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# LIMNOLOGICAL STUDIES IN ARKANSAS*

## 1. Physico-chemical and Net Plankton Studies of Lake Fort Smith in Its Fourth Year of Impoundment

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This limnological investigation gives information on the physico-chemical features, kinds and numbers of net plankters and seasonal distribution of the plankton of a lake in the early years of its impoundment. Little is known concerning the development of plankton populations in an artificial lake over a period of years. A second study, now in progress, is concerned with net and nannoplankton studies of Lake Fort Smith in its fourteenth and fifteenth years. This lake was selected for this study because it was built primarily for a water supply and, up to the present time, has not been drained or fertilized and, with the exception of occasional restocking of fish, has not been purposely altered since the lake was filled to its capacity in May 1936.

Grateful acknowledgments are made to Professor Paul S. Welch of the University of Michigan for reading the manuscript and for his helpful suggestions; to Mr. H. S. Peck, of the City of Fort Smith Water Department, for the use of a boat and other assistance; to Dr. Virgil Sleight, Department of Geology, Miami University, for help in determining the nature of the total suspended matter and obtaining hydrographic data; to Dr. Perry Max Johnston, Mrs. Barbara Carson and Mr. Andrew Hulsey for aid in computing morphometric data; and to the Research Committee of the College of Arts and Sciences, University of Arkansas and Dean Virgil L. Jones for continued interest and grants which made this work possible.

### METHODS AND EQUIPMENT

Although occasional trips for plankton collections and temperature determinations were made during the first half of 1938, regular trips were begun in June of 1938 and continued at intervals of from one to two weeks throughout 1939. Beginning in December of 1938 chemical studies were included. The data of this paper are essentially for a year beginning in December, 1938 and extending on through all of 1939. Records taken during 1938 are referred to as needed.

Temperatures were determined with a Taylor maximum and minimum thermometer until the early fall of 1938 when an H-B Instrument Company "Deep Sea" reversing thermometer was substituted. Temperatures were always taken at each meter from the surface to the bottom. Transparency was estimated by means of a standard Secchi's disc and turbidity by the platinum wire method.

The chemical determinations of dissolved oxygen, free carbon dioxide and alkalinity were made in accordance with the methods described in the Standard Methods of Water Analyses (1936). Hydrogen-ion concentration determinations were made with a Hellige disc colorimeter.

The water samples for chemical analyses and plankton were obtained with a modified Kemmerer sampler and a rope calibrated in meters. For the plankton samples 20 liters of water were concentrated through a number 25 silk bolting-cloth plankton net. The settling suspended matter was determined by pouring each plankton sample into a 100 cc. graduated centrifuge tube and allowing the solids present to settle. This same sample was later used to determine the number of organisms per liter. Counting of the plankton was done in a counting chamber, all of the organisms in two different cubic centimeters being counted and the results expressed in terms of liter numbers. This method of counting was used by Raymond (1937).

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## DESCRIPTION OF THE LAKE

Lake Fort Smith is in northwestern Arkansas, twenty-five miles northeast of the city of Fort Smith. The area is in the Humid Subtropical climatic zone, near the northern border of the latter. It is located several hundred miles farther north than the lakes in Texas and Louisiana which have been investigated by Harris and Silvey (1940), Cheatum, Longnecker, and Metler (1942) and Moore (1950).

The watershed for Lake Fort Smith lies on the southern side of the Boston Mountains, and is hemmed in by the latter on all sides but towards the south. The surrounding mountains rise from 1000 to 1500 feet above the valley, being the lowest to the east. The watershed generally trends from northeast to southwest, and is 65 square miles in extent.

Lake Fort Smith is a reservoir lake formed by damming a mountain valley just above the village of Mountainburg, Arkansas. The long axis of the lower end of the lake lies in a roughly north-south direction, with the dam at the southern end while the long axis of the upper end is in an east-west direction. The lake thus formed by impounding the water of Clear Creek (Jones Fork of Frog Bayou on the topographical map) covers 525.5 acres. The lake is surrounded by steep, wooded hills except at the northeast end where Clear Creek enters and the southern end where a dam 2,000 feet long and 90 feet high forms its boundary. The dam closing was completed in February, 1936, and the lake was filled to capacity by May of the same year. The lake is about 800 feet above sea level.

The slope of the basin is generally steep, except at the northern end. The bottom deposits of the deeper portions of the lake were those of a drowned mountain valley, namely, rocks of limestone, sandstone, and shale, with sand and gravel in the old stream bed, all with a thin superficial cover of clay. Practically no aquatic vegetation had appeared along these steeper slopes of the basin. At the northern end of the lake the water is shallow and, at low water level, expanses of several acres of the bottom became exposed, revealing tree stumps, dead bushes and some evidence of one time cultivation. In the fall of 1939 the old rows of corn stalks were still visible in the former field. A very small amount of *Typha, Sagittaria, Chara* and *Dianthera* was found at the northern end.

Clear Creek becomes dry, except for an occasional waterhole, during the summer. The channel where it enters the lake is a long meandering Bayou, with the transitional area between the stream and lake covering several acres. In 1939 this area was similar to bottom lands subject to periodic overflow.

## MORPHOMETRY

| | |
|---|---|
| Direction of axis, upper end | east-west |
| Direction of axis, lower end | north-south |
| Maximum length | 13,800 feet |
| Maximum effective length, upper end | 7,900 feet |
| Maximum effective length, lower end | 6,850 feet |
| Maximum width | 2,600 feet |
| Mean width | 1,660 feet |
| Maximum depth | 72 feet |
| Mean depth | 22.94 feet |
| Shore line | 38,800 feet |
| Area | 22,896,000 square feet |
| Shore development | 2.29 |
| Volume | 525,598,000 cubic feet |
| Volume development | 0.95 |

## PHYSICAL

### Temperature

Temperature studies for the year 1939 showed that Lake Fort Smith had a stratification period and one of nonstratification. The water during the latter period was near enough to being homothermal to allow circulation. According to Whipple's classification of lakes, Lake Fort Smith during 1939 would be regarded as a tropical lake of the second order, with bottom temperatures always above 4.0°C. The lowest surface temperature recorded during the year 1939 was 5.2°C., while the lowest bottom temperature was 4.9°C. During the winter of 1940 the lake was covered with a thin coating of ice which would classify it as a temperate lake for that year. Table I summarizes the temperature conditions for the period from December 28, 1938 through December 10, 1939 and gives the position of the thermocline during stratification.

In 1938 nonstratified water was first found on November 20 when the surface water was 12.8°C., and water at the bottom was 11.8°C. In 1939 circulation began on November 12, when the surface water was 12.8°C. while the water at the bottom was 13.0°C. In a few instances the bottom temperature at the time of nonstratification was slightly warmer than the water at a meter or two above; the greatest difference at this time was 0.4°C.

TABLE I. Summary of Thermal Conditions in Lake Fort Smith from December 28, 1938 through December 10, 1939.

| | Epilimnion | | Thermocline | | | Hypolimnion | | |
|---|---|---|---|---|---|---|---|---|
| Date | Top (°C.) | Bottom (°C.) | Meter below Epilimnion (°C.) | Meter above Hypolimnion (°C.) | Location (meters) | Top (°C.) | Lowest (°C.) | Bottom (°C.) |
| 12/28 | 5.2 | | No stratification | | | | 5.2 | 5.3 |
| 1/8 | 6.8 | | No stratification | | | | 5.8 | 5.8 |
| 1/22 | 5.9 | | No stratification | | | | 5.6 | 5.9 |
| 2/5 | 5.4 | | No stratification | | | | 4.9 | 4.9 |
| 2/12 | 6.2 | | No stratification | | | | 5.2 | 5.4 |
| 3/7 | 8.1 | | No stratification | | | | 6.4 | 6.4 |
| 3/14 | 10.0 | | No stratification | | | | 7.2 | 7.2 |
| 3/19 | 10.4 | | No stratification | | | | 7.6 | 7.6 |
| 4/2 | 18.0 | 15.0 | 13.2 | 11.6 | 4-5 | 10.4 | 8.2 | 8.2 |
| 4/8 | 12.2 | | No stratification | | | | 9.0 | 9.0 |
| 4/23 | 14.2 | | No stratification | | | | 9.8 | 9.8 |
| 5/7 | 19.2 | 18.0 | 15.4 | 13.4 | 5-6 | 12.0 | 10.6 | 10.6 |
| 5/14 | 19.0 | 17.2 | 14.6 | 14.6 | 5 | 12.4 | 10.6 | 10.6 |
| 5/23 | - - | - - | 23.3* | 16.0 | 0-5 | 14.8 | 10.4 | 10.6 |
| 6/7 | - - | - - | 26.4* | 16.4 | 0-5 | 14.6 | 10.8 | 10.8 |
| 6/15 | 27.6 | 26.2 | 24.0 | 15.0 | 3-6 | 13.6 | 10.8 | 10.8 |
| 6/23 | 29.8 | 29.6 | 28.0 | 17.8 | 2-6 | 12.0 | 11.0 | 11.0 |
| 6/27 | 28.8 | 27.8 | 23.2 | 18.0 | 5-6 | 14.2 | 11.0 | 12.2 |
| 7/6 | 29.6 | 28.6 | 25.8 | 17.6 | 4-6 | 15.0 | 10.8 | 10.8 |
| 7/15 | 31.6 | 28.6 | 23.0 | 13.6 | 5-9 | 12.4 | 10.0 | 10.0 |
| 7/21 | 30.4 | 28.4 | 22.6 | 14.4 | 5-7 | 13.0 | 11.2 | 11.2 |
| 7/28 | 29.4 | 28.4 | 23.4 | 15.0 | 5-7 | 13.8 | 11.0 | 11.4 |
| 8/11 | 28.0 | 27.0 | 25.0 | 13.8 | 5-8 | 12.6 | 11.0 | 11.0 |
| 8/17 | 27.6 | 27.0 | 24.4 | 13.2 | 5-9 | 12.0 | 11.0 | 11.0 |
| 8/24 | 27.0 | 25.8 | 18.8 | 13.0 | 6-8 | 12.0 | 11.0 | 11.0 |
| 8/31 | 27.0 | 26.8 | 24.7 | 14.4 | 5-7 | 12.8 | 10.9 | 10.9 |
| 9/7 | 27.8 | 27.6 | 24.0 | 13.2 | 5-8 | 12.2 | 11.0 | 11.0 |
| 9/24 | 24.0 | 23.6 | 15.0 | 15.0 | 7 | 12.7 | 11.2 | 11.2 |
| 10/1 | 20.6 | 20.0 | 19.0 | 19.0 | 7 | 13.0 | 11.0 | 11.0 |
| 10/15 | 18.6 | 18.4 | 15.9 | 13.4 | 8-9 | 12.0 | 11.0 | 11.0 |
| 10/29 | 17.0 | 17.0 | 13.6 | 13.6 | 10 | 12.0 | 11.2 | 11.4 |
| 11/12 | 12.8 | | No stratification | | | | 12.6 | 13.0 |
| 11/26 | 10.8 | | No stratification | | | | 10.6 | 10.8 |
| 12/10 | 10.8 | | No stratification | | | | 9.2 | 9.6 |

* Surface temperature

On April 2, 1939 a temporary stratification appeared. On this date the temperature varied 9.8°C. from the surface to the bottom. Permanent stratification began on May 7 with a surface temperature of 19.2°C., and with the bottom temperature of 10.6°C. Temperature records taken in 1940 showed that the lake was stratified by May 12 of that year.

In 5 records secondary thermoclines were found: on April 2 there was a drop of 2.4°C. between the surface water and the water at meter 1; on May 14 there was a 1.4°C. drop between the surface and the first meter; on May 23 there was a 1.0°C. drop between meters 8 and 9; on July 15 and July 21 there was a 1.2°C. drop between meters 2 and 3.

### Transparency and Turbidity

The authors are aware of the limitations of the Secchi's disc but feel that it does give some relative measure of the changes in water transparency throughout a year. Table II summarizes the Secchi's disc readings for the year 1939.

The disc readings from March 7 through May 23 varied from 25 to 65 cm. This period can be correlated with the heavy late winter and spring rains and the inflow from the surrounding hills. The wind action may have played a small part at this time but, because of the nature of the bottom, this influence was probably small; the bottom was composed of rock and gravel. The correlation between rainfall and transparency was not as evident later in the year as in the spring, which may have been due to the rapid absorption of the rainfall by the extremely dry, vegetation-bearing soil of the watershed in summer and fall. An additional factor may have been that substances accumulated on the hills during the winter were brought down by the rains in large quantities in the spring. The shortest disc reading for Lake Fort Smith was 25 centimeters while the longest was 300 centimeters.

TABLE II. Summary of Secchi's Disc Readings in Centimeters for the Year 1939

| Date 1939 | Transparency | Date 1939 | Transparency | Date 1939 | Transparency |
|---|---|---|---|---|---|
| Feb. 12 | 150 | June 7 | 130 | Aug. 24 | 240 |
| Mar. 7 | 25 | June 15 | 150 | Aug. 31 | 150 |
| Mar. 14 | 33 | June 23 | 200 | Sept. 7 | 200 |
| Mar. 19 | 33 | June 27 | 200 | Sept. 24 | 200 |
| Apr. 2 | 65 | July 6 | 190 | Oct. 1 | 190 |
| Apr. 8 | 50 | July 15 | 300 | Oct. 15 | 190 |
| Apr. 23 | 50 | July 21 | 290 | Oct. 29 | 150 |
| May. 7 | 50 | July 28 | 240 | Nov. 12 | 130 |
| May 14 | 50 | Aug. 11 | 200 | Nov. 26 | 150 |
| May 23 | 65 | Aug. 17 | 200 | Dec. 10 | 250 |

TABLE III. Summary of Precipitation, Secchi's Disc Readings, Settling Suspended Materials and Averaged Organisms per Liter from January 8 through May 7, 1939.

| Date 1939 | Precipitation in Preceding 7 Days in Inches | Secchi's Disc in cm. | Averaged Settling Suspended Materials in cc. Per 20 Liters | Averaged Organisms Per Liter |
|---|---|---|---|---|
| Jan. 8 | 0.00 | - - | 0.08 | 181 |
| Jan. 22 | 0.53 | - - | 0.08 | 334 |
| Feb. 5 | 1.13 | 150 | 0.07 | 192 |
| Feb. 12 | 0.73 | 150 | 0.07 | 264 |
| Mar. 7 | 1.56 | 25 | 0.36 | 19 |
| Mar. 14 | 0.52 | 33 | 0.04 | 4 |
| Mar. 19 | 0.00 | 33 | 0.08 | 209 |
| Apr. 2 | 0.11 | 65 | 0.05 | 253 |
| Apr. 8 | 1.38 | 50 | 0.1 | 137 |
| Apr. 23 | 2.24 | 50 | 0.1 | 10 |
| May 7 | 0.00 | 50 | 0.08 | 38 |

A number of investigators (e.g., Chandler, 1940, 1942) have suggested that turbidity may influence productivity of organisms, especially phytoplankton. In this investigation turbidity readings were not taken during the year 1939 but some information is available about settling suspended materials present in the lake. The materials designated as such are both organic and inorganic in nature, and are what was collected by a number 25 silk bolting cloth plankton net from a 20 liter sample. To determine the amount of settling suspended materials the water sample was introduced into a graduated 100 cc. centrifuge tube and allowed to settle. The readings obtained by this method do not give the volume of the organisms. Table III summarizes the averaged amount of settling suspended materials present in 20 liters of lake water derived from equal samples obtained at the surface, 5, 10 and 15 meters. The average number of organisms per liter of water derived from equal samples from the same levels is also included. The table also gives information concerning the amount of rainfall in the 7 days previous to the time the sample was collected.

Table III shows that there was an accumulation of settling suspended materials after the late winter and spring rains. In summer and fall this correlation is not as evident. A study of suspended materials present in the fall showed it to be mostly flocculent material, while in the spring it was composed of portions of lichens, quartz grains, flat fragments of shale, fragments of limonite and silt.

The best example of the correlation between the presence of settling suspended matter, rainfall and number of organisms was found in March. On February 12 the average reading for suspended matter for the 4 different levels was 0.07 cc. for 20 liters of water. The organisms present averaged 264 per liter. On March 7, after 1.56 inches of rainfall, the average amount of suspended matter was 0.36 cc. for the 20 liter sample, while the average number of organisms had dropped to 19 per liter. On this date a 20 liter sample at meter 5 had 1.1 cc. of suspended matter and 15 organisms per liter. By March 14 the average number of organisms was lower than on March 7; 4 organisms per liter were present, and the average amount of suspended materials was reduced to 0.04 cc. per 20 liters. The latter tends to show that the effects of heavy rainfall may influence the productivity of plankton for a period of a week at this time of the year.

Similar examples can be found on April 8 and 23, but the amount of suspended material is not as high as it was in March. This may have been due to the material having already settled down to the bottom by the time the samples were taken. The dominant organism present during these four months was *Kirchneriella obesa*; it disappeared after the heavy April rains. This organism formed 80 per cent of the total net plankton during this period. Although there are indications that turbidity may have some influence on zooplankton definite conclusions in this investigation are limited to the phytoplankton since they accounted for 93 per cent of the total net plankton at this time.

During the week previous to February 5 there was 1.13 inches of rainfall which should have been sufficient to bring about the same results as it did in March and April. Studies of the rainfall records during this time revealed that this amount of rainfall was fairly evenly distributed over the 7 days instead of being concentrated on one or two days as it had been in March and April. In the February rainfall the water was absorbed by the soil on the hills at the time of the downfall, while in the other instances the heavy short rains carried away large quantities of materials.

Although turbidity readings were not taken during the year 1939, some are available for the years 1940 and 1941, and these are presented together with the Secchi's disc readings. December 20, 1940 the Secchi's disc reading was 150 centimeters and the turbidity reading was 7 parts per million; on February 23, 1941 the disc reading was 40 centimeters and the turbidity reading was 25 ppm.; on October 11, 1941 the disc reading was 200 centimeters and the turbidity was less than 7 ppm.

## CHEMICAL

### Dissolved Oxygen

The dissolved oxygen content of Lake Fort Smith can be divided into two periods: a period in which the dissolved oxygen has a fairly uniform distribution throughout the depths and another in which the dissolved oxygen is disappearing from the bottom. Table IV summarizes the oxygen distribution at significant meters on some representative dates.

At the time when the lake was circulating a slight reduction in oxygen was noticeable at certain meters, e. g., on January 8 there was a slight reduction at the fifth meter. Other examples of this small reduction are: March 7 at the fifth meter, March 14 and 19 at the surface and April 8 and 23 at the surface and bottom.

Reduction of the dissolved oxygen content in the water near the bottom began May 14. The first oxygen free water was found August 31 at 17 meters; the oxygen free water finally included meter 15 on October 15. Beginning August 17 and continuing through September 7 there was a noticeable reduction of oxygen in the sixth meter.

TABLE IV. Summary of Chemical Factors in Lake Fort Smith of Selected Dates from December 28, 1938 to December 10, 1939.

| Date | Depth in Meters | Oxygen ppm. | Free $CO_2$ ppm. | M. O. Alkalinity ppm. | pH |
|---|---|---|---|---|---|
| Dec. 28, | 0 | 7.8 | 1.5 | 24.0 | 6.8 |
| 1938 | 15 | 7.3 | 1.5 | 24.0 | 6.8 |
| Jan. 22, | 0 | 10.0 | 1.0 | 26.0 | 6.8 |
| 1939 | 15 | 10.0 | 1.0 | 26.0 | 6.8 |
| Feb. 12 | 0 | 8.0 | 1.0 | 24.0 | 6.8 |
| | 19 | 8.2 | 1.0 | 22.0 | 6.8 |
| Mar. 7 | 0 | 8.3 | 0.5 | 23.0 | 6.6 |
| | 18 | 8.6 | 1.0 | 22.0 | 6.4 |
| Mar. 14 | 0 | 9.5 | 2.0 | 23.0 | 6.6 |
| | 15 | 10.1 | 2.0 | 22.0 | 6.6 |
| Apr. 2 | 0 | 7.9 | 0.5 | 20.0 | 6.8 |
| | 19 | 7.3 | 1.5 | 20.0 | 6.4 |
| Apr. 8 | 0 | 7.1 | 1.0 | 17.0 | 6.8 |
| | 18 | 6.9 | 1.0 | 20.0 | 6.4 |
| Apr. 23 | 0 | 8.3 | 0.5 | 21.0 | 6.8 |
| | 17.5 | 8.2 | 1.0 | 20.0 | 6.4 |
| May 14 | 0 | 6.5 | 0.5 | 20.0 | 6.7 |
| | 19 | 5.0 | 1.5 | 21.0 | 6.4 |
| June 27 | 0 | 6.6 | 1.5 | 21.0 | 6.8 |
| | 10 | 5.7 | 2.5 | 20.0 | 6.4 |
| | 18 | 3.7 | 2.5 | 23.0 | 6.4 |
| Aug. 17 | 0 | 7.8 | 2.0 | 20.0 | 6.8 |
| | 5 | 7.6 | 2.0 | - - | 6.8 |
| | 10 | 4.4 | 2.5 | 22.0 | 6.6 |
| | 15 | 2.5 | 3.0 | - - | 6.4 |
| | 17.5 | 1.0 | 3.0 | 26.0 | 6.4 |
| Aug. 31 | 0 | 7.2 | 1.0 | 22.0 | 6.9 |
| | 5 | 7.2 | 1.0 | - - | 6.8 |
| | 6 | 3.0 | 2.5 | - - | 6.6 |
| | 8 | 3.8 | - - | - - | - - |
| | 10 | 3.7 | 3.0 | 24.0 | 6.4 |
| | 15 | 1.1 | 3.0 | - - | 6.4 |
| | 17.5 | 0.0 | 3.5 | 24.0 | 6.4 |
| Sept. 7 | 0 | 6.7 | 2.0 | 24.0 | 6.8 |
| | 5 | 6.5 | 2.5 | - - | 6.8 |
| | 6 | 2.2 | 3.0 | - - | 6.2 |
| | 8 | 3.0 | - - | - - | 6.2 |
| | 10 | 2.7 | 4.0 | - - | 6.2 |

--*Continued*

TABLE IV. Summary of Chemical Factors in Lake Fort Smith of Selected Dates from December 28, 1938 to December 10, 1939. --(Continued)

| Date | Depth in Meters | Oxygen ppm. | Free $CO_2$ ppm. | M. O. Alkalinity ppm. | pH |
|---|---|---|---|---|---|
| Sept. 7 | 12.5 | 1.4 | - - | - - | 6.4 |
| | 15 | 0.6 | 4.5 | - - | 6.4 |
| | 17.5 | 0.0 | 5.5 | 46.0 | 6.6 |
| Oct. 1 | 0 | 7.5 | 1.0 | 31.0 | 6.8 |
| | 6 | 7.8 | 1.0 | - - | 6.8 |
| | 7 | 6.0 | 1.5 | - - | 6.8 |
| | 8 | 0.6 | 3.0 | - - | 6.4 |
| | 10 | 0.7 | 3.5 | 28.0 | 6.4 |
| | 12.5 | 0.6 | 4.0 | - - | 6.4 |
| | 15 | Tr. | 4.0 | - - | 6.4 |
| | 17 | 0.0 | 4.0 | 42.0 | 6.6 |
| Oct. 29 | 0 | 8.7 | 0.5 | 20.0 | 6.6 |
| | 9 | 6.5 | 1.5 | - - | 6.4 |
| | 10 | 2.0 | 2.0 | 30.0 | 6.4 |
| | 11 | 0.3 | 2.0 | - - | 6.4 |
| | 12.5 | 0.1 | 2.5 | - - | 6.4 |
| | 15 | 0.0 | 3.0 | - - | 6.4 |
| | 17 | 0.0 | 3.0 | 39.0 | 6.4 |
| Nov. 12 | 0 | 9.0 | 0.5 | 32.0 | 6.8 |
| | 17 | 8.8 | 0.5 | 29.0 | 6.8 |
| Dec. 10 | 0 | 9.5 | 0.5 | 22.0 | 6.8 |
| | 17 | 8.4 | 0.5 | 23.0 | 6.8 |

## Free Carbon Dioxide

Some free carbon dioxide was always present during the year 1939. Table IV shows the free carbon dioxide at significant meters for some representative dates for the year 1939. During the period when the lake was circulating the carbon dioxide varied from 0.5 to 2.0 parts per million; the highest reading during this time was on March 14, a week after the heaviest March rain. There was an increase in carbon dioxide in the water of the hypolimnion during stratification. The highest reading for the year was 5.5 parts per million, found on September 7 in the water just above the bottom.

## Hydrogen-Ion Concentration

Table IV contains some selected hydrogen-ion concentration readings for the year 1939. The pH was always below 7.0. At the time of circulation the pH was usually 6.8 but varied from 6.6 to 6.4 after the heavy rains in March. When the water was stratified the pH near the bottom was usually at 6.4; in 2 instances, however, September 7 and October 1, the water at the bottom was 6.6, while that in 2 meters above was 6.4.

## Alkalinity

The alkalinity in Lake Fort Smith was due entirely to bicarbonates. When the water was circulating the methyl orange alkalinity varied from 17 to 32 parts per million of calcium carbonate. The highest methyl orange alkalinity readings were found from September 7 up to the time of circulation; the methyl orange alkalinity reading at the bottom on September 7 was 46 parts per million. The range of methyl orange alkalinity on selected dates is summarized in Table IV.

## NET PLANKTON

### Seasonal Distribution

#### *Total Net Plankton*

The information presented here deals with the number and identification of species found in the various plankton groups, the seasonal occurrence of some of the more important species, seasonal variations of the main plankton groups and the relative abundance of the species to the total net plankton. No attempt was made in this investigation to enumerate the nannoplankton, therefore, all data given here deal with net plankton (mesoplankton) only.

Table V is a summary of the seasonal distribution of the various plankton groups for the year 1939, giving averages in numbers per liter for four depths, which are, surface, 5, 10 and 15 meters. Collections made at each meter, from the surface to the bottom, and those taken at various stations in the lake showed that data obtained from the above 4 levels give a reliable picture of the seasonal distribution and numbers of plankton; these data were obtained from averaging the above four levels at the deepest station. Although collections were made during the year 1938, this paper deals essentially with those of the year 1939, the former data being used only for comparison. In this study colonies were considered as one unit but the average number of individuals for each important species that forms colonies is presented in the discussion of that particular species.

From the standpoint of numbers of forms (species and varieties) the net plankters were well represented in Lake Fort Smith; qualitative and quantitative studies showed that there were 115 forms in 83 genera. These forms were poorly represented in numbers of individuals, averaging 106 organisms per liter in the collections of the year 1939. Of the 83 genera found in the lake, two *Kirchneriella* and *Conochilus*, comprised 56 per cent of the total net plankton. The Bacillarieae, often an important group in plankton counts, formed only 1.9 per cent of the total plankton. The Protozoa contributed only 0.7 per cent to the total.

No systematic study of the stream supplying Lake Fort Smith was attempted but, from occasional quantitative samples taken from the stream it is apparent that it also is high in numbers of species but low in individuals; many of the species found in the lake were also collected in the stream but not in numbers greater than those found in the lake. No collections were made during the late summer months when the stream ceases to flow.

Because of the few species in abundance in 1939 and the apparent influence of the late winter and spring rains the pulses were very irregular. During this investigation the lake had a tendency toward 2 main pulses; one extended from early October 1938 into April 1939 and another from the end of August through early September. In the year 1939 minor pulses occurred in May, June, October and early December.

The following plankters were found in qualitative and quantitative samples. Numbers, in parentheses, after the specific names indicate the references used in determination of species.

PHYTOPLANKTON

Myxophyceae

*Anabaena* sp.
*Aphanocapsa rivularis* (Carm.) Rab. (9,29,33)
*Aphanothece* sp.
*Dactylococcopsis acicularis* Lemm. (?) (9,29)
*Gloeothece* sp.
*Lyngbya* sp.
*Microcystis* sp.
*Oscillatoria* sp.

Chrysophyceae

*Dinobryon bavaricum* Imhof (24,29)
*Dinobryon cylindricum* Imhof (24)
*Mallomonas* sp.

Bacillarieae
*Achnanthes* sp.
*Amphora* sp.
*Cyclotella* sp.
*Cymbella parva* (W. Smith) Cleve (2,8,28)
*Diatoma* sp.
*Epithemia zebra* (Ehr.) Kűtz. (2,28)
*Fragilaria crotonensis* Kitton (1,28)
*Fragilaria* sp.
*Gomphonema acuminatum* Ehr. (2,8,28,39)
*Gomphonema constrictum* Ehr. (2,8,28,39)
*Gomphonema olivaceum* (Lyngb.) Kűtz. (2,8,28)
*Gyrosigma* sp.
*Meridion circulare* (Grev.) Ag. (1,8,28)
*Melosira crenülata* (Ehr.) Kutz. (?) (1,39)
*Surirella elegans* Ehr. (2,8,28,39)
*Surirella robusta* Ehr. (2,8,28,39)
*Surirella splendida* (Ehr.) Kütz. (2,28,39)
*Synedra acus* Kütz. (1, 28)
*Synedra pulchella* (Ralfs) Kütz. (1,8,28)
*Synedra ulna* (Nitzsch.) Ehr. (1,8,28)
*Synedra* sp.

Chlorophyceae
*Ankistrodesmus* sp.
*Arthrodesmus octocornis* Ehr. (30,38)
*Bulbochaete* sp.
*Cladophora* sp.
*Closteriopsis longissima* Lemm. (?) (18,29)
*Closterium moniliferum* (Bory) Ehr. (30,32,38)
*Closterium* sp.
*Cosmarium botrytis* (Bory) Menegh. (30,32,38)
*Cosmarium contractum* Kirchn. (30,38)
*Cosmarium contractum* var. *papillatum* W. & G. S. West (30)
*Desmidium baileyi* (Ralfs) Nordst. (26,30)
*Desmidium swartzii* Ag. (26,30,32,38)
*Eudorina elegans* Ehr. (7,23,29)
*Golenkinia radiata* Chod. (18,29)
*Gonatozygon aculeatum* Hastings (30)
*Gonatozygon* sp.
*Gymnozyga moniliformis* Ehr. (30)
*Hyalotheca dissiliens* (Smith) Bréb. (26,30,32,38)
*Hyalotheca mucosa* (Dillw.) Ehr. (26,30,38)
*Kirchneriella obesa* (W. West) Schmidle (18,29)
*Micrasterias americana* (Ehr.) Ralfs (30,32)
*Micrasterias radiata* Hass. (26,30,38)
*Micrasterias radiosa* var. *ornata* Nordst. (30)
*Mougeotia* sp.
*Netrium* sp.
*Oedogonium* sp.
*Onychonema laeve* (var. *latum* ?) W. & G. S. West (25,30)
*Pediastrum duplex* var. *gracillimum* W. & G. S. West (18,29)
*Pleurotaenium trabecula* (Ehr.) Näg. (30)
*Sphaerocystis schroeteri* Chod. (18,29)
*Spondylosium planum* (Wolle) W. & G. S. Smith (30,32)
*Staurastrum arctiscon* (Ehr.) Lund. (30)
*Staurastrum chaetoceras* (Schrőd.) Smith (30)
*Staurastrum dickiei* var. *maximum* W. & G. S. West (30)
*Staurastrum floriferum* W. & G. S. West (30)
*Staurastrum megacanthum* Lund. (30,38)
*Staurastrum protectum* var. *planctonicum* G. M. Smith (30)
*Tetraspora* sp.
*Trochiscia* sp.
*Ulothrix subconstricta* C. S. West (29)
*Ulothrix zonata* (Weber and Mohr) Kűtz. (7,29,37)

*Volvox* sp.
*Xanthidium antilopaeum* var. *minneapoliense* Wolle (30)
*Xanthidium subhastiferum* var. *toweri* (Cushm.) G. M. Smith (30)

Dinophyceae
*Peridinium* sp.

Euglenophyceae
*Euglena proxima* Dang. (34)
*Phacus longicauda* (Ehr.) Duj. (34)
*Trachelomonas volvocina* Ehr. (34)

ZOOPLANKTON

Protozoa
*Arcella* sp.
*Cyclidium* sp.
*Codonella cratera* (Leidy) (17,19)
*Difflugia* sp.
*Epistylis* sp.
*Vorticella* sp.

Rotifera[1]
*Asplanchna* sp
*Collotheca mutabilis* (Hudson) (6, 14)
*Conochilus unicornis* Rousselet (6)
*Euchlanis* sp.
*Gastropus hytopus* Ehr. (6, 14, 15)
*Keratella cochlearis* (Gosse) (6, 15)
*Lecane luna* (Müller) (6, 12, 15)
*Monostyla* sp.
*Notholca longispina* (Kellicott) (6, 15)
*Polyarthra euryptera* Wierzejski (6)
*Polyarthra trigla* Ehr. (6)
*Synchaeta pectinata* Ehr. (?) (6, 14)
*Trichocerca cylindrica* (Imhof) (6, 16)
*Trichocerca longiseta* (Schrank) (16)

Crustacea

Cladocera
*Alona quadrangularis* (O. F. Müller) (35)
*Bosmina longispina* Leydig (?) (35)
*Bosmina obtusirostris* Sars (35)
*Bosminopsis deitersi* Richard (35)
*Chydorus sphaericus* (O. F. Müller) (35)
*Daphnia longispina* var. *hyalina* Leydig (35)
*Daphnia* sp.
*Diaphanosoma leuchtenbergianum* Fisher (35)
*Simnocephalus vetulus* (O. F. Müller) (35)

Copepoda[2]
*Cyclops bicuspidatus* Claus (10, 21, 35)
*Cyclops leuckarti* Claus (?) (10, 21, 35)
*Cyclops modestus* Herrick (21, 35, 36)
*Cyclops prasinus* Fisher (10, 21, 35)
*Cyclops* sp.
*Diaptomus pallidus* Herrick (20, 35)

## Phytoplankton

The phytoplankton of Lake Fort Smith was composed of 80 forms which constituted 67.3 per cent of the total net plankton. Although phytoplankters were well represented qualitatively, the following 5 genera, *Kirchneriella, Sphaerocystis, Cosmarium, Dinobryon* and *Staurastrum* accounted for the quantity during the year 1939. The average number of phytoplankton for the collections for that

[1]Nomenclature according to Harring (1913)

[2]Nomenclature according to Gurney (1933) and Ward and Whipple (1918)

year was 71 organisms per liter. This group showed one main pulse with variations within it following the heavy spring rains; it began in October 1938 and continued into April. A secondary pulse was present in May and June. The maximum for the main pulse was 324 units per liter and was found on January 22, 1939; the maximum for the secondary pulse was 60 units. When compared with pulses found in some other lakes the phytoplankton numbers of this lake were very low.

### Myxophyceae

This group was represented by 8 species in 8 different genera. These accounted for 1.0 per cent of the total plankton for the year 1939. Only 3 species appeared in numbers during this investigation, namely:

*Aphanocapsa rivularis* (Carm.) Rab. This form was found on March 19, 1939 with an average of 28 colonies per liter.

*Dactylococcopsis acicularis* Lemm. (?) Found only in numbers during the months of June and July of 1938 with a maximum of 32 on June 16.

*Gloeothece* sp. Found only in numbers during the month of October in 1938 with a maximum of 33 per liter on October 9.

### CHRYSOPHYCEAE

The Chrysophyceae made up 4.9 per cent of the total net plankton for the year 1939. Except for an occasional *Mallomonas* and *Dinobryon bavaricum* the entire quantity was formed by one species, *Dinobryon cylindricum*. During the year 1939 the latter species was most numerous in the month of May and reached a maximum of 52 colonies per liter on May 23. This species was again present in small numbers from January to the latter part of February and September through December. In the latter periods, except for one date, October 15, when the organisms reached 13 colonies per liter, the numbers were less than 10. In 1938 this form was found in small numbers from early October through December with one exception, November 6, when there were 23 colonies per liter. The average number of cells per colony was 32.

### Bacillarieae

Qualitatively this is the second largest group but numerically it is one of the more poorly represented. The Bacillarieae amounted to only 1.9 per cent of the total net plankton. Of this percentage the genus *Synedra* made up 0.9 per cent. Analyses of the plankton of the stream supplying this lake showed that it also is rich qualitatively but poor quantitatively.

### Chlorophyceae

This group of phytoplankton was the most important in both quality and quantity during the year 1939; the group is represented by 44 forms in 29 genera. The Chlorophyceae contributed 59 per cent to the total net plankton during the year 1939. As a matter of fact, 4 genera accounted for the greater share of the percentage attributed to the Chlorophyceae. One species, *Kirchneriella obesa*, formed 39 per cent of the total net plankton. Some Chlorophyceae were present in every month of the year. In 1939, the largest numbers were found from January through early April and from the middle of October through December; the greatest number, 314, was found on January 22. On two dates, within the above months, March 7 and 14, the numbers were less than 15 per liter and probably can be explained by the high turbidity and excessive rainfall during that time. Chlorophyceae were found, in numbers less than 15 per liter, during the remaining months of 1939 with the exceptions of June, early July and late August. In the year 1938 the Chlorophyceae were present in numbers from early October through December reaching a maximum of 44 on November 20.

*Kirchneriella obesa* (W. West) Schmidle. This species was the most important member of the group Chlorophyceae; it accounted for 39 per cent of the total net plankton and about 2/3 of the total Chlorophyceae. During 1939, with the exception of the time around March 7 and 14 it was abundant from the end of December, 1938 to April 8, 1939, during which time the averages ranged from 2 colonies to 254. On March 7 only 11 colonies per liter were found and again on March 14 only 2. This decline in colonies was probably due to the high turbidity in the lake at this time. In the year 1939 none had appeared by December 10 while during 1938 they were encountered by October but were not present in quantities larger than 6 colonies per liter until November 20 when 20 were present. The largest number found in the winter of 1937-38 was 2 colonies per liter on January 8.

*Sphaerocystis schroeteri* Chodat. This species contributed 7.6 per cent to the total plankton. It was found in numbers during the months of June and July and reached its maximum of 42 colonies on June 27, 1939. This species, in 1939, was also present from January to early April and from the latter part of August through December, but was found in numbers only in January, early February and December. In the year 1938 this form began to appear in numbers in the early part of October reaching a maximum of 41 on December 28.

*Cosmarium contractum* No attempt was made to separate the 2 forms of this species in the plankton counts. These two made up the third most important group of Chlorophyceae in that they accounted for 7.3 per cent of the total net plankton. This genus appeared in significant numbers during the year 1939 from mid-October through December. In the same year it was also abundant from the first of January through February. The maximum number, 66 per liter, appeared on December 10, 1939; during the rest of this pulse the averages varied from 9 to 27 per liter. Also, in this year the genus made an appearance during June and July but not ever in numbers more than 11 per liter. In the year 1938 it was found in numbers only from October through December with a maximum of 20 per liter on November 20. *Cosmarium botrytis* made only an occasional appearance.

*Staurastrum*. In quantitative work this genus was considered as one group and no attempt was made to separate the species. This is the fourth important genus in the Chlorophyceae forming 4.0 per cent of the total net plankton. During the year 1939, members of this genus were present from early June to the end of December and from January to early March but appeared in significant numbers only from the end of August to early December. During this time they appeared in numbers greater than 15 per liter only on two occasions; on August 24 there were 20 per liter and on December 10 there were 49. At no time during 1938 did this genus appear in numbers greater than 3 per liter.

### Dinophyceae

This group was represented by one genus and accounted for 0.5 per cent of the total net plankton. This genus, *Peridinium*, appeared in small numbers in collections from the latter part of August to early December with a maximum of 13 individuals per liter on August 31, 1939.

### Euglenophyceae

The Euglenophyceae were found only in qualitative samples and consisted of 3 species in 3 genera.

### Zooplankton

The Zooplankton was represented by 35 species and composed 32.7 per cent of the total net plankton. The average number of Zooplankton for the collections of the year was 35 per liter. Again, as in the Phytoplankton, a very few species contributed to most of the precentage of the Zooplankton. This group showed one main pulse during the year 1939; it extended from the end of August through the first week of September with a maximum of 401 on September 7, 1939. With the exception of the Protozoa, the Zooplankton compare much more favorably with more productive lakes than do the Phytoplankton.

### Protozoa

This group was represented by 6 species in 6 genera. This is one of the less important groups numerically, contributing only 0.7 per cent to the total net plankton.

### Rotifera

The Rotifera was the important Zooplankton group forming 21.4 per cent of the total net plankton. One species, Conochilus unicornis, comprised 17 per cent of the total plankton. This group was represented by 11 genera and 13 species. Some individuals of this group were found in every month of the year except March. The largest numbers were found during the months of August and September in the year 1939 with a maximum of 381 on September 7. They were also more abundant in early April with a maximum of 28 on April 8. They increased in numbers on three other dates: May 23 with 27 per liter, June 23 with 19 and June 27 with 34. At all other times there were less than 10 per liter.

*Conochilus unicornis* Rousselet. This was the most important species of the Rotifera. It accounted for 17 per cent of the total net plankton, appearing in the first week of April and remaining until the end of September. Except for 4 collecting dates it never exceeded 10 organisms per liter. These four dates and average numbers were: May 23, 27 individuals; June 27, 32; August 31, 141; and September 7, 373.

*Synchaeta pectinata* Ehr. (?) This was the second species of importance and formed 1.9 per cent of the total plankton. This species appeared in December and, with March an exception, continued through June. During this period it reached its maximum of 23 on April 8 and never exceeded 3 organisms on any other date. It again appeared in September and October reaching a maximum of 6 on October 15.

*Polyarthra*. No attempt was made to separate the two species quantitatively. This was the third genus of importance forming 1.1 per cent of the total net plankton. It was present in numbers of less than 3 organisms per liter in each month with the exceptions of March and June. In March none were present and on June 23, 1939, 14 organisms per liter were found.

*Keratella cochlearis* (Gosse). This species appeared in collections from the end of June through December of the year 1939; it was also present in January of that year. A maximum of 4 was found on July 21, 1939.

### Cladocera

This group contributed 3.5 per cent to the total net plankton and was represented by 9 forms. The Cladocera showed three increases during the year 1939. The first extended from January into April with the organisms showing a decline during March near the end of the turbid period. The maximum of 5 was found on March 7 at the beginning of the turbid period. The second extended from June through July having a maximum of 6 on June 27 and July 15. The third extended from the beginning of September into December; the maximum number, 22, was found on December 10. In 1938 they were abundant from the beginning of October to the end of November with a maximum of 7 on October 23, during which year they were also present in larger numbers in January, June and July.

*Daphnia*. Although 2 species were present, *Daphnia longispina* was the dominant form. In counting, the two species were enumerated together. This genus formed 2.2 per cent of the total net plankton. During the year 1939 *Daphnia* showed a tendency toward 3 pulses. The first extended from January into February with a maximum of 3 on January 8. The second extended from the first of June through the month of July with a maximum of 6 on July 15. The third extended from early September through the first of December with a maximum of 19 on December 10. In 1938 they were found in increased numbers in July and again from the beginning of October through the month of November; they were also present in January.

*Bosmina*. The 2 species of *Bosmina* were not separated quantitatively. This genus accounted for 0.8 per cent of the total net plankton. It showed two pulses. One ranged from the middle of February into April with a reduction during March. The maximum at this time was 3 on April 8. The other extended from September through October with a maximum of 4 on October 15. This form was unimportant in 1938.

*Diaphanosoma leuchtenbergianum* Fisher. This species made up 0.4 per cent of the total net plankton. It appeared in numbers only during October reaching a maximum of 6 per liter on October 15.

### Copepoda

In the Zooplankton this was the second group of importance in numbers of individuals per liter. The Copepoda contributed 7.1 per cent to the total net plankton. Two genera and six species of Copepoda were identified and were present in every month of the year. In all months except March and May they were present in numbers greater than 3 per liter. During the months of September and October they showed a definite pulse having the following numbers per liter on the respective dates: September 7, 12; September 24, 16; October 1, 56; October 15, 24; and October 29, 26.

*Cyclops.* Although *Cyclops prasinus* was the most abundant form, all 5 species were counted as one group. This genus accounted for 2.0 per cent of the total net plankton. Even though *Cyclops* occurred all during the year the numbers started to increase beginning about the middle of June to a definite pulse in September and October. Dates and numbers of individuals per liter during those months were: September 7, 4; September 24, 2; October 1, 17; October 15, 6; and October 29, 8.

*Diaptomus pallidus* Herrick. *Diaptomus* was the other important genus in the Copepoda contributing 1.1 per cent to the total net plankton. This genus followed the same pattern as Cyclops being present throughout the year. It showed an accumulating of numbers beginning the first of July and had a definite pulse from September through December. Dates and numbers of individuals per liter during the latter months were: September 7, 3; September 24, 2; October 15, 3; October 29, 2; and December 10, 4.

Nauplii. Nauplii formed 4.0 percent of the total net plankton. Some were present in every sample throughout the year 1939 but in quantities less than 6 per liter with the exceptions of September and October. Dates and numbers of individuals per liter in September and October were: September 24, 12; October 1, 39; October 15, 15; and October 29, 16.

## SUMMARY


1. Lake Fort Smith is an artificial lake formed by damming a valley in the Boston Mountains and is located twenty-five miles northeast of the city of Fort Smith, Arkansas. Very small amounts of rooted aquatic plants were present in 1939 due in part to the steep slopes of the basin and the newness of the lake. The lake was in its fourth year of impoundment.
2. The lake has a shore line of 7.3 miles, an area of 525.5 acres, shore development of 2.29, volume development of 0.95 and a mean depth of 22.94 feet.
3. During 1939 the lake had one stratification and circulation period. The minimum surface temperature in the winter was 5.2°C. The average bottom temperature for the summer was 10.98°C.
4. Oxygen free water first appeared near the bottom on August 31 and remained until November. Alkalinity was due entirely to bicarbonate and it varied from 17 to 46 parts per million. Some carbon dioxide was present throughout the year 1939.
5. Heavy late winter and early spring precipitation and its resulting turbidity in the lake had a harmful influence on the productivity of Phytoplankton, especially *Kirchneriella obesa*. Heavy rains at other times during the year had little effect on turbidity in Lake Fort Smith
6. Additional information concerning temperatures, transparency, dissolved oxygen, carbon dioxide, hydrogen-ion concentrations, alkalinity and morphometric measurements is presented.
7. In numbers of forms (species and varieties) the net plankters were well represented in Lake Fort Smith; there were 115 forms in 83 genera. The number of forms in the different plankton groups were: Myxophyceae, 8 species; Chrysophyceae, 3; Bacillariae, 21; Chlorophyceae, 44 forms; Dinophyceae, 1 species; Euglenophyceae, 3; Protozoa, 6; Rotifera, 13; Cladocera, 9; Copepoda, 6.
8. In numbers of individuals the net plankters were poorly represented in Lake Fort Smith; the average number of individuals per liter for the collecting dates for 1939 was 106. Of the 83 genera in the lake, two, *Kirchneriella* and *Conochilus*, formed 56 per cent of the total net plankton; 12 genera accounted for 87.96 per cent. The percentages for the individual plankton groups were Myxophyceae, 1.0 per cent; Chrysophyceae, 4.9; Bacillariae, 0.9; Chlorophyceae, 59; Dinophyceae, 0.5; Protozoa, 0.7; Rotifera, 21.4; Cladocera, 3.5; Copepoda, 7.1.
9. The Phytoplankton pulse began in October 1938 and continued into April 1939. The Zooplankton pulse extended from the end of August, 1939 through the first week in September. The seasonal cycles of some individual species of plankters are presented.

10. The average number of Phytoplankton per liter for the collecting dates for the year 1939 was 71, the maximum number 324, the minimum 3. The average number of Zooplankton for the collecting dates for the year 1939 was 35 per liter, the maximum 401, the minimum 1.

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TABLE V

Averaged Number of Net Plankters Per Liter for Surface, 5, 10 and 15 Meters.

| Group | Dec. 28 1938 | Jan. 8 1939 | Jan. 22 | Feb. 5 | Feb. 12 | March 7 | March 14 | March 19 | Apr. 2 | Apr. 8 | Apr. 23 | May 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Myxophyceae | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 28 | 1 | 0 | 1 | 0 |
| *Dinobryan cylindricum* | 7 | 6 | 8 | 3 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 27 |
| Chrysophyceae | 9 | 6 | 9 | 3 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 27 |
| Bacillarieae | 12 | 0 | 0 | 0 | 4 | 1 | 0 | 0 | 0 | 1 | 6 | 0 |
| Dinophyceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Kirchneriella obesa* | 130 | 121 | 254 | 166 | 216 | 11 | 2 | 177 | 231 | 99 | 1 | 0 |
| *Sphaerocystis schroeteri* | 41 | 22 | 33 | 1 | 8 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Cosmarium contractum* | 22 | 21 | 27 | 10 | 18 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| Chlorophyceae | 193 | 164 | 314 | 177 | 243 | 12 | 3 | 178 | 232 | 100 | 1 | 1 |
| TOTAL PHYTOPLANKTON | 214 | 170 | 324 | 180 | 254 | 13 | 3 | 206 | 233 | 101 | 8 | 28 |
| Protozoa | 2 | 1 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| *Conochilus unicornis* | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 4 | 0 | 6 |
| *Synchaeta pectinata (?)* | 3 | 1 | 2 | 2 | 1 | 0 | 0 | 0 | 16 | 23 | 0 | 1 |
| Rotifera | 4 | 2 | 2 | 5 | 1 | 0 | 0 | 0 | 17 | 28 | 0 | 9 |
| Cladocera | 1 | 4 | 2 | 2 | 3 | 5 | 0 | 1 | 1 | 4 | 0 | 0 |
| Copepoda | 7 | 4 | 4 | 4 | 6 | 1 | 1 | 1 | 1 | 4 | 1 | 1 |
| TOTAL ZOOPLANKTON | 14 | 11 | 10 | 12 | 10 | 6 | 1 | 3 | 20 | 36 | 2 | 10 |
| TOTAL NET PLANKTON | 228 | 181 | 334 | 192 | 264 | 19 | 4 | 209 | 253 | 137 | 10 | 38 |

| Group | May 14 | May 23 | June 7 | June 15 | June 23 | June 27 | July 6 | July 15 | July 21 | July 28 | Aug. 11 | Aug. 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Myxophyceae | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Dinobryon cylindricum* | 36 | 52 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chrysophyceae | 36 | 52 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Bacillarieae | 0 | 7 | 1 | 2 | 4 | 6 | 1 | 2 | 1 | 3 | 4 | 1 |
| Dinophyceae | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Kirchneriella obesa* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

--*Continued*

TABLE V --*(continued)*

| Group | May 14 | May 23 | June 7 | June 15 | June 23 | June 27 | July 6 | July 15 | July 21 | July 28 | Aug. 11 | Aug. 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sphaerocystis schroeteri* | *0* | *1* | *4* | *15* | *34* | *42* | *15* | *12* | *0* | *1* | *0* | *0* |
| *Cosmarium contractum* | *0* | *0* | *5* | *10* | *6* | *6* | *1* | *1* | *11* | *1* | *0* | *0* |
| Chlorophyceae | 0 | 1 | 12 | 27 | 41 | 49 | 17 | 14 | 11 | 3 | 1 | 10 |
| TOTAL PHYTOPLANKTON | 36 | 60 | 14 | 30 | 46 | 60 | 18 | 16 | 12 | 6 | 5 | 13 |
| Protozoa | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| *Conochilus unicornis* | *1* | *27* | *3* | *1* | *3* | *32* | *1* | *1* | *1* | *1* | *10* | *8* |
| *Synchaeta pectinata (?)* | *1* | *0* | *1* | *3* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
| Rotifera | 2 | 27 | 5 | 4 | 19 | 34 | 2 | 5 | 6 | 4 | 12 | 11 |
| Cladocera | 1 | 0 | 1 | 2 | 4 | 6 | 2 | 6 | 4 | 1 | 0 | 1 |
| Copepoda | 2 | 1 | 3 | 7 | 2 | 2 | 7 | 5 | 5 | 5 | 7 | 4 |
| TOTAL ZOOPLANKTON | 5 | 28 | 9 | 14 | 25 | 43 | 11 | 17 | 15 | 10 | 20 | 16 |
| TOTAL NET PLANKTON | 41 | 88 | 23 | 44 | 71 | 103 | 29 | 33 | 27 | 16 | 25 | 29 |

| Group | Aug. 24 | Aug. 31 | Sept. 7 | Sept. 24 | Oct. 1 | Oct. 15 | Oct. 29 | Nov. 12 | Nov. 26 | Dec. 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Myxophyceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Dinobryon cylindricum* | *0* | *0* | *4* | *0* | *0* | *13* | *2* | *1* | *0* | *1* |
| Chrysophyceae | 1 | 0 | 4 | 0 | 0 | 13 | 2 | 1 | 0 | 3 |
| Bacillarieae | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 0 | 4 |
| Dinophyceae | 0 | 13 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 0 |
| *Kirchneriella obesa* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* | *0* |
| *Sphaerocystis schroeteri* | *1* | *7* | *1* | *3* | *0* | *3* | *2* | *3* | *3* | *21* |
| *Cosmarium contractum* | *0* | *1* | *1* | *2* | *2* | *9* | *10* | *12* | *18* | *66* |
| Chlorophyceae | 26 | 17 | 10 | 9 | 9 | 26 | 25 | 30 | 30 | 137 |
| TOTAL PHYTOPLANKTON | 28 | 32 | 15 | 11 | 10 | 42 | 31 | 32 | 30 | 144 |
| Protozoa | 0 | 1 | 2 | 0 | 0 | 1 | 2 | 8 | 2 | 1 |
| *Conochilus unicornis* | *11* | *141* | *373* | *0* | *0* | *1* | *0* | *0* | *0* | *0* |
| *Synchaeta pectinata (?)* | *0* | *0* | *1* | *0* | *4* | *6* | *1* | *1* | *0* | *0* |
| Rotifera | 14 | 145 | 381 | 3 | 6 | 9 | 4 | 2 | 1 | 3 |
| Cladocera | 1 | 1 | 6 | 7 | 13 | 12 | 4 | 2 | 4 | 22 |
| Copepoda | 11 | 6 | 12 | 16 | 56 | 24 | 26 | 4 | 8 | 7 |
| TOTAL ZOOPLANKTON | 26 | 153 | 401 | 26 | 75 | 46 | 36 | 16 | 15 | 33 |
| TOTAL NET PLANKTON | 54 | 185 | 416 | 37 | 85 | 88 | 67 | 48 | 45 | 177 |