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Preliminary Report on the Distribution of Bottom Organisms in West Lake Okoboji, Iowa

By JOHN E. BARDACH, JOHN MORRILL[1] and FRANK GAMBONY[2]

INTRODUCTION

"Little is known of the bottom fauna of the locality." This passage is taken from an Extension Bulletin of the State University of Iowa which describes the Iowa Lakeside Laboratory on West Lake Okoboji and its facilities for biological investigations. It should be stressed at the outset that there are few lakes which do not share with Okoboji this relatively unexplored state of their bottom biota.

A study was begun in July 1950 with a view to eventually answering the following questions:

1. What is the distribution of macroscopic bottom dwelling animals in the lake?
2. Does this distribution follow a pattern that can be correlated with environmental factors such as the nature of bottom deposits, slope of the bottom in various regions, temperature, dissolved gases in the water, currents in the lake and others?

West Lake Okoboji is one of the deepest mid-continental lakes short of the Great Lakes. Its morphometry was described by Birge and Juday (1920) and due to its bottom configuration it is outstanding with respect to the temperature and stratification conditions which prevail in it. An ecological study of its bottom fauna promises to be of practical as well as theoretical interest.

Inasmuch as the daily press has spoken of Lake Okoboji as "polluted" it should be mentioned that studies have been made in other parts of the country which established that there are certain indicator organisms which herald incipient or severe pollution (Wurtz and Wallace 1949). Yet it must be emphasized that any such organisms which occur in the deeper regions of Lake Okoboji are found in locations where their presence can under no circumstances be due to pollution or the direct action of domestic effluents.

METHODS ANE PROCEDURE

Between July 17 and August 17, 1950, a total of 78 bottom samples was taken with an Eckman dredge of 1525 cc. capacity (235 cm^2 area) at stations along three transects traversing the lake from

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east to west (Figure 1). The stations were spaced at depth intervals of 5 meters, though some samples were also taken at depth intervals of only 2 meters in order to investigate the influence of slope on the concentration of organisms. Two dredge-hauls were made at each station. Sampling was begun at a depth of 10 meters, the bottom fauna of the littoral areas purposely not being included in this study. The entire procedure was patterned after the investigations of Juday (1922) who assessed the quantitative distribution of the bottom fauna in the deeper waters of Lake Mendota, Wis., Along the very steep east shore it was occasionally necessary to collect with a Peterson dredge rather than with the lighter and more delicate Ekman bottom-sampler.

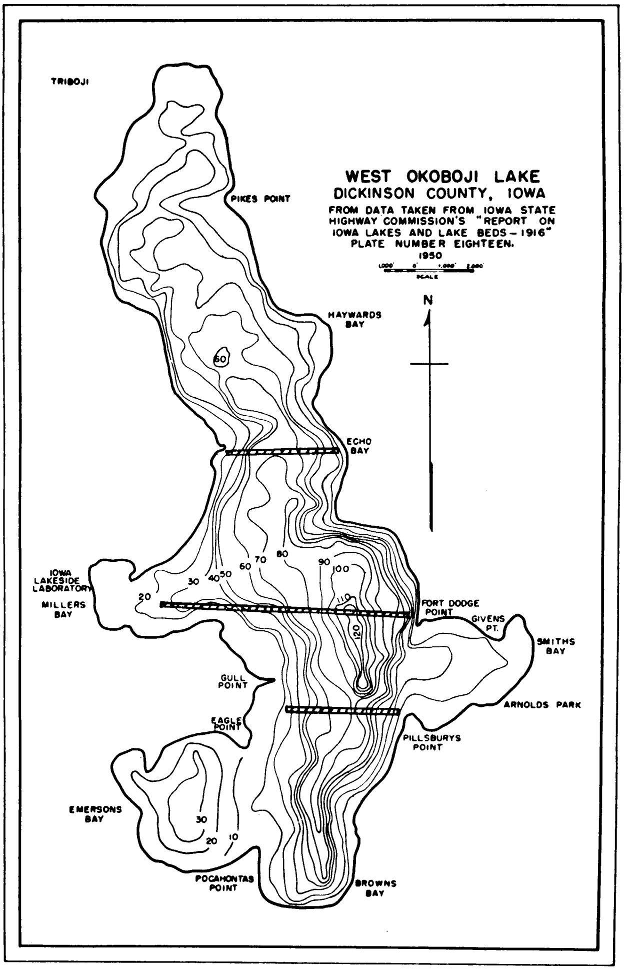

Figure 1. Map of West Okoboji Lake with location of sampling transects.

The samples were washed on graded wire and gauze screens, the organisms were counted, and their frequency per square meter recorded. Equipment difficulties prevented the calculation of the dry weight per square meter, though this is planned for future studies of this kind. The volume of the organisms per square meter, rather than wet weight, is given here as a rough indication of productivity (Figure 2, Table 3).

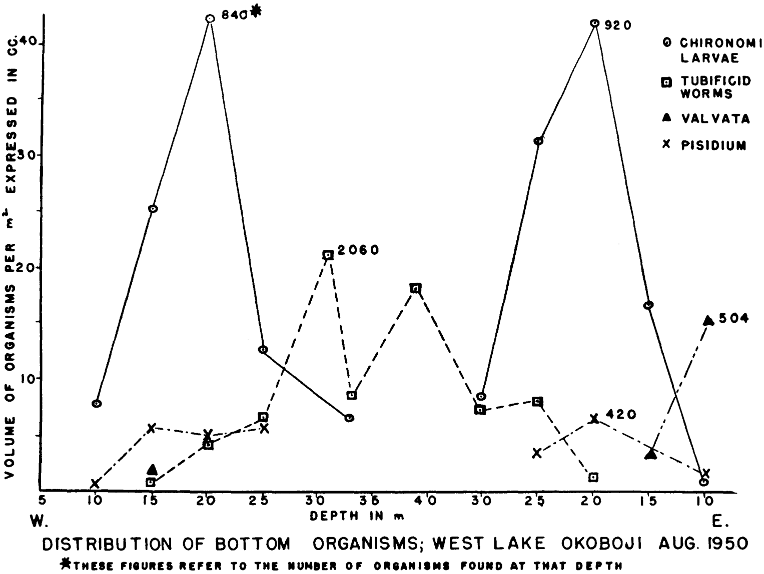

Figure 2. Distribution of bottom organisms along middle transect of Figure 1, expressed in cc per m2 (from Table 3).

The organisms were identified according to Ward and Whipple (1918), except for the Chironomid larvae. Dr. U. A. Hauber obliged us greatly with his generous assistance in the identification of this group.

Water temperatures and tests for dissolved oxygen were taken at various intervals during the summer (Tables 1 and 2).

RESULTS

Noticeable differences were found in the bottom fauna of Lake Okoboji as sampling progressed from shallower to deeper water. Three fairly distinct types of habitat could be identified. For each of these one group of organisms stood out as dominant (Table 3 and Figure 2).

1. In the shallowest region of our sampling, between 10 and 15 m., mollusks occurred in fair abundance. One of the pillclams of

Table I

Temperature observations in West Lake Okoboji in various summers between 1919 and 1950.

Temp. in °C / Depth in m.	July 26 1916[1]	July 30 1919[2]	July 27 to Aug. 16 1923, Aver.[3]	July 27 1925[3]	July 26 1950	Aug. 8 1950
Surface	26.5	......	23.8	21.6	22.7	23.2
0 - 5	26.3	24.6	23.2	21.6	21.8	22.5
5 - 10	24.7	23.9	22.8	21.4	21.2	21.6
10 - 15	18.6	18.8	14.1	21.0	20.4	20.6
15 - 20	17.2	13.1	12.5	17.6	17.0	17.6
20 - 25	16.2	11.6	11.6	16.1	......	15.4
25 - 30	15.4	11.1	11.5	15.8	15.3	15.2
30 - 35	15.2	10.9	......	......	15.0	15.1
35 - 40	15.0	10.8	......	......	......	......

[1] From Tilton 1917 (1918).
[2] From Birge and Juday 1920.
[3] From Stromsten 1926 (1927).

Table II

Observations of dissolved oxygen present in West Lake Okoboji.

Oxygen, cc. per liter / Depth in m.	July 31 1919[1]	July 26 1950	Aug. 8 1950
0	5.8	5.9	5.7
5	5.4	5.3	5.3
10	5.4	5.1	....
15	2.2	4.8	4.7
20	1.8	2.2	2.1
25	.9	....	0.2
30	.9	1.1	0.0
33	.8	....	....
35	....	0.6	0.0

[1] From Birge and Juday 1920.

the genus *Pisidium* was most plentiful. The distribution of the snail, *Valvata tricarinata*, was restricted, with few exceptions, to a sandy bottom where some small pebbles were also present. Such conditions prevailed especially between the 15 and 20 m. contours along the very steep east slope of the lake basin where light-weight debris and ooze from decaying plankton material could not settle. Progressing into deeper mater the number of Chironomid larvae increased and also Oligochaetes became more plentiful.

2. The region between the 15 and 25 m. contour lines was predominantly populated by several species of Chironomus larvae, mainly *Ch. plumosus* L. and *Ch. decorus* Joh.

3. Oligochaetes of the family Tubificidae (*Tubifex* and *Limnodrilus*) became more numerous beyond a dept of 25 meters. In the deepest part of the lake (around 39 m.) they were the only macroscopic animals found. This region had become depleted of oxygen in the beginning of August and it was interesting to note that these facultatively anaerobic bottom dwellers encroached later in the season on territory further shoreward. This expansion of territory became more pronounced as the season progressed when the lack of dissolved oxygen was felt in an increasingly larger volume of water.

Discussion

Two facts appear noteworthy in the distribution of bottom organisms from the samples taken so far, namely, (1) certain mollusks were largely confined to specific types of bottom material and (2) there was a shift in dominance of invertebrate groups as one went from shallow to deep regions.

Facultative anaerobes inhabited the deepest zone, and the transition between these (Oligochaetes and deep-water Chironomids) and forms less tolerant of water with low oxygen content, (such as some mollusks and other insect larvae) seemed to coincide with the mesolimnion. Where thermal stratification occurs this layer is equivalent to the thermocline and it is usually also the layer of water where oxygen conditions change pronouncedly.

Such a zonation of organisms is to be expected and very similar patterns of distribution have been observed under comparable conditions (Juday 1922). Even the numbers of organisms present per square meter of bottom area in Lake Mendota, Wis., and in Lake Okoboji are of comparable magnitude. The absence of a common bottom dweller, the larva of *Chaoborus* ("phantom larva") should be noted. Late July and early August is the time of the year when these larvae reach their yearly low level due to the timing of the life cycle of the insect. A total absence of these animals was, however, not expected and it may be worthwhile here to seek for an explanation.

Temperatures observed in Lake Okoboji throughout several decades were more variable than is usually the case in deep eutrophic

Table III

Distribution of macroscopic bottom organisms on a transect across West Lake Okoboji, August 1950.

Name of Organism	Depth in m.	West				Numbers and (in parenthesis) mass of organisms per m^2. expressed in cc.				East			
		10	15	20	25	31	33	39	30	25	20	15	10
Mollusks:													
Pisidium		40 (.64)	420 (6.7)	294 (4.7)	336 (5.4)	....	....	....	....	210 (3.4)	420 (6.7)	?[1]	84 (1.3)
Valvata		....	42 (1.3)	....	....	....	....	....	....	....	....	126 (3.8)	504 (15.1)
Physa		....	....	....	....	....	....	....	....	....	....	....	125
Amnicola		400[2]	....	40	....	....	....	....	....	....	....	....	80
Chironomid Larvae:		580[3] (7.5)	830 (25.0)	840 (42.1)	250 (12.5)	?[1]	120 (6.3)	....	170 (8.5)	630 (31.5)	920 (42.0)	1010[3] (16.3)	43 (.5)
Tubificid Worms:		....	50 (.5)	420 (4.2)	630 (6.3)	2060 (21.1)	930 (9.3)	1560 (17.2)	750 (7.5)	820 (8.2)	130 (1.3)	....	....

[1] Organisms present but samples damaged or upset so that estimates could not be made.
[2] Sample taken between 5 and 10 m. depth.
[3] Mostly made up of smaller species, such as *Ch. decorus* Joh.

lakes of the temperate zone. This variation appears to be connected with the morphometry of the lake and the climate of the region and is bound to have considerable influence on the biota of the lake.

Thermal stratification was shown to occur either early or late in the summer; an early thermocline appeared to be stable. A late one seemed to depend on climatic conditions for its stability. This is exemplified in Table 1 and Figure 3; all temperature series were taken at the same time of the year. The following conditions prevailed in the five seperate years under comparison:

1) The deep regions of the lake had a relatively high temperature and the thermocline was stable (Tilton 1917).
2) The deep regions of the lake had a relatively low temperature and the thermocline was stable (Birge and Juday 1920, Stromsten 1926).
3) The deep regions of the lake had a relatively high temperature and the thermocline was unstable (Stromsten 1926, and present authors 1951).

Daily temperature series taken in 1925 (Stromsten 1926) illustrated than an unstable thermocline may be established for a few days and then vanish again. The relative stability of stratification is expressed by the amount of thermal resistance present under the prevailing conditions; such thermal resistances were calculated for all years mentioned here (Figure 3), and it can be seen that in 1925 and again in 1950 much less work would have been required to erase the thermocline by mixing than in the other years for which we have data.

Tests for dissolved oxygen were available in 1919 and 1950; the figures are almost identical (Table 2), in spite of the fact that there was a stable thermocline in 1919 which must have been established early in the year while no permanent stratification occurred in 1950 at the time of our investigation. On the strength of the temperature data alone one would expect the hypolimnion to have more dissolved oxygen in 1950 than in 1918 (when we know that it was effectively cut off from the circulation of the upper waters early in the summer), yet it appears that complete depletion of oxygen occurred in both cases.

In this connection it should be mentioned that warm water lakes may have a stable stratification within narrow limits of temperature, extremes being noted by Ruttner (1931) in tropical lakes. Since stability (thermal resistance) changes with changing density of the water and since the rate of change in density is less near 4°C. than it is near 20° C. it requires over 4 times as much work to mix a column of water whose bottom measures 20° and whose top is 25° C. than if the same column lay between 5 and 10° C. This illustrates that in such years as 1925 and 1950 when all the water was warmed

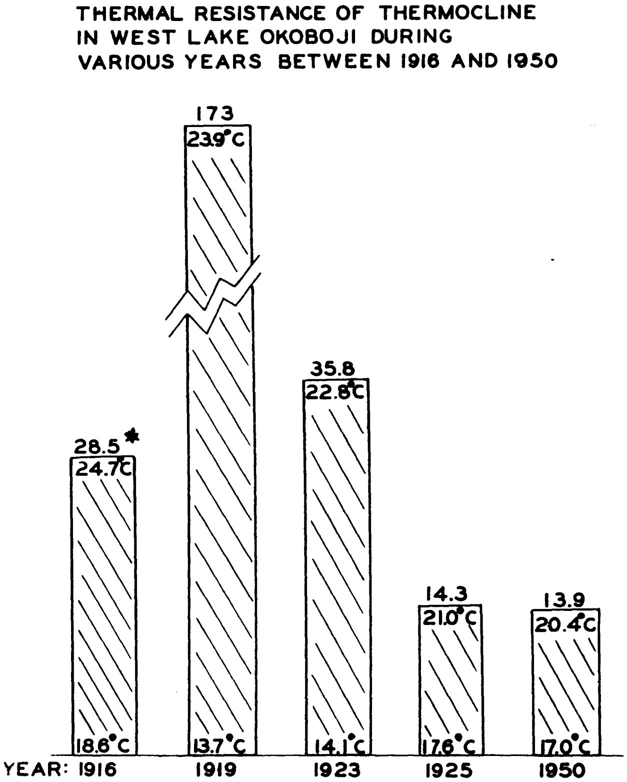

Figure 3. Thermal resistance of thermocline in West Okoboji Lake during various years between 1916 and 1950, from data in Table 1.

*The columns indicate the work in ergs required to eliminate the thermoclines in various years. (Calculated after Birge /1910/ for water in an upright prism of 1 cm2 base and varying height and temperature /figures inside columns/ to stimulate actual conditions.)

to a relatively high level before any stratification occurred, the layers of water may, in fact, have been separated quite effectively though probably only intermittently.

Another important influence of temperature which ought to be given consideration is its effect on the rate with which the oxygen becomes used up near the bottom of the lake. In 1919 11° C. were measured there, while the summer of 1925 showed 16° C. in the same region. This represents a differential of 5° C. during comparable periods of two different years. Decomposition is accelerated at the higher temperature and one can expect a depletion of oxygen to be as effective in years of late and, perhaps unstable, thermocline as it would be in years of early stratification with cold bottom waters. This explains the similarity in oxygen conditions in 1919 and 1950.

The distribution of Tubificid worms roughly coincided with the regions of anaerobic conditions; Wurtz and Wallace (1949) have illustrated that these organisms can often be taken as indicators of exactly such conditions whatever their cause may be. A more detailed investigation into the chemical conditions prevailing in the deep regions of the hypolimnion ought to be of interest in this connection.

It is to be expected that knowledge of circulation patterns in the lake would shed further light on many, if not all of the physical and biological phenomena mentioned here. Some pertinent observations have already been made but many more are required; it is hoped that we shall soon be able to add such data to the many that are needed in order to integrate the metereological, chemical, physical and biological observations which have accumulated up to now about West Lake Okoboji.

SUMMARY

Samples of bottom fauna were taken at 5 m. intervals from three transects across West Lake Okoboji, starting at the 10 m. contour and proceeding to deeper water. Three definite zones were shown to exist by the distribution of animal forms. Mollusks predominated in the shallowest sampling area (10 - 15 m.), Chironomid larvae were most numerous at intermediate depth (15 - 25 m.). This was also the most productive zone when the mass of organisms per m^2 was assessed. In the deepest region of the lake (25 - 40 m.) Tubificid worms abounded; at 40 m. they were the only macroscopic animals found.

Year by year changes in the conditions of thermal stratification of the lake are discussed and estimates are made of the stability of the thermoclines in the respective years. The influence of these phenomena on the biota of the lake is stressed and approaches for further research are suggested.

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