TRENDS IN ABUNDANCE OF THE MAYFLY (*HEXAGENIA LIMBATA*) AND CHIRONOMIDS IN ONEIDA LAKE[1]

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ABSTRACT

Analysis of bottom samples collected at three stations in Oneida Lake from 1956 to 1964 showed a decrease in the abundance of the mayfly (*Hexagenia limbata*) and an increase in chironomid populations. Oxygen depletion in the hypolimnion during periods of calm weather and possibly increased eutrophication of Oneida Lake were probably responsible for these population changes.

During the summer each year from 1956 to 1964 a series of bottom samples were taken at three stations near Shackelton Point on Oneida Lake, New York (Figure 1) to obtain a rough index of the invertebrate fish food present. With so small a sample area, no comprehensive measurement of subtle fluctuations in bottom fauna was intended. But since the results agreed so well with observed trends in abundance of the mayfly (*Hexagenia limbata*) and chironomids on the entire lake, these fragmentary findings seem worthy of notice.

Oneida Lake is a eutrophic body of water located in central New York State. It is roughly rectangular and has an area of 80.4 square miles. Maximum and mean depths are 55 feet and 25 feet, respectively (Mt. Pleasant *et al.*, 1962). The relatively flat surrounding terrain, coupled with the fact that the lake's long axis lies east and west, provides the prevailing westerly winds with a fetch of nearly 19 miles. These factors cause almost continuous mixing of the lake water at all levels during the ice-free months. However, during extended periods of calm weather, stratification may occur with subsequent depletion of oxygen in the hypolimnion.

The past abundance of mayflies in Oneida Lake has been well documented (Baker, 1916, 1918a and 1918b; Adams and Hankinson, 1928). Baker (1918b) published a photograph of windrows of dead mayfly adults along the lake shore. He also recorded ". . . large areas

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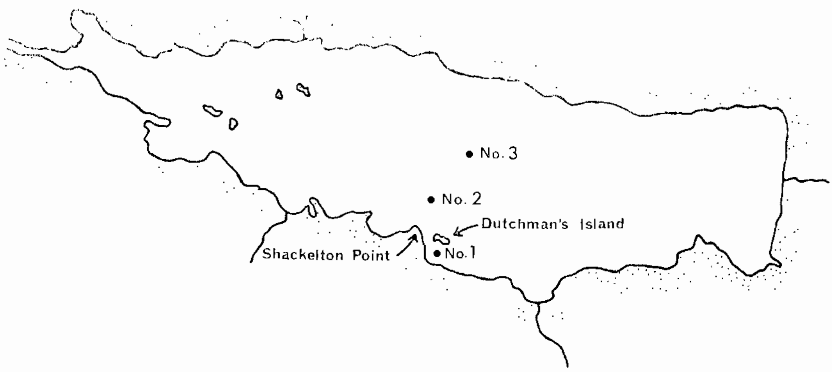

Figure 1. Location of the three stations in Oneida Lake where bottom samples were taken.

of the lake where the surface of the water was completely covered with dead bodies of mayflies". Residents of the Oneida Lake area have reported enormous mayfly hatches which occurred in the middle 1950's.[3] Dr. Forney stated that in June of 1957, while electrofishing for walleyes on Oneida Lake, he had to discontinue operations because the mayfly hatch was so dense that it was impossible to see the water. Conditions such as these have not been characteristic of this lake for several years.

METHODS

The sampling procedure consisted of taking two to five (generally five) Ekman dredge (6 by 6 inch) samples at each of three stations (Figure 1). An effort was made to sample each station at 2-week intervals throughout the summer, but before 1960 this procedure was not closely followed (Table 1). Bottom samples were screened and all organisms, except mollusks, were counted and preserved in 70 per cent alcohol. Volumes were determined by displacement after preservation.

The sampling stations differed considerably in depth and exposure to the lake proper. All were located by triangulation with landmarks; no effort was made to sample at precisely the same spot each time.

Station 1 was located at the western end of Delmarter Bay about one third mile from the mainland. This mud and sand-bottomed site had a depth of 14 feet and was the shallowest of the three. It was protected from the lake by Dutchman's Island which borders the northwestern side of the bay.

Station 2 was located in the lake proper about one half mile from the Shackelton Point mainland. A mud bottom, rich in black organic ooze, was found at a depth of 40 feet.

[3] John Forney, Paul Liable, and Charles Taylor, personal communications.

TABLE 1. AVERAGE VOLUME (IN MILLILITERS) OF MAYFLIES (*H. limbata*) AND CHIRONOMIDS IN EKMAN DREDGE SAMPLES TAKEN AT THREE STATIONS IN ONEIDA LAKE, 1956–64

Year	Day	Mayflies			Chironomids		
		1	2	3	1	2	3
1956.....	August 25	0.09	0.75	..	0.11	0.14	..
	September 19	0.07	0.47	..	0.12	0.10	..
	October 13	0.01	1.02	..	0.06	0.08	..
1957.....	April 25	0.02	0.29	..	0.15	0.13	..
	May 8	..	..	0.25	..	..	0.51
	June 25	0.06	0.14	0.11	0.00	0.11	0.40
	July 20	0.06	0.14	0.02	0.05	0.07	0.17
	September 3	0.06	0.06	0.23	0.10	0.09	0.06
	November 16	..	0.36	..	..	0.08	..
1958.....	May 7	0.05	0.07	0.20	0.05	0.05	0.05
	June 3	0.05	0.94	0.18	0.06	0.09	0.25
	July 8	0.09	2.09	0.24	0.13	0.06	0.29
	August 14	0.21	0.05	..	0.05	0.15	..
	September 11	0.00	0.06	0.06	0.20	0.13	0.60
1959.....	May 4	0.04	0.16	0.04	0.09	0.46	0.49
	June 20	..	0.06	..	..	0.45	..
	October 15	0.00	0.04	0.00	0.03	0.05	0.10
1960.....	June 8	0.02	0.09	0.05	0.07	0.26	0.33
	June 22	0.03	0.14	0.07	0.14	0.17	0.29
	July 8	0.04	0.28	0.05	0.05	0.30	0.17
	July 25	0.00	0.004	0.07	0.12	0.11	0.19
	August 5	0.00	0.004	0.00	0.09	0.14	0.20
	August 30	0.08	0.04	0.003	0.09	0.18	0.20
	September 8	0.02	0.03	0.00	0.08	0.13	0.40
	October 10	0.00	0.05	0.00	0.05	0.10	0.17
1961.....	June 2	0.04	0.07	0.04	0.02	0.45	0.28
	June 14	0.00	0.00	0.00	0.07	0.27	0.01
	July 21	0.00	0.01	0.00	0.22	0.23	0.19
	August 18	0.00	0.00	0.00	0.18	0.15	0.35
1962.....	May 9	0.00	0.00	0.00	0.05	0.47	0.67
	May 24	0.00	0.00	0.00	0.38	0.62	0.34
	June 20	0.025	..	0.05	0.11	..	0.42
	July 11	0.06	0.00	0.04	0.27	0.48	0.49
	August 20	0.02	0.06	0.02	0.58	0.62	0.84
	September 6	0.01	0.00	0.00	0.20	0.53	0.40
1963.....	May 20	0.00	0.00	0.00	0.06	0.48	0.20
	June 13	0.03	0.00	0.00	0.11	0.15	0.16
	June 24	0.05	0.00	0.00	0.10	0.10	0.17
	July 11	0.00	0.00	0.00	0.17	0.12	0.25
	July 25	0.00	0.02	0.00	0.08	9.12	0.10
	August 12	0.00	0.00	0.00	0.09	0.30	0.35
	August 26	0.00	0.00	0.00	0.07	0.68	0.85
	September 10	0.00	0.05	0.00	0.25	0.65	0.90
1964.....	June 10	0.003	0.00	0.001	0.10	0.27	0.30
	July 1	0.00	0.006	0.03	0.23	0.12	0.19
	July 16	0.00	0.00	0.03	1.00	0.51	0.31
	August 6	0.006	0.00	0.00	3.14	0.95	0.86
	August 19	0.00	0.00	0.00	2.71	0.34	0.99
	September 2	0.07	0.00	0.00	2.52	0.16	1.10

Station 3 was located in about the center of the lake 2½ miles from the nearest shore. A mud bottom at a depth of 40 feet was characteristic.

RESULTS

Mayflies, chironomids and other organisms were separated for analytical purposes. At least four genera and several species of mayflies occur in Oneida Lake (Baker, 1918b), but *Hexagenia limbata* was by far the most numerous and conspicuous species. Other species of mayfles were rarely found at the sites sampled in this study. No attempt was made to identify the various species of chironomids.

The miscellaneous group of organisms was composed primarily of isopods and oligochaetes. The volmetric values for this category were so small that they were not included in the tabular data.

Volumes of mayflies and chironomids were estimated for each sample, and those for each day at each site were averaged (Table 1). In addition the average annual volumes were computed for each sampling station (Table 2). A marked decrease in mayflies and

TABLE 2. AVERAGE ANNUAL VOLUME (IN MILLILITERS) OF MAYFLIES (*H. limbata*) AND CHIRONOMIDS AT EACH STATION

Year	Mayflies			Chironomids		
	1	2	3	1	2	3
1956	0.06	0.81	..	0.10	0.11	..
1957	0.05	0.20	0.15	0.70	0.10	0.29
1958	0.08	0.64	0.17	0.10	0.10	0.30
1959	0.02	0.09	0.02	0.06	0.32	0.30
1960	0.02	0.08	0.03	0.09	0.17	0.24
1961	0.01	0.02	0.01	0.16	0.26	0.28
1962	0.05	0.01	0.02	0.27	0.54	0.53
1963	0.01	0.01	0.00	0.12	0.33	0.37
1964	0.02	0.00	0.01	1.61	0.39	0.63

increase in chironomids occurred at each of the three sites during the 9-year period (Figure 2).

To determine if observed trends in abundance were significant, a rank correlation test was computed for mayflies and chironomids at each sampling station using the method described by Siegal (1956, pp. 202–213). The dates of sampling, as shown in Table 1, were ranked in chronological order and their respective volumes were ranked consecutively. Results of this test showed that a statistically significant decrease in the volume of *H. limbata* nymphs and a

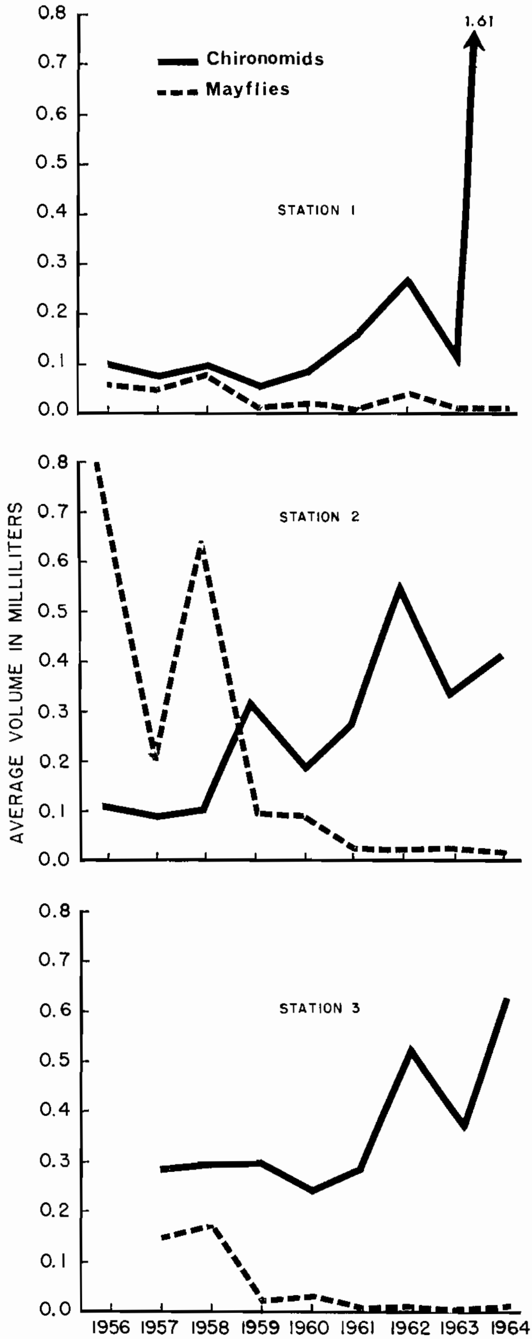

Figure 2. Mean volumes of ma-flies and chironomids in Ekman dregde samples collected at each station during the summers of 1956 to 1964.

TABLE 3. RANK CORRELATION BETWEEN VOLUME AND DATE OF COLLECTION RANKED IN CHRONOLOGICAL ORDER FROM 1956 TO 1964 FOR MAYFLIES (*H. limbata*) AND CHIRONOMIDS AT EACH STATION

Station	Correlation coefficient	
	Mayflies	Chironomids
1	r = 0.4570 t = 3.773** d.f. = 44	r = 0.4819 t = 3.641** d.f. = 44
2	r = 0.8677 t = 11.710** d.f. = 45	r = 0.5889 t = 4.891** d.f. = 45
3	r = 0.6811 t = 5.883** d.f. = 40	r = 0.3204 t = 2.171* d.f. = 40

* Significant at 5 per cent level.
** Significant at 1 per cent level.

statistically significant increase in the volume of chironomid larvae occurred concurrently in the samples from each site (Table 3).

CONCLUSIONS

A similar decline in mayfly and increase in chironomid populations has been documented for Lake Erie (Britt, 1955a, 1955b, and 1963; Beeton, 1961; Carr and Hiltunen, 1963). Changes in the bottom fauna of Lake Erie have been associated with the increasingly frequent and severe oxygen depletion in the hypolimnion in recent years (Carr, 1962).

Oxygen determinations were made in Oneida Lake whenever periods of prolonged warm, calm weather or a decrease in the catch of fish from deep water suggested a temporary oxygen depletion had occurred. Low concentrations of dissolved oxygen (2.6 ppm or less) were detected in the bottom waters during 1959, 1961 and 1963. Probably the most severe oxygen deficit occurred in 1959 when the concentration at Station 2 remained below 1 ppm for 6 days and a survey indicated concentrations of less than 2 ppm in the bottom waters for over 50 per cent of the lake area during the same period. Since oxygen deficits develop rapidly following stratification and are quickly dissipated by turbulence caused by winds (Table 4), it is possible that low oxygen occurred in other years but was not detected.

The changes in bottom fauna of Oneida Lake may have resulted from repeated oxygen depletion in the deeper waters during recent years. Mayfly larvae will die within 30 to 48 hours when exposed to 1.0 ppm dissolved oxygen (Hunt, 1953). Chironomids can survive

TABLE 4. OXYGEN AND TEMPERATURE DETERMINATIONS TAKEN IN ONEIDA LAKE AT STATIONS 2 AND 3 DURING A 9-DAY PERIOD IN 1963*

Date	Depth (feet)	Station 2		Station 3	
		Temperature (in degrees F.)	Oxygen (ppm)	Temperature (in degrees F.)	Oxygen (ppm)
July 24	5	60.5	13.0	64.5	13.6
	10	60.5	..	64.0	..
	15	60.0	10.0	62.7	10.0
	20	60.0	..	62.0	..
	25	59.0	..	62.0	10.0
	30	58.0	..	62.0	..
	35	58.0	7.0	62.0	5.2
July 29	5	82.0	11.6	81.6	13.0
	10	75.5	11.4	79.0	12.6
	20	71.2	7.2	72.0	9.2
	30	69.0	4.4	69.2	5.6
	40	67.0	3.4	69.0	3.2
July 30	5	78.5	8.6	78.0	8.8
	10	78.5	8.2	78.5	8.6
	15	78.0	8.2	78.0	8.2
	20	76.5	7.4	76.5	7.8
	25	74.5	6.8	74.5	6.8
	30	70.5	4.2	70.0	6.8
	35	70.0	2.6	69.5	4.2
	40	69.5	2.6	69.5	4.0
Aug. 1	5	74.0	6.6	74.5	7.0
	10	73.5	6.4	74.0	6.2
	20	71.0	6.4	72.0	6.4
	30	71.0	6.5	71.0	6.4
	40	71.0	7.0	71.0	7.0

* Light winds occurred from July 24 through July 29 with above normal temperature. A strong northwest wind on July 30 followed the passage of a cold front.

these conditions. Meterological factors, particularly extended periods of calm weather, may have favored unusually frequent and severe oxygen depletion in deep water during the period of study. However, it is also possible that Oneida Lake has undergone eutrophication to the point where an oxygen depletion in deep water can take place during relatively brief periods of calm weather. Beeton (1961) stated that a change in bottom fauna, from one in which mayflies predominate to one in which chironomids predominate, indicates an increase in organic matter in the sediments and thus could possibly be used as an indication of increased eutrophication.

From these data it seems evident that there has been a reduction in mayfly abundance in Oneida Lake. Furthermore, it would probably be valid to state that the niche occupied by the once abundant *H. limbata* population is being filled by various species of chironomids. Further limnological studies would be needed to determine if changes in bottom fauna reflect an accelerated rate of eutrophication associated with rapid urbanization of the Oneida Lake watershed.

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