A STUDY OF THE LARGEMOUTH BASS SPAWNING CONDITIONS, BEHAVIOR, AND LOCATIONS OF SPAWNING AREAS AT SPRING MEADOW LAKE

Submitted in Partial Fulfillment of the Requirements for Graduation with Honors to the Department of Biology at Carroll College, Helena, Montana

by PAULA K ROOS
April 4, 1986

This thesis for honors recognition has been approved for the Department of Biology by:

Dr. James J. Manion, Advisor

Dr. Jean Smith, Reader

Dr. Ruth Carrington, Reader

April 4, 1986

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

I wish to thank Stan Bradshaw, Paul Pacini and especially George Holton of the Department of Fish, Wildlife, and Parks for getting me started on the idea for this thesis and patiently helping me throughout the study. My parents, Paul and Kay, also very much deserve a note of thanks for finding a word processor for me to work on and copying the rough draft. I also wish to thank Dick Seitz for his generous help with the word processor. And of course Dr. Jean Smith, Dr. Ruth Carrington, and Dr. James J. Manion, the two readers and director of this thesis, receive an immense thank-you for meticulously combing this paper for its numerous mistakes!

ABSTRACT

For two months lasting from the middle of May till mid-July of 1985, a set of early, middle, and late observations were made upon the spawning of largemouth bass (*Micropterus salmoides*) at Spring Meadow Lake. A shoreline total averaged count of 333 bass was initially made. In the early investigations, two suspected spawning areas were observed, both of which proved to be nesting areas in the late investigations. During the middle observations, one possible and five probable spawning areas were detected. In the late investigations, six nests, five probable spawning areas, and five unlikely spawning areas were observed. Behavior of guardian male bass as well as location and description of each of these areas is given in the results. This study helped to confirm some spawning behavior and locate spawning areas. It also called into question the reliability of some reports on spawning behavior and conditions. It is hoped that this thesis will play a part in the determination of future construction work at Spring Meadow Lake with the idea of sparing valuable spawning areas of the largemouth bass.

LIST OF TABLES

LIST OF MAPS

INTRODUCTION

In order to make Spring Meadow Lake into a small park for the Helena public, much construction began to take place along its shorelines in September of 1984 and especially May through August of 1985. The construction included only the north and northwest shores except for the trail loop and foot bridges around the perimeter. Concern for the largemouth bass (Micropterus salmoides) arose in the fisheries division of the Montana Fish, Wildlife, and Parks. Since largemouth bass spawn along the shallow shorelines, the fish appeared to be in danger of losing many of their valuable spawning areas. To prevent this possibility, George Holton of the fisheries division suggested that it would be helpful to locate the spawning areas of these bass. While locating these spawning areas, however, I undertook to study the spawning behavior of the largemouth bass and conditions under which this spawning took place.

The history of Spring Meadow Lake actually began in 1928 under the operation of the Helena Sand and Gravel Company, which has no relation to the sand and gravel company operating today with the same name. After the devastation of the 1928 fire in the Helena area, the small gravel pit served as a convenient source of sand and gravel necessary for reconstruction in downtown Helena. Much of the gravel mined by the original Helena Sand and Gravel Company was also used by the railroad. As the company dug deeper, the cavity filled with water from underground springs. In about 1957, a new owner of the gravel operation gave instructions to create fish habitat by carving out the channels and islands which exist today on the east side of the lake. In October of 1964, the Helena Sand and Gravel operation closed down, but only after having created Spring Meadow Lake.

Spring Meadow Lake has an approximate surface area of 20 acres and a perimeter distance of about 2590 meters. It lies near the banks of Ten Mile Creek and is surrounded by cottonwoods, willows and grass. Largemouth bass, rainbow trout, perch, painted turtles, and muskrats are included in the habitants of this lake.

LITERATURE REVIEW

GENERAL CHARACTERISTICS OF LARGEMOUTH BASS

The largemouth bass is often found in open water and sometimes at considerable depths, but most of its activities are associated with the shoreline (Heidinger 1975, Scott and Crossman 1973). Scott and Crossman (1973) claim that this bass is rarely at depths of over 20 feet (6.1 m) and typically resides in habitats of soft bottom, stumps, and extensive submerged vegetation such as pond weed. As a matter of fact, Houser and Rainwater (1975) found extensive success rates in survival of largemouth bass after extreme flooding had occurred, causing a drastic increase in submerged vegetation.

The growth rate of largemouth bass is variable. Heidinger (1975) states that at the end of one year, a largemouth bass may be 2 to 14 inches (5 to 35 cm) long. Fish do not stop growing and thus their longevity influences their ultimate size.

Fishes exhibit senses of sight, hearing, smell, taste, and touch. Brown (1939) reports that the largemouth bass exhibits all of these senses, including differentiation of colors (cited in Heidinger 1975). Sound is the most effective type of longrange communication underwater. Whereas the inner ear of the bass detects high frequencies, the lateral line detects low frequencies such as those produced by forage fish swimming (Heidinger 1975).

SPAWNING BEHAVIOR OF LARGEMOUTH BASS

The largemouth bass belong to a group of fishes that prepare nests in their spawning activities. Kramer and Smith (1962) and Swingle (1956) showed that this bass begins spawning activity in the spring when water temperatures reach 60 to 75° F, although Allan and Romero (1974) claim spawning has been observed in waters of temperatures as low as 54° F (cited in Heidinger 1975). Scott and Crossman (1973) state that even when spawning activity begins at 60 F, most spawning occurs at 62 to 65° F. They also showed that the actual temperature range of spawning success remains questionable as shown by a report of sustaining populations of largemouth bass in Puerto Rican waters which average 78° F. Siler and Clugston (1975), however, found that extremely high temperatures may reduce survival of eggs and larvae, even if spawning is completed. Caldwell et al. (1957) found that even in a constant temperature spring in Florida, spawning occurs chiefly in spring and summer (cited in Heidinger 1975). Thus, it seems other factors such as day length must affect the spawning cycle. Brauhn and Holz (1972) showed that bass can be induced to spawn in late summer by changing the day length cycle (cited in Heidinger 1975).

Sexual maturity in largemouth bass appears to be more related to size than to age. James (1939) reported that female bass reach maturity when approximately 10 inches (25 cm) long whereas male bass may be mature at a smaller size (cited in Heidinger 1975). Scott and Crossman (1973) claim that this correlates to about 3 to 4 years for males and 4 to 5 years for females.

Preparatory to spawning the male bass selects a nest site, usually in water 1 to 4 feet (0.3 to 1.3 m) deep (Heidinger 1975, Scott and Crossman 1973). Observations of males guarding nests in 6 inches (15 cm) to 18 feet (5.5 m) of water have been reported (Heidinger 1975). Nests may be constructed anywhere in a lake, but most often are grouped near specific shorelines or in coves, as observed by Miller and Kramer (1971). These areas are warmest and provide some protection from winds. Miller and Kramer (1971) also showed that nests are often constructed to take advantage of protection given by rocks, stumps, or slopes (cited in Heidinger 1975). The male bass guards a large spawning area so that nests must be 6 feet (1.8 m) or more apart, as Carr

(1942) reported (cited in Heidinger 1975), and usually at least 30 feet (9.2 m) apart (Scott and Crossman 1973). Breder (1936) explained that if nests are less than 6 feet (1.8 m) apart, there is some obstruction between them to prevent visibility between nests (cited in Heidinger 1975).

Lakes offering a small variety of habitat types can be severely limiting to bass production. Observations made on Lake Mead nesting site variables did not indicate a lack of selectivity of site preference. In this study, nests were found on a variety of substrate, including bedrock, tamarisk rootlets, sessile filamentous algal mats, rocks, rubble, and gravel. No nesting sites were observed on dominant sand or silt. Many nests, however, were noted on typical substrate from which inch-deep silt or sand had been removed (Allan and Romero 1975).

Some nest failures in the Lake Mead study were attributed to steep gradients composed of loose material. Also, receding water levels and extreme wind condition caused excessive bank erosion and resulted in burial and/or suffocation of several nests. Nests subjected to wind and wave action were not productive. Heavy water surges as great as 10 feet (3.0 m) deep were recorded by divers during moderate windstorms. Nests so exposed produced no fry and disappeared during observation (Allan and Romero 1975).

Bass nests were not found in centers of dense vegetation, but locations near the edge were always selected. Cold weather and wind during the spring months have an adverse effect on spawning bass. Wind action causes movement of colder water from open basins into the exposed shorelines where bass spawn. A drop in water temperatures of 4 to 6° F and wave action caused bass to display erratic spawning behavior, often abandoning their nests (Allan and Romero 1975)..

Carr (1942) observed that the male bass, while nest-building, places his head in the center of the nest and sweeps debris out in front of him with powerful movements. Then returning with his head in the middle of the nest, he pivots around in a circle. The nest thus assumes a near circular shape with a diameter about equal to two times the male's length (Heidinger 1975), 2 to 3 feet (0.6 to 0.9 m) (Scott and Crossman 1973). Generally, nests built on hard substrate are shallower than those built on soft substrate (Heidinger 1975), 1 to 8 inches (2.5 to 20.3 cm) deep and often, the bottom of a nest contains roots of vegetation (Scott and Crossman 1973).

Few published records exist of actual observations of largemouth bass laying eggs. Most investigators such as Carr (1942), Kelley (1962), and Reighard (1906) believe the majority of spawning occurs near dusk or dawn, although some do lay their eggs in the daytime. Carr (1942) and Reighard (1906) state that after nest construction is complete the male becomes nervous and repeatedly leaves the nest in search of a ripe female. During courting behavior the male stimulates the female to lay her eggs by physical contact, both undergoing vivid color changes. The pair swim over their nest with their vents in as close contact as possible as the eggs and the sperm are released, resulting in fertilization. The pair then rests before this process is repeated several times. When the female deliberately leaves the nest, spawning ends and the male is left to guard the nest. The female may then continue to lay her eggs in other nests (cited in Heidinger 1975). Snow (1970) and Kramer and Smith (1962) reported successful bass nests to contain 5,000 to 43,000 eggs. Therefore, it is obvious that the number of eggs found in wild nests does not represent the eggs from only one female bass. One nest as reported by Allan and Romero (1975) was observed to contain eggs, sac-fry and new swim-up fry (cited in Heidinger 1975).

Little is known about the spermatozoa of largemouth bass. One important property, however, is their inability to live for over approximately one minute after they are shed. There is little chance, therefore, of hybridization caused by drift to the nest of another species of fish (Heidinger 1975). The ovaries of a ripe female bass contain 2,000 to 145,000 eggs as reported by Carlander (1973) and Bishop (1968) (cited in Heidinger 1975). This correlates to about 2,000 to 7,000 per pound of female as stated by Scott and Crossman (1973). Fertilized eggs of largemouth bass are yellow to orange, spherical, adhesive, and about 0.05 to 0.07 inches (1.4 to 1.8 mm) in diameter as reported by Meyer (1970), Carr (1942), and Kelley (1962) (cited in Heidinger 1975), (Scott and Crossman 1973).

After fertilization, the eggs settle to the bottom of the nest and adhere to the substrate. The male bass then continually fans the eggs with his fins, causing a current to keep the eggs free of silt. While fanning the eggs, the male guards the nest from predators such as bluegill sunfish. Slow moving organisms such as snails, dragonfly larvae, and aquatic beetles are ignored (Heidinger 1975). Kramer and Smith (1960) and Carr (1942) found that other species of fish are allowed to lay their eggs in the bass nests and the male bass aerates and protects these eggs as his own (cited in Heidinger 1975), (Scott and Crossman 1973).

Because of hormonal factors, male bass do not eat when they are guarding the nest or fry. To remove a potential predator from the nest, the bass simply "mouths" the intruder. The male bass continues to guard the young fish for several weeks after they hatch. Since much stress is placed on the male bass during spawning, many weak ones probably die at this time (Heidinger 1975).

In a Lake Mead study, typical guardian male behavior was to threaten attack by moving toward the diver and flexing gill covers, sometimes resorting to repeated physical assault. Late-nesting males were less aggressive than males of optimum-temperature nests (Allan and Romero 1975).

Swim-up fry from adjacent nests often converged so that one guardian ended up with as many as three swarms. The male guardian will protect a swarm till it reaches the fingerling stage, about 1 inch (2.5 cm) (Heidinger 1975).

As water temperature increases, it takes less time for the transparent eggs to hatch (Heidinger 1975), (Scott and Crossman 1973). Carr (1942), Johnston (1953), Kelley (1962), and Meyer (1970) reported the size of the fry at hatching to range from 0.12 to 0.22 inches (3 to 5.5 mm) in total length, usually ranging from 5,000 to 7,000 in number (cited in Heidinger 1975), (Scott and Crossman 1973). Time required for hatching is generally between 48 and 72 hours (Coutant 1975).

Johnson (1953) reports that at this time the larvae have no mouth and must gain all nourishment from the yolk sac, lying on their sides in the nest, only able to "right" themselves and rise from the nest after their swim bladders have begun to inflate (cited in Heidinger 1975). Similarly to the hatching of the eggs, the rate of larvae development increases with increase of water temperature (Heidinger 1975). Fry become free-swimming after about 240 hours (Heidinger 1975) and (Scott and Crossman 1973), and must eat within six days or they will die. The small bass fry do not feed at night, so to conserve energy during the night fasting period, they settle to the bottom and their metabolic rate is reduced (Heidinger 1975). These fry may remain in the nest for as long as 31 days (Scott and Crossman 1973).

Hatching success in a suitable environment may exceed 80%. Predation and environmental factors, however, can cause great losses of eggs and larval fish. Success of the guarding of the nest by the male bass depends upon the physical placement of the nest, the male's ferocity, and the number of predators around. If the nest exists near large numbers of smaller bluegills, the bass has little chance of successfully protecting his brood. Such predation can lead to elimination of a year-class of bass (Heidinger 1975).

Allan and Romero (1975) claim that should a sudden drop in temperature occur, the male deserts his nest, (cited in Heidinger 1975), (Summerfelt 1975). Kelly (1968) and Bradenhuizen (1969) found that extremely high temperatures may reduce survival of eggs and larvae, even if spawning is completed (cited in Siler and Clugston 1975). Apparently, the fanning action of the male is necessary for egg survival. Removal of the male bass from the nest site by angling results in complete mortality of the eggs as well. The released male bass, however, ordinarily returns to his nest (Heidinger 1975). A drop in water level also proves detrimental to hatch success due to wave action and temperature fluctuation (Summerfelt 1975).

Other factors affecting survival were studied in the Lake Mead study. It was observed that large amounts of excape cover proved desireable for fry and fingerling survival. Flooded terrestrial plants, for example, act as cover for excape as well as cover for bass prey (Allan and Romer 1975). Allan and Romero (1975) also found that predation by the bluegill (Lepomis macrochirus) as well as by older fry and fingerling upon smaller fry and fingerling have detrimental affects upon survival as well. For example, 1 to 2 inch (2.5 to 5.1 cm) fry prey upon 1/4 to 3/4 inch fry (6 to 18 mm), 3 inch (7.6 cm) fingerling prey upon 1 inch (2.5 cm) fry, and 6 inch (15.2 cm) fingerling prey upon smaller sizes (Allan and Romero 1975). These investigators also found that food availability, such as zooplankton obviously limits survival of the swarms as well (Allan and Romero 1975). Aggus and Elliot (1975) also claim that cover influences early survival of young bass but that rate of growth during this period may be more important to annual survival. They also state the importance of proper feeding habits of the fry.

In summary, the size of a bass year-class depends primarily on survival of the young during the first few months of life. Heidinger (1975) explains that although data on reproductive potential of the bass is available, to predict what percentage of the eggs and young fish will survive in a given lake is, at this time impossible. Eipper (1975) states that such biological factors as diseases, fungus, predation, and starvation, as well as physical and chemical factors such as silt concentration, pH, light, temperature, and wind all play an integral part in determination of success of hatches.

MATERIALS AND METHODS

EARLY OBSERVATIONS

My early observations began May 15 of 1985, before I had a boat in which to row around the lake, and lasted for two weeks. During this time I walked around the shoreline noting spawning areas, behavior, and the number of bass.

I numbered the areas of my observation. The sizes of the areas varied from small coves of 1.5 m. (5 ft.) in diameter to expanses of shoreline covering one whole side of the lake. Since some large areas showed no evidence of spawning, I was able to keep a few of these larger areas undivided. If during my observations, however, I noted differences in bass behavior between two adjacent areas of shoreline, I subdivided the two areas by number in order to emphasize these potential differences in my future observations.

MIDDLE OBSERVATIONS

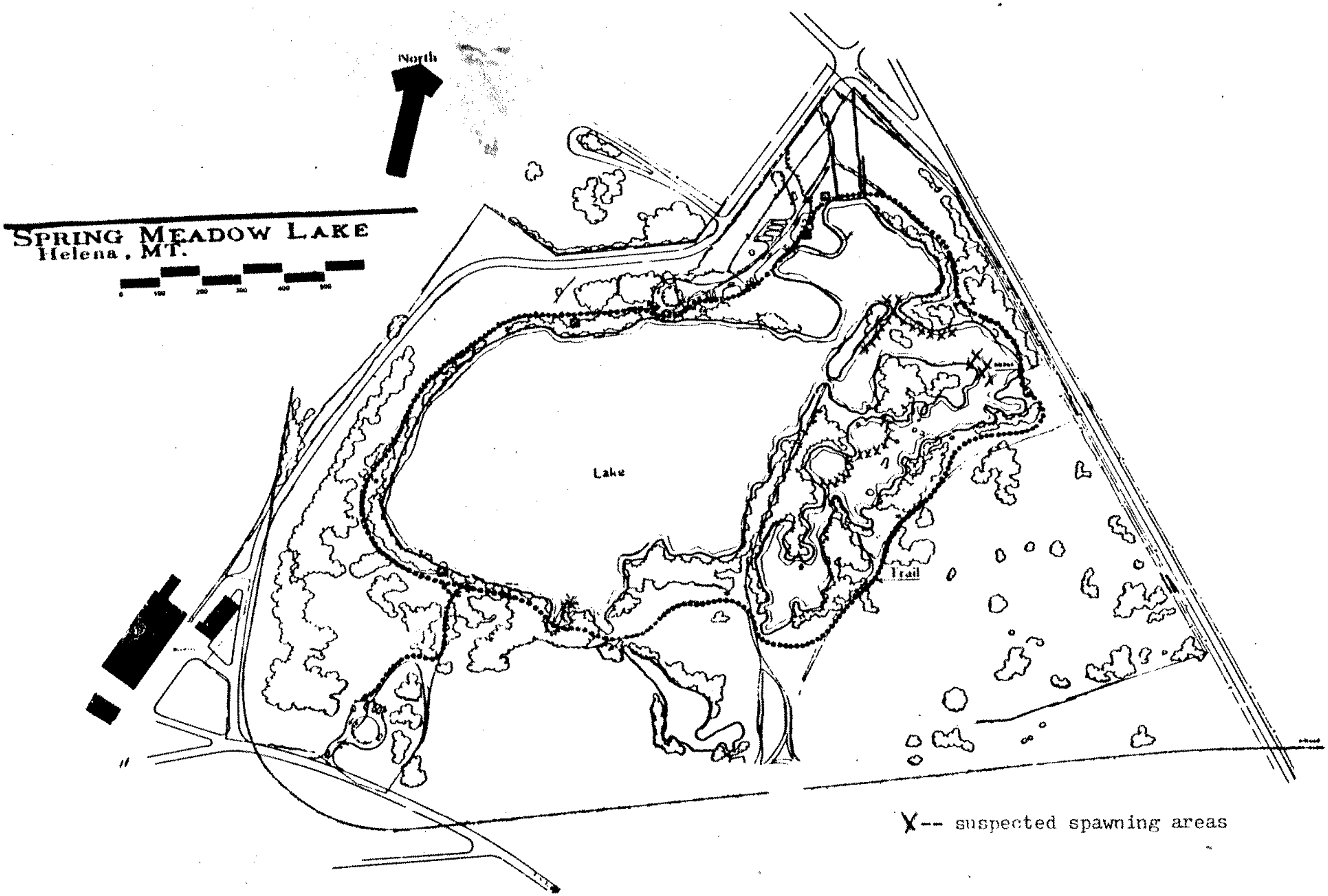
On May 28, I bought a boat in order to increase the area of my observations. For these observations, which lasted another two weeks, I rowed around the whole perimeter of the lake in early mornings and late evenings when the wind was calm and the reflection from the sun was at a minimum. Here, I again attempted to find areas of obvious spawning, also noting other types of fish present.

On tips from George Holton and Stan Bradshaw at the Department of Fish, Wildlife, and Parks, I began to concentrate on some specific areas at which some spawning had been suspected (see Map 1). I thus continued to spend most of my hours in the eastern part of the lake, returning only every two or three days to the large western part of the lake in order to check for any missed spawning areas.

LATE OBSERVATIONS

From June 15 through July 17, when observing the areas of most probable spawning, I sat quietly in the boat for periods of 15 to 30 minutes in each spot. Specifically, I was looking for nests, spawning pairs of bass, or male bass guarding nests. In this latter case, solitary bass of medium to large size, approximately 8 to 10 inches (20.3 to 25.4 cm) swimming monotonously about a definite area drew my attention. When I found such areas, I merely observed the behavior of the supposed guardian, took the water temperature, and wrote down details of the lake bottom material and shoreline vegetation of the area. To detail the lake bottom and attempt to see the nest, I used the underwater viewer for clearer observations.

MAP 1 Suspected spawning areas as given by Fish, Wildlife, and Parks



RESULTS

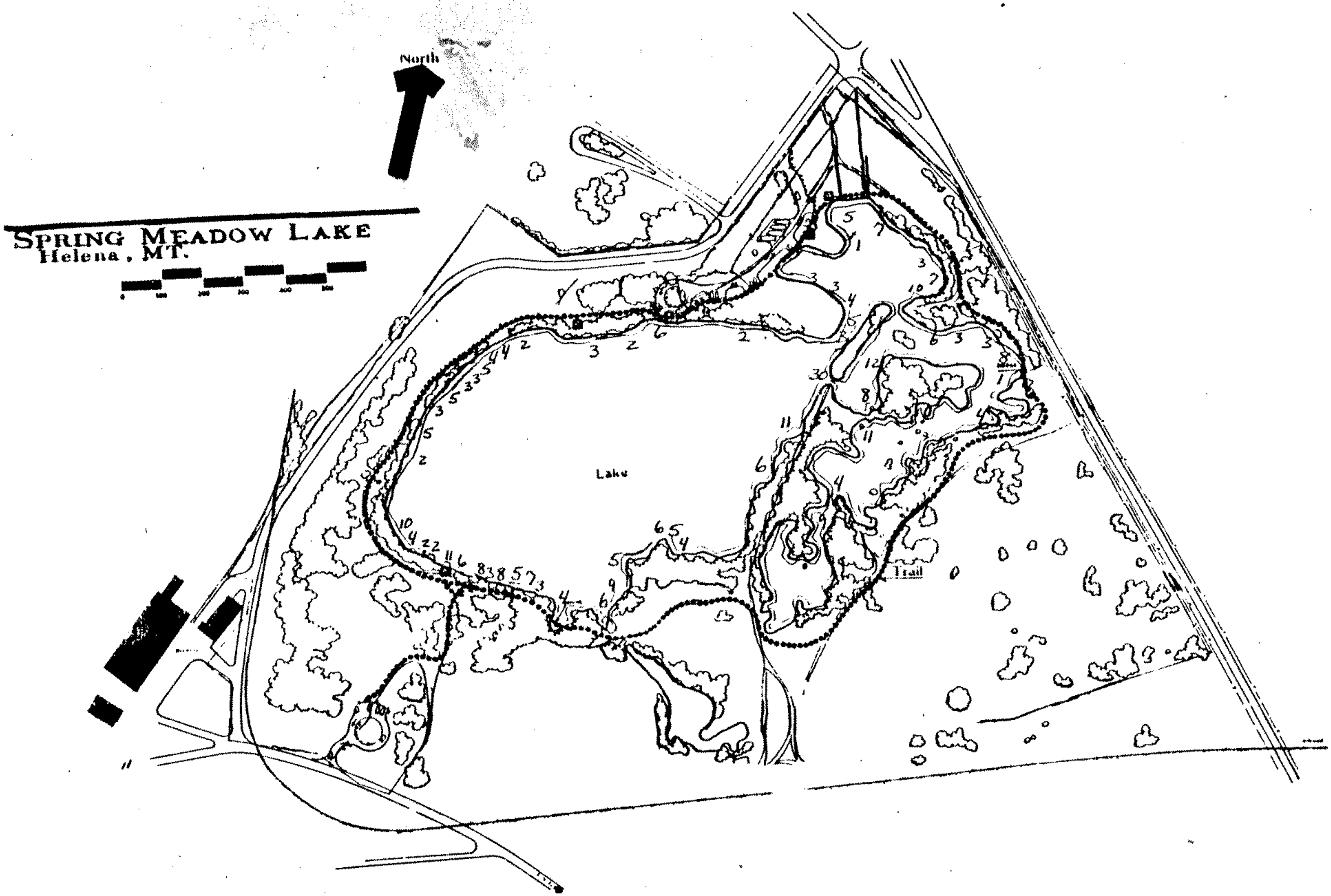
EARLY OBSERVATIONS

In order to note the number of bass detectable along the shoreline and their normal behavior, my early observations consisted of a set of counts on various days which I have averaged for each area (see Map 2), as well as short descriptions of bass behavior. Temperature of the shallow water during these early observations was in the range of 60 to 64° F.

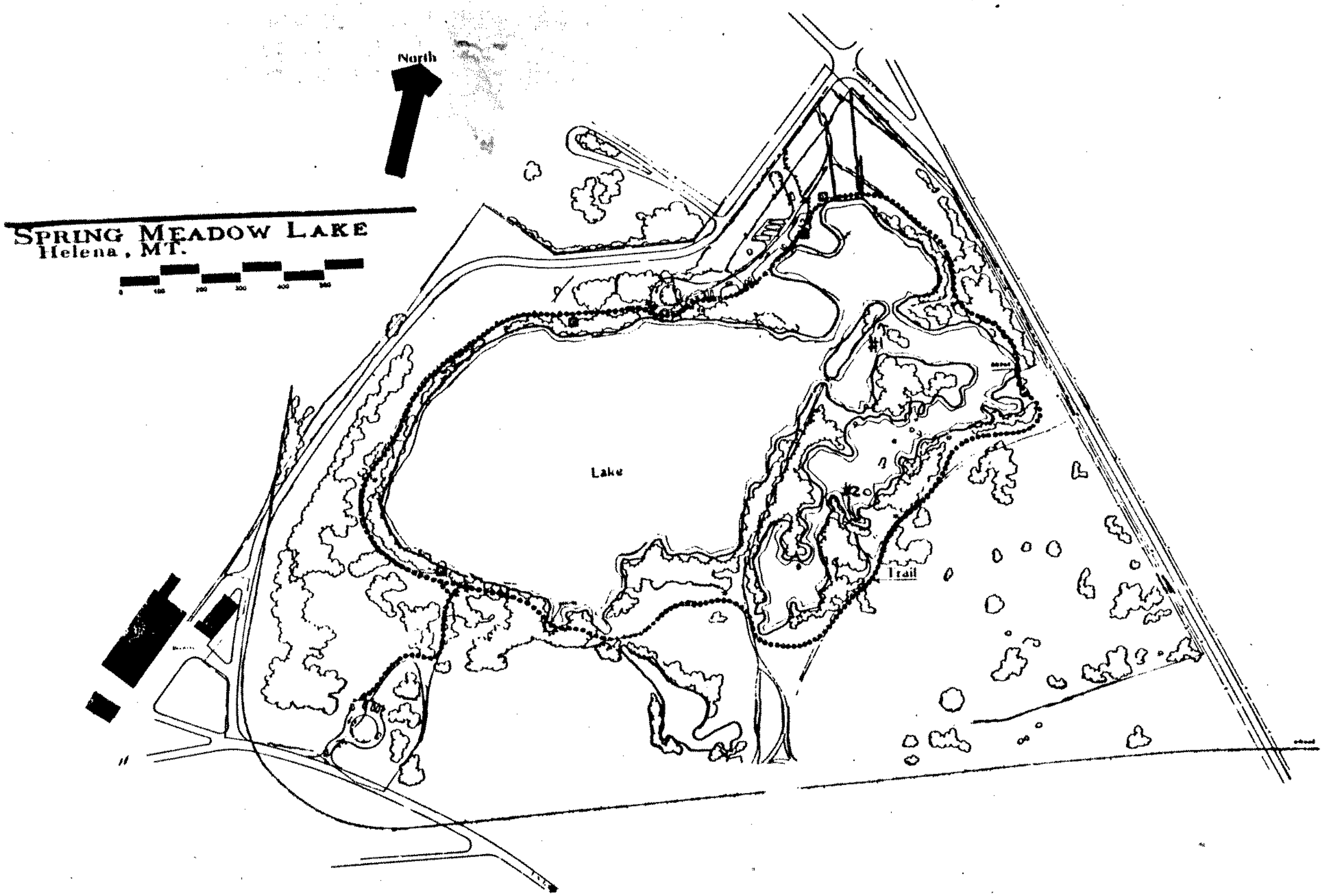
The majority of bass I observed along the shorelines swam continuously in schools of what appeared to be fixed numbers. Upon detecting my movements, the school always retreated to an adjacent area for about one minute's span before venturing back. If I continued to move about, no bass returned to the area. The schools spent most of their time swimming parallel to and in varying distances from the shoreline.

Large, solitary bass were occasionally seen darting out from the banks, apparently frightened by my movements along shore. If I remained motionless, the large fish always returned. These occasions gave me reason to suspect spawning activity in the area, and are marked accordingly as areas #1 and 2 on Map 3.

MAP 2 Average area counts of Largemouth bass



MAP 3 Suspected spawning areas of Early Observations



MIDDLE OBSERVATIONS

After conferring with Stan Bradshaw and George Holton at the Department of Fish, Wildlife, and Parks, I spent most of my hours on the eastern part of the lake where they had suspected spawning activity. Concentrating on those areas marked on Map 1, I found numerous spawning possibilities as shown and described on Map 4 and Table 1.

I distinguished at this point between possible and probable spawning areas. Those labeled possible spawning areas were characterized by water of 0.2 to 4 m. (7.8 in. to 13 ft.) in depth, without profuse bottom vegetation, with a gentle slope, and with medium to large bass of from 3 to 5 in number. The probable spawning areas were conversely defined by solitary large bass patrolling an area of approximately twice the length of the bass in radius, of shoreline depths of 0.2 to 4 m. (7.8 in. to 13 ft.), and also without sharply inclined bottom or profuse vegetation. The main point of distinction between the two area types is that, in the latter, a single large bass patrolled a definite area whereas in the former, one or more bass were seen swimming about in an undefined and large expanse of water. Temperature was found to be similar in all area types. The temperature ranged from 62 to 64 $^{\circ}$ F in the middle observations.

MAP 4. Suspected spawning areas of Middle Observations as they apply to Table 1

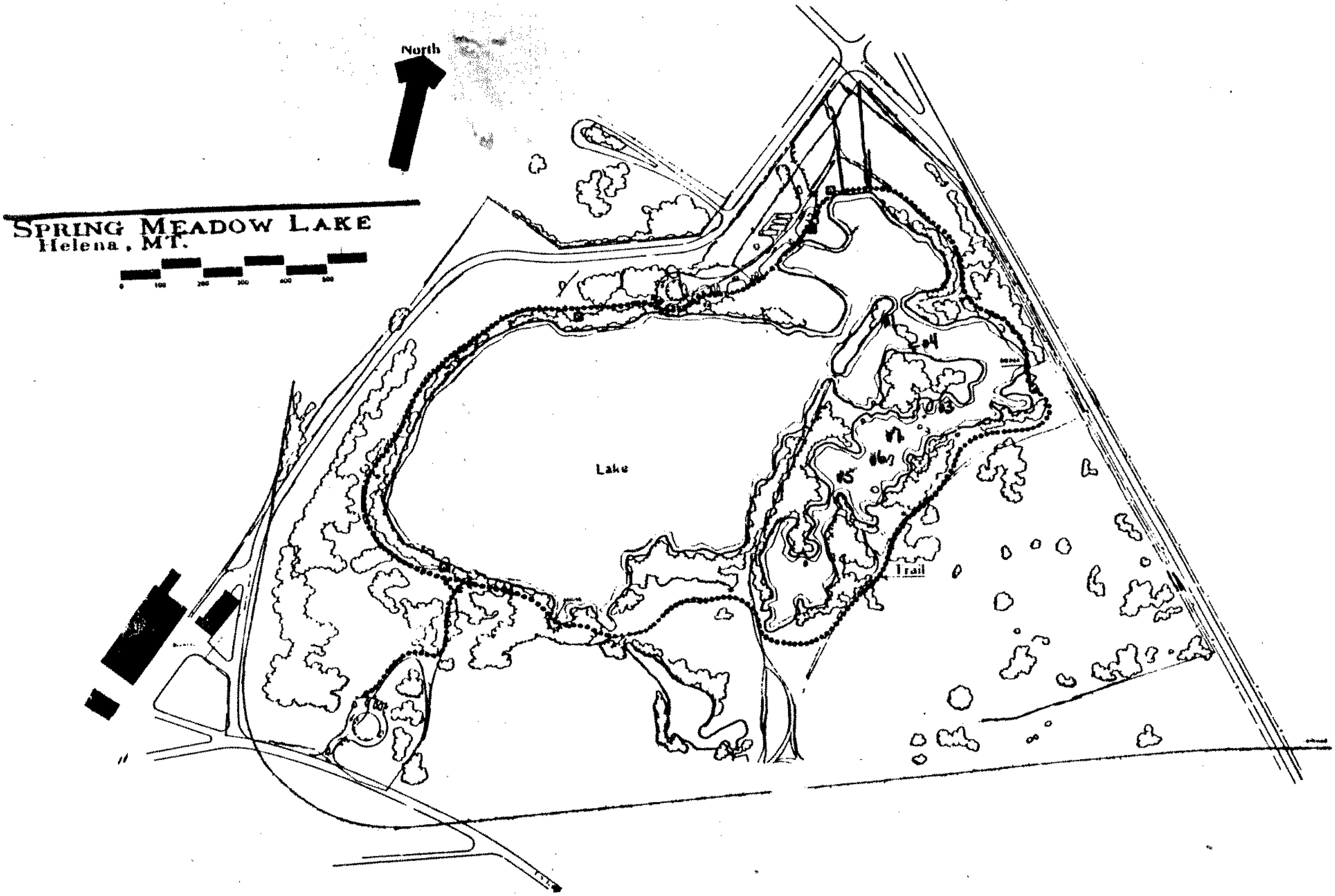


TABLE 1 Probable and possible spawning areas of Middle Observations as they apply to Map 4.

AREA #	1	3	4	5	6	7
AREA TYPE	probable	probable	possible	probable	probable	probable
DEPTH RANGE	0.5-1 m	1 m	1 m	1-1.5 m	1-2 m	1-1.5 m
BASS PATROL	large, solitary bass	large, solitary bass	5 medium sized bass	1 medium sized bass	1 medium-sized bass	1 medium-sized bass
DESCRIPTION	wide channel, small inlets to shoreline, protected on western and northeastern sides by shrubs, level bottom, low silt, moderately rocky and vegetative offshore.	small cove, protected all sides by shrubs, narrow entrance on southern side, moderate silt, level bottom, sparse rocks, vegetation in middle.	wide channel, gradual slope, moderately rocky and vegetative, fine soil.	edge of deep pool, slight incline, heavily silted near shore, fine soil and rocky offshore with moderate vegetation.	similar to # 5	similar to # 5

LATE OBSERVATIONS

I concentrated my observations to areas of possible and probable spawning, while occasionally spot-checking other areas of no known spawning activity. I was able to define three distinct groupings of spawning activity for the lake shoreline.

Areas guarded by a single large bass and which sometimes showed the presence of bass fry were grouped as spawning areas shown in Table 2. Areas which had more than one bass at a time staying in the area or showed the presence of fry were designated probable spawning areas shown in Table 3. Finally, those areas showing no bass patrol aside from the common course of the bass schools were designated unlikely spawning areas (where no spawning activity was seen) and are shown in Table 4. Unlikely spawning areas are included in the results to define such conditions under which no spawning activity was suspected. These three tables coincide with Map 5. Temperature range was found to be uniform throughout all area types and thus was not considered a factor in determination of spawning sites. This range during the late observations was 65 to 71° F.

TABLE 2 Spawning areas of Late Observations as they apply to Map 5.

AREA #	1	2	3	5	6	7
DEPTH RANGE	1 m	1 m	1 m	1-1.5 m	1-2 m	1-1.5 m
BASS PATROL	medium-sized bass present through Late Observations.	solitary, large bass.	see Middle Observations # 3, bass patrol gone at end of Late Observations.	1 large bass swam alone against schools, disappeared at end of Late Observations.	1 large bass swam alone.	1 large bass swam alone, disappeared at middle of Late Observations.
FRY PRESENCE	11- 2.5 cm fry seen approx 1 wk. I spotted this patrol.	30- 5.1 cm fry seen 2 wks. after patrol first noticed.	15- 5 cm fry seen approx. 2 1/2 wk after patrol began.	none seen	none seen	none seen
DESCRIPTION	see Middle Observations # 1	inlet, protected 3 sides by shrubs, north side open, level bottom, heavy silt, slight vegetation, few rocks.	see Middle Observations # 3	see Middle Observations # 5	similar to # 5, more offshore	similar to # 5

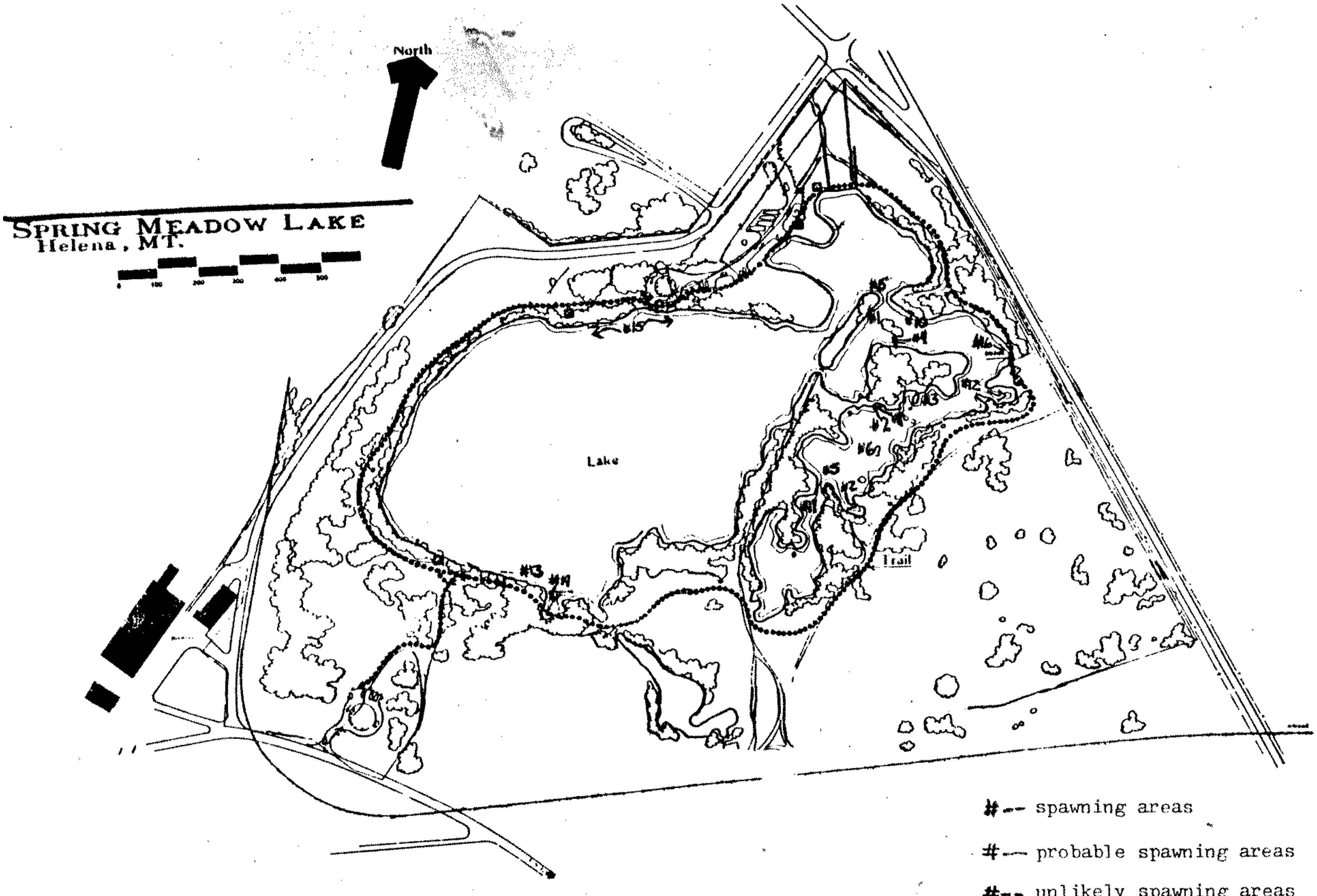
TABLE 3 Probable spawning areas of Late Observations as they apply to Map 5.

AREA #	4	8	9	10	11
DEPTH RANGE	1 m	0.3-1.5 m	0.2-1 m	0.5-1 m	0.2-0.8 m
BASS PATROL	no solitary patrol, bass schools present.	occasional solitary patrol by medium-sized bass, schools of bass common	no solitary patrol, bass schools present.	occasional solitary patrol by medium-sized bass, schools of bass common.	no solitary patrol, many medium-sized bass
FRY PRESENCE	30- 8 cm fry	2 swarms of 20- 2.5 cm fry	20- 8 cm fry	none	3 swarms: 1 of 40- 5.1 cm fry; 1 of 30- 8 cm fry; 1 of 45- 8 cm fry
DESCRIPTION	see Middle Observations # 4	shoreline, slight decline from shore, not protected on eastern and southern sides, vegetation offshore, some rocks, silt moderate	open area, protected on eastern side by trees and shrubs, gradual decline from bank, moderate silt, moderate rock cover.	shoreline, fairly protected by shrubs, somewhat open on eastern side, slight vegetation, few rocks, low silt content	wide and shallow channel, fairly level bottom, protected from wind by tall shrubs, silt heavy with slight vegetation, few rocks

TABLE 4 Unlikely spawning areas of Late Observations as they apply to Map 5.

AREA #	12	13	14	15	16
DEPTH RANGE	1.5-2.5 m	0.2-0.8 m	1-2 m	rapid slope from shore	0.8-1.5 m
BASS PATROL	no bass seen	many bass ranging from small to large size common in schools, no solitary patrols	little bass activity	many bass of small to medium size common in schools, no solitary patrols	few bass seen, no solitary patrols
FRY PRESENCE	none	none	none	none	none
DESCRIPTION	inlet, protected by shrubs, open on western end, level bottom, much dead brush in water, extreme silt, no rocks.	shoreline, unprotected on 3 sides, fairly sharp decline from shore, bank over-hang, silt negligent, rocks moderate, vege-tation offshore	inlet area, fairly well protected by shrubs, level bottom, heavy vegetation, turtles and muskrats common to area	shoreline, unprotected on eastern side, sharply sloping bottom heavy rock cover, little vegetation near shore	slight inlet, fairly protected, level bottom, few rocks, vegetation, fine soil, trout and blue-gill sunfish common

MAP 5 Spawning, probable spawning, and unlikely spawning areas of Late Observations as they apply to Tables 2, 3, and 4



DISCUSSION AND CONCLUSIONS

EARLY OBSERVATIONS

Bass counts averaged on Map 2 are given to describe an estimated number of the largemouth bass that were studied at Spring Meadow Lake. Since most bass activities are associated with the shoreline, the numbers are assumed to be fairly indicative of the total bass population.

During this time, the temperature rose from 60 to 63° F. Bass, therefore, should have begun spawning activities. Behavior that is characteristic of a male guarding a nest was observed in a few areas as marked on Map 3. While guarding a nest, a male bass would usually swim in some roughly-defined path, occasionally chasing intruders out of his territory.

The two areas studied in early observations showed male guardians of varying behavior. One male was seen patrolling area #1 whereas three different males patrolled area #2. The #1 male showed more of a definite pathway of guard than did the three guardians in area #2. None of these males, however, were ever seen to chase an intruder out of his territory.

The behavior of non-spawning bass observed coincided with past studies in their tendency to aggregate into schools and remain near the shoreline. This habit of aggregation provided a point of distinction between non-spawning and spawning bass. Whereas direct observation of a male bass nest-building or a pair of bass spawning did not occur, a male bass guarding a nest could be easily detected, since this activity required that he did not swim in a school, but rather, in a solitary path.

MIDDLE OBSERVATIONS

The distinction made between possible and probable spawning areas in middle observations was one of bass patrol. A probable spawning area showed a definite patrol by a guardian bass whereas a possible spawning area showed random movement of one or more bass in a large and undefined area. The other factors of the areas included water depth of 0.2 to 4 meters (7.8 in. to 13 ft.) lack of profuse bottom vegetation, and a gentle or nonexistent floor slope. Whereas these factors are included as criteria for the two area types, most of the shoreline of the eastern part of Spring Meadow Lake fit this description. For example, although the lake contains much floor vegetation, most of these submerged plants grew at a distance from the shore, at least giving room enough for nest-building on the shoreline. Likewise, in this eastern portion of the lake, most of the shoreline showed a very gradual slope towards the middle of the lake, a necessary condition for spawning success according to the literature. Finally, it can be seen from Tables 1,2, and 3 that no area with water depth over 2 meters was considered a possible, probable, or spawning area, even though the upper limit was 4 meters (13 ft.). At depths over 2 meters (6.5 ft.), the bottom vegetation and slope of the floor often became inhibiting variables.

Although water temperature increased during the middle observations, it did not appear to determine spawning sites. This finding could be a result of the fairly even temperature of shoreline areas of similar depth, within 0.2 to 2 meters (7.8 in. to 6.5 ft.).

The bass in area #3 showed a very definite path of patrol in guarding his nest. His path was roughly the shape of an ellipse approximately 2.5 m. (8 feet) by 6 m. (20 ft.) and close to the shoreline. Although a nest was not observed, there were two strong possibilites for a nest location, both very protected by the brush of the bank. Although the pathway and both supposed nest locations existed entirely over a silt bottom with few rocks, there was submerged vegetation at a distance from the shore. This bass swam continuously in his path and chased two bass intruders out of his territory while observations were made. This behavior was observed near the end of Middle Observations, in mid-June.

Area #4 was suspected at this time of being a possible spawning area. The water depth and the type of bottom coincided with the literature reports of spawning areas. The presence of four medium-sized bass which did not school together but rather roamed the area individually also provided some evidence for spawning, although no nests were seen and no actual guarding the the four bass was detected.

The solitary bass in area #1 did not swim a continuous unchanging path as did bass #3. Rather, this guardian seemed to hover in a small inlet, the most likely place for the nest, only moving away from shore occasionally for short intervals.

The three bass in areas #5, 6, and 7 were all approximately medium-sized and behaved in much the same manner. Unlike bass #3 and more like bass #1, these three appeared to hover in their respective nest-sites for long periods of time, only wandering away infrequently for short intervals, sometimes to chase intruders out.

The literature states that a male guardian continuously fans the eggs with his fins to keep them free of silt

(Heidinger 1975). This activity can clearly be seen in bass of areas #1, 5, 6, and 7. Bass #3, however, showed a rather large path of patrol and did not hover over one spot for long periods. Since he swam the course continuously, however, he could very possibly have fanned the nest well enough to keep it free of silt.

LATE OBSERVATIONS

Table 2 contains information for areas #3, 1, 2, 5, 6, and 7. At the middle of Late Observations, in the beginning of July, the presence of approximately 15- 5 cm (2 in.) fry in area #3 was noticed. These small bass fry hung in a school, not venturing far from the shoreline and moving always as one unit unless disturbed. When disturbed, the school momentarily lost its integrity before immediately coalescing into its solitary unit. During the next two weeks, the male guardian remained to guard his brood until the end of the Late Observations, when he disappeared from the site.

Near the beginning of Late Observations, in mid-June, a new inhabitant of area #1 was seen. The first supposed guardian in this area had been a large bass, but the new fish was of medium size. No school of bass fry had been seen during the interval of the first inhabitant's stay.

Approximately one week after first observation of the new bass, however, a school of 11- 2.5 cm. (1 in.) fry appeared.

A similar occurrence to this became known when a single, large bass came to inhabit area #2. Whether or not this bass was one of the three former inhabitants or a new bass could not be determined. Since no bass were seen in this area during Middle Observations, however, a new bass had most likely adopted the area. A school of approximately 30- 5 cm. (2 in.) fry was seen after two weeks of first seeing the new guardian. Since no swarms had been seen during the interval when the three former bass had occupied the area, these bass were not likely to have been successfully spawning.

No fry were observed in areas #5, 6, and 7 throughout their guard. The three bass in these areas, however, showed definite guardian behavior as described in Middle Observations above. Whereas the bass in area #6 remained in the area throughout Late Observations, the bass in areas #5 and 7 disappeared as shown in Table 2. As stated in the literature, this disappearance could be due to death of the guardians (Heidinger 1975), or simply their leaving the nest.

Throughout these observations, at no time did a male guardian physically attack the boat or even feint attack.

This apparent unconcern could possibly be due to the distance of the boat from the nests. In the Lake Mead study, the divers who were attacked by the bass directly approached the nest, threatening its well-being (Allan and Romero 1975). My boat did not get close to any of the nests.

Table 3 contains information for areas #4, 9, 11, 10, and 8. Areas #4, 9, and 11 were similar in that none of them showed solitary patrols of bass, only having the presence of schools common to their area. The presence of fry in all three of these areas lends some weight to the probability of these areas being spawning areas. Since the fry in all three cases are 8 cm. (3-in.) fry, however, they could have possibly come from an adjacent nest. For instance, the fry in area #11 could have come from area #5.

Areas #10 and 8 were similar in that both showed occasional patrols by medium-sized bass with schools of bass being common to each area. Area #10, however, showed no sign of bass fry whereas area #8 had two schools of 2.5 cm (1-in.) fry. These fry could also have come from an adjacent area such as #7.

Table 4 contains information for areas #12, 13, 14, 15, and 16. Area #12 was the only area showing no bass activity. Reasons for this are most likely the presence of dead brush in the water (Allan and Romero 1975), extreme silt (Heidinger 1975), (Allan and Romero 1975), and the range of depth reaching 2.5 meters (8 ft.) (Heidinger 1975), (Scott and Crossman 1973). Extreme silt cover refers to silt over two inches thick. All three of these conditions have been shown to inhibit the spawning of largemouth bass.

None of the areas of Table 4 showed the presence of any fry, although schools of bass were seen at least occasionally. Among these areas is #13 which had a sharply sloping bottom and was unprotected from the wind. Area #14 had a heavy cover of vegetation on its bottom. Area #15 showed a rapidly sloping bottom and little protection from the wind, as well as having very sparse vegetation close by. Area #16 did not show any of these inhibiting physical factors, but the replacement of most bass in this area by trout and bluegill may have been an inhibiting factor.

Most reports of spawning behavior by largemouth bass in the literature have been supported by this study. One report called into question, however, claims that spawning of largemouth bass does not occur upon floors of heavy silt or sand (Allan and Romero 1975). The construction that was going on during the summer caused much silt to drift to various areas around the lake. This silt was thicker than the one inch reported in the Lake Mead study in many of the areas used as nests or designated as probable spawning areas. Nevertheless, many of the nests and probable spawning areas showed heavy silt cover as in areas #2 and 11, and partially in areas #5, 6, and 7. The reason for this disregard of heavy silt cover could be the limitations of perfect spawning conditions. This heavy silt cover was fairly common throughout the lake shorelines, especially during Late Observations.

The Lake Mead study showed one type of dominant substrate where nests were found to be rock. In this thesis, however, it can be seen that this claim is not supported. Here again, this report could be due to coincidence of other factors such as sharply sloping floors.

The results of this thesis have provided new insight into the spawning behavior of largemouth bass and the conditions under which this spawning takes place. Whereas many of the former reports on such studies have been confirmed throughout the body of this paper, a few others have been called into question Furthermore, the origin of some new ideas on the subject of largemouth bass spawning at Spring Meadow Lake have been introduced. I hope these ideas can be of some use in any future fisheries management of Spring Meadow Lake.

LITERATURE CITED

Aggus, L. R., and G. V. Elliot (1975) Effects of Cover and Food on Year-Class Strength of Largemouth Bass, Black Bass Biology and Management, Sport Fishing Institute, Washington, D. C.

Allan, R. C., and J. Romero (1975) Underwater Observations of Largemouth Bass Spawning and Survival in Lake Mead, Black Bass Biology and Management, Sport Fishing Institute, Washington, D. C.

Coutant, C. C. (1975) Responses of Bass to Natural and Artificial Temperature Regimes, Black Bass Biology and Management, Sport Fishing Institute, Washington, D. C.

Eipper, A. W. (1975) Environmental Influences on the Mortality of Bass Embryos and Larvae, Black Bass Biology and Management, Sport Fishing Institute, Washington, D. C.

Heidinger, R. C. (1975) Life History and Biology of the Largemouth Bass, Black Bass Biology and Management, Sport Fishing Institute, Washington, D. C.

Houser, A., and W. C. Rainwater (1975) Production of Largemouth Bass in Beaver and Bull Shoals Lakes, Black Bass Biology and Management, Sport Fishing Institute, Washington, D. C.

Scott, W. B., and E. J. Crossman (1973) Freshwater Fishes of Canada, Fisheries Research Board of Canada, Ottawa.

Siler, J. R., and J. P. Clugston (1975) Largemouth Bass Under Conditions of Extreme Thermal Stress, Black Bass Biology and Management, Sport Fishing Institute, Washington, D. C.

Summerfelt, R. C. (1975) Relationship Between Weather and Year-Class Strength of Largemouth Bass, Black Bass Biology and Management, Sport Fishing Institute, Washington, D. C.