Physicochemical Conditions of Boomer Lake, Payne County, Oklahoma

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INTRODUCTION

A benthic macroinvertebrate study was conducted on Boomer Lake, Payne County, Oklahoma, from March 1966 to February 1967 (Craven, 1968). Certain physicochemical parameters were measured to aid in interpreting seasonal trends in standing crops of benthos. The purpose of this paper is to describe physicochemical conditions existing in the lake during the benthos study.

DESCRIPTION OF LAKE

Boomer Lake, completed in 1925, is located three kilometers north of the intersection of state highways 51 and 177. The deepest portion of the lake is the old creek channel near the dam and the shallowest portion is on either side of the creek channel at the upper end where Boomer Creek widens into the lake (Fig. 1). The shallow areas at the north end were heavily vegetated during the summer of 1966 as was some of the shoreline (excluding the riprapped portion of the dam and windswept areas) to a depth of approximately 1 m. Morphometric data are shown in Table I.

The storage capacity of the original reservoir was calculated to be 2.77 million m^3 with a surface area of 92 hectares. In 1933, the spillway level was raised 0.61 m which increased surface area to 102 hectares and storage capacity to 3.47 million m^3. Eakin (1936) reported that 210,713 m^3 of sediment had accumulated between 1925 and 1935. However, Har-

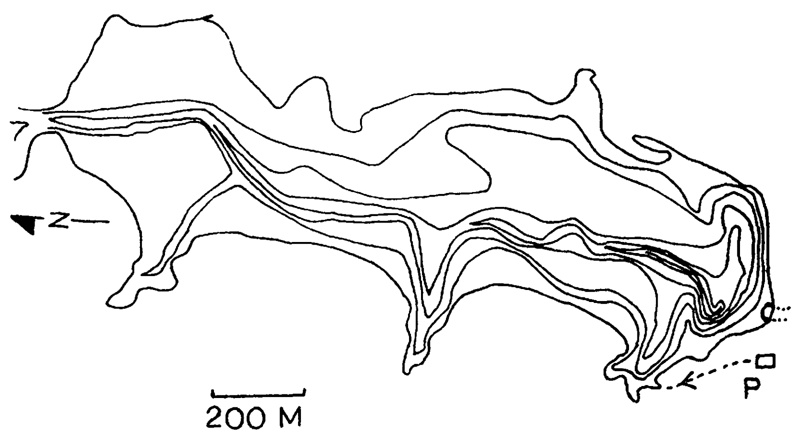

Figure 1. Boomer Lake with Contours in 1.5 m Intervals. P = Power Plant and Flume.

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TABLE I. MORPHOMETRIC DATA FOR BOOMER LAKE

Water-shed Hectares	Surface Area Hectares	Water Shed-Surface Area Ratio	Shoreline Length Kilometers	Shoreline Development	Mean Depth Meters
3,625	102	36 to 1	13.77	4.17	2.98

per (1941) estimated that only 63,718 m^3 of sediment had accumulated from 1925 to 1940.

The reservoir initially was used for a municipal water supply, but in 1951, due to a high bacterial count of the water and increased water needs, the city discontinued use of the lake for this purpose. Presently, the water is used for irrigation of the park around the lake and as a source of coolant water for the power plant turbines. Water is piped from near the bottom at the southwest corner of the lake to the power plant. After being used as a coolant for the natural gas turbines, the water returns to the lake via a 200-m concrete flume (Fig. 1). The water, as it enters the lake, is about 6 C warmer than the intake water of the plant, but apparently has little if any adverse effect on the macrobenthos (Craven and Brown, 1970).

METHODS

Dissolved oxygen, pH, and temperature were measured near the bottom at the time of each benthos collection. Surface determinations, in addition to the above, included water transparency. Rainfall and lake level data were obtained from records maintained by personnel at the Boomer Lake power station.

Dissolved oxygen and temperature were measured with a Galvanic Cell Oxygen Analyzer with a thermistor attached. Dissolved oxygen was measured close to the substrate-water interface by the following technique. A weight attached to a 0.30-m chain was suspended from the base of the oxygen probe, and the probe, thermistor, and weight lowered until the weight reached bottom. The probe and thermistor were lowered a little farther and quickly raised and lowered to develop a 0.30-m/sec water current necessary for correct operation of the oxygen probe.

Hydrogen-ion concentration was measured with a Hellige comparator and transparency of the water with a 20-cm Secchi's disc. A Kemmerer water sampler was used to collect water for pH determination.

A Bendix depth recorder, loaned by the Oklahoma Fishery Research Laboratory, Norman, was used to estimate depths as the lake was traversed in a boat. The depths, recorded on paper, was transposed in 1.5-m intervals to a map of the shoreline.

Shoreline development was calculated using Welch's (1948) formula.

RESULTS AND DISCUSSION

Rainfall and Lake Level—The annual rainfall for the Boomer Lake area averages 81.28 cm. In 1966, total rainfall was only 60.98 cm, 20.30 cm below the mean. The greatest amount of precipitation (18.51 cm) was recorded in July, while the least amounts (0.48 cm) were recorded in March and November (Fig. 2).

In January of 1966, the lake was 0.92 m below, and by July had decreased to 1.34 m below spillway level (Fig. 3). This was the lowest lake level encountered during the study. Copious rainfall in July resulted in a rise of 0.92 m in the lake level. The July rainfall was 11.9 cm, recorded

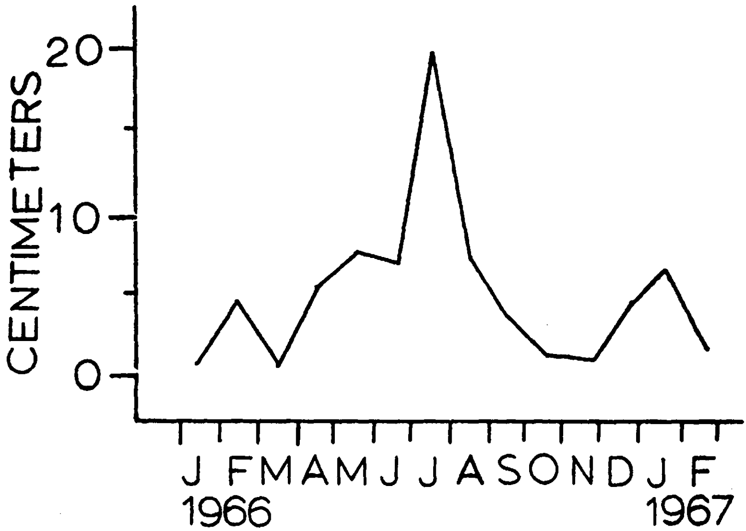

Figure 2. Monthly Rainfall

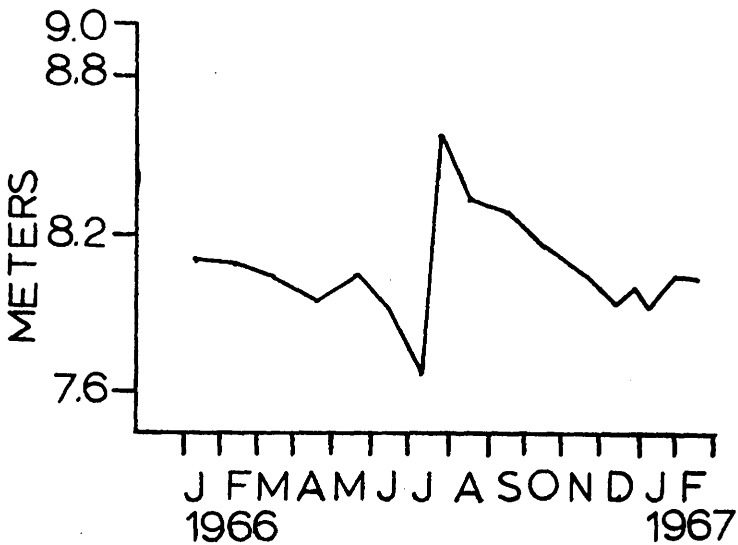

Figure 3. Monthly Fluctuations in Lake Level. Spillway Level was at 9.0 m.

for the 24-hour period ending 8:00 AM 23 July. Prior to this rainfall, littoral vegetation was abundant. After the rainfall, weekly benthic samples seemed to show more decaying vegetation. This possibly could have been caused by the increased water level reducing the sunlight available to the plants and also to decreased transparency as a result of material being added to the lake during runoff.

Hydrogen-ion concentration—The pH near the lake bottom ranged from 7.2 in July at 6.05 m to 9.0 in May at 0.18 m (Table II). Low pH was associated with anoxic conditions and a silt-clay substrate while high pH was associated with dissolved oxygen of 11 mg/l and dense littoral vegetation. Crowder (1940) reported pH values of surface and bottom water from 6.6 to 8.0 during summer months in Boomer Lake. Littoral vegetation during Crowder's study was removed by city personnel. The higher pH measured in some areas during the present study possibly was associated with the occurrence of macrophytes.

TABLE II. MEAN QUARTERLY VALUES FOR DISSOLVED OXYGEN, PER CENT OF SATURATION, TEMPERATURE, AND RANGES FOR BOTTOM pH

1966-1967	Bottom pH Range	Surface D.O. mg/l	Surface D.O. % Sat.	Bottom D.O. mg/l	Bottom D.O. % Sat.	[1]Sur. Temp. C	[1]Bot. Temp. C
Mar.-May	8.5-9.0	9.1	95	8.7	91	16.1	15.2
June-Aug.	7.2-8.4	6.9	92	6.3	81	28.1	26.9
Sept.-Nov.	8.2-8.6	9.9	112	9.4	105	19.7	18.8
Dec.-Feb.	8.2-8.5	11.7	100	11.8	100	7.1	6.8

[1]No data for March

Transparency of the water—Fluctuations in transparency resulted from runoff and addition of suspended matter, wind actions, and changes in plankton populations. Tebo (1955) indicated that, in a eutrophic lake in Iowa, turbidity was almost entirely due to silt suspended in water after periods of high winds. Mean transparency of the Boomer Lake water on 6 May was 127 cm and was the highest measured (Fig. 4). This measurement was preceded by several days of calm, sunny weather which possibly resulted in a settling of particles.

Transparency decreased to a mean of 16 cm on 28 July, and then increased to a mean of 76 cm on 28 December. The mean on 27 January was 30 cm, a decrease of 46 cm in one month. High turbidities followed rainfall but moderate turbidities were probably maintained by wind action.

Dissolved oxygen—Quarterly mean surface and bottom dissolved oxygen were lowest during summer and highest during winter (Table II). Super-saturation of surface and bottom water during fall possibly was associated with calm days, relatively high temperatures, and high rate of photosynthetic oxygen production. Dissolved oxygen determinations in spring and fall were similar, indicating transition seasons. Only during June and July was the dissolved oxygen content 2.0 mg/l or lower. Anoxic conditions were indicated in the deeper areas during several sampling periods. Maximum surface and bottom dissolved oxygen measured were both 12.6 mg/l.

Temperature profiles—Temperature data indicate that the lake water was almost in constant circulation. Stratification with development of a metalimnion occurred for short periods only during the warmer months. A well-developed metalimnion was present 6 May, but by 13 May, it was disappearing (Fig 5). Temperature profiles for March, April, November,

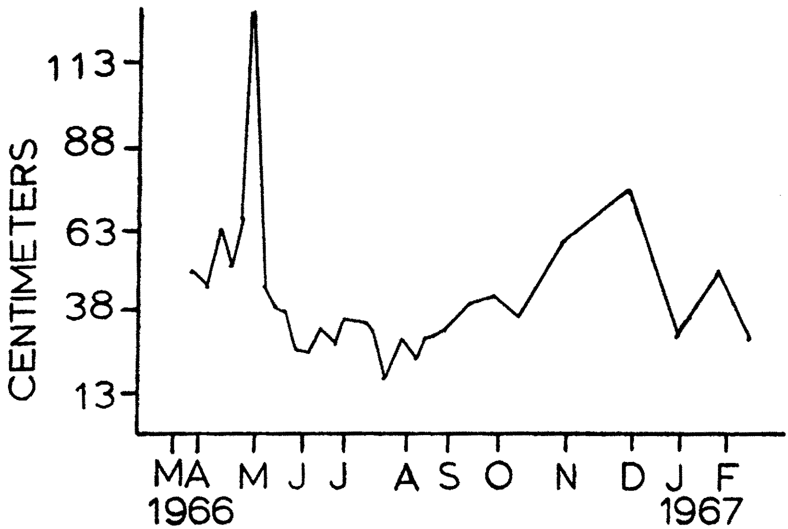

Figure 4. Mean Secchi Disc Transparency for Each Sampling Period.

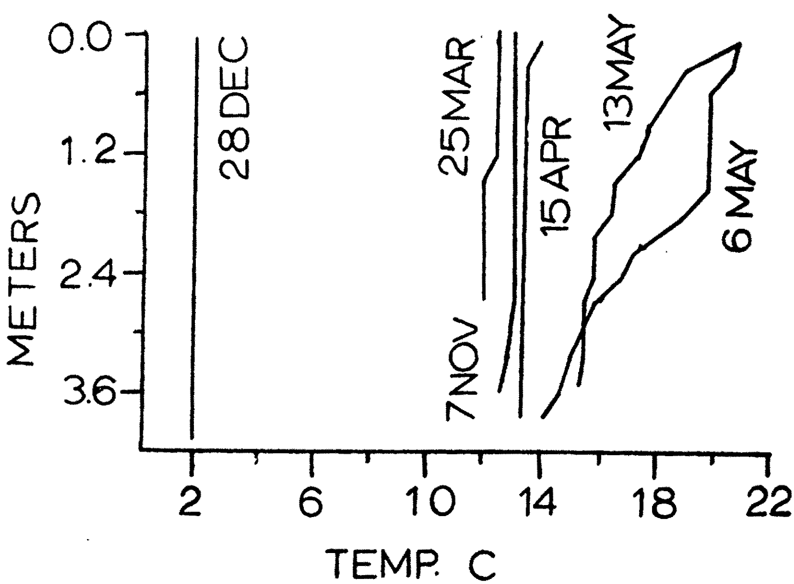

Figure 5. Temperature Profiles for March, April, May, November, and December.

and December indicated a homothermous condition. General absence of stratification is apparently due to the high mean wind velocity, shallow basin, and north-south orientation of the lake basin.

Quarterly mean surface and bottom water temperatures were highest in summer and lowest in winter (Table II). Lowest mean surface and bottom temperatures both were 1.7 C on 28 December. Highest mean surface and bottom temperatures were 33.0 and 30.8 C on 15 July.

Interrelations of Environmental Variables—Transparency, pH, temperature, dissolved oxygen, and rainfall exhibited a trend characteristic of seasonal variation in climatic conditions. Amount of rainfall seemed to be a factor, along with wind action, controlling transparency of the water that partially determined the dissolved oxygen concentrations. The period in May when transparency was greatest was accompanied by a rise in dissolved oxygen and was preceded by relatively little rainfall. The rise in oxygen content probably was due to increased rate of photosynthesis during warm, sunny days when the lake was clear.

Transparency and dissolved oxygen were lowest following the July rainfall. During the same period, pH was also lowest. Low dissolved oxygen possibly was due, in part, to the high temperatures that decreased the solubility of the oxygen. The dissolved oxygen level possibly was affected by rainfall because nutrients added to the lake may reduce the dissolved oxygen by increasing chemical and biological oxidation. A reduction in the volume of the euphotic zone due to decreased transparency also would decrease dissolved oxygen by decreasing photosynthesis and increasing the volume of the aphotic zone. Also, the increased temperature probably resulted in increased metabolism which would require increased amounts of dissolved oxygen.

Transparency, pH, and dissolved oxygen increased during fall and winter when rainfall was minimal. The decrease of 46 cm in transparency from December to January may have resulted from the rainfall in December. An increase in transparency during February was accompanied by low rainfall.

These phenomena indicate that dissolved oxygen, pH, transparency, and temperature were dependent for their values on climatic factors consonant with a seasonal trend characteristic of the latitude and longitude.

ACKNOWLEDGEMENTS

We appreciate the cooperation of Messrs. A. Faust, G. Keeler, M. King, J. May, F. Wade, and Dr. R. Summerfelt. This study was supported by funds from the U. S. Bureau of Sport Fisheries and Wildlife.

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