

A COMPARATIVE INVESTIGATION OF THE WATER OF  
LAKE BRIDGEPORT WITH REFERENCE TO PLANT  
AND ANIMAL LIFE

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## INTRODUCTION

### Aim and Purpose

This investigation of the waters of Lake Bridgeport is to obtain data essential for a satisfactory understanding of the effects of the physical and chemical factors on the aquatic life. These factors determine the kinds of food available for life there. When a comparative study is made over a period of one year, the facts are more reliable for studying the life cycles and forms of animal life.

The problem is confined to the physical and chemical factors in the lake. Quantitative studies were made once a month over a period of one year which included the following determinations: temperature, depth, turbidity, pH, alkalinity, dissolved oxygen, free carbon dioxide, ammonia nitrogen, nitrates, organic nitrogen, and dissolved phosphates. One complete quantitative analysis included the following determinations: silica, iron, calcium, magnesium, sodium and potassium, bicarbonate, carbonate, sulphate, chloride, residue on evaporation, non-carbonate hardness, and soap hardness.

Frequently lakes are artificially stocked with animal life, but if the chemical and physical factors are not favorable, there will be little productivity. Therefore, this investigation is of importance economically as well as scientifically and has been studied with the hope that

the facts may aid in perpetuating plant and animal life in Lake Bridgeport.

#### Physiography, Morphometry, and Geology

Lake Bridgeport is located in Wise County, Texas. Wise County lies in approximately the north central part of the state between the ninety-seventh and ninety-eighth meridians, and is cut by the thirty-third parallel. The lake is located six miles west of Bridgeport, Texas.

Lake Bridgeport is the first of a series of three lakes from which Fort Worth receives its water supply. The water flows from Lake Bridgeport into Eagle Mountain Lake, then into Lake Worth from which it is used directly.

The shore line of Lake Bridgeport is 86.69 miles; the area 183.10 square miles; maximum length 6.89 miles; maximum breadth 2.46 miles; and the maximum depth is 60 feet. The main axis runs north and south. The volume of Lake Bridgeport is not definite in that it varies with heavy rains and floods, but its capacity is approximately 290,000 acre-feet (Fig. 1).

Following any general classification which has been made Lake Bridgeport might be in any one of several classes, but it probably has more nearly the requirements of Class B, Type II, in the classification set up by Birge. In this class the water is completely circulated during all the year except summer. Also in June, July, and August no oxy-

gen is found in the bottom.<sup>1</sup>

One reason for the construction of this lake other than as a water supply was to aid in prevention of floods. The lake has a drainage area of 1,000 square miles including northwestern part of Wise, and all of Jack and Montague Counties. This area is drained by the West Fork of the Trinity River and its tributaries. During fall and late winter the rains are heavy, generally causing floods which fill the lake and bring huge amounts of soil and debris.

The lake drains areas located in the Brad and Caddo Creek formations. In these formations sand and gravel deposits appear along all of the larger streams mixed with limestone, shale, clay, and some coal.

Lake Bridgeport is drained from the bottom although the outflow of water is not constant. In July, 1936, there was thermal stratification, but the water was completely mixed in August when a large amount of water was drained from the lake. The effect of this interruption has not been determined as the lake is approximately two years old and has never been full.

#### Methods and Equipment

All of the methods of chemical analysis except soluble phosphates were based on Standard Method of Water Analysis

<sup>1</sup> Kemmerer, Boyard, and Boorman, "Northwestern Lakes of the United States," Bulletin of United States Bureau of Fisheries, pp. 57-140.



by the American Public Health Association. The colorimetric method used by Juday, Birge, and Kemmerer (1925-26) was employed in determining the dissolved phosphates in this study.<sup>2</sup>

Two especially constructed sample cases were used in the field to aid in the determinations. The larger sample case was about sixteen inches by thirty-one inches by twelve inches and was partitioned for sample bottles and for apparatus needed in the field. The smaller box was constructed in like fashion with partitions for holding reagent bottles and with a double lid for carrying the pipettes.

Apparatus for determining the pH of the water by the colorimetric method, dissolved carbon dioxide, and part of the oxygen was carried to the field, so that determinations could be made there. The other chemical tests were made immediately on return to the laboratory.

A reversing thermometer of the Negretti-Zambra type was used in taking temperature. The thermometer was let down by means of a calibrated line to the desired depth and the messenger was dropped, reversing the thermometer. The mercury remained stationary; therefore, the reading could not change as the thermometer was drawn to the top.

Samples were taken once a month for one year with a Juday Sampler at a station located near the deepest part

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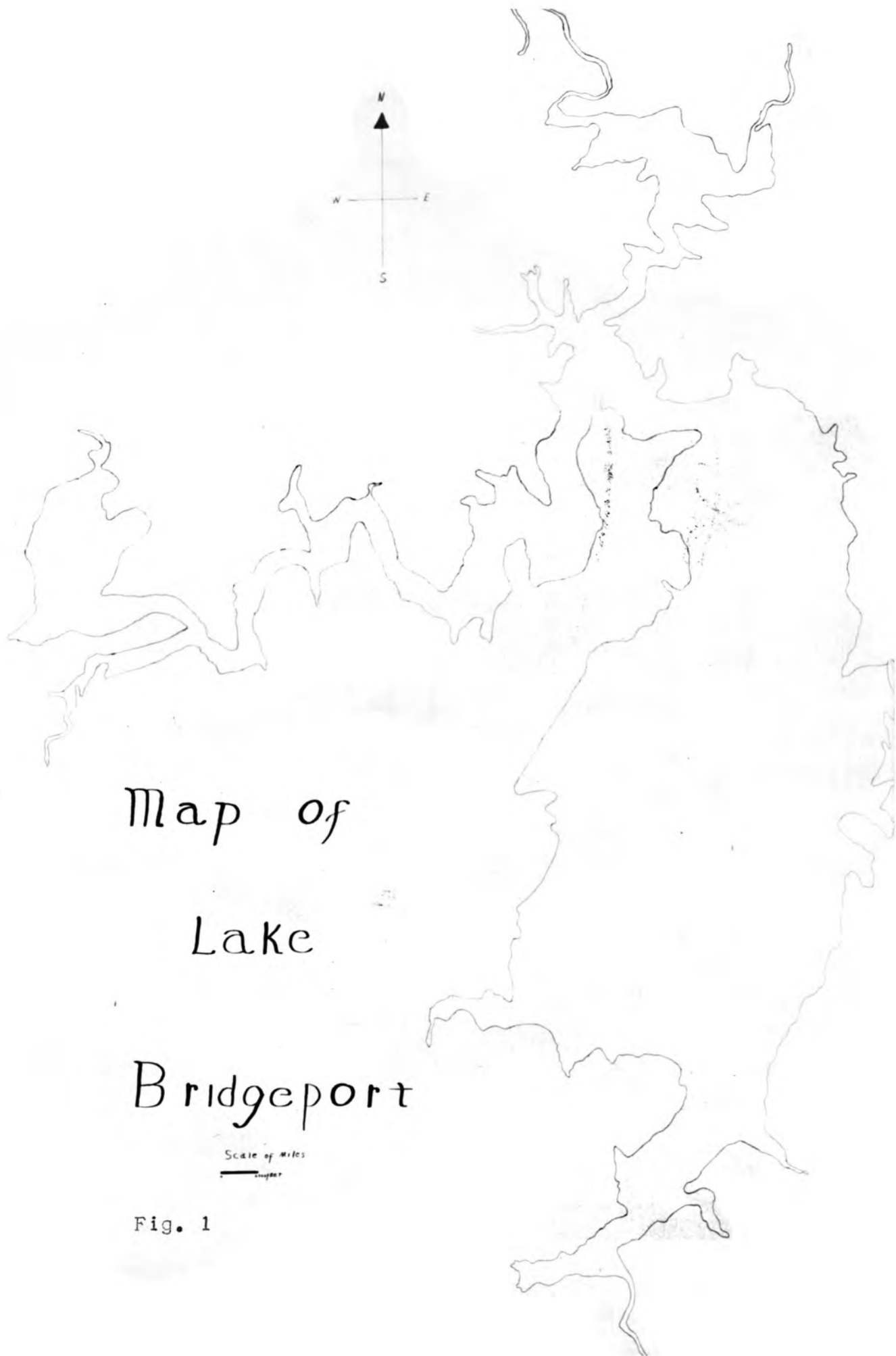
<sup>2</sup> Juday, Birge, Kemmerer, and Robinson, "Phosphorus Content of Lake Waters of Northeastern Wisconsin," Wisconsin Academy of Sciences, Arts, and Letters, pp. 236-237.

of the lake. The samples for determining bicarbonates, dissolved oxygen, dissolved carbon dioxide, and pH were taken in separate 250 cubic centimeter bottles at every two meters from surface to the bottom. Reagents were added to the oxygen samples in the field; carbon dioxide and pH were determined in the field; and bicarbonates were taken to the laboratory. The samples for all other determinations were taken in liter bottles at surface, eight meters, and bottom.

The bottles were filled by placing the tube of the sampler to the bottom of the bottle and filled to overflowing. The tube was slowly removed while the water was flowing, and the bottle closed so there would be no air bubbles.

In obtaining the samples at different depths the sampler was set open and lowered to the required depth by means of a calibrated line. The messenger was then dropped, closing the sampler at that depth, so that it might be drawn to the surface. A spring valve at the bottom of the container was opened to allow the water to flow into the bottles.

Other general methods of equipment such as maps, drawing boards, polar planimeter, map-measure, and obviously an automobile and motor boat for transportation were employed on occasions when necessary.



Map of  
Lake  
Bridgeport

Scale of Miles  
—

Fig. 1

TABLE I  
COMPLETE WATER ANALYSIS  
LAKE BRIDGEPORT

Substance Found	Parts Per Million
Silica ( $\text{SiO}_2$ )	4.00
Iron ( $\text{Fe}^{+++}$ )	0.12
Calcium (Ca)	34.40
Magnesium (Mg)	5.44
Sodium and Potassium (Na, K)	22.00
Bicarbonate ( $\text{HCO}_3$ )	103.68
Carbonate ( $\text{CO}_3$ )	0.00
Sulphate ( $\text{SO}_4$ )	35.40
Chloride (Cl)	10.00
Nitrites ( $\text{NO}_2$ )	trace
Residue on Evaporation ( $103^\circ\text{C}.$ )	200.00
Non-carbonate Hardness	13.40
Soap Hardness	659.75

TABLE II

## WATER ANALYSIS OF LAKE BRIDGEPORT

LOCATION LAKE BRIDGEPORT

DATE AUGUST 2, 1936

TIME 8:00-11:00 A.M.

SKY CLEAR

WIND S.W. SLIGHT

DEPTH METERS	TEMPERATURE CENTIGRADE	TURBIDITY P.P.M.	PH	FREE CARBON DIOXIDE P.P.M.	DISSOLVED OXYGEN P.P.M.	AMMONIA NITROGEN P.P.M.	ORGANIC NITROGEN P.P.M.	NITRATE NITROGEN P.P.M.	DISSOLVED PHOSPHATES P.P.M.	BICARBONATE P.P.M.
SURFACE	29.50		8.1	5.09	4.91	0.02	0.195	0.15	0.60	98.42
2	29.00		8.2	5.09	5.34					96.77
4	28.50		8.1	5.09	5.18					105.86
6	28.00		8.0	4.82	5.44					105.34
8	27.50		8.1	5.36	6.51	0.02	0.195	0.15	0.60	102.40
10	27.50		8.1	4.82	5.43					100.48
12	27.00		8.1	4.82	5.42					98.56
14	25.00		8.0	6.50	5.42					98.42
16	22.90		8.1	6.75	5.42	0.02	0.195	0.15	0.60	98.29

TABLE III

## WATER ANALYSIS OF LAKE BRIDGEPORT

LOCATION LAKE BRIDGEPORT

SKY CLOUDY

DATE AUGUST 31, 1936

WIND S.W. MILD

TIME 11:30-2:30 P.M.

DEPTH METERS	TEMPERATURE CENTIGRADE	TURBIDITY P.P.M.	PH	FREE CARBON DIOXIDE P.P.M.	DISSOLVED OXYGEN P.P.M.	AMMONIA NITROGEN P.P.M.	ORGANIC NITROGEN P.P.M.	NITRATE NITROGEN P.P.M.	DISSOLVED PHOSPHATES P.P.M.	BICARBONATE P.P.M.
SURFACE	29.50		8.3	5.35	4.60	0.06	0.19	0.15	0.60	110.7
2	29.00		8.4	4.82	5.00					108.8
4	28.50		8.4	5.35	6.60					108.2
6	28.00		7.9	4.28	6.40					110.0
8	27.50		8.3	4.82	6.20	0.06	0.19	0.15	0.60	107.5
10	27.50		7.9	5.35	5.60					107.5
12	27.50		7.8	5.89	4.80					107.5
14	25.00		7.7	5.89	3.60					107.5
16	22.90		7.4	8.03	0.00	0.06	0.19	0.15	0.60	107.5

TABLE IV

## WATER ANALYSIS OF LAKE BRIDGEPORT

LOCATION LAKE BRIDGEPORT

DATE OCTOBER 2, 1936

TIME 5:20-6:30 P.M.

SKY CLEAR

WIND NONE

DEPTH METERS	TEMPERATURE CENTIGRADE	TURBIDITY P.P.M.	PH	FREE CARBON DIOXIDE P.P.M.	DISSOLVED OXYGEN P.P.M.	AMMONIA NITROGEN P.P.M.	ORGANIC NITROGEN P.P.M.	NITRATE NITROGEN P.P.M.	DISSOLVED PHOSPHATES P.P.M.	BICARBONATE P.P.M.
SURFACE	22.20		7.8	4.00	7.80	0.09	0.19	0.15	0.20	96.6
2	20.00		7.7	4.00	7.60					99.8
4	19.80		7.6	5.00	7.60					99.8
6	19.80		7.3	6.00	7.50					99.8
8	18.00		7.3	7.00	6.00	0.05	0.265	0.15	0.20	80.0
10	17.70		7.2	8.00	5.60					60.0
12	17.60		7.3	9.00	5.10					60.0
14	17.60		7.2	10.00	5.10	0.07	0.19	0.15	0.20	57.00

TABLE V

## WATER ANALYSIS OF LAKE BRIDGEPORT

LOCATION LAKE BRIDGEPORT

SKY CLEAR

DATE OCTOBER 29, 1936

WIND NONE

TIME 9:45 A.M. - 12:45 P.M.

DEPTH METERS	TEMPERATURE CENTIGRADE	TURBIDITY P.P.M.	PH	FREE CARBON DIOXIDE P.P.M.	DISSOLVED OXYGEN P.P.M.	AMMONIA NITROGEN P.P.M.	ORGANIC NITROGEN P.P.M.	NITRATE NITROGEN P.P.M.	DISSOLVED PHOSPHATES P.P.M.	BICARBONATE P.P.M.
SURFACE	14.90	273	8.0	4.80	10.00	0.035	0.19	0.15	0.20	87.6
2	14.40		7.7	3.50	9.48					86.4
4	14.40		7.7	3.50	9.30					88.3
6	14.40		7.5	3.70	9.30					85.5
8	14.30		7.5	3.20	9.00	0.045	0.215	0.15	0.20	87.0
10	12.90		7.5	3.20	8.94					74.9
12	12.40		7.4	4.20	8.74					67.2
14	12.30		7.4	5.20	8.28	0.065	0.215	0.15	0.20	67.2



TABLE VI  
WATER ANALYSIS OF LAKE BRIDGEPORT

LOCATION LAKE BRIDGEPORT  
DATE DECEMBER 10, 1936  
TIME 9:30 - 10:30 A.M.

SKY CLOUDY  
WIND WEST LIGHT

DEPTH METERS	TEMPERATURE CENTIGRADE	TURBIDITY P.P.M.	PH	FREE CARBON DIOXIDE P.P.M.	DISSOLVED OXYGEN P.P.M.	AMMONIA NITROGEN P.P.M.	ORGANIC NITROGEN P.P.M.	NITRATE NITROGEN P.P.M.	DISSOLVED PHOSPHATES P.P.M.	BICARBONATE P.P.M.
SURFACE	9.20		7.7	6.00	10.48	0.022	0.20	0.20	0.20	78.34
2	9.20		7.7	6.00	10.40					81.28
4	9.20		7.7	7.00	10.08					83.84
6	9.20		7.7	8.00	10.26					80.64
8	9.20		7.7	8.00	10.06	0.027	0.27	0.20	0.20	84.48
10	9.20		7.7	8.00	10.06					80.25
12	9.20		7.6	9.00	10.00	0.027	0.27	0.20	0.20	83.20

TABLE VII

LOCATION LAKE BRIDGEPORT  
 DATE FEBRUARY 7, 1937  
 TIME 10:00 - 12:00 A.M.  
 WATER ANALYSIS OF LAKE BRIDGEPORT  
 SKY CLEAR TO CLOUDY  
 WIND NORTH

DEPTH METERS	TEMPERATURE CENTIGRADE	TURBIDITY P.P.M.	PH	FREE CARBON DIOXIDE P.P.M.	DISSOLVED OXYGEN P.P.M.	AMMONIA NITROGEN P.P.M.	ORGANIC NITROGEN P.P.M.	NITRATE NITROGEN P.P.M.	DISSOLVED PHOSPHATES P.P.M.	BICARBONATE P.P.M.
SURFACE	5.30		7.6	6.00	13.36	0.055	0.019	0.20	0.20	88.06
2	5.20		7.6	7.00	13.72					87.04
4	5.20		7.6	7.00	13.72					87.04
6	5.20		7.6	7.00	13.72					87.29
8	5.15	112	7.6	7.00	13.68	0.055	0.019	0.20	0.20	87.29
10	5.15		7.6	7.00	13.68					87.04
12	5.15		7.6	7.00	13.68					85.77
14	5.20		7.6	7.00	13.64					85.76
16	5.20		7.6	7.00	13.60	0.055	0.200	0.20	0.20	85.00

TABLE VIII  
WATER ANALYSIS OF LAKE BRIDGEPORT

LOCATION LAKE BRIDGEPORT SKY CLOUDY  
DATE MARCH 20, 1937 WIND NORTH STRONG  
TIME 10:00 A.M. - 12:00 P.M.

DEPTH METERS	TEMPERATURE CENTIGRADE	TURBIDITY P.P.M.	PH	FREE CARBON DIOXIDE P.P.M.	DISSOLVED OXYGEN P.P.M.	AMMONIA NITROGEN P.P.M.	ORGANIC NITROGEN P.P.M.	NITRATE NITROGEN P.P.M.	DISSOLVED PHOSPHATES P.P.M.	BICARBONATE P.P.M.
SURFACE	10.6		7.8	5.00	10.40	0.05	0.19	0.20	0.20	92.80
2	10.6	87	7.8	5.00	10.40					94.72
4	10.4		7.8	5.00	10.40					94.72
6	10.4		7.8	5.00	10.42					94.08
8	10.4		7.8	5.00	10.42	0.05	0.19	0.20	0.20	93.44
10	10.4		7.8	5.00	10.40					93.44
12	10.4		7.8	5.00	10.40					93.44
14	10.4		7.8	5.00	10.38					93.44
16	10.4	116	7.7	6.00	10.38	0.05	0.19	0.20	0.20	92.80

TABLE IX  
WATER ANALYSIS OF LAKE BRIDGEPORT

LOCATION LAKE BRIDGEPORT  
DATE APRIL 25, 1937  
TIME 3:30 - 6:30 P.M.

SKY SLIGHTLY CLOUDY  
WIND NORTH STRONG

DEPTH METERS	TEMPERATURE CENTIGRADE	TURBIDITY P.P.M.	PH	FREE CARBON DIOXIDE P.P.M.	DISSOLVED OXYGEN P.P.M.	AMMONIA NITROGEN P.P.M.	ORGANIC NITROGEN P.P.M.	NITRATE NITROGEN P.P.M.	DISSOLVED PHOSPHATES P.P.M.	BICARBONATE P.P.M.
SURFACE	18.40		7.7	7.00	8.54	0.06	0.197	0.15	0.20	92.80
2	18.60		7.7	7.00	8.54					94.08
4	18.40		7.7	7.00	8.70					94.72
6	18.15		7.7	7.00	8.70					94.08
8	18.10		7.7	7.00	8.70	0.06	0.197	0.15	0.20	94.08
10	18.00		7.7	7.00	8.70					94.08
12	17.80		7.7	7.00	8.70					94.08
14	17.20		7.7	6.00	8.70					94.08
16	15.80		7.7	6.00	8.70	0.06	0.197	0.15	0.20	94.08

TABLE X  
WATER ANALYSIS OF LAKE BRIDGEPORT

LOCATION LAKE BRIDGEPORT

DATE MAY 22, 1937

TIME 10:00 - 12:00 A.M.

SKY CLEAR

WIND NONE

DEPTH METERS	TEMPERATURE CENTIGRADE	TURBIDITY P.P.H.	PH	FREE CARBON DIOXIDE P.P.M.	DISSOLVED OXYGEN P.P.M.	AMMONIA NITROGEN P.P.M.	ORGANIC NITROGEN P.P.M.	NITRATE NITROGEN P.P.M.	DISSOLVED PHOSPHATES P.P.M.	BICARBONATE P.P.M.
SURFACE	22.4	80	7.8	5.00	7.20	0.02	0.20	0.00	0.30	106.00
2	22.3		7.8	5.00	7.20					106.00
4	22.3		7.8	5.00	7.20					104.00
6	22.3		7.7	5.00	7.20					104.00
8	22.2		7.7	5.00	7.20	0.02	0.20	0.00	0.30	104.00
10	22.2		7.6	5.00	7.20					103.00
12	22.2		7.5	6.00	6.80					101.00
14	20.8		7.4	7.00	6.00					100.00
16	17.0		7.4	7.00	5.00					99.00
18	13.0		7.2	9.00	2.80	0.03	0.30	0.00	0.30	90.00

TABLE XI  
WATER ANALYSIS OF LAKE BRIDGEPORT

LOCATION LAKE BRIDGEPORT  
DATE JUNE 21, 1937  
TIME 1:00-4:00 P.M.

SKY CLEAR  
WIND NONE

DEPTH METERS	TEMPERATURE CENTIGRADE	TURBIDITY P.P.M.	PH	FREE CARBON DIOXIDE P.P.M.	DISSOLVED OXYGEN P.P.M.	AMMONIA NITROGEN P.P.M.	ORGANIC NITROGEN P.P.M.	NITRATE NITROGEN P.P.M.	DISSOLVED PHOSPHATES P.P.M.	BICARBONATE P.P.M.
SURFACE	35.8		7.9	0.0	8.20	0.015	0.325	0.20	0.60	103.68
2	32.8		7.9	0.0	8.80					103.68
4	30.2		7.9	4.0	7.00					103.68
6	29.8		7.9	2.5	6.00					103.68
8	27.0		7.9	5.0	6.00	0.015	0.325	0.20	0.60	103.68
10	26.8		7.9	7.0	5.20					93.44
12	24.8		7.6	8.0	3.80					93.44
14	24.2		7.5	10.0	1.30					93.44
16	23.4		7.4	17.0	0.80	0.030	0.325	0.20	0.60	93.44

## DISCUSSION

### PHYSICAL FEATURES

#### Water Movement

In lakes the water is mixed by wave motion and currents. The waves are mainly produced by wind. The local conditions such as area of lake, shape of shoreline, and the direction, duration, and velocity of wind determine the size and type of wave action. The waves and currents in Lake Bridgeport tend to keep the water completely mixed throughout the year, except summer. Then the wave action is decreased and thermal stratification occurs.

#### Turbidity

The plant life in a lake is partially proportional to the amount of light admitted, and the light is determined largely by the turbidity of the water. In Lake Bridgeport the high winds, heavy rains, and soil erosion cause the waters to be very turbid in fall, winter, and spring. The turbidity of these waters probably decreases the life production in the lake more than any other single factor.

Suspended matters in the water cause it to be turbid. Any finely divided material contribute to turbidity, but the most prominent among these materials are (1) finely divided non-living substances of organic origin, (2) silt, and (3) plankton organisms. These substances have been divided into two groups: (1) the settling suspended matters,

and (2) the non-settling suspended matters.

Settling suspended matters are those substances which in motionless water will sooner or later settle to the bottom.

From the results of laboratory experiments in 1927, Kindle concluded that the sharply contrasted densities and viscosities of the epilimnion and the hypolimnion cause a distinct delay in the settling of finely divided sediments.<sup>1</sup>

Non-settling suspended matters are those materials whose specific gravities are less than water or materials which are in colloidal suspension, and hence are permanently suspended.

#### Thermal Conditions

The temperature during the greater part of the year varies little between the surface and bottom in this lake. In June, July, and August the surface temperatures are much higher than the bottom which induces thermal stratification (Table XI).

There must be a complete understanding of the features of thermal stratification as this phenomenon has a profound influence upon the whole biological and chemical "set-up." Lake Bridgeport does not have all of the cycle of events expected in a large natural lake with thermal stratification. This particular lake has complete circulation in fall, spring, and winter; thermal stratification in summer; and

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<sup>1</sup>Welch, Limnology, pp. 186.



a fall "turnover." The description will begin arbitrarily with the conditions as they exist in spring.

In spring the whole lake is homothermous (Table VIII). When the density is the same throughout the lake, the winds cause the waters to mix from surface to bottom. But as the air becomes warmer in early summer, the temperature of the surface water begins to rise thereby decreasing its density. This condition continues until the temperature of the surface water is several degrees above that of the underlying waters. Then only the surface waters can be circulated by wind, and a condition of thermal stratification comes into existence. The lake water separates into three distinct layers (Fig. 2). The epilimnion, the upper layer, is the zone of summer circulation and uniform temperature. The thermocline, the next stratum, is the zone where there is a drop in temperature of one degree centigrade per meter. The hypolimnion, the lowermost region, is a stratum of nearly uniform temperature from its upper limit to the bottom.

When thermal stratification is permanently established the lake enters upon the summer stagnation period (Fig.2). The water of the hypolimnion during summer becomes "stagnated."

In early autumn the cool air begins to cool the surface of the lake. As the surface waters are cooled and become heavier, the denser water sinks and convection currents are

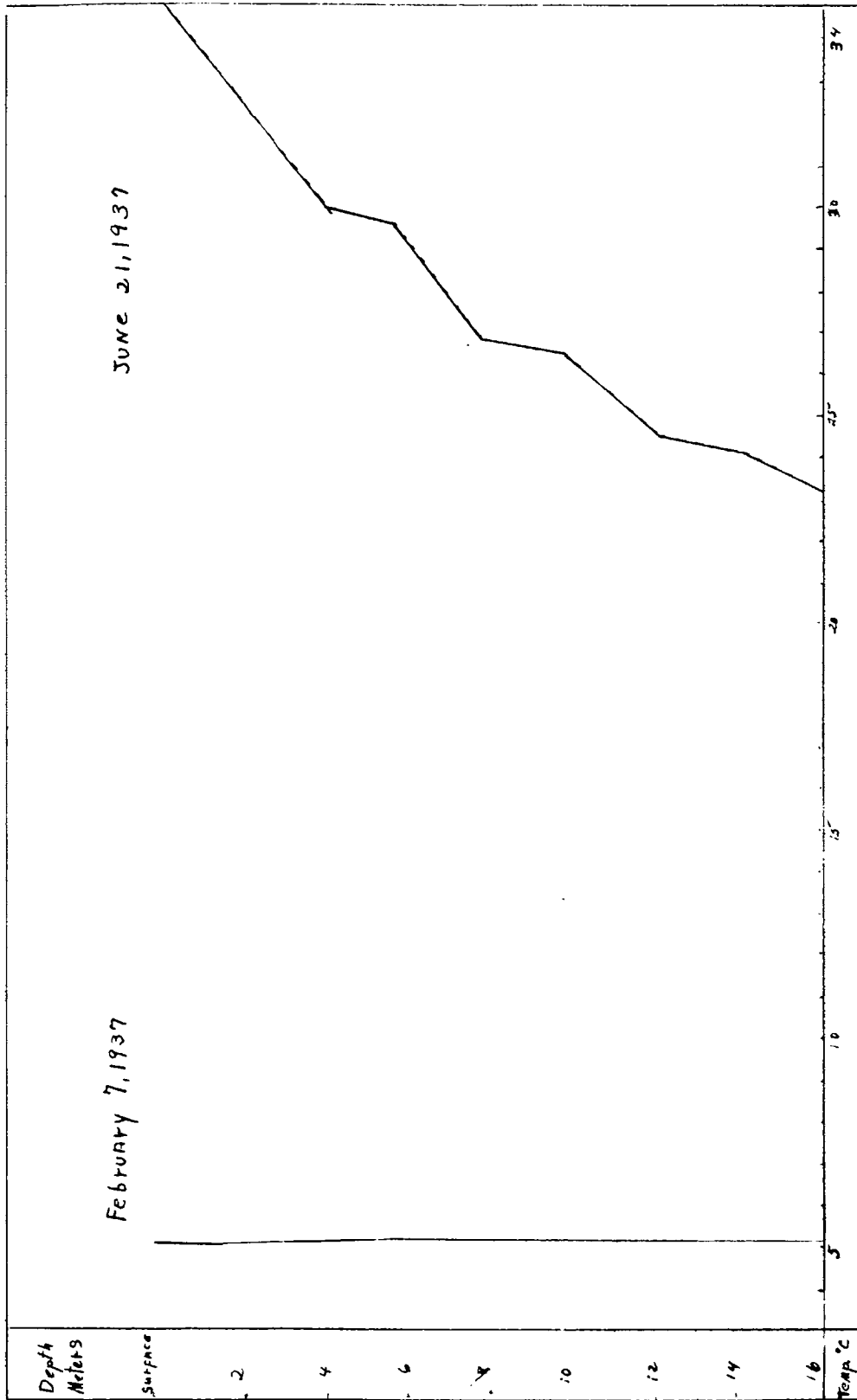


Figure 1. Variation of Temperature with Depth in the Summer and in the Winter

set up equalizing the temperature throughout the lake.

The lake remains homothermous throughout the winter (Fig. 2). Some lakes have a winter stagnation period and a spring turnover, but due to the continuous mixing of the water and lack of continuous temperature below 4° Centigrade, Lake Bridgeport does not.

All organisms have a maximum and a minimum environmental temperature, but many aquatic animals remain active through wide ranges of temperatures. Lake Bridgeport varies from 5.20°C. to 35°C. during the year (Tables II - XI), but the greatest variation in the lake at one time was from 35.0°C. at surface to 23.4°C. at the bottom on June 21, 1937 (Fig. 2), (Table XI).

### CHEMICAL FEATURES

#### Hydrogen Ion Concentration

Some recent literature seems to indicate that pH is an important factor and that very small changes in hydrogen ion concentration may result in very significant changes in the functioning of the animal mechanisms.

Coker in 1925 stated that the pH of the water may be a limiting factor in its suitability for fish. He reported that the brook trout inhabits waters which are acid or at most neutral. More recently, however, Creaser has shown that brook trout tolerate a pH range from 4.1 to 9.5. Also Behre in 1925 stated that in an investigation of Pacific Slope waters, he found them to vary between pH 6.8 and 8.4, and that fish were found to

be independent of a considerable variation in pH.<sup>2</sup>

The pH of water is the measurement of the combined effects of carbon dioxide, and various salts. pH readings are merely indicators of the conditions existing in the lake.

The pH of Lake Bridgeport ranged between 7.2 to 8.4 which indicates a favorable equilibrium between the electrolytes in the water (Tables II - XI).

#### Alkalinity

The alkalinity of natural water is a measure of its carbonate, bicarbonate, hydroxide, and occasionally borate, silicate, and phosphate content. The alkalinity in this lake is produced by soluble bicarbonates and phosphates, mainly those of sodium, potassium, calcium, and magnesium. Since the bicarbonates are high, Lake Bridgeport is a temporary hard water lake. The phosphates remain constant between 0.2 to 0.6 parts per million (Tables II-XI). The bicarbonates vary from 80.00 to 110.00 parts per million at the surface during the year. They did not show chemical stratification to any great extent (Fig. 8).

#### Phosphates

Phosphates are good buffers and have pronounced ef-

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<sup>2</sup>Curbo, Addie Mae, Chemical Factors Affecting Fish Production: Lake Dallas, pp. 28-29.

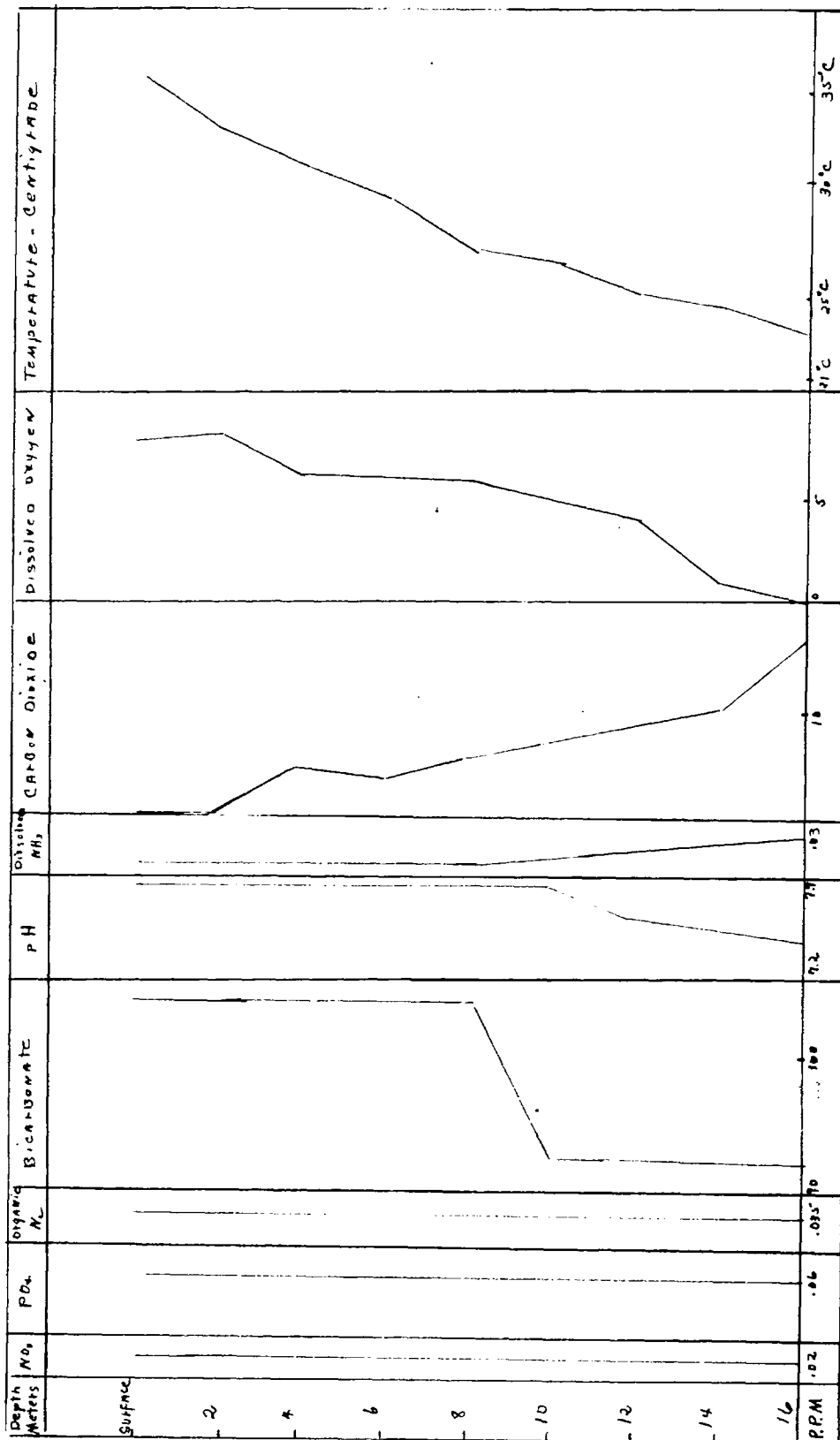


Figure 2. Variation of Chemical and Physical Factors with  
Depth on June 21, 1937

fect upon the pH of the waters. Some literature indicates that phosphorus may be a limiting factor, but Birge, Juday, Kemmerer, and Robinson (1925-26) found after studying 88 lakes that is apparently not a limiting factor. They found that the amount of phosphorus did not matter and that it could be a limiting factor only when there was no phosphorus.<sup>3</sup>

In waters where there is a very small amount of soluble phosphates a large growth of phytoplankton would exhaust the supply, and in that case the phosphorus content could be a limiting factor. The phosphorus content of Lake Bridgeport ranges between 0.2 to 0.6 parts per million (Tables II - XI).

#### Dissolved Oxygen

An adequate supply of dissolved oxygen is one of the prime requirements of most aquatic organisms; hence, the oxygen content of water is very important. The principal sources of dissolved oxygen in water are (1) the atmosphere through the exposed surface and (2) the photosynthesis of chlorophyll-bearing plants.

There is always sufficient oxygen in the upper strata of Lake Bridgeport; however, during June, July, and August there is little found in the bottom water, which is a result of stratification. The oxygen content varies at sur-

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<sup>3</sup>Juday, Birge, Kemmerer, and Robinson, "Phosphorus Content of Lake Waters of Northeastern Wisconsin," Transactions of the Wisconsin Academy, pp. 234-244.

face from 4.6 to 13.6 parts per million (Fig. 5) and from 0.0 to 13.6 parts per million at 16 meters depth (Fig. 7).

The causes of the oxygen decrease in Lake Bridgeport are practically the same as in any lake. Respiration of animals and plants, decomposition of organic matter, automatic release due to temperature, and presence of iron are the principal reasons.

In a lake exhibiting thermal stratification, chemical stratification may also occur. Although the two phenomena occur often together, they may exist independently of each other. Chemical stratification is an expression sometimes used to describe a condition existing during the summer and winter stagnation periods. During these periods one horizontal stratum becomes quite different chemically from adjacent ones.

In spring the water carries a maximum load of dissolved gases, and there is equal distribution of dissolved oxygen, pH, carbon dioxide, and dissolved substances from surface to bottom (Fig. 4). Decomposition gases such as free carbon dioxide, hydrogen sulphide, methane, and others are carried from the bottom to surface and are discharged. The lake becomes ventilated.

With the establishment of the summer stagnation period, there comes a series of distinct conditions existing in the epilimnion, thermocline, and hypolimnion. Due to rise in temperature the capacity for dissolved gases decreases in

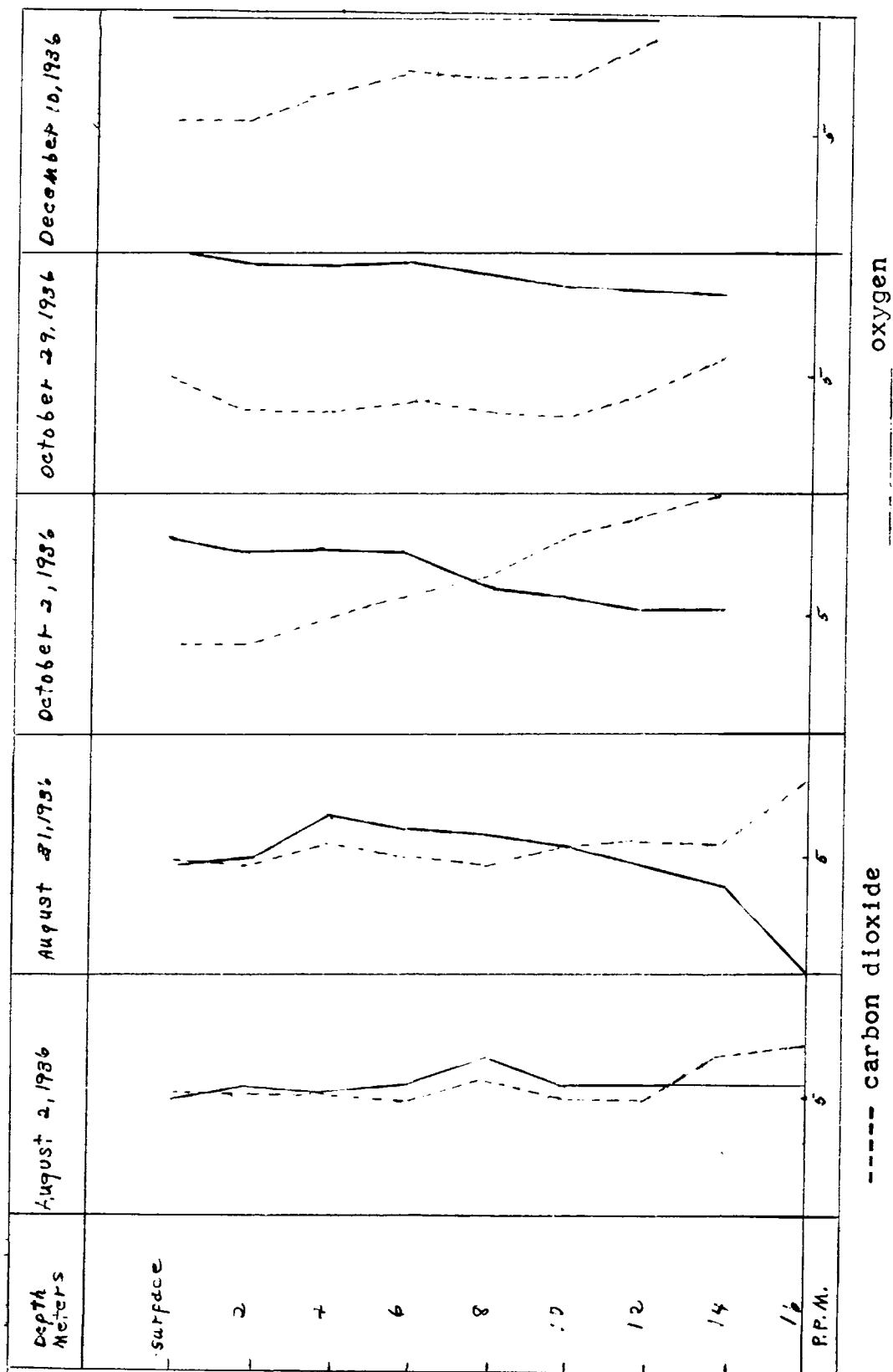


Figure 3. Variation of Carbon Dioxide and Oxygen with Depth



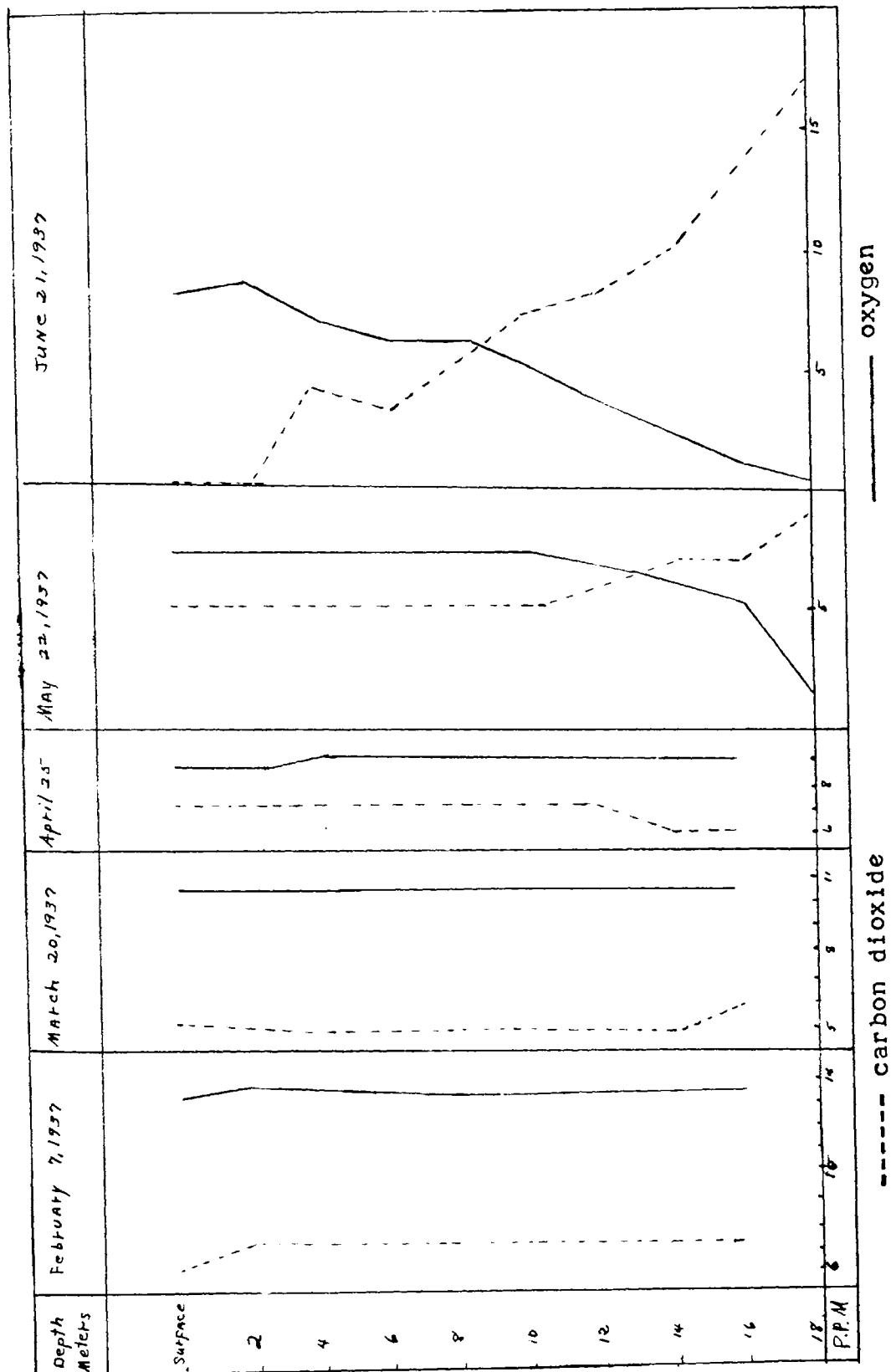


Figure 4. Variation of Carbon Dioxide and Oxygen with Depth

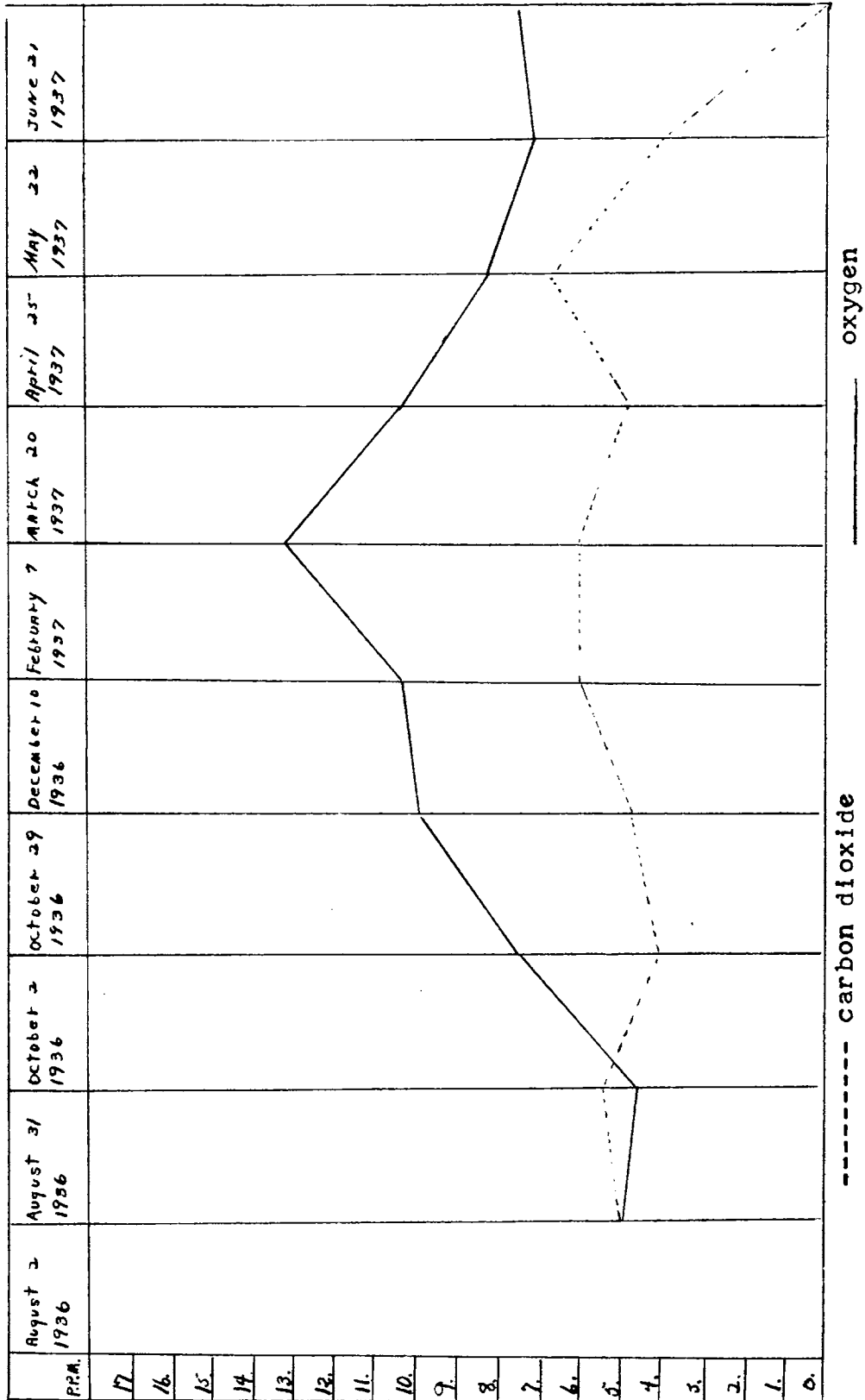


Figure 5. Variation of Carbon Dioxide and Oxygen at Surface

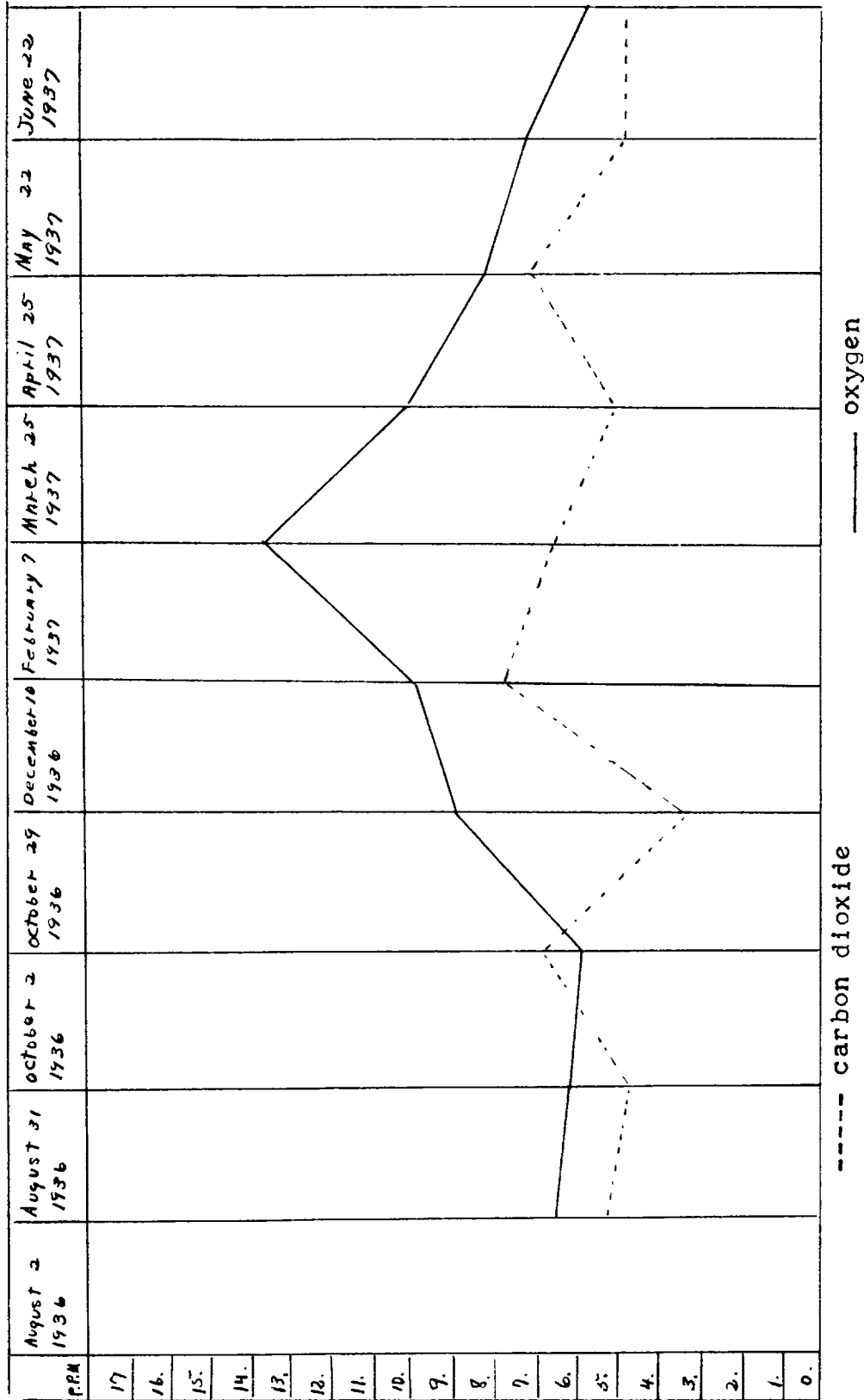


Figure 6. Variation of Carbon Dioxide and Oxygen at Eight Meter Depth

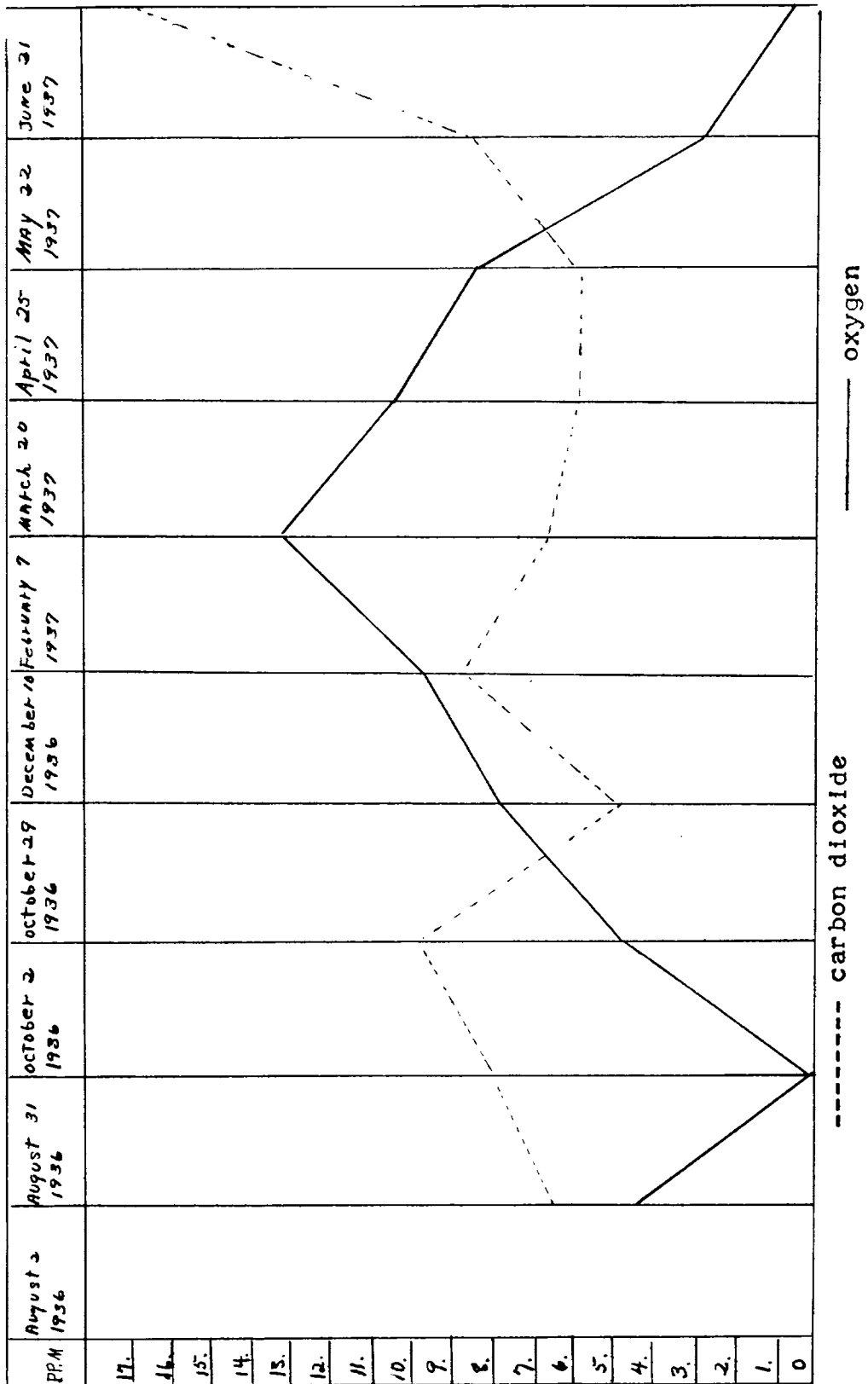


Figure 7. Variation of Carbon Dioxide and Oxygen at the Bottom of the Lake

the epilimnion. Since the waters of the epilimnion continue to circulate throughout the summer, the factors remain approximately the same throughout the zone. A saturated condition of oxygen, carbon dioxide, and nitrogen may exist during this period. The hydrogen ion concentration tends to remain constant, but often increases with increasing depth in or near the thermocline.

In the thermocline the oxygen content decreases; the carbon dioxide increases slightly; pH approaches a neutral or acid condition; suspended matters are concentrated; and dissolved substances are usually uniformly distributed.

In the bottom layer of water organic substances begin to undergo decomposition which consumes the dissolved oxygen and liberates carbon dioxide. The oxygen supply becomes completely exhausted (Fig. 4). Methane, hydrogen sulphide, and other decomposition gases also accumulate, and the pH approaches an acid condition.

Stratification of one factor or of all the chemical factors may occur in a lake. There is not complete chemical stratification in Lake Bridgeport (Table XI).

When the fall turnover occurs, the water becomes very turbid and is completely mixed giving a condition similar to the one existing in spring (Table V).

#### Free Carbon Dioxide

The free carbon dioxide in natural waters helps bring

about conditions of acidity, alkalinity, or neutrality. The sources of carbon dioxide in Lake Bridgeport are (1) the air; (2) inflowing ground water; (3) decomposition of organic matter; and (4) respiration of animals and plants.

Carbon dioxide is necessary for photosynthesis which makes it essential for practically all plant life. Consumption of free carbon dioxide in photosynthesis is dependent on several circumstances, such as the amount of green plants, both phytoplankton and higher plants; duration of effective day light; transparency of the water; and time of the year.

The carbon dioxide varies in Lake Bridgeport from a total absence to 7.0 parts per million at the surface (Fig. 5) and from 5.20 to 17.0 parts per million at the bottom (Fig. 7). During the summer the carbon dioxide increases at the bottom of the lake, and oxygen decreases (Fig. 4). The oxidation of organic matter liberates carbon dioxide and consumes oxygen.

### Nitrogen

Dissolved ammonia nitrogen was found in small amounts in Lake Bridgeport. Ammonia is largely a product of the decomposition of organic matter in the bottom of the lake. In summer free ammonia increases with depth (Table XI). Ammonia nitrogen varies from 0.02 to 0.09 parts per million at the surface (Tables II - XI). The bottom water content

was higher.

Very little information is available on the biological relations of gaseous ammonia as produced in natural waters. Although some say it can become toxic, it evidently is not in Lake Bridgeport.<sup>4</sup>

Ammonium salts, nitrites, and nitrates furnish a supply of nitrogen which is essential in the fundamental food relations of organisms. Nitrates supply nitrogen in a more usable form for plant life. Nitrate content is not high in Lake Bridgeport, but there is a constant and adequate supply (Table II - XI).

A dilute solution of nitrites is injurious to some plants and beneficial to others. A trace of nitrites was found in Lake Bridgeport (Table I).

Ammonium salts in excess have been reported poisonous to fish if present with carbonates. But Wiebe (1931) found that apparently this is not a limiting factor.<sup>5</sup>

#### Silicon

Since diatoms require silicon for the manufacture of their valves, and since they constitute a very prominent and strategic group in the plankton at large, the available supply of silicon in the water is regarded as a matter of

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<sup>4</sup>Welch, Limnology, pp. 185.

<sup>5</sup>Welch, Limnology, pp. 186.

real consequence.<sup>6</sup>

The silicon content of Lake Bridgeport was 4.00 parts per million, but a little excess is not a hinderance (Table I). All plants profit by its presence, although there is a possibility of higher plant growth in the absence or in the merest trace of silicon.

#### Calcium, Magnesium, Sodium, and Potassium

Calcium is an essential element for most green plants (not essential for many algae), and magnesium is desirable. It has also been well established that, other things being equal, the more calcium and magnesium in water the greater the productivity. Therefore any process which would precipitate calcium and magnesium would be a hindrance to life production. Calcium is not only a necessity in plant growth, but its ions make available in the desirable form other indispensable nutrient ions.

Calcium has several physiological roles, such as (1) relation to the proper translocation of the carbohydrates; (2) an integral component of plant tissue; (3) facilitating the availability of other ions; and (4) an antidoting agent reducing the toxic effects of single-salt solutions of sodium, potassium, and magnesium.<sup>7</sup>

Chlorophyll is composed of some magnesium and is dependent on magnesium for its proper development. The element appears to act as a carrier of phosphorus at least in some

<sup>6</sup> Welch, Limnology, p. 186.

<sup>7</sup> Welch, Limnology, p. 186.



instances.

The calcium content of Lake Bridgeport was 34.40 parts per million existing mostly as bicarbonate and chloride, and the magnesium content was 5.44 parts per million (Table I). Both factors are favorable for production of life.

Potassium is a fixed requirement for plants. Its function is imperfectly known, but it appears to be a fundamental requirement in food manufacture and catalysis.

While apparently not absolutely necessary for plant growth and development, sodium is a very desirable element. Sodium and potassium were determined together and the content was 22.00 parts per million which is sufficient (Table I).

### Iron

When water has a ferric oxide content of 0.2 to 2.0 parts per million most algae grow best, but distinct toxicity occurs when the available iron exceeds 5 parts per million. However, Smith (1933) found some natural waters contain more than 5 parts per million of iron without being toxic, as a result of the buffer action of organic compounds of calcium salts.<sup>8</sup> The iron content of Lake Bridgeport was 0.12 part per million (Table I).

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<sup>8</sup> Welch, Limnology, p. 188.

### Sulphur

Sulphur must be present for plant growth and development. It forms a necessary material in the composition of protein and other constituents of the plant. Sulphur occurring mostly as sodium and potassium sulphates was 35.40 parts per million in Lake Bridgeport (Table I).

## CONCLUSION

1. Lake Bridgeport is a typical Texas reservoir lake. It does not have complete circulation during summer; and in June, July, and August there is no oxygen in the bottom layer of water.

2. Waters were usually basic having a pH range from 7.2 to 8.4. The alkalinity was due to high bicarbonate content.

3. The lake has been filling rapidly with silt during the past year.

4. The conditions of temperature, dissolved gases, alkalinity, hydrogen ion concentration, iron content, and electrolytes were favorable for production of life.

5. During mid-summer there was an excess of carbon dioxide but little oxygen present in the bottom of the lake. This condition prohibits the existence of some life in the bottom waters during summer months.

6. The slight variation in physical and chemical factors of the water at different depths was probably the result of the complete circulation of water.

7. The growth of chlorophyll-bearing plants decreases as the depth increases due to the turbidity of the water.

8. Since Lake Bridgeport is a reservoir lake and is drained from the bottom, the draining process removes the bottom layer of water, thus preventing any great thermal

stratification. When the lake is drained, it generally stirs the water causing a "turn-over."

9. As most of the plant and animal life exists in the surface water, the draining of a lake from the bottom should increase the productivity.

## SUMMARY

1. Investigation of aquatic environment in North Texas is rather a new field.

2. This investigation was a comparative monthly study of the aquatic environment in Lake Bridgeport.

3. Standard chemical methods, some approved apparatus, and other newly designed equipment were used.

4. The physiography and morphometry of Lake Bridgeport were studied, mapped, and measured.

5. The data presented are the results of monthly analyses.

6. The discussion of the data is based on the biological features of lakes of similar environment.

7. The facts presented in the data obtained suggest possibilities of greater productivity in Lake Bridgeport.

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