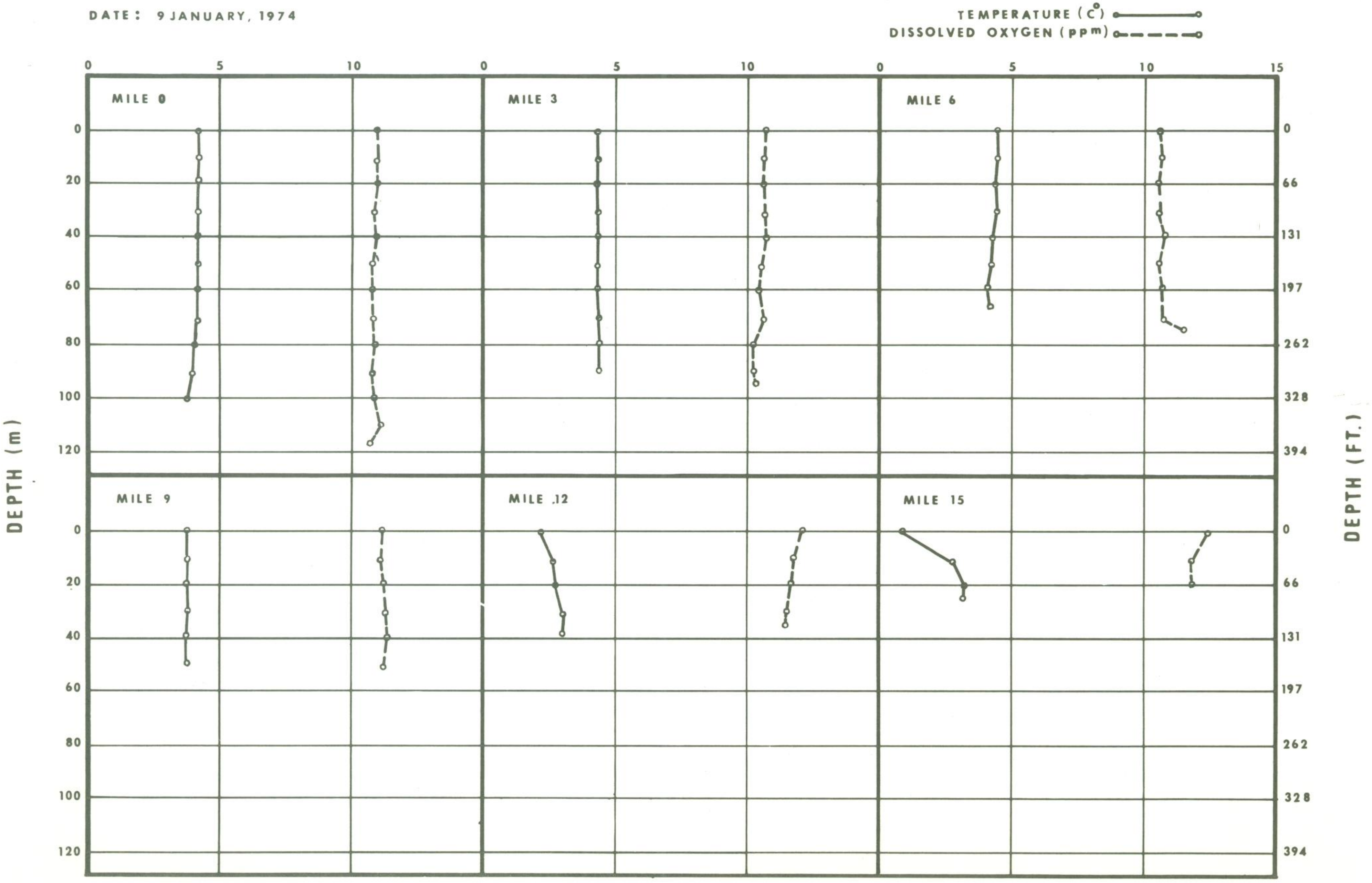


FIGURE 2.1-3(cont'd)

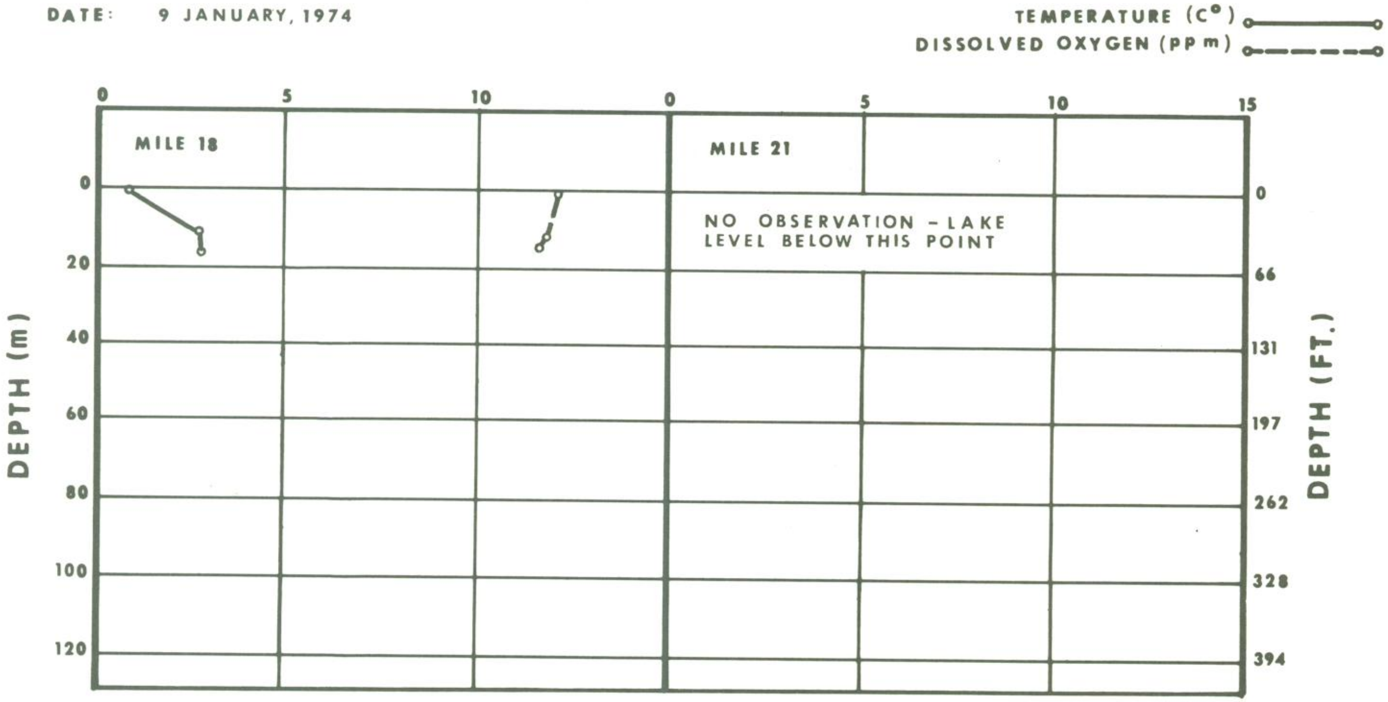
ROSS LAKE TEMPERATURE AND DISSOLVED OXYGEN



DATE: 9 JANUARY, 1974

FIGURE 2.1-3(cont'd)

ROSS LAKE TEMPERATURE AND DISSOLVED OXYGEN



DATE: 9 JANUARY, 1974

TABLE 2.1-1 SECCHI DEPTH READINGS IN ROSS LAKE, 1973

	Mid-lake stations (miles from dam)							Creek mouth stations				
	0	3	6	9	12	15	18	Ruby Creek	Big Beaver Creek	Devils Creek	Lightning Creek	Little Beaver Creek
Date								Secchi depth (ft)				
3/29	30											
3/30	31				21							
4/4	37											
4/5	28											5
4/6	26											
4/11	35							1-1/2		20+		
4/12	31											
4/13	30							2				
4/16	31							9				
4/17	29											
4/18	27											
4/19	30											
4/20	29											
4/24	31											
4/25	28											
4/26	30							5				
4/27	29											
4/30	30											
5/2	28							4				
5/3	26											
5/4	28											
5/7	21											
5/8	26											
5/9	22											
5/10	24											
5/11	22											
5/14	33							2	10+		3-1/2	
5/15	26											
5/16	24											
5/17	26											
5/18	22											
5/22	11											
5/29	15											
5/30	20											
5/31	18											
6/4	14											

TABLE 2.1-1 - Continued

	Mid-lake stations (miles from dam)							Creek mouth stations				
	0	3	6	9	12	15	18	Ruby Creek	Big Beaver Creek	Devils Creek	Lightning Creek	Little Beaver Creek
Date								Secchi depth (ft)				
6/5	22											
6/7	17											
6/8	17											
6/11	17-1/2											
6/12	22											
6/13	25											
6/14	21				21							
6/15	23											
6/18	22											
6/19	25											
6/20	15											
6/21	26											
6/22	25											
7/9	21											
7/10	28											
7/12	27											
7/17	35											
7/19					35							
7/23	25											
8/20	33											
8/21	35											
8/22	27-1/2											
10/25	38	36										
10/26			34	31	31	30	30					
11/6	35											
11/7			30	27								
11/19	27											
11/20		27	29	26	24	24	22+					
12/4	39	34										
12/5			35	35	32	28	28					
12/19	34	41										
12/20			36	34	34	34	31					

At other locations in Ross Lake Secchi depth during April and May varied according to distance from runoff sources. In Ruby Arm, Secchi depths of 1½ to 2 ft. in April and 2 ft. in May illustrate the effects of the spring runoff on turbidity in lake areas near stream mouths.

In 1972 the runoff was heavier and more prolonged than in 1973 (Fig. 2.1-4). Consequently the lake was clearer during the runoff period in 1973 than in 1972. In 1972 Secchi depth at the south end of the lake was 8 ft. on May 24 and 4.5 ft. on June 30. In 1973 Secchi depth was 11 ft. on May 22 and 25 ft. on June 22.

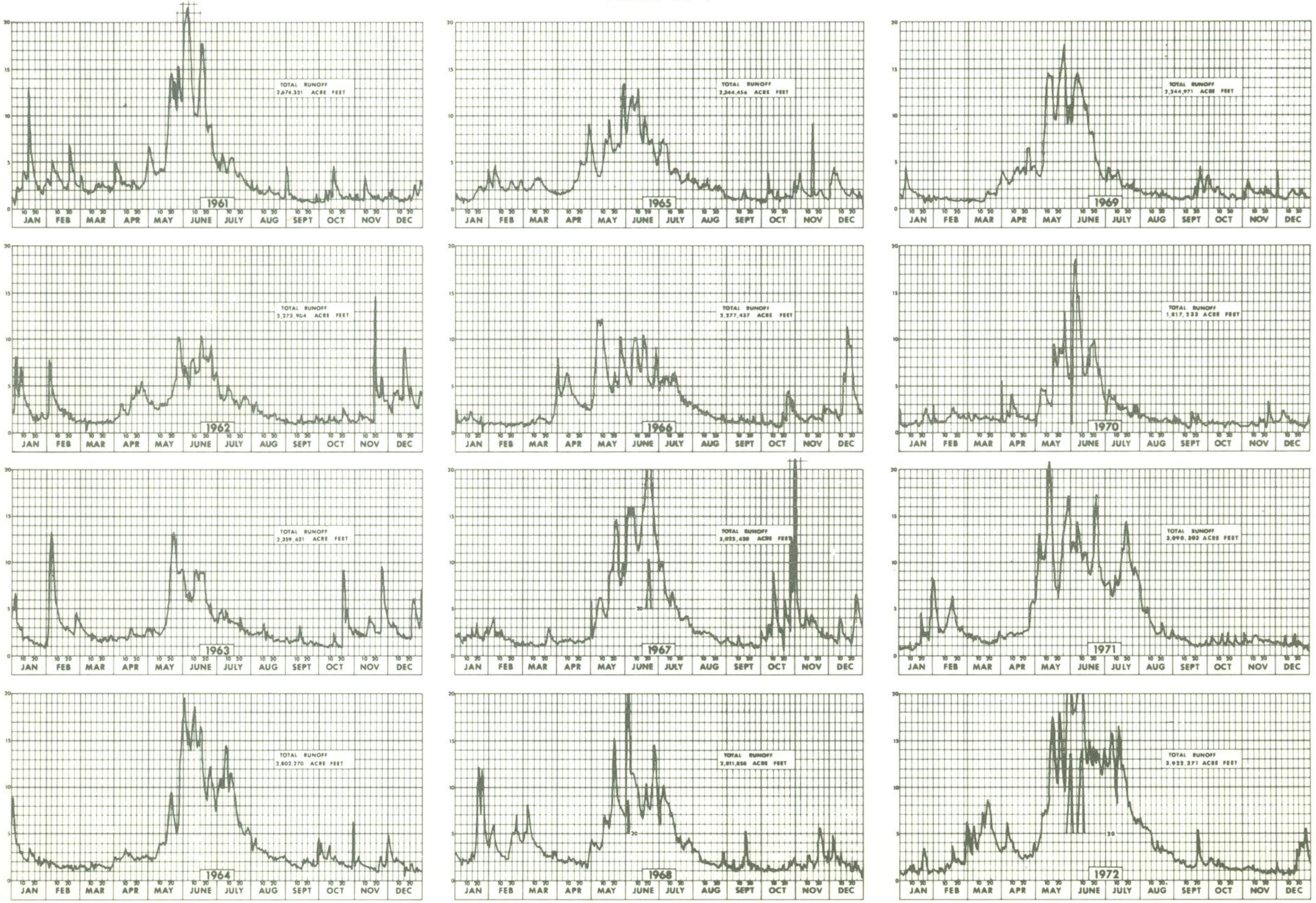
2.1.4 Water Chemistry

Water samples from Ross Lake were collected in 1973 by Institute personnel from midlake 1 mile above Ross Dam. Replicate samples were taken from 3 and 40 m, 3 times from mid-June to mid-September. The samples were analyzed in the field using Hach Model DR-EL apparatus. Results are given in Table 2.1-2.

Conductance measurements of the surface water of Ross Lake were also made frequently from March 30 to June 20, 1973 and on August 8 and 20, 1973 at the mile 0 station (Appendix 2). The range of values and the mean of the surface water conductance measurements from March 30 to August 8, 1973 were 49-69 μmhos/cm and 62 μmhos/cm at 25°C, respectively. In comparison the 1972 range and mean of conductance measurements in the same location from mid-April to mid-July were 55-69 μmhos/cm and 61 μmhos/cm at 25°C, respectively.

In addition, water sampling for conductance was done simultaneously with the expanded D.O. sampling at approximately two-week intervals from late October through early January, 1974. The conductance

FIGURE 2.1-4



MEAN DAILY DISCHARGE IN THOUSANDS OF SECOND FEET

FIGURE 2.1-4 (page 2)

MEAN DAILY DISCHARGE IN THOUSANDS OF SECOND FEET

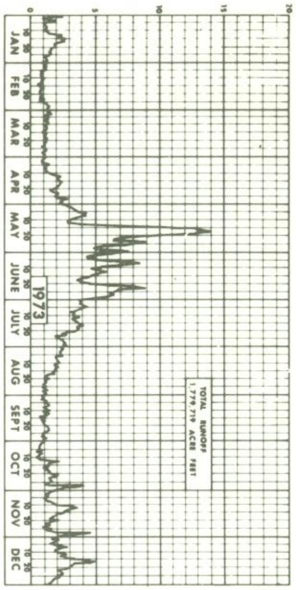


TABLE 2.1-2

ROSS LAKE WATER CHEMISTRY 1973 (ALL VALUES IN PPM UNLESS OTHERWISE NOTED)

Station: Midlake	Depth	3 m			40 m		
1 mile North of Dam	Date	6/17	8/9 18,24	9/16	6/17	8/9	9/16
Alkalinity		34	36	40	32	30	33
CO_2 (Dissolved)		2.0	1.2	2.0	2.4	1.2	2.4
Hardness (Ca)		29	30	25	25	21	29
Hardness (Mg)		2	1	9	5	5	8
Hardness (Total)		31	31	34	30	26	37
Fe		0.08	0.02	0.04	0.09	0.07	0.10
Mn		BDL*	0.5	0.25	BDL	0.4	0.55
N (NH_3)			0.3	0.3		0.3	0.4
Silica (SiO_2)		8.5	8.2	12.4	8.3	8.3	14.4
Sulfate		1.0	5.1	5.0	1.0	5.0	6.0
Chloride		2.5	5.0	5.0	2.5	5.0	5.0
Temp. ^{o}F		53	60	61	42	47	49
pH		7.8	8.3	8.2	7.8	7.6	7.5
Color (Alpha Pt-Cobalt Std)		4	1	10	3	3	4
Turbidity (JTU)		10	5	7	5	9	5
Secchi Disc (ft)		19'	35'	34'			
Conductance (μ mhos/cm)		56	54				

*BDL = below detectable level.

measurements were taken at 10 m depth intervals from 1 m below the surface to within 3 m of the bottom at stations 0, 3, 6, 9, 12, 15, 18, 19, and 21 miles from Ross Dam (Table 2.1-3).

During fall stratification, conductivity in the water column was slightly lower in the epilimnion than in the hypolimnion. The general level of conductance increased from late October to early January.

2.2 ROSS LAKE TRIBUTARY STREAMS (1973)

Physical characteristics of the tributaries to Ross Lake were discussed in City of Seattle, Department of Lighting (SCL), 1973.

The stream temperatures of 6 tributaries were monitored with maximum-minimum recording thermometers in 1973. Means of the recorded maxima and minima are plotted in Fig. 2.2-1. The graphs show that Big Beaver Creek averaged the coldest of all the streams over the June to mid-August period and Dry and Roland Creeks, the warmest. Mean temperatures over the June-July and June-mid-August periods (Fig. 2.2-1) are of particular interest because this is the primary period when the trout eggs and alevins are incubating in the stream bottom gravels. Big Beaver Creek was the coldest stream in these time periods - 46.8^{O}F average from June to mid-August and 46.9^{O}F average from June through July. The warmest streams, Dry and Roland Creeks, had very similar temperature means (both are very small streams - see SCL, 1973). Dry Creek averaged 50.3 and 48.7^{O}F and Roland Creek averaged 50.2 and 48.3^{O}F over the June to mid-August and June through July time periods, respectively. Temperatures for each respective time period in Ruby, Lightning and Pierce Creeks were between the ranges represented by Big Beaver and Dry and Roland Creeks. The plots of the stream temperatures (Fig. 2.2-1) show that the streams were at nearly the same temperature in mid-May

TABLE 2.1-3

CONDUCTIVITY MEASUREMENTS IN ROSS LAKE OCTOBER 25, 1973
TO JANUARY 9, 1974. ALL VALUES ARE IN μ MHOS/CM
STANDARIZED TO 25° C (American Public Health Association, 1965)

	Date					
Depth (m)	10/25-26	11/6-7	11/19-20	12/4-5	12/19-20	1/8-9
Station: Mile 0						
1	61	90	104	70	62	103
10	62	64	85	68	69	75
20	63	64	67	70	71	73
30	66	64	64	70	69	74
40	65	63	64	71	68	73
50	64	66	68	70	70	75
60	65	69	72	70	71	75
70	66	71	75	76	71	73
80	67	69	75	75	73	75
90	66	71	75	75	74	76
100	69	70	74	77	73	74
	69 (107 m)					
110		71	77	78	77	74
		73 (117 m)				
120			76	77	75	77
			78 (123 m)			
Station: Mile 3						
1	66	65	68	71	73	74
10	66	66	67	69	73	74
20	65	65	69	71	71	76
30	64	65	78	69	70	74
40	64	64	74	71	71	-
50	66	66	79	71	70	76
60	67	67	71	72	73	76
70	70	70	71	73	73	74
80	69	68	74	73	74	74
90	70	71	75	73	75	76
	72 (97 m)	73 (97 m)	72 (95 m)	75 (96 m)		74 (93 m)

TABLE 2.1-3 Page 2

CONDUCTIVITY MEASUREMENTS IN ROSS LAKE OCTOBER 25, 1973 TO JANUARY 9, 1974. ALL VALUES ARE IN μ MHOS/CM STANDARIZED TO 25^{o} C (APHA, 1965)- CONTINUED

	Date					
Depth (m)	10/25-26	11/6-7	11/19-20	12/4-5	12/19-20	1/8-9
Station: Mile 6						
1	68	67	68	71	73	74
10	67	67	70	69	71	74
20	69	65	70	71	72	74
30	67	65	71	70	73	74
40	69	66	71	73	73	74
50	69	67	69	74	73	74
60	71	71	74	72	69	74
70	75	71	75	74	75	76
	75(77 m)	73(76 m)	76(75m)		75(76 m)	77(73 m)
80				74		
Station: Mile 9						
1	71	68	69	-	72	79
10	69	68	71	-	71	75
20	69	67	70	-	71	76
30	68	69	71	-	73	74
40	71	69	72	-	69	77
60	72	69	73	-	75	78
	73(52 m)	75(55 m)	73(51 m)		77(54 m)	
60						
Station: Mile 12						
1	71	73	73	-	75	81
10	71	71	71	-	71	72
20	71	71	71	-	71	76
30	73	69	71	-	73	74
	71(36 m)	71(38 m)	71(34 m)	-	73(33 m)	78(35 m)

TABLE 2.1-3 Page 3

CONDUCTIVITY MEASUREMENTS IN ROSS LAKE OCTOBER 25, 1973 TO JANUARY 9, 1974. ALL VALUES ARE IN μ MHOS/CM STANDARIZED TO 25° C (APHA, 1965)- CONTINUED

	Date					
Depth (m)	10/25-26	11/6-7	11/19-20	12/4-5	12/19-20	1/8-9
Station: Mile 15						
1	75	73	73	-	72	90
10	77	75	73	-	72	86
20	75	73	73	-	74	79
	75(25 m)	77(29 m)	73(27 m)	-	75(27 m)	
Station: Mile 18						
1	75	73	76	-	78	90
10	75	75	76	-	77	79
	80(15 m)	83(19 m)	82(19 m)	-	79(17 m)	76(12 m)
Station: Mile 19						
1	-	-	-	-	-	103
Station: Mile 21						
1	79	87	79	-	103	

FIGURE 2.2-1

STREAM TEMPERATURES

1973

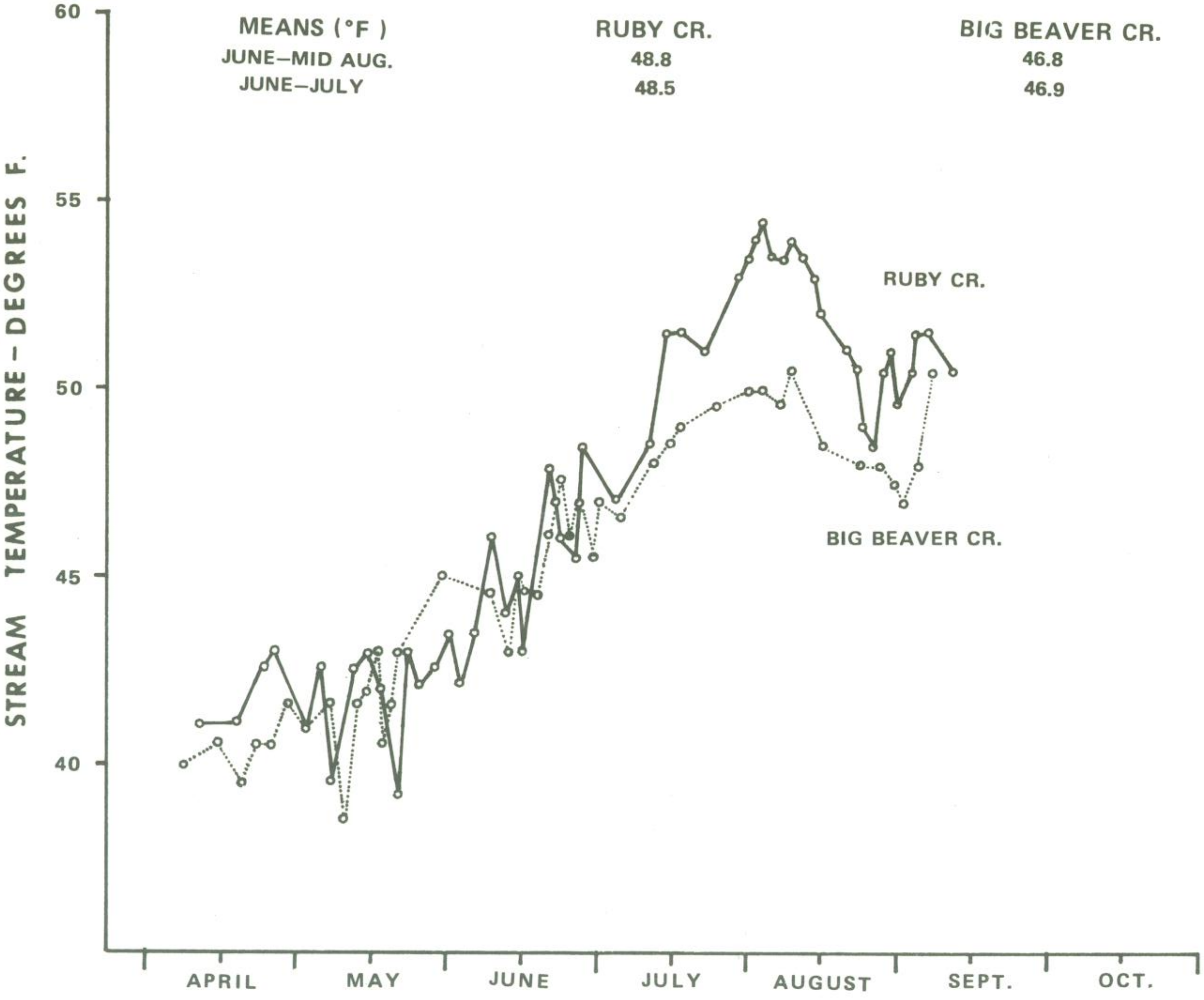


FIGURE 2.2-1 (page 2)

STREAM TEMPERATURES

1973

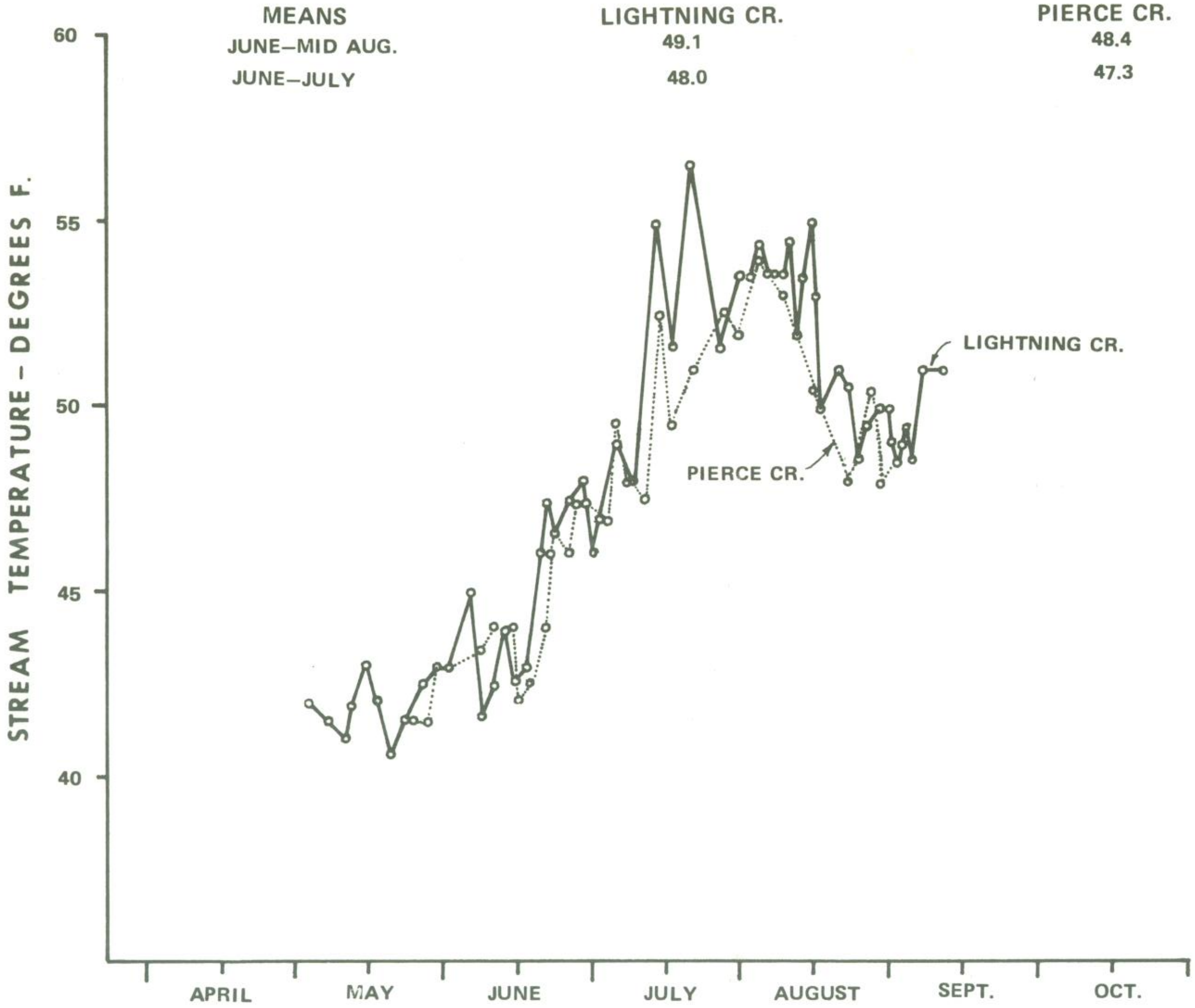
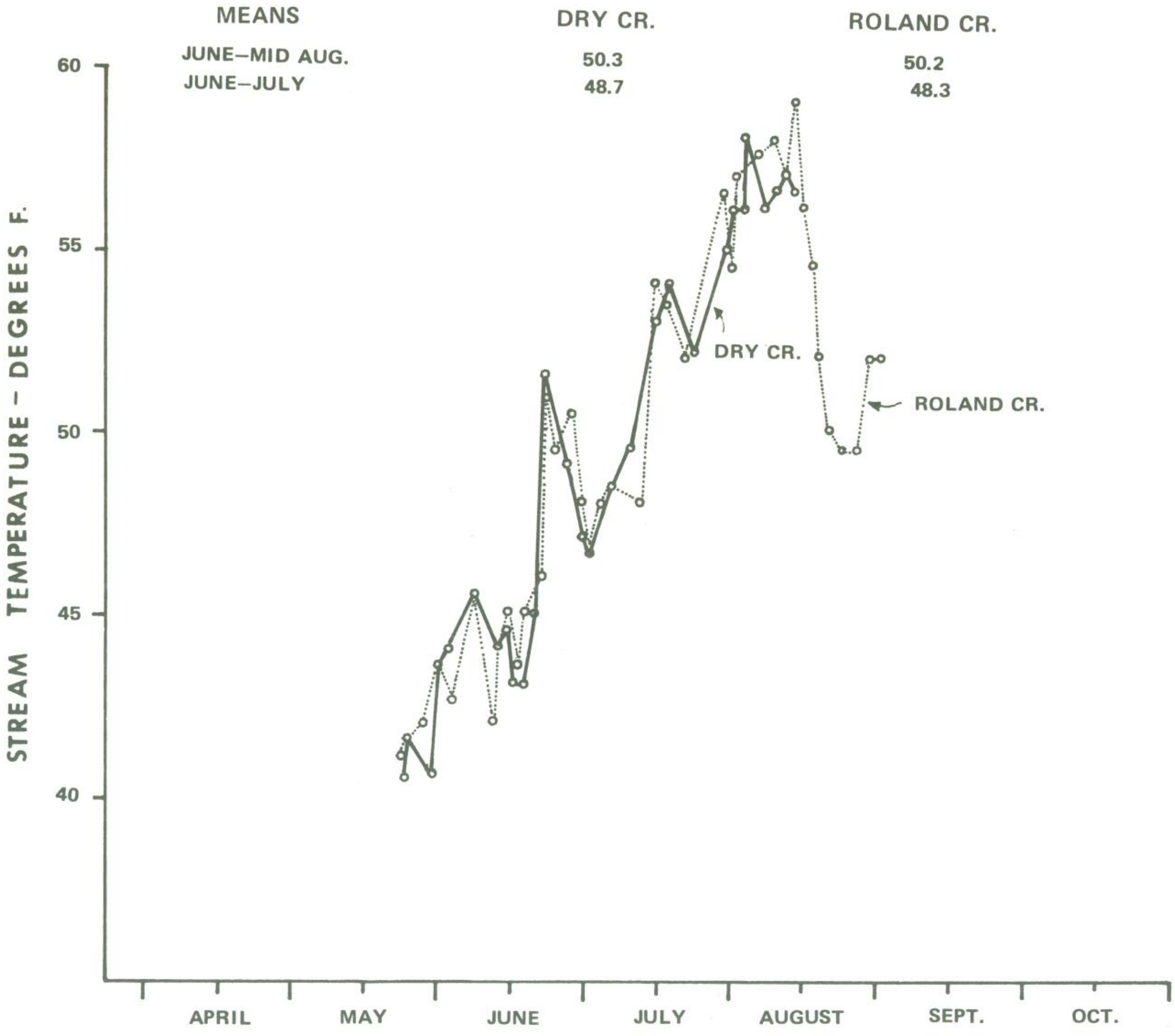


FIGURE 2.2-1 (page 3)

STREAM TEMPERATURES
1973



MEANS	DRY CR.	ROLAND CR.
JUNE–MID AUG.	50.3	50.2
JUNE–JULY	48.7	48.3

but that Dry and Roland Creeks warmed up faster and had higher temperature maxima than the other larger streams. Big Beaver Creek, fed by glaciers, warmed up at the slowest rate and had the lowest temperature maximum of all streams.

Comparison of the June to mid-August stream temperature data for Big Beaver, Ruby and Lightning Creeks, 1971 through 1973 (Fig. 2.2-1 and SCL, 1973) shows that Ruby and Lightning Creeks varied in the same manner from year to year; both were coldest in 1972 (44.0 and 45.0°F, respectively) and warmest in 1973 (48.8 and 49.1°F, respectively). In 1971 their June to mid-August means were 46.0 and 45.7°F, respectively. The temperature mean of Big Beaver Creek in the same time period was also highest in 1973 (46.8°F) but was lowest in 1971 (43.9°F) and intermediate in 1972 (45.8°F). The variation between years was greatest in Ruby Creek (4.8°F), slightly less in Lightning Creek (4.1°F), and least in Big Beaver Creek (2.9°F). Undoubtedly, the glacial runoff into Big Beaver Creek tends to maintain a colder and more constant temperature than the other streams not fed directly by glaciers.

June to mid-August temperature means in Dry and Roland Creeks were 3.7 and 4.0°F, respectively, warmer in 1973 than in 1972 (Fig. 2.2-1 and SCL, 1973).

The significance of these annual differences in June and mid-August stream temperatures as related to egg incubation rate, hatching and emergence time of the trout fry will be discussed in Section 3. Late fall 1973 temperature readings were taken in Ruby, Big Beaver, Devils, Lightning and Little Beaver Creeks and the Skagit River above Ross Lake (Appendix 1).

Conductance of nine of the Ross Lake tributary streams was monitored at their mouths in 1973 and early January 1974. The data are presented in Table 2.1-4.

Conductance was lower in the west side streams (Pierce, Big Beaver, Little Beaver) than in the east side streams and Skagit River. Conductance was generally higher during low flow periods than during heavy runoff from snow melt.

2.3 SKAGIT RIVER, 1973 (by F.F. Slaney and Company)

A general description of the physical characteristics of the Skagit River, including profile and gradients, bottom substrates, and detailed maps is provided in SCL (1973). Sampling sections in 1973 remained the same as in previous years.

2.3.1 Discharge

Discharge of the Skagit River was determined in cubic feet/second in 1973 by the methods used in previous years (see SCL, 1973). Discharge values at Chittenden's Bridge are shown by day in Figure 2.3-1. Mean monthly discharge values are also shown. The 1973 mean monthly discharge is compared with previous years in Figure 2.3-2.

2.3.2 Temperatures

Temperatures of the Skagit River in 1973 at Chittenden's Bridge are shown in Figure 2.3-3.

2.3.3 Tributary Streams

Physical characteristics of the tributaries to the Skagit River were presented in Interim Report No. 2 (SCL, 1973).

TABLE 2.1-4 SPECIFIC CONDUCTANCE (AT 25^{o}C) OF NINE ROSS LAKE TRIBUTARY STREAMS IN 1973 AND EARLY JANUARY 1974

	Stream								
Date	Ruby Creek	Roland Creek	Pierce Creek	Big Beaver Creek	Devils Creek	Dry Creek	Lightning Creek	Little Beaver Creek	Skagit River (above Ross Lake)
4/4/73	101			36					
4/5								40	
4/6	64			33					
4/11	82			35	82				
4/13	81								
4/16				32					
4/17	73								
4/19				32	69			34	
4/24				32					
4/26	74			34					
4/27	70								
5/2	67			32					
5/4							84		
5/7	60								
5/8	60			28			80		
5/9				30					
5/10							84		
5/14	52								
5/15		49		21			68		
5/16	40			23			60		
5/18				21					
6/1	47	65	20			63	66		
6/4		74	23			78			
6/12							61		
6/14	42	62	19	21		58	67		
6/15							71		
10/26									116
10/27	73			35	67		102	35	
11/7	77			48	74		91	42	114
11/20	77			44	76		109	47	117
12/5	79			48	86		98	45	109
12/20	81			37	79		119	48	113
1/9/74				49			106		

FIGURE 2.3-1

DAILY AND MEAN MONTHLY DISCHARGE
at
Chittenden's Bridge Station
1973

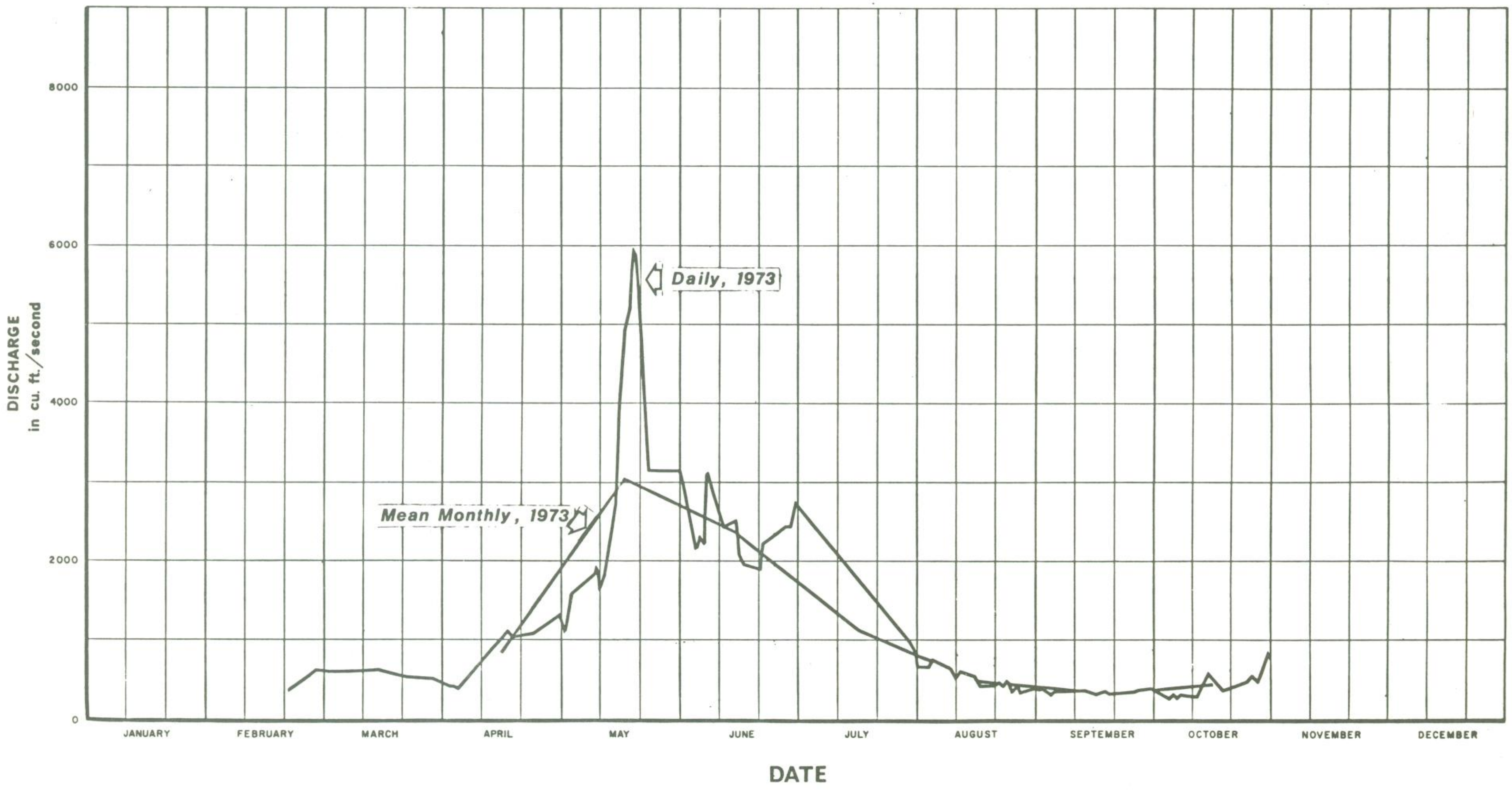


FIGURE 2.3-2

MEAN MONTHLY DISCHARGE OF SKAGIT RIVER

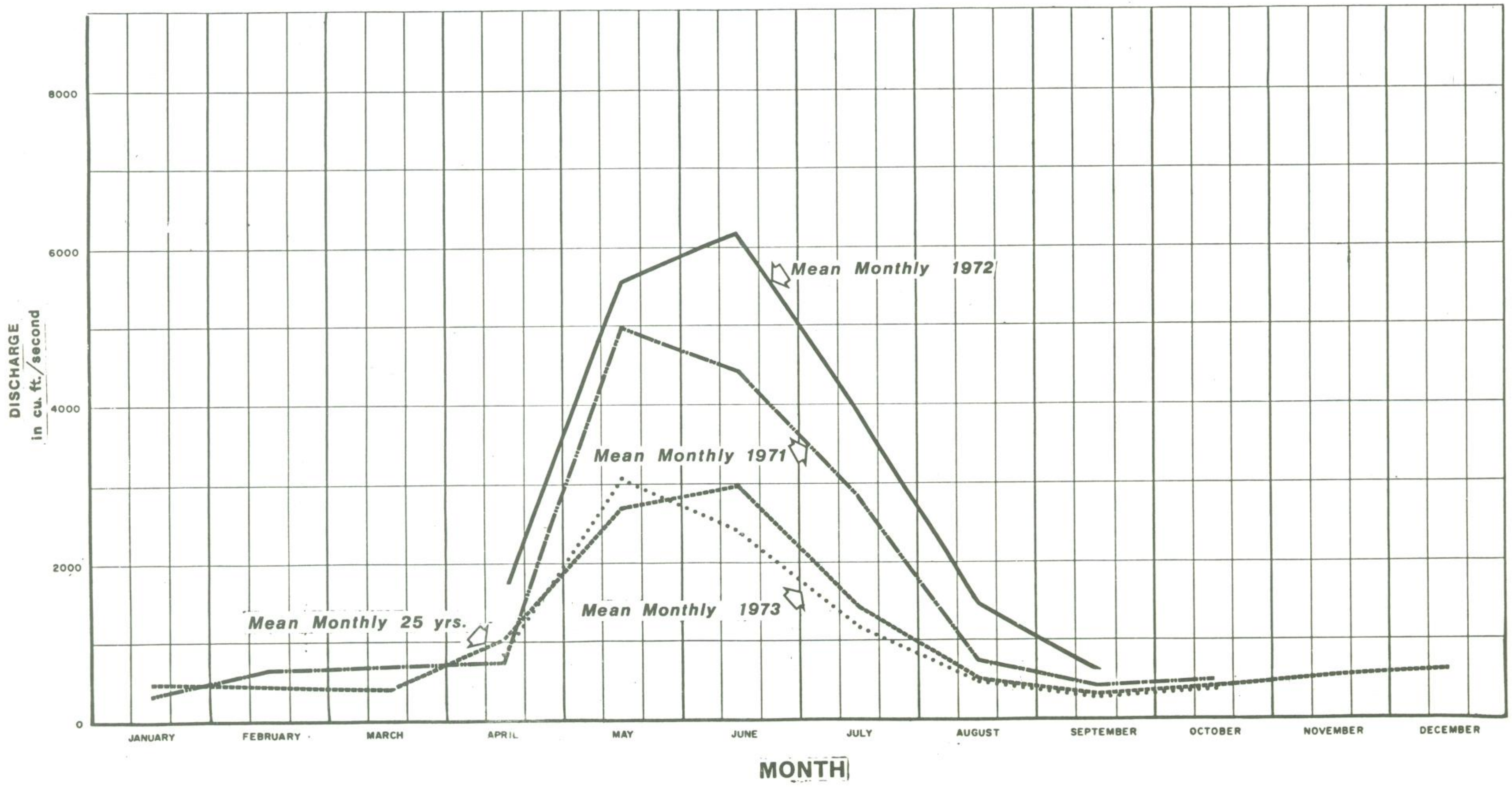
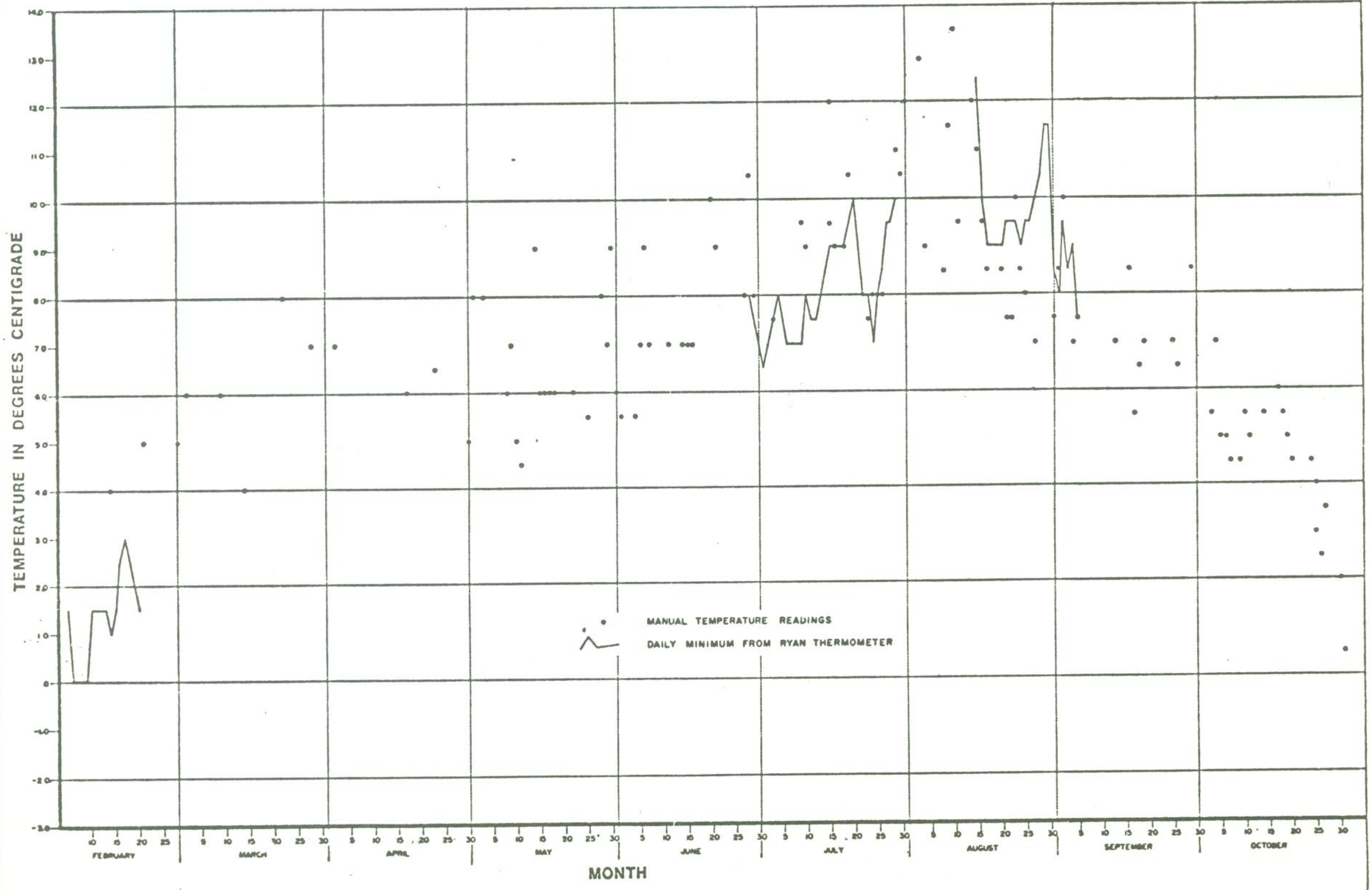


FIGURE 2.3-3

DAILY TEMPERATURE READING OF SKAGIT RIVER
at
Chittenden's Bridge Station
1973



PART 3

PRESENT STATE OF FISHES AND FISHERY

3.1 INTRODUCTION (by F.F. Slaney and Company)

3.1.1 Species Present

Fishes found in the Skagit River-Ross Lake system include rainbow trout, brook trout, Dolly Varden char and cutthroat trout. Golden trout and steelhead trout have been introduced to the system, as have rainbows, brook and cutthroat.

Table 3.1.1 summarizes the morphological, life history and other characteristics of the four major species of fish found in the system and presents the characteristics of the species throughout their ranges (see SCL, 1973).

Hybridization between the cutthroat and rainbow trout populations appears to have occurred in the Skagit-Ross system. Individuals showing the characteristics of both species as well as intergrades between the two have been sampled. The two species may perhaps more properly be referred to as a "rainbow - cutthroat complex".

TABLE 3.1-1

CHARACTERISTICS OF FISH SPECIES FOUND IN SKAGIT RIVER-ROSS LAKE SYSTEM

Name					
Common	Scientific	Description	Distinguishing Characters	Distribution	Notes
Rainbow trout	Salmo gairdneri Richardson	Body trout-like; color variable (silver to bluish green or brown); up to 45" long and 52 lbs.	Lack of teeth at base of tongue; absence of red "slash" under jaw	Native: Pacific and Bering slopes (Mexico to Alaska). Introduced: world wide	Cool water fish; found in lakes and streams; spawning: late spring and early summer; few native populations; anadromous steel-head
Coastal cutthroat trout	Salmo clarki clarki Richardson	Body trout-like; dark green above, silver below; small dark spots on back and sides; up to 30" long and 17 lbs.	Red slash beneath lower jaws; small teeth at base of tongue	Northern California to S.E. Alaska on Pacific slopes	Cool water fish; lake and stream resident; spawning: late spring and early summer
Dolly Varden char	Salvelinus malma (Walbaum)	Body trout-like; color variable: olive-green with many round light spots; up to 50" and 32 lbs.	Small round spots(yellow, orange or pink) on back and sides	Northern California to Northwestern Alaska to Japan	Cool water fish; some anadromous populations; spawn in fall (August to November)
Brook trout	Salvelinus fontinalis (Mitchill)	Body deep,trout-like; color variable: olive-green above, lighter below; many small greenish spots with red centers and blue border	Red spots with blue halos; dark green marbling on back and dorsal fin	Native: streams and lakes of N.E. North America. Introduced: Western North America and world-wide	Cold, clear streams preferred; spawn in fall

3.2 PROCEDURES OF FISH SAMPLING, 1973 (by Fisheries Research Institute)

Fish sampling and processing procedures in 1973 were essentially the same as in 1972 (SCL, 1973) except that ganged trolls were not used to capture fish in 1973.

3.3 SPAWNING TIME AND LOCATIONS, 1973

3.3.1 Introduction (by Fisheries Research Institute)

The major and minor American tributaries of Ross Lake which are important spawning areas for Ross Lake trout have been identified (SCL, 1973). In 1973, an objective was to determine precisely the timing of spawning by trout and char and their spawning distribution relative to existing spawning areas which would be inundated, those which would remain, and spawning areas which would become accessible to spawners from Ross Lake if the level of Ross Lake is raised as proposed.

3.3.2 Ross Lake and American Tributary Streams (by Fisheries Research Institute)

3.3.2.1 Methods

Location and time of spawning was determined by direct observation of spawning activity, capture of sexually mature females (described in SCL, 1973) and by observation of the location and sampling of newly emerged fry. Back calculation from time of fry observation to spawning time based on accumulated temperature units was used in 1973 as in 1972 (SCL, 1973). Stream temperature data and their equivalents in temperature units were collected and calculated by FRI personnel and are presented in Appendix 3.

Fry sampling in 1973 employed the use of small fyke nets (2 ft. x 2 ft. and 2 ft. x 4 ft.) set for approximately 24-hour periods in Ruby Creek at the 1604 ft. elevation and the 1720 ft. elevation (two 2 ft. x 4 ft. nets at each location), Roland Creek at the 1603 ft. elevation (one 2 ft. x 2 ft. net), Dry Creek at the 1606 ft. elevation (one 2 ft. x 2 ft. net), Lightning Creek at the 1603 ft. elevation (two 2 ft. x 4 ft. nets), and Big Beaver Creek at the 1645 ft. elevation (two 2 ft. x 4 ft. nets).

The fyke nets were set in Big Beaver Creek at the 1645 ft. elevation (above the outlets of the beaver ponds) rather than near the stream mouth because the fry produced in Big Beaver Creek may be rainbow or cutthroat trout which could rear in the ponds, thus would not enter Ross Lake. Observations and fyke net sets in 1971 and 1972 (SCL, 1973) just above the stream mouth indicated no significant input of trout fry from Big Beaver Creek to Ross Lake (no fry were observed on foot surveys and only one fry was captured in the fyke net in 1971). It is believed that, if the beaver pond cutthroat trout spawn in the Big Beaver Creek drainage, spawning would occur above the outlets of the beaver ponds (approximately 2 miles upstream from Ross Lake) because favorable appearing spawning habitat occurs above the lower 3 mile reach of Big Beaver Creek (the lower 3 mile reach of Big Beaver Creek generally is slow and meandering through a deep silty channel in which favorable appearing spawning habitat is nil).

The nets were placed in stream riffles with the open end resting on the stream bottom and facing upstream. Except for those sets indicated in Table 3.3-1 each net was set in the morning and checked the following morning (approximately 24 hours later).

TABLE 3.3-1

FRY CATCHES (ALL SETS OVERNIGHT UNLESS OTHERWISE NOTED)

	Ruby Cr (1604')		Upper Ruby Cr (1720')				Lightning Cr (1603')		Big Beaver Cr (1645')	
Date Date	North net	South net	North net	South net	Roland Cr (1603')	Dry Cr (1606')	North net	South net	North net	South net
31 July					3(part lost)	467				
1 Aug					137	838				
2 Aug					500	1083				
3 Aug	23	24					3	6	1 DV(1 1/2")	0
4 Aug	29	-	11	17			19 + 1 fing.	47	2	2 DV
8 Aug							35	124		
9 Aug	85	88			409	306	40	107	2 DV	0
10 Aug	45	91	51	27	293	718	50	187	1 DV	2
11 Aug	61	-	-	-	197	959	64	260	-	-
14 Aug	79	113	17	39		Stream	-	-	-	-
15 Aug	33	45	68	76	-	dried	19	37	1,2 DV	0
16 Aug	25	31	45	53	-	up	70,1 DV	132	2 DV	0
17 Aug			30	113	582		188	57,1 DV	0	0
20 Aug			109	143			236* (night set)	247 (night set)		
20 Aug		1 (day set)					0 (day set)	3 (day set)		
21 Aug		108 (night set)					328 (night set)	387,1DV (night set)		
22 Aug		69	79	108	51		300,1DV	249,1DV	1 DV	1,1 DV
23 Aug	77	90	80		27,1DV	21	210	299,3DV		
24 Aug	120**	137	172	249	87		181,2DV	340,6DV	2 DV	4 DV
25 Aug			82	115	34,1RB2 1/2" 1DV2"		126,1DV	183,1DV		
28 Aug	47	52			5		125	130		
29 Aug	11	43	40	52	4,2DV		135	247	1,1 DV	1 DV
30 Aug	22,1RB (7")	27	54	149	10		87,1DV	133,1BT fing	1,1 DV	1 DV
31 Aug	41,1RB (fing)	10	29	65	7, 1DV(5")		54,1BT	123		
1 Sept	37	23	47	96			46	67		

TABLE 3.3-1 - Page 2

Date	Ruby Cr (1604')		Upper Ruby Cr (1720')		Roland Cr (1603')	Dry Cr (1606')	Lightning Cr (1603')		Big Beaver Cr (1645')	
	North net	South net	North net	South net			North net	South net	North net	South net
2 Sept			15	60			51	85		
5 Sept	25	13	22	13			41	63		
6 Sept	9	11	8	12			2	51	1	1
7 Sept	21	23					38	41	2	0
11 Sept	4	6	17	18			15	17		
12 Sept	0	2	2	2			5	14	1	0
13 Sept			1	0					0	1
14 Sept									0***	1
18 Sept										

*Moved toward south net (8' from south net).
**Moved 20' farther north.
***Net moved to north side from midstream.

3.3.2.2 Time of Rainbow Spawning

Sexual Condition of Adults

The plot of the distribution of sexual maturity stages of Ross Lake rainbow trout females over time in 1973 is shown in Fig. 3.3-1.* Females only were utilized because they ripen into spawning condition at once just prior to actual spawning while males ripen progressively, beginning earlier than the females (Brannon, personal communication). Brannon further states that male rainbow trout, by ripening progressively, can spawn with more than one female at different times. This promiscuous nature of male salmonids was demonstrated by Mathisen (1962) who observed one male sockeye salmon spawn with 14 different females in a 9-day period.

Included in this analysis are all sexed females captured in lake sampling by research personnel including those captured in stream mouths. Fish captured in stream spawning surveys were not included in the graph because these samples were selective only for spawning fish. Stream mouth sampling possibly was also selective for spawning fish. The percentage occurrence of females by maturity stage from February through July tends to place the peak spawning period between late May and mid-June.

Emergence of Fry

In 1973 fry were captured on July 31 in the first sets of the Roland and Dry Creek fyke nets, on August 3 in the first sets of the fyke nets in Ruby and Lightning Creeks and on August 4 in the second sets of the fyke nets in Big Beaver Creek (see Table 3.3-1). The first observations of fry by personnel on foot surveys preceded the fry catches made with the fyke nets by 2 days in Ruby and Lightning Creeks and by one day in Dry Creek (Table 3.3-2). No fry were observed in Roland Creek before the first fry catches were made. In Big Beaver

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* Eggs from a ripe female captured at the mouth of Ruby Creek on July 5 were used in the egg survival experiment. This fish was not included in the samples used in Figure 3.3-1.

FIGURE 3.3-1

SEXUAL CONDITION OF ROSS LAKE FEMALE RAINBOW TROUT, 1973

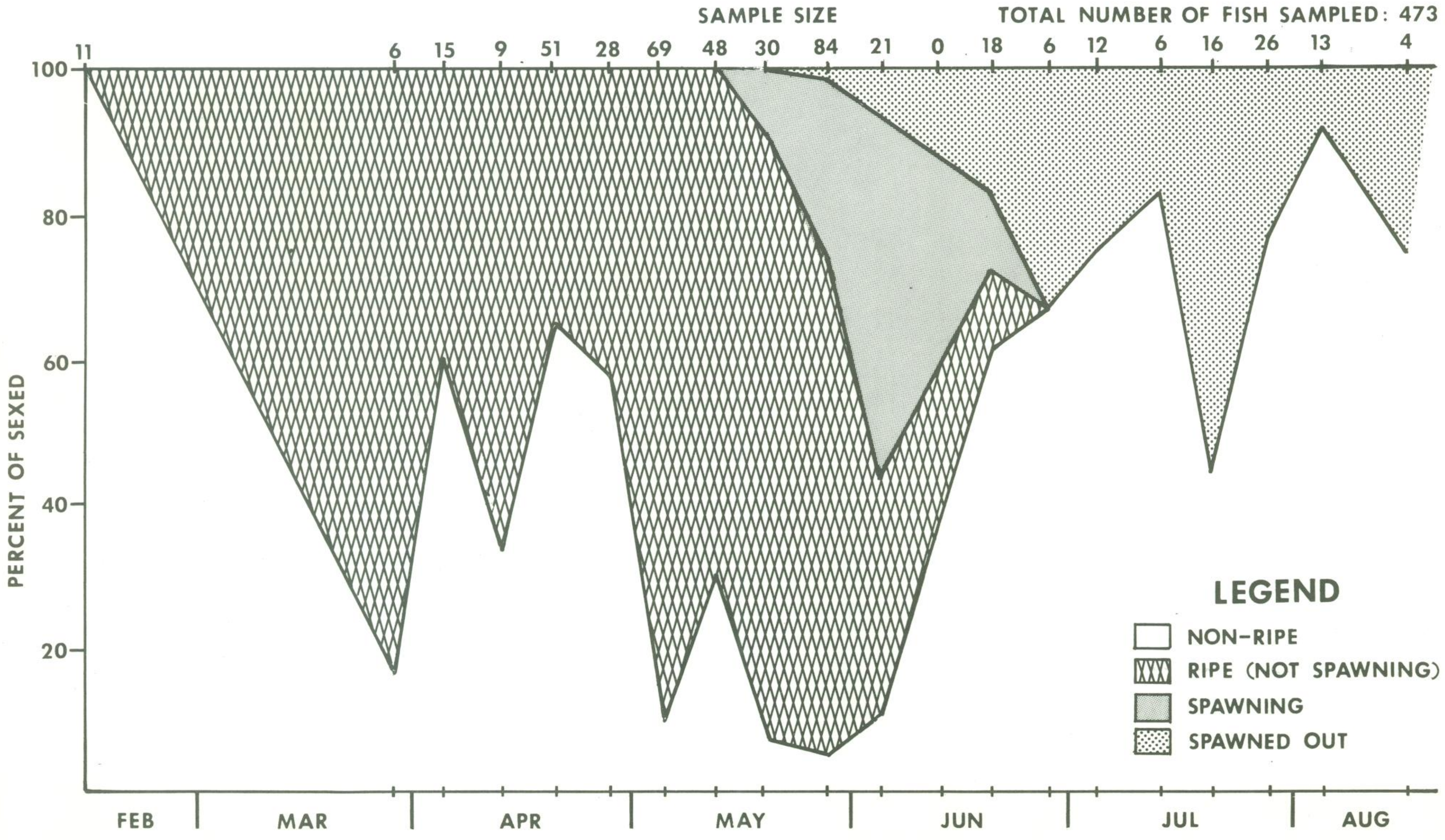


TABLE 3.3-2

OBSERVATIONS OF AGE 0 FISH IN ROSS LAKE AND TRIBUTARY STREAMS, 1973

LOCATION	DATE	DISTANCE COVERED	COUNTS
Ruby Creek	July 16	150 ft. at mouth of stream	0
	July 17	500 ft. along Ruby Arm and mouth of stream	0
	July 30	150 ft. at mouth of stream	0
	August 1	150 ft. at mouth of stream	2
Roland Creek	July 26	30 ft. at mouth of stream	0
	July 29	100 ft. at mouth of stream	0
	July 30	100 ft. at mouth of stream	0
Dry Creek	July 17	from stream mouth to 150 ft. upstream	0
	July 23	from stream mouth to 150 ft. upstream	0
	July 26	30 ft. just above stream mouth	0
	July 30	from stream mouth to 150 ft. upstream	3
Lightning Creek	July 17	from stream mouth to 600 ft. upstream	0
	July 23	from stream mouth to 600 ft. upstream	0
	July 31	from stream mouth to 600 ft. upstream	0
	August 1	from stream mouth to 600 ft. upstream	3

Creek no surveys were made on foot except for casual observations at the fyke net site on days when the nets were fished. No fry were observed in Big Beaver Creek except those captured by the fyke nets. The small size of the fry (23-26 mm) in the first fyke net catches and the presence of remaining yolk sacs on many of them indicates that emergence from the gravel had occurred within one week of capture.

Based on back calculation from time of fry observation by numbers of temperature units required for incubation and emergence, spawning in Ruby, Roland, Dry and Lightning Creeks was under way by late May (Fig. 3.3-2). Hatching and fry emergence were under way in early and late July respectively. Although catches of fry in Big Beaver Creek were small, back calculation from date of first fry capture indicates that spawning and hatching and emergence of fry occurred at about the same time as in the other streams mentioned above (see Fig. 3.3-2).

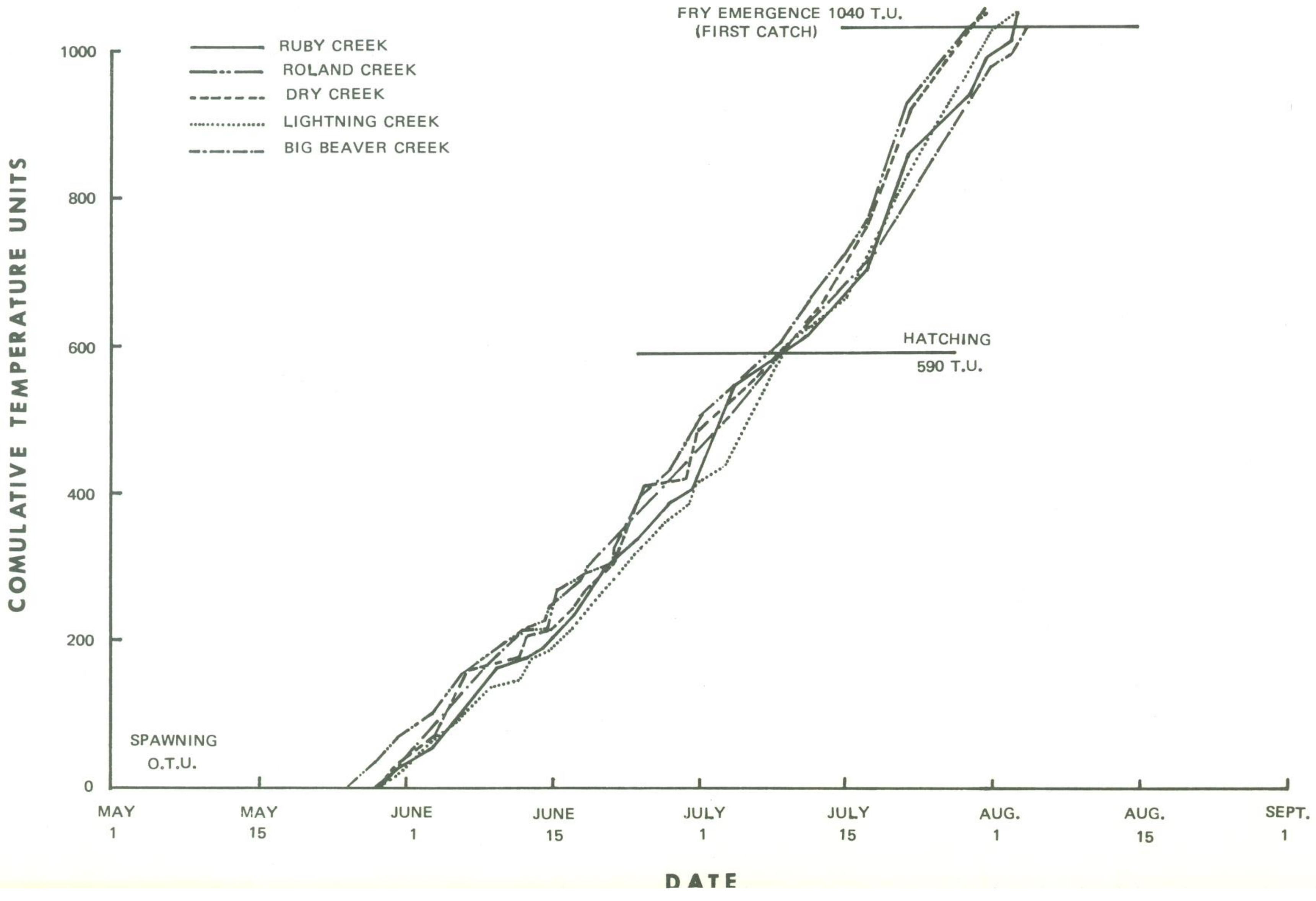
Comparison of the time of beginning of hatching and fry emergence in 1973 (Fig. 3.3-2) with that of hatching and fry emergence times in 1972 (SCL, 1973) indicate that in Ruby, Dry, Roland, and Lightning Creeks, they began about 2 weeks earlier in 1973 (hatching in early July and fry emergence in late July to early August) than in 1972 (hatching in mid-July and fry emergence in mid-August). Time of beginning of spawning was approximately the same in both years in Dry and Roland Creeks (late May). Beginning of spawning was about 1½ weeks earlier in 1972 (mid-May) than in 1973 (late May) in Ruby Creek. In Lightning Creek, begining of spawning was about one week earlier in 1973 (late May) than in 1972 (early June). The speed-up in incubation and time to fry emergence in the American streams in 1973 was a result of the higher temperatures discussed

FIGURE 3.3-2

APPROXIMATE BEGINNING OF RAINBOW SPAWNING, HATCHING AND EMERGENCE

ROSS LAKE AMERICAN TRIBUTARIES

1973



in Section 2. Based on determination of maturity stage of adult rainbows, peak spawning time in 1972 appeared to coincide closely with the time of peak runoff which was around June 10 (see Figure 2.1-4). In 1973, based on maturity stage and back calculations of temperature units from the peak fry catches in the Ruby and Lightning Creek fyke nets, spawning was 3-4 weeks later than the peak of runoff around May 18.

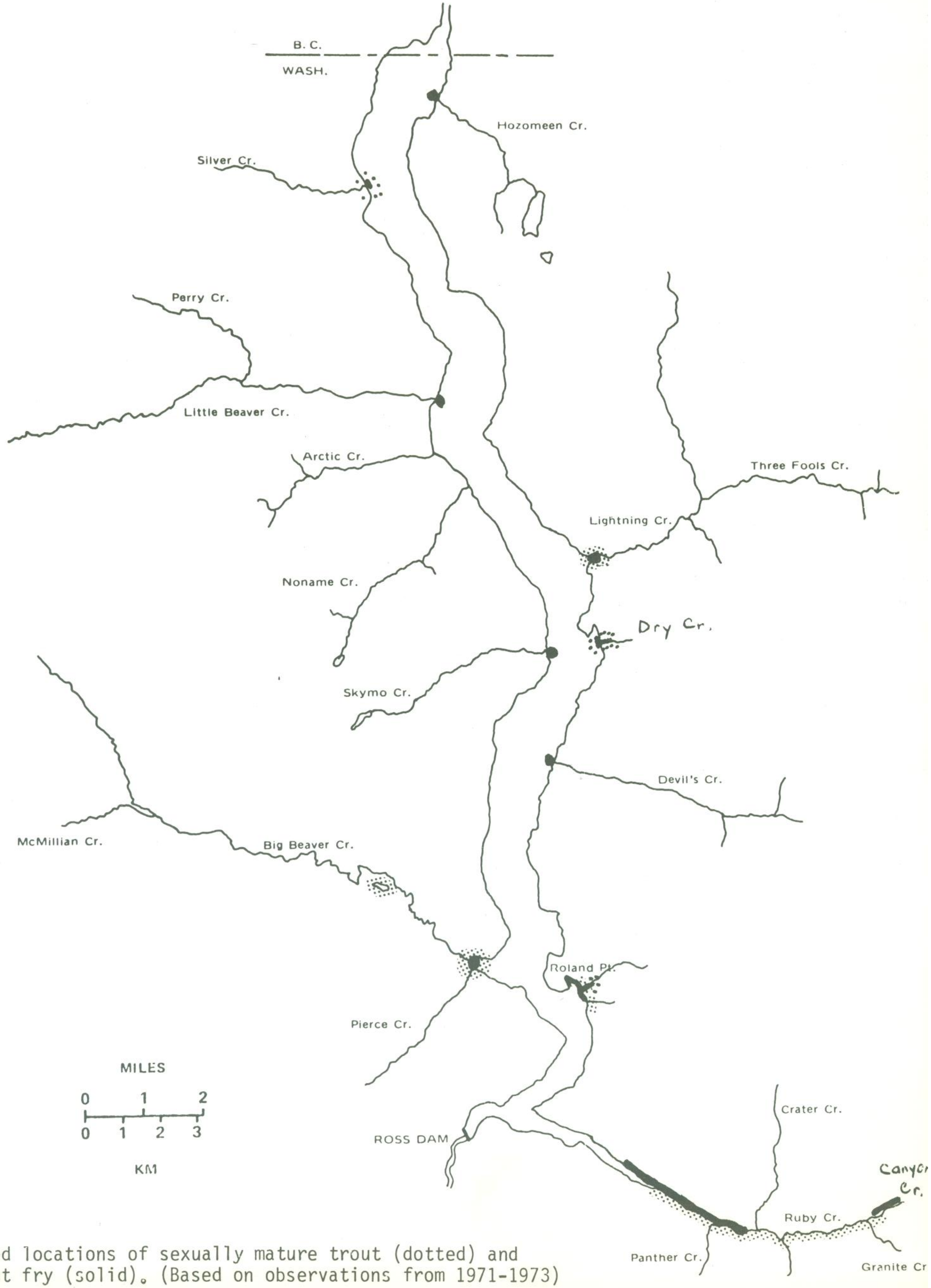
3.3.2.3 Location of Rainbow Spawning

Information on location of spawning in areas accessible to Ross Lake trout was also provided by the sampling of ripe fish, observation of activity related to spawning (Fig. 3.3-1 and Appendix 4), and fry sampling in the lake near stream inlets and in streams (Fig. 3.3-3).

Fish sampling in 1972 and 1973 in stream sections inaccessible to fish from Ross Lake in Lightning, Cinnamon, Three-Fools, Little Beaver, and Granite Creeks show that resident fish populations exist in these streams.

The results are consistent with those of 1972 which show that the lower ¼ mile and mouth of Lightning Creek, the lower ¼ mile and mouth of Dry Creek, the lower 1/3 mile and mouth of Roland Creek, as well as Ruby Creek, and Lower Canyon Creek are important spawning tributaries for Ross Lake trout on the American side of the U.S./Canadian border. In 1973, it became evident from casual observations of the migration block at the 1648 ft. elevation on Lightning Creek (about 1/4 mile from Ross Lake) that erosion of the bank during periods of extremely high stream flow had caused diversion of some of the flow around the barrier during the 1973 runoff. On July 10, 1973, a rainbow trout, which had been tagged in Ross Lake on

FIGURE 3.3-3



Observed locations of sexually mature trout (dotted) and emergent fry (solid). (Based on observations from 1971-1973)

April 13, was recovered just above the migration block (Appendix 4). Apparently, the fall is a complete block below a certain stream flow level and a partial block when stream flow is above this level. Other areas known to be utilized by Ross Lake trout for spawning in 1972, i.e., the mouth of Silver Creek and the mouth of Pierce Creek, were not sampled in 1973 because amount of spawning habitat is limited and fry production based on 1972 observations in these areas is relatively minor.

Fry abundance data were also obtained using the fyke nets described earlier. The nets were set in the morning and left for approximately 24 hours at a time. They were then emptied of their catch and reset. Several night and day sets were made in Ruby and Lightning Creeks (see Table 3.3-1). Results show that virtually all downstream fry movement occurred during dark hours.

To estimate the number of fry passing the fyke net locations per day the following formula was used:

$$N = \frac{\text{total catch (Table \quad) x total stream discharge at net site}}{\text{total volume of water strained by net(s)}}$$

where N = number of fry passing the location during the set. At locations where two nets were fished (see Table 3.3-1) total catch is the sum of the catches of each net and total amount of water strained is the sum of the amounts of water strained by each net.

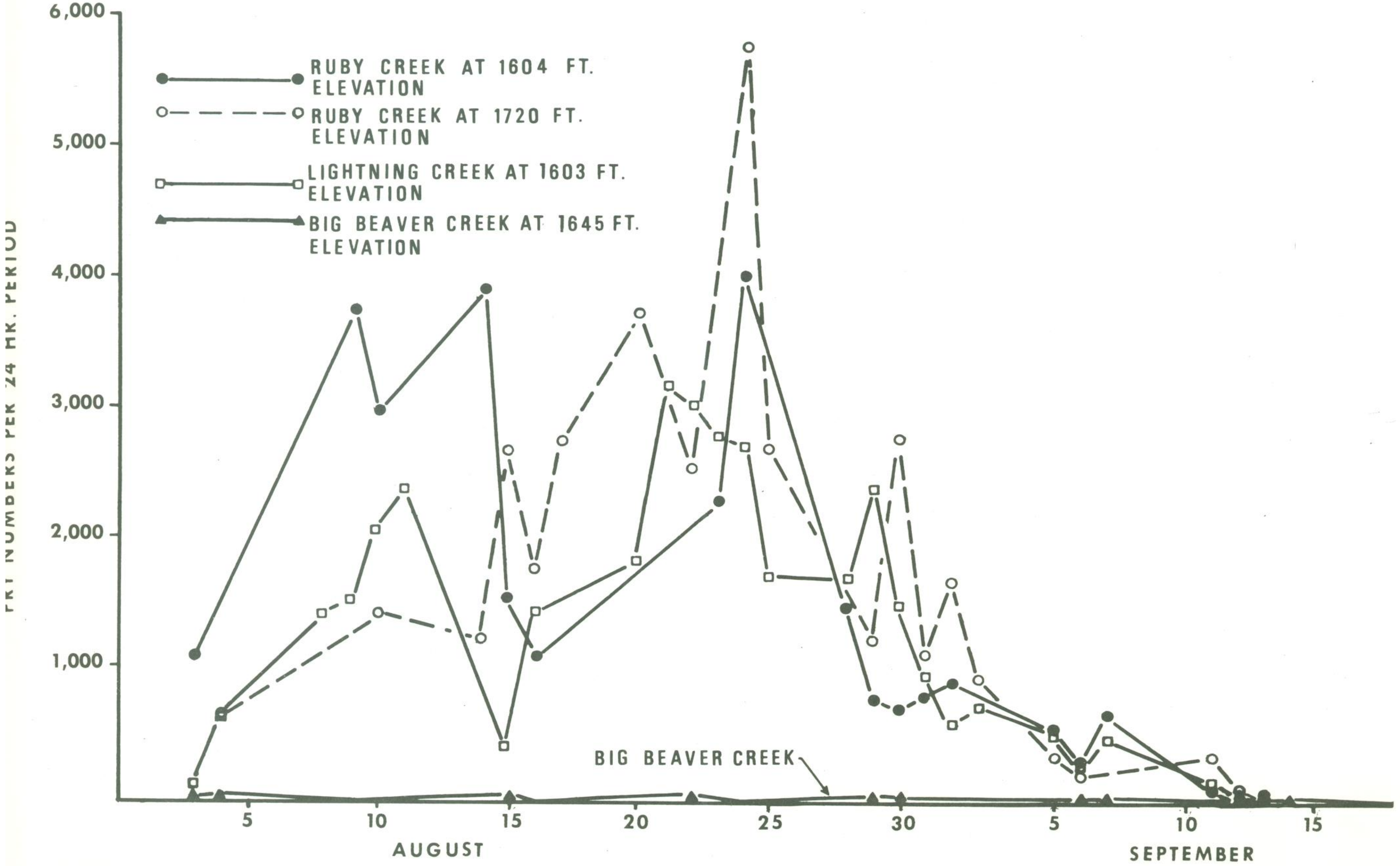
Values for amount of water strained through the nets and total stream flow at the fyke net location were obtained from depth, width and velocity measurements.

The resulting data were graphed (Figs. 3.3-4 and 3.3-5) and the plots used to estimate fry production on days when the nets were not fished. The daily estimates are tabulated in Table 3.3-3 for each stream location. The totals in Table 3.3-3 represent the estimates of total fry produced in each tributary based on the above method. The estimates do not include fry which probably had passed downstream before installation of the fyke nets. Fry were observed in some of the streams prior to the first sets (Tables 3.3-1 and 3.3-2). Also all of the first fyke net sets except those in Big Beaver Creek captured fry. Indications of the catch trends and fry count data in Table 3.3-2 are that fry emergence began only 1 or 2 days before the first fyke net sets, except in Big Beaver Creek; thus, the abundance estimates were not seriously affected. In Ruby Creek the estimated abundance of fry (73,321) produced above the 1604 ft. elevation (1.5 ft. above Ross Lake at full pool) was greater than that in any other American tributary. The abundance estimate of fry produced above the 1720 ft. elevation on Ruby Creek (5 ft. below full pool elevation of the proposed reservoir) was 67,089. Estimated abundance in Lightning Creek above the 1603 ft. elevation was second highest (52,416). Roland Creek above the 1603 ft. elevation and Dry Creek above the 1606 ft. elevation produced 23,046 and 10,280 fry respectively and Big Beaver Creek above the 1645 ft. elevation produced the least (604).

3.3.2.4 Spawning of Other Species

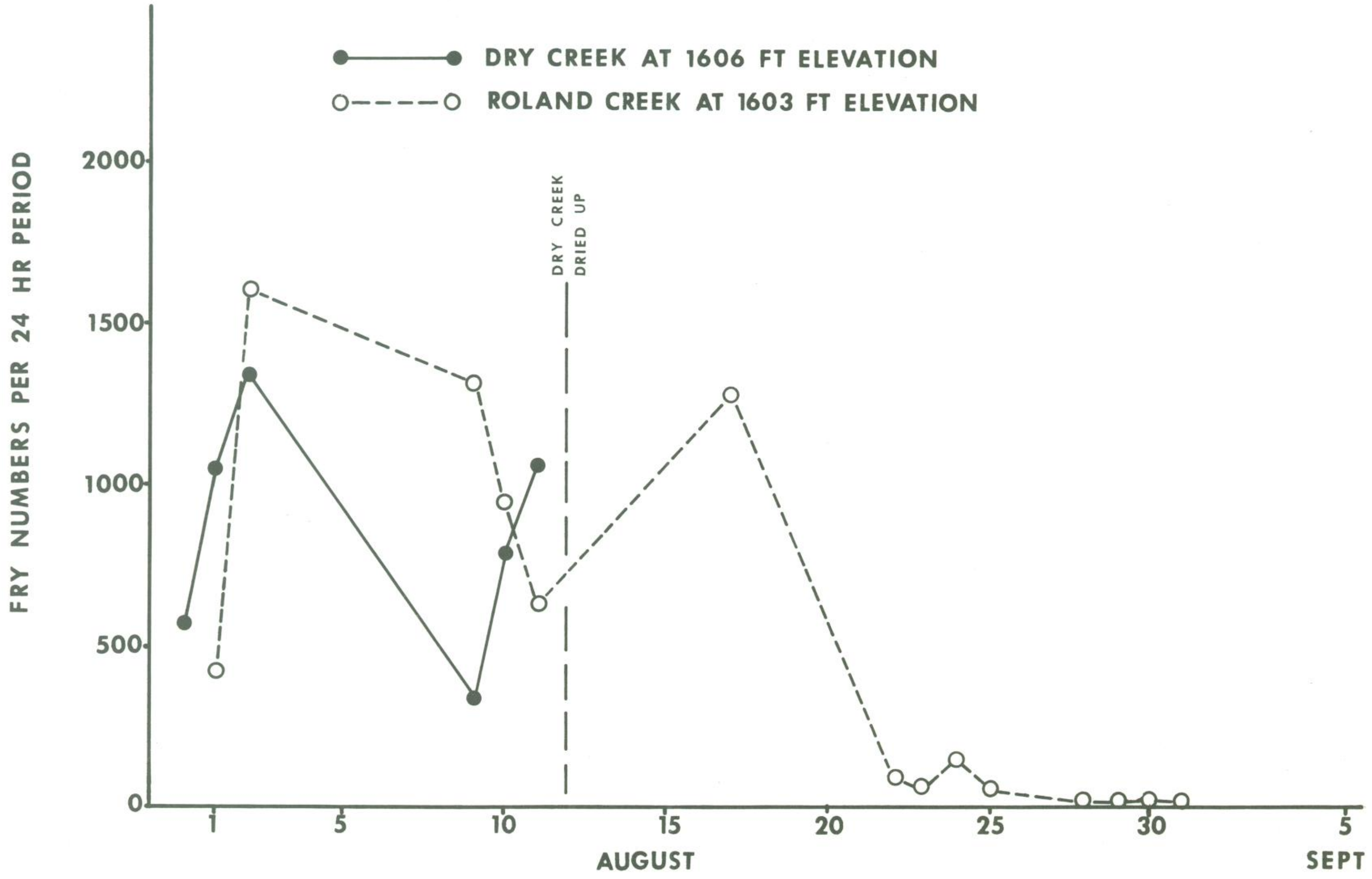
Sampling of cutthroat trout in 1971 and 1972 (SCL, 1973) and in 1973 indicated that this species spawns at about the same time as rainbow trout in the Ross Lake watershed. In 1973, sampling of ripe cutthroat trout in Ross Lake and in two ponds along Big Beaver Creek (Appendix 5) indicated that the males were in spawning condition between mid-April and late May. A spawned-out male and two spawned-out female cutthroat were captured in the beaver pond

FIGURE 3.3-4



ESTIMATED TROUT FRY PRODUCTION IN THE MAJOR U.S. TRIBUTARIES TO ROSS LAKE
1973

FIGURE 3.3-5



TROUT FRY ABUNDANCE ESTIMATES , DRY AND ROLAND CREEKS 1973

TABLE 3.3-3 TROUT FRY PRODUCTION - 1973

	Ruby Cr. (1604')	Ruby Cr. (1720')	Lightning Cr.(1603')	Dry Cr. (1606')	Roland (1603')	Big Beaver Cr.(1645')
July 30						
July 31		100		584	*	
Aug. 1	275	250		1048	442	
2	700	400		1354	1613	
3	1117	500	90	1210	1580	0
4	1600	638	642	1060	1530	25
5	2000	800	815	925	1490	19
6	2475	900	1010	775	1440	13
7	2900	1025	1210	630	1400	8
8	3350	1200	1430	290	1360	4
9	3765	1300	1536	340	1319	0
10	2993	1431	2071	798	945	25
11	3250	1390	2394	1066	635	22
12	3480	1325	1900		740	19
13	3700	1300	1350		850	17
14	3925	1238	875		960	15
15	1581	2695	412		1070	13
16	1091	1782	1457		1180	0
17	1250	2748	1510		1293	0
18	1425	3100	1610		1040	3
19	1600	3400	1710		790	6
20	1800	3733	1820		575	8
21	2000	3100	3216		330	10
22	2175	2579	3045		102	13
23	2332	4200	2771		50	7
24	4027	5808	2718		150	0
25	3425	2717	1740		55	3
26	2800	2325	1730		45	5
27	2175	1975	1720		25	7
28	1534	1600	1710		8	9
29	805	1268	2394		6	13
30	755	2815	1533		14	13
31	824	1142	959		9	15
Sept. 1	917	1720	600			17
2	825	964	723			18
3	775	775	675			19
4	675	550	600			21
5	589	369	539			23
6	303	236	223			25
7	670	250	525			25
8	550	290	410			22
9	400	330	325			19
10	300	370	210			17
11	159	397	140			15
12	29	45	68			13
13		9				13
14						13
15						13
16						13
17						13
18						13
Totals:	73321	67089	52416	10280	23046	604

* Part of catch lost (Table 1)

on June 27. Back calculation of temperature units from first catch of trout fry in Big Beaver Creek place time of first spawning in late May (Fig.3.3-2). Since the newly emergent rainbow and cutthroat fry could not be distinguished visually, the fry may have been either rainbow or cutthroat. The general pattern of distribution of catches of ripe and spawned-out cutthroat trout in the system and the ponds along Big Beaver Creek strongly indicate that spawning of this species occurs mainly in the Big Beaver drainage.

A mark and recapture experiment (simple Petersen method) was conducted in the spring and summer of 1973 in the larger pond along Big Beaver Creek. On April 18, May 1, and May 17, 164 trout were tagged and released in the pond. On June 27 and August 22, 62 fish were captured, 10 of which were recoveries of previously tagged fish, giving a rough population estimate of approximately 1,000 fish. Basic assumptions using this type of estimate were discussed in SCL (1973). Recoveries of tagged fish by anglers in Ross Lake in 1973 included 3 of those tagged in the beaver pond (Appendix 6); thus, some interaction of the beaver pond and Ross Lake populations is known to occur.

State of Washington Game Department records show that plants of cutthroat trout were made in Big Beaver Creek in 1916 and 1919 before Ross Lake was formed (SCL, 1973). It is probable that these introductions resulted in the existing cutthroat trout population in the Big Beaver valley. The 14-foot fall at the 1535 ft. elevation on Big Beaver Creek would have prevented movement of the cutthroat into the existing Big Beaver valley if they had been planted or occurred naturally below this obstruction prior to initial reservoir filling above elevation 1535 in 1947. No resident cutthroat trout populations have been found in other stream tributaries accessible to fish from Ross Lake.

No direct observations of spawning of Dolly Varden char and brook trout were made in 1973. Samples of juvenile Dolly Varden taken from fyke nets in Lightning and Big Beaver Creeks indicate that both streams may be utilized for spawning by Dolly Varden. Adult Dolly Varden char have been observed in previous years in Ruby and Lightning Creeks and were believed to be fish which had moved in to spawn (SCL, 1973). In Big Beaver Creek a Dolly Varden in spawning condition was captured at the 1722 ft. elevation in late September, 1971.

3.3.2.5 A Preliminary Genetic Survey of Rainbow and Cutthroat Populations in the Ross Lake Drainage

Introduction

This survey was conducted to determine which types of enzymes, if any, are of a polymorphic nature in rainbow and cutthroat trout populations from the Ross Lake drainage. The existence of polymorphism in rainbow and cutthroat trout has been documented by the following authors: Allendorf (1973); DeLigny (1969); Northcote, et al (1970); Tsuyuki and Roberts (1965); and Utter and Hodgins (1972). Because of the evidence of polymorphism in rainbow trout populations studied by the above authors it was strongly suspected that rainbow and cutthroat trout populations in the Ross Lake drainage would exhibit distinct polymorphism. It was also suspected that differences in gene frequencies would exist in rainbow and cutthroat populations which exist in a variety of isolated locations within the Ross Lake drainage.

The specific locations which were sampled are: beaver ponds above a waterfall in Big Beaver valley; Granite Creek above a waterfall; Little Beaver Creek above a waterfall; Lightning Creek in two locations above waterfalls; Three Fools and Cinnamon Creeks above a waterfall; and Ross Lake. These sampling locations and waterfalls are shown on Figure 3.3-6. The waterfalls previously mentioned are

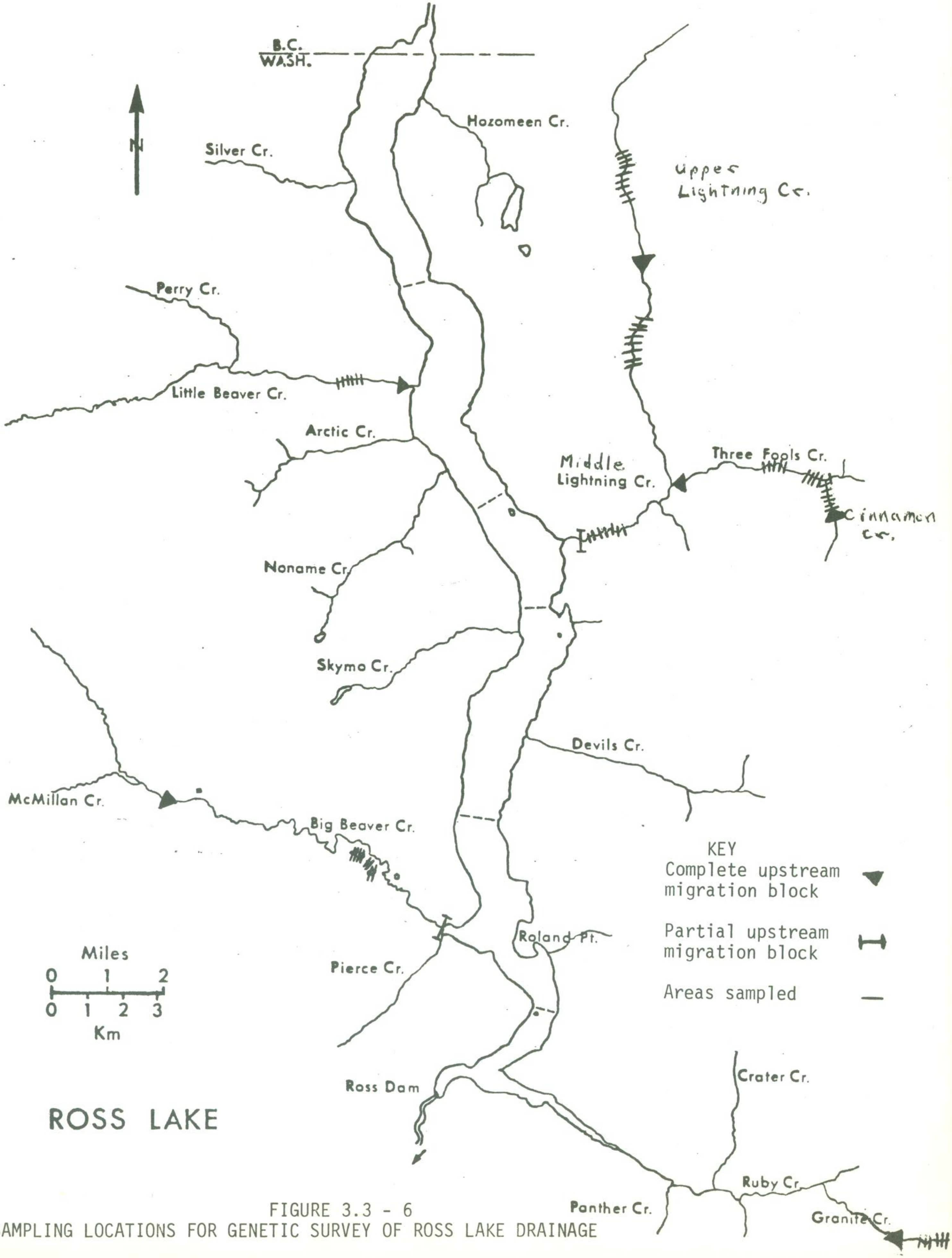


FIGURE 3.3 - 6
SAMPLING LOCATIONS FOR GENETIC SURVEY OF ROSS LAKE DRAINAGE

upstream migration barriers only and the waterfalls closest to Ross Lake in both Big Beaver and Lightning Creeks are not migration barriers during the entire year. The waterfall at the mouth of Big Beaver Creek is present from approximately February through May each year when Ross Lake is drawn down below 1555 ft. elevation (SCL, 1973). The rest of the year this waterfall is inundated by Ross Lake. The waterfall in Lightning Creek which is not a complete migration barrier is located at 1648 ft. elevation and probably is passable by some fish from Ross Lake at times during the high spring stream flow, April through June. One trout tagged in Ross Lake was recovered above the waterfall in Big Beaver Creek, and another was recovered above the waterfall in Lightning Creek (SCL, 1973 and ibid).

Methods of Study

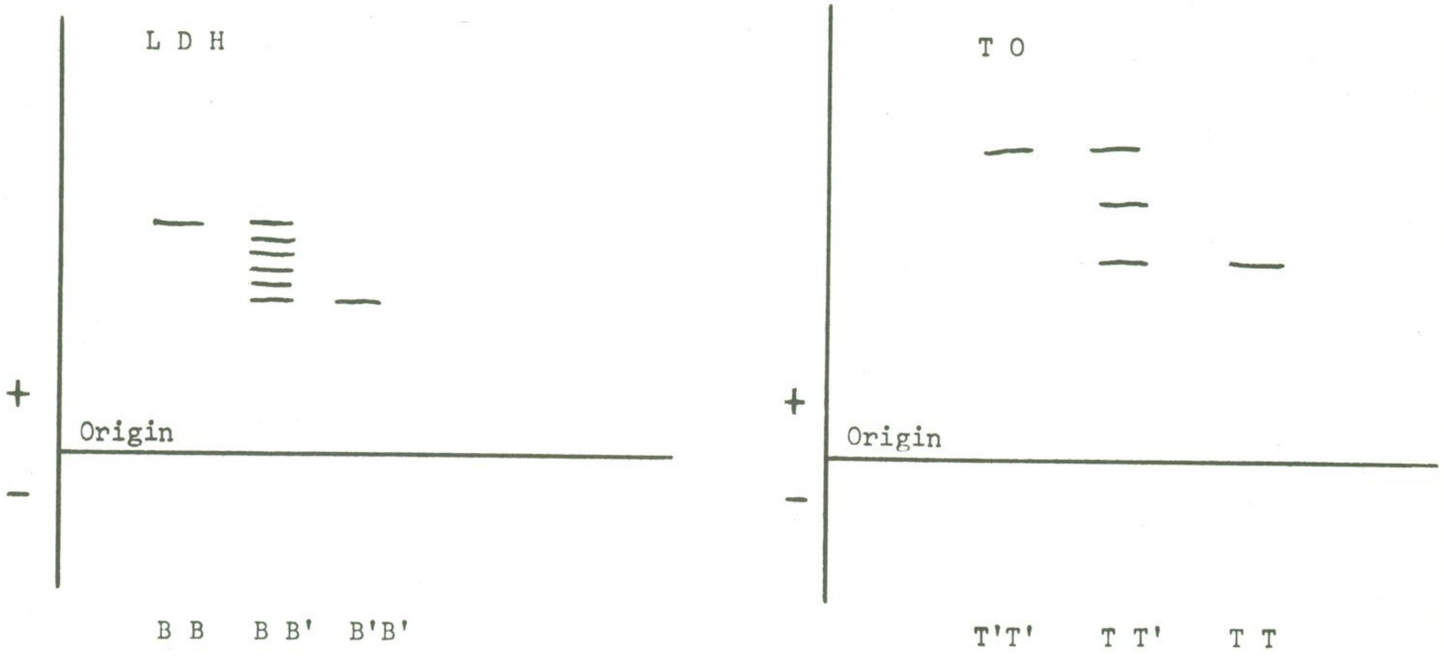
The fish collected in the previously designated areas were kept refrigerated until the tissue samples were taken. Samples of liver and muscle tissue were taken from most fish, liver tissue only from Ross Lake angler-caught fish sampled during creel census, and placed in self-sealing plastic bags. The samples were frozen and kept frozen until analysis was conducted at the University of Washington College of Fisheries.

Standard starch gel electrophoresis was utilized to determine the presence or absence of polymorphic enzyme systems. The electrophoresis was conducted using a buffer system described by Ridgway et al, (1970). The liver tissue was used to examine lactate dehydrogenase (LDH) and tetrazolium oxidase (TO). The muscle tissue was used to examine malate dehydrogenase (MDH), phosphoglucomutase (PGM) and alpha-glycerophosphate dehydrogenase (AGPDH).

Results

The liver samples gave good clear staining for (LDH) and (TO). The polymorphic patterns of these two enzymes are diagrammed in Figure 3.3-7. The gene frequencies obtained for (LDH) and (TO) for all sampling locations are given in Tables 3.3-4 and 3.3-5, respectively. The expected phenotypes and X^2 values were calculated for each of the populations sampled. These values are also given in Tables 3.3-4 and 3.3-5. The Little Beaver Creek population which showed polymorphism in (LDH) was the only population which had a significant X^2 which would indicate rejection of Hardy-Weinberg equilibrium. However, the importance of this deviation is diminished by the small sample size, twenty-one individuals, and increased sampling would increase the reliability of the data on this population.

Examination of Table 3.3-4 reveals that polymorphism in (LDH) exists in the following populations: Big Beaver pond cutthroat trout; Middle Lightning Creek rainbow trout; Little Beaver Creek rainbow trout; Ross Lake rainbow trout; and Upper Lightning Creek rainbow trout. No (LDH) polymorphism was observed in Cinnamon, Three Fools or Granite Creek samples. Of particular interest of the gene frequencies on Table 3.3-4 are the distinct differences between areas of the Lightning Creek drainage (Figure 3.3-7). Middle Lightning Creek is known to receive some genetic input from fish residing in Ross Lake because one spawned-out female which had been tagged in Ross Lake was captured in this portion of Lightning Creek. Since Middle Lightning Creek has a gene frequency for (LDH) closest to that of Cinnamon and Three Fools Creeks, it is possible that the rainbow trout of this area are primarily of the same stock with minor genetic contamination in Middle Lightning Creek from either Ross Lake rainbows or Upper Lightning rainbows which both have much higher frequencies of the B' gene, .325 and .833, respectively, than Middle Lightning Creek, .125.



Diagrammatic representation of lactate dehydrogenase (LDH) and tetrazolium oxidase (TO) phenotypes observed in liver tissue from rainbow and cutthroat trout collected in the Ross Lake drainage area.

FIGURE 3.3-7

TABLE 3.3-4

LDH DISTRIBUTION, ROSS LAKE DRAINAGE

		Phenotypes			Gene Frequency		Expected phenotypes			χ^2
Species	Location	BB	BB'	B'B'	B	B'	BB	BB'	B'B'	d.f.=2
CT	Big Beaver Ponds	18	6	0	.875	.125	(18.375)	(5.250)	(0.375)	.1224
RB	Middle Lightning Creek	14	6	0	.850	.150	(14.450)	(5.100)	(0.450)	.1868
RB	Little Beaver Creek	8	7	6	.548	.452	(6.306)	(10.403)	(4.290)	17.3741
RB	Cinnamon and Three Fools Creeks	41	0	0	1.00	0.00	(41.0)	(0.0)	(0.0)	
RB	Upper Lightning Creek	0	2	4	$.16\overline{6}$	$.83\overline{3}$	(.165)	(1.659)	(4.163)	.2414
RB	Granite Creek	10	0	0	1.00	0.00	(10.00)	(0.0)	(0.0)	
RB	Ross Lake	53	56	11	.675	.325	(54.675)	(52.650)	(12.675)	.4857

TABLE 3.3-5

TO DISTRIBUTION, ROSS LAKE DRAINAGE

		Phenotypes			Gene Frequency		Expected Phenotypes			χ^2
Species	Location	TT	TT'	T'T'	T	T'	TT	TT'	T'T'	d.f.=2
CT	Big Beaver Ponds	9	13	2	.646	.354	(10.015)	(10.976)	(3.007)	.8133
RB	Middle Lightning Creek	15	4	1	.850	.150	(14.450)	(5.100)	(0.450)	1.815
RB	Little Beaver Creek	21	0	0	1.00	0.00	(21.00)	(0.0)	(0.0)	
RB	Cinnamon and Three Fools Creeks	41	0	0	1.00	0.00	(34.0)	(0.0)	(0.0)	
RB	Upper Lightning Creek	6	0	0	1.00	0.00	(6.00)	(0.0)	(0.0)	
RB	Granite Creek	10	0	0	1.00	0.00	(10.00)	(0.0)	(0.0)	
RB	Ross Lake	61	51	8	.721	.279	(62.380)	(48.278)	(9.340)	.3842

Examination of Table 3.3-5 reveals that polymorphism in (TO) exists in the following populations: Big Beaver Pond cutthroat trout; Middle Lightning Creek rainbow trout; and Ross Lake rainbow trout. No (TO) polymorphism was observed in the samples from Little Beaver, Cinnamon, Three Fools, Granite, and Upper Lightning Creeks. The (TO) enzyme system of Middle Lightning Creek rainbows is intermediate between Upper Lightning, Cinnamon-Three Fools and Ross Lake in the frequency of the T' gene. Since the samples from Upper Lightning, Cinnamon, and Three Fools Creeks contained no T' genes, the only possible source of this gene would be genetic input from Ross Lake rainbows.

Several difficulties were encountered with the analysis of the muscle samples and no definitive information was obtained on polymorphism in (MDH), (PGM), and (AGPDH). Polymorphism seemed to be present in some of the samples but accurate interpretation was not possible because of unclear staining in the gels being used to analyze these enzymes.

Conclusions

It was shown that polymorphism in two enzyme systems (LDH) and (TO) exists in rainbow and cutthroat trout populations found in the Ross Lake drainage. The existence of distinct gene frequencies in several of the populations sampled lends firm genetic support to the identity of these populations which were previously distinguished on the basis of physical isolation alone.

The existence of population differences within one stream drainage, Lightning Creek, is indicated by the different gene frequencies involving (LDH) and (TO) observed in Lightning Creek and its tributaries (Tables 3.3-4 and 3.3-5). This observation could be strengthened by larger sample sizes but the differences in gene frequency are strong indicators of truly distinct populations even with the present small sample sizes.

The cutthroat trout in the ponds of Big Beaver valley seem to have distinct gene frequencies which would indicate genetic isolation. However, lack of comparative cutthroat samples from Ross Lake makes it uncertain whether this is a population or species differentiation.

In conjunction with the interest in these populations as examples of segregation of natural populations there is a baseline of data available in Lightning and Big Beaver Creeks to compare with future conditions. The waterfalls closest to Ross Lake in these streams will be completely removed if Ross Lake is raised from its present full pool elevation of 1602.5 ft. to 1725 ft. as proposed by Seattle City Light (SCL, 1973). This would make access to upstream areas of Big Beaver and Lightning Creeks readily available to Ross Lake trout and if utilization of these areas did occur it could be detected by a shift in the gene frequencies now existing in these two areas. Utilization of these upstream areas by Ross Lake trout is expected to be substantial, especially in Lightning Creek. Electrophoretic analysis of samples from this area could accurately determine the extent of such utilization. The usefulness of such investigations has been indicated by DeLigny (1969) in the following statement.

> "If a genetic system is detected and a sufficient number of phenotypes can be recognized the application of methods of population genetic analysis can reveal the structure of the groups involved, their relationship and eventually the underlying mechanisms involved in their differentiation."

3.3.3 Skagit River and Tributaries (by F.F. Slaney and Company)

3.3.3.1 Methods

Sightings

Foot surveys in order to observe spawning rainbow trout from the river banks were made in 1973, as in previous years.

River conditions were more conducive to wetsuit floatdowns than in previous years. Seven dives were made between March 23 and May 24 in various sections of the Skagit, Klesilkwa, and Sumallo Rivers.

Gillnet Sets

The gillnetting program for adult rainbow trout was reduced in 1973. Only minimal sampling took place during the spawning period to monitor the presence of ripe fish in the river.

Fry Net Sets

Fry sampling in 1973 used the same type of fyke nets as those described in Section 3.3.2.1 (above). These sampled the midstream portions effectively by attaching the net to a 1/8 inch steel cable which spanned the entire river. Comparative data between these nets and those fished in previous years were collected periodically by fishing the two nets side by side.

All fyke net sets in the Skagit and Klesilkwa Rivers in 1973 were for either one or two nights. It is known from the literature (e.g., Northcote, 1969) and from catch data in this report

(Section 3.3.2.3) that downriver movement of emergent fry occurs at night. Daylight hours of fishing by the fyke nets caught few emergent fry. Thus, 24-hour catches can be considered directly comparable in terms of effective fishing time for the 1973 data. In addition, the catch per hour of daylight net set used in 1971 and 1972 is not a good indication of total fry production since the fry move and are caught primarily at night.

Amount of river flow at each net site was determined for measured and extrapolated velocities between August 9 and October 30, 1973. The bottom profile of the river bed at each of the net locations was surveyed in October 1973 in order to calculate the cross-sectional area of the river at the various water levels.

Each overnight catch was divided by the percent of the river flow which the net strained to adjust the actual catch to an estimated daily total catch for that location. This method was used to adjust the actual catches between August 9 and October 30. Occasionally nets were left for two nights before the fry could be counted. This catch was adjusted by allotting one half of the total to each of the two days. Also, some locations on certain days had two or three nets fishing; catches from these nets were adjusted individually and then averaged to provide a single estimate for that location.

Fry were distinguished as either "emergents' or "fingerlings". Emergents were typically up to 30 mm total length (TL) with cylindrical bodies and poorly developed locomotory powers. This stage lasts two weeks in hatchery-reared emergents under a continuous feeding program; wild emergents would probably remain in this category longer.

Fingerlings are fry over 30 mm TL. They have better swimming abilities and can maintain or advance position in fast water. The nets used prior to 1973 tended to underestimate the fingerling catch because of their increased ability to survive and thus to escape that sampling year.

The fyke nets began fishing on August 8 at F4 and August 9 at M1, M4, and K1 (see Figures 3.3-8 and 3.3-9). Some earlier data were collected using the nets used in 1971 and 1972 (see SCL, 1973) on July 29 and 30 at F4, M4, and K1. These earlier catches were adjusted by the percent of the river's cross-sectional area sampled by the net, since river flow measurements were not made. Comparison of this method with the preceding one which used percent of flow sampled, indicates the adjustment is of the same order of magnitude for 90 percent of the catch data. When both the fyke nets and the old style nets were fished at the same location on a given day, the old nets tended to catch fewer fry 62 percent of the time. Thus, it is likely that the production estimated prior to August 9 at F4, M4, and K1 using the older nets provides a conservative estimate.

No netting was conducted at M1 prior to August 9. However, high densities of emergent fry (330 in 610 feet of shoreline) were observed at M1 on July 31 (Appendix 11). If one assumes that emergent fish were not present at M1 until July 31, then the expected catch on the preceeding day, July 30, would be zero. Extrapolation from zero fish on July 30 to the catch (3,273 fry) on August 9 provides a conservative estimate of the M1 production.

Figures 3.3-8 and 3.3-9 show the emergent and fingerling production estimates using percent flow sampled (after August 8-9) in black, while estimates based on percent of the cross-sectional area are white (July 29 through August 8-9).

FIGURE 3.3-8

1973 ESTIMATES OF RAINBOW EMERGENT FRY IN THE CANADIAN SKAGIT DRAINAGE

N.B. Unshaded portions are estimates based on fry catches in simple Fyke nets. Shaded portions are estimates based on Fyke nets with incorporated traps.

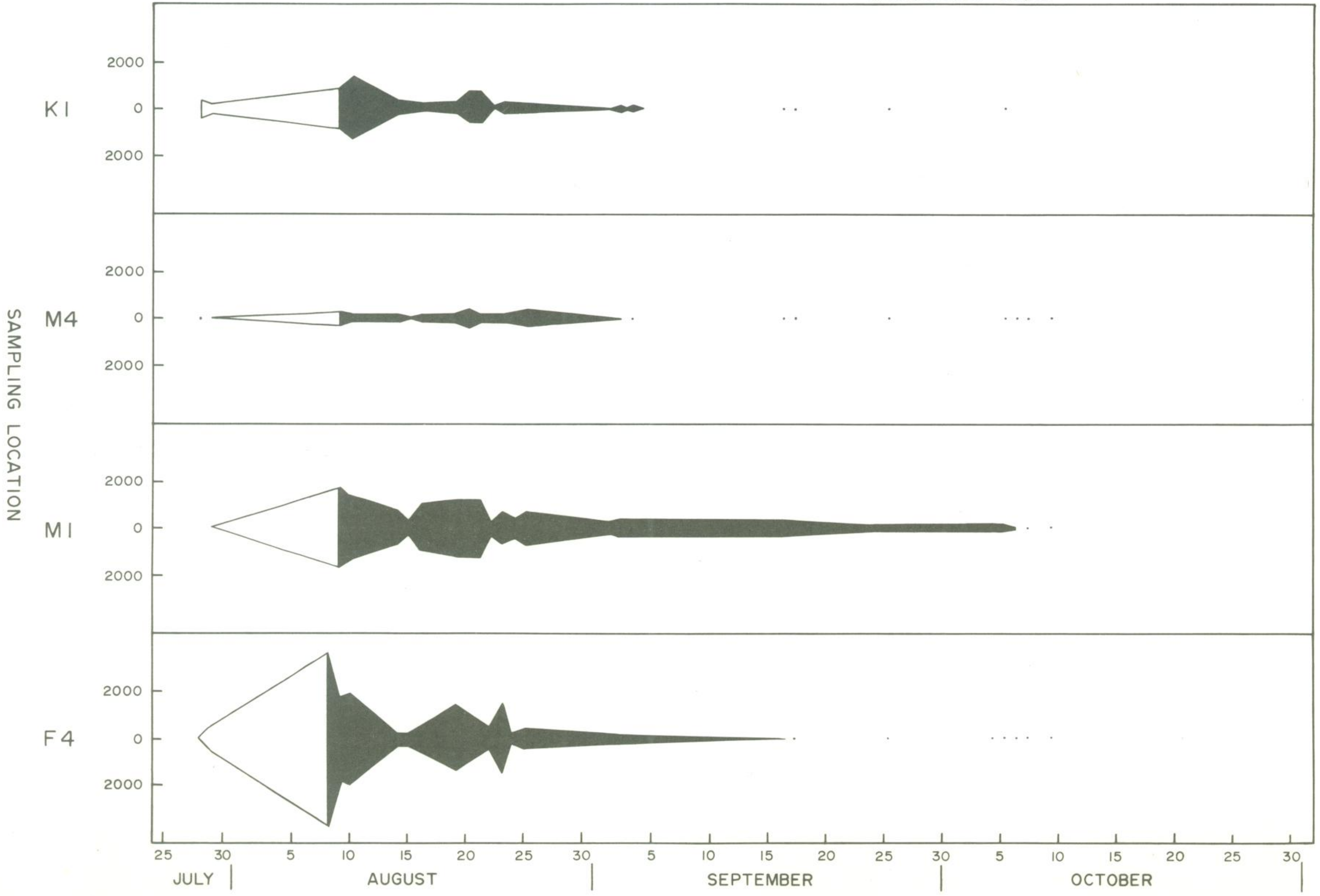
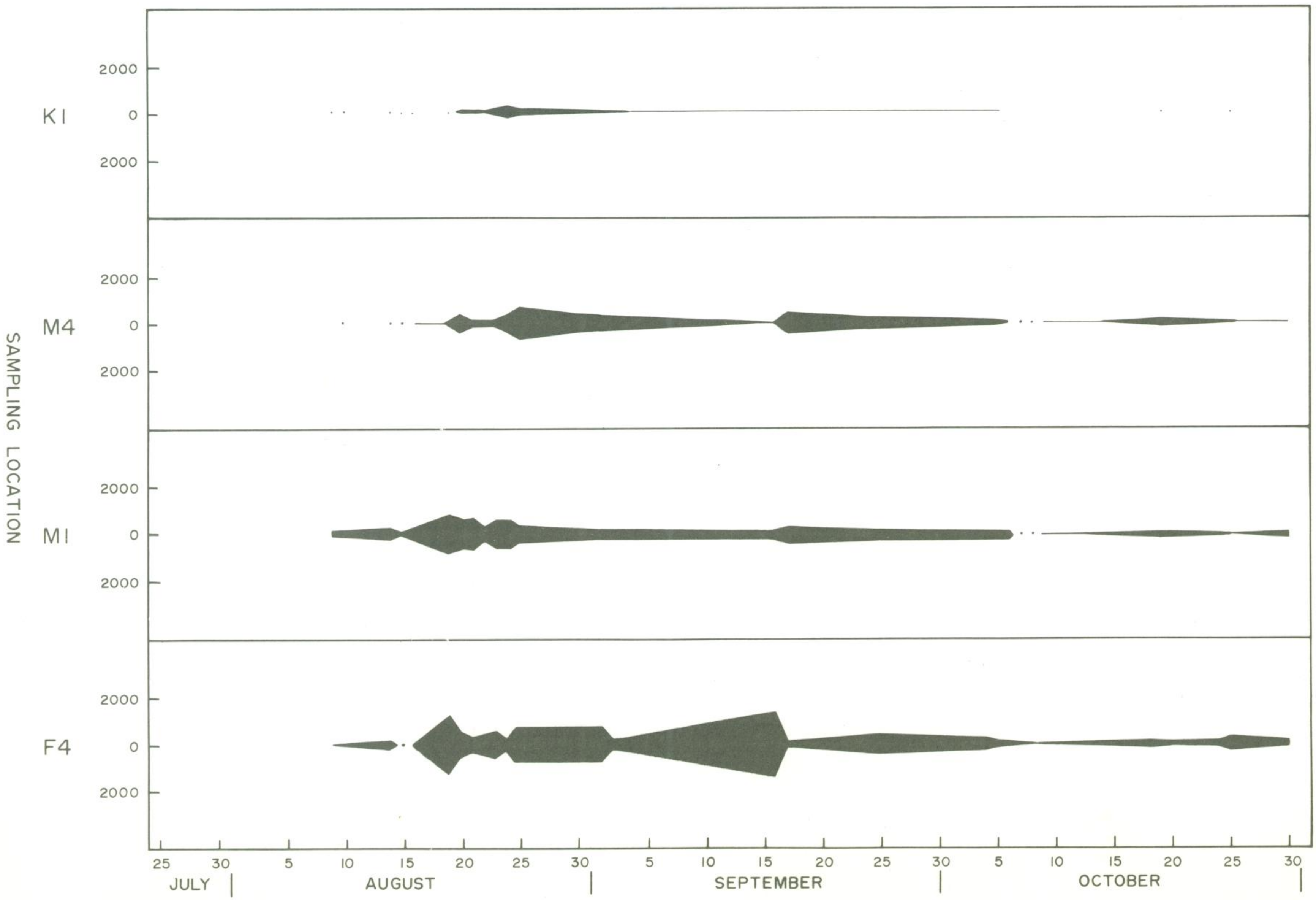


FIGURE 3.3-9

1973 ESTIMATES OF RAINBOW FINGERLING FRY IN THE CANADIAN SKAGIT DRAINAGE



3.3.3.2 Time of Rainbow Spawning

Sexual Condition of Adults

The gillnet sampling of adult fish began on May 15. Ripe and spawning fish were taken in the drainage system between May 15 (when spawning started) and June 16 (Appendix 12). Observations of spawning fish were recorded from May 10 through May 28 in the Klesilkwa River (K4).

Observations during river floatdowns (Appendix 13) indicate a large increase (217 in 5.5 miles) in the adult rainbow population on April 30 compared with the number sighted (1 in 3.0 miles) on April 17. This increase probably represents potential spawners entering the river from Ross Lake.

Spawning coloration was observed by divers on the last dives on May 23 in the Klesilkwa and May 24 in the Sumallo. Turbid water prevented observations in the Skagit.

Anglers informally reported that ripe fish were being caught in F1 until the end of June.

Emergence of Fry

Appendix 14 gives the dates, locations, and catches of rainbow emergent fry and fingerlings in 1973. The estimated total daily production of emergent fry at K1, M4, M1, and F4 is shown in Figure 3.3-8.

The first 1973 observation of rainbow emergent fry was on July 19 at F4. The numbers of emergent fry observed by date, adjusted to the numbers in a 50-foot length of shoreline, are listed in Appendix 11. Individual stream banks within a given river section give highly variable fry counts, as seen in Appendix 11; highest concentrations of fry occurred in shallow side pools along gravel bars.

Back calculation of temperature units to time of spawning from the date of first observation indicates that first 1973 spawning occurred in the Skagit River system about May 2.

The largest numbers of emergent fry were sampled on August 8. Back calculation of temperature units estimates that peak river spawning in 1973 occurred around June 4.

The last emergent fry capture was made on October 5 in M1. Using the same method as above, the last spawning in 1973 took place near July 29.

Details of the back calculations are provided in Appendix 15.

3.3.3.3 Location of Rainbow Spawning

Catches and Sightings of Adults

Gillnetting effort was reduced in 1973, as previously noted. Time and locations of spawning could not be precisely determined using gillnet catches, as in 1971; ripe fish were sampled by gillnet in K4, F16, M12, U8 and during creel census in F1 and M8.

Counts and locations of adult fish sighted during floatdowns are shown in Appendix 13. Adult rainbows were observed in K4 and in Shawatum Creek in F17 where it reappears in the valley floor. A single 12 inch rainbow was seen on May 22 and May 28 in the latter location.

Catches and Sightings of Fry

Appendices 11 and 14 give the locations of catches and sightings of rainbow trout fry in the Skagit River system in 1973.

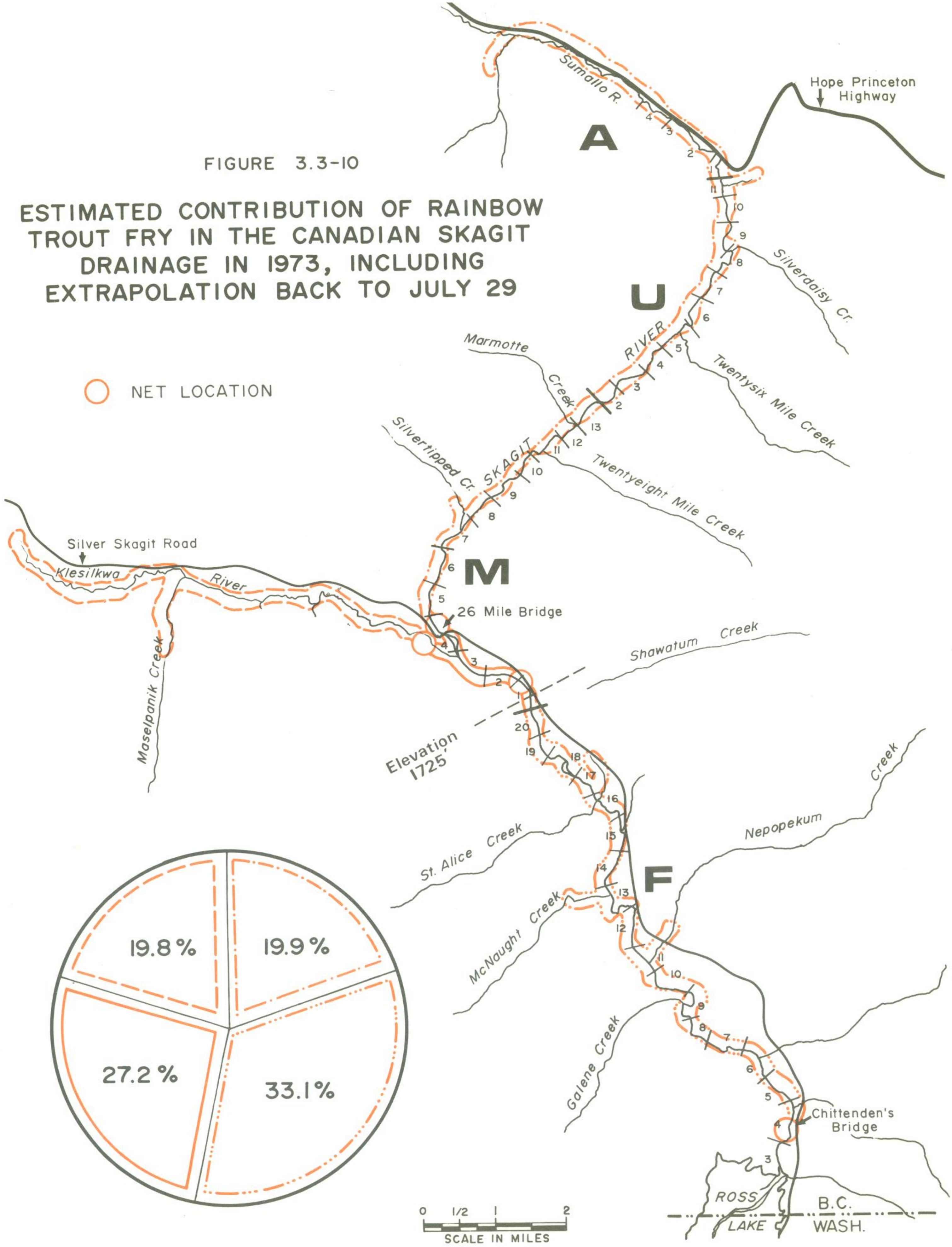
The total 1973 catch figures are 2,417 emergent fry and 1,885 fingerlings for 182 overnight net sets. Seven percent of the sampling effort (12 nights) was from scattered locations (Nepopekum Creek, McNaught Creek, Shawatum Creek, U8, M6, M7, M8) and yielded 34 emergents and 79 fingerlings. These locations were not surveyed for stream cross-section, and thus, the catches cannot be expanded to estimate the total production. It is expected that the two tributary creeks (Nepopekum and McNaught), where emergent fry were captured in 1973, do not contribute significantly to the total drainage production.

Adjustment of the 1973 catches at each of the four principal sampling locations (F4, M1, M4, K1) is given in Appendix 14 and shown graphically in Figures 3.3-8 and 3.3-9.

Using the combined adjusted numbers of emergents and fingerlings (128,979) from F4 as an estimate of the total Skagit drainage production, then the Klesilkwa contributes about 20 percent, the Skagit above 1,725 contributes about 47 percent, and the Skagit below 1,725 contributes 33 percent (Figure 3.3-10) of total Skagit River system production. The Klesilkwa production is somewhat underestimated since the 1973 sampling missed an unknown number of fry emerging before July 29.

FIGURE 3.3-10

ESTIMATED CONTRIBUTION OF RAINBOW TROUT FRY IN THE CANADIAN SKAGIT DRAINAGE IN 1973, INCLUDING EXTRAPOLATION BACK TO JULY 29



3.3.4 Skagit-Ross System (by F.F. Slaney and Company)

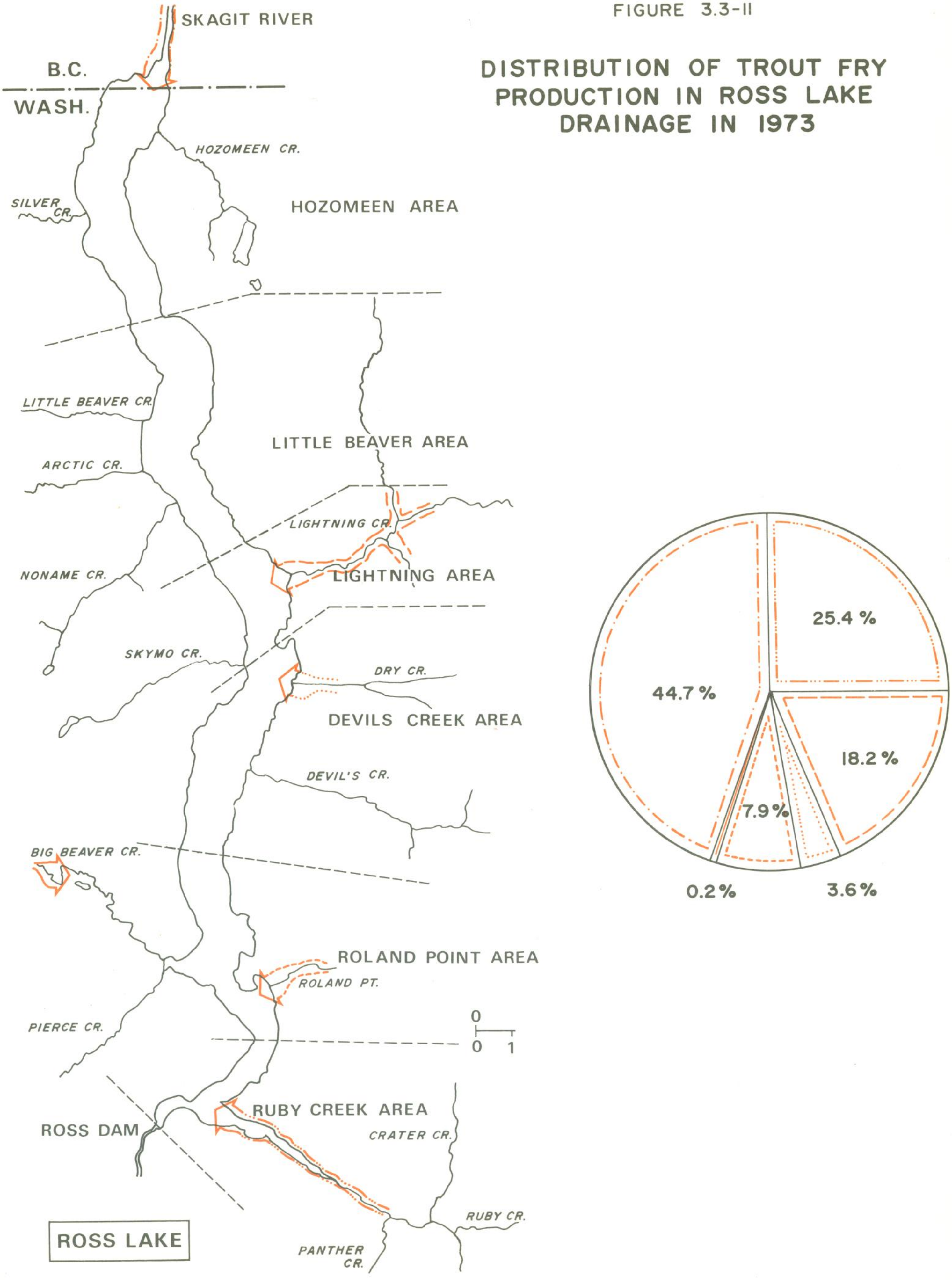
3.3.4.1 Fry Production

Estimated fry production in the Skagit-Ross system for 1973 as measured by the fyke net sampling in the main tributaries was 288,646 fry.

The fry production was distributed in 1973 as shown on Figure 3.3-11. About 45% of measured production came from the Skagit River system, about 25% from Ruby Creek, 18% from Lightning Creek, 8% from Roland Creek, and 4% from Dry Creek. Big Beaver Creek contributed less than 1% of the measured Skagit-Ross system trout fry production in 1973.

FIGURE 3.3-11

DISTRIBUTION OF TROUT FRY PRODUCTION IN ROSS LAKE DRAINAGE IN 1973



3.4 FOOD AND FEEDING (by Fisheries Research Institute)

3.4.1 Primary Production - 1973

3.4.1.1 Introduction

Because the proportion of deep to shallow water in Ross Lake is high and winter drawdowns and wave action prevent the establishment of rooted aquatic plants, primary production is confined mostly to phytoplankton. The trout which feed directly on the pelagic zooplankton thereby obtain their food energy indirectly from phytoplankton. Measurements were taken of chlorophyll a to provide a general indication of seasonal trends in phytoplankton standing crop and for comparison with values obtained in other lakes in the northwest and Alaska.

3.4.1.2 Methods

Chlorophyll a measurements were made in midlake off Green Point near the south end of Ross Lake on replicated samples taken with a two-liter Van Dorn bottle at six depths, 1, 10, 20, 30, 40, and 50 meters on five dates from early April to mid-September, 1973. The spectrophotometer method and computational formula used in 1972 (SCL, 1973) was again used in 1973.

3.4.1.3 Results

Results (Fig. 3.4-1 and Table 3.4-1) show that highest concentrations of chlorophyll a in sampling of the 50 meter water column occurred on July 23 and September 14 when the mean concentrations for the entire 50 m water column were 0.99 and 0.97 mg/m^3 respectively. The graph in Fig. 3.4-1 indicates that most of the change in chlorophyll a concentration through spring and summer occurred in the upper 30 m of the water column.

TABLE 3.4-1

1973 CHLOROPHYLL $\underline{a}$ MEASUREMENTS

CHLOROPHYLL $\underline{a}$ CONCENTRATION (mg/m^3)

ROSS LAKE

DATE	4/4	4/30	6/13	7/23	9/14
SECCHI DEPTH	37 FT. (11.3m)	31 FT. (9.4m)	25 FT. (7.6m)	25 FT. (7.6m)	34 FT. (10.4m) (9/16)
DEPTH m(ft.)			CHL A (mg/m^3)		
1(3.3)	.47	.53	1.05	1.02	1.00
10(32.8)	.43	.54	.94	1.72	1.14
20(65.6)	.61	.75	.55	1.44	1.75
30(98.4)	.62	.44	.21	.81	.90
40(131.2)	.46	.36	.11	.45	.52
50(164.0)	.58	.37	.15	.28	.48
WEIGHTED MEAN	0.53	.58	.45	.99	.97

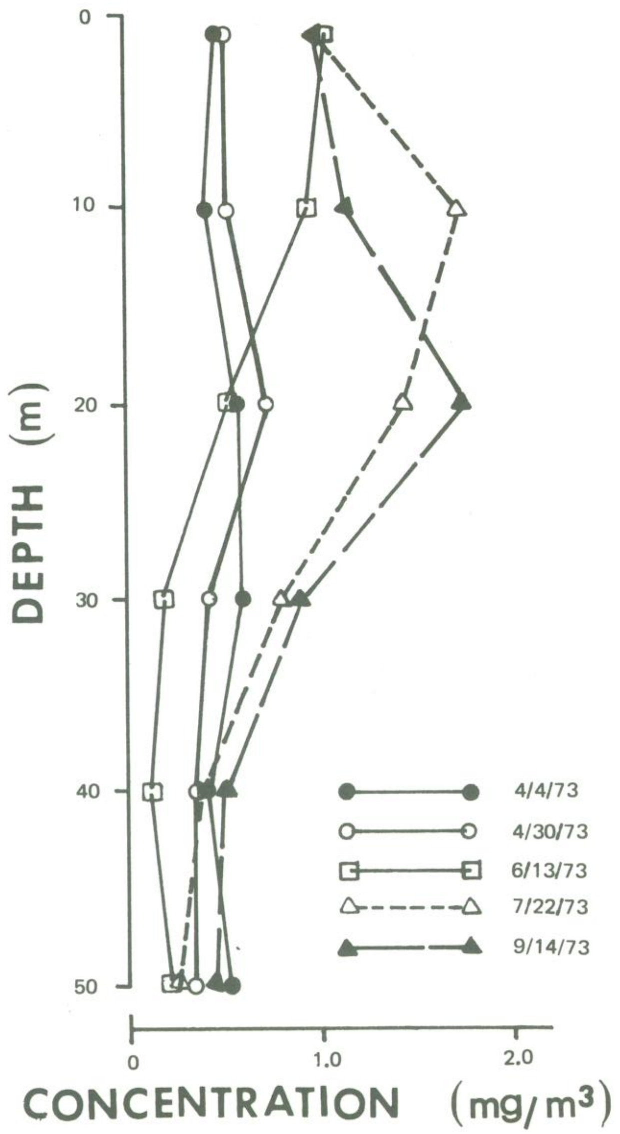


FIGURE 3.4-1

CHLOROPHYLL $\underline{a}$ CONCENTRATION, ROSS LAKE, 1973

The September 16 chlorophyll a concentration of 0.97 mg/m^3 in Ross Lake is identical to the 11 year September mean (1962-1972) in highly oligotrophic Lake Aleknagik (Rogers, unpublished data). Summer chlorophyll a concentrations in 10 Alaskan lake systems were compared by Narver (1966) and Burgner, et al, (1969). The range of values for these lakes was 0.2-15.3 mg/m^3 with a mean of 1.83 mg/m^3. In July 1973 the mean chlorophyll a concentration in the upper 10 meters of Ross Lake was 1.37 mg/m^3. In comparison, July and August values in Lake Washington in 1970 were 8-9 mg/m^3 in the upper 10 m (Edmondson, 1972).

A comparison of mid-September measurements for 1972 and 1973 in Ross Lake indicates that the chlorophyll a concentration in 1973 was nearly double that of 1972 (1.37 mg/m^3 and 0.74 mg/m^3 respectively in the upper 10 m; 0.97 mg/m^3 and 0.47 mg/m^3 respectively in the upper 50 m).

In summary, the standing crop of phytoplankton as measured by chlorophyll a in Ross Lake is low compared to that of cold, deep, highly oligotrophic lakes in Alaska and Washington State. Phytoplankton abundance in 1973 was higher than in 1972 which could partially explain why zooplankton abundance was also slightly higher in 1973 than in 1972.

3.4.2 Ross Lake Zooplankton - 1973

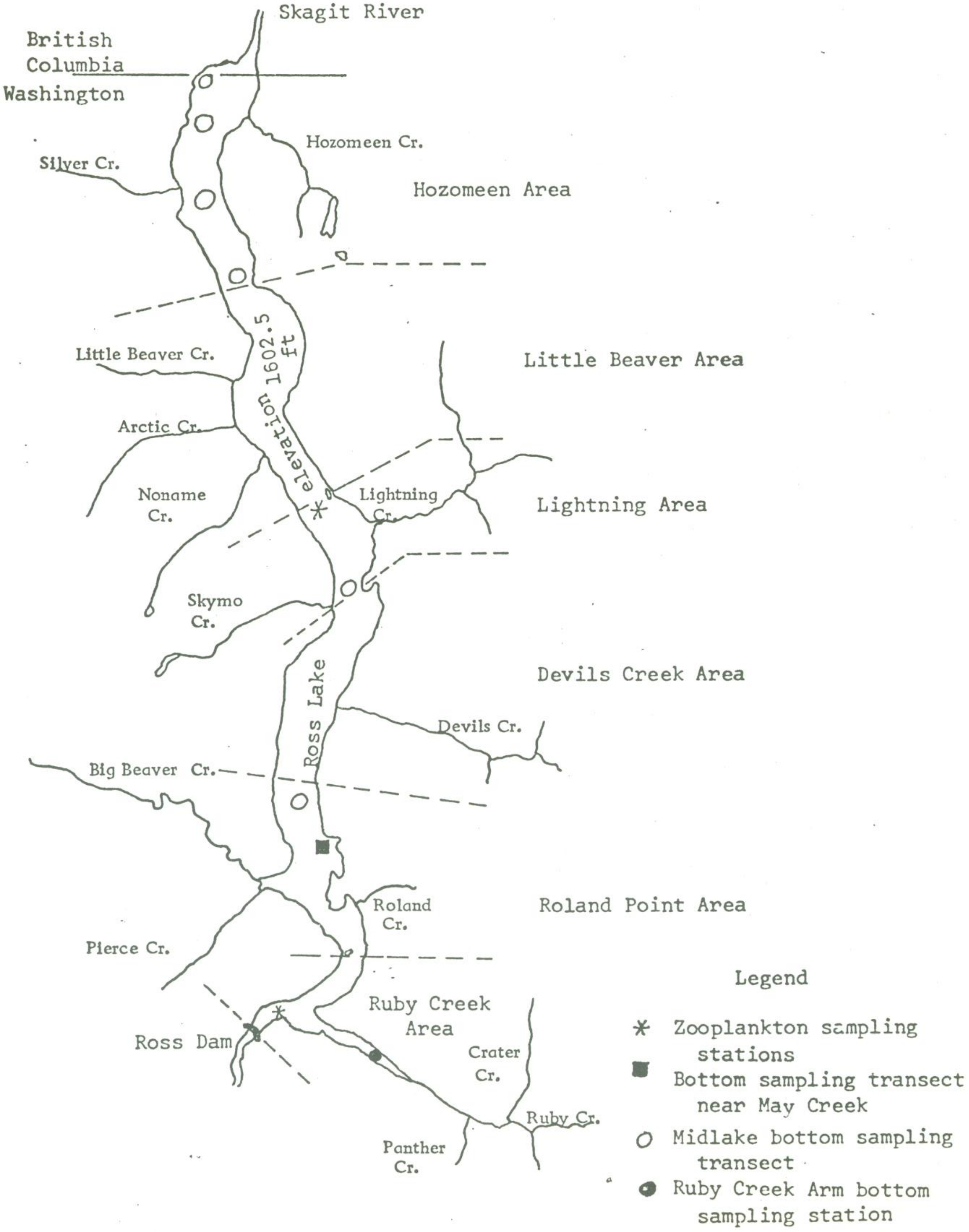
3.4.2.1 Methods

The two stations used in 1971 and 1972 were again sampled in 1973 (Fig. 3.4-2). Station depths from maximum lake level were:

Station 1: the south station, midlake south of Green Point at a depth of 410 feet.

FIGURE 3.4-2

Locations of sampling stations, Ross Lake, 1972.



Station 5: midlake off Cat Island at a depth of 130 feet. The equipment and procedures used for both vertical and horizontal sampling were identical to those used in 1971 and 1972.

With the exception of May, vertical plankton sampling was conducted once a month from February to September at Stations 1 and 5. In October, two series of two vertical hauls each were taken at night at Station 1. One series was taken shortly after sunset and the second at 0130 hours the following morning.

Horizontal tows were made in March, April, June, August, September and October. Tows were not made at 50 meters in March or April because of inadequate water depth. The October horizontal tows were taken after dark. Towing speed was approximately 3 ft/sec. The wire angle was recorded in order to calculate the actual depth of the sampler during the tows. The plankton concentrates were placed in separate collection bottles, labelled, and preserved.

Identification of the genera and species (whenever possible) was made using Ward and Whipple (1966). Permanent mounts of each identified taxon were available from 1971 studies for further positive identification.

The data provide a relative estimate of zooplankton abundance since it is assumed that the net efficiency did not change appreciably over the sampling season or from 1971 to 1973, and that the total water column was adequately sampled on each date. Abundance is reported in average numbers of organisms per cubic meter in the water column and in average number per square meter of water surface, assuming 100 percent straining efficiency.

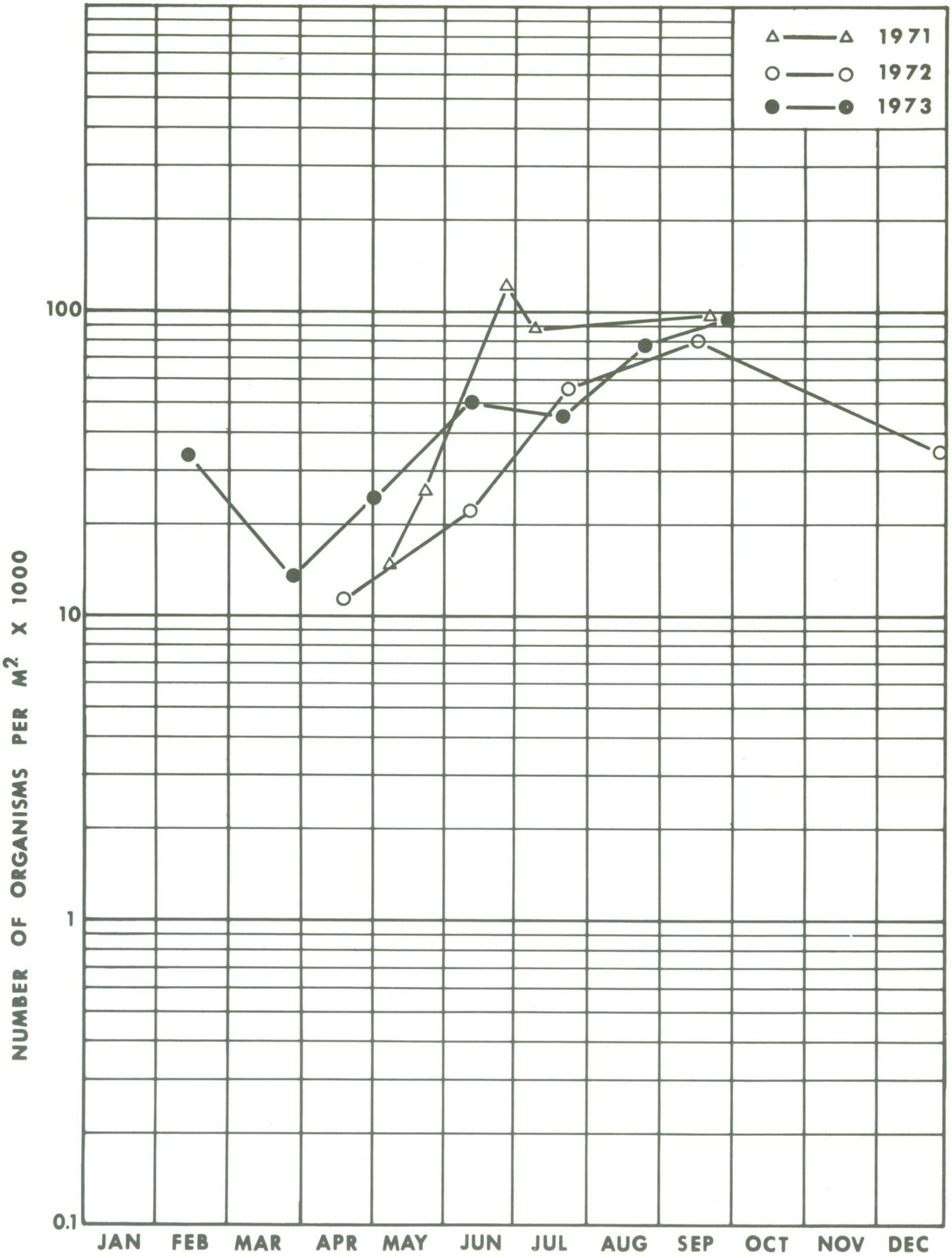
3.4.2.2 Results

Analysis of the samples indicated the same species present as in the previous two years. No new genera or species were identified. Plankters found included the cladocerans, *Daphnia*, *Bosmina*, *Leptodora*, *Holopedium*, and *Polyphemus*, the calanoid copepod *Diaptomus*, the cyclopoid copepod *Cyclops*, and the rotifer *Asplanchna*. Copepod nauplii were also present. The abundance data by species, station location, and sample date are presented in numbers per m^2 of lake surface in Table 3.4-2. Abundance data are also tabulated in numbers per subsample and numbers per m^3 in Appendices 7 and 8 respectively.

To graphically present plankton abundance trends in Ross Reservoir as a whole over the 1971-1973 sampling periods the abundance values for stations 1 and 5 were averaged and plotted on a log scale over time in Figs. 3.4-3 to 3.4-6. The mean values are presented in Table 3.4-3. Total crustacean abundance in June of each year (Fig. 3.4-3) varied considerably. Fluctuations in the abundance of *Daphnia*, *Bosmina* and *Diaptomus* were responsible because they varied in the same manner. June abundance of each of the three was greatest in 1971 and least in 1972 (Figs. 3.4-4 to 3.4-6). In contrast, total crustacean abundance in September was very constant in the three years but September abundance of individual species comprising the total crustacea was not. September abundance of each of the three organisms, *Daphnia*, *Bosmina*, and *Diaptomus* fluctuated from 1971 to 1973 in different ways that offset each other and resulted in little change in overall abundance of total crustaceans.

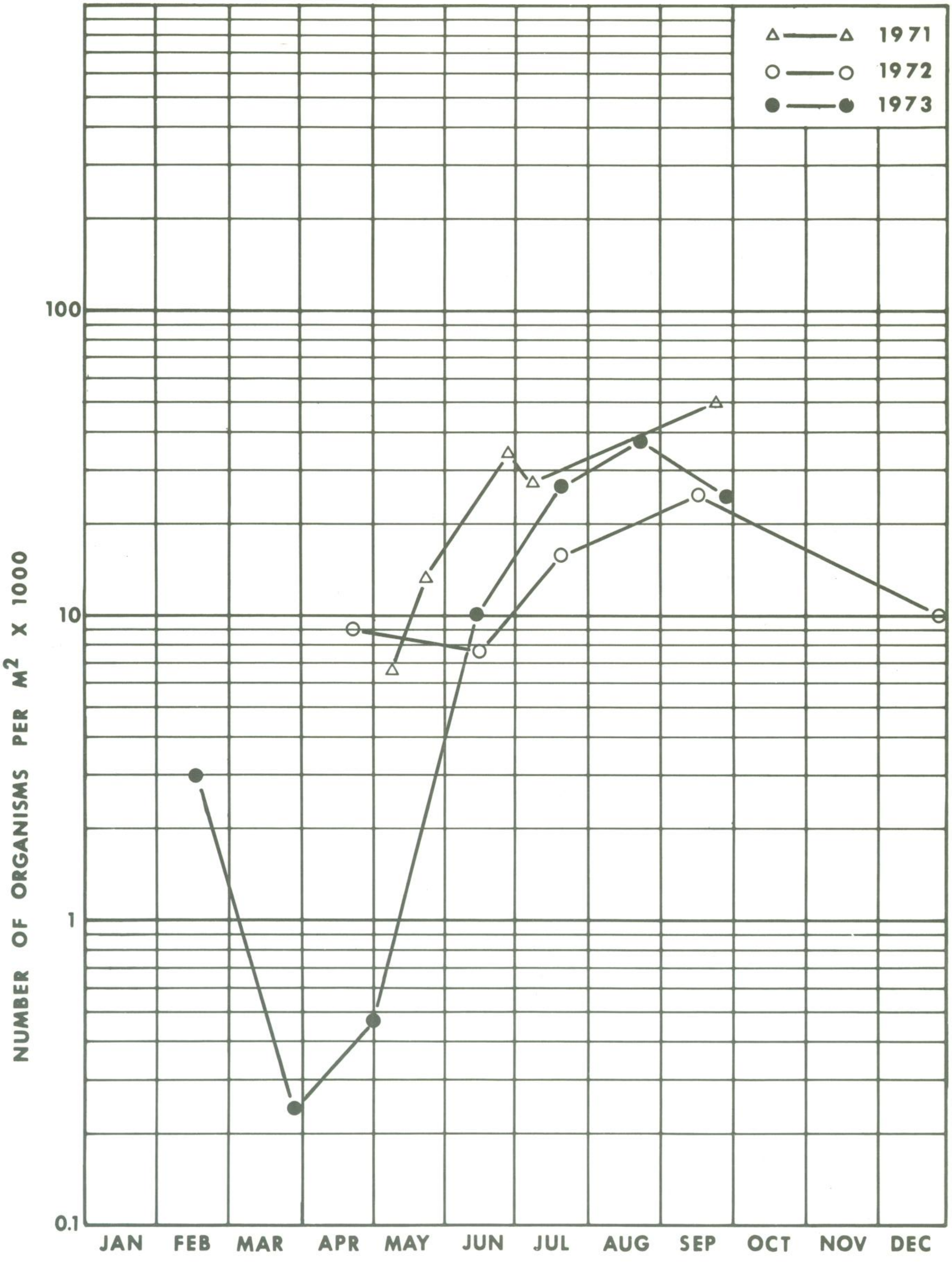
The data show fairly consistent abundance trends for *Diaptomus* and *Daphnia*; the low points occurred during the spring and the peaks in

FIGURE 3.4-3



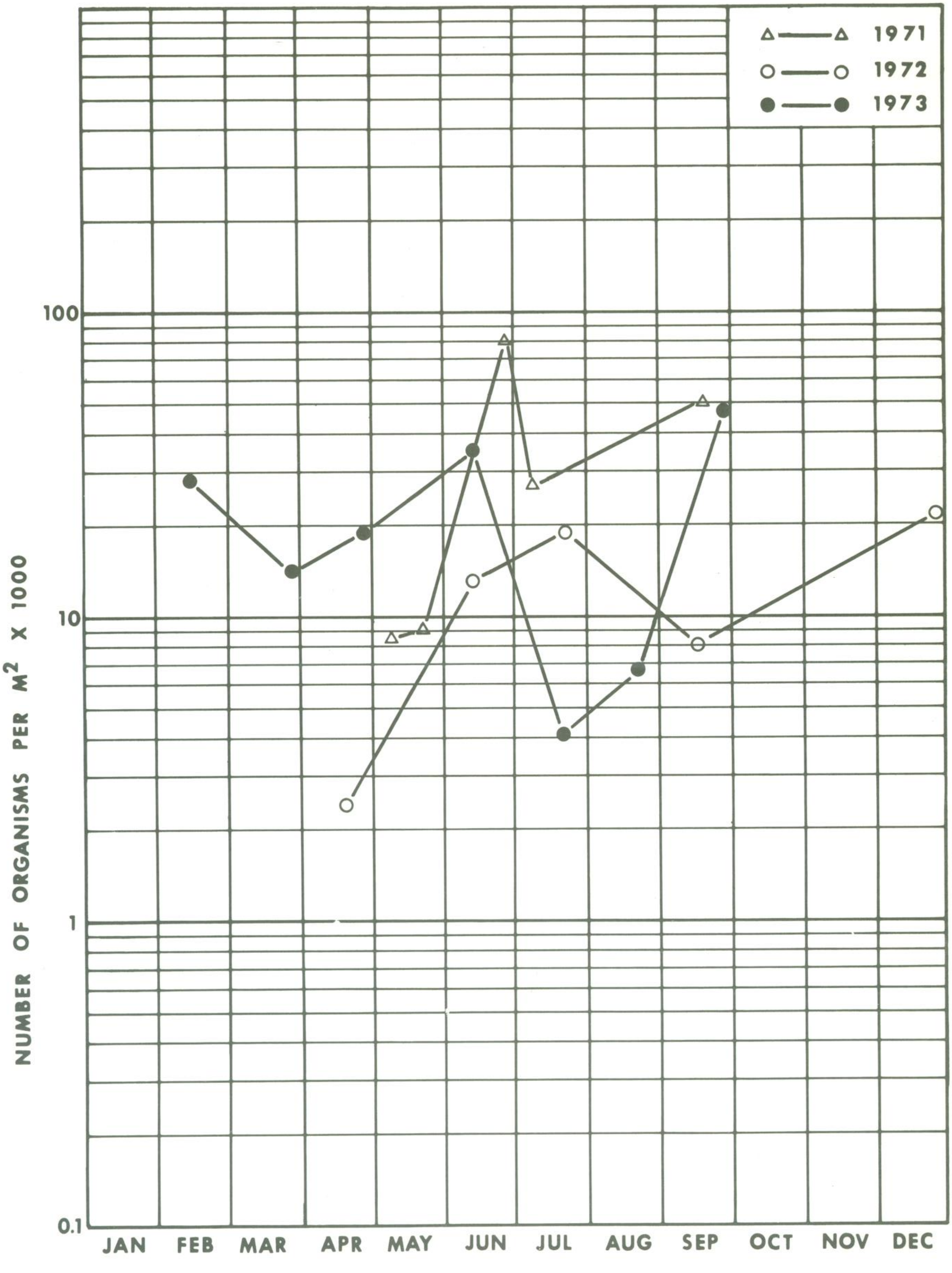
TOTAL CRUSTACEA ABUNDANCE PER M^2 (EXCLUDING NAUPLII) ROSS LAKE. VALUES ARE MEANS OF STATIONS I AND 5.

FIGURE 3.4-4



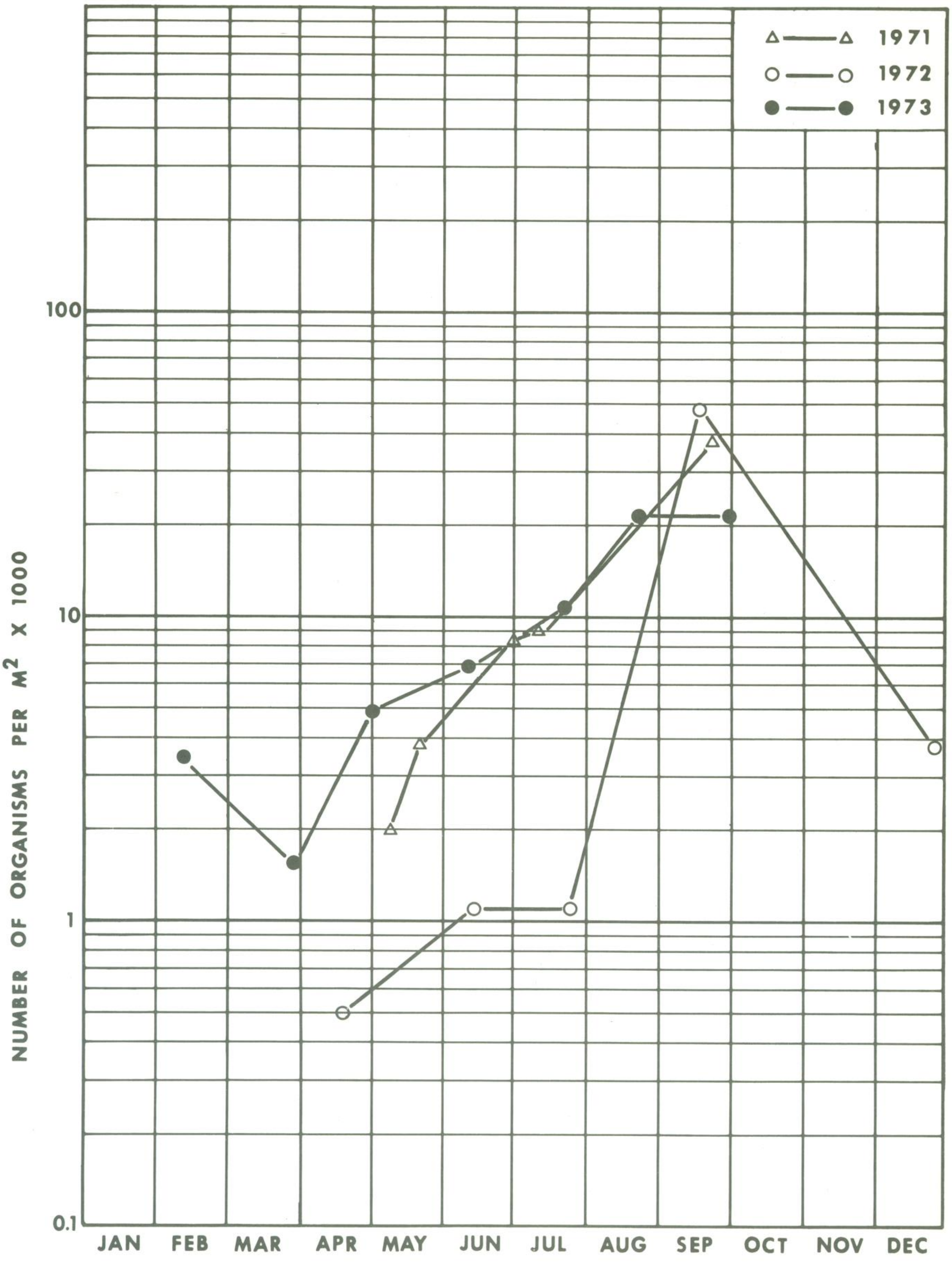
DAPHNIA ABUNDANCE PER M^2, ROSS LAKE
VALUES ARE MEANS OF STATIONS I AND 5

FIGURE 3.4-5



BOSMINA ABUNDANCE PER M^2, ROSS LAKE
VALUES ARE MEANS OF STATIONS 1 AND 5

FIGURE 3.4-6



DIAPTOMUS ABUNDANCE PER M^2, ROSS LAKE
VALUES ARE MEANS OF STATIONS 1 AND 5

TABLE 3.4-2

AVERAGE NUMBER OF PLANKTONIC ORGANISMS PER M^2, ROSS LAKE, 1973
(VERTICAL HAULS)

Species		14 Feb	29 Mar	30 Apr	13 June	19 July	21 Aug	28 Sept	5 Oct**	6 Oct***
Daphnia	1	3,823	234	892	1,784	27,523	47,783	21,662	9,939	6,881
	5	2,039	255	469	20,133	26,504	28,925	29,898	-	-
Bosmina	1	35,805	11,045	5,479	11,682	2,467	5,352	66,259	16,055	12,997
	5	20,897	15,291	32,365	53,563	5,861	7,518	25,056	-	-
Leptodora	1	0	0	0	0	469	637	0	0	0
	5	0	0	0	341	127	255	0	-	-
Holopedium	1	0	0	0	428	510	3,950	1,529	255	0
	5	0	255	989	173	127	637	1,784	-	-
Polyphemus	1	0	0	0	0	0	127	0	0	0
	5	0	0	0	0	0	1,402	0	-	-
Diaptomus	1	4,715	1,147	851	1,193	5,352	18,476	23,445	15,698	10,321
	5	1,911	1,937	8,665	11,723	16,055	29,817	21,575	-	-
Cyclops	1	0	0	0	1,320	2,931	3,823	0	255	127
	5	0	0	510	892	7,263	9,811	0	-	-
Total crustacea	1	44,343	12,426	7,222	16,407	39,252	80,148	112,895	42,202	30,326
Except nauplii	5	24,847	17,738	42,998	86,825	55,937	78,365*	78,313	-	-
Nauplii	1	2,421	1,040	1,147	2,518	8,410	7,390	0	0	0
	5	2,039	892	3,380	5,861	7,773	11,086	0	-	-
Asplanchna	1	135,321	48,843	95,270	3,400	4,760	6,244	33,894	28,084	1,147
	5	105,632	255,479	58,787	173	2,039	13,761	18,145	-	-

*Includes 765 Chydorus spp.
**Night hauls (2100 hrs.)
***Night hauls (0130 hrs.)

TABLE 3.4-3

ABUNDANCE OF PLANKTONIC CRUSTACEA PER M^2, ROSS LAKE, 1971-1973.

VALUES ARE MEANS OF STATION 1 AND 5.

YEAR	NAME	DATE									
1971					7 May	20 May	28 June	9 July		20 Sept	
	Daphnia				6,752	13,124	33,737	26,316		50,028	
	Bosmina				8,259	8,958	82,910	47,346		2,438	
	Diaptomus				1,942	3,811	8,671	8,904		38,306	
	Others				244	883	2,364	5,495		1,314	
	Total				17,197	26,776	127,682	88,061		92,086	
1972				18 Apr			14 June	19 July		15 Sept	28 Dec
	Daphnia			9,106			7,260	17,002		25,023	10,571
	Bosmina			2,290			12,609	18,212		7,578	21,269
	Diaptomus			509			2,038	18,467		46,740	3,757
	Others			448			1,336	3,184		1,594	381
	Total			12,353			23,243	56,865		80,935	35,978
1973		14 Feb	29 Mar	30 Apr			13 June	19 July	21 Aug	28 Sept	
	Daphnia	2,931	245	681			10,958	27,014	38,354	25,780	
	Bosmina	28,351	13,168	18,922			32,623	4,164	6,435	45,658	
	Diaptomus	3,313	1,542	4,758			6,458	10,704	24,147	22,510	
	Others	0	127	749			1,577	5,713	10,321	1,656	
	Total	34,595	15,082	25,110			51,616	47,595	79,257	95,604	

late summer in all three years. Late spring and summer abundance values of Daphnia were highest in 1971, lowest in 1972, and intermediate in 1973. Late spring and summer abundance levels of Diaptomus were very similar in 1971 and 1973. In 1972 late spring and summer abundance of Diaptomus was much lower than in 1971 and 1973 until September when it was similar.

Generally, the samples indicated that total crustacean abundance during spring and summer in 1973 was higher than in 1972 except that in July 1972 abundance was slightly higher than in July 1973 (Fig. 3.4-3). This was due to a drop in Bosmina numbers from June to July, 1973. In 1972, abundance of Bosmina showed an increase from June to July sampling (Fig. 3.4-5). The total crustacean abundance pattern in spring and summer of 1971 seems to differ from that of the 1972 and 1973 patterns, which were similar (Fig. 3.4-3). In 1971 abundance in samples began at a low level and built up rapidly, peaking in late June (due mainly to increase of Bosmina, Fig. 3.4-3). Abundance buildup in 1972 and 1973 was more gradual and peaked in mid- to late September.

Again in 1973 the large predaceous cladoceran Leptodora was relatively scarce, being found only in June, July, and August (Table 3.4-2). Holopedium was present from March to September, but in very low numbers. Polyphemus was found at both stations only in August.

Cyclops was found only from April until August and in traces in October, 1973. Asplanchna was most abundant in February and March, least abundant in June and remained in relatively low abundance for the remainder of the sampling period.

The results of the horizontal tows again strongly indicate that the zooplankton primarily inhabit the epilimnion. As thermal stratification developed in spring and summer the zooplankton distribution became more concentrated near the surface (Figs. 3.4-7 to 3.4-14). This trend was also found in 1972. In the late summer samples of 1973, a sharp increase in density occurred from approximately 50 feet to the surface. Two series of hauls were made at night in October. The results of both agreed with the previous findings of vertical stratification. Vertical distribution was little different on the night of October 5 and dark morning hours of October 6 than on the day of September 28. Total crustacean catches on October 5 and 6 was only one-third that of September 28, however. This was primarily due to the decrease in numbers of Bosmina (Figs. 3.4-11 to 3.4-14).

3.4.3 Ross Lake Benthos - 1973

3.4.3.1 Methods

Bottom fauna in Ross Lake were sampled above and below the maximum 1973 drawdown level (1529 ft. elevation) in the same manner as described in SCL (1973). A 0.1 m^2 Van Veen dredge was used for all samples. The 1971 and 1972 transects near May Creek and the 1972 mid-lake transect were repeated in 1973 to provide comparable data.

The May Creek and mid-lake transects were both sampled in April, May, June, July, and September. Sampling depths relative to full pool and maximum drawdown elevations are presented graphically in Figs. 3.4-15 and 3.4-16 . The Ruby Creek mouth station was also sampled in July, 1973.

FIGURE 3.4-7

NUMBERS OF ORGANISMS PER 2-MINUTE HORIZONTAL TOW

29 MARCH 1973

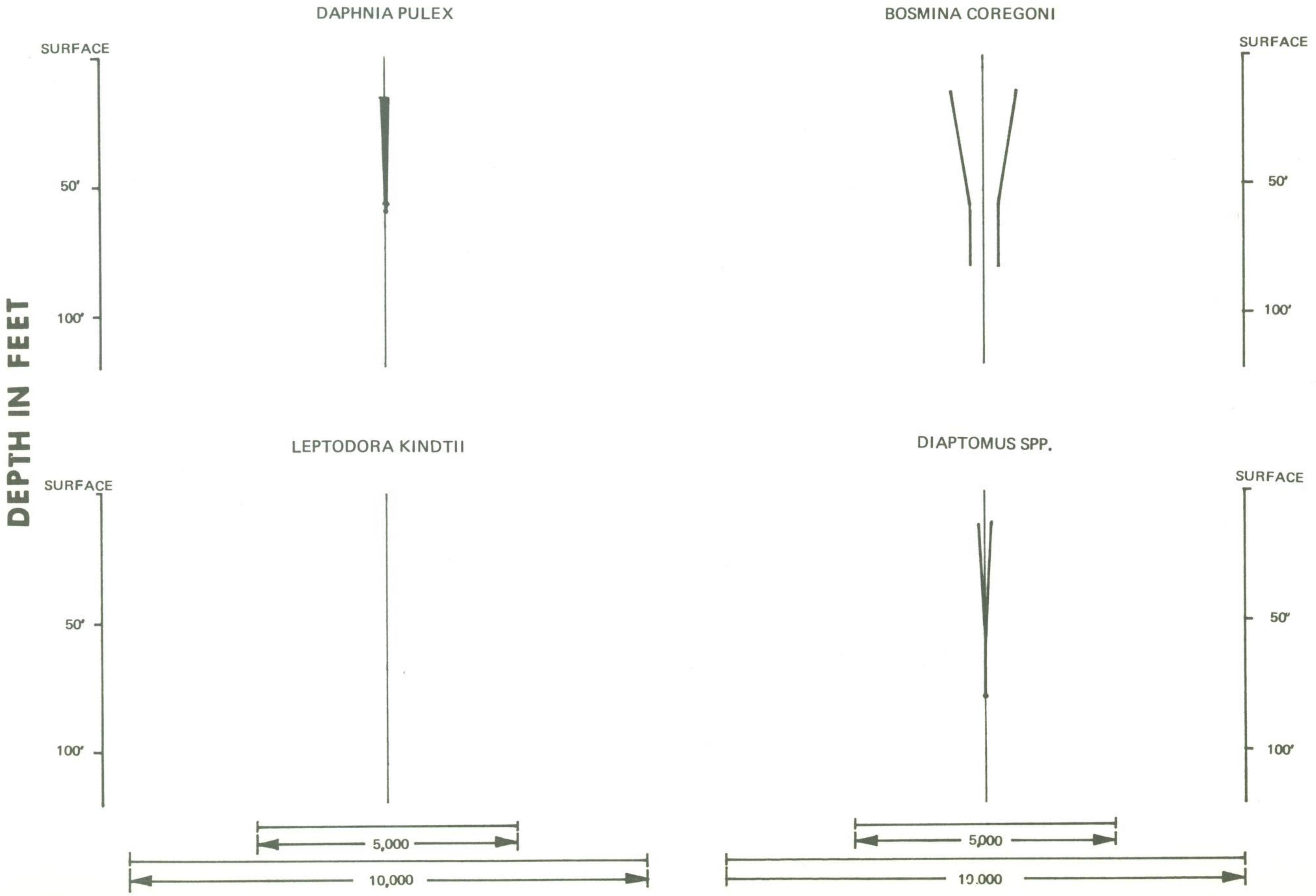


FIGURE 3.4-8

NUMBERS OF ORGANISMS PER 2-MINUTE HORIZONTAL TOW

30 APRIL 1973

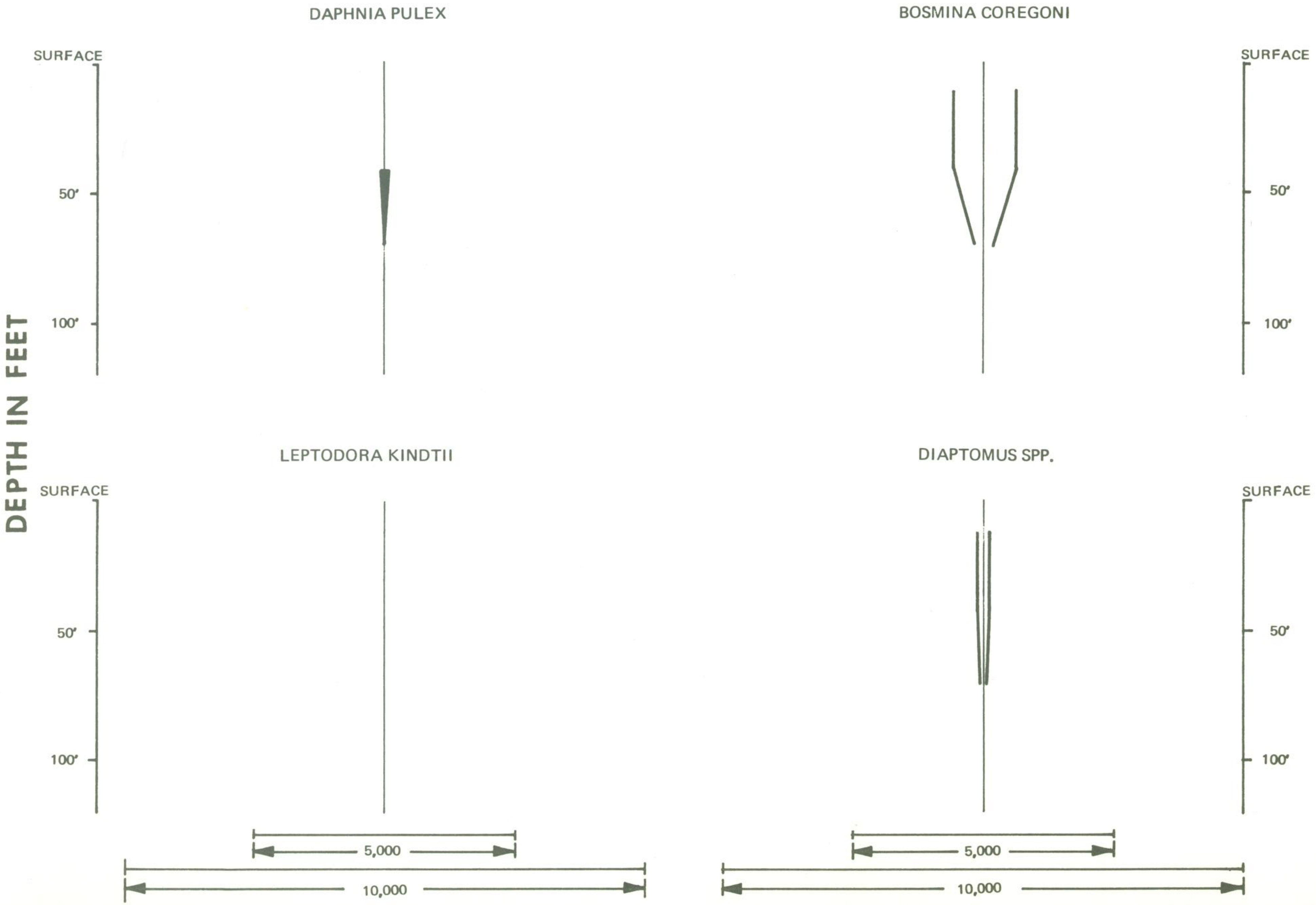


FIGURE 3.4-9

NUMBERS OF ORGANISMS PER 2-MINUTE HORIZONTAL TOW

13 JUNE 1973

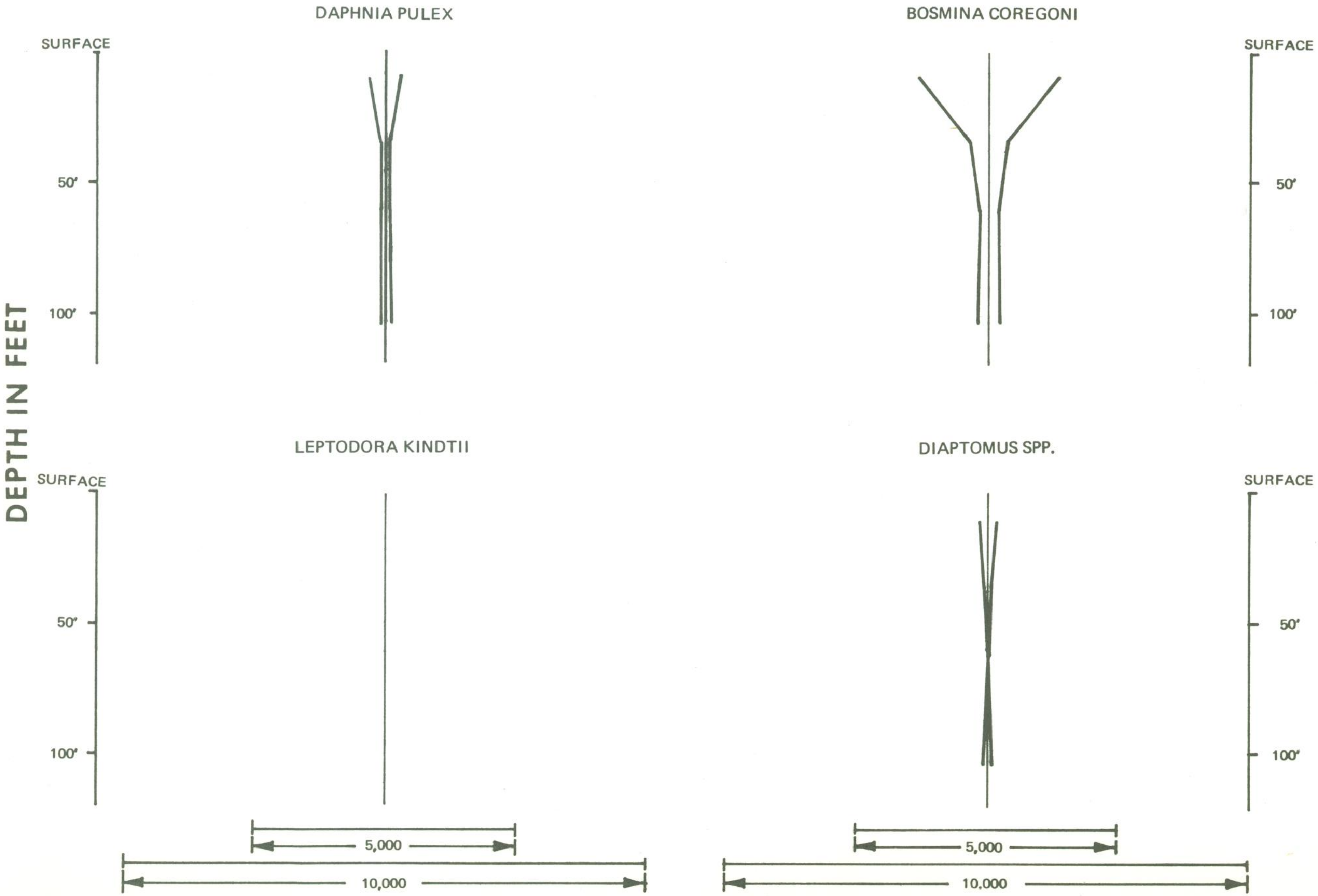


FIGURE 3.4-10

NUMBERS OF ORGANISMS PER 2-MINUTE HORIZONTAL TOW

21 AUGUST 1973

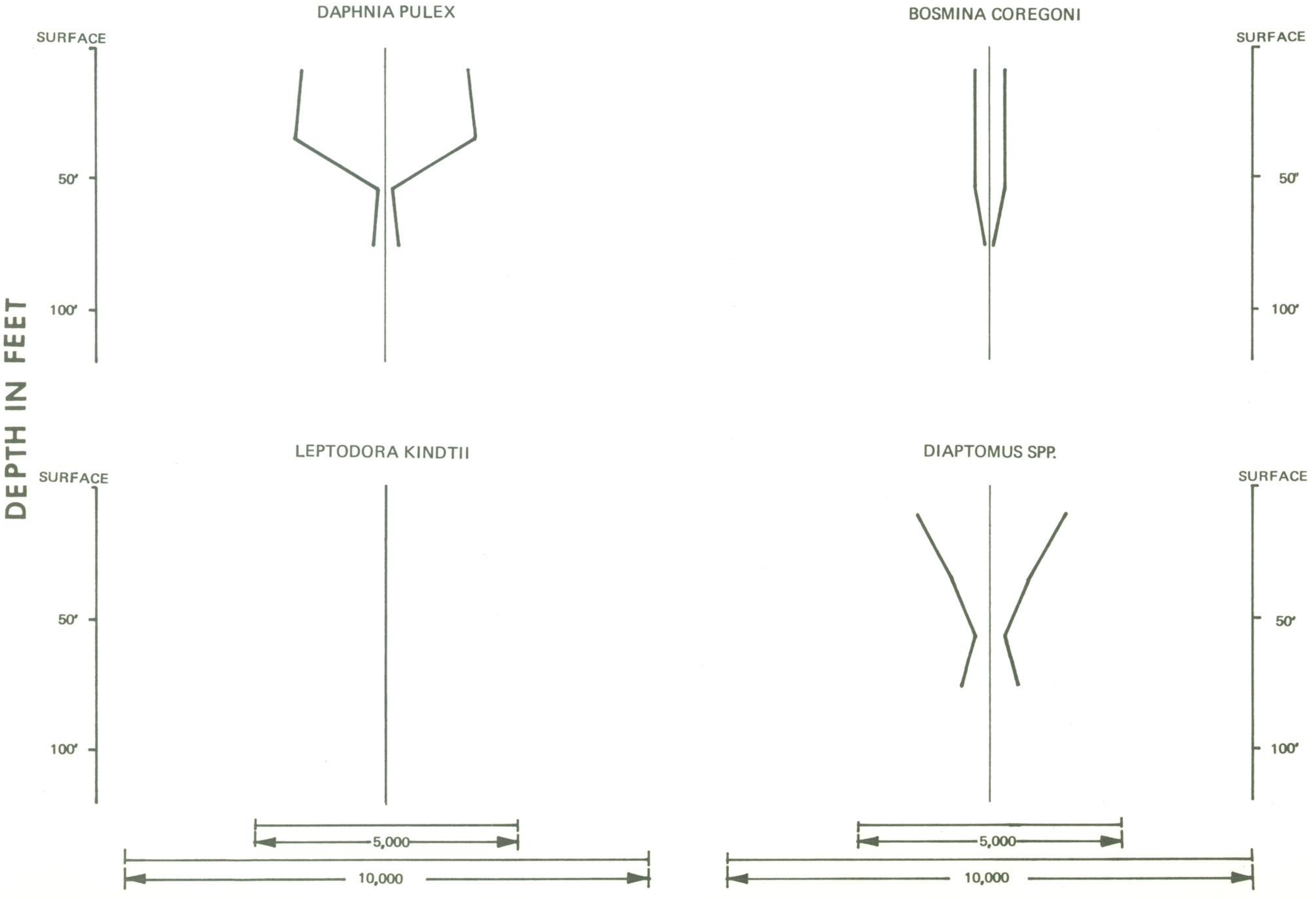


FIGURE 3.4-11

NUMBERS OF ORGANISMS PER 2-MINUTE HORIZONTAL TOW

28 SEPTEMBER 1973

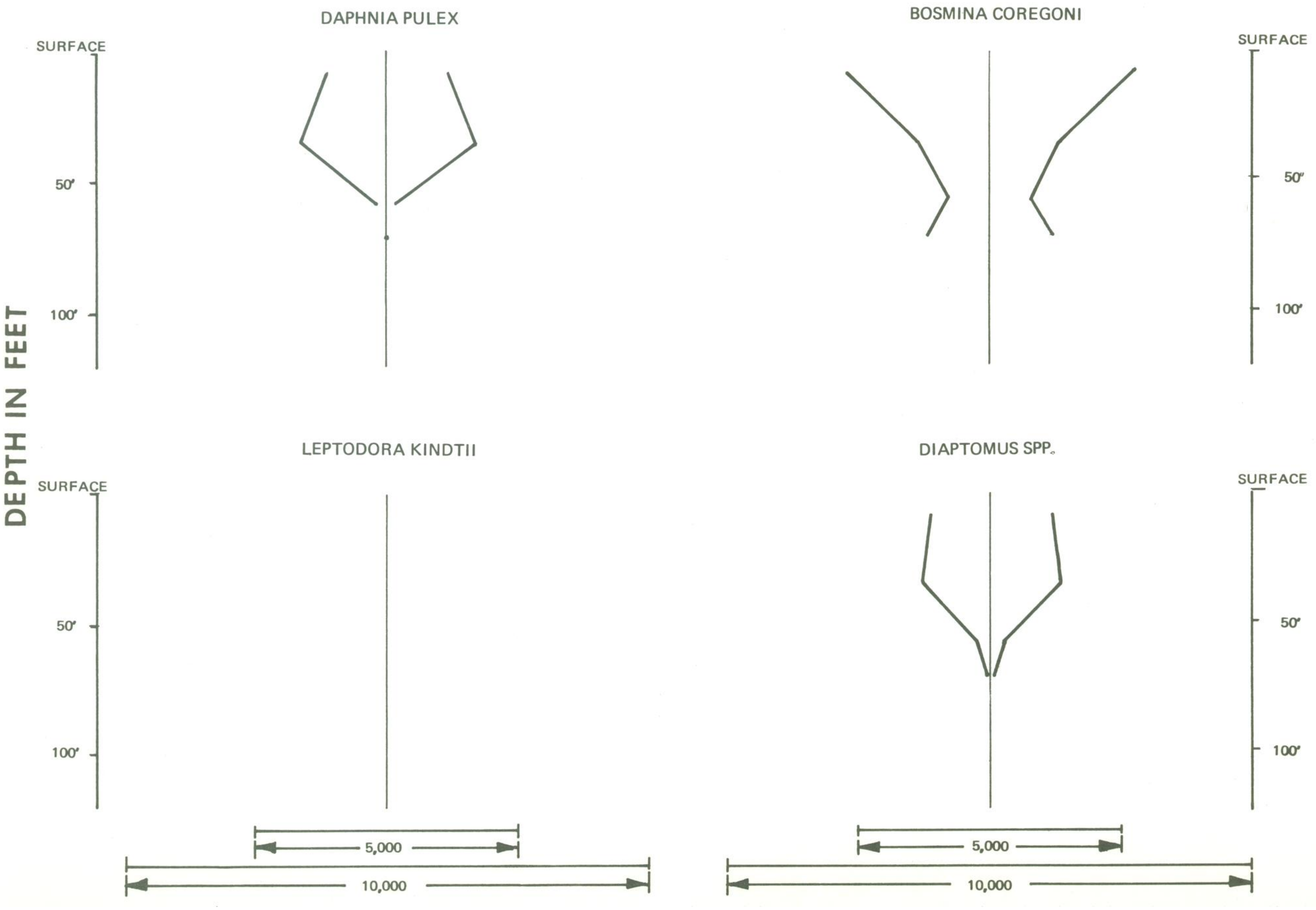


FIGURE 3.4-12

NUMBERS OF ORGANISMS PER 2-MINUTE HORIZONTAL TOW

5 OCTOBER 1973

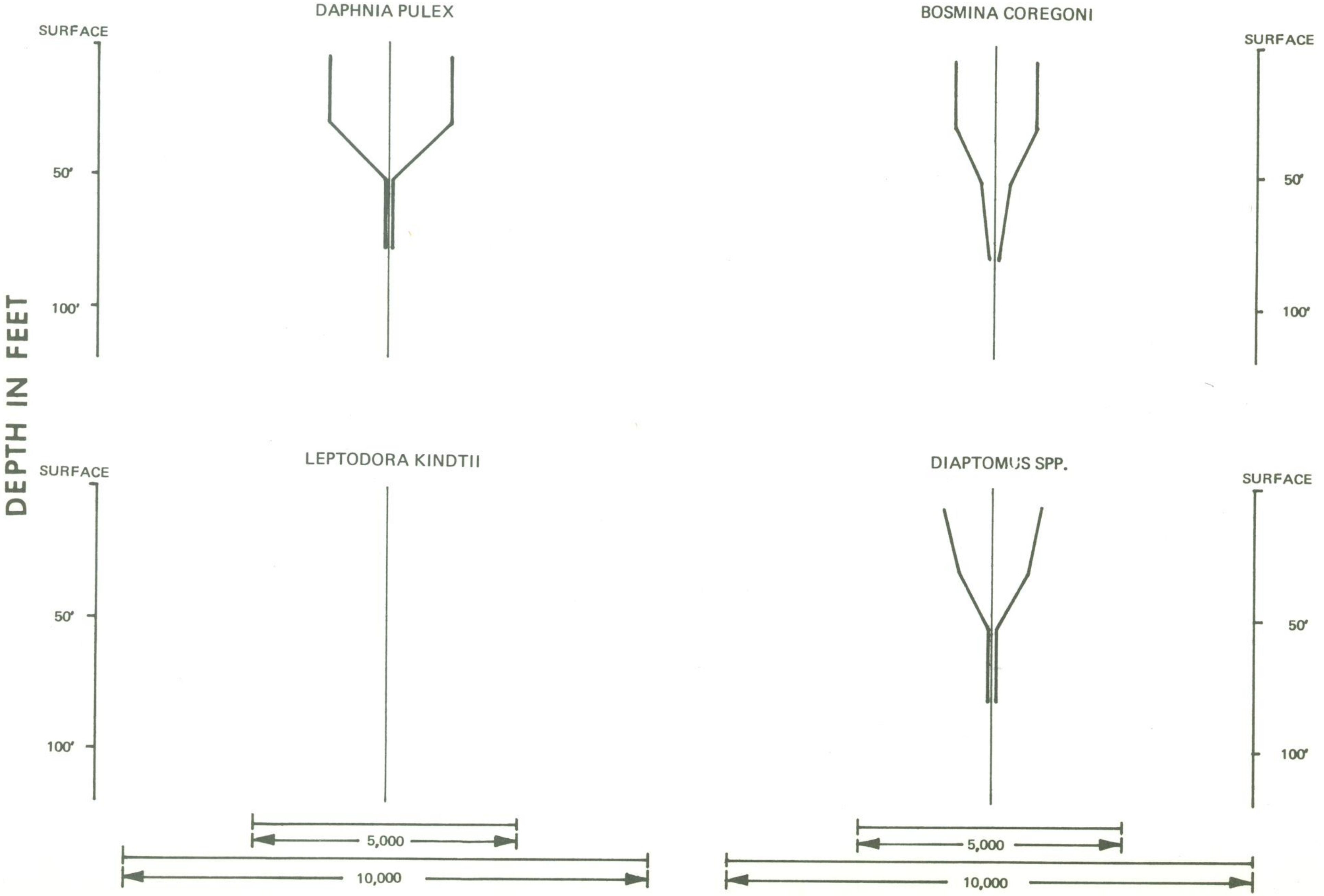


FIGURE 3.4-13

NUMBERS OF ORGANISMS PER 2-MINUTE HORIZONTAL TOW

6 OCTOBER 1973

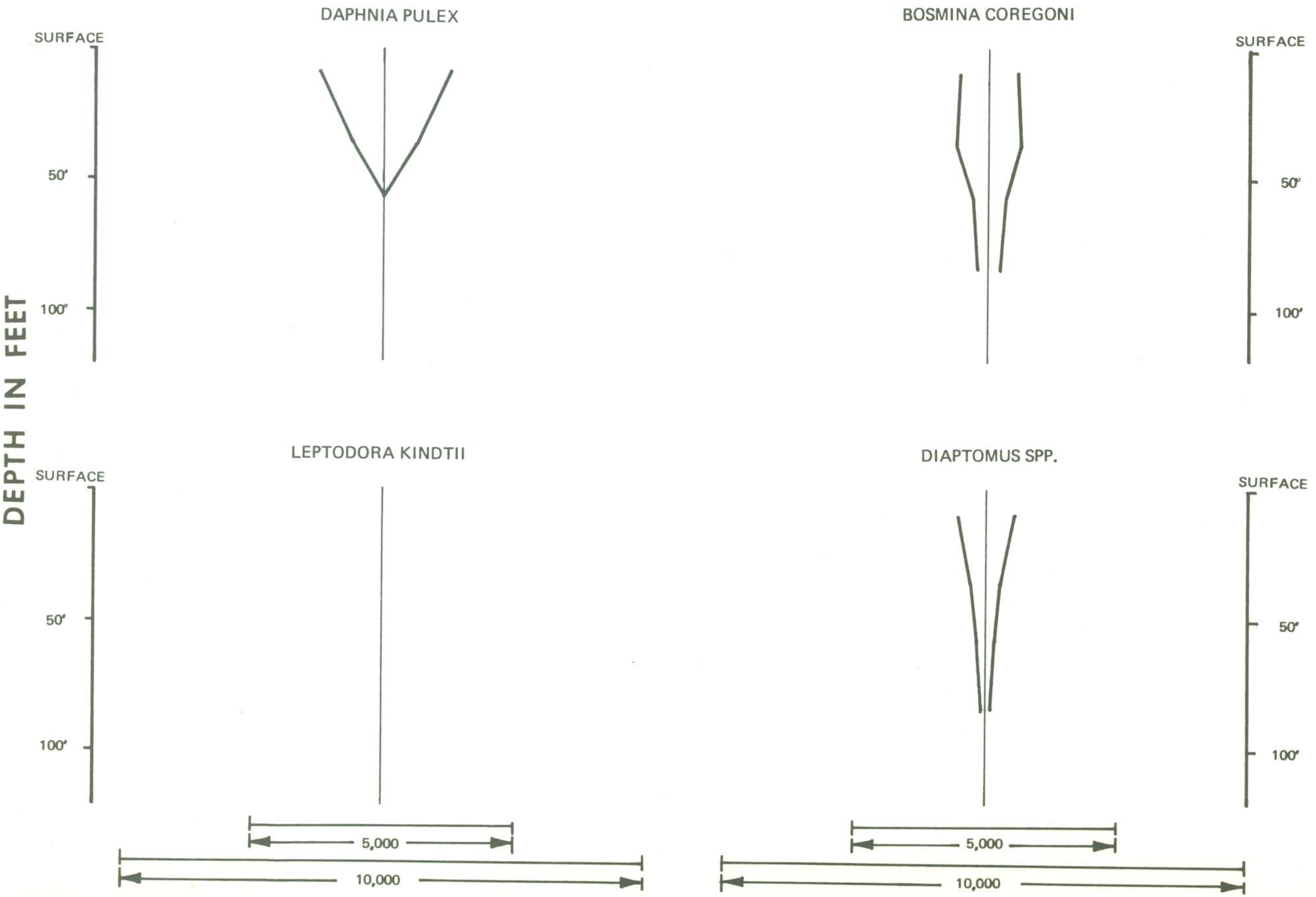


FIGURE 3.4-14

TOTAL CRUSTACEA (EXCLUDING NAUPLII)

1973

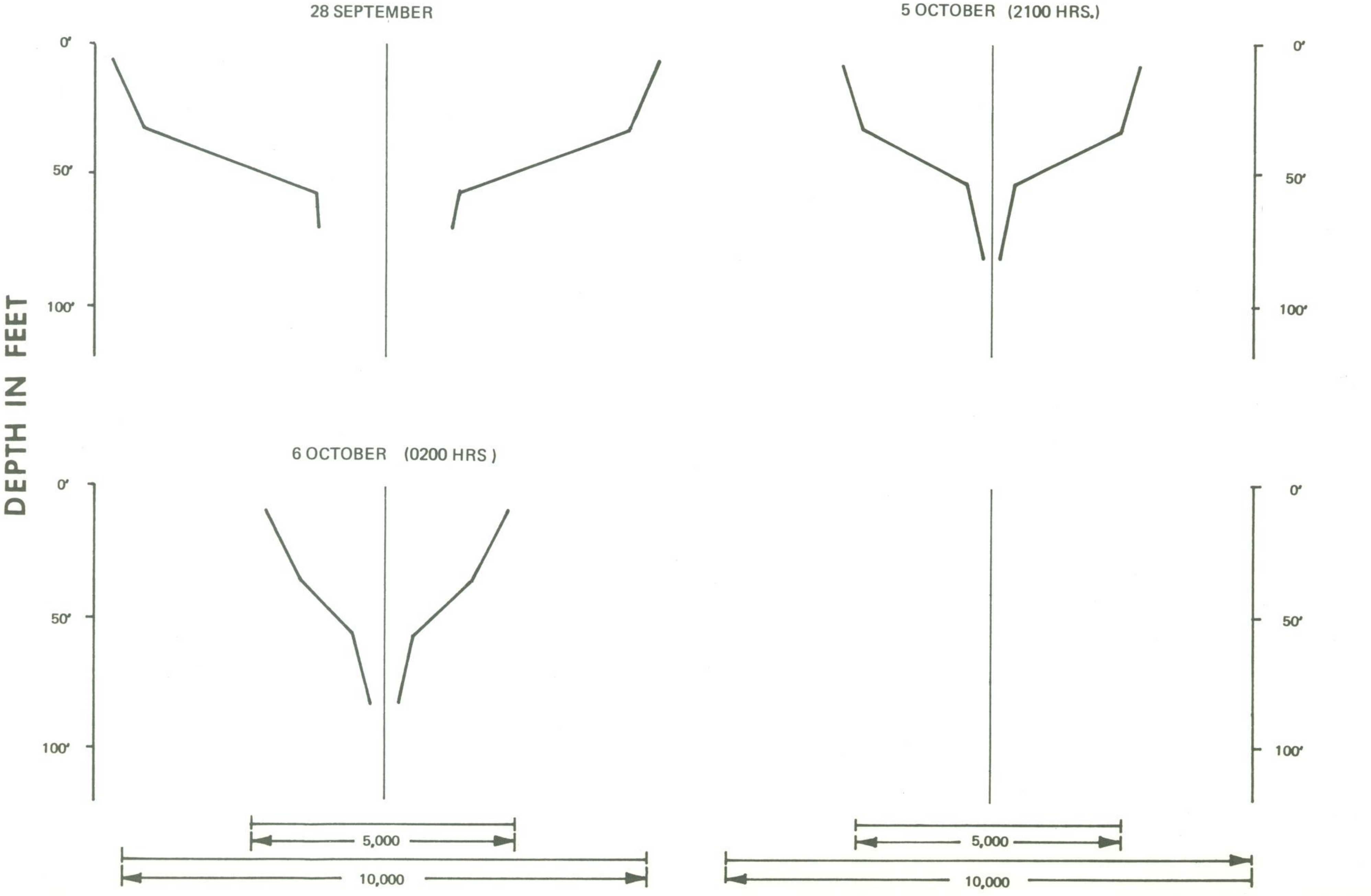


FIGURE 3.4-14 (cont.)

TOTAL CRUSTACEA (EXCLUDING NAUPLII)

1973

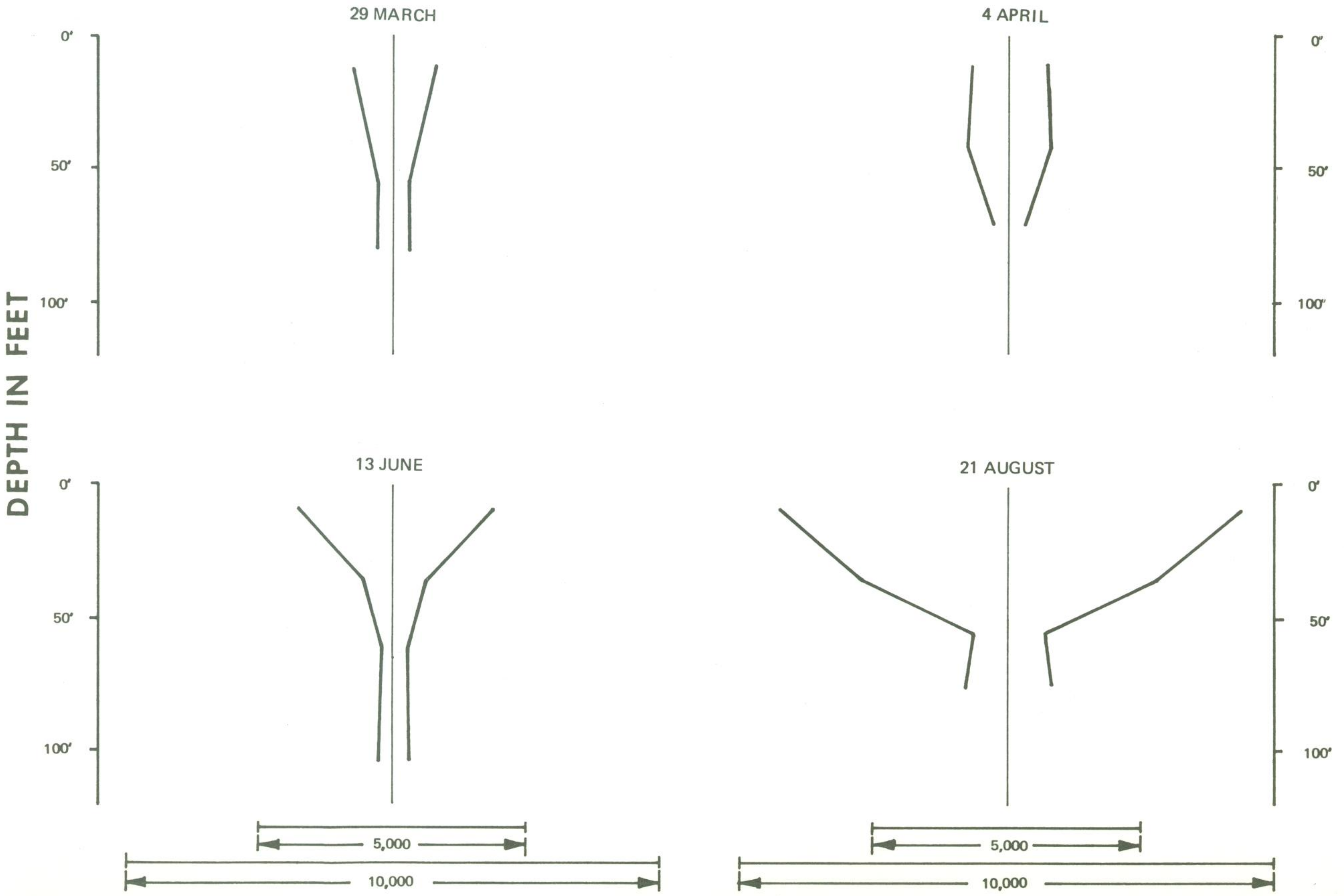


FIGURE 3.4-15

SAMPLE STATION LOCATION FOR BENTHIC SAMPLING LAKE TRANSECT NEAR MAY CREEK IN RELATION TO MAXIMUM 1973 DRAWDOWN AND FULL POOL ELEVATIONS

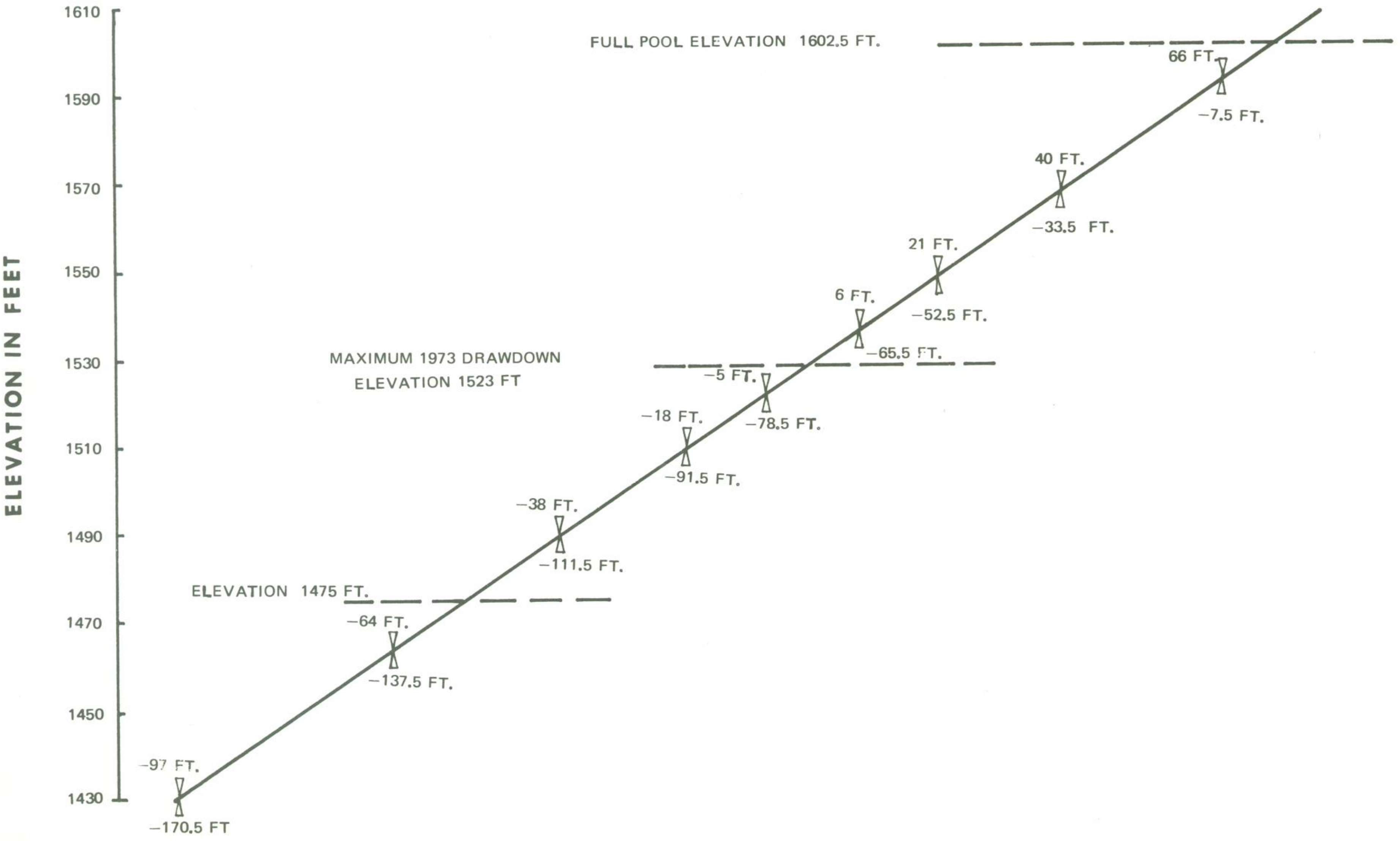
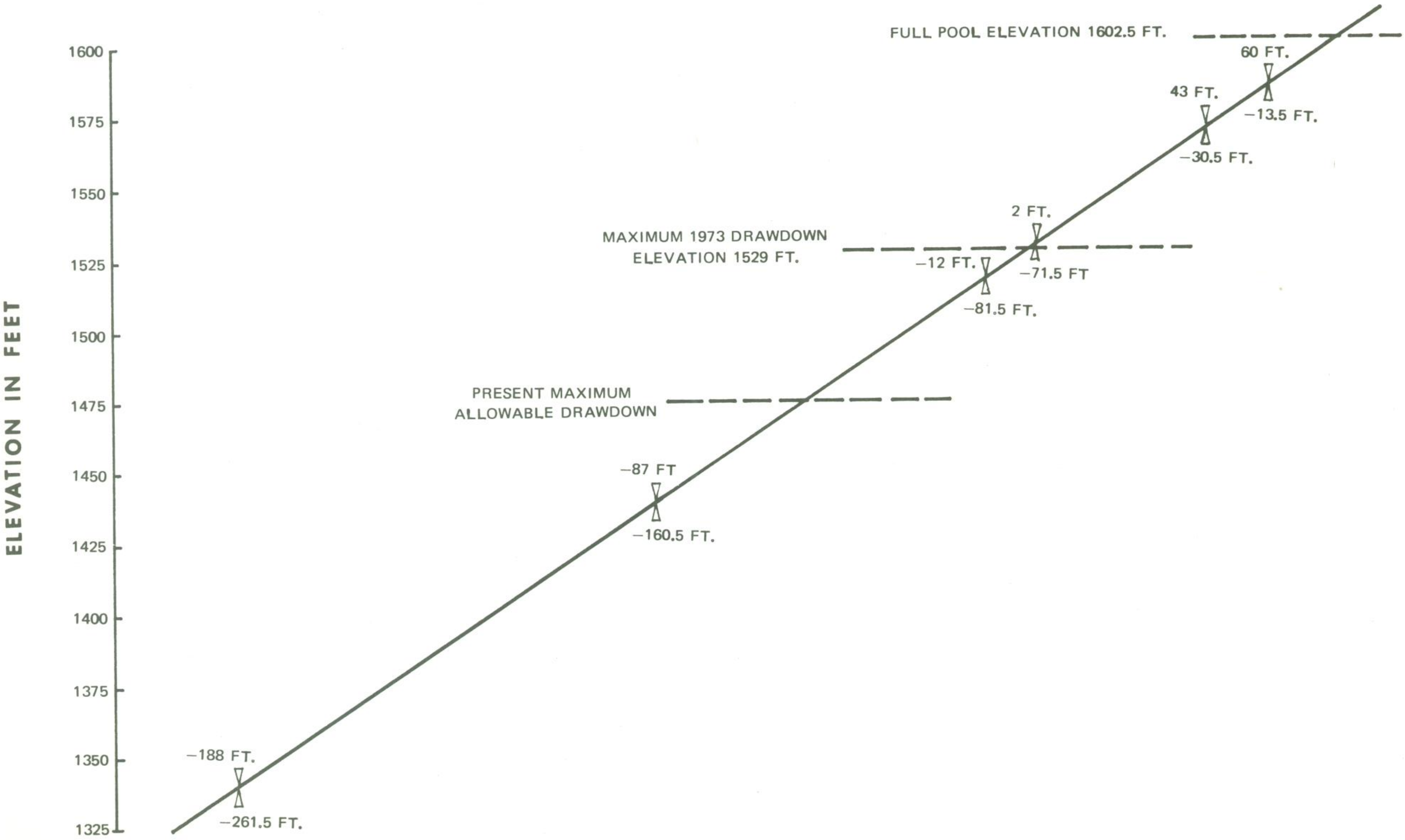


FIGURE 3.4-16

SAMPLING STATION LOCATIONS FOR BENTHIC SAMPLING, MID – LAKE TRANSECT IN RELATION TO MAXIMUM 1973 DRAWDOWN AND FULL POOL ELEVATIONS



Sample processing following collection differed from that of 1972 (SCL, 1973) only in the fact that the samples were stained with a Rose Bengal dye added to the preservative to facilitate easier picking.

3.4.3.2 Results

The substrate composition for the May Creek transect consisted of rocks, gravel and sand with organic material in the steeper drawdown area. The proportions of organic debris, silt and finer inorganic materials increased with depth. In addition, considerable numbers of stumps and roots occurred along the transect.

The composition of substrate along the mid-lake transect was composed mainly of organic debris, sand, silt and mud. Large quantities of tree branches, bark and logs occurred in the transect substrate. The Ruby Creek mouth sampling site consisted mainly of sand and fine organic debris.

Comparing the gradients of the two transects, May Creek is very steep relative to the mid-lake transect. The latter attains its maximum depth over approximately 15 miles.

Results of the sampling along the transect near May Creek are presented in Table 3.4-4 and Fig. 3.4-17. The 1973 results are similar to those of previous years, 1971 and 1972, in that mean numbers of invertebrates were greater near the level of maximum drawdown (1529 ft. elevation). As the season progressed and the lake level rose, organism abundance also increased, peaking above the maximum drawdown in July and near the surface in September. This again suggests that recolonization of the drawdown area takes place as the lake rises.

TABLE 3.4-4

MEAN NUMBERS OF INVERTEBRATES PER M^2. SAMPLE LOCATIONS ARE DESIGNATED BY DEPTH OF WATER AT FULL POOL ELEVATION (1602.5 FT.) AND BY FEET ABOVE (+) AND BELOW (-) 1973 MAXIMUM DRAWDOWN ELEVATION (1529 FT.)

Transect near May Creek

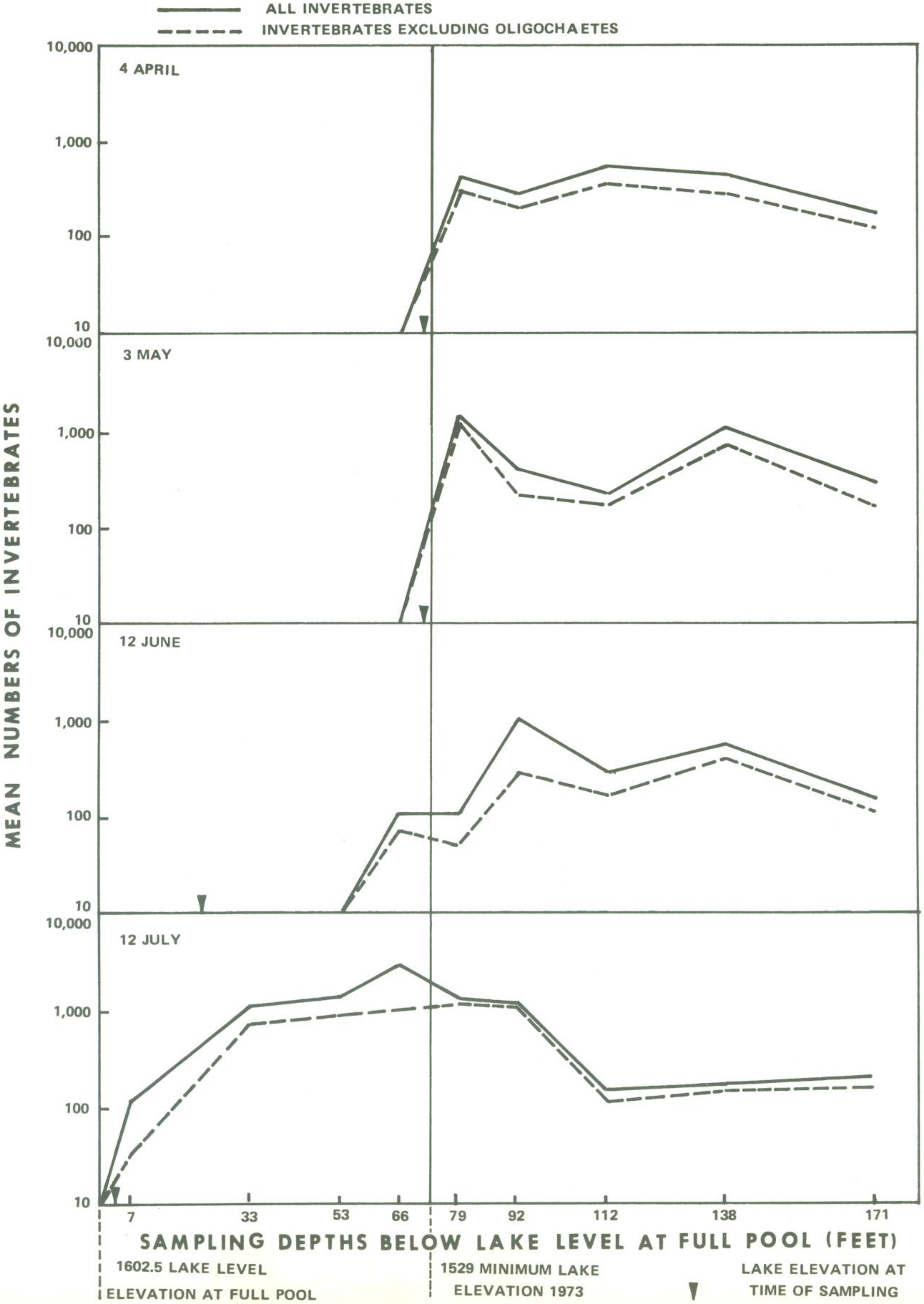
Depth of sta. at max. pool (1602.5 ft.)	7.5	33.5	52.5	65.5 (ft.)	78.5	91.5	111.5	137.5	170.5	Total Percentages
Feet above (+) and below (-) max. drawdown	+66	+40	+21	+6 (ft.)	-5	-18	-38	-64	-97	
4 April (Lake elev. 1530 ft.)										
Tendipedidae				0	470	255	355	285	200	55.0
Oligochaetes				0	110	135	195	195	100	26.0
Amphipods				0	20	5	0	0	0	1.0
Others				0	10	90	210	195	0	18.0
Total				0	610	485	760	675	300	
3 May (Lake elev. 1531 ft.)										
Tendipedidae				0	1395	255	265	495	255	47.0
Oligochaetes				0	645	235	90	355	210	39.0
Amphipods				0	20	40	0	5	0	1.0
Others				0	265	65	20	380	10	13.0
Total				0	2325	595	375	1235	475	
12 June (Lake elev. 1580 ft.)										
Tendipedidae	0	-	0	0	55	260	165	400	120	37.0
Oligochaetes	0	-	5	20	40	540	215	125	95	39.0
Amphipods	0	-	0	10	10	20	0	0	0	1.0
Others	0	-	5	75	5	190	105	200	10	22.0
Total	0	-	10	105	110	1010	485	725	225	
12 July (Lake elev. 1599 ft.)										
Tendipedidae	35	820	980	550	1430	1140	145	170	210	44.1
Oligochaetes	100	475	995	3865	340	140	60	40	70	49.1
Amphipods	0	5	0	25	0	0	0	0	0	0.2
Others	15	20	15	430	130	95	10	65	45	6.6
Total	150	1320	1990	4875	1900	1375	215	275	325	
17 Sept. (Lake elev. 1598 ft.)										
Tendipedidae	470	575	205	185	350	695	480	115	615	39.2
Oligochaetes	4530	155	35	170	145	250	85	45	95	58.5
Amphipods	10	0	5	0	5	0	0	0	0	0.2
Others	25	0	5	25	40	5	5	0	90	2.1
Total	5035	730	250	380	540	950	570	160	800	

1973 Maximum drawdown 1529 ft. elevation

MEAN NUMBERS OF INVERTEBRATES PER m²

FIGURE 3.4-17

ROSS LAKE
MAY CREEK TRANSECT 1973

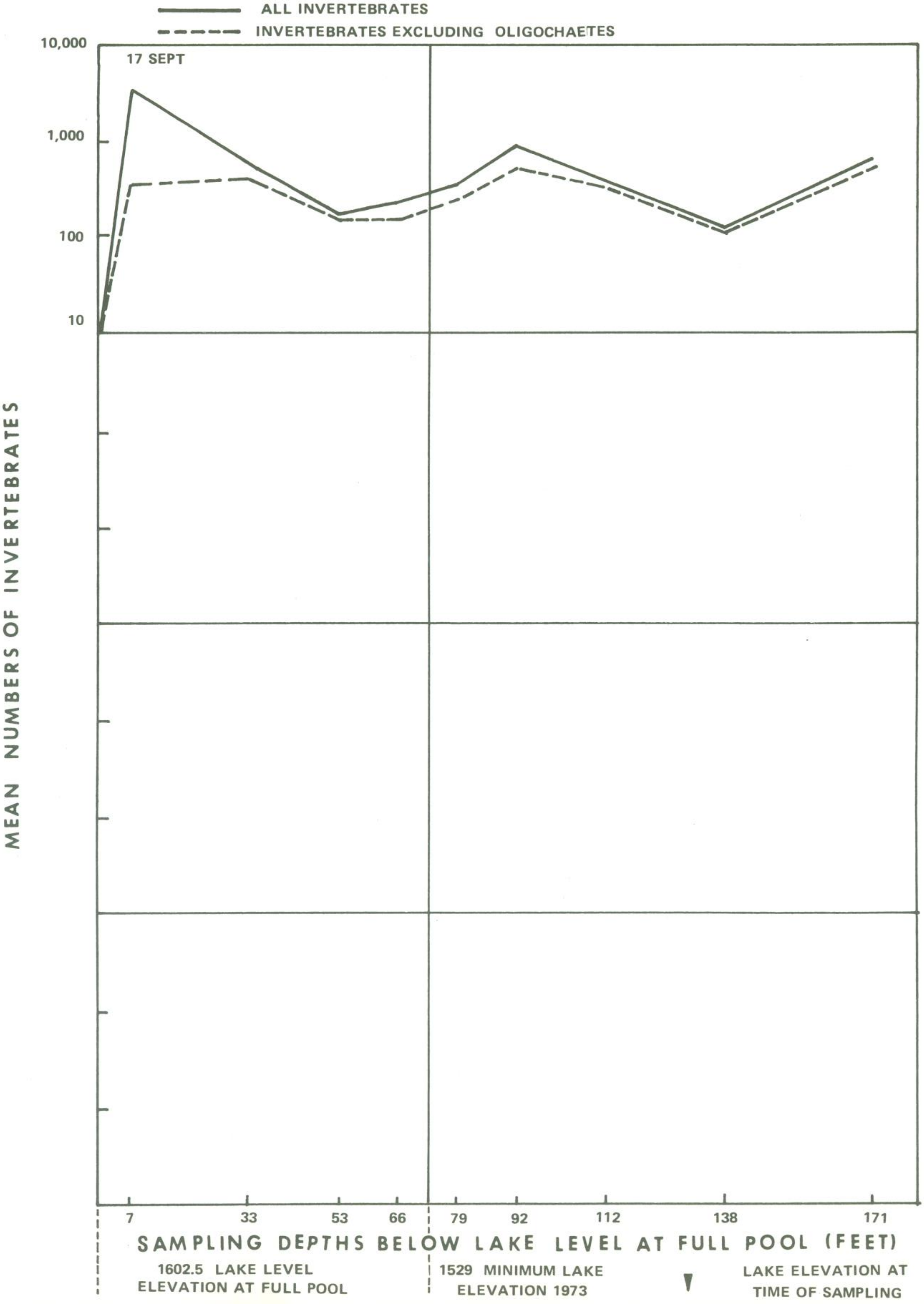


MEAN NUMBERS OF INVERTEBRATES PER m^2

ROSS LAKE

FIGURE 3.4-17 (cont.)

MAY CREEK TRANSECT 1973

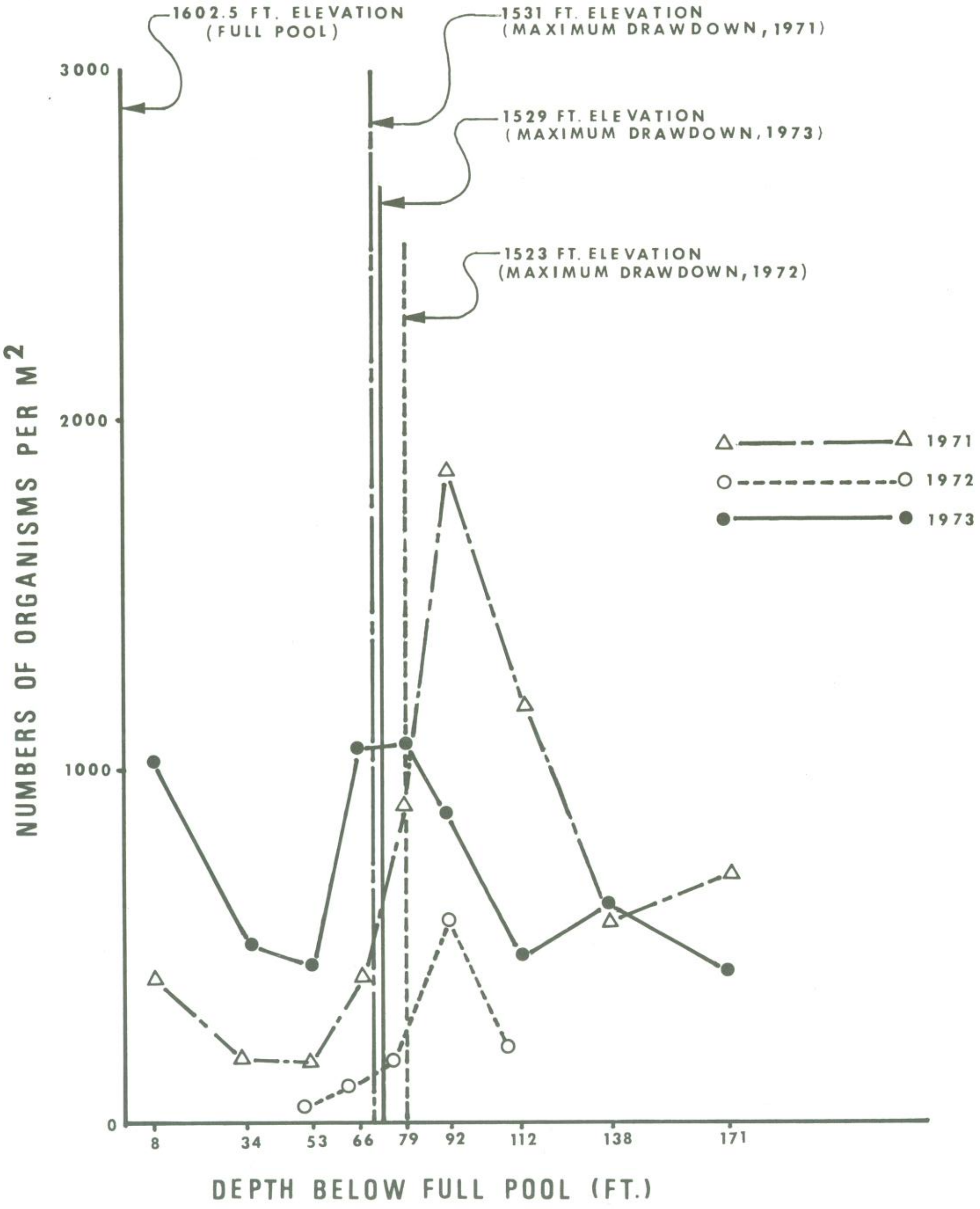


The season average counts for stations below maximum drawdown for the 1973 May Creek transect when compared to previous years indicates an intermediate level of abundance of invertebrate organisms relative to 1971 and 1972; abundance in 1971 was greatest (Fig. 3.4-18). Average abundance in the exposed area above maximum drawdown was greatest in 1973. Tendipedid larvae and Oligochaeta comprised 45 percent and 46 percent respectively, of the total invertebrate abundance for 1973, compared to 88 and 10 percent in 1971 and 27 and 66 percent in 1972.

The mid-lake transect results are presented in Table 3.4-5 and Fig. 3.4-19. As in 1972, an increase in invertebrate abundance occurred in the exposed drawdown areas following inundation. This increase occurred throughout the summer, being highest in the September sample. In this sample, two similar abundance peaks occurred, the first at 41 ft. above the maximum drawdown elevation ($1340/m^2$); the other at 9 ft. below ($1665/m^2$). In the deepest area, organism abundance was less, as in 1972. The abundance levels for July and September samples in 1973 were greater than in July and August samples in 1972. Sample composition for the mid-lake transect (Tendipedid, 45 percent, and Oligochaeta, 46 percent) was similar to that of the transect near May Creek for 1973. In 1972 average sample composition of the mid-lake transect over the sample season was 21 percent Tendipedidae and 76 percent Oligochaeta.

The abundance peaks above the maximum drawdown elevation (Fig. 3.4-20) are indicative of the high productivity of flat drawdown areas and show that benthic invertebrates can re-establish themselves and thrive in these areas following inundation.

FIGURE 3.4-18



VERTICAL DISTRIBUTION OF MEAN NUMBERS OF INVERTEBRATES (PER M^2) FROM BENTHIC STUDIES IN ROSS RESERVOIR, TRANSECT NEAR MAY CREEK 1971-1973

TABLE 3.4-5

MEAN NUMBERS OF INVERTEBRATES PER M^2. SAMPLE LOCATIONS ARE DESIGNATED BY DEPTH OF WATER AT FULL POOL ELEVATION (1602.5FT.) AND BY FEET ABOVE (+) AND BELOW (-) 1973 MAXIMUM DRAWDOWN ELEVATION (1529 FT.)

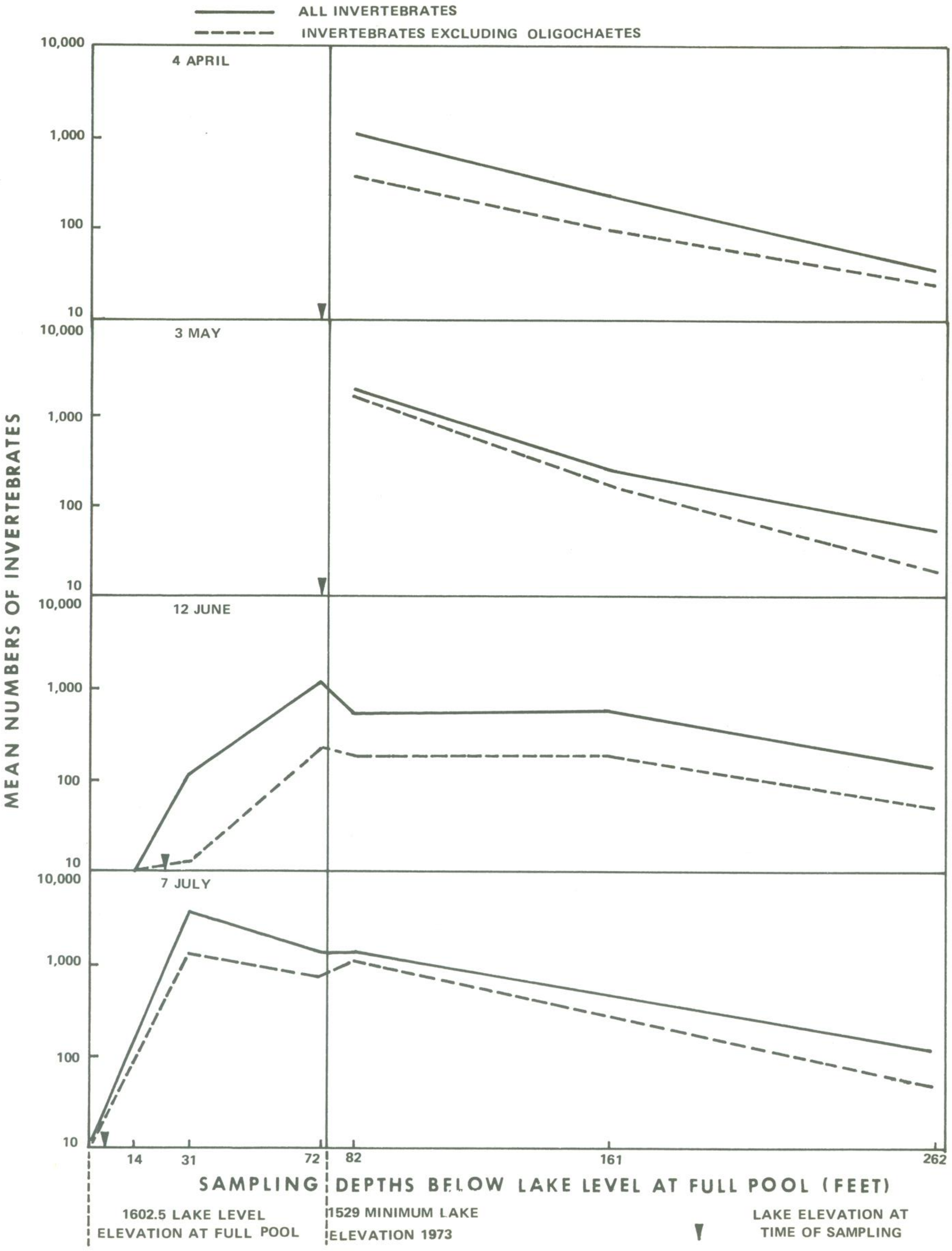
Mid-Lake Transect

Depth of sta. at max. pool (1602.5 ft.)	13.5	30.5	71.5	(ft)	81.5	160.5	261.5	
Feet above (+) and below (-) max. drawdown	+60	+43	+1	(ft)	-12	-87	-188	Total Percentages
		4 April (Lake elev.			1530 ft.)			
Tendipedidae			-		475	165	40	40.1
Oligochaetes			-		795	120	15	54.9
Amphipods			-		10	5	0	0.9
Others			-		60	10	0	4.1
Total			-		1340	300	55	
		3 May (Lake elev.			1531 ft.)			
Tendipedidae			-		2530	200	30	82.0
Oligochaetes			-		300	140	45	15.4
Amphipods			-		0	15	0	0.5
Others			-	1973 maximimum drawdown 1529 ft. elevation	30	35	0	2.1
Total			-		2680	390	75	
		12 June (Lake elev.			1580 ft.)			
Tendipedidae	0	10	305		280	195	40	26.4
Oligochaetes	0	135	975		415	450	140	67.2
Amphipods	0	0	0		5	10	0	0.5
Others	0	5	50		10	90	30	5.9
Total	0	150	1330		710	745	210	
		2 July (Lake elev.			1599 ft.)			
Tendipedidae	85	1910	680		1150	375	65	41.1
Oligochaetes	75	3605	1090		630	245	60	54.9
Amphipods	0	0	0		10	0	0	0.1
Others	5	0	185		155	60	0	3.9
Total	165	5515	1955		1945	680	125	
		20 Sept (Lake elev.			1598 ft.)			
Tendipedidae	120	660	130		1260	325	40	67.1
Oligochaetes	5	305	235		335	125	45	27.8
Amphipods	5	25	40		55	0	0	3.3
Others	5	45	25		0	0	0	1.8
Total	135	1035	430		1650	450	85	

MEAN NUMBERS OF INVERTEBRATES PER m^2

FIGURE 3.4-19

ROSS LAKE
MID-LAKE TRANSECT 1973



MEAN NUMBERS OF INVERTEBRATES PER m^2

FIGURE 3.4-19 (cont.) ROSS LAKE

MID-LAKE TRANSECT 1973

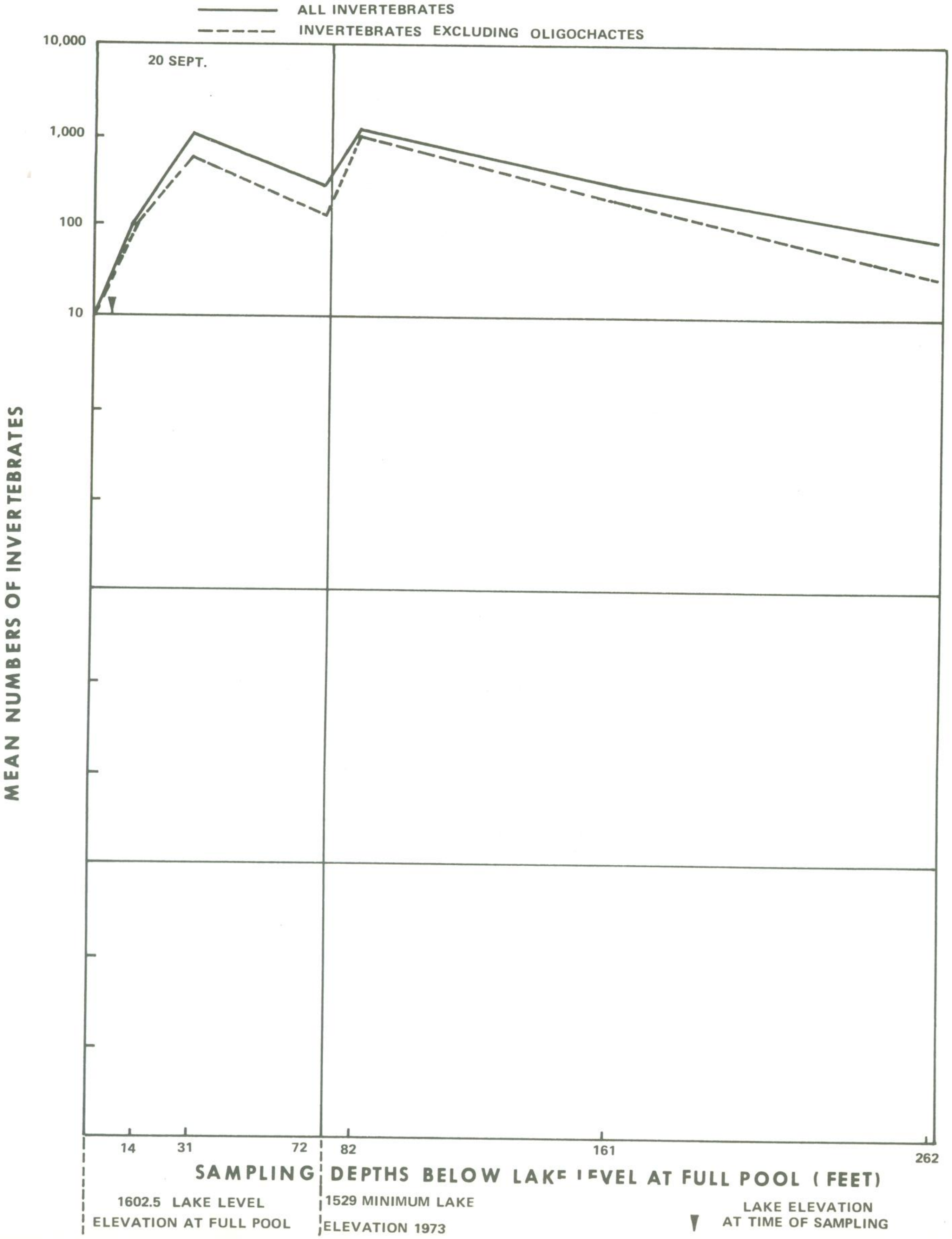
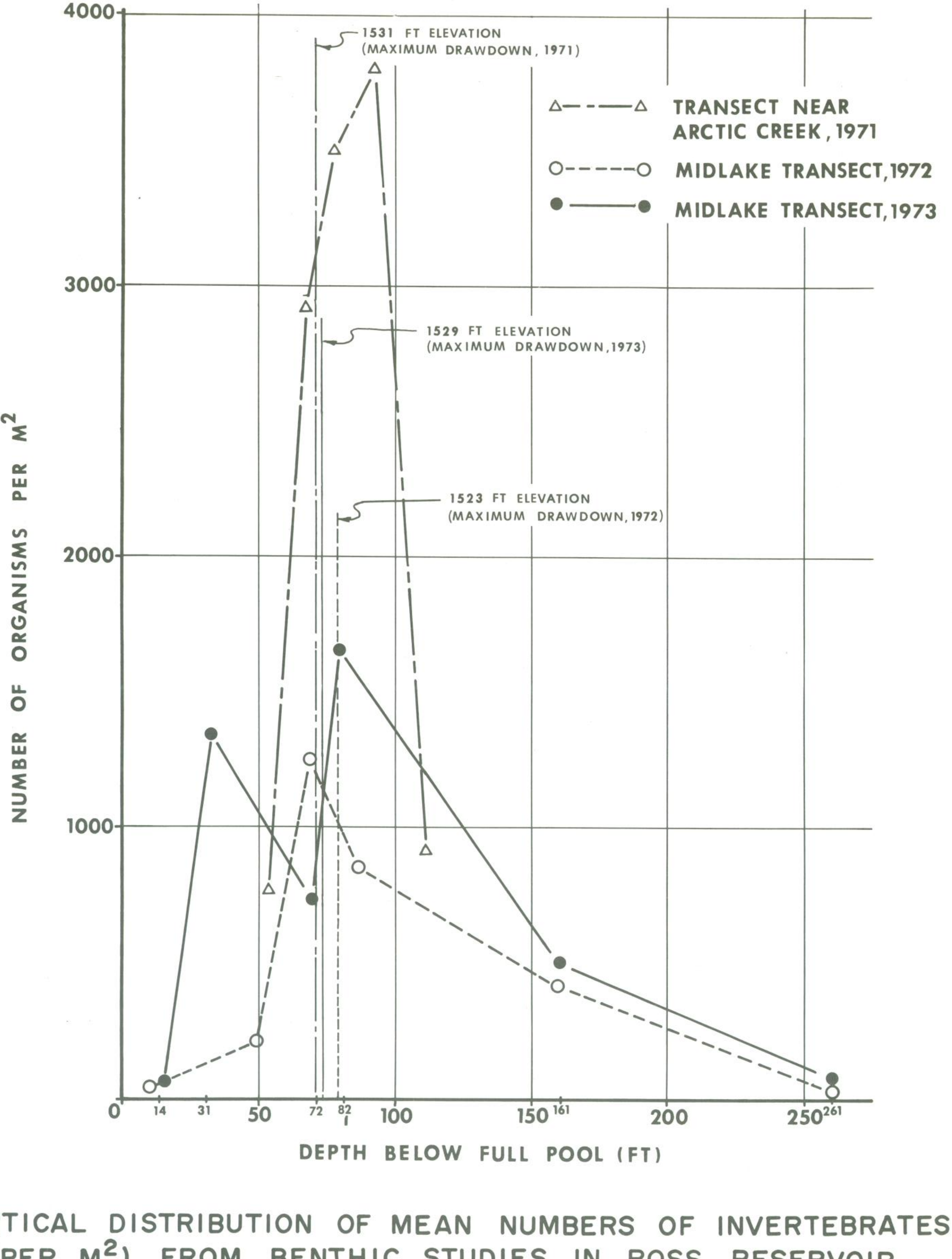


FIGURE 3.4-20



VERTICAL DISTRIBUTION OF MEAN NUMBERS OF INVERTEBRATES (PER M^2) FROM BENTHIC STUDIES IN ROSS RESERVOIR, MID-LAKE TRANSECT, 1972 AND 1973, AND TRANSECT NEAR ARCTIC CREEK, 1971

Seasonal average counts for the mid-lake transect in 1972 and 1973 were plotted in Fig. 3.4-20 along with those of the transect near Arctic Creek in 1971 (SCL, 1973) for comparison. Abundance levels were generally higher in 1973 than in 1972 along the mid-lake transect both above and below maximum drawdown.

Comparison of Transect Locations

Figs.3.4-18 and 3.4-20 compare invertebrate abundance between the May Creek area and mid-lake transects. General levels of abundance below the maximum drawdown were higher along the mid-lake transect in 1972 and 1973. Differences in abundance above the maximum drawdown between the two transects are not readily apparent although vertical distribution of organisms on each transect was different. The abundance peak above maximum drawdown occurred at a deeper depth below full pool along the mid-lake transect. If recolonization of the exposed drawdown area occurred from below, it may have occurred more slowly along the mid-lake transect because its horizontal length was much greater than that of the steeper transect near May Creek.

Creek Mouth Sampling

The 1973 creek mouth sampling was limited to a single site and date (July 12). The results are presented in Table 3.4-6. Invertebrate abundance for the Ruby Creek mouth station in 1973 was about 11 times that of 1972 on the same date and at the same depth and 2 times that of June 22, 1971 taken in slightly deeper water. Species composition was similar to the previous two years; Tendipedidae usually comprised 95 percent or more of the total. Compared to an equivalent depth on the mid-lake transect, the Ruby Creek samples

TABLE 3.4-6

MEAN NUMBERS OF INVERTEBRATES PER M^2. SAMPLE LOCATIONS ARE DESIGNATED BY DEPTH OF WATER AT FULL POOL ELEVATION (1602.5 FT.), AND BY FEET ABOVE (+) AND BELOW (-) 1973 MAXIMUM DRAWDOWN ELEVATION (1529.0 FT.)

RUBY CREEK ARM TRANSECT

Depth of station at maximum pool 1602.5 ft.	68.5 ft.	Total Percentages
Feet above (+) and below (-) maximum drawdown	+5 ft.	
12 July (Lake elevation 1599 ft.)		
Tendipedidae	10775	97.0
Oligochaetes	200	2.0
Amphipods	0	0.0
Others	95	1.0
Total	11070	

1973 Maximum drawdown 1529 ft. elevation had about 6 times greater total numbers of organisms. Oligochaetes made up a greater proportion of the mid-lake sample than did Tendipedidae.

Summary and Discussion

1. Relative abundance of Tendipedidae and Oligochaeta were nearly equal for both lake transects in 1973.

2. Benthic fauna in exposed drawdown areas apparently become re-established from lower wetted areas, but with average spring-summer abundance highest near the zone of maximum annual drawdown. As depth increases below maximum drawdown, abundance declines.

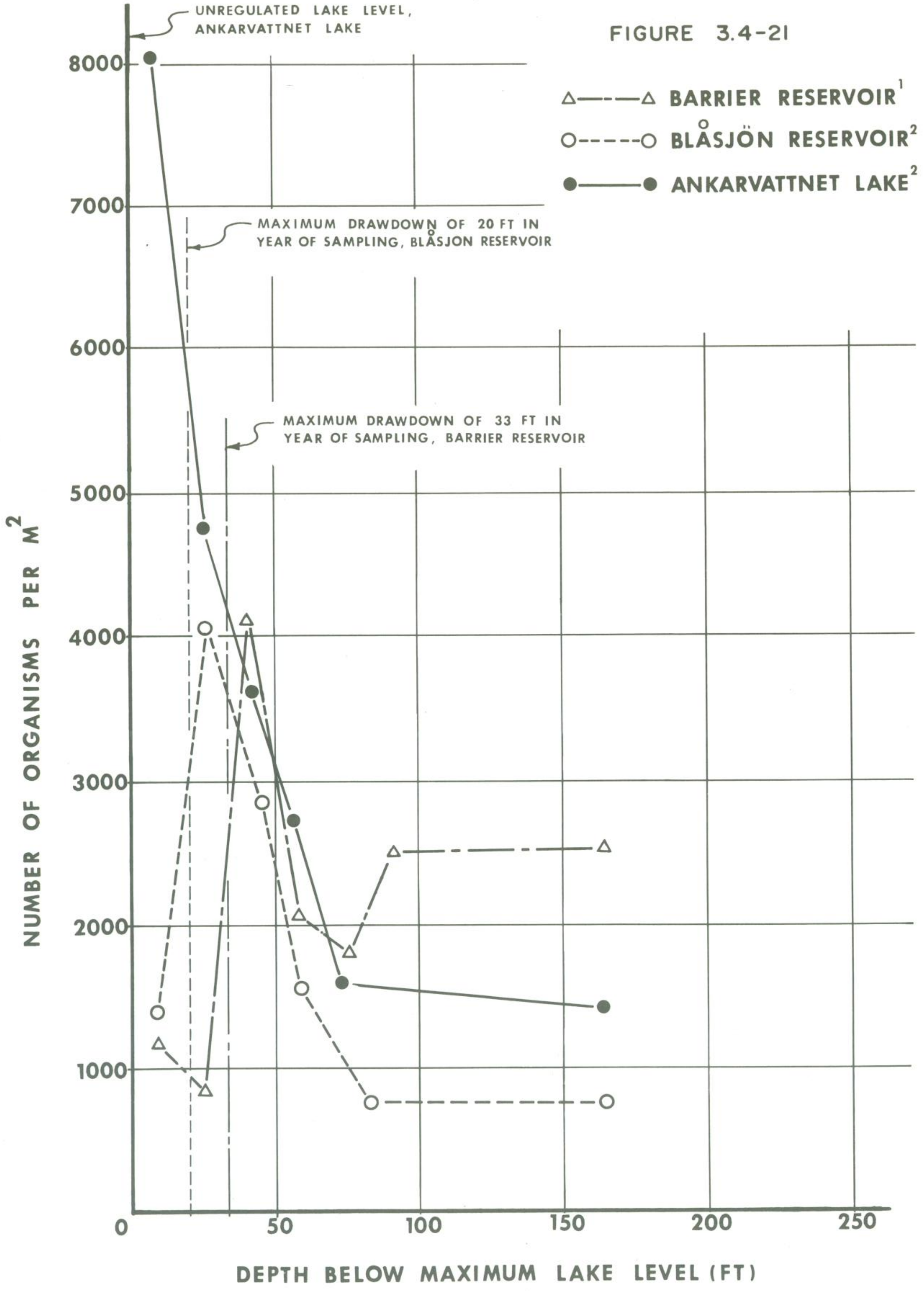
3. Absolute abundances of invertebrates on the transect near May Creek were 2-6 times greater than in 1972. Tendipedidae abundance levels for 1973 were about half of 1971 levels while abundance of Oligochaeta was 6 times that of 1971. For the mid-lake transect in 1973 Tendipedids were about 3 times as abundant as in 1972 while abundance of Oligochaetes was about equal to that of 1972.

4. Tendipedidae greatly predominated in Ruby Creek mouth samples. Total abundance of invertebrates at Ruby Creek was about 6 times greater than similar depths along the mid-lake transect.

Conclusions regarding benthic production in 1973 are the same as those stated in SCL (1973), i.e., macro-invertebrate production is severely restricted by drawdown area exposure.

Comparison of vertical distribution of Ross Lake benthos (Figs. 3.4-18 and 3.4-20) to that of three other reservoirs (Fig. 3.4-21) shows that benthos abundance peaks usually occurred just below the maximum drawdown level in all four reservoirs. A similar distribution relative to

FIGURE 3.4-21



VERTICAL DISTRIBUTION OF MEAN NUMBERS OF INVERTEBRATES (PER M^2) FROM BENTHIC STUDIES IN BARRIER AND BLASJON RESERVOIRS AND LAKE ANKARVATTNET

[1] FILLION, 1967

[2] GRIMÅS, 1961

reservoir drawdown was also found in Gorge and Diablo Lakes in 1973 (FRI, unpublished data). The data also indicate that greater drawdown results in fewer organisms in shallow areas when the lake is at full pool.

With the 1973 drawdown to 1529 ft. elevation, 32 percent of the total lake area was exposed compared to 30 percent in 1971 and 36 percent in 1972. Since 1953, the exposed area has averaged 38 percent and has ranged from 15 to 54 percent.

3.5 AGE, GROWTH AND CONDITION (by Fisheries Research Institute)

3.5.1 The Sample

The growth analysis for 1973 is based on the sample of rainbow trout taken during creel census and scientific sampling programs in 1973. Sampling and age determination procedures were essentially the same as in 1972 (SCL, 1973) except that all scales sampled in 1973 were analyzed rather than subsampled. A total of 2,231 rainbow trout was utilized in the length-frequency and weight-frequency analysis (Fig. 3.5-1 and 3.5-2).

The average length and weight of rainbow trout in the 1973 sport catch was 294 mm (fork length) and 279 grams respectively (based on 436 fish sampled during creel census).

3.5.2 Length-Weight Relationship

Fork length (mm) and weights (g) were fitted to the logarithmic form of the general length-weight equation; $W = aL^B$ for 1973 rainbow trout for which both lengths and weights were available.

FIGURE 3.5-1

LENGTH-FREQUENCY DISTRIBUTION
SKAGIT-ROSS RAINBOW TROUT
1973

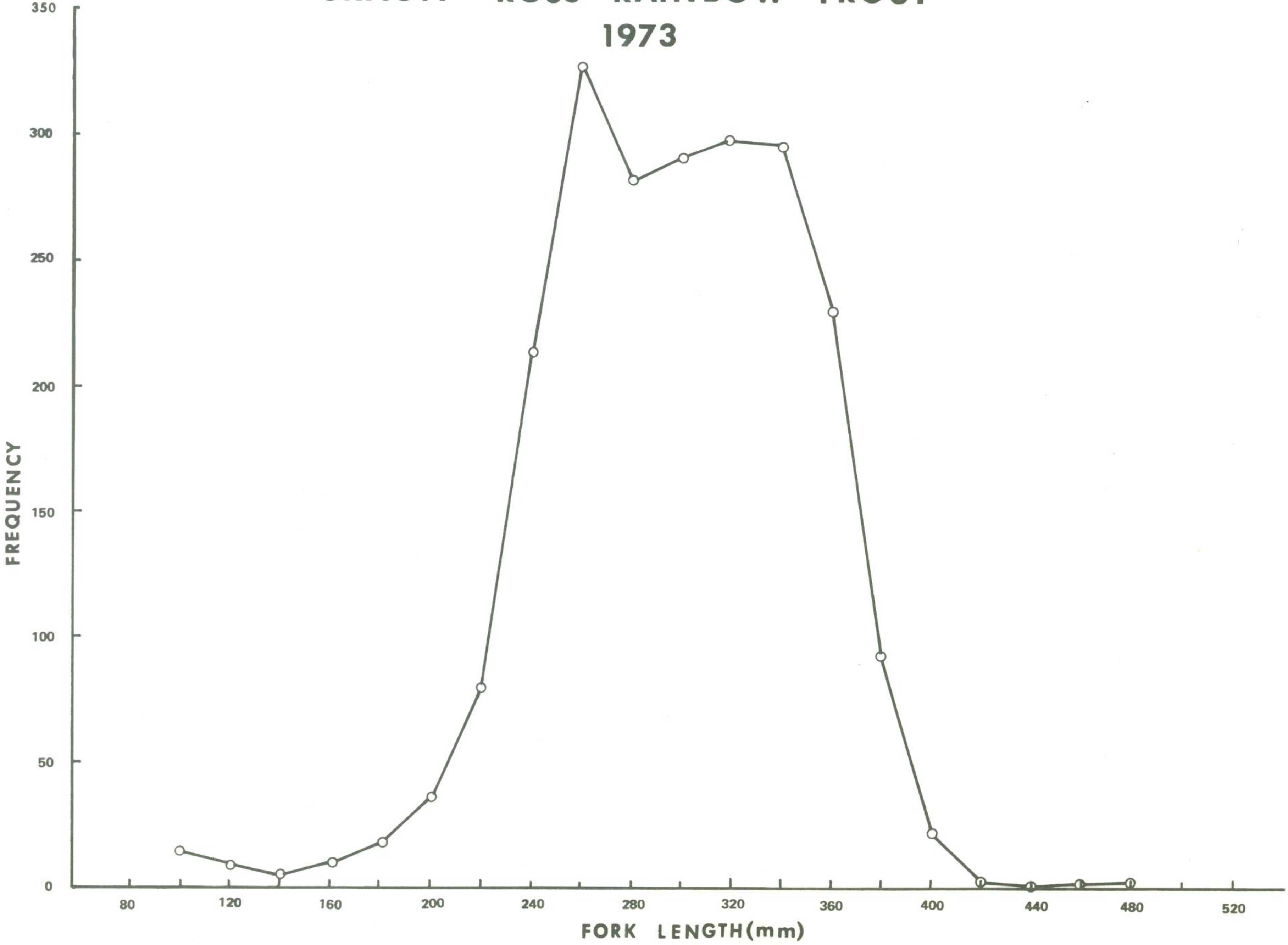
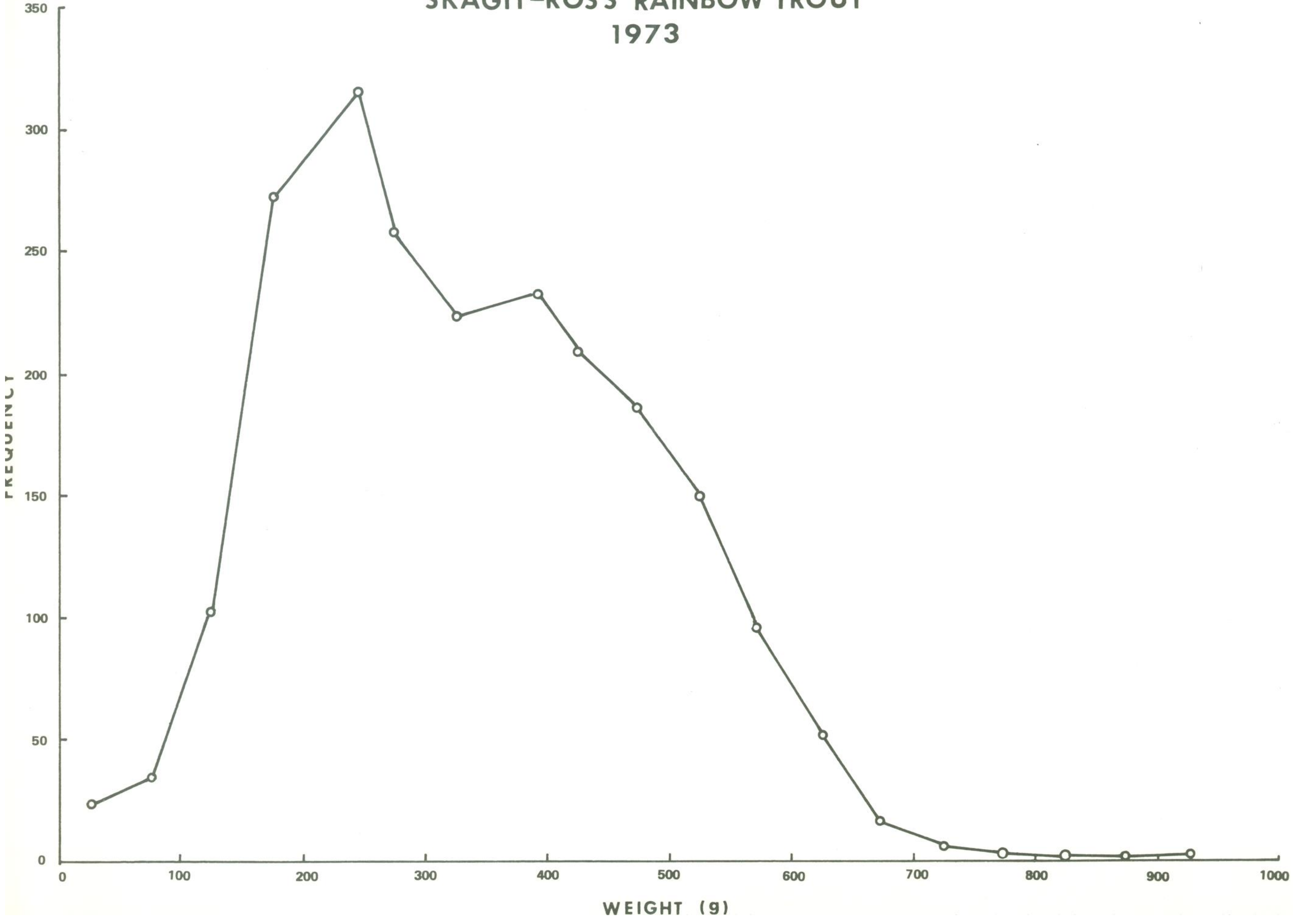


FIGURE 3.5-2

WEIGHT-FREQUENCY DISTRIBUTION

SKAGIT-ROSS RAINBOW TROUT

1973



The logarithmic equation,

$$\text{Log}_{10} W = \text{Log}_{10} a + B \text{ Log}_{10} L$$

is the linear equivalent of

$$Y = a + BX$$

The length-weight relationships for males, females and the total sample are presented graphically in Fig. 3.5-3 and below in logarithmic form.

1973 Total sample N = 2,192

$$Y = -4.54419 + 2.82855X$$

1973 Males N = 548

$$Y = -4.43197 + 2.77903X$$

correlation coefficient .975

1973 Females N = 746

$$Y = -.4.62716 + 2.86095X$$

correlation coefficient .975

3.5.3 Growth Rate

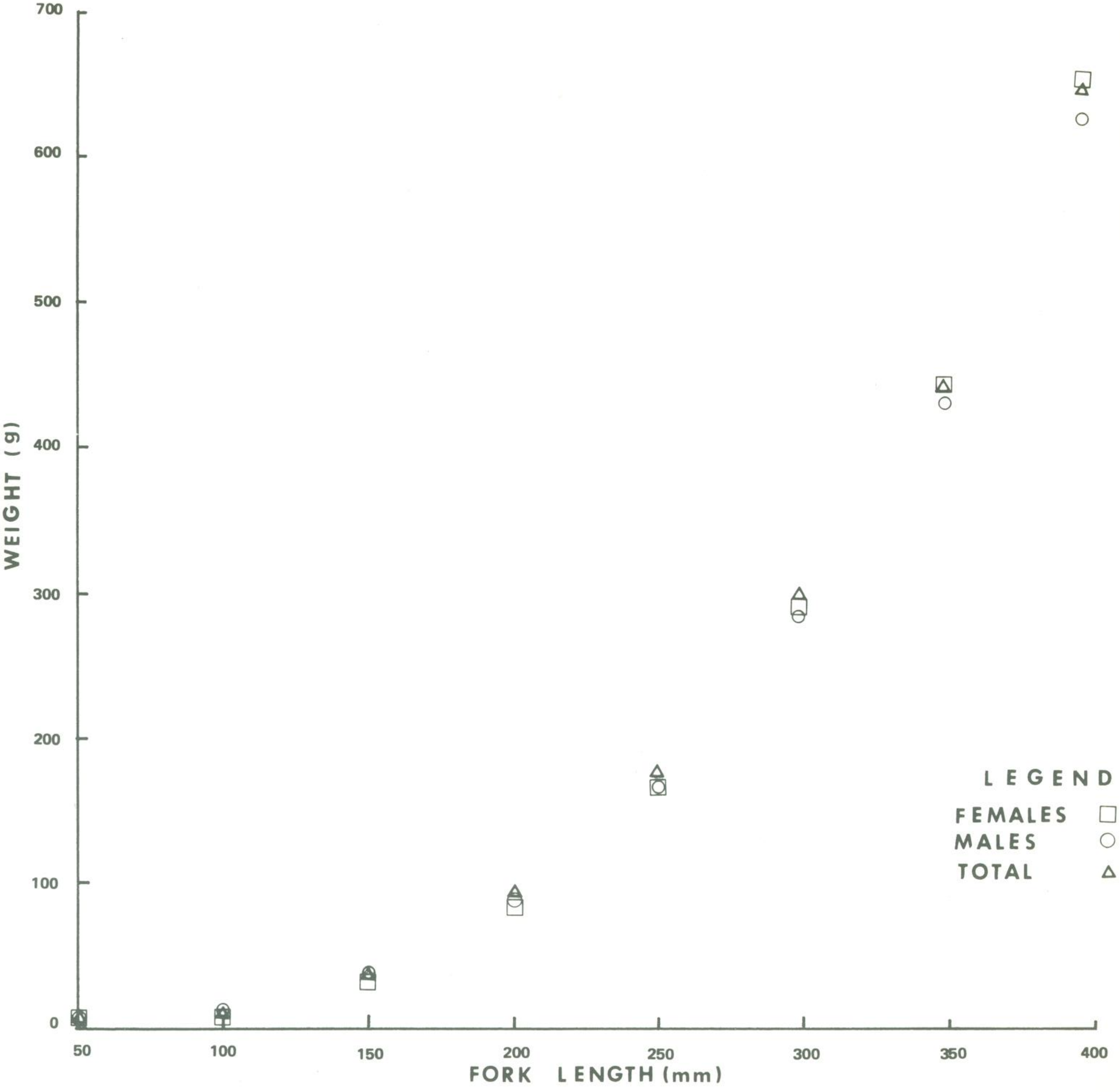
The analysis of growth rate presented in SCL (1973) utilized a regression of scale diameter on body length instead of body length on scale diameter. Since that is not the usual method of representing these data; the standard body-scale regressions for 1971, 1972 and 1973 data are given below.

FIGURE 3.5-3

LENGTH-WEIGHT RELATIONSHIP

SKAGIT-ROSS RAINBOW TROUT

1973



1971 (N = 527)

$Y = 107.64 + 1.28X$ correlation coefficient .849

1972 (N = 556)

$Y = 64.61 + 1.52X$ correlation coefficient .936

1973 (N = 1993)

$Y = 126.34 + 1.19X$ correlation coefficient .855

In SCL (1973) the back-calculated lengths reported for 1971 and 1972 data were derived utilizing the direct proportion equation:

$$\frac{\text{length of scale radius to annulus i } (S_i)}{\text{total length of scale radius } (S)}$$

$$= \frac{\text{length of fish when annulus i was formed } (l_i)}{\text{length of fish when scale was obtained } (L)}$$

or $$\frac{S}{S_i} = \frac{L}{l_i}$$

The back-calculation technique utilized in this report also uses a proportion equation but is preferable because it takes into account the Y intercept from the body-scale regression equation.

The equation is:

$$\frac{S}{S_i} = \frac{L-C}{l_i-C}$$

where C is the intercept from the body-scale regression.

To facilitate comparison of the 1971 and 1972 growth rate data in SCL (1973) with the 1973 data in this report, Table 3.5-1 presents the mean back-calculated length obtained by the above equations for 1971 and 1972.

Growth rates for 1973 rainbow trout are shown in tabular form in Tables 3.5-2 to 3.5-4 and graphically in Figs. 3.5-4 to 3.5-6. Average length to last annulus at each age for the total sample and for males and females separately are presented in Table 3.5-2 and Fig. 3.5-4. Weight at mean length at each age for the total sample and for males and females separately was determined from the respective length-weight relationship discussed earlier and illustrated in Fig. 3.5-3 and is presented in Table 3.5-3 and Fig. 3.5-5. Average increments of growth in length during the year preceding each age (growth from focus or annulus to annulus) for the total sample and for males and females separately are presented in Table 3.5-4 and Fig. 3.5-6.

Generally, the length and weight data for 1973 indicate the following:

1. That the growth in length in the first year from length at emergence to length at first annulus is about the same as

TABLE 3.5-1

AVERAGE LENGTHS OF RAINBOW TROUT TO LAST ANNULUS, 1971 AND 1972

1971			1972		
Age	No.	Total average* length to annulus (mm)	Age	No.	Total average* length to annulus (mm)
1	39	140	1	101	93
2	170	236	2	180	222
3	127	306	3	112	316
4	60	351	4	46	363
5	15	378	5	8	381

* Average back-calculated length

TABLE 3.5-2

AVERAGE LENGTH OF RAINBOW TROUT TO LAST ANNULUS, 1973

Age	No.	Total average* length to annulus(mm)	Age	No.	Males average* length to annulus(mm)	Age	No.	Females average* length to annulus(mm)
1	42	142	1	18	142	1	20	144
2	733	259	2	239	255	2	195	254
3	879	326	3	153	326	3	287	329
4	306	358	4	69	361	4	143	360
5	33	378	5	9	385	5	12	384

*Average back-calculated length

Total column includes additional unsexed fish

FIGURE 3.5-4

MEAN CALCULATED LENGTH

SKAGIT-ROSS RAINBOW TROUT

1973

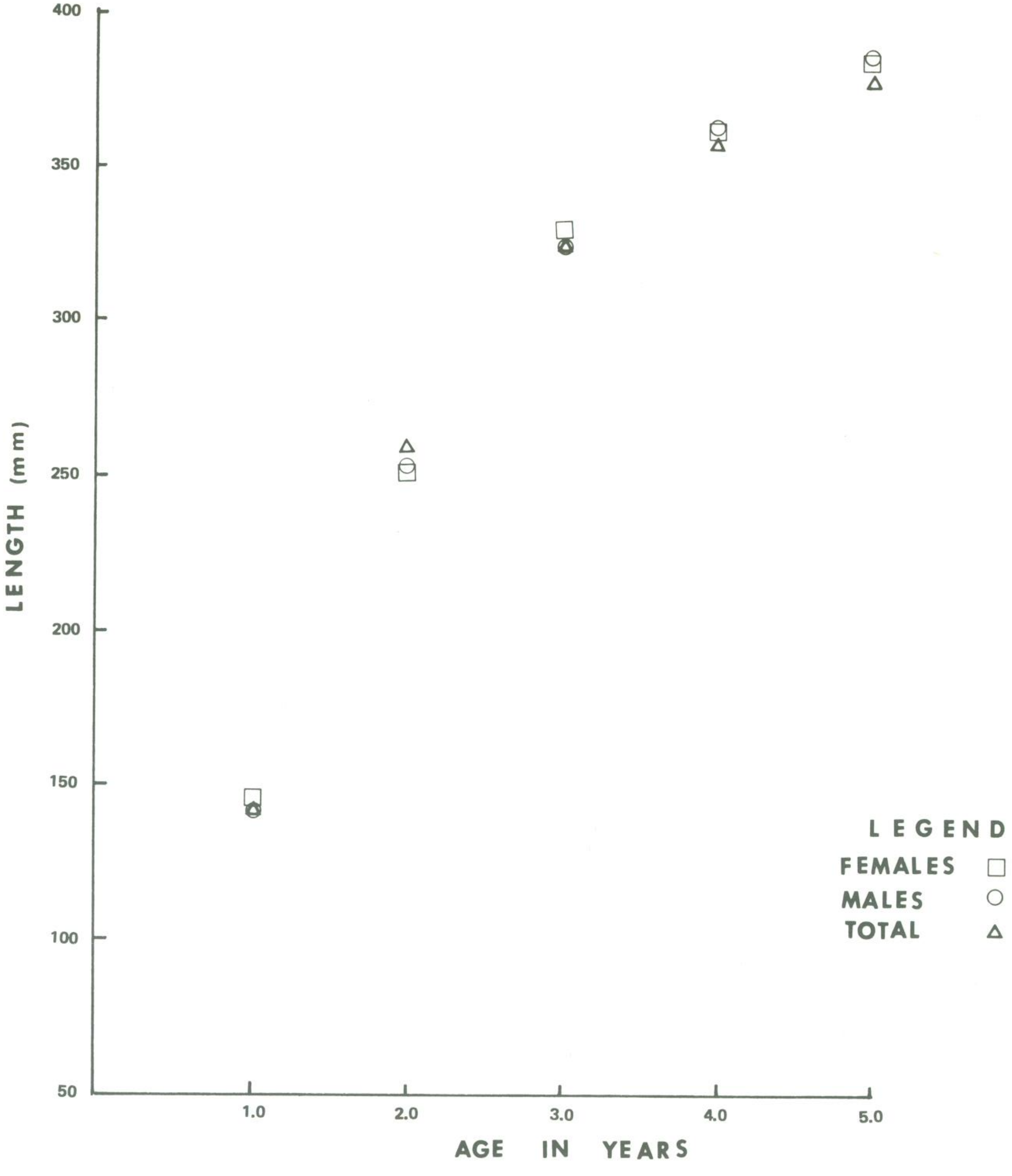


TABLE 3.5-3

WEIGHT OF RAINBOW TROUT AT MEAN BACK-CALCULATED LENGTH, 1973

Age	No.	Total* weight of av. fish at annulus(g)	Age	No.	Males weight of av. fish at annulus(g)	Age	No.	Females weight of av. fish at annulus(g)
1	42	35	1	18	35	1	20	36
2	733	191	2	239	183	2	195	181
3	879	367	3	153	367	3	287	376
4	306	478	4	69	490	4	143	486
5	33	558	5	9	587	5	12	583

*Includes unsexed fish

FIGURE 3.5-5

CALCULATED WEIGHT OF AVERAGE FISH

SKAGIT-ROSS RAINBOW TROUT

1973

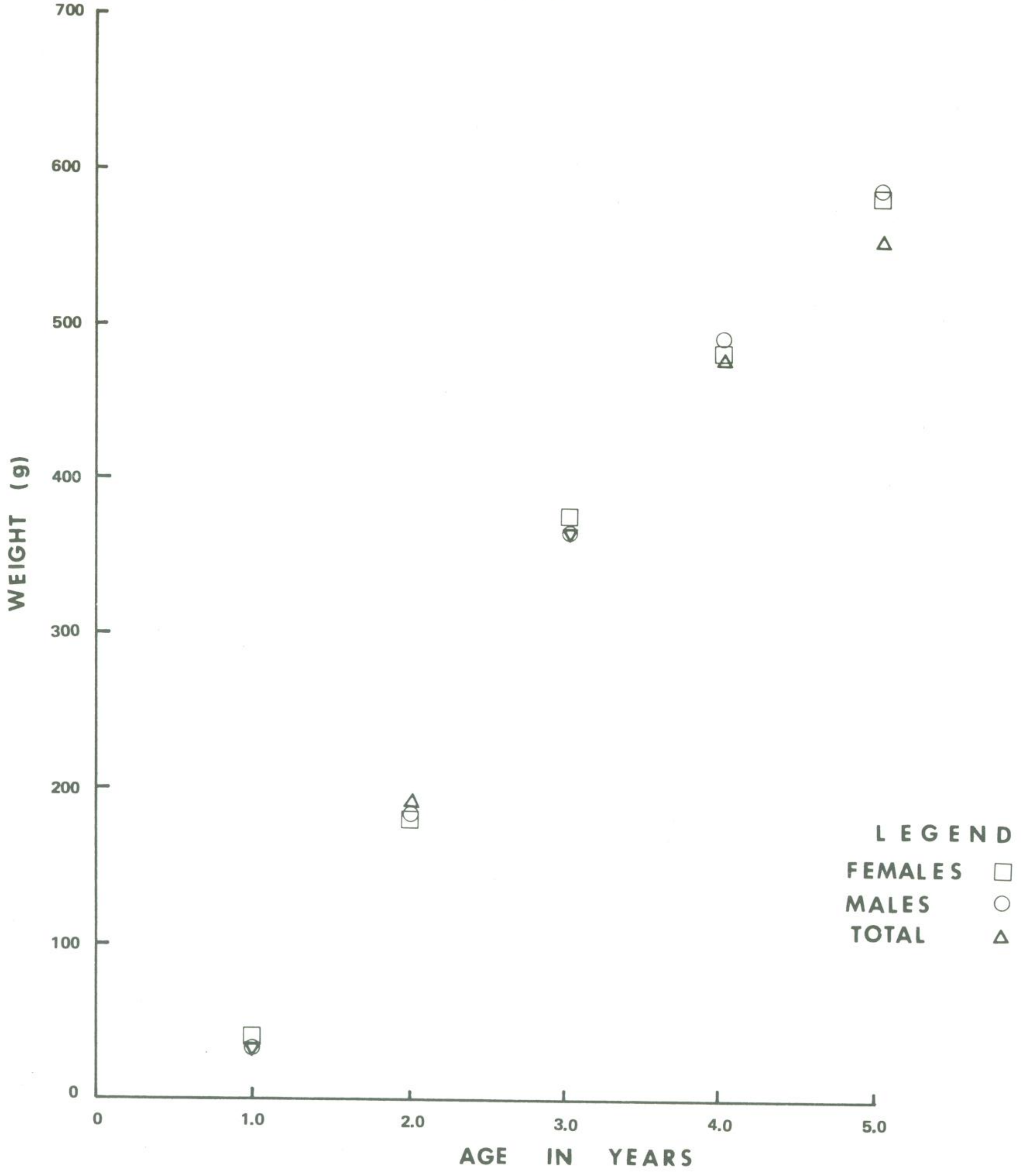


TABLE 3.5-4

AVERAGE INCREMENTS OF GROWTH IN LENGTH AND WEIGHT FOR RAINBOW TROUT, 1973

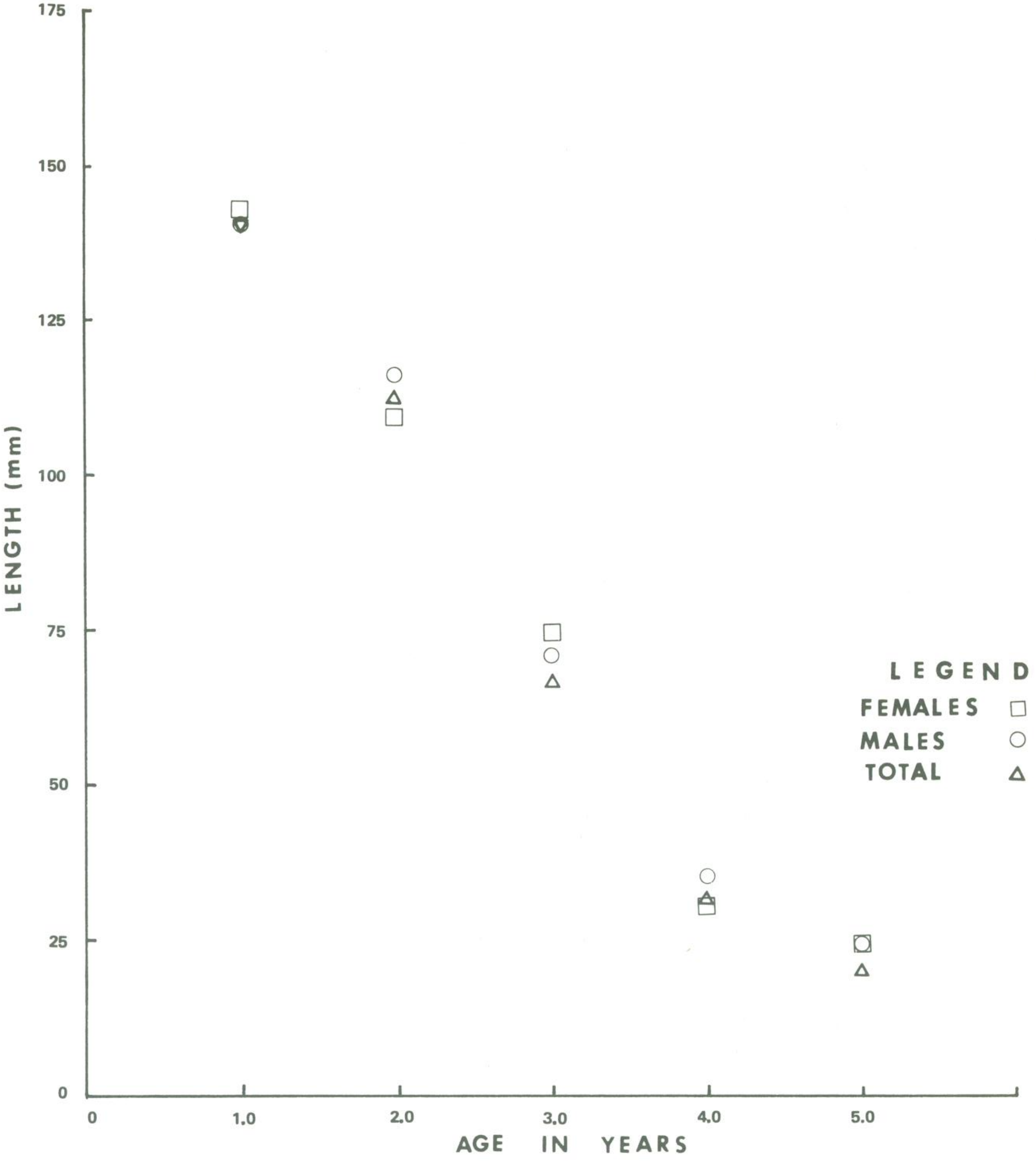
		Total* average increment of growth				Males average increment of growth				Females average increment of growth	
Age	No.	Length(mm)	Weight(g)	Age	No.	Length(mm)	Weight(g)	Age	No.	Length(mm)	Weight(g)
1	42	142	35	1	18	142	35	1	20	144	36
2	733	117	156	2	239	113	148	2	195	110	145
3	879	67	176	3	153	71	184	3	287	75	195
4	306	32	111	4	69	35	123	4	143	31	110
5	33	20	80	5	9	24	97	5	12	24	97

*Includes unsexed fish

Note: Age 1 growth includes alevin growth

FIGURE 3.5-6

MEAN INCREMENT OF GROWTH IN LENGTH SKAGIT-ROSS RAINBOW TROUT 1973



during the second year and that growth rate in length decreases in each succeeding year. The 1972 data indicate a smaller mean size of age 1 fish. The differences between years in size of age 1 fish is probably largely a result of size selection of sampling gears. Relatively more gillnet effort was extended in 1972 to obtain samples of small fish, which are less vulnerable to capture by hook and line.

2. The greatest growth in weight occurs in the third year; growth rate in weight decreases with each succeeding year.

The above analyses and discussion apply to Ross Lake rainbow trout sampled in the reservoir and Canadian Skagit River. In addition, samples of rainbow trout were collected in 1972 and 1973 in stream areas which are inaccessible to Ross Lake trout (portions of Little Beaver, Lightning, Cinnamon, Three Fools and Granite Creeks). These samples were pooled and analyzed for age and growth (in length and weight). The results (Tables 3.5-5 and 3.5-6), compared with those of Ross Lake rainbow trout sampled in 1973 (Tables 3.5-2 and 3.5-3) indicate that, after their first year, growth rate of the stream resident trout is considerably less than that of trout residing in the reservoir.

3.5.4 Age and Maturity

The preliminary results of scale studies of Skagit-Ross rainbow trout completed to date are: a substantial portion of the male rainbow trout spawn first at age 2 and the age at first spawning for females is age 3 (Appendix 18). There is evidence that repeat spawning occurs in both sexes and is probably more frequent among females than males.

TABLE 3.5-5 AVERAGE LENGTH OF STREAM RESIDENT RAINBOW TROUT TO LAST ANNULUS, 1972-73. TOTAL COLUMN INCLUDES UNSEXED FISH.

		Total			Males			Females
Age	No.	average* length(mm) to annulus	Age	No.	average* length(mm) to annulus	Age	No.	average* length(mm) to annulus
1	18	119	1	9	118	1	7	112
2	63	152	2	35	159	2	20	138
3	47	175	3	22	173	3	20	181
4	15	185	4	5	190	4	8	188
5	3	217	5	1	243	5	1	189
6	1	214	6	-	-	6	1	214

---

* Average back-calculated length

TABLE 3.5-6 WEIGHT OF STREAM RESIDENT RAINBOW TROUT AT MEAN BACK-CALCULATED LENGTH, 1972-73. TOTAL COLUMN INCLUDES UNSEXED FISH.

		Total			Males			Females
Age	No.	weight(g) of average fish at annulus	Age	No.	weight(g) of average fish at annulus	Age	No.	weight(g) of average fish at annulus
1	18	17	1	9	16	1	7	14
2	63	36	2	35	40	2	20	27
3	47	56	3	22	53	3	20	62
4	15	65	4	5	70	4	8	70
5	3	107	5	1	150	5	1	71
6	1	104	6	-	-	6	1	104

The above information is based on the occurrence of spawning checks on scales of Skagit-Ross rainbow trout and ages of mature rainbow trout sampled. The presence of spawning checks has only been examined in a general manner. Therefore total number of spawning checks per individual fish or age at first spawning is not available at this time.

3.6 THE FISHERY (by F.F. Slaney and Company)

3.6.1 Creel Census and Angler-Provided Data, 1973

3.6.1.1 Ross Lake, 1973

Methods

In 1973 the Ross Lake creel census included the complete fishing season from opening day on 16 June through the close of the season on 31 October. For the 1973 creel census, as in 1972, two approaches were used. One included on-lake boat and angler counts plus brief angler interviews to assess fishing effort and catch per unit of effort on the lake. The sampling effort was randomized by day of the week throughout the season, time period during the day, and lake section.

The second method was essentially similar to that carried out in 1971 and described in SCL (1973) (Section 3.6.2.2). By this approach, lake entry point sampling was carried out and anglers were questioned as to their personal characteristics, preferences, catch, and effort upon returning to sampling stations on the shore of the lake. For these angler interviews the format was the same as utilized in 1970 through 1972 and described in SCL (1973) (Section 3.6.2.1).

On-lake sampling took place on 49 days chosen by day of the week throughout the season, plus 3 additional days (opening day, Dominion Day, Labour Day). Sampling days were divided into seven, 2-hour time periods from 0600 to 2000. The lake was divided into the seven sections (L1 through L7) described previously (see SCL, 1973). Sampling days, time periods and locations were selected at random and pre-determined before the field season commenced. Sampling effort was distributed evenly across the days of the week, time periods and lake sections.

Field samplers arrived at the specified location during the specified time period. Once there, they counted anglers and numbers of boats in that section and noted the time of the count. Up to 10 anglers within the lake section were questioned on the lake about the length of time they had been fishing and the number of fish they had taken. This abbreviated angler interview was an attempt to minimize interference with anglers' fishing and still provide accurate effort and catch data by lake section. The only exception to this procedure was on the three additional days when attempts were made to count boats and anglers in each lake section during each time period. When more than 10 anglers were found in the given section a randomized procedure for sub-sampling within the section was available. When fewer than 10 anglers were found in the given section interviews were continued in subsequent sections until at least 10 were completed.

In proceeding to or from the selected lake section counts of anglers and boats were made by section and the time of these counts noted. In most cases it was possible, therefore, to get counts of all sections of the lake within the chosen 2-hour time period. Angler interviews were carried out only within the selected section, however.

The Ross Lake sampling schedule for 1973 showing dates, time periods and locations of sampling is reproduced in Appendix 16.

The Sample

A total of 1,092 interviews of lake anglers was conducted in 1973. During the abbreviated on-lake interviews all the questions used in the shore-based survey were not asked. Thus, questions such as those on residence, bait use, habitat preference and judgement of success were not answered by all those providing catch and effort replies. Data presented here on catch and fishing effort were available from all interviews, however.

Anglers

Male fishermen made up 78.1% (853) of the lake anglers interviewed in 1973; females were 21.9% (239). The age distribution of the anglers in the sample is shown in Table 3.6-1.

TABLE 3.6-1

AGE DISTRIBUTION OF LAKE ANGLERS
1973 SAMPLE

Age	Number	Percent
Children	76	7.0
Teenagers	66	6.0
20-29	154	14.1
30-39	255	23.4
40-49	255	23.4
50 +	286	26.2

Of the anglers interviewed about the duration of their visit, 97.0% (449) were overnight campers in the area. The remainder were day fishermen only.

Distribution of Anglers and Fishing Methods

The distribution of lake anglers in the sample across the seven lake sections is shown in Table 3.6-2.

TABLE 3.6-2

DISTRIBUTION OF LAKE ANGLERS
1973 SAMPLE

Age	Number	Percent
L-1	175	16.0
L-2	163	14.9
L-3	39	3.6
L-4	80	7.3
L-5	156	14.3
L-6	332	30.4
L-7	147	13.5

Fishing techniques used by fishermen in the 1973 sample are shown in Table 3.6-3. The "combination" was primarily bait (e.g. worms) and lures ("pop gear") that were trolled behind the boat. Total fishing effort in the 1973 sample was 3612.3 hours. Average fishing period of all anglers in the sample was 3.3 hours.

TABLE 3.6-3

FISHING TECHNIQUES USED BY LAKE ANGLERS
1973 SAMPLE

Method	Number	Percent
Flies	37	3.7
Lures	65	6.4
Bait	193	19.1
Combination	715	70.8

Fishing began anywhere between 6:00 A.M. and 8:00 P.M. but 65.5% of the fishing began between 6:00 and 11:00 A.M.

Catch

The total catch by anglers in the 1973 sample was 1,554 fish of which 1,523 were of legal size (6" in U.S., 8" in Canada) and are utilized in the following analysis. Species composition of the legal catch was 1,399 (91.8%) rainbow trout, 111 (7.3%) Dolly Varden char, 9 (0.01%) brook trout and 4 cutthroat trout.

Total legal catch, overall catch per unit of effort (CPUE) and mean CPUE are shown by lake section and for all areas combined in Table 3.6-4.

TABLE 3.6-4

CATCH, OVERALL AND MEAN CPUE BY LAKE AREA
1973 SAMPLE

Area	Catch	Overall CPUE	Mean CPUE
L-1	320	.54	.54
L-2	305	.45	.43
L-3	88	.45	.38
L-4	95	.36	.51
L-5	190	.43	.54
L-6	393	.36	.52
L-7	132	.35	.44
All areas	1523	.42	.49

3.6.2 Skagit River System, 1973

Methods

The creel census sampling in 1973 on the Skagit River system was carried out on the same days as the sampling on Ross Lake. Thus, sampling was carried out on 49 days selected at random throughout the season plus 3 additional days when attempts were made to sample all sections.

Sampling sections were chosen from within the two combined areas (A+U; M+F) of the Skagit River system. Sampling sections were predetermined and selected at random. Time periods were chosen randomly: early in the season separate time periods were chosen for the river; later, a time period two periods after that sampled on the lake was sampled on the stream. Up to 8 anglers were interviewed on each stream sampling day.

Field workers sampled the specific section noted at the given time. Sampling was also done within the entire area as time and density of anglers permitted. The Skagit River system 1973 creel census locations are shown by day in Appendix 17.

The Sample

The 1973 Skagit River creel census analysis is based on interviews with 354 river anglers.

Anglers

Of the 1973 river fishermen, 87.0% (308) were male while 13.0% (46) were female in the sample. Age distribution of the sample population is given in Table 3.6-5.

TABLE 3.6-5

AGE DISTRIBUTION OF RIVER ANGLERS
1973 SAMPLE

Age	Number	Percent
Children	22	6.2
Teenagers	43	12.1
20-29	113	31.9
30-39	91	25.7
40-49	55	15.5
50+	30	8.5

Of the 340 anglers responding about their place of residence, 90.1% (309) were from British Columbia; the remainder were residents of Washington State.

Although only 126 anglers responded to the question on their fishery preference, 64 (50.8%) preferred streams, 17 (13.5%) preferred lakes and 45 (35.7%) had no preference.

Distribution of Anglers and Fishing Methods

Anglers in the sample were distributed between the four major areas of the Skagit River system as shown in Table 3.6-6.

TABLE 3.6-6

DISTRIBUTION OF RIVER ANGLERS
1973 SAMPLE

Area	Number	Percent
A	48	13.6
U	66	18.6
M	41	11.6
F	199	56.2

Techniques used by anglers fishing in the Skagit River system are shown in Table 3.6-7.

TABLE 3.6-7

FISHING TECHNIQUES USED BY RIVER ANGLERS
1973 SAMPLE

Method	Number	Percent
Flies	36	11.4
Lures	12	3.8
Bait	252	80.0
Combination	15	4.8

Total fishing effort in the sample was 972.9 hours. Average fishing period of anglers in the sample was 2.74 hours. Fishing began at any time of day and was quite widely distributed. For example 74.0% of the fishermen began fishing between 5:00 A.M. and 3:00 P.M.

Catch

Total catch of fish by river anglers in the 1973 sample was 241 fish. Of these, 225 (93.4%) were legal size and are considered in the following analysis. Species composition of the legal catch was 190 (84.4%) rainbow trout, 35 (15.6%) Dolly Varden char.

Total legal catch, overall CPUE and mean CPUE are shown for the river sample by section in Table 3.6-8.

TABLE 3.6-8

CATCH, OVERALL AND MEAN CPUE BY AREA
1973 SAMPLE

Area	Catch	Overall CPUE	Mean CPUE
A	11	.10	.18
U	75	.31	.57
M	31	.55	.40
F	108	.18	.48

3.7 POPULATION SIZE, MOVEMENTS AND MORTALITY (by Fisheries Research Institute)

3.7.1 Introduction

Population size of the fish, their movements and fishing and natural mortality are important factors in studying the fish and the fishery of the Ross Lake-Skagit River system. These data, combined with a knowledge of the growth rates, fecundity, maturity schedules and spawning requirements of the fish, provide a basis for estimating the effects of a changed environment on the population dynamics of the species.

3.7.2 Distribution and Movements, 1973

3.7.2.1 Ross Lake, 1973

Information on the movements of fish in Ross Lake was provided by tag recoveries from angler and investigator catches.

Results from Tagging, 1973

A total of 1,353 rainbow trout, 230 cutthroat trout, 36 Dolly Varden, and 8 brook trout were tagged and released in Ross Lake, the Canadian Skagit River and two beaver ponds in the Big Beaver Valley in 1973. Recoveries of tagged fish were made by anglers and research personnel. As in 1971 and 1972 informational signs, leaflets and deposit boxes were again used. Representatives of the Washington Department of Game, F.F. Slaney and Company Ltd., and the Fisheries Research Institute censused the angler fishing on Ross Lake and the Canadian Skagit River.

Table 3.7-1 presents the number of tags released and recovered by species for each tagging area. Distributions of tag recoveries by tagging area and species are presented in Figs. 3.7-1 to 3.7-8, which also include recoveries of fish tagged in these locations in 1971 and 1972.

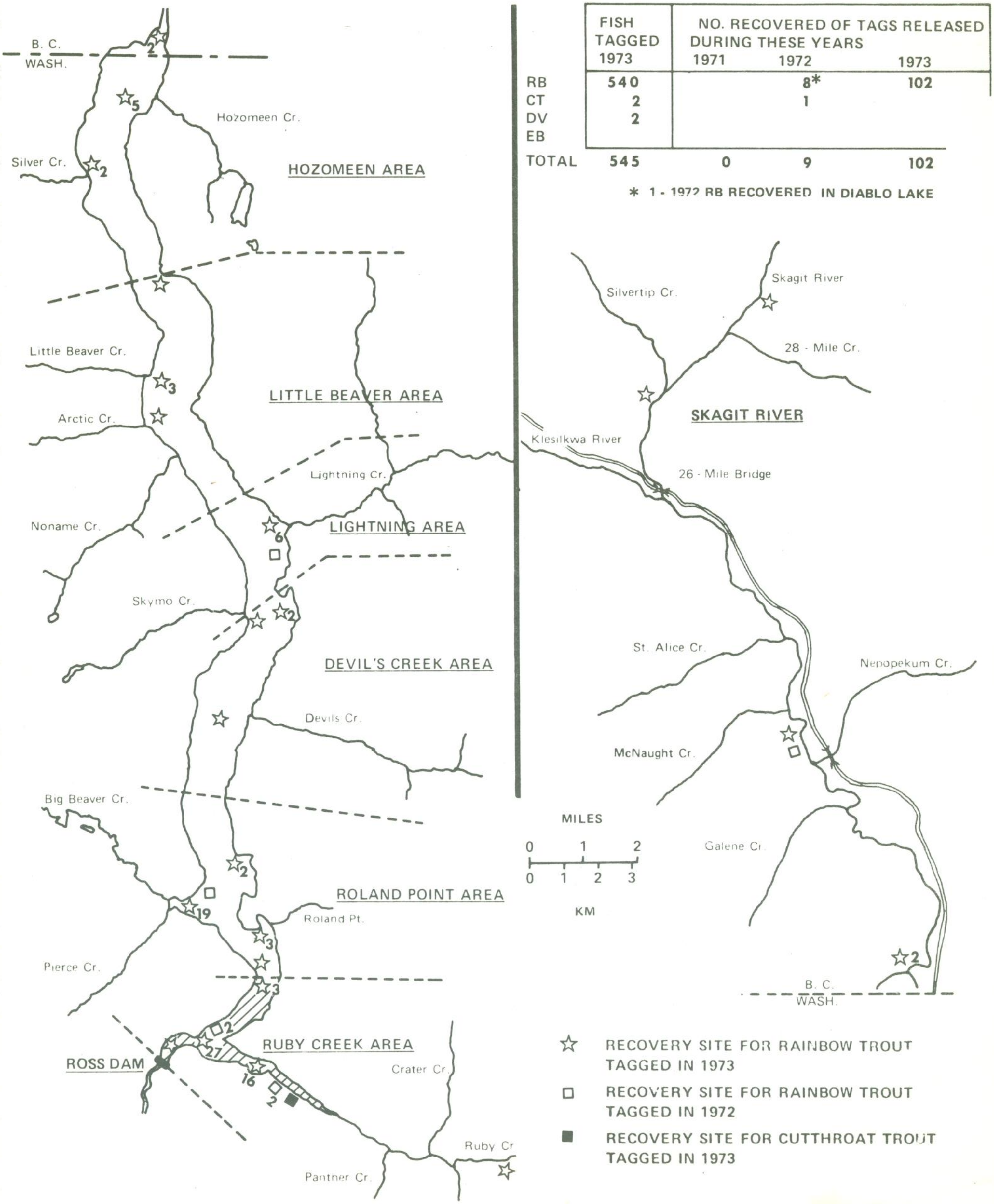
TABLE 3.7-1

TOTAL TAGS RELEASED (MARCH 30 - AUGUST 22, 1973) AND RECOVERED IN THE ROSS LAKE BASIN FOR EACH SPECIES BY MAJOR TAGGING AREA, 1973. TOTAL RECOVERY VALUES REPRESENT ALL RECOVERIES OF A GIVEN COLOUR OR AREA BY SPECIES IN ALL AREAS COMBINED.

Major tagging area	Rainbow Trout		Cutthroat Trout		Dolly Varden		Brook Trout		Total		
	Tags re-leased	Tags recov-ered	Tags re-leased	Tags recov-ered	Tags re-leased	Tags recov-ered	Tags re-leased	Tags recov-ered	Tags re-leased	Tags recov-ered	Percent
Ruby Creek*	540	102	2	0	3	0	0	0	545	102	18.72
Roland Point*	241	35	26	2	6	0	0	0	273	37	13.55
Devils Creek*	132	19	1	0	9	2	0	0	142	21	14.79
Lightning Creek*	328	82	0	0	4	0	0	0	332	82	24.70
Little Beaver Creek*	90	27	1	1	10	0	3	1	104	29	27.89
Hozomeen*	6	0	0	0	2	0	2	1	10	1	10.00
Canadian Skagit River	10	1	0	0	0	0	3	0	13	1	7.69
Big Beaver Ponds	6**	0	200	3	2	0	0	0	208	3	1.44
TOTAL	1,353	266	230	6	36	2	8	2	1,627	276	16.96

* designates names of adjacent lake area

** includes 3 rainbow/cutthroat hybrids



	FISH TAGGED 1973	NO. RECOVERED OF TAGS RELEASED DURING THESE YEARS 1971	1972	1973
RB	540		8*	102
CT	2		1	
DV	2			
EB				
TOTAL	545	0	9	102

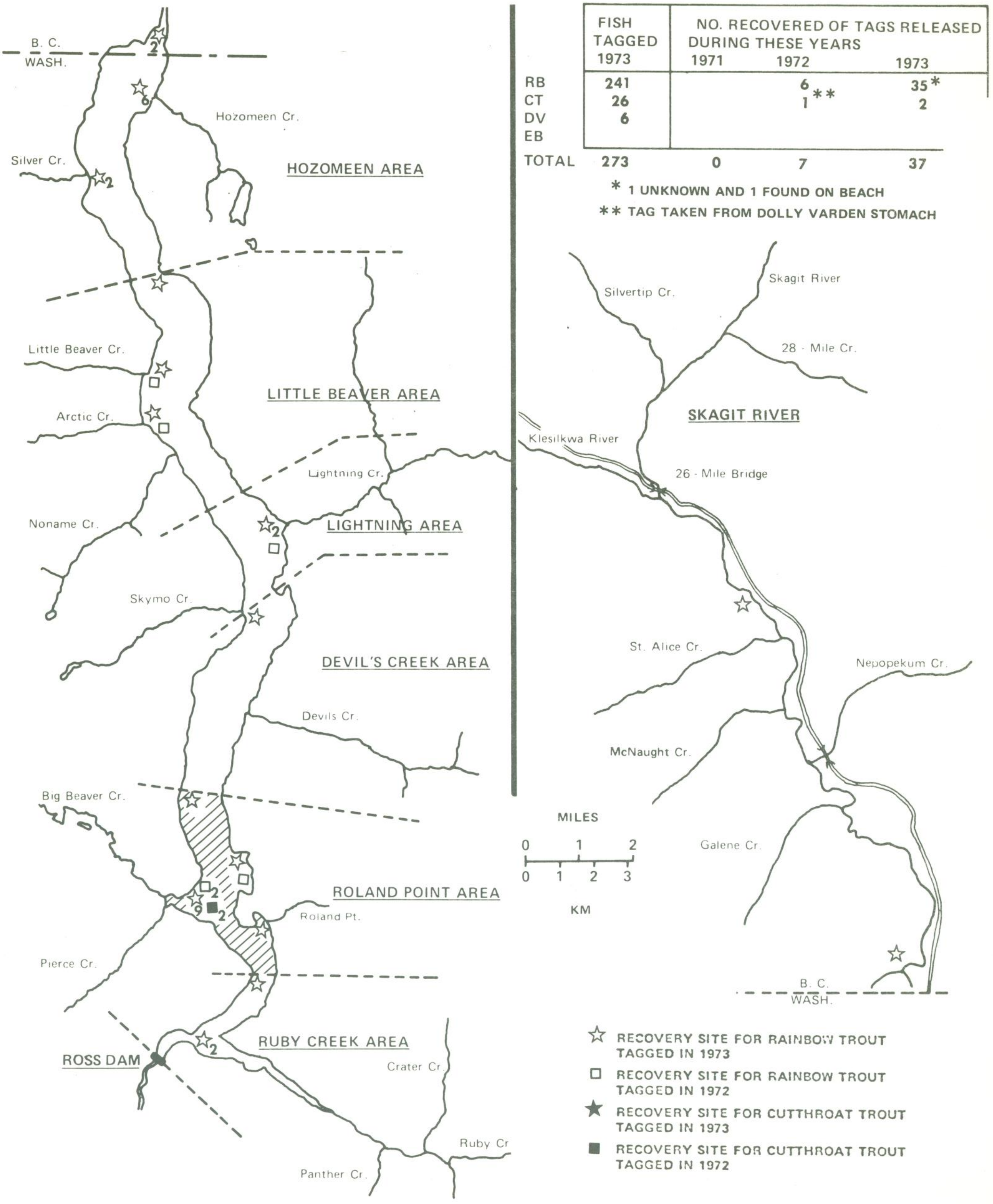
* 1 - 1972 RB RECOVERED IN DIABLO LAKE

☆ RECOVERY SITE FOR RAINBOW TROUT TAGGED IN 1973

□ RECOVERY SITE FOR RAINBOW TROUT TAGGED IN 1972

■ RECOVERY SITE FOR CUTTHROAT TROUT TAGGED IN 1973

FIGURE 3.7-1 Recovery locations for fish tagged in the Ruby Creek area (blue tags), 1973



	FISH TAGGED 1973	NO. RECOVERED OF TAGS RELEASED DURING THESE YEARS		
		1971	1972	1973
RB	241		6	35*
CT	26		1**	2
DV	6			
EB				
TOTAL	273	0	7	37

* 1 UNKNOWN AND 1 FOUND ON BEACH

** TAG TAKEN FROM DOLLY VARDEN STOMACH

FIGURE 3.7-2 Recovery locations for fish tagged in the Roland Point area (green tags), 1973

	FISH TAGGED 1973	NO. RECOVERED OF TAGS RELEASED DURING THESE YEARS		
		1971	1972	1973
RB	132		2	19
CT	1			
DV	9			2
EB				
TOTAL	142		2	21

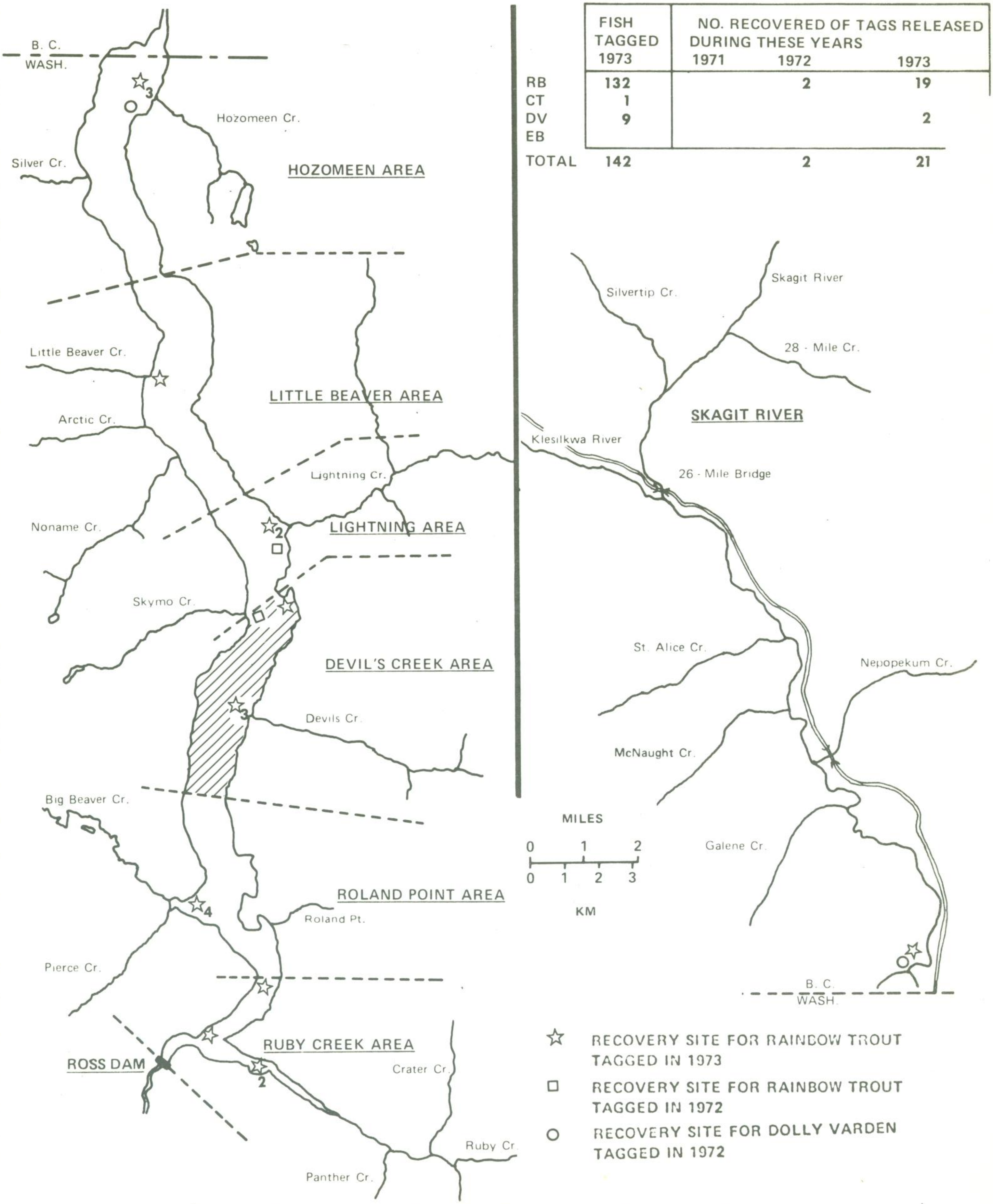
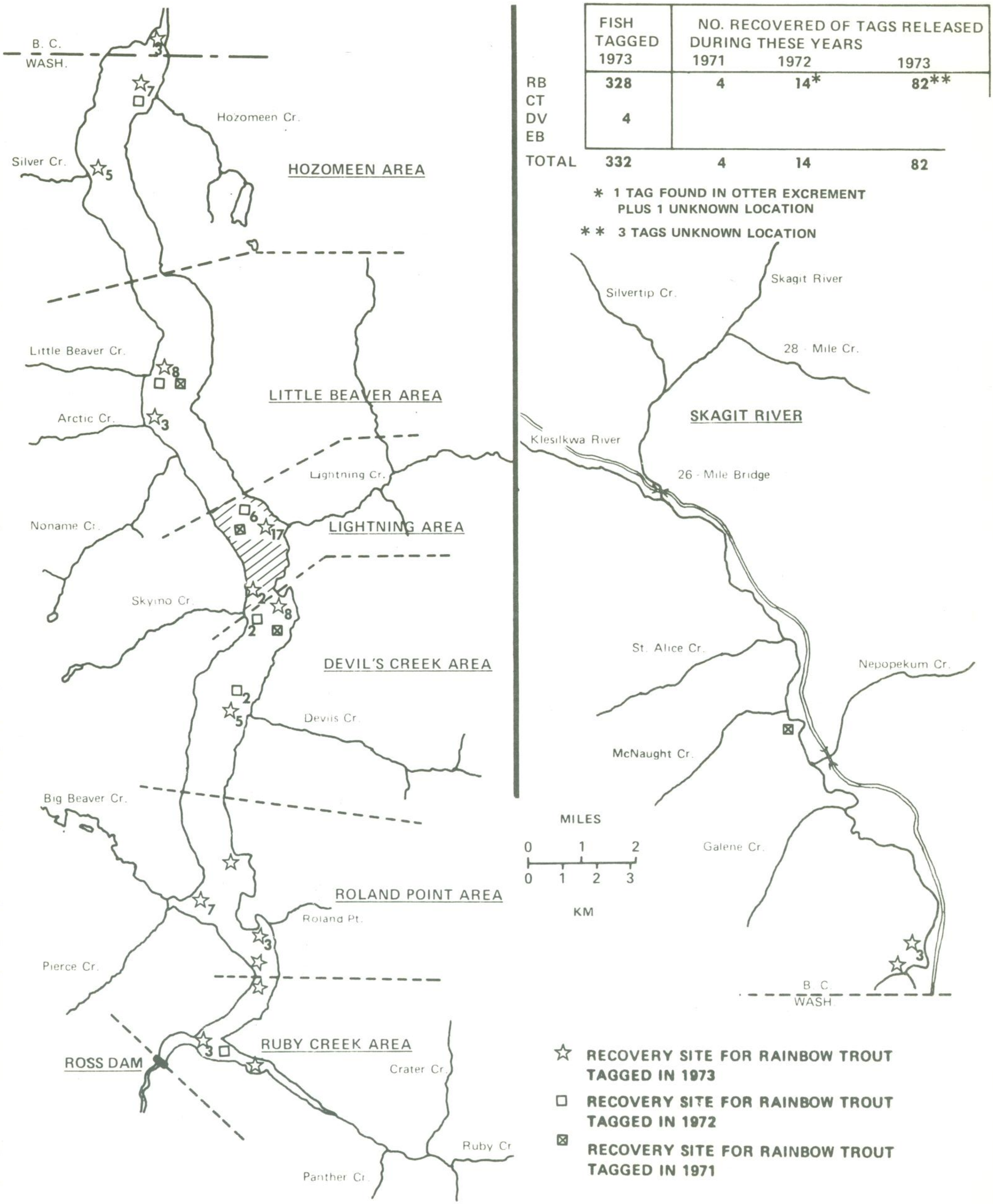


FIGURE 3.7-3 Recovery locations for fish tagged in the Devils Creek area (yellow tags), 1973



	FISH TAGGED 1973	NO. RECOVERED OF TAGS RELEASED DURING THESE YEARS 1971	1972	1973
RB	328	4	14*	82**
CT				
DV	4			
EB				
TOTAL	332	4	14	82

* 1 TAG FOUND IN OTTER EXCREMENT PLUS 1 UNKNOWN LOCATION

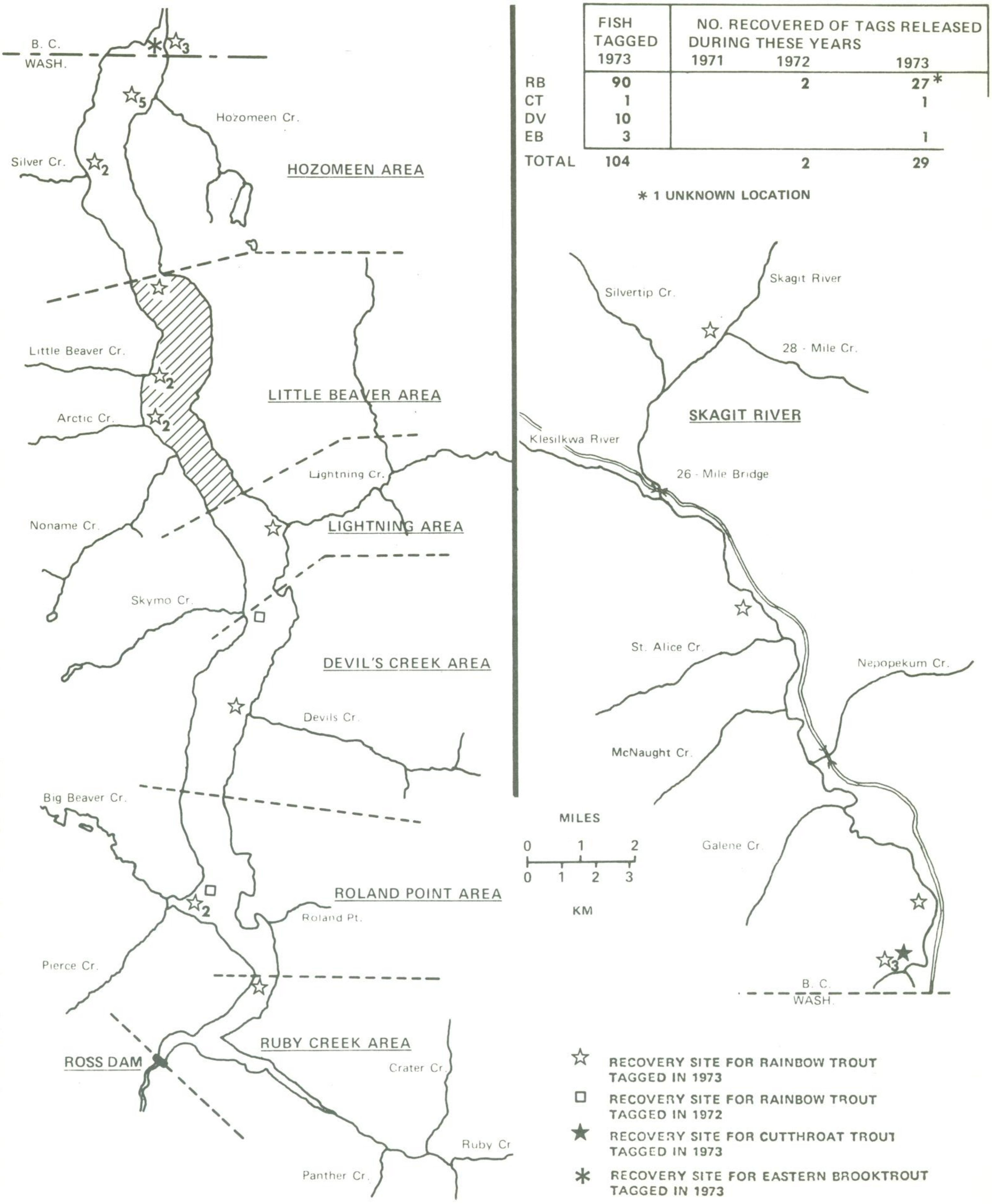
** 3 TAGS UNKNOWN LOCATION

☆ **RECOVERY SITE FOR RAINBOW TROUT TAGGED IN 1973**

□ **RECOVERY SITE FOR RAINBOW TROUT TAGGED IN 1972**

☒ **RECOVERY SITE FOR RAINBOW TROUT TAGGED IN 1971**

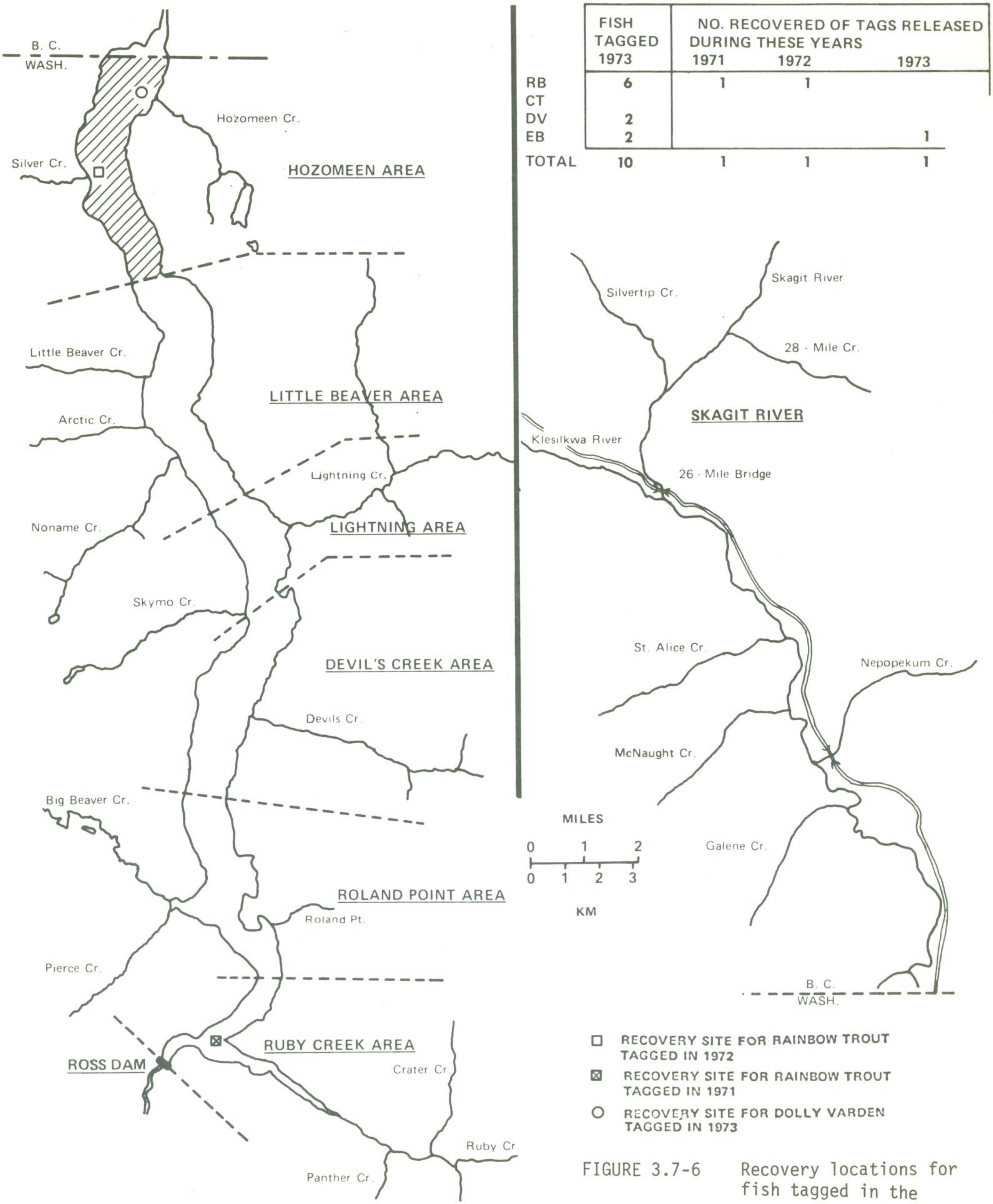
FIGURE 3.7-4 Recovery locations for fish tagged in Lightning Creek area (orange tags), 1973



	FISH TAGGED 1973	NO. RECOVERED OF TAGS RELEASED DURING THESE YEARS		
		1971	1972	1973
RB	90		2	27*
CT	1			1
DV	10			
EB	3			1
TOTAL	104		2	29

* 1 UNKNOWN LOCATION

FIGURE 3.7-5 Recovery locations for fish tagged in the Little Beaver Creek area (red tags), 1973



	FISH TAGGED 1973	NO. RECOVERED OF TAGS RELEASED DURING THESE YEARS 1971	1972	1973
RB	6	1	1	
CT				
DV	2			
EB	2			1
TOTAL	10	1	1	1

☐ RECOVERY SITE FOR RAINBOW TROUT TAGGED IN 1972

☒ RECOVERY SITE FOR RAINBOW TROUT TAGGED IN 1971

○ RECOVERY SITE FOR DOLLY VARDEN TAGGED IN 1973

FIGURE 3.7-6 Recovery locations for fish tagged in the Hozomeen area (white tags), 1973

	FISH TAGGED 1973	NO. RECOVERED OF TAGS RELEASED DURING THESE YEARS 1971	1972	1973
RB	10		1*	1
CT				
DV				
EB	3			
TOTAL	13		1	1

* UNKNOWN LOCATION

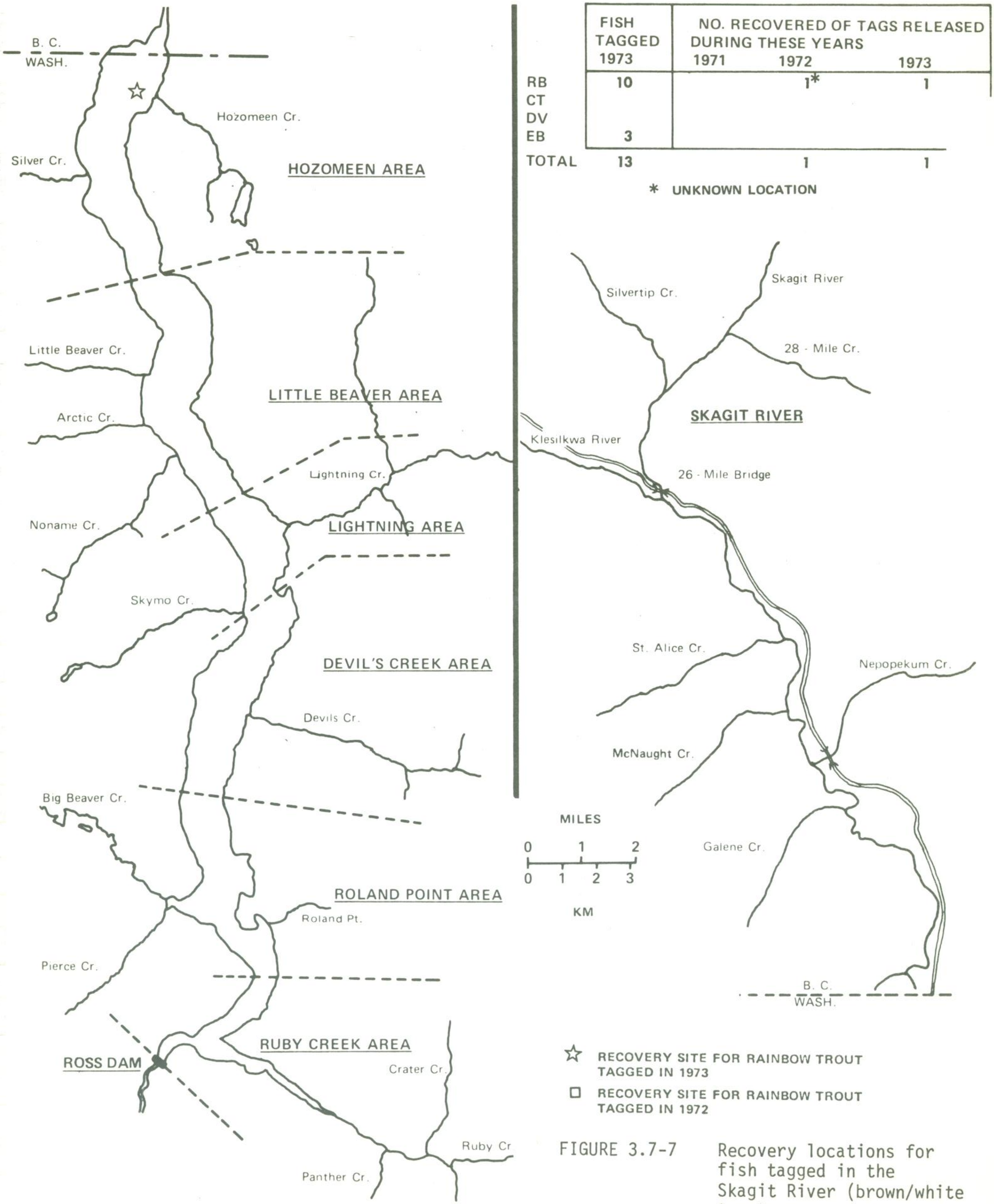
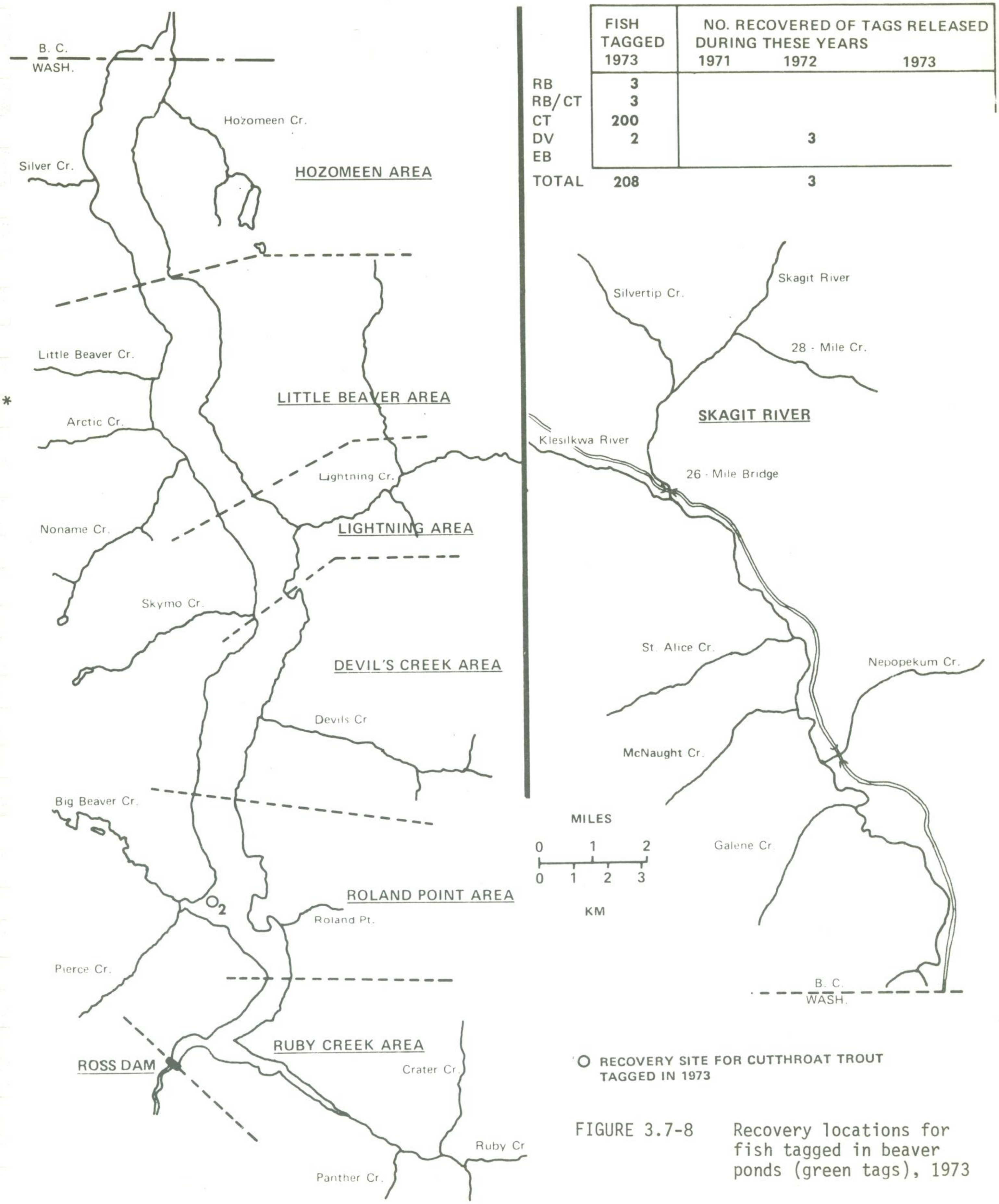


FIGURE 3.7-7 Recovery locations for fish tagged in the Skagit River (brown/white tags), 1973

	FISH TAGGED 1973	NO. RECOVERED OF TAGS RELEASED DURING THESE YEARS 1971	1972	1973
RB	3			
RB/CT	3			
CT	200			
DV	2		3	
EB				
TOTAL	208		3	



○ RECOVERY SITE FOR CUTTHROAT TROUT TAGGED IN 1973

FIGURE 3.7-8 Recovery locations for fish tagged in beaver ponds (green tags), 1973

Appendix 6 presents the location and date of tagging and recovery for recovered tagged fish. All data taken at time of fish tagging are presented in Appendix 5.

The tag recovery pattern in 1973 is shown in Fig. 3.7-9 which is a schematic diagram of the 1973 tag release and recovery location. Fish tagged in 1973 showed a considerable range of movement following tagging. Fish tagged in the Ruby Creek area were recovered in all areas of the reservoir, in the Skagit River upstream of 28-mile Creek and in Canyon Creek, a tributary of Ruby Creek. Recovery locations of the fish tagged in the Ruby Creek area ranged up to 42 miles apart. Fish tagged in the Roland Point, Devils, Lightning and Little Beaver areas were also recovered in areas as far separated as the Ruby Creek area and the Canadian Skagit River. Very few fish were tagged in the Hozomeen area and the Canadian Skagit River in 1973. Recovery locations indicate a rather uniform distribution of tag recoveries in the lake and river. This is probably due to offsetting effects of more tagging effort at the south end of the lake than at the north end and greater angler pressure at the north end than at the south end of the reservoir.

Comparison of 1971, 1972 and 1973

The results of tag recoveries made in 1971 and 1972 were discussed in SCL (1973). In the entire Ross Lake basin 1627 tags were released in 1973 compared to 569 in 1971 and 954 in 1972. Fish tagged in Lightning Creek area showed the greatest range in movement in 1971 and 1972. (Ruby area to the Canadian Skagit River). In 1973, fish tagged in the Ruby area showed the greatest range in movement as described above. This could be because more fish were tagged in the Ruby area in 1973 (545) than in 1971 or 1972 (143 and 189 respectively). In the Lightning area 332 fish were tagged in 1973 compared to 156 and 220 in 1971 and 1972 respectively.

FIGURE 3.7-9

DISTRIBUTION OF TAG RECOVERIES BY LAKE AREAS 1973

LOCATION RECOVERED
SOUTH → NORTH

LOCATION TAGGED
SOUTH → NORTH

	RUBY CREEK AREA	ROLAND POINT AREA	DEVILS CREEK AREA	LIGHTNING CREEK AREA	LITTLE BEAVER CR. AREA	HOZOMEEN AREA	CANADIAN SKAGIT AREA	
CANADIAN SKAGIT AREA						1 1	0 13 0 7.7%	
HOZOMEEN AREA						1 10 1 10%		
LITTLE BEAVER CR. AREA	1 1	2 2	1 1	1 1	5 104 5 27.9%	7 7	11 11	1 RECOVERY SITE UNKNOWN
LIGHTNING CREEK AREA	5 5	12 12	14 14	15 332 15 24.7%	12 332 12	12 12	9 9	3 RECOVERY SITES UNKNOWN
DEVILS CREEK AREA	4 4	4 4	4 142 4 14.8%	2 2	1 1	4 4	2 2	
ROLAND POINT AREA	3 3	16 273 16 13.6%		1 1	4 4	8 8	4 4	1 RECOVERY SITE UNKNOWN
RUBY CREEK AREA	44 545 44 18.7%	28 28	3 3	8 8	3 3	9 9	6 6	1 TAG RECOVERED FROM CANYON CR

LEGEND

In 1972, 14 tagged fish were recovered below Ross Dam, 4 in Gorge Lake or its tributaries and 10 in Diablo Lake. Two of the fish had been tagged in 1971, one of which was recovered in Gorge Lake and the other in Diablo Lake. In 1973, one additional rainbow trout tagged in Ross Lake in 1972 was recovered in Diablo Lake. No tagged fish were recovered below Ross Dam in 1971 nor were any that were tagged in 1973. The occurrence of tagged fish from Ross Lake below Ross Dam in 1972 was attributed to the record heavy spill over Ross Dam in 1972 (SCL , 1973). No spill occurred at Ross Dam in 1973.

In 1973, 208 fish in two Beaver Ponds in the Big Beaver Valley were tagged. Of these, 200 were cutthroat trout, 6 were rainbow trout or rainbow/cutthroat hybrids and 2 were Dolly Varden. Three of the tagged cutthroat trout were recovered by anglers in Ross Lake in 1973 (2 in the Roland Point area and 1 in the lower Canadian Skagit River). In addition, 19 tagged cutthroat trout were recaptured by scientific sampling in the Beaver Ponds in late spring and summer, 1973.

3.7.3 Population Size Estimate, 1973

Methods of fish capture, tagging and release for fish movement and population estimate studies for 1973 were the same as in 1971 and 1972. The same assumptions regarding short-term sampling mortality were made as in 1971 and 1972. Assumptions inherent in the mathematical process of estimating population size from angler catch and tag recoveries were discussed in SCL (1973).

The population estimate based on tagging and recovery is limited to fish above 200 mm in length because virtually all tagged fish and those in the sport catch were above this size.

The Petersen equation (Lagler, 1961) was used to estimate the fish population size on opening day of the 1973 fishing season (June 16, 1973). The formula and results are:

$\hat{N} = mc/_{r}$

where m = 1277 = total number of tagged fish at large in the population (Number of tagged fish released - tagging mortality) on June 16, 1973

c = 42,937 = a number of fish in the catch during fishing season (includes untagged and any tagged fish)

r = 259 = number of tagged fish in the season catch from fish tagged before June 16 (recoveries)

$\hat{N}$ = 211,701 = population estimate as of June 16, 1973 based on Ross Lake and Skagit River catch and tag recovery

95% C.I. = 211,701 ± 23,419

The multiple sample-tag recovery method of population estimation (SCL, 1973) was also used to estimate the population at the beginning of the fishing season. The fishing season was divided into four week time periods beginning on June 16, 1973 and ending with a three week time period on October 31, 1973. Angler catch within each time period was estimated from angler effort and CPUE (catch per unit effort) within each time period. The equation used to estimate the population size and the results of this method are shown in Table 3.7-2. This method provides an estimate of 191,480 fish with a 95 percent confidence interval of 170,751 to 217,983.

The 1973 population estimates of 211,701 (simple Petersen estimate) and 191,480 (multiple sample tag recovery estimate) do not differ

TABLE 3.7-2

ESTIMATION OF THE LEGAL-SIZED FISH POPULATION FROM TAGGING AND ANGLER RECOVERIES, ROSS LAKE-SKAGIT RIVER SYSTEM, 1973.

Period	Periodic Catch C_t	ΣC_t	Tag Recaptures R_t	ΣR_t	No. of tags at large at start of time period M_t	C_tM_t	ΣC_tM_t	$\hat{N}$*	95% C.I.
June 16 - July 13	18079	18079	145	145	1277	23,086,883	23,086,883	159,220	136,537- 190,912
July 14 - Aug. 10	6183	24262	40	185	1178	7,283,574	30,370,457	164,165	143,129- 206,210
Aug. 11 - Sept. 7	9066	33328	44	229	1169	10,598,154	40,968,611	178,902	157,964- 206,210
Sept. 8 - Oct. 5	6209	39537	27	256	1142	7,090,678	48,059,289	187,732	166,865- 214,539
Oct. 6 - Oct. 31	3400	42937	15	271	1127	3,831,800	51,891,089	191,480	170,751- 217,983

$$* \hat{N} = \frac{\Sigma C_tM_t}{\Sigma R_t}$$

significantly from their respective 1972 estimates (214,975 and 206,185) but the 1971 multiple sample-tag recovery estimate is significantly lower than the corresponding estimates for 1972 and 1973 (Fig.3.7-10). The difference between the 1971 Petersen estimate and those of 1972 and 1973 approaches statistical significance. Apparently the legal size population in the reservoir and Skagit River has increased slightly since 1971. Further discussion of this will be made in a later section.

3.7.4 Survival and Mortality

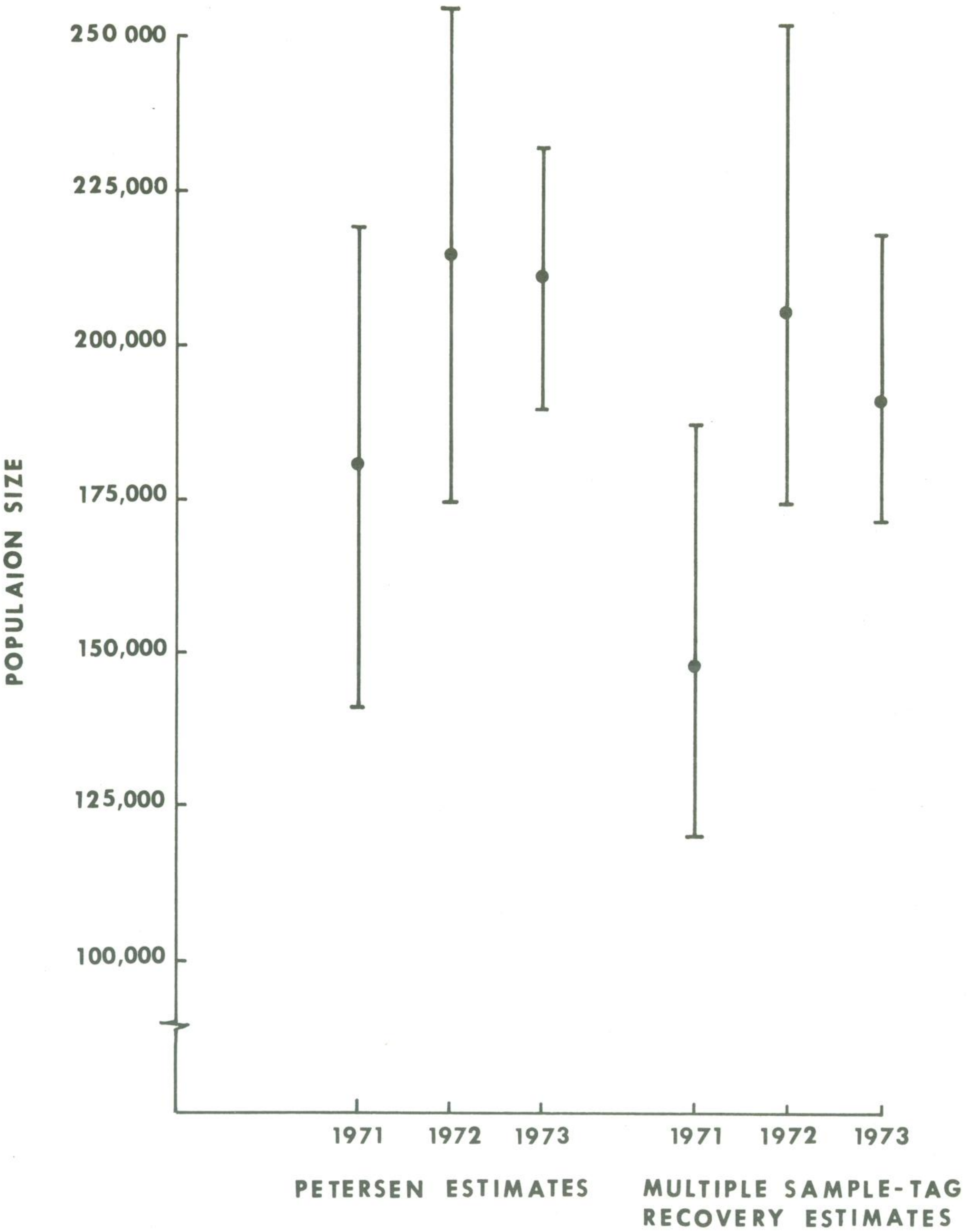
3.7.4.1 Analysis

The mortality of Skagit-Ross rainbow trout has been estimated with three methods. Two of the methods involve the analysis of the age composition of the angler caught rainbow trout sampled in the years 1971-1973 and the third involves analysis of the recovery rate of tagged rainbow trout. These three methods of analysis have been presented in considerable detail by Ricker (1948, 1958).

The two analyses based on age composition will be considered first. The following assumptions must be made to estimate mortality from age data (Ricker, 1948, p. 9).

"1. The survival rate is uniform with age, over the range of age-groups in question.
2. Since survival rate is the complement of mortality rate, and the latter is composed of fishing and natural mortality, this will usually mean that each of these, individually, is uniform.
3. There has been no change in mortality rate with them.
4. The sample is taken randomly from the age-groups involved.
5. The age-groups in question were equal in numbers at the time each was being recruited to the fishery."

FIGURE 3.7-10



POPULATION ESTIMATES AND 95 PERCENT CONFIDENCE INTERVALS FOR ROSS LAKE 1971 - 1973

The first analysis is done by plotting the "catch curve", which is the logarithm of the percentage of each age in the catch of a given year. The "catch curves" for 1971, 1972 and 1973 are illustrated in Fig. 3.7-11. Annual mortality rate (A), annual survival rate (S) and instantaneous mortality rate (Z) for the three, four and five year old fish were computed for each of the three years, 1971, 1972 and 1973 and are presented in Table 3.7-3. The mean values of A, S and Z over the three years and their respective 95 percent confidence limits are also presented in Table 3.7-3.

The second method of analyzing the distribution of age groups in the angler catch is to break the catch down by year classes and examine the decline in abundance of a year class at successive ages. Table 3.7-4 illustrates the year class distribution of the sampled angler catches for 1971, 1972 and 1973.

The decline in abundance of a year class was analyzed in the same manner as the decline in ages in the catch of a single year to give estimates of A, S, and Z. This analysis however was limited to estimating survival and mortality from 1971 to 1972 and 1972 to 1973. The results of this analysis are presented in Table 3.7-5. The means of S, A and Z and their 95 percent confidence limits are also included in Table 3.7-5.An alternative is to calculate the catch of each age group in each year, and use the changes between years in numbers of each year class to estimate mortality. This would avoid the concern for variability in year class strength, but would necessitate the assumption that effort and catchability were constant between years. Since the estimated total catch of rainbows in the 3 years varied only between 35239 (1973) and 39645 (1971), and the catch per hour between .48 (1971) and .52 (1972), we can assume that effort and catchability were constant. Because the use of percentages (assuming equal year class recruitment) or

FIGURE 3.7-11

CATCH CURVES FOR ROSS LAKE ANGLER CAUGHT RAINBOW TROUT

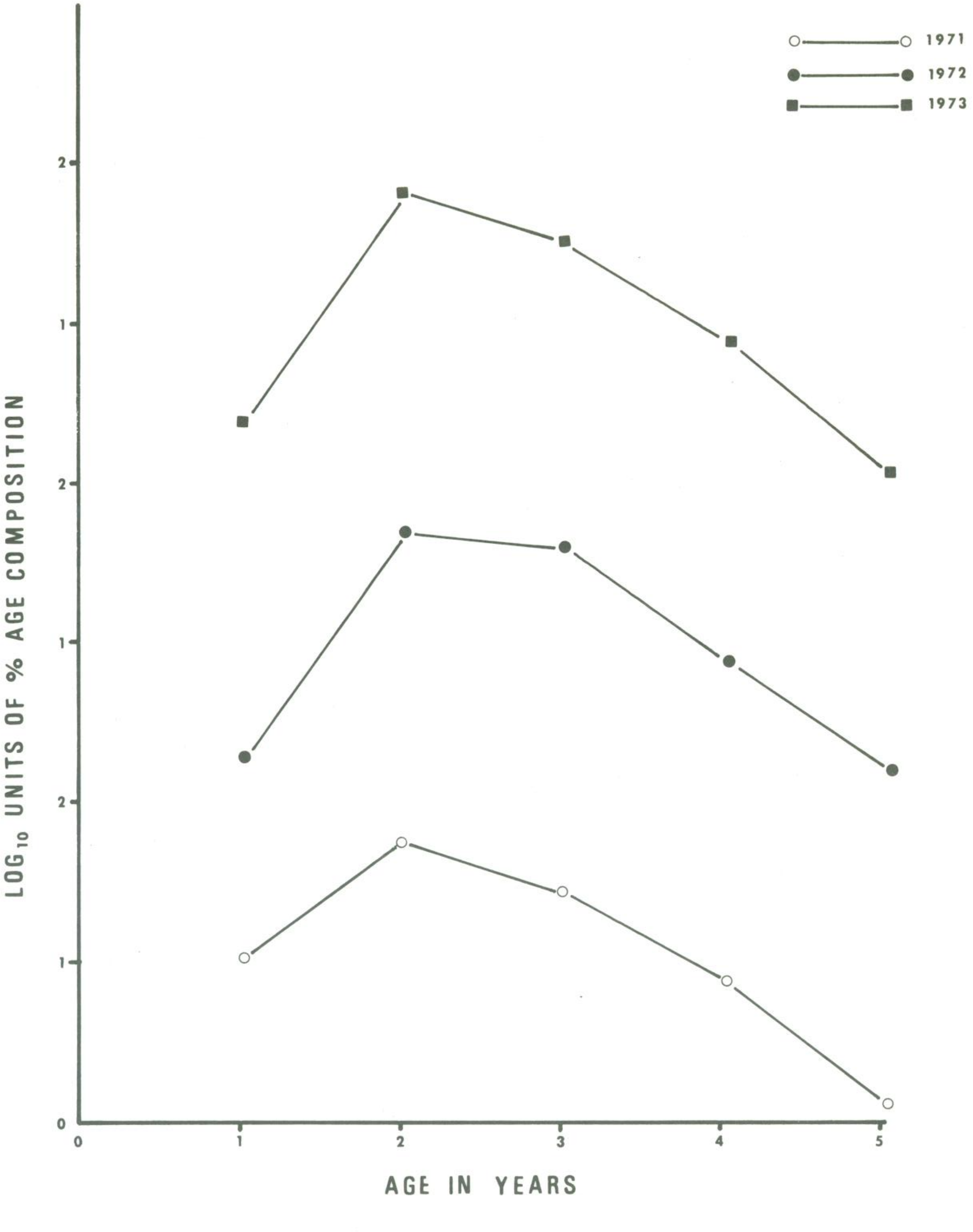


TABLE 3.7-3. ESTIMATES OF ANNUAL SURVIVAL RATE (S)*, ANNUAL MORTALITY RATE (A), AND INSTANTANEOUS MORTALITY RATE (Z), FOR THE YEARS 1971, 1972, AND 1973 WITH MEANS AND 95% CONFIDENCE LIMITS FROM YEARLY CATCH DATA.

Age Interval	1971			1972			1973			Mean		
	S	A	Z	S	A	Z	S	A	Z	$\bar{S}$	$\bar{A}$	$\bar{Z}$
2-3	.469	.530	.756	.795	.205	.229	.470	.530	.756	.578 ±.376	.422 ±.375	.580 ±.608
3-4	.288	.712	1.24	.195	.804	1.54	.222	.778	1.50	.235 ±.096	.765 ±.096	1.43 ±.326
4-5	.177	.823	1.73	.204	.795	1.59	.167	.833	1.79	.183 ±.038	817 ±.038	1.70 ±.206

*Symbols in parentheses from Ricker, 1969.

TABLE 3.7-4. YEAR CLASS DISTRIBUTION IN PERCENTAGE OF ANGLER CAUGHT RAINBOW TROUT

Year Sampled	*Year Class						
	1966	1967	1968	1969	1970	1971	1972
1971	1.31	7.39	25.63	54.59	11.09		
1972		1.57	7.69	39.34	49.48	1.92	
1973			1.07	6.40	28.80	61.33	2.40

*Year in which fry were hatched.

TABLE 3.7-5. ESTIMATES OF ANNUAL SURVIVAL RATE (S), ANNUAL MORTALITY RATE (A), AND INSTANTANEOUS MORTALITY RATE (Z) FOR THE YEARS 1972 AND 1973 WITH MEANS AND 95% CONFIDENCE LIMITS FROM YEAR CLASS ABUNDANCE DATA.

Age	1971 to 1972			1972 to 1973			Mean		
Interval	S	A	Z	S	A	Z	$\bar{S}$	$\bar{A}$	$\bar{Z}$
2-3	.721	.279	.328	.582	.418	.541	.652 ±.196	.348 ±.197	.434 ±.301
3-4	.300	.700	1.20	.163	.837	1.82	.232 ±.194	.769 ±.194	1.51 ±.876
4-5	.212	.787	1.55	.139	.861	1.97	.176 ±.104	.824 ±.104	1.76 ±.594

numbers (with essentially constant effort and catchability) give essentially the same mortality estimates, it thus appears that year class strength has been relatively constant. This alternative analysis is presented in Appendix 10 as a supplement to this section.

The third method of analyzing mortality utilized the rates of recovery of tagged rainbow trout. Estimates of survival and mortality between years were attained by calculating the proportion of tagged fish surviving in successive years. The analysis makes use of the same assumptions presented in SCL (1973) concerning population estimates based on recovery of tagged fish. The rate of fishing mortality within the year, 1973, was estimated from the tagged rainbow trout recovered the same year they were tagged (1973).

The estimates of overall suvival of rainbow trout based on the tag recoveries are shown in Table 3.7-6. The following example illustrates the method utilized to obtain the survival estimates. This method was presented by Ricker (1958).

Survival of rainbow trout tagged in 1971 to 1972.

1) $A/B = C$, $D/C = E$
2) $S = E/T$

A = number of rainbow tagged in 1972 recovered in 1972
B = number of rainbows tagged in 1972
C = tag recovery rate for 1972
D = number of 1971 tagged rainbows recovered in 1972
E = *number of 1971 tagged rainbows available in 1972
S = annual survival rate
T = number of tagged rainbows in 1971 minus number recovered in 1971.

---

*Assuming 1971 tagged fish recovered at same rate in 1972 as 1972 tagged fish.

TABLE 3.7-6. ESTIMATES OF ANNUAL SURVIVAL RATE (S), ANNUAL MORTALITY RATE (A) AND INSTANTANEOUS MORTALITY RATE (Z) WITH MEANS AND 95% CONFIDENCE LIMITS CALCULATED FROM TAG RECOVERY DATA.

Year Interval	S	A	Z
1971 to 1972	.173	.827	1.76
1972 to 1973	.220	.780	1.52
Mean	.196 ±.066	.804 ±.066	1.64 ±.339

The estimates of survival obtained with this method of anlaysis and shown in Table 3.7-6 were utilized in the relationships presented by Richer (1958); $A = 1 - S$ and $S = e^{-z}$, to obtain estimates of annual mortality rate and instantaneous mortality rate. These values are also presented in Table 3.7-6.

For 1973 all of the rainbow trout with readable scale samples were aged. This made it possible to make a direct comparison between trout recaptured by anglers during the 1973 fishing season. Table 3.7-7 was constructed to examine possible differences in age composition between the tagged and recaptured rainbow trout. The proportion of each age in the overall tagged group was applied to the total number of tags recaptured to obtain the theoretical expected age composition of the recaptured group. A chi-square test was conducted to test the assumption that the age composition of all tagged rainbow trout was the same as that of those that were recaptured later in the year by anglers. The result was: x^2 5 d.f. = 1.06, $.95 < p < .975$ which indicates the above assumption would be valid 95 percent of the time, thus satisfying assumption 4 above. The above result also shows that fishing mortality was the same for all age groups available to the anglers (age composition of the catch was the same age composition of the legal-sized fish population).

An estimate of annual fishing mortality for all rainbow trout over 200 mm in length is the ratio of tag recaptures during the season to total tagged rainbow trout available at the start of the fishing season. For 1973 this value is 229/1147 = .1996. Since the annual fishing mortality is essentially the same for fish of age 2 through 5 an estimate of natural mortality for each age 2 through 5 individually or for ages 2 through 5 combined can be computed by applying the following equation: $A = m + n = mn$ (Ricker, 1948).

TABLE 3.7-7. AGE DISTRIBUTIONS OF RAINBOW TROUT TAGGED* AND RECAPTURED IN 1973.

Age	Tagging		Recaptures	
	No.	%	obs.	exp.
1	1	.09	0	0
2	333	29.03	64	66
3	577	50.30	123	116
4	212	18.48	38	42
5	24	2.09	4	5
Total	1147		229	

* Number tagged before start of fishing season adjusted for post-tagging mortality.

The method utilized in this study to obtain survival and total annual mortality for ages 2 through 5 utilized the rate of tag recoveries in years subsequent to tagging which is not yet applicable to fish tagged in 1973. Therefore, estimates of annual natural mortality for each age, 2 through 5, were made utilizing the above annual fishing mortality and the estimates of annual total mortality based on the 1973 catch curve. These natural mortality rates are presented in Table 3.7-8. The instantaneous rates of total, fishing and natural mortality are also included in Table 3.7-8.

3.7.4.2 Discussion

The analyses presented above provide three separate estimates of annual rates of total survival and mortality which are based on two sources of data - the age structure of the anglers catch and the tagging and recapture data. These estimates can be compared and the relative value of each assessed by examining how the differences between data bases affects each estimate.

The two methods of estimating total survival and mortality based on age composition of the catch differ in the manner in which the age structure data was grouped for analysis. The "catch curve" method calculated the decline in abundance of each age for ages 2 through 5 in the angler catch of a given year. The anglers' catch is represented by a random sample of rainbow trout taken during creel census operations throughout the fishing season. The catch curve method utilizes a sample from each of four separate year classes. Inherent in the analysis of four year classes in a one year sample is the assumption that uniform recruitment to all year classes has occurred.

The analysis based on decline in abundance of a year class eliminates this potential source of error but is limited to two estimates of

TABLE 3.7-8. MORTALITY COMPONENTS FOR 1973 SKAGIT-ROSS RAINBOW TROUT

Statistic	Age Intervals 2 - 3	 3 - 4	 4 - 5
* Survival rate (S)	.470	.222	.167
* Annual rate of total mortality (A)	.530	.778	.833
** Annual rate of fishing mortality (m)	.1996	.1996	.1996
** Annual rate of natural mortality (n)	.4128	.7226	.7913
* Instantaneous rate of total mortality (Z)	.7550	1.5049	1.7894
* Instantaneous rate of fishing mortality	.2226	.2226	.2226
* Instantaneous rate of natural mortality (M)	.5324	1.2823	1.5668

* Symbols in parentheses are those used by Ricker (1969).
Z computed from equation Z = F + M.

** Symbols in parentheses are those used by Ricker (1958).

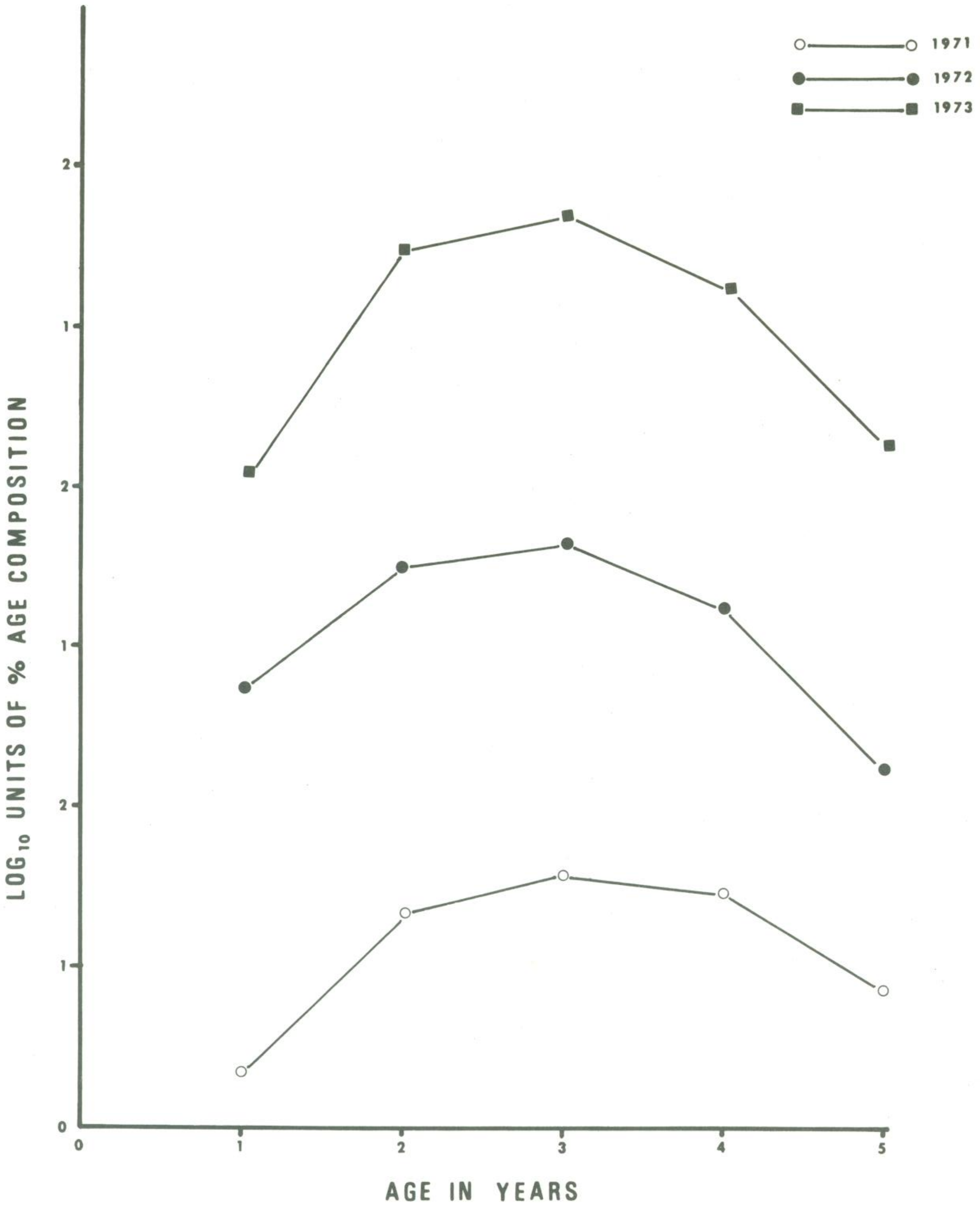
total survival and mortality based on the data collected to date. In Table 3.7-4 the 1968, 1969 and 1970 year classes are the only ones sampled each of the three years of this study and they are the only ones presently comparable in abundance. The contribution of 1969 year class at age 3 (39.34%) appears to be significantly greater than that of the 1968 (25.63%) or 1970 (28.89%) year classes at age 3. The presence of at least one somewhat dominant year class in the three years suggests that the assumption of uniform recruitment for all age classes may not be valid; therefore greater emphasis should be put on the year class estimates than on the catch curve estimates. However statistical comparison of the means for these two methods (Tables 3.7-3 and 3.7-5) demonstrates that all the means from Table 3.7-3 are within the 95 percent confidence limits of the corresponding means from Table 3.7-5. This indicates that at the 95 percent confidence level there is no statistically significant difference in the two sets of mean values.

The second data base, that of the tagged and recaptured rainbow trout, was not broken down by age before calculation of total survival and mortality because separation by age of the few recaptures made in the years subsequent to tagging yielded sample groups of inadequate size. As illustrated in the example problem (value E) the recaptures which were made were used to approximate the number of tagged rainbow trout actually available, before the survival and mortality estimates were computed.

The estimates (Table 3.7-6) are not age specific, thus represent the average for all ages tagged. Figure 3.7-12 illustrates the age composition of the rainbow trout sampled for tagging in 1971, 1972 and 1973. It is apparent that the majority of the tagged rainbow trout were age 3 and older; therefore the survival and mortality estimates based on the tag and recapture data are more representative of the conditions that existed from age 3 on.

FIGURE 3.7-12

CATCH CURVES FOR ROSS LAKE RAINBOW TROUT SAMPLED FOR TAGGING WITH ANGLING GEAR



The estimate of fishing mortality for 1973 was combined with the catch curve estimate of total annual mortality for 1973 to give an estimate of annual natural mortality. This estimate should be considered only as an approximateion of true natural mortality because 1) the catch curve represents the result of conditions prior to 1973 and the fishing mortality is specifically for 1973 and 2) Ricker (1948) demonstrated that estimates of annual fishing loss and natural mortality are not valid when both are operating concurrently because, "some of the fish which are caught would have died from natural causes within the year and vice versa" (Carlander, 1958). Therefore, estimates of the instantaneous rates for total mortality were presented in Tables 3.7-3, 3.7-5, and 3.7-6, the approximation of instantaneous natural mortality and the estimate of fishing mortality were included in Table 3.7-8. Ricker (1948) defined instantaneous rates as "the fraction of fish present at the start of a year which would die during that year from the given cause, if no other cause of death existed."

PART 4

ENVIRONMENTAL PROJECTIONS

4.1 ENVIRONMENT DURING CONSTRUCTION AND FILL PERIOD

4.1.1 Ross Lake and American Tributary Streams (by Fisheries Research Institute)

The construction schedule provided by Seattle Department of Lighting calls for drawdowns to elevation 1475 feet in two consecutive years followed by a filling of the reservoir to elevation 1725 feet within the following two years. The schedule of anticipated reservoir elevation changes was described in detail and discussed relative to the pattern of annual reservoir fluctuations in past years in Interim Report No. 2 (SCL, 1973). Although 1973 runoff was lighter than normal, monthly reservoir elevation changes were well within the previous 20-year monthly ranges (1953-1972) and were quite close to the mean in each month. The greatest deviations above and below the mean were 4.8 ft. in October and -3.1 ft. in June, respectively (Table 4.1-1). Total runoff in 1973 (1,779,719 acre/ft) was the lowest since 1952 (1,778,000 acre/ft).

The 1973 conditions, if they occurred during either construction year, would permit operation of the reservoir well above those of the lower elevation limit based on the lowest water year, 1928-1929.

With the addition to the data base of information obtained in 1973 on turibidity, water chemistry, temperature and dissolved oxygen, there is no reason to change or modify conclusions presented in Part 4 of Interim Report No. 2 (SCL, 1973) with respect to environmental impacts on the reservoir and its American tributaries of Project No. 553 during the 4 year construction and fill period.

TABLE 4.1-1

MONTHLY RESERVOIR ELEVATION CHANGES (IN FEET) FOR PERIOD JAN-DEC, 1953-1973 AND PROJECTED CHANGES FOR CONSTRUCTION AND FILL YEARS

Month	1953-1972		1973	First Construction Year		Second Construction Year			
	Mean Elevation Change	Range	Elevation Change	Minimum level	Maximum level	Mininum level	Maximum level	First fill year	Second fill year
January	-17.7	(-1.0,-28.8)	-19.2	-19	-5	-17	-35	-2	-1
February	-11.8	(2.5,-27.4)	-13.2	-88	-105	-58	-58	-2	-1
March	-15.2	(18.6,-28.1)	-16.5	0	0	0	0	-2	0
April	- 3.2	(7.8,-20.9)	- 1.5	0	0	22	73	6	8
May	38.4	(66.4, 13.1)	37.2	0	15	38	57	27	14
June	31.5	(69.2, 7.8)	28.4	38	35	45	N.A.	25	17
July	4.8	(22.0,- 0.1)	4.8	30	30	17	N.A.	12	18
August	- 0.9	(0.4,- 5.5)	-3.2	8	10	1	N.A.	1	-2
September	- 2.7	(1.3,- 6.6)	0	5	N.A.	3	N.A.	-1	0
October	- 4.9	(1.1,-11.2)	-0.1	10	N.A.	2	N.A.	-1	-1
November	- 7.4	(-3.9,-13.9)	-5.2	-2	N.A.	-1	N.A.	0	-4
December	-10.9	(5.6,-20.7)	-7.1	-14	N.A.	0	N.A.	0	-10

4.1.2 Skagit River and Tributaries (by F.F. Slaney and Company)

4.1.2.1 Construction Period

The levels of Ross Lake during the construction period have been described in Section 4.1.1. As a result of the drawdown to elevation 1475 feet during the two winters of construction the length of the drawdown river in these two years will be increased to between 10 and 12 miles. No falls would be exposed by the increased drawdown. Accumulated silt and debris would be removed from the stream gravels in the newly exposed drawdown. Full scale logging operations within the proposed High Ross Reservoir site in Canada would be initiated by the B.C. Forest Service when the decision to proceed with the High Ross project is reached. The government would probably auction the timber from Lot 1103 to the highest bidder. Supervision of the logging operation would be a Forest Service responsibility.

The terms of the logging contract could be expected to reflect the need to protect stream beds and operations could be designed to leave a protective fringe of forest cover adjacent to the river until the spring prior to flooding.

Clearing operations that followed the logging would be scheduled primarily for dry weather operations. Most of the soils are gravelly and no major erosion problems are anticipated from clearing activity. The desirability of removing stumps from the edge of the existing river bank is questionable from a fisheries aspect. Some adjustments in clearing specifications may be feasible to accommodate specific fishery concerns identified during the study.

Basically the proposed clearing specifications in Canada require that all trees below 1670 feet elevation (the drawdown line) be removed to a stump height of less than 12 inches. Above elevation 1670 feet trees would be cut flush with ground except that on slopes greater than 40 percent stump heights less than 6 inches would be permissible.

Woody material would be disposed of prior to flooding.

4.1.2.2 Fill Period

The effects of rising water levels during the fill period will include the permanent inundation of 5.6 miles of the present river below the 1669-foot elevation level over two years and seasonal inundation to the 1725-foot elevation of up to an additional 4.4 miles of drawdown river. These areas can be expected to accumulate more fine particle size gravels than they presently contain. The habitat in general will change from flowing river to more stable lake conditions.

4.2 ROSS LAKE AT ELEVATION 1725 FEET

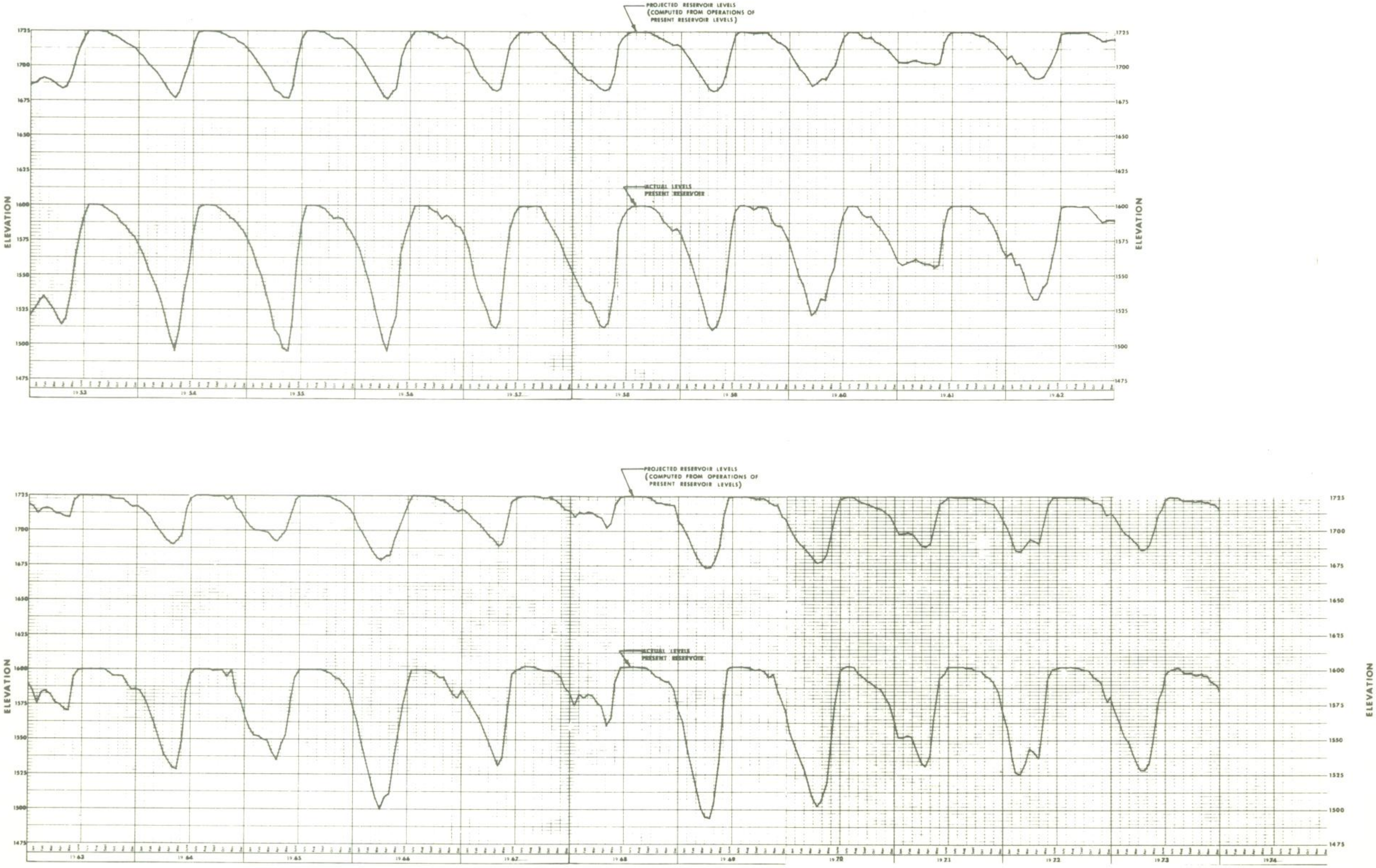
4.2.1 Ross Lake (by Fisheries Research Institute)

The physical effects of the proposed raising of Ross Dam on lake size, volume, elevation, drawdown schedule and flushing rate have been discussed in SCL (1973). Observed and projected Ross Lake elevation fluctuations are presented for comparison in Figure 4.2-1.

Temperature and dissolved oxygen profiles for 1973 have been discussed with respect to the existing reservoir. Changes in the temperature regimen and dissolved oxygen profile from the existing reservoir to the high reservoir would result from the greater thickness of the hypolimnion at the new height. Burt (1971) indicated that the temperature regimen in the upper 100 feet of High Ross Lake would not change greatly because the geometry of the main lake basin does not change much from the 1500 feet to the 1725 feet elevation and temperature of the upper 100 feet of the lake is controlled by weather conditions. He further stated that the thermocline would form at about the same time in the spring and its gradient would remain about the same with minor exceptions. Figs. 14 and 15 of King and Orlob (1973) present Ross Lake isotherms for calendar year 1971 weather conditions for the existing and proposed reservoir elevations, based on their deep reservoir model. Under 1971 conditions, homoiothermy was achieved by mid-December for the existing elevation and would have been achieved about a week later at the proposed elevation. According to their model, the average lake temperature would not drop quite as low during winter. The difference would be less than 1^{o} C.

Our measurements in 1973 and early 1974 indicated that the hypolimnion of Ross Lake remained at approximately 4.5^{o} - 5.5^{o} C during the period of cooling of the epilimnion until complete overturn of the

FIGURE 4.2-1



OBSERVED AND PROJECTED ROSS LAKE ELEVATION FLUCTUATIONS, 1953 - 1973 lake between December 20 and January 9 (Fig. 2.1-3 Sec. 2.1). Thus, it is suggested that the time at which the reservoir becomes homothermous is determined primarily by the rate of cooling of the epilimnion (which is controlled by weather conditions). The increased thickness of the hypolimnion would cause a slight delay in the time at which the reservoir would reach completely homothermous conditions.

Oxygen replenishment of the hypolimnion would continue to occur during the late fall-early winter and early spring overturns of the lake water. Information on D.O. in 1973 and early January, 1974 (see Fig. 2.1-3 Sec. 2.1) support the conclusions made in SCL (1973) relative to hypolimnial oxygen.
Inundation of new land and increased amounts of organic matter would raise the BOD for a few years, but the effect on D.O. in the hypolimnion would be slight because (1) the total oxygen available for BOD processes per unit area of water column in the thicker hypolimnion would be greater than in the present reservoir, and (2) decreased annual drawdown in High Ross Lake would result in more of the particulate matter entering the reservoir settling in shallower water and remaining there.

Data on turbidity and water chemistry for 1973 were presented in Section 2. They provide further basis for the projections discussed in SCL, 1973 on turbidity and water chemistry in High Ross Lake.

4.2.2 Skagit River and Tributaries (by F.F. Slaney and Company)

Characteristics of the Skagit River with Ross Lake at elevation 1725 feet were outlined in SCL (1973).

The Skagit River would have a length of 10.2 miles, a gradient of 0.53 percent and a drainage area of 296 square miles. Substrate would be primarily pebble and cobble. Maximum length of the drawdown river with Ross Lake at 1725 feet would be approximately 4.4 miles with a gradient of 0.25 percent. The mean drawdown elevation of 1710 feet would expose about one mile of river channel.

PART 5

PROJECTIONS FOR FISHES AND FISHERY

5.1 CONSTRUCTION PERIOD

5.1.1 Spawning Time, Location, and Success

5.1.1.1 American Tributaries (by Fisheries Research Institute)

The time of rainbow trout spawning in 1973 was found to occur between mid-May and late June as discussed in Section 3.3.2.2 and in 1971 and 1972 was from mid-May to mid-July. Time of spawning should not deviate from this normal range during the construction period. The Ross Lake trout would be expected to respond as usual to the increased stream discharge and rising stream temperature. Spawning of char (Dolly Varden and brook trout) would occur also at the normal time in the fall (approximately Sept. - Oct.).

The areas of potential trout spawning would be altered somewhat due to deviations in lake elevation patterns during construction, particularly in the first calendar year after construction would begin. The normal mid-May to mid-July spawning season would occur when the lake elevation was between 1475 and 1530 feet (SCL, 1973). These elevations are considerably lower than normal. Spawning areas available during the second construction year would more closely approach the normal. The consequence of the lower lake elevations is that generally more stream spawning area would be available. Blocks in Big Beaver Creek and in Lightning Creek were discussed in SCL (1973) and Section 3.3.2.3.

In Lightning Creek, the falls described in SCL (1973) at the 1565 ft elevation have been modified by stream flow. In 1973, observation in late winter and early spring revealed that heavy deposits of rubble and gravel had filled in the stream channel in the drawdown zone (presumably a result of the record 1972 runoff) and reduced the falls at the 1565 ft elevation to rapids. Observations at this elevation in May, 1974 showed that the migration block at the 1565 ft elevation no longer exists; therefore, the conclusion with respect to spawning utilization of Lightning Creek by Ross Lake trout is that the stream reach now utilized for spawning would remain accessible during the entire construction period. However, if further natural changes in the stream channel should result in reformation of this migration block, minor improvement of the streambed should make the channel passable.

The gravels in the drawdown area stream channels would be low in fine materials (sand and silt) because of the rather rapid cleaning by stream flow as inundated stream channels become exposed during drawdown. It is expected that these drawdown stream gravels would provide satisfactory water percolation for incubating eggs and alevins if used for spawning for trout and char. However, we have observed that the drawdown stream channel gravels tend to be less stable than in stream channels immediately above the drawdown zone, which could adversely affect trout spawning success in the drawdown channels during heavy spring runoff.

Observations to date indicate that no significant spawning utilization of Big Beaver Creek by Ross Lake trout occurs. No spawning utilization would be expected in Big Beaver Creek in the drawdown between 1530 ft. and 1602.5 ft. during the construction period because 1) migration blocks (falls) exist at the 1531 and 1578 ft.elevation and 2) no adequate appearing spawning gravel was found in this section of the stream during early spring foot surveys when the reservoir was drawn down (SCL, 1973).

Because of the change observed in Lightning Creek, areas of char (Dolly Varden and brook trout) spawning in this stream would remain accessible during their spawning in the fall of the first construction year; however, Big Beaver Creek would remain inaccessible until the following spring. Total area of char spawning thus would be reduced somewhat during the fall at the end of the first year of construction but would not be significantly affected by the construction schedule in the fall at the end of the second construction year.

Timing of fill during the two construction years would be delayed so that inundation of stream areas would continue into July and August to a greater degree than normal, particularly in the first construction summer (Table 4.1-1). In the second construction summer, redd inundation could be greater than normal because of the delayed fill and slightly higher maximum lake elevation (SCL, 1973).

Since some trout production appears to occur in inundated stream inlet areas (SCL, 1973) the influence of inundation of redds in stream areas by rising lake level on survival of eggs and alevins is of concern. This was investigated again in 1973.

Plastic containers, described in SCL (1973) and screened trays were used to hold the eggs. Control stations were set in Lightning Creek (1630 ft.elevation) and Ruby Creek (1604 ft.elevation). The control stations each consisted of a 1 ft. x 1 ft. x 4 ft. long plywood box anchored in the stream bottom by the weight of the gravel placed inside the box. The inside of the box was designed to insure upwelling of the stream water through the gravels in the box (McNeil, personal communication). The boxes were kept covered to keep light from the eggs. The remaining stations were set simply by burying the egg containers 6" deep in the stream gravels. Stream depths in stream drawdown areas ranged from 2.5 ft. to 45.0 ft. below full pool and are shown in Table 5.1-1.

Because the 1973 runoff was relatively light all sample containers in the experiments were recovered. The results (Table 5.1-1) show that survival from egg to alevin stage in the inundated stream gravels was variable, but could occur under certain conditions to 30.5 ft below full pool. The survival data from Table 5.1-1 were averaged for the following stations:

Lightning Creek Arm, 22.5 ft. below full pool = 16% survival
Pierce Creek Arm, 30.5 ft. below full pool = 74% survival
Roland Creek Mouth, 2.5 ft. below full pool = 66% survival

However, in other inundated stations, Roland Creek at 30 and 45 ft below full pool, Ruby Creek Arm at 23.5 and 30.5 ft. below full pool, and Dry Creek at 25.5 ft. below full pool 100% mortality occurred before hatching. The controls in Lightning Creek averaged 89% survival to alevin stage while those in Ruby Creek controls were at variance with the excellent survival in the Lightning Creek controls. Mortality due to the handling process is suspected to be at least partially responsible; however, eggs planted at 23.5 and 30.5 ft. below full pool suffered 100% mortality (Table 5.1-1).

Generally, mortality was greater in inundated gravels than in incubation box gravels above full pool elevation. It is assumed that the incubation boxes placed in the stream bottom provided as good survival conditions as in natural redd sites chosen by

TABLE 5.1-1

EGG SURVIVAL EXPERIMENTS, 1973

Location of Planting	Date Eggs Planted in gravel	Lake Level (ft)	Station elev. in ft. below (-) or above (+) full pool (1602.5 ft)	Type and Number of Containers	Date and Number of Containers recovered	Number of Containers with living eggs or fry	Percent living sac fry	Percent Living Eggs	Percent Mortality	Location of origin of Fertilized Eggs
Lightning Creek at 1630 ft. elev.	5 June	1572	+27.5	Plastic (3) in incubation box	17 July (1)	1	95.0	4.2	0.8	Lightning Creek
					26 July (1)	1	99.9	-	0.1	" "
					2 Aug (1)	1	96.8	-	3.2	" "
	7 June	1575	+27.5	Plastic (3) in incubation box	17 July (1)	1	51.1	43.5	5.4	Dry Creek
						1	97.7	-	2.3	" "
						1	92.2	-	7.8	" "
	7 June	1575	+27.5	Screened tray (2) in incubation box	2 Aug (1)	1	58.0	-	42.0	Lightning Creek
					2 Aug (1)	1	85.0	-	15.0	Dry Creek
Lightning Arm of Ross Lake	7 June	1575	-22.5	Plastic (4)	17 July (1)	1	27.4	39.3	33.3	Mouth Lightning Creek
					31 July (2)	2	19.1	12.8	68.1	
					15 Aug (1)	0	0	0	100.0	"
Dry Creek	7 June	1575	-25.5	Plastic (3)	17 July (1)	0	0	0	100.0	Mouth of Dry Creek
					31 July (2)	0	0	0	100.0	" " "
Roland Bay	8 June	1576	-45.0	Plastic (3)	26 July (1)	1	-	2.8	97.2	Mouth of Roland Creek
					10 Aug (2)	0	0	0	100.0	" " "
	8 June	1576	-30.0	Plastic (3)	26 July (1)	1	0	4.5	95.5	" " "
					10 Aug (2)	0	0	0	100.0	" " "
Mouth of Roland Cr.	26 June	1593	- 2.5	Plastic (4)	30 July (1)	1	60.3	2.0	37.7	" " "
					25 Aug (3)	3	67.5	-	32.5	" " "

TABLE 5.1-1 - CONTD.

Location of Planting	Date Eggs Planted in gravel	Lake Level (ft)	Station elev. in ft. below (-) or above (+) full pool (1602.5 ft)	Type and Number of Containers	Date and Number of Containers recovered	Number of Containers with living eggs or fry	Percent Living sac fry	Percent Living Eggs	Percent Mortality	Location of origin of Fertilized Eggs
Pierce Creek Arm	14 June	1582	-30.5	Plastic (4)	17 July (1)	1	78.3	16.2	5.5	Pierce Creek
					31 July (1)	1	48.1	32.0	19.9	" "
					15 Aug (1)	1	95.6	-	4.4	" "
	14 June	1582	-15.5	Plastic (4)	17 July (1)	1	-	35.9	64.1	" "
					17 July (1)	0	0	0	100.0	" "
					31 July (1)	0	0	0	100.0	" "
					15 Aug (1)	0	0	0	100.0	" "
Mouth of Pierce Creek	26 June	1593	- 3.5	Plastic (4)	30 July (1)	1	2.2	74.3	23.5	Pierce Creek
					15 Aug (1)	1	77.8	3.7	18.5	" "
					15 Aug (2)	0	0	0	100.0	" "
Ruby Cr. Arm	14 June	1582	-30.5	Plastic (2)	17 July (1)	0	0	0	100.0	Mouth of Ruby Creek
					31 July (1)	0	0	0	100.0	" "
	14 June	1582	-23.5	Plastic (3)	17 July (2)	0	0	0	100.0	" " " "
					31 July (1)	0	0	0	100.0	" "
Ruby Cr. at 1604 ft. elev.	5 July	1598	+ 1.5	Plastic (4) in incubation box	30 July (1)	1	-	22.2	77.8	" "
					7 Aug (1)	1	-	26.3	73.7	" "
					14 Aug (2)	2	16.9	0.5	82.6	" "

spawning trout. (This may well not be so.) With this assumption, it is concluded that survival of eggs to alevin stage in inundated stream gravels during the construction period would be adversely affected. It is therefore recommended that as much filling as possible be accomplished before beginning of spawning in mid-May in the construction and fill years.

In summary, essentially all stream areas now utilized for spawning by Ross Lake trout would be available. Additional stream area would also be available due to the increased drawdown exposure of stream channels but this additional habitat appears to have less potential for survival of eggs to alevin stage than the spawning areas now utilized. It is expected that the primary spawning would take place in present trout spawning areas in the American tributaries but that a small proportion of the spawning would occur in the drawdown stream channels. The 1973 studies in Ruby Creek indicated that approximately 90% of the fry production occurred above the 1720 ft. elevation (see Section 3.3.2.3), indicating extensive upstream distribution of spawning fish.

In Lightning Creek the improvement of stream accessibility at the 1648 ft. elevation, previously discussed in Section 3.3.2.3, could allow spawning in the stream reach above this point which would reduce spawning density in the presently used spawning areas. Spawning habitat in Roland Creek drawdown channel appears nil because of stream gradient and rapids.

Overall, spawning success in American tributaries and their inlets will probably not be materially reduced during the construction period.

5.1.1.2 Skagit River

(by F.F. Slaney & Company)

The time of rainbow trout, Dolly Varden, and brook trout spawning in the Skagit River should not be affected during the construction period.

Ross Lake will be drawn down in winter during the construction period to lower levels than the recent average (SCL, 1973). The figure also shows that the spring risings of the lake elevation will begin later than average in the first summer. These two factors may result in rainbow spawning activity being located further downstream in the first year of construction than in recent years.

The total increase in lake elevation during May through August of the first summer will be between 76 and 90 feet. This elevation change is greater than the 1953-72 mean elevation change but within the range experienced in recent years (see Table 4.1-1 and Figure 4.1-2 in SCL , 1973 for comparison). The lake elevation will also continue to rise throughout the incubation and hatching period for eggs and larval rainbows during the first summer of construction.

The effects of this total elevation change on egg and larval rainbows should be within the range of recent conditions since the rise in water levels is within the range of those of recent years even though it occurs later in the year.

During the second spawning season after construction commences, water level increase and rates of fill during rainbow spawning and egg incubation times will again be greater than the average condition in recent years but will be essentially the same as in 1969 (see Fig. 4.1-2 in SCL, 1973). The rainbow population can be expected to respond as it has in recent years with no adverse effects anticipated.

Spawning success during the construction period could be detrimentally affected by deposition of fine particles in the gravels from clearing operations. However, it is anticipated that clearing will be scheduled to accommodate the fish to reduce this possibility.

5.1.2 Feeding Conditions and Fish Growth (by Fisheries Research Institute)

5.1.2.1 Food Production

Data collected in 1973 and described in Section 3.4 relative to primary producers, zooplankton and benthos support the conclusions presented in SCL (1973). Conclusions with respect to input to Ross Lake of allocthonous food and stream food were also presented and will not be modified or expanded in this report.

5.1.2.2 Fish Growth

A sharp or complete reduction in fishing effort in Ross Reservoir would be expected during the two construction years due to restricted access or closure of the reservoir to fishing. The effect on growth of the resulting buildup in number of fish in the population was discussed in SCL (1973). The conclusions reached were that growth rate of the trout would be reduced during the first construction year because of decreases in food availability but that growth rate would be similar to present growth rate in the second construction year because of improved feeding conditions. Average fish size would increase because of an accumulation of larger fish due to reduction in angler effort.

5.1.3 Fish Production (by Fisheries Research Institute)

Information to date indicates that over-all recruitment to stream and lake areas would not be materially affected during the construction period. The fishable population is expected to increase if the lake is not utilized by anglers during construction. Means of the estimates of total and natural mortality within age groups and 1973 abundance for each age group (Appendices 9 and 10) were used to determine the magnitude of the buildup in the fishable population in the absence of angler effort during the construction period (Table 5.1-2). Cessation of angler effort would eliminate the fishing mortality component from total mortality leaving only natural mortality operating. It should be remembered that these components of total mortality cannot be arithmetically added to each other to obtain an estimate of total mortality for the reasons discussed in Section 3.7.4.2. The abundance projections in Table 5.1-2 represent an increase of about 13 percent in the fishable rainbow trout population during the two-year construction period if no fishing mortality occurred. If the Canadian Skagit River catch of 4,000 trout per year continued during the construction period the population size increase would be approximately 11 percent if fishing was discontinued in the lake. A buildup in the spawning population would likewise occur and an increase in average age of spawners would be expected (see Table 5.1-2). This would increase recruitment to the fishery for 1-2 years following the construction period.

5.2 DURING AND AFTER THE FILL PERIOD - SHORT TERM

5.2.1 Spawning Time, Location and Success

5.2.1.1 American Tributaries (by Fisheries Research Institute)

Time of trout spawning in Ross Lake during and after the two-year filling period following construction should remain unchanged.

TABLE 5.1-2 PROJECTED FISHABLE POPULATION OF RAINBOW TROUT IN ROSS LAKE WITH AND WITHOUT FISHING IN TWO CONSECUTIVE YEARS. NUMBERS IN PARENTHESES (-) INDICATE PROPORTION OF THE POPULATION.

Beginning of year			Year Class				Total fishable population
	1969	1970	1971	1972	1973	1974	
1974 no fishing in 1973	3,000(.012)	19,449(.079)	89,587(.363)	129,836(.526)*	5,081**		246,953
with fishing in 1973	2,378(.011)	15,364(.068)	73,487(.326)	128,990(.573)*	5,081**		225,300
1975 no fishing in 1973 or 1974		4,784(.019)	28,578(.111)	89,587(.347)	129,836(.504)*	5,081*	257,866
with fishing in 1973 and 1974		2,996(.013)	18,519(.081)	73,008(.319)	128,990(.564)*	5,081*	228,594

Note: Means of natural mortality estimates from Appendix A are:

Age 2-3, .310
Age 3-4, .681
Age 4-5, .754

Means of total mortality estimates (includes natural and fishing mortality) from Appendix A are:

Age 2-3, .434
Age 3-4, .748
Age 4-5, .805

*Assume fishing mortality = total mortality (natural mortality unknown but assume equal to zero).

**Assume same absolute recruitment (equal year class strength as previous year).

Time of spawning has previously been discussed in SCL (1973) and in Section 3.3.2.

Accessibility of the Ross Lake tributary streams to fish from Ross Lake was discussed in SCL (1973). Conclusions with respect to spawning location based on all information to date are substantially the same as in the above report except that a limited (probably minimal) number of Ross Lake trout spawners presently could utilize Lightning Creek above the intermittent migration block at the 1648 ft. elevation. The natural change in the stream channel at the falls at 1648 ft elevation in Lightning (Section 3.3.2.3) is considered permanent. It is not yet known at what level of stream flow, water begins to flow around the falls through the erosion channel. Unsuccessful attempts by fish to jump the falls (Section 3.3.2.3) indicated that upstream movement beyond this point would occur if this intermittent migration block were made permanently passable (cost would be relatively low). Improved accessibility of Lightning Creek above the 1648 ft. elevation at the present time would be beneficial because if Ross Dam is raised at a future date the trout will have had a longer time to adapt to new spawning areas.

Survival of eggs and alevins to fry emergence in stream redds inundated to varying depths by rising lake level was discussed in SCL (1973) and in Section 5.1.1.1. The results of these studies indicate that it would be feasible to artificially fertilize and incubate native trout eggs in stream areas above the 1725 ft. elevation, thus balancing out possible adverse effects of redd inundation. If stream inundation by rising lake level does decrease survival of eggs and larvae, as it appears to do, the decreased annual fluctuation of lake level at the proposed new level would be advantageous. The adaptability of the Ross Lake rainbow trout population and its response to the formation of Ross Reservoir, the series of elevation changes and changes in available spawning areas have been discussed in SCL (1973).

Observations indicate that the upstream areas in the Ruby Creek watershed and the newly accessible areas in Lightning Creek above elevation 1648 are of equal or better quality than areas to be inundated and that total available spawning area in American tributaries would not be decreased. Increased recruitment during and after the construction period (see Section 5.1.3) would result in slightly higher spawning densities overall but spawning density would still be well below the level which would result in a reduction in survival from egg to fry emergence. Spawning female pink salmon densities of .5 per yd^2 in Seton Creek spawning channels resulted in excellent survival from egg to fry emergence (60-70 percent) and densities of 1.5 per yd^2 resulted in lower survival 20-30 percent according to Brannon personal communication). Rainbow trout female spawning densities were not measured in the American spawning tributaries, but casual observations indicated no density exceeding .5 per yd^2, even in Dry and Roland Creeks, which had the highest spawning female densities. Another point of interest is the present relatively high production in the short (1/4 mile) stream reach of Lightning Creek (Section 3.3.2.3), which suggests potential for a several-fold increase in production upstream if the falls at the 1648 ft. elevation are inundated or made passable. Spawning density in Lightning Creek probably would decrease because of the large increase in available spawning gravel.

Density dependent mortality from egg to fry emergence would not be expected to occur in the American tributaries.

Stream observations to date indicate that resident stream populations in stream areas that are or would become available to Ross Lake trout are not large. Scale measurements indicate that the growth rates of rainbow trout spending more than one year in the stream is less than of trout in Ross Reservoir. The total stream length available for stream resident fish would be reduced by raising the reservoir, resulting in adaptations to the lake environment or reduction in numbers. Competition with reservoir trout utilizing the American streams to spawn probably is not severe because the spawning fish drop back into the lake after spawning and fyke net sampling in streams indicate that the newly emerged fry move rather quickly downstream into the reservoir.

The cutthroat population in beaver ponds of Big Beaver valley was discussed in SCL (1973) and Sections 3.3.2.4 and 3.7.2.1. As indicated in Section 3.3.2.4, this population probably resulted from planting in 1916 and 1919. Tag and recapture estimates in the main beaver pond in 1972 and 1973 indicated a fishable population of 1000 - 1200 cutthroats. The fish have access to Big Beaver Creek from the ponds and probably move up the creek to spawn in more favorable gravel. Fyke net sampling below this area in 1973 indicated low total fry productions.

If the reservoir is raised, the main beaver pond and other small ponds below elevation 1725 would be inundated, as well as the probable present spawning area. Inspection of the rapids in Big Beaver Creek immediately above elevation 1725' indicates they may be passable to trout migration. However the beaver pond areas above elevation 1725 do not offer the volume or area equivalent to those below, and undoubtedly would not sustain the same population level as the present ponds below. Unless the cutthroat population could adapt successfully to lake residence, a reduction in this essentially unfished population would be expected.

5.2.1.2 Skagit River

(by F.F. Slaney & Company)

As the high reservoir fills above present levels in the first spring and summer following completion of construction, the rate and time of filling and total change in lake elevation will be nearly identical to the 19-year (1953-71)average fill curve. The differences will be that this fill will occur upstream of present levels and that more rise will occur during July than average.

In the second year after completion the rate of fill will be slower than the recent average condition. The fill will also occur about one month later than the average predicted fill with High Ross Lake. The total increase in lake elevation will be less than the past average, but greater than the anticipated average with High Ross Dam (see Figure 4.1-2 in SCL, 1973).

In both years it is anticipated that spawning rainbow trout will move upstream in the Skagit River to spawn in the river and its tributaries, including the Klesilkwa River (see also Section 5.2.1.1). This population has been subject to greater rises in water levels and elevation fluctuations in the past. It appears to have adjusted well to those changed circumstances and can be expected to adapt as well with another, more moderate, elevation change. Closely related fish species are also known to utilize newly available spawning areas as they become available, suggesting that these trout will move upstream. Adequate substrate is available upstream (see Section 4.2.3.1) to accommodate the spawning population.

On the basis that the rainbow population will move upstream in the Skagit River to spawn, spawning success can be expected to be at least as good as that in recent years. During both years of the fill period the elevation fluctuations in the lake will be less than recent average conditions. If inundation of stream areas does indeed decrease survival of eggs and larvae then the decrease in elevation fluctuations can be expected to increase the survival of rainbow eggs and larvae. Results of egg survival studies in 1972 indicated reduced survival in some but not all inundated spawning gravels due to siltation. The time of rainbow spawning should not be affected by the filling of the higher reservoir.

5.2.2 Feeding Conditions and Growth (by Fisheries Research Institute)

5.2.2.1 Primary Production, Ross Lake

Additional baseline data collected in 1973 (Sections 2 and 3.4.1) provide no reason to modify the essential conclusion in SCL (1973) that primary production per unit area of Ross Lake would be higher during the fill period and immediate post-fill years and the total area of the lake would increase by 71% at new full reservoir. The depth of the euphotic zone would not be fixed, but would vary seasonally according to the degree of increase in primary production, the turbidity of inflows, and the change in configuration of the epilimnion as the reservoir fills. With increase in lake volume, lake turbidity resulting from normal spring runoff turbidity would become less, tending to increase euphotic zone depth. Increased turbidity resulting from inundation of new land can be expected during fill along with enrichment of lake waters.

5.2.2.2 Fish Growth

The expected increase in zooplankton and benthos per unit area during the fill and immediate post-fill years because of enrichment and the increase in lake size would provide the increased trout population with growth conditions better than at present. The percentage increase in zooplankton abundance during the fill years cannot be accurately predicted but could be considerably greater than the percentage increase of trout abundance during the construction (discussed in Section 5.1.2) and fill years. Thus the trout food supply would be greater per fish than at present and better fish growth would result. Because of increase of lake shore relative to stream inlet areas, allochthonous food would provide a lower proportion and benthos a higher proportion of the trout diet.

5.2.3 Fish Production (by Fisheries Research Institute)

As indicated in Section 5.1.3, an increase in the rainbow trout spawning population would occur if fishing is restricted during the construction period. Possible reduced fishing effort during the fill period would allow some further build-up. Although spawning success may be affected because of redd inundation and during the period of adjustment of the population during the fill and immediate post-fill period, it appears feasible to balance out losses by transferring artificially fertilized eggs from fish in spawning areas to be flooded to spawning areas not to be flooded and incubating them. This technique proved quite successful with eggs transferred from spawners at Dry Creek and incubated to fry emergence at Lightning Creek. Average survival of eggs to alevin stage from both streams (see Table 5.101) was comparable (80-90 percent). This level of survival is much higher than that to be expected in natural spawning areas. This technique could be implemented at relatively low cost.

Reduced fishing mortality would allow recruitment exceeding that occurring at present. A larger total rainbow trout population would be expected immediately after the reservoir is completed and for the few years thereafter.

As indicated in Section 5.2.1.1 a reduction in the small cutthroat trout population now occupying beaver ponds in Big Beaver Valley is probable unless a portion can adapt to lake residence.

5.3 ROSS LAKE AT 1725 FEET - STABILIZED CONDITIONS

5.3.1 Spawning Time, Location, and Success

5.3.1.1 American Tributaries (by Fisheries Research Institute)

No changes in spawning time are anticipated. The distribution of spawning in American tributaries is expected to shift to greater proportional use of Lightning Creek. A buildup of gravel in stream estuaries would occur which could be utilized for spawning. Reduction in annual lake level fluctuation would reduce the possible adverse effects of redd inundation.

It is probable that an increase in the spawning population would be accompanied by greater utilization of the upstream portion of available American streams; however, survival from egg to fry emergence is not expected to suffer if this did not occur because spawner density should remain well below the upper limit for optimum survival.

5.3.1.2 Skagit River

(by F.F. Slaney & Company)

The long term effects of Ross Lake at 1725 feet on rainbow spawning in the Skagit River will be minimal. As mentioned previously (Section 5.2.1.2) the spawning rainbows are expected to move upstream, where gravels are adequate (Section 4.2.3.1), and spawn successfully.

Annual lake elevation fluctuations will be reduced as will the length of the drawdown river. Both of these conditions should reduce the uncertainty in spawning success due to inundation of developing eggs.

The time of rainbow spawning is not expected to be influenced by the increased elevation of Ross Lake.

Silt loads in the gravels of the Skagit River will not be affected by the higher lake elevation.

5.3.2 Feeding Conditions and Fish Growth (by Fisheries Research Institute)

5.3.2.1 Primary Producers - Ross Lake

Factors bearing on change in abundance of primary producers at the higher lake level have been discussed in SCL (1973).

An additional factor affecting the euphotic zone is turbidity caused by silt and glacial flour carried into the lake during heavy runoff. With a larger epilimnial volume, turbidity from this cause would be less, increasing light penetration considerably during spring and early summer. This should allow more primary production to occur in hypolimnial waters.

5.3.2.2 Ross Lake Zooplankton

Zooplankton production per unit lake surface area is expected to follow phytoplankton production trends. Little loss is expected through the deep turbine intakes. Total zooplankton standing crop would be greater because of the greater lake surface area.

5.3.2.3 Ross Lake Benthos

As indicated in Section 5.2.2.3 the lesser drawdown at the higher elevation would result in less lake bottom exposed during winter drawdown and twice the area of unexposed lake bottom. These factors favor increased production of benthic invertebrates. Production should also increase because bottom undisturbed by winter drawdown will include more areas exposed to warmer summer water above the thermocline depth. The effects of greater depth of the lake on benthic invertebrate production in deep water was discussed in Section 5.2.2.3.

5.3.2.4 Allochthonous Food

As indicated in Section 5.2.2.4, stream insect drift contribution to the lake would remain essentially unchanged, so that contribution per unit lake area would be less because of the increased lake area. Terrestrial insect contribution may increase somewhat in proportion to shoreline length, which will be 47 percent greater.

5.3.2.5 Stream Food

No substantial change is anticipated in availability of stream and terrestrial invertebrates to stream feeding fish (the discussion in 5.2.2.5 also applies here).

5.3.2.6 Fish Growth

Fish growth in the reservoir is dependent on population size and the combined factors of food production per unit of lake area, per unit of lake shoreline and per unit volume of stream inflow because of the food sources discussed in previous sections. In general, combined production of zooplankton and benthos per unit area is expected to be maintained, as is production per unit area of shoreline and per unit volume of stream flow. Lake area would increase by approximately 71 percent and shoreline length by 47 percent. Because stream inflow would be unchanged and the fish population would be larger stream drift entering the lake would provide less food per fish. This probably would be offset by increased production of snails and amphipods in shallow bottom areas; thus the utilization of these items by large fish would increase. The increased importance of these food items in the diets of large fish in summer and early fall (when stream flows are low) was discussed in Section 3.4.6.1.

If food supply is now limiting growth the lake could probably support a population of trout 50 percent larger with no decrease in growth rate of individual fish, if the relative availability of larger food organisms is unchanged. Growth of larger trout is probably now limited by availability of food of large particle size.

5.3.3 Fish Production (by Fisheries Research Institute)

Under present conditions it appears that egg to fry survival of Ross Lake rainbows is probably independent of spawning density, and that structure of the lake population is essentially controlled by growth conditions and mortality rates, affecting age at first maturity, fecundity, and number of times individual females spawn before death.

A buildup in the rainbow trout population during the construction period is expected. Maintenance of a higher population level will depend on the adaptability of the trout population to a shift in available spawning areas, relative quality of these areas, lake-stream food resources, ameliorative measures, and fishing pressure.

We have indicated that utilization of newly available spawning areas would occur and that egg to fry survival is not expected to suffer. It was indicated in SCL (1973) that the food supply of the proposed reservoir would support a trout population 50 percent larger than at present with no decrease in individual growth rate if the relative availability of larger food organisms is unchanged. A study by Gosho (unpublished) of the large freshwater shrimp, *Mysis relicta* (food item of rainbow trout), indicates that following introduction into lakes of the Northwest, this species has been utilized in the diets of salmonids. Further evaluation of this potential on Ross Lake is continuing. Finally, fishing pressure will undoubtedly increase with time, whether or not the reservoir is raised, but will be affected by accessibility and attractiveness of the area to U.S. and Canadian anglers. Because natural mortality of the fishable population greatly exceeds fishing mortality, it would take a substantial increase in fishing effort to materially affect the population.

As indicated in Section 5.2.1.1, a reduction in the small cutthroat population is anticipated. Maintenance of the population level, if deemed necessary, would probably require artificial enhancement.

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