INVESTIGATIONS INTO THE LIMNOLOGY OF DOW LAKE, ATHENS COUNTY, OHIO

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Scientific literature includes many limnological studies of both natural and artificial lakes and ponds. However, almost all of these studies deal with bodies of water which had existed for a number of years. This study was initiated to determine the conditions existing in a newly impounded body of water and changes in these conditions as the lake matures. Current plans call for this to be an extended study continuing for a number of years in the future. This paper is a report on the data collected from May, 1959, through January, 1962.

Stanley (1961) studied the aquatic insects and also worked on some limnological aspects of Dow Lake during the summer of 1960. Limnological investigations were also carried out by Keller (1960) in the spring of 1960. Some of the unpublished data of these investigators have been incorporated into this paper.

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DESCRIPTION OF THE LAKE

Dow Lake is located in Stroud's Run State Park about 3.5 miles east of Athens, Ohio, and lies in sections 22, 23, and 29 of Canaan Township, Athens County, Ohio. The lake is formed by a 775-ft earthen dyke built across a narrow valley through which a small stream known as Stroud's Run had previously flowed. The lake is approximately 1.9 miles long with an average width of about 200 yards (see fig. 1). The maximum depth is approximately 40 ft near the dam, and the mean depth of the lake is estimated at 12 to 14 ft. The lake has many small inlets and at normal pool has a surface area of 161 acres. Dow Lake is fed directly by Stroud's Run and another small stream and has a drainage area of 7.30 square miles.

The area comprising the lake bottom had previously been uncultivated farm lands consisting of both wooded and open areas. Prior to the impoundment of water, all large trees were cut and removed from the lake bottom, while most of the smaller trees and plants remained untouched in areas where they would be submerged. In a large area of the lake bottom, the topsoil and associated plants were left intact. The overflow gates were closed on May 22, 1959, and by March, 1960, the lake had completely filled.

METHODS

Two regular sampling stations, A and E, were established at the locations indicated in figure 1. Several other stations were included in the initial samplings but were dropped as a result of limitations of time and the fact that each yielded results similar to one of the above stations. The depth at station A was normally 39 or 40 ft but reached a low of 36 ft in the fall of 1961. The depth at station E was normally 16 ft but varied between 11 and 16 ft as a result of late summer droughts and a winter drawdown of the lake in the fall of 1961. During ice-free periods, all sampling was carried out from an anchored 18-ft wooden outboard motor boat. When the lake was frozen, a hole of sufficient size to permit sampling was chopped through the ice.

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The surface temperature of the water was measured by inserting a standard 12-in. laboratory thermometer into the upper 2 in. of water. Temperatures below the surface were obtained from a 2-liter Kemmerer water sampler suspended at the desired depth for a period of time sufficient to permit the temperature of the sampler to equilibrate with that of the surrounding water. The sample was hauled to the surface and emptied into a shaded bucket where the temperature was immediately recorded. Surface and bottom temperatures were recorded on each trip, and a number of intermediate depth temperatures sufficient to indicate thermal conditions between surface and bottom were also taken. Air temperatures were measured approximately 1 in. above the water surface.

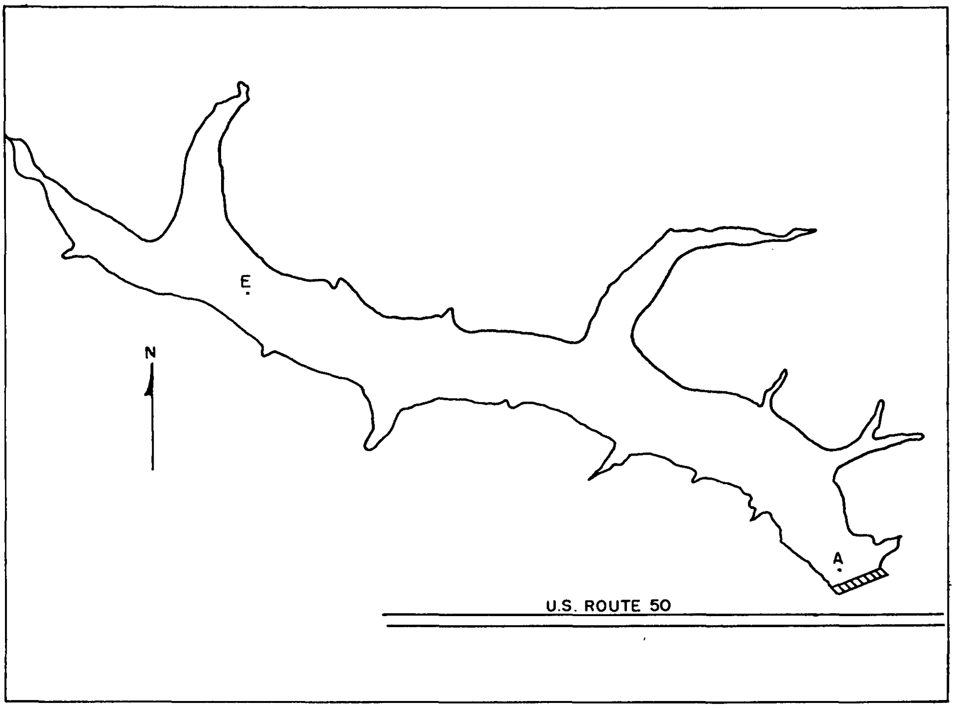

FIGURE 1. Map of Dow Lake showing the locations of stations A and E. (½ inch = 1060 ft).

Turbidity was measured with a United States Geological Survey turbidity rod with graduations ranging from 7 to 3,000 ppm.

Dissolved oxygen was determined in parts per million in the field by the standard Winkler metho . Oxygen determinations were made for surface and bottom waters on all trips and at intermediate depths when any great differences in temperature existed between these two levels.

Water samples were returned to the laboratory in 250-cc glass stoppered bottles and tested for free carbon dioxide, phenolphthalein alkalinity, and methyl orange alkalinity according to the procedures outlined by Welch (1948). Hydrogen ion concentration measurements were made with a Beckman Zeromatic pH meter.

Plankton samples were taken at the surface and bottom of the lake on all trips and in most instances, at mid-depth also. Water samples to be filtered were collected directly into a bucket having a volume of 8 liters, except during periods of ice cover when it was necessary to use the Kemmerer water sampler to obtain an uncontaminated sample from below the water-ice interface. All samples from below the surface were brought to the surface with a Kemmerer sampler and emptied into the standard bucket until it was full, whereupon it was then poured through the plankton net which was suspended over the side of the boat by a small crane. Bottom samples for all tests were collected with the sampler from 6 to 12 in. off the bottom to prevent contamination by bottom debris.

Prior to May 20, 1961, a standard tow net having 125 meshes to the inch was used to concentrate the water samples into a 15-ml centrifuge tube. After this date, a Wisconsin plankton net of number 25 silk bolting cloth and its attached plankton bucket were used. The concentrate from the plankton bucket was rinsed with distilled water into a 15-ml centrifuge tube to which additional distilled water was added to make exactly 15 ml. The tubes were then stoppered and returned to the laboratory where they were examined.

Plankters of a 1-cc aliquot of the 15-ml sample were identified to genus and counted on a Sedgewick-Rafter counting chamber. When the numbers of plankters were relatively low, the entire counting chamber was examined with the 16-mm objective to identify the smaller forms; and the large forms, such as the Copepods and Cladocera, were counted by covering the entire chamber with a 40-mm objective. When large numbers of plankters were present, only a portion (usually one-third) of the chamber was examined with the 16-mm lens and the numbers of the smaller forms were calculated on the basis of this fraction.

Two 24-hr surveys were conducted on the lake to detect any diurnal changes; the first on September 8 and 9, 1960, and the second on August 28 and 29, 1961. Complete physical and chemical analyses were conducted at 4-hr intervals, and plankton collections were made at 8-hr intervals.

PHYSICAL CONDITIONS

Temperature

Table 1 shows the temperature recordings for the period covered by this study. Thermal stratification was recorded at both station A and E but was more complete at the deeper station A. In 1960, thermal stratification was present at station A from April to October or November, and in 1961, from May to late October or early November.

The water at station E was thermally stratified from March to October in 1961. The less efficient stratification at station E was probably the result of the shallower water and greater wind action at that end of the lake.

Turbidity

The turbidity at both stations fluctuated over a fairly wide range with the maxima occurring in the spring and fall and the minima in the summer and winter months (table 1). The maxima were mainly the result of spring and fall precipitation causing the inflow of heavily silted water. Since station E was nearer the mouths of the two main streams feeding the lake, it was more subject to increased turbidity after severe storms than was station A.

The greatest turbidity recordings were made in 1959 when the lake was not yet completely filled. Since that time, the turbidity has not been so great and it might be expected that as the lake ages and plants become established on some of the bare shore areas, the turbidity should decrease still more.

CHEMICAL CONDITIONS

Dissolved Oxygen Concentrations

As shown in table 1, the dissolved oxygen recordings followed the pattern typical of dimictic lakes. Oxygen was always present at the surface and oxygen depletion occurred during periods of thermal stratification.

Oxygen was depleted at the bottom of station A very early in the summer of 1961, and by August, oxygen was lacking at a depth of 20 ft. At station E the bottom oxygen concentrations were very low during summer stratification but reached zero on only one sampling trip.

During the summer of 1961, dissolved oxygen concentrations at a depth of 10 ft sometimes exceeded surface concentrations. Tests showed that a dense layer of green flagellates often existed near this depth and the increased oxygen concentrations were probably the result of photosynthetic activity.

When compared to some other Ohio lakes, the oxygen concentrations of Dow Lake seem to be somewhat low. Tressler et al. (1940) report surface oxygen concentrations of up to 14.6 ppm during August; Kraatz (1941) reports surface concentrations which almost always ranged between 10 and 14 ppm over a period of 17 months; and Winner et al. (1962) report surface oxygen concentrations of 10 to 13 ppm during the summer months. The relatively low summer surface oxygen concentrations are probably related to the low production of phytoplankton in Dow Lake.

TABLE 1

Temperatures in degree centigrade and turbidity and dissolved oxygen in parts per million

	Station A									Station E					
Date	°C			Turbid	Dissolved oxygen					°C			Turbid	Dissolved oxygen	
	Air	0'	40'		0'	10'	20'	30'	40'	Air	0'	16'		0'	16'
5/ 7/59	23.0	24.0		180	9.2										
8/ 2/59					6.6										
8/21/59	33.0	29.3		30											
9/24/59	22.5	25.0		18											
10/ 1/59	19.5	21.0		51											
10/15/59	13.0	16.0		24											
10/22/59	19.0	14.2		29	9.3										
10/29/59	15.5	10.5		28											
11/19/59	5.7	5.3													
12/ 3/59	4.0	3.0		30	12.9										
1/ 7/60	10.5	2.9		31	10.9										
3/10/60	4.5	0.5													
4/ 2/60	23.0	8.0		26	12.8										
4/ 2/60		10.5	11.0	12	11.6				11.7						
4/23/60	28.0	21.0		16	9.2										
4/30/60	21.5	18.0	10.0	16	7.5				4.6						
5/ 8/60	10.5	15.0	10.5	13	8.8				5.1						
5/14/60	13.0	13.0	9.5	11	4.4				8.7						
6/ 6/60	23.0	26.0			7.4										
6/12/60	22.5	25.0	15.0		8.0				2.4						
6/18/60	16.0	24.0	12.0	7−	6.7				0.6	17.0	23.0	19.0	7−	6.0	2.0
6/22/60	23.5	24.0	11.5	7−	6.6				0.6						
6/28/60	23.0	26.0	14.0	7−	7.6				0.0	22.5	27.0	24.0	7−	7.4	3.8
6/30/60	24.7	25.7	10.4												
7/ 7/60														7.4	0.0
7/12/60	27.5	28.0	11.5		7.4				0.0						
7/27/60	27.3	27.8								27.0		29.2			
8/16/60	20.8	26.7		7−	8.0				0.0	22.1	26.0		9	6.5	0.8
9/ 8/60	27.2	27.3		7−	6.6				0.0	27.7	27.9		7−	6.2	1.1
9/29/60	26.0	22.3		7−	8.1				0.0	26.0	23.0		9	5.7	5.5
11/25/60	8.8	8.8			5.8				4.7						
12/ 9/60		4.0		7−									7−		
2/12/61	3.5	0.5		7−	6.0				6.8						
3/ 3/61		5.5	6.0	12							6.0	7.0	75		
3/27/61	18.0	7.5		13	8.8				7.9	15.5	10.5	9.0	13	10.4	9.8
4/ 3/61										9.0	7.2	7.5	85	8.6	7.0
4/ 8/61	9.0	9.8	9.5	45	9.3				7.1	8.5	9.0	7.8	46	9.3	8.8

TABLE 1—*Continued*

Date	Station A									Station E					
	°C			Turbid	Dissolved oxygen					°C			Turbid	Dissolved oxygen	
	Air	0'	40'		0'	10'	20'	30'	40'	Air	0'	16'		0'	16'
4/20/61	15.5	9.5		13	9.2				8.4	15.8	9.5		45	8.7	8.8
5/ 3/61	15.0	12.8	9.0	13	9.2				5.9	15.0	9.5		15	9.4	7.8
5/29/61	15.0	19.0	10.0	7−	8.8				1.4	17.0	18.4	14.4	7−	8.8	8.6
6/ 2/61	26.0	21.5	12.0	7−	8.7				0.6	20.1	21.2	16.8	7−	8.4	3.5
6/ 5/61	21.5	22.0	11.0	7−	8.1				0.7	26.8	23.5	17.5	7−	8.2	4.2
6/ 9/61	21.0	22.5	10.2	11	7.8		6.2	1.3	0.0	20.5	22.5	19.0	17	8.0	5.2
6/12/61	26.7	26.0	11.0	7−	6.8		5.2	0.8	0.0	31.0	27.8	19.2	7−	7.2	3.7
6/16/61	16.2	22.0	11.5	7−	7.5	7.6	5.6	0.6	0.0	18.5	22.0	18.0	7−	7.8	0.8
6/19/61	22.9	23.2	10.8	7−	7.5	8.4	5.6	0.6	0.0	24.0	24.0	18.0	7−	7.2	1.4
6/23/61	22.0	22.0	11.6	7−	6.2	7.3	5.2	2.5	0.0	22.2	23.0	19.0	7−	8.0	0.4
6/26/61	19.0	21.8	11.0	7−	7.8	7.0	4.2	2.6	0.0	20.0	21.3	19.8	7−	7.0	1.9
6/30/61	24.5	25.0	11.0	7−	7.2	7.5	5.8	0.6	0.0	28.0	25.5	19.8	7−	7.8	2.0
7/ 3/61	19.2	26.5	12.2	7−	7.4	7.6	4.1	0.6	0.0	24.8	25.5	18.5	7−	7.0	1.4
7/ 7/61	22.0	25.0	10.9	7−	7.2	7.2	3.3	0.8	0.0	25.5	25.8	21.2	7−	7.3	1.2
7/10/61	23.0	25.0	11.0	7−	7.1	6.9	4.1	0.9	0.0	25.0	25.0	22.5	7−	7.2	7.2
7/14/61	24.8	25.2	11.0	7−	7.7	6.8	4.4	0.9	0.0	27.1	26.0	22.0	7−	7.2	2.8
7/17/61	23.4	24.8	11.7	7−	7.2	7.1	4.0	0.3	0.0	26.0	26.0	22.2	7−	7.2	0.9
7/21/61	26.0	26.7	11.1	7−	7.2	6.8	4.5	0.0	0.0	29.0	28.3	22.2	7−	7.6	3.0
7/24/61	25.7	28.0	11.0	7−	7.1	7.4	5.5	0.0	0.0	28.5	28.5	23.0	7−	7.4	0.8
7/31/61	25.7	28.1	11.7	7−	7.1	7.0	5.2	0.2	0.0	29.0	28.1	23.8	7−	6.9	2.2
8/ 4/61	23.8	28.0	11.1	7−	6.7	7.4	4.3	0.0	0.0	25.5	27.9	22.3	7−	6.8	5.0
8/ 7/61	22.7	27.0	10.8	7−	7.2	7.5	0.4	0.0	0.0	24.5	27.2	22.4	7−	7.4	2.6
8/11/61	26.5	26.8	11.4	7−	7.7	7.4	0.7	0.0	0.0	25.4	27.2	22.4	7−	8.5	0.6
8/14/61	21.0	26.2	11.2	7−	7.6	7.2	0.0	0.0	0.0	23.0	26.0	23.4	7−	7.5	1.8
8/18/61	24.0	27.2	11.6	7−	7.5	7.1	0.0	0.0	0.0	25.5	26.4	23.8	7−	7.6	0.3
8/21/61	20.6	26.0	11.3	7−	7.6	7.3	0.6	0.0	0.0	22.1	25.8	23.0	7−	7.6	5.3
8/25/61	23.0	25.8	11.5	7−	7.6	7.3	0.0	0.0	0.0	25.0	26.5	23.2	7−	7.7	2.1
8/28/61	23.8	26.6	11.6	7−	7.3	8.1	0.0	0.0	0.0	25.5	27.4	26.2	7−	7.6	2.0
8/29/61	22.9	28.6	11.7	7−						21.0	27.2	23.4	7−		
9/ 1/61	26.5	27.0	11.5	7−	7.2	8.1	0.0	0.0	0.0	26.8	27.3	25.1	7−	7.7	0.9
9 /5/61	26.8	28.4	11.8	7−	7.5	7.9	0.0	0.0	0.0	27.7	28.0	24.1	7−	7.2	0.4
9/ 8/61	23.8	28.0	11.7	7−	7.3	10.6	0.0	0.0	0.0	26.2	27.8	24.0	7−	7.4	0.3
9/11/61	24.0	27.5	11.6	7−	8.2	9.5	0.0	0.0	0.0	26.2	28.0	25.4	7−	7.2	0.4
9/15/61	14.5	25.3	11.2	12	6.4	6.4	0.0	0.0	0.0	16.0	25.4	24.0	7−	5.4	0.3
9/18/61	15.5	22.5	11.2	7−	5.5	5.7	0.0	0.0	0.0	18.5	23.0	22.1	7−	5.5	3.8
10/ 1/61	21.3	20.9	10.2	7−	5.9	5.6	0.6	0.0	0.0	22.5	21.7	21.2	7−	6.3	5.8
10/21/61	18.0	16.0	14.0	7−	6.0		5.9	3.8	0.0	18.0	25.5	15.3	7−	6.8	7.0
11/10/61	9.0	11.8	11.2	14	7.4		5.9	6.7	7.1	11.0	11.0	8.5	7−	7.9	8.8
11/25/61	10.0	9.0	8.7	22	7.8	7.7	7.7	7.7	7.7	10.8	7.8	7.5	15	9.2	9.2
12/17/61	8.0	5.2	5.2	7−	9.7				9.5	7.5	4.2	4.2	7−	10.4	9.9
1/16/62	0.6	3.0	4.0	7−	9.6				4.5						

Free CO_2

As shown in table 2, free CO_2 reached maxima of 13 ppm at the surface and 70 ppm near the bottom. The highest surface recordings usually occurred after the breakdown of thermal stratification while the highest bottom values occurred just prior to the breakdown of stratification. At both stations the maximum bottom water concentrations during the summer months were higher in 1960 than in 1961. These differences may possibly be a result of more dead organic material being present and undergoing decomposition on the new lake bottom when the lake was younger. During summer stratification, free CO_2 concentrations at station A were greater and showed a progressive increase while those at station E fluctuated. This is probably the result of more efficient thermal stratification at the deeper station A.

Hydrogen Ion Concentration

On all but a few occasions a pH of 7 or higher was recorded at both stations (table 2). At the bottom of station A, a reading of less than pH 7 was recorded only near the end of summer stratification in 1960 and 1961, when a high concentration of carbon dioxide was present. At station E, a pH of 6.8 was recorded at the surface and near the bottom in June, 1961.

The recorded pH values show considerable variance but fall within the range of pH 6.5 to 8.5 which is considered normal for most freshwater lakes of this region (Welch, 1935). The pH values recorded at Dow Lake are quite similar to the values reported by Dexter et al. (1942) for five other Ohio lakes.

Alkalinity

Phenolphthalein alkalinity was zero at all times, indicating that the alkalinity of the lake was the result of bicarbonates only (table 2). Methyl orange alkalinity values varied directly with CO_2 concentrations. The bottom maxima occurred during periods of stratification and surface maxima were recorded at the time of the spring and fall overturns. As did the CO_2 concentrations, alkalinity values at the bottom of station A showed a progressive increase during periods of stratification.

TABLE 2

Free carbon dioxide, phenophthalein, and methyl orange alkalinity expressed in parts per million and pH

Date	Station A								Station E							
	CO_2		pH		Phenol.		M–O		CO_2		pH		Phenol.		M–O	
	0'	40'	0'	40'	0'	40'	0'	40'	0'	16'	0'	16'	0'	16'	0'	16'
5/ 7/59			8.8													
8/21/59			8.2													
9/24/59			8.6													
10/ 1/59			8.3													
10/15/59			8.0													
10/29/59			7.8													
12/ 3/59			8.5													
12/ 7/59			8.0													
3/10/60			8.2													
6/28/60	3	16	7.6		0	0	84	90			7.6	7.0				
6/30/60	3	17			0	0	76	94	3	38			0	0	79	156
7/12/60	3	7			0	0	85	83								
7/27/60			8.1	7.7	0	0					7.8	7.6	0	0		
8/16/60			8.2	7.6	0	0					8.2	7.3	0	0		
8/19/60	4	51			0	0	90	204								
9/ 8/60	2	61	7.7	7.0					2	19			0	0	93	113
9/29/60	3	70	7.9	6.8	0	0	94	121					0	0	99	98
11/25/60			7.4	7.3	0	0	114	107								
12/ 8/60									8	12	7.5	7.6	0	0	103	105
2/12/61	8	12	7.6	7.1	0	0	117	136								
3/ 3/61	7	13	7.5	7.3	0	0	109	120	9	8	7.6	7.3	0	0	30	71
3/27/61			7.4	7.4	0	0	114	136			7.6	7.5	0	0	31	114
4/ 3/61									3	2			0	0	73	69
4/ 8/61	4	4	7.6	7.8	0	0	76	76	6	6	7.6	8.0	0	0	68	69
4/20/61	9	5	7.4	7.6	0	0	76	75	5	5	7.7	7.5	0	0	72	65
5/ 3/61	8	8	7.6	7.5	0	0	75	80	7	5	7.4	7.6	0	0	76	78
5/29/61	10	11	7.4	7.8	0	0	64	95	9	11	7.8	7.4	0	0	77	90
6/ 2/61	2	10	8.0	7.2	0	0	69	93	2	10	8.2	7.2	0	0	69	93
6/ 5/61	3	13	7.8	7.1	0	0	75	101	5	10	7.9	7.2	0	0	79	100
6/ 9/61	8	12	7.4	7.1	0	0	77	102	13	5	8.8	7.3	0	0	71	89
6/12/61	4	12	7.3	7.2	0	0	79	107	6	11	8.0	7.1	0	0	80	86

TABLE 2—*Continued*

Date	Station A								Station E							
	CO_2		pH		Phenol.		M-O		CO_2		pH		Phenol.		M-O	
	0'	40'	0'	40'	0'	40'	0'	40'	0'	16'	0'	16'	0'	16'	0'	16'
6/16/61	5	12	8.0	7.2	0	0	77	107	4	19	7.6	6.8	0	0	71	93
6/19/61	6	13	8.0	7.3	0	0	77	116	3	13	7.9	7.3	0	0	86	109
6/23/61	6	13	7.3	7.3	0	0	77	118	3	15	7.9	7.1	0	0	77	110
6/26/61	4	13	8.0	7.3	0	0	78	125	4	11	7.7	7.2	0	0	99	96
6/30/61	5	14	7.7	7.3	0	0	99	133	5	16	7.9	7.2	0	0	88	110
7/ 3/61	5	16	8.1	7.3	0	0	82	132	3	14	8.0	7.3	0	0	84	113
7/ 7/61	4	18	8.2	7.4	0	0	86	137	7	14	8.1	7.3	0	0	88	119
7/10/61	4	18	8.2	7.4	0	0	95	135	4	4	8.1	8.2	0	0	85	91
7/14/61	5	17	8.0	7.3	0	0	85	149	7	13	8.0	7.3	0	0	105	121
7/17/61	4	19	8.0	7.3	0	0	91	146	5	15	7.9	7.3	0	0	91	136
7/21/61	5	22	8.1	7.4	0	0	89	135	5	13	8.2	7.3	0	0	89	90
7/24/61	3	18	8.0	7.2	0	0	86	148	4	14	7.8	7.1	0	0	85	110
7/31/61	4	21	8.0	7.3	0	0	93	144	3	12	8.0	7.2	0	0	86	123
8/ 4/61	4	20	7.9	7.3	0	0	88	157	3	9	7.8	7.2	0	0	91	96
8/ 7/61	2	20	8.1	7.4	0	0	85	155	3	13	8.2	7.3	0	0	93	116
8/11/61	3	22	8.1	7.2	0	0	86	164	1	18	8.4	7.1	0	0	84	125
8/14/61	3	22	8.2	7.3	0	0	92	146	2	10	8.2	7.4	0	0	93	111
8/18/61	3	23	7.9	7.2	0	0	96	146	1	16	8.3	7.1	0	0	99	132
8/21/61	2	24	8.2	7.3	0	0	93	141	2	9	8.2	7.4	0	0	94	115
8/25/61	2	24	8.3	7.3	0	0	85	144	7	10	8.1	7.3	0	0	100	118
8/28/61	1	24	8.3	7.1	0	0	81	146	3	12	7.7	7.1	0	0	81	105
9/ 1/61	5	33	7.5	7.2	0	0	94	169	5	7	7.6	7.5	0	0	100	101
9/ 5/61	3	30	5.0	7.2	0	0	91	157	2	16	8.0	7.0	0	0	85	117
9/ 8/61	1	28	8.3	7.3	0	0	88	174	3	15	8.2	7.0	0	0	92	114
9/11/61	1	30	8.5	7.2	0	0	83	166	3	13	8.2	7.1	0	0	87	106
9/15/61	3	32	8.0	7.2	0	0	93	162	5	8	7.6	7.3	0	0	89	98
9/18/61	4	29	7.8	7.2	0	0	93	165	5	7	7.6	7.3	0	0	92	93
10/ 1/61	5	33	7.5	7.2	0	0	93	169	5	7	7.6	7.5	0	0	100	101
10/21/61	9	43	7.3	6.9	0	0	111	203	8	8	7.4	7.5	0	0	102	101
11/10/61	8	8	7.4	7.4	0	0	109	117	8	8	7.4	7.5	0	0	104	115
11/25/61	6	5	7.5	7.6	0	0	105	103	6	4	7.4	7.6	0	0	104	94
12/17/61	4	5	7.6	7.7	0	0	99	100	5	4	7.6	7.7	0	0	95	105

PLANKTON

Chlorophyceae and Cyanophyceae

Algal counts were not started at either station until June, 1960. Algal pulses were recorded at station A in August, 1960, and in the summer and fall of 1961 (fig. 2). The 1960 pulse reached a peak in August and consisted of *Pleurococcus* only. During 1961, a gradual increase in algae/liter occurred until a peak of 14,400 organisms/liter was reached in the bottom water in December. The most important forms during this period were *Anabaena*, *Oscillatoria*, and an unidentified colonial form. The maximum algal count at the surface of station A, 13,634 organisms/liter, was recorded on October 1, 1961. This pulse consisted mainly of *Anabaena*.

An algal pulse was also observed during August, 1960, at station E. This pulse consisted mainly of *Mougeotia* and *Zygnema*. A bloom of *Oscillatoria* and *Mougeotia* resulted in a June peak in 1961, and a pulse of *Anabaena* resulted in another peak during September, 1961. The largest pulse of algae recorded at station E occurred in December, 1961, and consisted of an unidentified colonial form and *Oscillatoria*.

Bacillariophyceae

During 1959 and 1960, there were no large pulses of diatoms at station A (fig. 3). However, during 1961, there was a spring maximum when diatoms exceeded 97 per cent of the total plankton and a secondary late fall pulse when diatoms made up 50 per cent of the total plankton. At the time of the spring overturn during April and May of 1961, a maximum number of 65,762 diatoms/liter of surface water was recorded. In the fall of 1961, a smaller pulse with a maximum of 21,836 organisms/liter of surface water was recorded. The two most prominent genera during the spring pulse were *Synedra*, which reached a peak of 588 organisms/liter at the surface on April 8 and *Asterionella*, which reached a peak of 65,628 organisms/liter at the surface on May 3. The fall pulse was mainly the result of *Asterionella*, which reached a peak of 29,160 organisms/liter at a depth of 20 ft on November 10.

Station E was quite similar to station A with the first large pulse of diatoms occurring in the spring of 1961, and a second pulse occurring in late fall. The maximum number of diatoms (48,765/liter) at the surface of station E in the spring was less than the maximum number (65,762/liter) at station A. However,

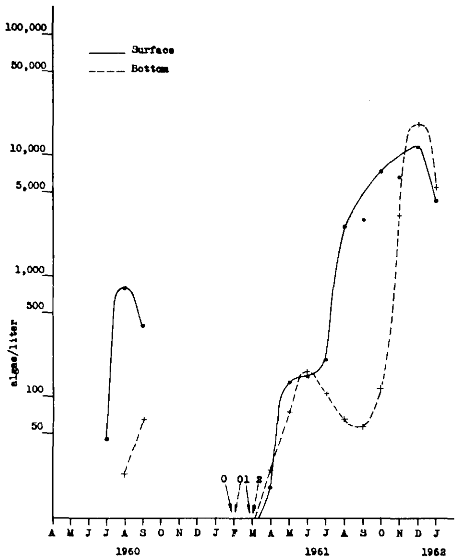

FIGURE 2. Semilogarithmic curves of the mean monthly number of algae per liter of water at station A.

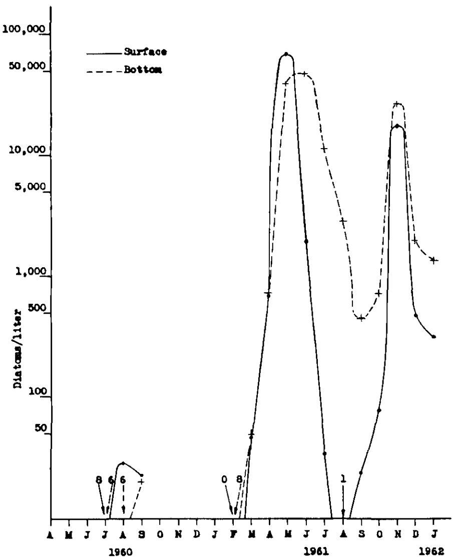

FIGURE 3. Semilogarithmic curves of the mean monthly number of diatoms per liter of water at station A.

in the fall, the number of diatoms in the surface water at station E (47,933/liter) was more than twice as great as the number at station A (21,836/liter). During most of the summer months, the number of diatoms at the surface of station E exceeded the number at the surface of station A, although the opposite condition was true in the bottom water. The dominant form at station E was *Asterionella*, which reached peaks of 48,745 organisms/liter in May and 47,925 organisms/liter in November. *Synedra* was important in the spring pulse only and never exceeded 167 organisms/liter.

Protozoa

Eleven genera of protozoa were collected from Dow Lake along with some unidentifiable ciliates (table 3). Only five genera, all members of the subclass Phytomastigina, were found in any abundance. *Peridinium* reached maxima of 4,980 organisms/liter at the surface of station A on June 19, 1961, and 12,420 organisms/liter at the surface of station E on July 3, 1961. Another Dinoflagellate, *Ceratium*, showed peaks of 1,740 organisms/liter at the surface of station A and 2,050 organisms/liter at the surface of station E on July 3, 1961. In 1960, *Ceratium* showed a maximum of 1,160 organisms/liter at the surface of station A. *Mallomonas* was present during the entire summer of 1961 and reached a maximum of 7,200 organisms/liter at the surface of station E on December 18, but never exceeded 236 organisms/liter (September 18) at station A. *Volvox* was collected only during June, July, and August of 1961 and reached a peak of 2,166 organisms/liter at station E on July 24. No large pulse of *Volvox* was recorded at station A and the maximum of 203 organisms/liter was recorded on August 14. Of all the protozoa, *Dinobryon* was the genus which occurred in greatest numbers. *Dinobryon* first appeared at stations A and E in October, 1961. A rapid increase occurred until December 18, when a maximum of 32,200 organisms/liter was recorded at station A and a peak of 78,300 organisms/liter was recorded at station E. With the exception of *Dinobryon* during the winter of 1961–62, few protozoa were present during the winter months (fig. 4).

TABLE 3

Genera of plankton found in Dow Lake

	ALGAE	
Cyanophyceae	Chlorophyceae	Bacillariophyceae
Anabaena	*Closterium*	*Asterionella*
Nostoc	*Docidium*	*Fragilaria*
Oscillatoria	*Mougeotia*	*Frustulia*
	Pediastrum	*Gyrosigma*
	Pleurococcus	*Navicula*
	Scenedesmus	*Nitzschia*
	Spirogyra	*Synedra*
	Ulothrix	
	Zygnema	
	PROTOZOA	
Ceratium	*Euglena*	*Stentor*
Codonella	*Mallomonas*	*Ulvella*
Difflugia	*Peridinium*	*Volvox*
Dinobryon	*Phacus*	
	ROTATORIA	
Asplanchna	*Gastropus*	*Polyarthra*
Brachionus	*Keratella*	*Rattulus*
Collotheca	*Monostyla*	*Rotifer*
Conochilus	*Notholca*	*Synchaeta*
Euchlanis	*Pedalion*	*Trichocerca*
Filinia	*Ploesoma*	
	COPEPODA	
Cyclops	*Diaptomus*	nauplii larvae
	CLADOCERA	
Bosmina	*Ceriodaphnia*	*Daphnia*
	MISCELLANEOUS	
Chaoborus	*Ostracoda*	

Rotatoria

The rotifer pulses recorded at station A are shown in figure 5. At station E, pulses occurred in June 1960, and in May, September, and December, 1961. Of the seventeen genera of rotifers collected (table 3), only two occurred in such numbers as to be worthy of individual attention. The genus *Notholca* showed a pulse near the bottom at both stations shortly before and on May 29, 1961. At station A, the pulse reached 337 organisms/liter; and at station E, a pulse of 169 organisms/liter was recorded. *Keratella* exhibited a peak of 633 organisms/liter near the bottom at station A in January, 1962. This was the maximum concentration of rotifers found during the period included in this study. The other genera of rotifers showed no pronounced pulses.

The greatest variety of rotifers was found during the warm months, especially August and September. At both stations, the Rotatoria were most numerous in relation to the total number of plankters present during the winter and spring months. At station A, rotifers made up 94 per cent of the total number of plankters in February, 1961; 46 per cent in March, 1961; and 9 per cent in April, 1961. At station E, rotifers comprised 22 per cent of the total plankton in March, 1961; and 15 per cent in April, 1961.

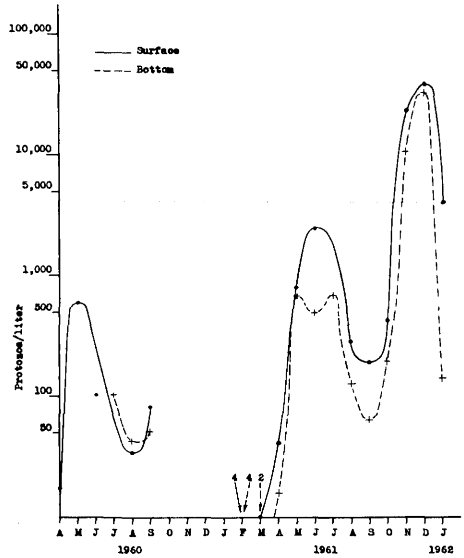

FIGURE 4. Semilogarithmic curves of the mean monthly number of protozoa per liter of water at station A.

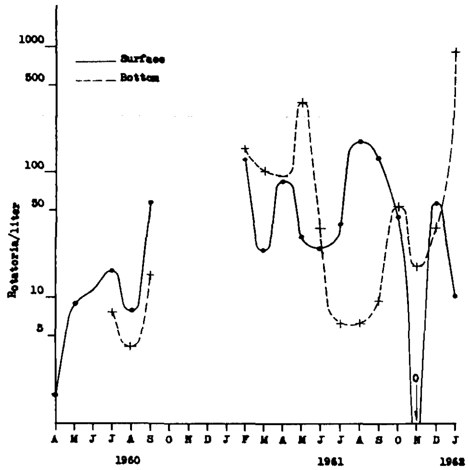

FIGURE 5. Semilogarithmic curves of the mean monthly number of Rotatoria per liter of water at station A.

Copepoda

Nauplii were usually present near the surface at station A and reached a maximum concentration of 296 organisms/liter on August 14, 1961. The greatest concentration of nauplii in the bottom waters occurred on October 21, 1961, when 28 organisms/liter were collected. However, the main pulse observed in the bottom waters occurred during April and May, 1961 (fig. 6). Near the surface at station E the maximum number of nauplii was 111 organisms/liter on August 21, 1961. At the bottom, a maximum of 94 organisms/liter was found on July 24, 1961. Nauplii never exceeded 6 per cent of the total number of plankters present at either station.

The monthly averages of nauplii/liter of water at station A are graphically shown in figure 6. At station E, a summer and fall peak occurred in 1960. In 1961, the main peak occurred during the late summer months with a secondary pulse in October.

The maximum number of Copepoda at the surface of station A was 39 organisms/liter on May 29, 1961. The maximum number in the bottom waters was 11 organisms/liter and occurred on October 21, 1961. The number of copepods at the surface exceeded the number near the bottom on all but three sampling dates. On the same date and at the same depth, the number of copeods present seldom exceeded the number of nauplii. The major Copepoda pulses at station A are shown in figure 7. The copepods comprised approximately 2 per cent of the total number of plankters present in June, August, and September of 1960, but never exceeded 1 per cent at any other time.

At station E, a maximum of 17 copepods/liter of surface water was recorded on July 3, 1961. The maximum bottom water concentration was 186 copeods/liter on July 24, 1961. On most dates the density of copepods at the bottom exceeded the density at the surface. On all dates when middepth (8 ft) samples were taken, the number of copeoods/liter at this depth was equal to or exceeded the number/liter at the surface. This same phenomenon was observed at station A in 1960, but was not found to be true in 1961. Copepod pulses occurred at station E in July and September, 1960, and in July and October, 1961, and were directly related to the nauplius pulses. The Copepoda comprised 3 per cent of the total plankton in July, 1960, and 2 per cent in September, 1960. However, on no other date did they exceed 1 per cent of the total plankton.

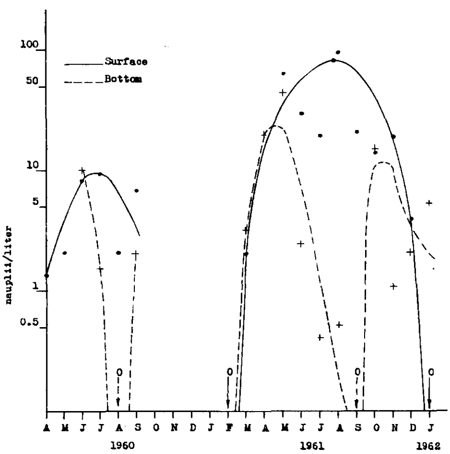

FIGURE 6. Semilogarithmic curves of the mean monthly number of nauplii per liter of water at station A.

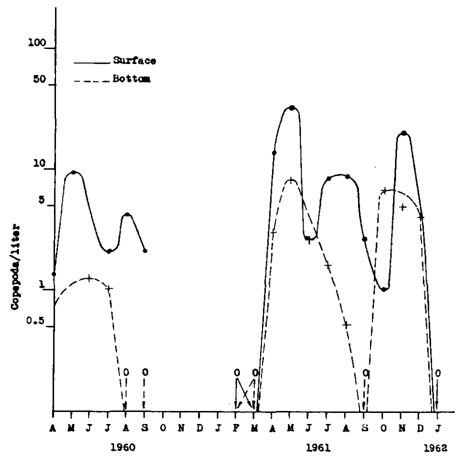

FIGURE 7. Semilogarithmic curves of the mean monthly number of Copepoda per liter of water at station A.

Cladocera

Of the three genera of Cladocera identified, only *Daphnia* occurred regularly and in any numbers. A maximum number of 26 Cladocera/liter was recorded at the surface of station A on September 29, 1960. The maximum concentration near the bottom was 54 Cladocera/liter on October 21, 1961; and the greatest concentration ever recorded at Dow Lake was 113 Cladocera/liter at a depth of 20 ft on September 29, 1960. Primary pulses of Cladocera at station A are shown in figure 8. Percentagewise, the greatest abundance of Cladocera occurred in June, July, and September of 1960, when they made up 5 per cent, 3 per cent, and 7 per cent respectively, of the total number of plankters present. During 1961, the Cladocerans always numbered less than 1 per cent of the total number of plankters.

At the surface of station E, the Cladocera were most numerous on September 29, 1960, when a count of 38 organisms/liter was recorded. A bottom water maximum of 98 organisms/liter was recorded on the same date. Cladocera were found in the bottom waters at station E on almost all sampling trips and the number of Cladocera/liter at the bottom usually exceeded the number/liter at the surface. Cladoceran pulses occurred at station E in September, 1960, and in the spring and fall of 1961. The Cladocera were important members of the total plankton community at station E only in September, 1960, when they comprised 12 per cent of the total plankton. Except for this month, they never exceeded 2 per cent of the total number of plankters.

General

As seen in figures 2 through 8, all of the different groups of plankters increased in number at station A as the lake aged. The same fact is evident when plankton collections from station E are graphed in a similar fashion. The extent of future increases (or decreases) in productivity of the lake cannot be estimated at this time. It is generally believed that the biological productivity of a newly impounded body of water increases with age. Harris et al. (1940) studied four artificial lakes in Texas ranging in age from 2 to 23 years and found that older

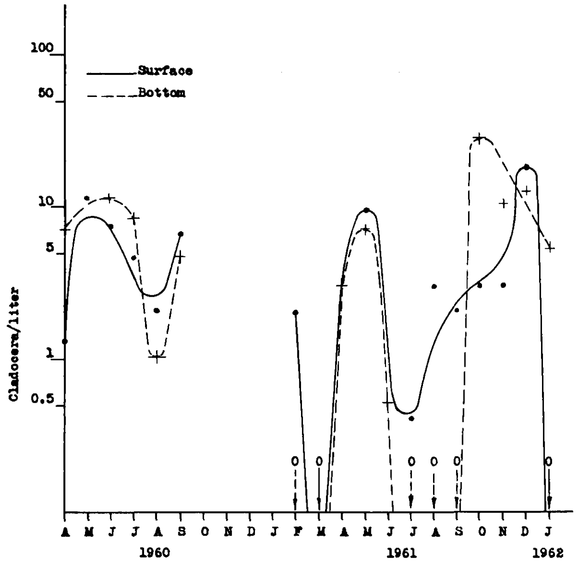

FIGURE 8. Semilogarithmic curves of the mean monthly number of Cladocera per liter of water at station A.

lakes equaled or exceeded the productivity of younger lakes. It is, therefore, probable that the biological productivity of Dow Lake will continue to increase for a number of years in the future.

Although all of the different groups of plankters increased as the lake aged, the Cladocera and Rotatoria did not show increases proportional to those of the lower forms, such as the diatoms and protozoa. One possible reason might be that since fish probably consume these large zooplankters in larger quantities than the smaller plankters, a rapid increase in numbers may be retarded by predation. Also, the reproductive rate of these higher forms is probably somewhat less than that of the lower forms, and thus the difference in rates of increase may be accounted for in part or in whole by physical limitations. It would appear that a low density of zooplankters in a very young lake is not an uncommon situation since Pennak (1955) found a similar condition in a 2 year old Colorado lake.

As shown in figures 6, 7, and 8, oxygen depletion and/or the accumulation of CO_2 near the bottom of station A seemed to have a definite limiting effect on crustacean plankters. The Cladocera appeared to be most sensitive to oxygen depletion in 1961 and were lacking in the bottom water from early June until the fall overturn. However, they were collected near the bottom during the entire summer in 1960. The Copepoda and nauplii were found to be lacking completely during the summer months of 1960 and 1961.

In a study on the aquatic insects of Dow Lake, Stanley (1961) found that the majority of the forms found in mature lakes were present in Dow Lake when it was only 1 year old. The same sudden appearance was found to be true in the case of the different planktonic forms. A comparison of the plankton forms present when Dow Lake was 2 years old with those forms present in mature lakes shows that almost all of the older lake plankters were present in Dow Lake.

Although a number of plankters and insects were present in Stroud's Run previous to impoundment, many of these forms are probably new additions to the lake. These facts suggest that many plankton forms, as well as many insects, are capable of being introduced and becoming established very quickly in new habitats. Introduction of new forms into Dow Lake was probably mainly the result of the wind's carrying desiccated eggs and also of aquatic birds transferring living plankters and their eggs from other lakes and ponds. Man may also have played a part in the appearance of new forms by introducing water from other ponds and lakes while stocking fish and keeping live bait.

DIURNAL CHANGES

Physical

On two occasions, September 8 and 9, 1960, and August 28 and 29, 1961, 24-hr surveys were conducted. As shown in table 4, maximum surface water temperatures on both dates occurred at the same time or shortly after the maximum air temperature was reached. In both cases, the maximum air temperature occurred during the afternoon hours when the sun had the greatest effect. The minimum surface temperatures occurred in the early morning, prior to the rise of the sun.

No bottom temperature was recorded in 1960, but had it been, it probably would have been similar to that of 1961. A variance of 0.7 degrees C was noted in the bottom water at station A, but this is a negligible change and probably the result of experimental error. At station E, a variance of 2.8 degrees C was recorded in the 24-hr period, with the maximum temperature occurring at 10:00 AM and the minimum at 2:00 AM. Since the bottom water temperature did fall during the night, it would appear that a condition of complete thermal stratification did not exist on this date.

Turbidity readings were possible only during the daylight hours of the 24-hr surveys. On both dates, no change in turbidity was recorded at either station (table 4). These results are what would be expected, since in 1960 the turbidity had not exceeded 7 ppm for several weeks and in 1961, for several months.

Chemical

Dissolved oxygen in the surface water reached a maximum during the afternoon and early evening hours, probably as a result of photosynthesis (table 4). In 1961, samples collected at a depth of 10 ft showed the highest oxygen concentrations. This, as mentioned previously, is probably the result of a dense population of green flagellates near this depth. In 1960, a complete lack of oxygen at the bottom of station E was recorded at 11:45 PM. However, by 3:30 AM, the bottom oxygen concentration had risen to 2.3 ppm, an event explainable only by the sinking of cool, oxygen-rich surface water. A similar phenomenon was observed in 1961 when 1.0 ppm of oxygen was recorded at 2:00 AM, but this figure had risen to 1.5 ppm by 6:00 AM and 2.0 ppm at 9:00 AM. From 9:00 AM until after 2:00 PM, no increase was recorded in bottom oxygen concentration, probably as a result of the fact that oxygen-rich surface water was no longer sinking and the oxygen produced was balanced by the oxygen utilized in decomposition and respiration. However, as the afternoon progressed, increased sunlight stimulated photosynthetic activity near thc bottom and resulted in an increased oxygen concentration.

Since some limitations are present in the method of determination, the only significant variations in free CO_2 are probably those recorded at the bottom of

TABLE 4

Temperatures in degrees centigrade and turbidity and dissolved oxygen in parts per million

	Station A									Station E						
Date and time	°C			Turbid	Dissolved Oxygen					°C			Turbid	Dissolved oxygen		
	Air	0'	40'		0'	10'	14'	20'	40'	Air	0'	16'		0'	10'	16'
9/ 8/60																
9:15 AM	27.2	27.3		7—	6.6		1.0		0.0							
10:15 AM										27.7	27.9		7—	6.2		1.1
12:50 PM	29.2	28.7		7—	6.6		2.6		0.0							
2:00 PM										31.7	29.0			6.9		3.2
7:15 PM										27.1	29.1			6.9		1.4
8:10 PM	25.5	28.0			7.0		2.8		0.0							
11:45 PM										23.0	28.6			6.8		0.0
9/ 9/60																
12:30AM	23.5	27.7			6.8		1.8		0.0							
3:30 AM										21.2	28.1			6.6		2.3
5:00 AM	22.1	27.5			6.6		1.3		0.0							
8/28/61																
5:00 AM				7—	7.9	8.2	4.2	0.0	0.0							
6:00 AM													7—	7.8	7.3	1.5
9:00 AM	23.8	26.6	11.6	7—	7.3	8.1	4.0	0.0	0.0							
10:00 AM										25.5	27.4	26.2	7—	7.6	7.3	2.0
1:00 PM	26.0	29.0	12.0	7—	7.5	7.4	6.4	0.0	0.0							
2:00 PM										28.0	29.0	24.3	7—	7.7	7.1	1.8
5:00 PM	28.0	30.0	11.5	7—	7.9	8.0	8.5	0.0	0.0							
6:00 PM										28.0	29.0	23.7	7—	8.0	7.7	3.1
9:00 PM	24.8	29.3	11.3		7.1	7.2	7.5	0.0	0.0							
10:00 PM										23.2	27.9	24.2		7.9	8.0	3.5
8/29/61																
1:00 AM	22.9	28.6	11.7		7.6	8.1	5.1	0.0	0.0							
2:00 AM										21.0	27.2	23.4		7.6	7.9	1.0

station E in 1961 (table 5). These data show a maximum concentration at 10:00 PM, but apparently shortly thereafter the concentration began to diminish, probably as a result of the sinking of surface water.

Ordinarily, the hydrogen ion concentration would be expected to reach a maximum during the predawn hours when the products of respiration and decomposition had accumulated. Likewise, a minimum concentration would be expected during and after the period of maximum photosynthesis. Although the variations in samples are rather small, they follow this general pattern.

Variations in methyl orange alkalinity were recorded at the bottom of both stations on the 1960 survey (table 5). The variance at station E with a minimum at 3:30 AM could hardly be accounted for by the sinking of surface water since the methyl orange alkalinity at the surface was far greater than the minimum bottom recording. At station A, such an extreme variation (approximately 30 ppm) would not be anticipated in the rather stable bottom water. It would seem quite likely that these low values are the result of some experimental error rather than actual conditions.

On the 1961 survey, the variations at both stations are of doubtful significance because of the irregular pattern followed. These fluctuations are probably the result of insufficient sensitivity of the method of determination and perhaps also of the sinking of surface water at station E.

TABLE 5

Free carbon dioxide, phenolphthalein, and methyl orange alkalinity expressed in parts per million and pH

	Station A								Station E							
Date and time	CO_2		pH		Phenol.		M–O		CO_2		pH		Phenol.		M–O	
	0'	40'	0'	40'	0'	40'	0'	40'	0'	16'	0'	16	0'	16'	0'	16'
9/ 8/60																
9:15 AM	4	49	7.7	7.0	0	0	94	185								
10:15 AM									4	53			0	0	94	
7:15 PM									3	10			0	0	92	100
8:10 PM	2	50			0	0	94	181								
11:45 PM									2	19	7.6	7.0	0	0	93	113
9 /9/60																
12:30 AM	2	50	7.5	6.9	0	0	90	182								
3:30 AM									2	34	7.6	6.8	0	0	93	77
5:00 AM	2	61	7.4	6.8	0	0	85	149								
6/28/61																
5:00 AM	3	25	8.0	7.1	0	0	87	146								
6:00 AM									3	15	7.6	7.0	0	0	89	122
9:00 AM	1	24	8.3	7.1	0	0	81	146								
10:00 AM									3	12	7.7	7.1	0	0	81	105
1:00 PM	4	28	8.3	7.1	0	0	95	143								
2:00 PM									3	10	8.2	7.3	0	0	99	107
5:00 PM	5	26	8.0	7.1	0	0	88	141								
6:00 PM									4	16	8.0	7.2	0	0	89	119
9:00 PM	4	28	8.2	7.2	0	0	80	142								
10:00 PM									4	19	8.2	7.4	0	0	98	102
8/29/61																
1:00 AM	2	24	8.1	7.2	0	0	95	156								
2:00 AM									3	16	8.1	7.1	0	0	95	117

Plankton

Although different lakes are highly variable, a vertical diurnal migration of plankters of the Class Crustacea can often be observed. The fact that no vertical plankton migrations were observed in the data from the two 24-hr surveys is probably the result of one or more factors: no vertical migrations existed or vertical migrations did exist, but were not observed because of the small number of samples collected.

SUMMARY

This study was initiated to determine the physical, chemical, and biological conditions occurring in a newly impounded body of water, Dow Lake, Athens County, Ohio. Two stations, A at the south end of the lake with a depth of 40 ft, and E at the north end of the lake with a depth of 16 ft, were established as permanent sampling locations. From May, 1959, through January, 1962, 76 sampling trips were conducted. The conditions sampled included air and water

temperatures, turbidity, dissolved oxygen concentrations, free carbon dioxide, pH, phenolphthalein and methyl orange alkalinity, and surface, middepth, and bottom net plankton.

Physical data show that the lake underwent a spring and fall turnover and was thermally stratified during the summer months and during periods of ice cover. Summer stratification at station A appeared to be more pronounced than the stratification at station E. The turbidity of the lake decreased with age and was low except for short periods in the spring and fall.

Oxygen concentrations were relatively low at most times while carbon dioxide concentrations were quite high. The maximum oxygen concentrations occurred during periods of circulation. During periods of thermal stratification, oxygen was depleted below the 20-ft level while maximum carbon dioxide concentrations at station A occurred in the hypolimnion near the end of periods of stratification. Carbon dioxide concentrations at station E were not so high as those at station A. The high concentrations of carbon dioxide were attributed to the large amount of decomposition occurring on the new lake bottom and are not expected to be a permanent condition.

Hydrogen ion values fell within the normal range for lakes of this region. Phenolphthalein alkalinity values were always zero. Methyl orange alkalinity varied directly with free carbon dioxide and showed that Dow Lake was a hard water lake.

Samples of net plankton showed that the productivity of Dow Lake was low compared to other Ohio lakes which have been studied. However, the same samples established the fact that most of the plankton forms found in mature lakes of this region were present, and that the productivity of the lake was increasing with age. Cycles of productivity were observed with major diatom and protozoan pulses in the spring and fall and algal pulses in the fall.

Two 24-hr sampling trips showed that maximum surface water temperatures and oxygen concentrations occurred during the afternoon and evening. Hydrogen ion concentrations reached maxima in the predawn hours. No distinct diurnal cycles of carbon dioxide or methyl orange alkalinity were observed. The net plankton was sampled at 8-hr intervals but the results of these samples did not show any vertical plankton migrations.

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