THE FISHERY RESOURCE OF MYSTIC LAKE, MONTANA

By

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of

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in

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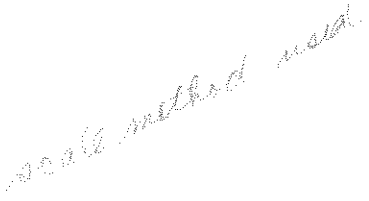
Approved:



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VITA

The author, Michiel Dwayne Poore, was born January 14, 1943 in Great Falls, Montana to Kenneth and Davida Poore. He graduated from Anchorage West High School in Anchorage, Alaska in June 1961. In September 1961, he entered the University of Alaska at College, which he attended for two years. In September 1963 he transferred to the University of Montana at Missoula, attending until December 1964. From January to July 1965, Michiel served on active duty with the U. S. Army Reserve. He again attended the University of Montana from January 1966 to March 1966. In June 1967, he married Patricia Kay Roan of Ft. Myers, Florida, and in April 1968 their son, Michiel Jr. was born. In March 1969, he re-entered the University of Montana from which he graduated in June 1969 with a Bachelor of Science degree in Wildlife Technology. In December 1969, their daughter, Lisa Marcelle, was born. Michiel began graduate studies at Montana State University in Bozeman in September 1970.

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ABSTRACT

A study of the brook trout, rainbow trout, cutthroat trout, rainbow X cutthroat trout hybrids, and lake trout in Mystic Lake was conducted during 1971 and 1972. Age and growth determinations and population estimates were made on fish captured by fyke nets, experimental gill nets, vertical gill nets, hoop nets, electrofishing and angling. Growth rates of rainbow trout, cutthroat trout, and rainbow X cutthroat trout hybrids were similar and greater than the growth rates of brook trout and lake trout. Brook trout grew faster than lake trout until age IV. A total of 1,805 trout over 8.5 centimeters in total length having a standing crop of 63.9 kilograms/hectare was estimated to be present by the Schnabel method. By the Petersen method, a total of 1,611 trout over 17 centimeters in total length having a standing crop of 67.4 kilograms/hectare was estimated to be present.

INTRODUCTION

The Bozeman Creek watershed provides a substantial portion of the municipal water supply for the city of Bozeman. In 1917, this drainage was closed to public access by joint order of the City of Bozeman, State Board of Health and U. S. Forest Service "to protect the quality of its water".

Adjacent to the Bozeman Creek watershed on the west is the Hyalite Creek (Middle Creek) drainage which also supplies a portion of Bozeman's water supply. This area has U. S. Forest Service campgrounds, hiking trails and a reservoir, all of which receive substantial recreational use by campers, hunters, hikers, fishermen and picnickers.

During 1969 and 1970, Bissonette (1971) compared the water quality of Bozeman and Hyalite drainages and found higher coliform counts in the Bozeman watershed than in the Hyalite drainage. He concluded wild animals caused a greater bacterial degradation of water quality in the closed watershed than substantial human recreational use did in the open watershed. The findings of Bissonette's study and increasing pressures from recreational interests resulted in opening the Bozeman Creek watershed to foot and horse traffic in March, 1970.

Mystic Lake is the major body of water in the Bozeman Creek drainage. Because the drainage had been closed to public use for over 50 years, little was known about the lake. In 1959, personnel

of the Montana Fish and Game Department surveyed the lake with two gill net sets and found rainbow trout *(Salmo gairdneri)*, brook trout *(Salvelinus fontinalis)*, cutthroat trout *(Salmo clarki)*, and rainbow X cutthroat trout hybrids present. In 1970, further sampling revealed the presence of an additional species, lake trout *(Salvelinus namaycush)*.

The purpose of this study was to obtain age and growth, and population information on the essentially unexploited fishery resource of Mystic Lake. This information may be useful in measuring changes in the fishery following the anticipated opening of the area to general public use. Field work was conducted from June, 1971 through October, 1972.

DESCRIPTION OF STUDY AREA

Mystic Lake is located in Gallatin County in southcentral Montana approximately 14.4 air kilometers southeast of Bozeman (Figure 1). It is situated in the Gallatin Range at an elevation of about 1,950 meters above sea level and, according to Bissonette (1971), receives runoff from approximately 1,152 hectares. It lies north of an earthfill regulatory dam built in 1903 and 1904 on the north fork of Bozeman Creek.

The lake lies in an elongate basin surrounded by steep hills bearing conifers. Its banks on the east, west and south sides are steep but the slope on the north is gentle. Nearly all of the shore is composed of silt, sand and sandstone. On the west side of the lake, there is a bar of angular, pebble to cobble-sized rock which at high water extends into the lake about 50 meters (Figure 2). Silt covers the bottom in the northern two-thirds of the lake and sapropel is found in areas over 10 meters deep.

Mystic Lake was subjected to severe fluctuations in water level (Figure 3) because its water was used for irrigation as well as by the city of Bozeman. In 1971 and 1972, the lake was held at minimum pool from October to May. During these months it had a surface area of about 6.4 hectares, a maximum depth of 9 meters, and held 55,500 cubic meters of water (Fargo 1969). The ice cover melted during the last of April. Filling began in early May with water entering primarily from streams A and B

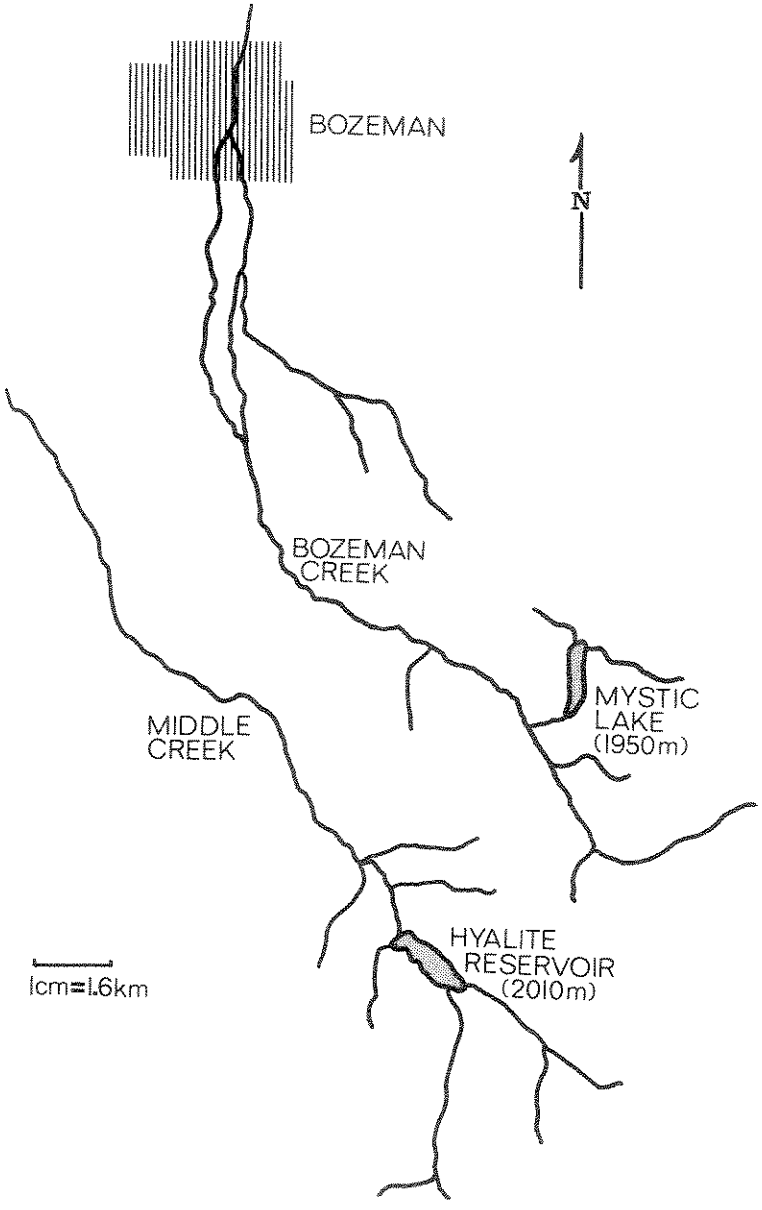

Figure 1. Map of Middle and Bozeman Creek drainages showing locations and elevations of Mystic Lake and Hyalite Reservoir.

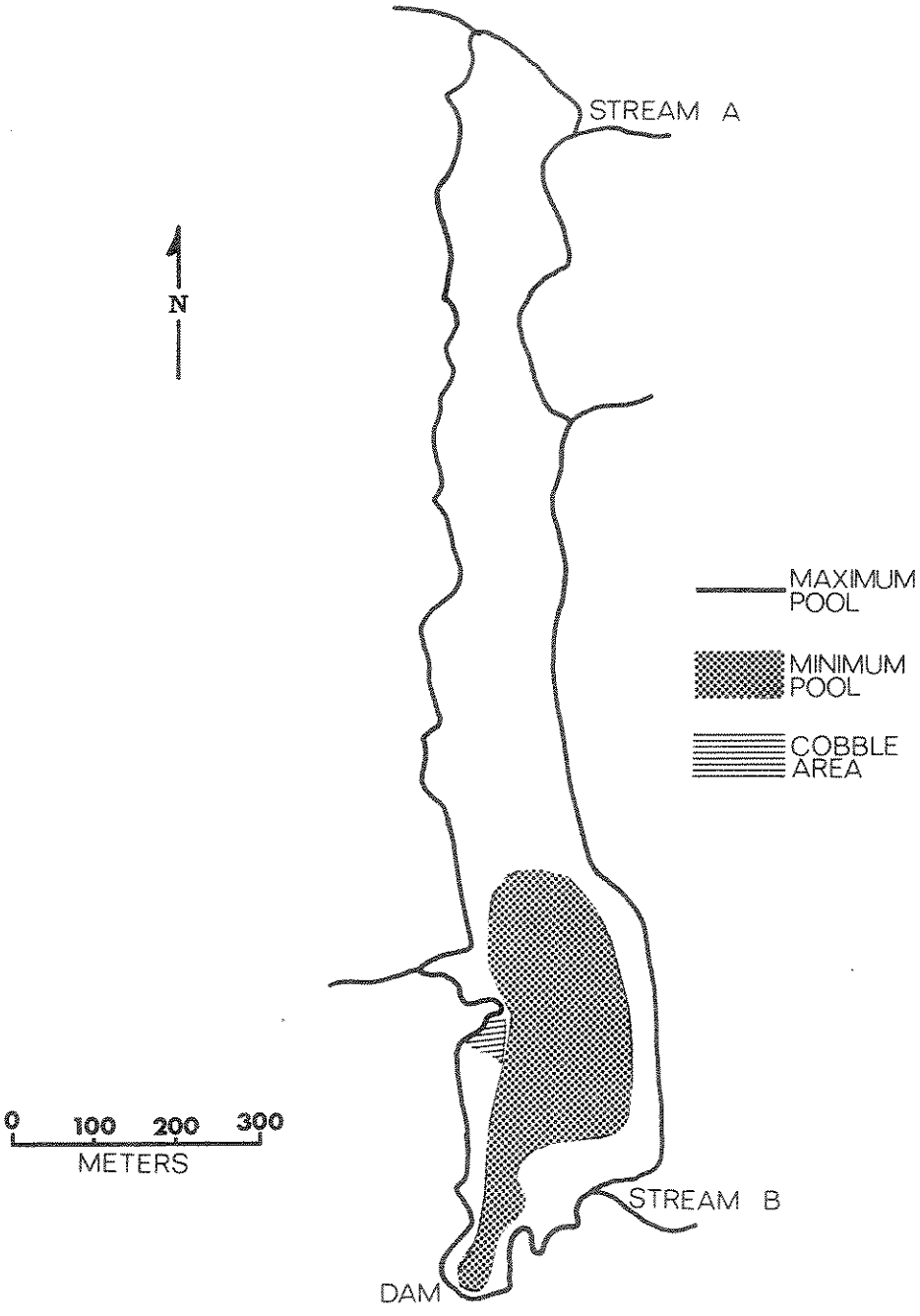

Figure 2. Map of Mystic Lake showing surface area at maximum and minimum pool.

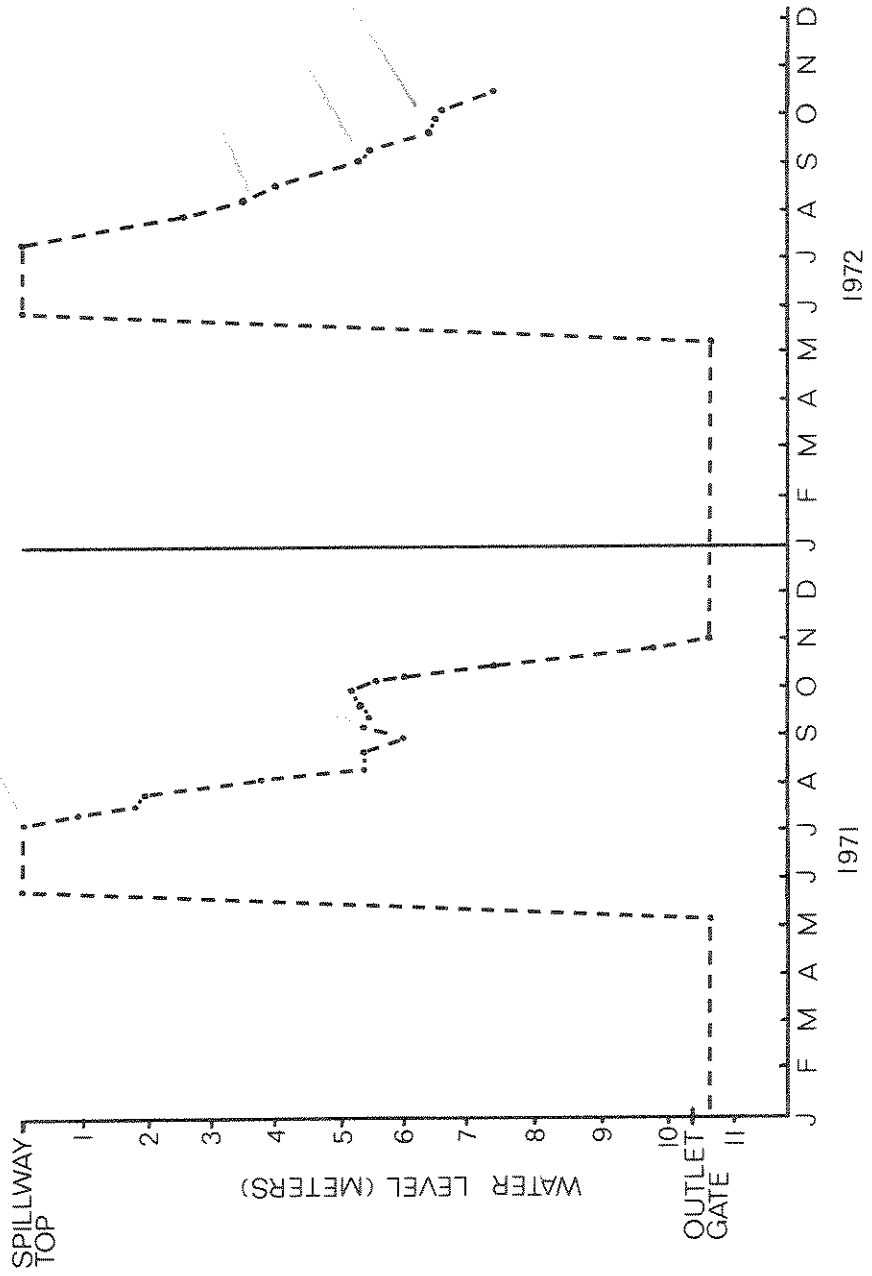

Figure 3. Water levels of Mystic Lake during 1971 and 1972.

(Figure 2) which flowed 11.9 to 17.0 m^3/min. and 6.8 to 10.2 m^3/min., respectively. The lake reached maximum capacity in late May and was held at this level through June. When full, the lake had a surface area of about 23.1 hectares, a maximum depth of 20 meters, and held 1,500,000 cubic meters of water. From June to May, streams A and B had flows of groundwater averaging 1.7 to 3.4 m^3/min. Drawdown began in July and was continued until minimum pool was reached in late October.

The physical-chemical properties (Table 1) of Mystic Lake, except conductivity, were not closely correlated with fluctuating water levels. Dissolved oxygen and temperature levels were consistently higher and total alkalinity, total hardness and conductivity measurements were consistently lower in surface than bottom samples. Conductivity values increased progressively as water levels decreased until fall overturn.

Turbidity readings were high during late May and early June because of spring snowmelt. Readings decreased through late June and early July. By the middle of July, they increased again due to a dense bloom of *Aphanizomenon* sp., a blue green algae, which persisted into September. Values, however, fluctuated substantially daily as a result of wave action on shoreline and bottom areas.

Mystic Lake stratified thermally. During both years of the study, the lake was isothermal during the first week in May, soon after the ice cover melted and before it began filling. By the first week

TABLE 1. SELECTED CHEMICAL AND PHYSICAL PROPERTIES OF MYSTIC LAKE MEASURED DURING 1971 AND 1972.

Property	Surface Range (Average)	Bottom Range (Average)
pH	8.0-8.8	7.6-8.2
Total Alkalinity (ppm $CaCO_3$)	62-101 (73)	100-145 (129)
Total Hardness (ppm $CaCO_3$)	56-99 (72)	98-161 (147)
Conductivity (microhms/cm.)	145-200 (166)	218-395 (323)
Turbidity (JTU)	2-25 (7)	3-28 (8)
Dissolved Oxygen (ppm)	7-12 (9)	1-3 (2)
Temperature (°C)	1.0-20.5 (13.2)	3.2-5.2 (4.0)

in June, a thermocline had become established at 2 meters. The thermocline descended throughout the summer until it lay at a maximum depth of 9 meters in late September. Fall overturn occurred in late October. The lake also stratified during the winter. In March 1972, it had an inverse temperature stratification with a thermocline lying between 2 and 4 meters.

METHODS

Fish were taken with hoop nets, modified fyke nets, a vertical gill net, experimental gill nets, by angling and electrofishing. The two hoop nets used were constructed of 2.5 centimeter square mesh. One net consisted of a 3.0 meter long cone preceded by a 1.5 X 1.8 X 0.9 meter box with 4.5 meter long wings attached. The other net was a 3.0 meter long cone with a 1.0 meter diameter opening and two 1.8 meter long wings. Four of the five modified fyke nets used were constructed with 1.3 centimeter square mesh. Each had a 3.7 meter long cone with a 0.9 meter diameter opening, preceded by a 0.9 X 1.8 X 0.6 meter box. The leads were 1.2 meters high and from 7.6 to 15.2 meters in length. The fifth fyke net was built with 2.5 centimeter square mesh and consisted of a 3.0 meter long cone preceded by a 1.5 X 1.8 X 0.9 meter box. The lead was 1.5 meters high and 20.0 meters long. The vertical gill net consisted of four 1.8 X 15.0 meter panels of 1.9 to 5.1 centimeter graded mesh attached to four sealed floats of 10.0 centimeter diameter plastic sewer pipe 1.8 meters long. Each float had snap swivels attached at both ends by which the sections were hooked together into a 4.3 meter long net. Three experimental gill nets were used. Angling consisted of trolling and bank fishing. Electrofishing was done with a D. C. generator.

The total lengths and weights were recorded and scale samples were collected from fish captured by all methods during 1971 and 1972 for age and growth determinations. In 1971, each fish captured was marked with a dorsal fin clip to eliminate duplicating measurements. Twenty-four lake trout over 30 centimeters in total length were marked with individually numbered T-tags. In 1972, all fish captured and released were marked with an adipose fin clip. Only these fish were used in making population estimates.

The fish populations of Mystic Lake were estimated by the Schnabel and Petersen methods. The formulas for the Schnabel estimate and its confidence limits were taken from Robson and Regier (1968). The Petersen estimate was made using Chapman's modification (Ricker 1958), and confidence limits were calculated using the formula cited in Vincent (1971).

RESULTS

Age and Growth

Scales were taken from all trout captured prior to August 5, 1972. After this date, scales were taken only from rainbow and lake trout. Age determinations and growth calculations were made from scales and lengths taken from 1,017 fish: 217 brook trout, 221 cutthroat trout, 104 rainbow trout, 251 rainbow X cutthroat hybrids, and 224 lake trout (Table 2). Since the age distribution of scales and calculated growth rates of fishes taken during 1971 and 1972, respectively, were similar, data from the two years were combined.

The number of each kind of fish by age group is presented in Table 2. Fewer fish were taken in age group 0 than age group I because the fishing gear was probably selective for the older and larger fish. There were greater numbers of brook trout, cutthroat trout, rainbow trout and rainbow X cutthroat hybrids, respectively, in age group I than any other age group. Fish in age group I comprised 47 to 38 percent of the respective kinds taken. Age groups II to VI of each taxon contained progressively smaller numbers of fish with age groups V and VI combined, making up 2% or less of each kind taken. Because scale samples were collected by various methods and over a long period of time, the age structure of these samples probably reflect the age structure of the populations at large, except for age group 0.

TABLE 2. AGE GROUPS AND AVERAGE CALCULATED TOTAL LENGTHS AT EACH ANNULUS FOR TROUT TAKEN DURING 1971 AND 1972. THE PERCENT COMPOSITION OF EACH TAXON BY AGE GROUP IS IN PARENTHESES.

Age Group	Number	Average Total Length	Calculated Length in cm at each Annulus												
			1	2	3	4	5	6	7	8	9	10	11	12	13
Brook Trout															
0	11(5.0%)	11.6													
I	102(47.0%)	18.3	9.1												
II	57(27.5%)	28.1	8.2	20.6											
III	36(16.0%)	32.3	8.1	16.5	26.7										
IV	10(5.0%)	34.5	7.2	14.4	24.2	31.8									
V	1(0.5%)	35.7	5.6	10.0	18.3	24.5	32.0								
Cutthroat Trout															
0	69(31.0%)	12.9													
I	85(38.0%)	16.9	8.7												
II	31(14.0%)	25.8	9.3	20.3											
III	24(11.0%)	34.9	8.8	19.1	30.8										
IV	10(5.0%)	40.0	9.4	17.4	28.4	37.0									
V	1(0.5%)	44.0	9.0	14.5	27.0	32.5	42.5								
VI	1(0.5%)	50.5	9.0	20.0	32.5	38.2	44.0	47.7							
Rainbow Trout															
0	17(16.0%)	15.7													
I	42(40.0%)	20.4	9.8												
II	18(17.0%)	30.2	9.3	22.5											
III	13(13.0%)	37.3	10.1	23.6	33.5										
IV	12(12.0%)	39.9	8.7	20.4	31.5	38.3									
V	1(1.0%)	45.0	10.3	19.5	32.3	39.0	43.0								
VI	1(1.0%)	48.4	9.2	21.6	34.3	41.0	45.1	48.4							

TABLE 2 (Continued)

Age Group	Number	Average Total Length	Calculated Length in cm at each Annulus												
			1	2	3	4	5	6	7	8	9	10	11	12	13
Hybrid Trout															
0	43(17.0%)	12.9													
I	115(46.0%)	16.6	8.9												
II	55(22.0%)	26.7	8.0	20.6											
III	22(9.0%)	35.5	7.9	18.9	31.5										
IV	11(4.0%)	41.0	8.4	20.7	31.2	39.3									
V	4(1.5%)	43.5	5.0	15.8	29.9	37.9	42.8								
VI	1(0.5%)	47.0	10.9	20.8	34.0	39.8	44.0	47.0							
Lake Trout															
0	0														
I	1(0.5%)	15.3	9.5												
II	8(3.5%)	20.6	8.0	16.1											
III	17(7.5%)	28.7	7.2	14.0	22.4										
IV	91(40.5%)	37.6	7.7	15.7	24.0	32.1									
V	60(27.0%)	43.2	7.8	15.4	22.9	30.5	37.9								
VI	26(11.0%)	48.2	8.0	15.5	23.9	29.7	38.1	44.0							
VII	13(6.0%)	53.6	7.6	14.5	22.0	29.3	36.2	38.4	48.4						
VIII	2(1.0%)	53.3	8.0	13.6	20.7	28.0	33.5	39.8	46.0	50.0					
IX	0														
X	0														
XI	4(2.0%)	83.8	7.9	14.4	20.6	29.3	37.6	44.7	52.7	60.3	67.0	73.3	78.2		
XII	1(0.5%)	90.2	9.2	21.2	28.8	36.0	42.2	52.5	59.1	64.0	72.1	76.0	81.1	86.7	
XIII	1(0.5%)	105.4	7.4	14.0	21.2	28.3	37.0	45.8	54.0	62.8	70.4	77.6	87.7	94.8	100.0

The oldest of these fish was age VI^{+}.

Forty percent of the lake trout taken were in age group IV. Progressively smaller numbers were taken in age groups V through VIII and none were taken in age class IX and X. Ten percent of the lake trout were VII or older, and one fish was aged at XIII^{+}.

The average back-calculated length of each kind of fish at each annulus is given in Table 2. The average growth rate of each kind of fish is presented graphically in Figure 4. Since the average growth rate of the rainbow trout, cutthroat and rainbow X cutthroat hybrids were nearly identical, they were combined in one line for this figure.

The combined rainbow trout, cutthroat trout, rainbow X cutthroat trout hybrid group had the highest growth rate. The growth rate of brook trout nearly equaled that of the combined group until age II, however, after age II, the relative rate of growth for brook trout declined. Lake trout had the slowest growth rate until age IV. Their growth rate was greater from VIII to XIII than it was from I to VIII. Evidence suggested the greater growth rate in older fish was probably the result of a switch from a diet of plankton to fish. Martin (1951) also found higher growth rates in lake trout feeding on fish than on plankton.

Five lake trout from 46.5 to 53.1 centimeters in total length were marked with individually numbered T-tags in November, 1971 and recaptured twelve months later. The average growth increment of these

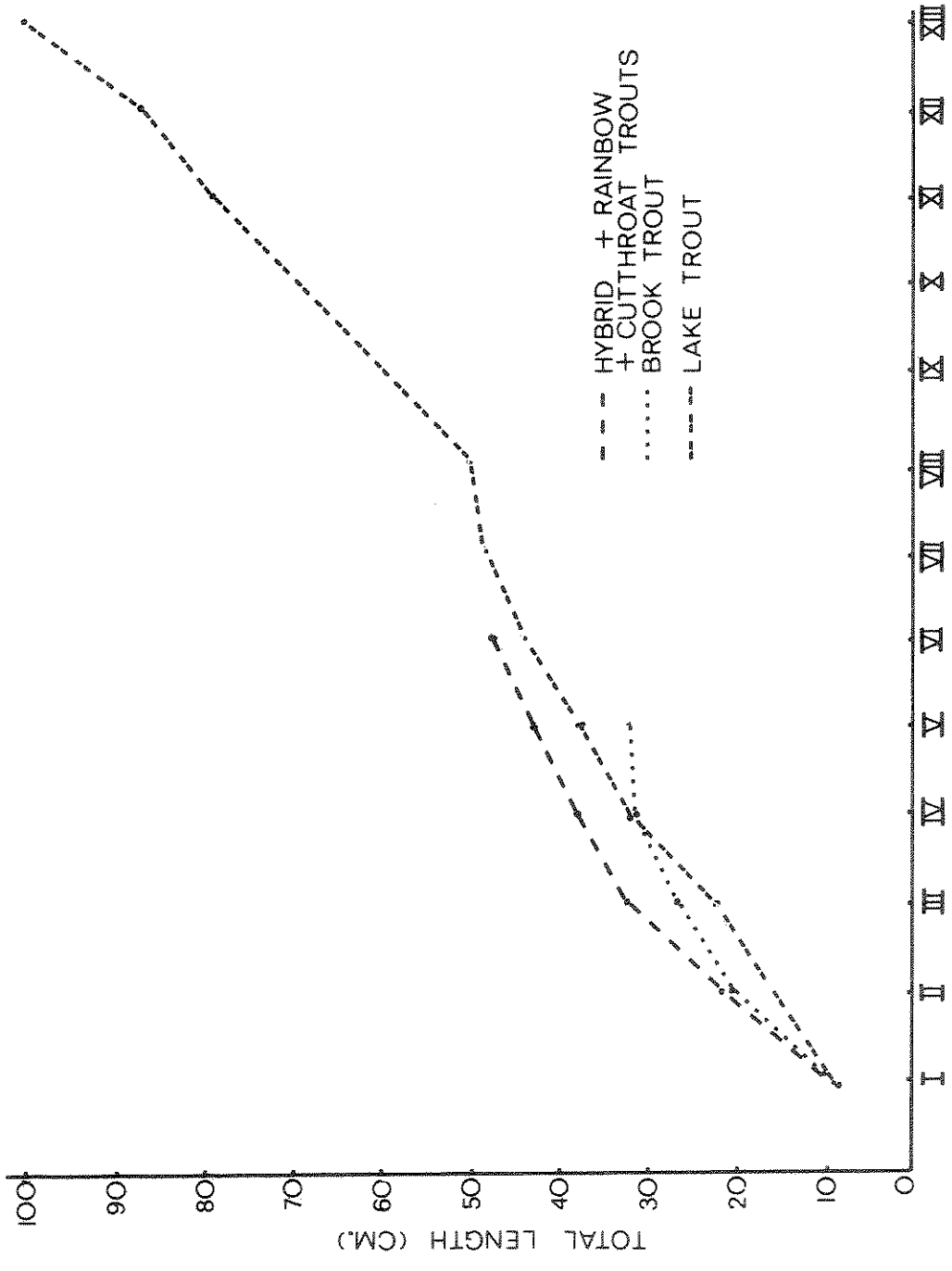

Figure 4. Average calculated growth rate of trouts taken during the study.

fish was 2.2 centimeters while the average calculated growth rate for fish of this length was 1.6 centimeters.

Population Estimates

Schnabel Estimate

A total of 1,248 trout were captured, marked and released from June 1 through September 24, 1972, for use in both the Schnabel and Petersen population estimates (Table 3). Rainbow X cutthroat hybrids

TABLE 3. THE NUMBER OF EACH KIND OF TROUT MARKED AND RELEASED MONTHLY DURING 1972. THE PERCENT OF THE TOTAL IS GIVEN IN PARENTHESES.

Trout Taxon	Month				Total
	June	July	August	September	
Rainbow	9	3	14	11	37(3)
Cutthroat	47	35	158	63	303(24)
Hybrid	70	46	207	178	501(41)
Brook	38	27	144	132	341(27)
Lake	9	8	4	45	66(5)
Total	113(14)	119(10)	527(42)	429(34)	1,248(100)

comprised 41%, brook trout 27%, cutthroat trout 24%, lake trout 5% and rainbow trout 3% of the total catch. Three-fourths of the fish captured were taken during August and September combined. This is probably the result of greater fishing effort and declining water levels during this time (Figure 5).

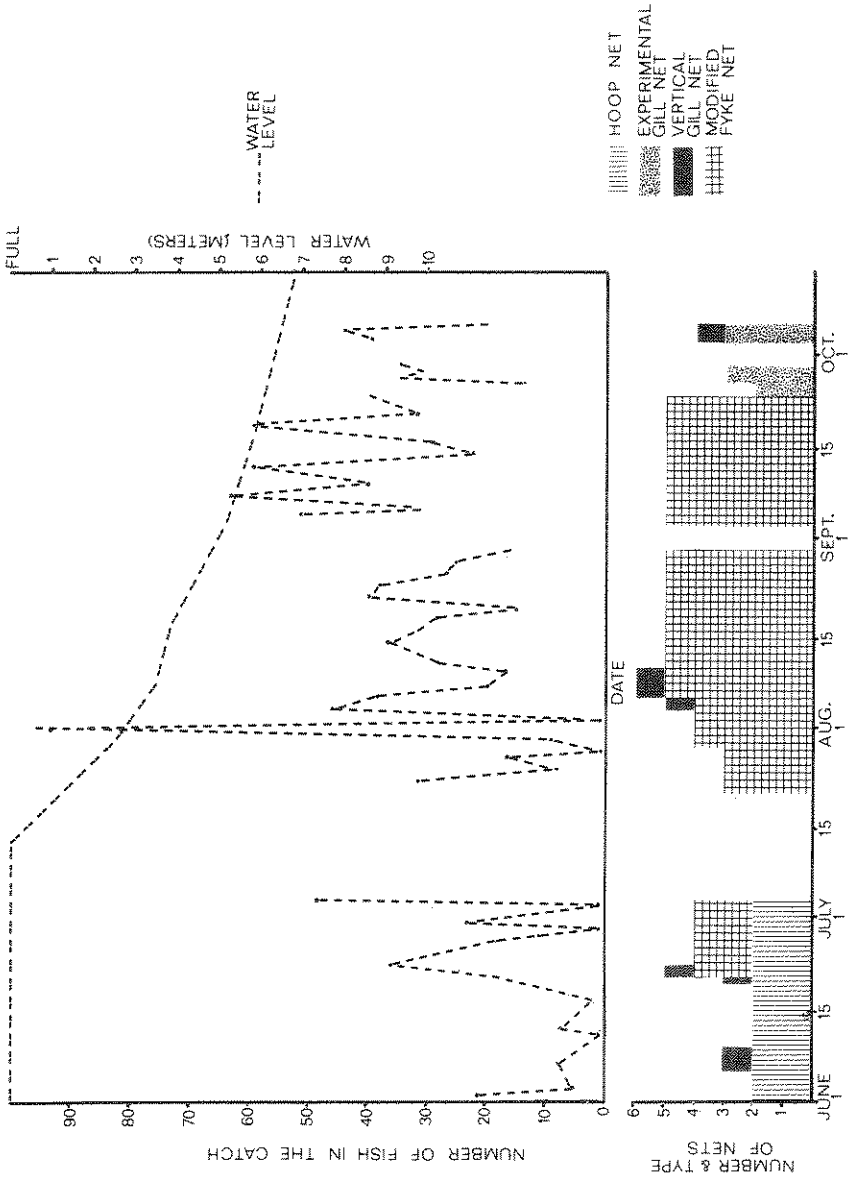

Figure 5. Use of nets, catch and water levels in Mystic Lake during 1972.

Fish were initially captured by hoop nets, electrofishing, vertical gill nets, modified fyke nets and angling. Hoop nets placed across the mouths of two streams at the north end of the lake during June (Figure 6) captured a total of 52 fish in 78 net sets (Table 4). A net set is one net fished for a 24 hour period. Six fish were

TABLE 4. THE NUMBER OF EACH KIND OF TROUT TAKEN BY FIVE METHODS OF CAPTURE DURING 1972. THE PERCENT OF THE TOTAL IS GIVEN IN PARENTHESES.

	Methods of Capture					
Trout Taxon	Hoop Nets	Electro-fishing	Vertical Gill Nets	Fyke Nets	Angling	Total
Rainbow	8	-	-	27	2	37(3)
Cutthroat	18	2	1	276	6	303(24)
Hybrid	17	4	10	455	15	501(41)
Brook	9	-	17	306	9	341(27)
Lake	-	-	-	56	10	66(5)
Total	52(4)	6(1)	28(2)	1,120(90)	42(3)	1,248(100)

captured by electrofishing in the streams above the hoop nets and vertical gill nets distributed over the deeper water in the southern one-half of the lake (Figure 6) took 28 fish in 17 net sets. Forty-two fish were captured by angling.

A total of 1,120 fish were taken in 317 fyke net sets with 89% of this total being taken in the nets having 1.3 centimeter square mesh. Nets were placed in 21 locations around the lake (Figure 6) having water depths of 1.2 to 2.4 meters and bottoms with gradual slopes. Not

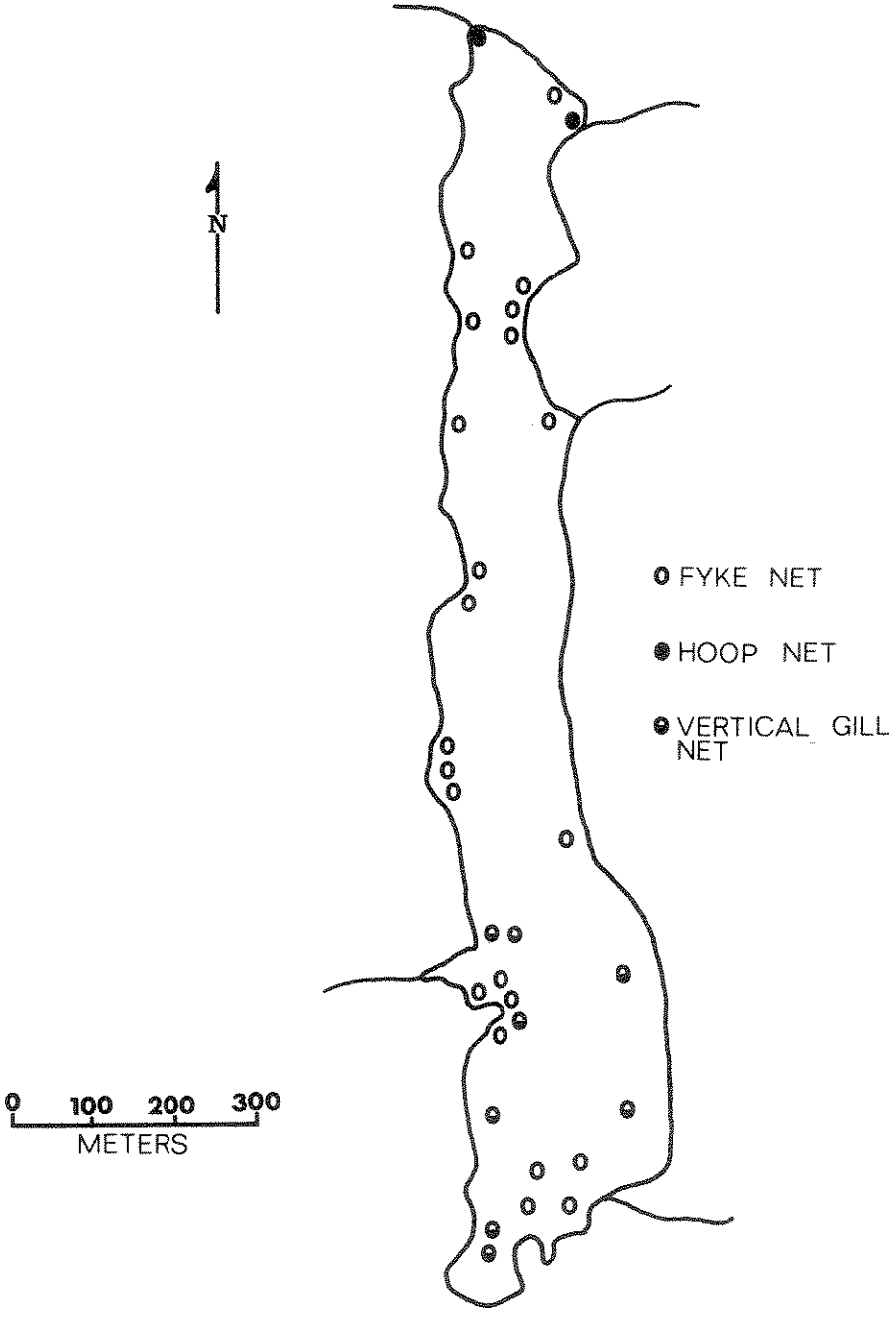

Figure 6. Map of Mystic Lake showing locations of fyke, hoop and vertical gill nets during 1972.

all areas of the lake received equal netting pressure with the majority of sets being confined to the northern and southern ends.

A requirement in making a valid mark and recapture estimate is that marked fish distribute themselves randomly throughout the population (Ricker 1958). In many studies attempts were made to compensate for possible non-random distribution of fish by applying equal fishing pressure around the entire lake. Because of the scarcity of suitable netting locations, not all areas in Mystic Lake received equal fishing pressure. To compensate for possible bias caused by the non-random distribution of fish, marked fish were transported some distance away from the site of capture before release. The continual decline in surface area and volume of the lake through the summer also forced the mixing of marked and unmarked fish.

A total of 743 marked fish were recaptured from July 23 to September 24 with 64% being taken in September (Table 5). The species composition of the recapture was similar to that of fish marked (Table 3) except hybrids were recaptured at a 9% higher rate than they were marked.

Fish were recaptured in fyke nets, vertical gill nets and by angling but over 95% of the recaptures came from 285 fyke net sets (Table 6). Of fish taken by this method, 75% were from 8.5 to 25.0 centimeters in total length. Only 35 fish were recaptured by vertical gill nets and angling, however, most of these were over 25.0 centimeters

TABLE 5. THE NUMBER OF TROUT RECAPTURED BY MONTH FOR THE SCHNABEL POPULATION ESTIMATE. THE PERCENT OF THE TOTAL IS GIVEN IN PARENTHESES.

Trout Taxon	Month			Total
	July	August	September	
Rainbow	1	6	14	21(3)
Cutthroat	6	65	87	158(21)
Hybrid	6	138	229	373(50)
Brook	2	41	137	180(24)
Lake	-	1	10	11(2)
Total	15(2)	251(34)	477(64)	743(100)

TABLE 6. THE NUMBER OF TROUT RECAPTURED BY METHOD FOR THE SCHNABEL POPULATION ESTIMATE. THE PERCENT OF THE TOTAL IS GIVEN IN PARENTHESES.

Trout Taxon	Methods of Recapture			Total
	Vertical Gill Net	Fyke Nets	Angling	
Rainbow	-	21	-	21(3)
Cutthroat	-	153	5	158(21)
Hybrid	6	349	18	373(50)
Brook	3	174	3	180(24)
Lake	-	11	-	11(2)
Total	9(1)	708(95)	26(4)	743(100)

in total length.

The number of "marked fish at large" (Table 7) for each kind was the number marked minus the known mortalities in that group which varied between 4 and 8%. Gerking (1952) also made compensation for

TABLE 7. CATCH STATISTICS, SCHNABEL POPULATION ESTIMATE WITH CONFIDENCE INTERVALS (C.I.), AND STANDING CROPS OF TROUT AT MAXIMUM AND MINIMUM POOL.

Trout Taxon	Total Recapture	Marked At Large	Estimated # (CI)	Total Weight (kg)	Standing Crop (kg/ha) Max.	(Min.)
Cutthroat	158	290	478 (402-554)	64.9	2.8	(10.1)
Hybrid + Rainbow	394	483	632 (568-696)	117.4	5.1	(18.3)
Brook	180	324	533 (453-613)	113.5	4.9	(17.7)
Lake	11	55	162 (64-260)	113.7	4.9	(17.8)
Totals	743	1,152	1,805	409.5	17.7	(63.9)

known mortality of marked fish. Rainbow trout were sampled in such small numbers that they were combined with the hybrids for a single estimate. Each estimate was made for all size groups combined because of the relatively small numbers obtained per size group. No compensation for growth and recruitment was necessary since the Schnabel method involves marking and recapturing simultaneously. The average weight of each kind of fish used in calculating standing crops was derived from the 1,017 fish from which scale samples were collected. Standing crop figures are calculated for the lake at both maximum and minimum pool. Since Mystic Lake is held at low water for at least six months a year, the standing crop figures for minimum pool are probably more realistic. Wohlschlag (1952) in a study on another fluctuating

reservoir concluded his standing crop figures at maximum drawdown were more realistic.

A total of 1,805 fish over 8.5 cm in total length weighing 63.9 kg/ha at minimum pool was calculated to be present in Mystic Lake (Table 7). There were three to four times as many brook trout and hybrid plus rainbow trout estimated to be present as lake trout, however, all three kinds had similar standing crops. The point estimate for the lake trout was less than the combined total taken during both years. Confidence limits were greatest for lake trout.

Petersen Estimate

Of the 1,248 fish captured and released during operations for the Schnabel estimate (Table 3 and 4), 943 also served as marked fish for the Petersen estimate. Recapture information for the Petersen estimate was gathered with 20 experimental gill net sets made from September 24 to October 5. Nets were set on the bottom in water from 2 to 9 meters in depth and moved daily until the entire perimeter of the lake had received equal fishing pressure (Figure 7).

The smallest brook, rainbow, hybrid, cutthroat and lake trout taken in the gill nets was 17, 17, 17, 20 and 27 cm long, respectively. Therefore, the respective population and standing crop estimates include only fish as large or larger than the above lengths. The number of "marked fish at large" (Table 8) for each kind was obtained by adding the number of fish larger than the minimum size when marked to

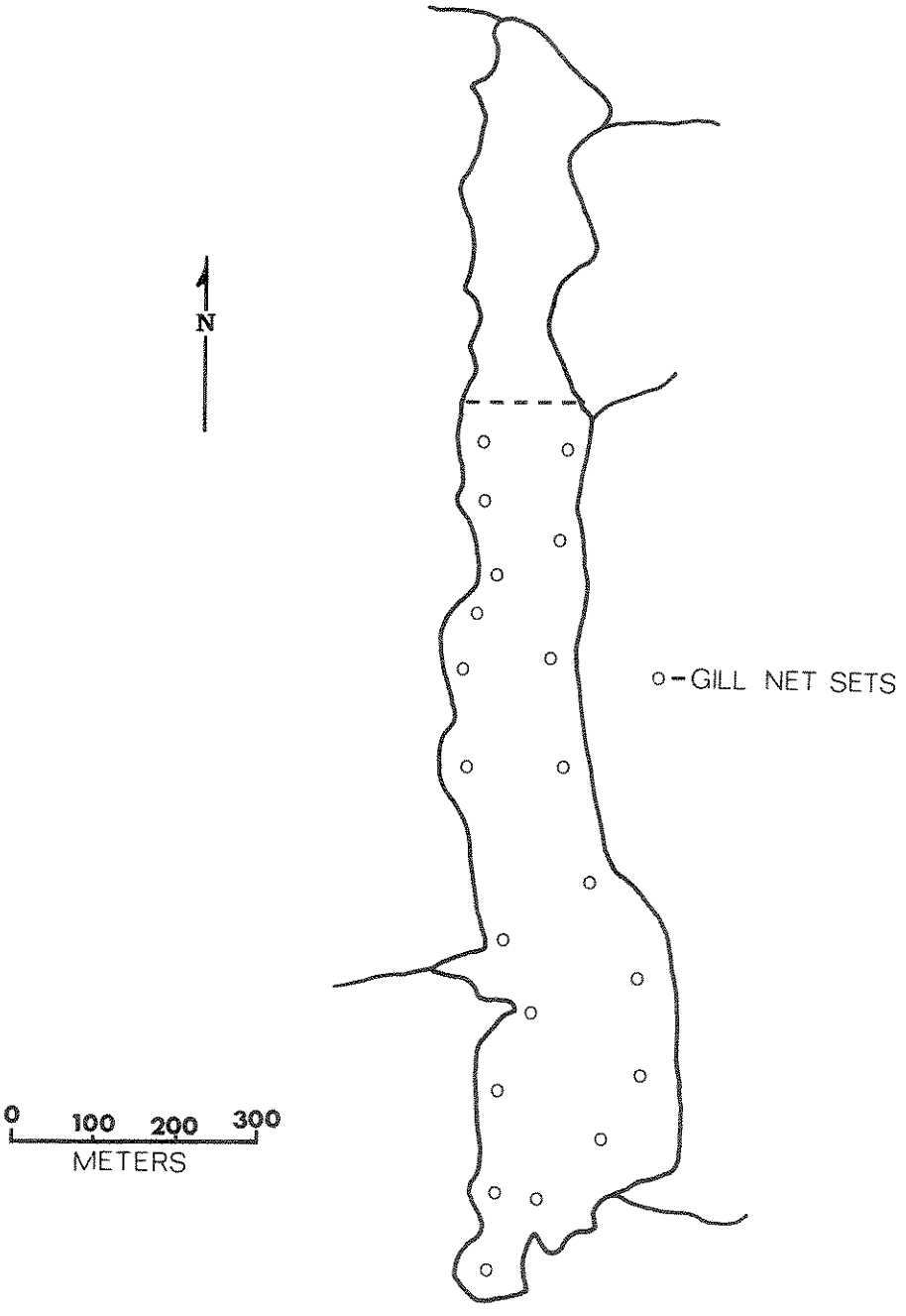

Figure 7. Map of Mystic Lake showing locations of gill net sets during 1972. Basin of lake north of dotted line is without water.

TABLE 8. CATCH STATISTICS, PETERSEN POPULATION ESTIMATE WITH CONFIDENCE INTERVAL (C.I.) AND STANDING CROPS OF TROUT AT MAXIMUM AND MINIMUM POOL.

Trout Taxon	Total Capture	Total Recapture	Marked At Large	Estimate (CI)	Total Weight kg	Standing Crop kg/ha Max.	(Min.)
Cutthroat	15	12	183	226 (174-278)	30.7	1.3	(4.8)
Hybrid + Rainbow	43	25	391	663 (501-825)	123.1	5.3	(19.2)
Brook	71	47	312	469 (393-545)	99.8	4.3	(15.6)
Lake	95	21	57	253 (73-345)	177.7	7.7	(27.8)
Totals	224	105	943	1,611	431.3	18.6	(67.4)

the number of those smaller than the minimum size but capable of attaining or surpassing it through growth by recapture time. This procedure lead to the elimination of about 20% of the total number of fish marked for the Schnabel estimate.

Compensation was also made for known mortality of marked fish. As with the Schnabel estimate, rainbow trout were combined with the hybrids for a single estimate and each estimate was made for all size groups combined. Standing crops were calculated using the same average weight for each kind of fish as derived for the Schnabel estimate.

A total of 1,611 fish weighing 67.5 kg/ha at minimum pool was estimated to be present by this method (Table 8). The combined hybrid and rainbow trout category had the greatest estimated number and lake

trout had the largest standing crop. The point estimate for cutthroat trout was less than the combined number taken during both years. Confidence limits were largest for the combined hybrid and rainbow trout category.

DISCUSSION

Age determinations showed yearly recruitment into all populations with the possible exception of the lake trout which may have had two (IX and X) missing age classes (Table 2). These "missing year classes" may have been present but not sampled or may actually have been absent because of unsuccessful spawning during those years.

In Maine, DeRoche (1969) found a drawdown of one foot at critical times on a lake resulted in a 90% loss of lake trout eggs. It is now a policy ~~in Maine~~ to have no drawdown between October 15 and May 1 on lakes containing lake trout. In Mystic Lake there appears to be only one suitable spawning location for the lake trout. It is the unsilted portion of a gravel bar (Figure 2). Drawdown during September and October exposes much of this bar and at least some of the lake trout eggs deposited on it. Greater than normal drawdowns could have eliminated the year classes in question. To insure the yearly recruitment of lake trout, the suitable portion of the spawning bar should be kept submerged and relatively silt free.

The growth rates of most of the fishes in Mystic Lake compared favorably with their average rates for the state. Although brook trout from Mystic Lake grew at a rate 32% less than the average for their species in lakes in Montana (Peters, 1964), they did grow at a rate similar to those in high non-regulated lakes in the Beartooth Mountains (Domrose 1963). Cutthroat, rainbow and hybrid trout in this

study had growth rates that were 21, 2, and 25% higher, respectively, than the reported state averages for lakes (Peters 1964). The growth rate of lake trout from Mystic Lake was similar to the state average for this species for the first two years of life but was less from age three to eight. However, the state average was based on only 32 fish, with the oldest of these aged as nine (Peters 1964). Growth rates for lake trout from age 8 to 13 were higher than most of the averages given by Carlander (1969) for the species over much of its range.

The total number of fish estimated to be in Mystic Lake by the Schnabel method is 11% higher than the number estimated by the Petersen method. This is probably the result of including smaller sized fish in the Schnabel estimate than in the Petersen estimate. I consider the Schnabel method to provide a more accurate estimate of the cutthroat, hybrid plus rainbow and brook trout groups because larger recapture samples were obtained for this method. Similarly, I consider the Petersen estimate for lake trout to be more accurate for the same reason. Also, in each of the above estimates, the range of the confidence limits expressed as a precent of the point estimate is less than its counterpart by the other method.

Although the Schnabel estimates include fish smaller than in the Petersen estimates, the standing crops for hybrid plus rainbow trout and brook trout calculated from both estimates are similar. The larger standing crop of cutthroat trout calculated from the Schnabel

estimate is believed to be the result of including fish smaller than those included in the Petersen estimate. The higher standing crop of lake trout calculated from the Petersen estimate is the result of their larger population estimate.

The total standing crop calculated from the Petersen estimate is about 5% higher than that calculated from the Schnabel estimate. This is the result of the higher number of lake trout estimated by the Petersen method coupled with their average weight being three times greater than that of any other taxon. The total standing crops calculated from both population estimates for maximum and minimum pool would probably rank as average and high, respectively, based on Carlander's (1955) compilations. At minimum pool, the standing crop calculated on a volume basis, which is only 3.7% of maximum volume, would have to be considered quite high.

LITERATURE CITED

Bissonette, G. K. 1971. A microbiological and chemical investigation of the effects of multiple use on water quality of high mountain watersheds. M.S. Thesis. Mont. State Univ. 130 p., Bozeman, Mont.

Carlander, K. D. 1969. Handbook of Freshwater Fishery Biology. The Iowa State Univ. Press, Ames, Iowa. 752 p.

_____. 1955. The standing crop of fish in lakes. J. Fish. Res. Bd. Canada, 12(4): 543-570.

DeRoche, S. E. 1969. Observations on the spawning habits and early life of Lake Trout. The Prog. Fish-Cult., 31(2): 47-62.

Domrose, R. J. 1963. Age and growth of brook trout *(Salvelinus fontinalis)* in Montana. Proc. Mont. Acad. Sci., 23: 47-62.

Fargo, R. C. 1969. History of Mystic Lake, unpublished mimeograph from files of City Engineer. Bozeman, Montana. 15 p.

Gerking, S. D. 1952. Vital statistics of the fish population of Gordy Lake, Indiana. Trans. Amer. Fish. Soc., 82: 48-67.

Martin, N. V. 1951. A study of the lake trout *Salvelinus namaycush*, in two Algonquin Park, Ontario, lakes. Trans. Amer. Fish. Soc., 81: 111-137.

Peters, J. C. 1964. Age and growth studies and analysis of bottom samples in connection with pollution studies. D. J. Completion Report. Project F-23-R-6. Mont. Fish and Game Dept. 76 p.

Ricker, W. E. 1958. Handbook of computations for biological statistics of fish populations. Fish. Res. Bd. Canada. Bulletin 119, 300 p.

Robson, D. S. and H. A. Regier. 1968. Estimation of population number and mortality rates, p. 124 to 158. In W. E. Ricker (ed.) Methods for assessment of fish production in fresh water. Biddles Limited, Guildford, England.

Vincent, R. E. 1971. River electrofishing and fish population estimates. Prog. Fish-Cult., 33(3): 163-167.

Wohlschlag, D. E. 1952. Estimation of fish populations in a fluctuating reservoir. Calif. Fish and Game. 38(1): 63-72.