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DIVISION OF THE
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Changes in the Small Bottom Fauna of Peoria Lake, 1920 to 1922

BY

ROBERT E. RICHARDSON

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ERRATA

Page 57, statistical headings: for *Year 1920* read *Year 1910;* for *Year 1909* read *Year 1920*; in the ratio heading, for *1909* read *1920*, and for *1920* read *1910*. The entries in the Year columns should change places.

Page 85, line 13 from bottom, for *87* read *86*.

Page 88, line 20, delete *red*.

Page 115, line 6, over the column of figures read *Acres*.

Page 136, line 5, for *135* read *131*.

Page 145, *First table*, 4th column, for *35.97* read *33.40;* last column, for .052 read .0418.

Second table, second column, for .2158 read .2004; 5th column, for .1131 read .0977; last column, for .0926 read .0772.

Last table, second column, for .714 read .663 and for total read $4.710; 5th column, for .374 read .323 and for total read $2.201; the last column, for .307 read .256 and for total read $1.700.

Page 146: *First table*, second column, for 8.02 read 7.45 and for total read 52.92; third column, for 3.45 read 2.88 and for total read 19.10; 4th column for 19.28 read 17.90 and for total read 127.18; last column, for 8.29 read 6.92 and for total read 46.35.

Second table, for 43.02 read 38.66.

Last table, for 8.0 read 6.7.

Page 382, line 10 from bottom, for *Platythemis* read *Plathemis*.

Page 385, in list, the specific names of No.'s 33, 35, and 40 should end in *us* instead of *a*.

Pages 445 (line 4), 448 (line 4), 449 (line 23), 454 (line 8 from bottom), read *Belostomidae* for *Belostomatidae*.

Page 457, line 21, for *cornutus* read *cornuta*.

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ARTICLE V.—*Changes in the Small Bottom Fauna of Peoria Lake, 1920 to 1922.* BY ROBERT E. RICHARDSON.

INTRODUCTION

Early in July 1922 the cooperative program of chemical and biological investigations of the middle Illinois River and Peoria Lake begun in the summer of 1920 by the State Natural History Survey and the State Water Survey was again taken up after an interval of two years. The summer's work included, as one item among several others, between the date of opening and the middle of September, quantitative bottom dredgings at seventy-one stations in the channel and wide waters of Peoria Lake and contiguous river between Chillicothe and the Peoria and Pekin Union Railway Bridge opposite the lower part of the city of Peoria. The dredging stations were distributed over approximately the area covered by the thirty-five stations worked in Peoria Lake in the summer of 1920, and covered a linear distance of 19.9 miles. Collections were made and handled as in 1920. Assistance was furnished by Dr. C. P. Alexander in determining the larval Chironomidae (midges), by Mr. F. C. Baker and by Dr. V. Sterki on snails of the family Sphaeriidae, and by Prof. Frank Smith and Dr. J. P. Moore on the worms and leeches. The nitrogen data on which the 1921 curve of per cent free ammonia is based have been furnished in advance of publication by the U. S. Public Health Service.

DESTRUCTION OF THE OLD BOTTOM FAUNA

In a paper* published in December, 1921, on the changes in the bottom and shore fauna of the middle Illinois River, it was shown that between the period 1913-1915 and the summer of 1920, there had been an almost complete extermination of the older normal bottom population over a stretch of around 90 miles of river, including Peoria Lake, extending from Chillicothe to Beardstown. The same period also saw

* Bul. Ill. Nat. Hist. Surv., Vol. XIV, Art. 4, pp. 33-75.

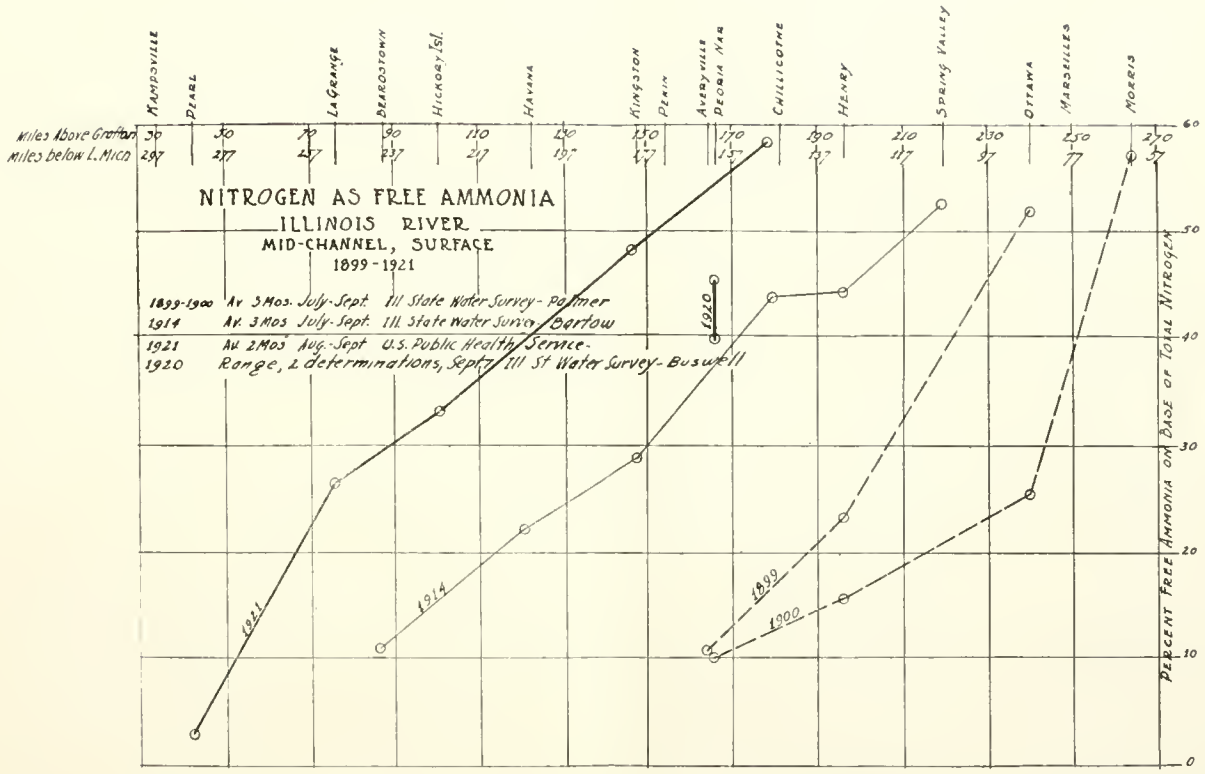
the point of practically complete oxygen exhaustion, a foot below the surface, in midsummer, move 83 miles down stream, from Morris, 63.5 miles below Chicago, to Chillicothe, 146.5 miles below; and saw the surface dissolved oxygen at the same time of year fall from around 4 p. p. m. to as low as 1 p. p. m. at Havana, 207 miles below Chicago. During the same five or six years, also, the zone of high free ammonia, with the ratio (per cent) on the base of the total nitrogen between 40 and 60 per cent, moved down the river more than 50 miles, or from Spring Valley, 108.6 miles below Chicago, to Peoria Narrows, 160.9 miles below; while the upper limits of the zone of well clarified effluent, with free ammonia around or under 10 per cent of the total nitrogen, receded from Beardstown to Kampsville, a distance of about 57 miles, or to within about 30 miles of the mouth of the 327 mile continuous waterway to Grafton. See charts following.

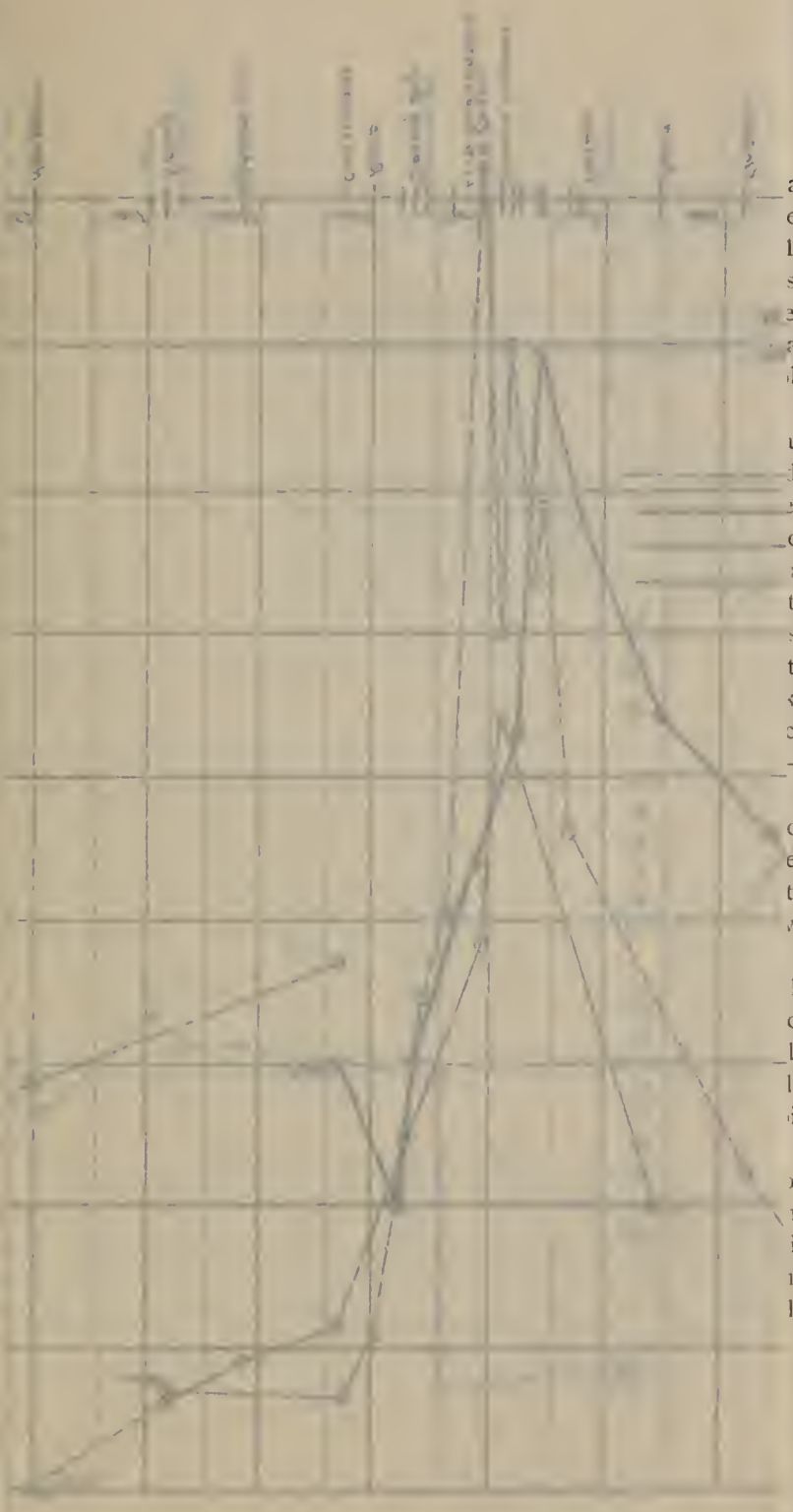
Between 1914 and 1918 the total weight of animals slaughtered at the Chicago stockyards (Tables, pp. 331 and 332) had increased at a rate more than eight times as fast as the estimated normal rate of increase of human population; and there had been large increase in the rates of operation of the Corn Products Refining plants both at Argo and Pekin; while the average dilution employed in the Chicago Sanitary Canal was changed in an amount relatively small.

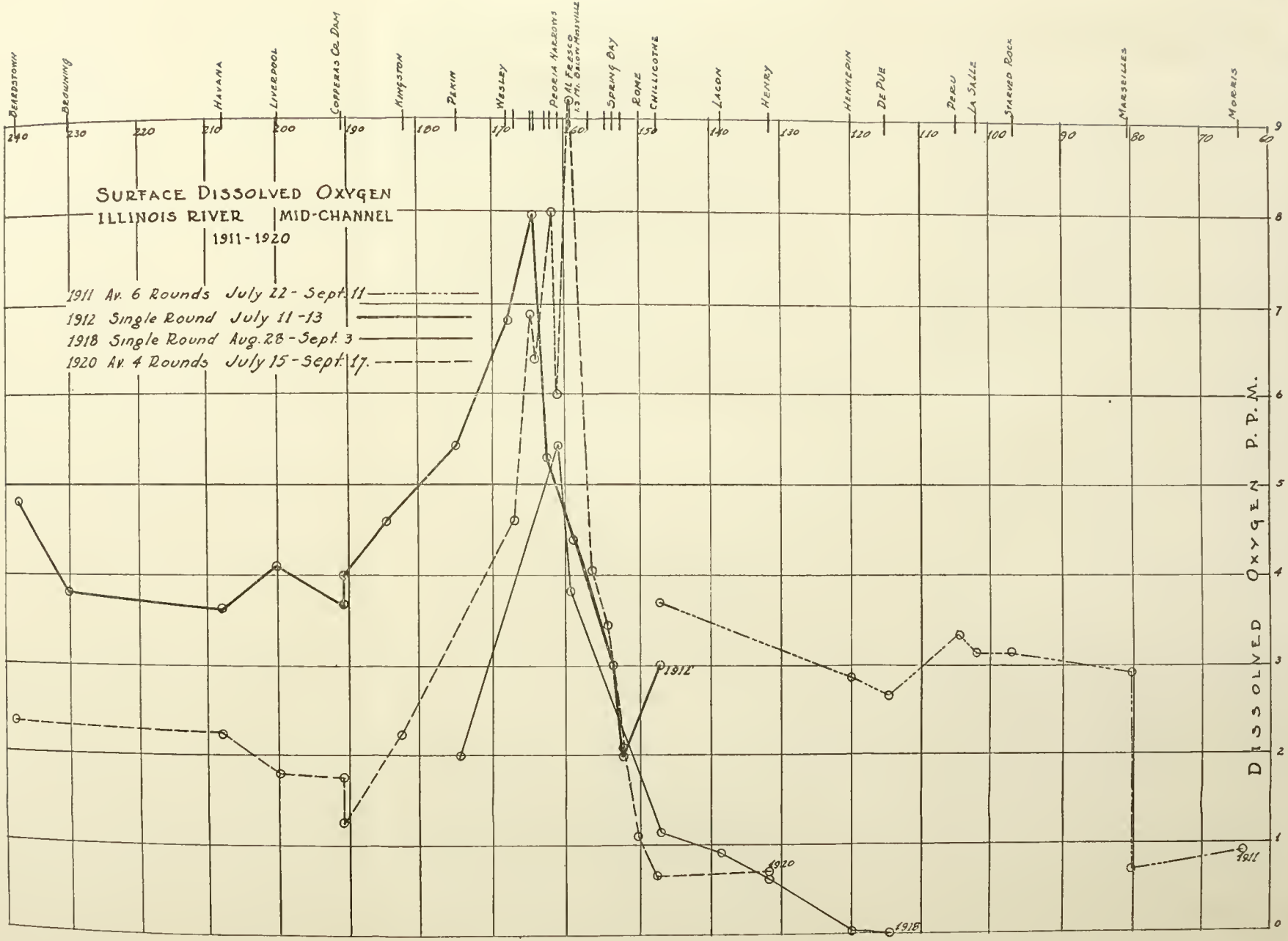
The years 1911 to 1914 inclusive had been rather quiescent years for the packing industry, the total weight of animals slaughtered dropping off gradually during that time from about 3,383 million pounds in 1911 to 3,040 million pounds in 1914. From the 1914 low figure the weight of slaughterings climbed rapidly, with only a slight recession during 1917, to a peak of 4,870 million pounds in 1918, representing an increase of fully 60 per cent over the 1914 yearly rate (Table, p. 332); and about 50 per cent over the average rate of 3,258 million pounds for the four years 1911-1914.

The increase in the Packingtown wastes entering the sanitary canal in the four years 1914 to 1918 amounted in population equivalent on the basis of the Sanitary District's own figures* to more than 523,000 persons, or almost treble the estimated actual increase in human population during the period; or to more than the total 1920 population of the city of Buffalo, New York. During peak weeks of 1916,

* Packingtown Report II, 1921, pp. 8, 14, 231, etc.


NITROGEN AS FREE AMMONIA
ILLINOIS RIVER
MID-CHANNEL, SURFACE
1899 - 1921
1899-1900 Av 3 Mos. July-Sept. Ill State Water Survey - Palmer
1914 Av. 3 Mos July-Sept. Ill State Water Survey Bartow
1921 Av 2 Mos Aug.-Sept U.S. Public Health Service -
1920 Range, 2 determinations, Sept 7 Ill St Water Survey - Bushnell
Miles Above Grafton
Miles below L. Mich
MAMPSVILLE
PEARL
LAGRANGE
BEARDSTOWN
HICKORY ISL
HAVANA
KINGSTON
PLANK
AVERYVILLE
PEORIA MAR
CHILLICOTHE
HENRY
SPRING VALLEY
OTTAWA
MARSEILLES
MORRIS
1921
1914
1920
1899
1900
PERCENT FREE AMMONIA ON BASE OF TOTAL NITROGEN




Beardstown
Beginning
Havana
Liverpool
Copperas Ck. Dam
Kingston
Plekin
Wesley
Peoria Harbors
Ill. River
Spring Bay
Rome
Chillicothe
Lacon
Henry
Hennepin
De Pue
Peru
La Salle
Starved Rock
Marseilles
Morris
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
SURFACE DISSOLVED OXYGEN
ILLINOIS RIVER MID-CHANNEL
1911-1920
1911 Av. 6 Rounds July 22 - Sept. 11
1912 Single Round July 11-13
1918 Single Round Aug. 28 - Sept. 3
1920 Av. 4 Rounds July 15 - Sept. 17.
1912
1920
1918
1911
DISSOLVED OXYGEN P.P.M.
9
8
7
6
5
4
3
2
1
0

1917, and 1918 the weekly rate of killings ran for weeks at a time at more than double the average weekly rate of 1914; and in November and December, 1918, particularly, at rates representing increases of 110 to 145 per cent over the average weekly rate five years earlier. These weekly peaks were in the late fall or early winter, when it is presumed that a large portion of the wastes would settle to the bottom, not far away from their source, ready to be washed out, still to a considerable extent undecomposed, with the first heavy rains of spring.

Heavy mortality among the snails was noted at points all the way from Spring Valley to Havana during and following summer floods in 1917. In August of that year dead snails acres in extent were seen floating down the Illinois past Peoria and Havana; and in places were from one to two feet deep along the water-front at Peoria. In late summer 1918, while in the field with chemists of the State Water Survey, it was noted that all snails except one species of Musculium and one Campeloma of unusual hardiness seemed already to have been killed both at Lacon and Chillicothe. During the five weeks July 22 to August 31 that year we got our first records of surface dissolved oxygen under one part per million south of Spring Valley—finding them then extending as far south as Lacon*.

After 1918, up to the end of 1921, there was a long-sustained recession in the packing industry, which carried the slaughtering figures off more than a billion and a third pounds from the 1918 peak, or to within 443 million pounds of the 1914 rate (only 14.5 per cent above the 1914 figure).

Between 1921 and 1922 the slaughtering rate moved up 400 million pounds to a year total for 1922 of 3,975 million, and this was accomplished without seeming to exert any further seriously unfavorable influence on chemical or biological conditions; except as it was possibly reflected in increase in numbers of the sludge or mud worms (Tubificidae).

The present paper compares the condition of the bottom fauna of Peoria Lake as found in July-September, 1922, with that of the summer of 1920, which was probably very close to its point of low condition following the mortality of 1917-1918, just referred to; with the result, in general, of indicating an essentially slight though measurable improvement in the two years.

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* Third Annual Report, State Div. Waterways, 1919-1920, pp. 28-32.

Since 1922 there has continued a gradual rise in the Packingtown slaughterings, which brought them at the end of 1923 to a year total of 4,461 million pounds, or to a point again only 8.4 per cent under the 1918 peak of 4,870 billion pounds.

TOTAL WEIGHT OF ANIMALS SLAUGHTERED AND POPULATION EQUIVALENT 1911-1924

	Million pounds	Population equivalent.[3]	
1911	3,380[1]	967,000	
1912	3,330[1]	952,000	[4]
1913	3,250[1]	929,000	
1914	3,040[1]	869,000	
1915	3,700[1]	1,058,000	
1916	4,000[1]	1,144,000	
1917	3,830[1]	1,096,000[5]	
1918	4,870[1]	1,393,000[6]	
1919	4,420[1]	1,264,000	
1920	3,638[2]	1,040,000	
1921	3,483[2]	994,000	
1922	3,975[2]	1,137,000	
1923	4,461[2]	1,276,000	
1924	4,332[2]	1,239,000	

[1] From Chart, Packingtown Rep. II, 1921, p. 32, yrs. 1911-1919, inclusive.
[2] Own calculations from Drover's Journal Year Books, 1920-1924 inclusive.
[3] Rate of 286.1 persons for each million pounds killed. See reference 1, above p. 14.
[4] Av. 4 years, 1911-1914, 929,825.
[5] Basic figure. See Packingtown Rep. II, p. 14.
[6] War-time peak.

WEIGHT OF ANIMALS SLAUGHTERED—CATTLE, SHEEP, AND HOGS ONLY

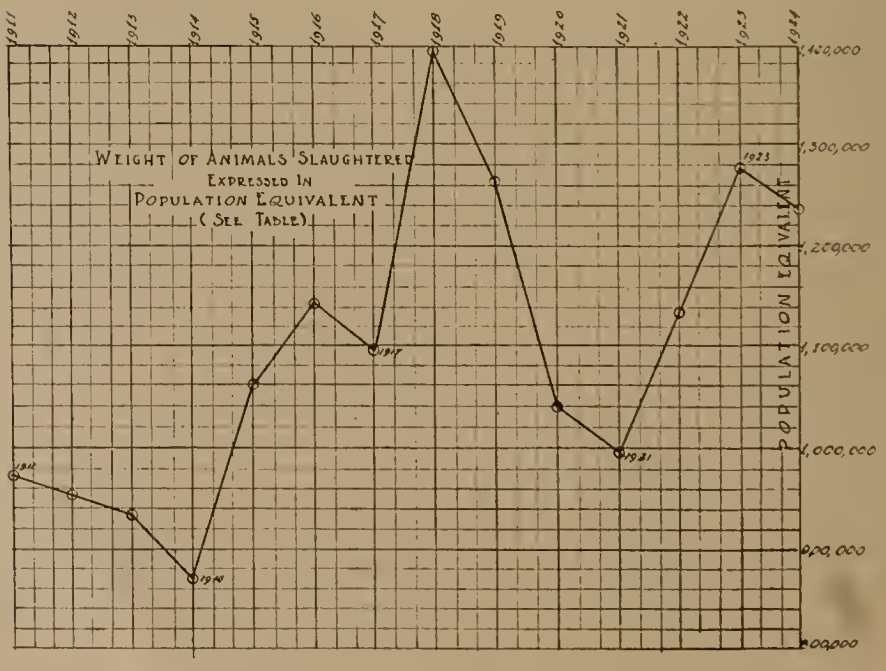
WEEKLY RATE, POUNDS

	1914	1918
Year Av.....	57,380,000	90,200,000
Hot season		
July Av., weekly	49,330,000	88,350,000
Aug. Av., "	43,950,000	71,020,000
Sept. Av., "	52,830,000	90,270,000
Peak weeks ending:		
Jan. 26	———	124,425,000
Feb. 9	———	107,206,000
Mar. 23	———	105,109,000
Nov. 23	———	131,698,000
Nov. 30	———	121,513,000
Dec. 7	———	140,621,000
Dec. 14	———	129,962,000
Dec. 21	———	128,030,000

CHANGES IN CHICAGO POPULATION (EST.) AND PACKINGTOWN EQUIVALENT, 1914 TO 1918

	Population	Total weight of animals killed Million lbs.	Population equivalent of animals killed	Sum of human population and population equiv.	Av. dis-charge san. canal, ft. per sec.
1914	2,437,526*	3,040	869,744	3,307,270	7,193‡
1918	2,613,647†	4,870	1,393,307	4,006,954	8,000¶
Increase	+176,121	+1,830	+523,556	+699,684	+807
Per cent. increase	+7.2	+60.0		+21.1	+11.2

* Chicago *Daily News* Almanac, from federal and school census reports.
† The 1914 figures plus 4 times the average yearly increase, 1914-1920.
‡ Alvord and Burdick, 1914 Report on Illinois River Bottomlands.
¶ Packingtown Report II, 1921, p. 8.



Terminology with Reference to Degree of Pollution and Tolerance

The terms used in the present paper to describe the varying degrees of tolerance exhibited by the small bottom animals do not differ essentially from those used by Forbes and Richardson, 1913: i. e., *septic, pollutional, contaminate,* and *clean-water,* in order of decreasing pollution. For the purpose of greater flexibility and at the same time better suitability of application to the animals themselves, I have substituted the word *tolerant*, with qualifying adjectives, for the word *contaminate* as used in the 1913 paper. After the comparatively few cases of species in the present bottom fauna with authentic previous records of pollutional or unusually tolerant habit*, the tests of tolerance used have been (1) survival under conditions of much lower than normal oxygen supply; (2) association with other authentic pollutional or unusually tolerant species; or (3) survival in areas where species of known cleaner preferences have wholly succumbed. It can not be too strongly urged that at the best we do not find in the actual field habitats the hard and fast lines perhaps too easily suggested by the use of these and other group terms by authors. The great flexibility called for in classifications of the kind is particularly well illustrated in the recent species lists from the bottom muds of Peoria Lake, which may be said to have been neither septic at the worst nor clean at the best, either in 1920 or 1922; by the occurrence there side by side in both years of tubificid worms and midge larvae characteristic of the septic zones of the upper Illinois, and of a number of species of sphaeriid snails thought of usually heretofore as of clean-water habit, though now shown to have more than the ordinary amount of tolerance.

The approximate position of the various subdivisions of Peoria Lake in the zonal system above recognized may be outlined as follows, basing conclusions on the chemical, plankton, and bottom-fauna data of 1920 and 1922.

1. Pollutional Zone:—Chillicothe to lower End of Upper Peoria Lake. Distance 7.5 miles

The dissolved oxygen in midsummer both in 1920 and 1922 ranged here normally between 0.5 and under 3 p. p. m. Though below the septic zone, in the most proper sense, this is still the zone of vast num-

* Includes *Tubifex tubifex; Chironomus plumosus,* and a very few others.

bers of Tubificidae, including Tubifex and several species of Limnodrilus; as well as of *Chironomus plumosus*. Practically the only snails surviving here recently are those that are more than ordinarily tolerant —the list including several species of Sphaeriidae, but only one member of the family Viviparidae (*Campeloma subsolidum*). On the plankton side this is the zone of blue-green algae, these organisms, both filamentous and non-filamentous types, giving a blackish blue color to the plankton samples, easily visible to the unaided eye immediately after treatment with alcohol-formalin preservative, in the case of collections made either in July, August, or September, and as far south as Spring Bay Narrows or even the upper end of the middle lake. *Rotifer tardus* was common in the plankton in the summer of 1920, while shelled rotifers were rare.

2. *Sub-pollutional or Contaminate Zone; or Zone of Tolerant Bottom Animals:—Head or Center of Middle Peoria Lake to foot of Lower Peoria Lake Distance about 12 miles*

The dissolved oxygen ranged usually from around 2.5 to more than 5 p. p. m. through the summer season, both 1920 and 1922. The blackish blue color given the upper lake plankton by the blue-greens begins to disappear rapidly at or just below Mossville; the blue-green organisms thereafter giving way to great increase in chlamydomonads and other chlorophyll-bearing forms. Shelled types of rotifers of the family Brachionidae increase rapidly down the middle lake and *Rotifer tardus* tapers out almost altogether at Peoria Narrows. In the bottom fauna, sphaeriid snails increase in variety in the middle lake, but the Viviparidae and Amnicolidae remain absent, both there and in the lower lake. In the lower lake, areas or zones of heavy local pollution and of unusually fast current cause mixed conditions; and there are otherwise in this portion of the river more or less insensible gradations between conditions nearly clean, contaminate, and pollutional.

Hydrographical Subdivision

The bottom collections made in the summer of 1922 were all made under substantially average low water conditions. Although we went several times within between 50 and 100 feet from shore with the dredge, few depths under five feet were found even at that distance;

while traces of vegetation worth mentioning were found at only two stations in all three lakes all summer. The collections of 1922 are thus practically altogether open-lake dredgings, from areas where the bottom animals are subject to the full influence of low oxygen when it occurs, and where they receive a minimum of aid from the reaerating or freshening effects of shore vegetation and spring water. Noting the very wide extent to which the largely deaerated waters of the river spread out in the upper lake wide-waters opposite Rome—where the bottom dissolved oxygen was under 1 p. p. m. for fully a half mile to the eastward of the mid-channel line on August 9, 1922—it has seemed best to emphasize distance from mid-channel rather than depth in the zonal subdivision of the wide waters. Thus in all cross-sections in 1922 in the lake proper we had first a mid-channel stop, in an imaginary channel some 700 feet wide, the approximate width of the main channel at Chillicothe; next a first wide-water zone embracing several collections in which the first haul was usually taken 400 to 600 feet to either side of the mid-channel line; and last a second wide-water zone extending from 1800 to 4500 feet eastward or westward of the mid-channel line, depending upon the width of the lake in the area crossed.

A table of distances down stream between stations at which cross-sections were made, follows.

TABLE OF MILE NUMBERS AND DISTANCES, PEORIA LAKE, 1922

	Miles below Lake Michigan	Distance below next station above	Distance below Chillicothe
*Chillicothe	146.5	——	——
Upper Lake			
*Rome	149.3	2.8	2.8
*1.5 miles above Spring Bay	151.7	2.4	5.2
Spring Bay	153.2	1.5	6.7
Foot of S. Bay Narrows	154.2	1.0	7.7
Middle Lake			
*Mossville	154.9	0.7	8.4
*Foot of Horshor Island	157.4	2.5	10.9
*Al Fresco Park	159.3	1.9	12.8
Lower Lake			
*Peoria Narrows, below bridge	161.0	1.7	14.5
*Workhouse Point	162.7	1.7	16.2
*Fulton Street	164.2	1.5	17.7
*P. P. U. R. R. Bridge	166.4	2.2	19.9

* Petersen dredge cross-section, 1922.

SUMMARY

1. Improvement in both the upper and middle lake since 1920 is indicated by the close to doubling of the species lists of both lakes in the two years ending summer 1922; but the increase in kinds was almost wholly confined to the group of tolerant sphaeriid snails, which seem to have survived the mortality (between 1915 and 1918) that destroyed practically all the other snail families, and between 1920 and 1922 to have again spread sufficiently over their old range to appear more frequently than in the first-named year in dredge hauls.

2. The extension of range of the surviving Sphaeriidae between 1920 and 1922 went hand in hand with large expansion (following the lull due to business depression of 1921) in the Packingtown slaughterings at Chicago, and with tremendous increase in numbers of tubificid worms in the muds of the upper lake and the river at Chillicothe; and suggests perhaps a progressive immunization of the already tolerant sphaeriid snails to conditions which a few years earlier might have gone harder with them.

3. Both in the upper and the middle lake in 1922 improvement in the condition of the muds is indicated by increase in variety of the species lists (1) as we proceed down stream; and (2) as we proceed outward from mid-channel stations into the wide waters.

4. In the lower lake there are various evidences of mixed conditions on the bottom, partly due, in the wide waters, to wind-blown local pollution; and so far as suitable situations for a few cleaner-preference forms are provided, apparently due to the much greater current that prevails in the lower lake channel, or in the narrows (in our results included as lake stations) immediately above or below it.

5. Species that have definitely disappeared from Peoria Lake since 1913-1915 include all but three or four kinds out of a total of more than forty kinds of fresh-water mussels; all of the snails of the family Amnicolidae; all but one species of the formerly important and especially conspicuous snail family Viviparidae; and a varied weed fauna.

6. From the rather restricted list of small bottom invertebrates that seem to have been exterminated in Peoria Lake since 1913-1915, compared with the decidedly larger lists from the vicinity of Havana*, it is suggested that upper and middle Peoria Lake may have been subjected to a measurable amount of injury from up-river pollution prior to 1915.

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* See Article VI of this volume, on 1923 fauna.

Upper Peoria Lake and the Illinois River, Chillicothe to Spring Bay. (Mile 146.5—153.2 below Lake Michigan)

Hydrography

The three cross-sections in the upper lake district in 1922 began with one in the river proper at Chillicothe, which is only a half mile above the present low-water head of the upper lake, 6.7 miles above its approximate foot at Spring Bay, and 14.5 miles above the head of the lower lake at Peoria Narrows. The two cross-sections through the lake proper included one at Rome, 2.8 miles below Chillicothe, where the extreme width at recent summer low water has been in the neighborhood of 4,800 feet; and one on a line a mile and a half above Spring Bay, 5.2 miles below Chillicothe, where low water widths have recently been somewhat more than 6,000 feet. Mid-channel depths at Chillicothe in August 1922 were around 22 feet, but were only 13 or 14 feet opposite Rome and Spring Bay, at the first of which places considerable filling has evidently occurred since 1901. The soundings made in the east wide-waters opposite Rome were not over 6.5 feet in the first 1,500 feet; and did not exceed 5 feet in the next 2,000. A mile and a half above Spring Bay depths in the open lake were much greater, nine- to more than ten-foot soundings continuing for 3,500 feet beyond the mid-channel line on the east or widest side. The bottom in the river at Chillicothe was deep mud; and throughout the upper lake was uniformly soft black mud at the stations visited, except on the far west side above Spring Bay, where harder mixed mud and gravel bottom reaches out a hundred feet or more from the bank at low water.

Though the odors of the bottom sediments in the upper lake showed striking differences between 1915 and 1920, as described in a previous paper, it was not always an easy matter to make out really definite differences between the summers of 1920 and 1922. While some average improvement evidently occurred in the two years, it was clear also that there was still abundant room for more. Summarizing the records from this portion of the lake for the summer of 1922, it is found that we noted abundant bubbling at all stations; distinctly foul odors at seven stations out of the total of twenty-three; mildly bad odors at nine out of the twenty-three stations; and had no

record or records of uncertain value at seven stations. This exhibit compares with bad odors at all stations in the summer of 1920, but is qualified in value by the feature that worse odors were noted in the summer of 1922 well to the east and west of the main channel than within it, both opposite Rome and just above Spring Bay; and rather milder ones in the river channel at Chillicothe than at the worst stations in the wide-water cross-sections three to five miles farther south. The possibility that the very unusual flood of January-April 1922 flushed out the channel at the same time that it brought in a new load of putrescible sediment to the wide waters suggests itself as a plausible explanation of some of these changes, as also of the fact that the spongy gas-filled mud noted in the summer of 1920 at several upper lake stations in or near the steamboat channel did not appear in any of our 1922 dredge hauls.

Toward the west bank below Rome some spreading of Potamogeton occurred between 1920 and 1922; and in September 1922 mats of Lemnaceae were found here, and also in the brushy southwest corner of the upper lake opposite Spring Bay. The total area supplied with vegetation is, however, insignificant compared with that of the low-water period between 1910 and 1915, on gages little if any lower. No living vegetation at all was encountered at any of the stations actually dredged in the summer of 1922.

Dissolved Oxygen

The dissolved oxygen one foot from the bottom in mid-channel at Chillicothe fell as low as 0.3 p. p. m. in July 1922, and to 0.2 p. p. m. in August. The bottom oxygen during the same period in mid-channel opposite Rome dropped to 0.2 p. p. m. on July 3, 1922; rose to 2.0 p. p. m. on July 27; fell to 0.5 on August 9; and rose again to 1.6 on August 29. On August 9, when the bottom oxygen in the channel at Rome was 0.5 p. p. m., bottom figures under one part per million were recorded at six wide-water stations east of the steamboat channel in the Rome cross-section, averaging more than 600 feet apart and extending altogether more than 3600 feet eastward of the mid-channel station.

At points between a mile and a half above Spring Bay and the foot of the upper lake at Spring Bay Narrows, which is 7.7 miles below Chillicothe, the bottom dissolved oxygen in July and August 1922

ranged between 1.4 and 3.9 parts per million. The bottom figure on July 28, 1922, at Spring Bay Narrows (1.4 p. p. m.) was lower than the figure at Rome the day before; but both on July 3, 1922 (when it was 3.3 at Spring Bay Narrows), and on August 29, 1922 (when it was 3.9), a relatively large improvement had taken place in the approximate five-miles distance between Rome and the foot of the lake. The variation in the gage at Peoria during the period July 3 to August 29 was a little less than two feet. The lowest bottom dissolved oxygen figures at Chillicothe were recorded on July 3, August 9, and August 29, on gages 11.3, 10.4, and 9.8 feet corresponding; and the highest on a gage of 10.7 feet on July 27. The lowest bottom figures at Rome occurred on July 3 at a gage of 11.3 feet Peoria, and on August 9 at gage 10.4; while the high figures (1.6 to 2.0 p. p. m.) came on July 27 and August 29 on gages 10.7 and 9.8 feet.

Bottom oxygen figures slightly lower than any of these were recorded at Chillicothe and Rome and in the vicinity of Spring Bay in the summer of 1920. A table comparing the channel figures from the upper lake and Chillicothe for 1922 and 1920 follows.

Bottom Dissolved Oxygen, Mid-Channel, Upper Peoria Lake, 1920-1922

midsummer figures, parts per million

Peo. gage ft.	Chillicothe Mile 146.5*		Rome Mile 149.3		1.5 miles above Spring Bay Mile 151.7		Spring Bay Narrows Mile 154.2		
	1922	1920	1922	1920	1922	1920	1922	1920	Dates
11.3	0.3	....	0.2	....	4.5	....	3.3	....	July 3
10.7	0.9	0.3	2.0	0.4	3.8	0.7	1.4	....	July 15–28
10.6	....	....	....	....	....	0.7	....	1.4	July 16
10.4	0.7	....	0.5	....	....	....	....	4.1	July 21–August 9
9.8	0.2	0.0	1.6	0.0	....	0.4	3.9	0.7	August 4–Aug. 29
9.7	....	0.3	....	....	....	....	....	1.2	Aug. 23–28

* Miles below Lake Michigan. Chillicothe is a river station just above the present upper low-water boundary of the Peoria Lake wide-waters.

Small Bottom Animals

Nineteen species of small bottom invertebrates were recorded from twenty-three dredging stations between Chillicothe and a mile and a half above Spring Bay, near the lower end of upper Peoria Lake, in the summer of 1922 (Table, p. 342). This increased number compares with eleven or twelve kinds taken at eight stations in very nearly the same area in the corresponding months of 1920. That the increase may to some extent be due to the greater number of stations visited, particularly in the wide waters, in 1922, has not been allowed to escape our notice. More probable explanations, however, include the increase in the worm list (+2) due to a more thorough study of that group in 1922, and the evident increase, mostly in the wide waters, of the less tolerant snails (+5), that seem to have escaped total destruction between 1915 and 1920, but that had not had time by 1920 to extend again over their old range sufficiently to make the chance good of getting them in collections. It will be noted, also, in ensuing pages, that other equally important changes were apparent at the end of the two year interval that could have no possible connection with an increase in the number of stations.

Both in 1922 and 1920 the majority of the species taken in the upper lake, whether in channel or wide waters, belonged to the more distinctly pollutional or tolerant groups of small bottom animals; that is, small annelid worms (Tubificidae), leeches, midge larvae, and tolerant snails. The more sensitive varieties of the old snail, insect, crustacean, and other small bottom population of 1915 and before were in 1922 as in 1920 wholly absent from all hauls taken in the upper lake more than 50 feet from shore. There was, however, to be set down fairly definitely on the side of improvement during the two years following 1920 the noticeable increase in the number of kinds and abundance of the tolerant snails, already mentioned; and, more qualifiedly, because they may have merely been washed out by the violent flood of the spring of 1922, the decrease in both numbers and kinds of more pollutional midge larvae. Suggesting caution, on the other hand, in accepting at face value these apparent evidences of improvement, was the remarkable increase in abundance at all stations in the upper lake in 1922 of the small oligochaete worms, which were present in numbers exceeding any that we have before recorded from anywhere in the Illinois River.

As will be seen in the tables that follow, there was noticeable a sharp difference between the rates of increase in the species lists in mid-channel and in the open lake from 1920 to 1922. In fact, substantially no favorable change in number seems to have occurred in the two years in the channel, where decrease in kinds of midges was balanced by increase in worms, leeches, and tolerant snails; and where, in 1922, the number of all species taken decreased instead of increasing as we proceeded down the lake from Chillicothe. In the wide waters, on the other hand, there was an increase in the list of species in the two years from 11+ to 18+; and the increase was almost all due to the multiplication in variety of the less tolerant kinds of snails and midges, (see Table below). Further evidence of improvement in the extra-channel zones is seen as we go down stream (see Table on following page); as also in the near to more than doubling of the species lists in size, both in the Rome and the Spring Bay cross-section, as we move outward from the channel into the wide waters (Table on p. 344).

SUMMARY OF BOTTOM SPECIES LISTS, UPPER PEORIA LAKE, SUMMER 1922

1. COMPARISON WITH 1920. NUMBER OF KINDS TAKEN

	Channel		Combined wide-water zones		All zones	
	1922	1920	1922	1920	1922	1920
Worms	4+*	3	5+	3	5	3+
Leeches	1	0	1	1	2	1
Pollutional midges	0	2	1	3	1	3
Other midges	0	2	4+	2+	4+	2+
Very tolerant snails	1	1	1	1	1	1
Less tolerant snails	2	0	5	1	5	1
Other snails	0	0	1	0	1	0
Total	8+	8	18+	11+	19+	11+

* The + after figures in this and other tables indicates a residue of undetermined material, definite returns on which might add one or more to the number of species given.

SUMMARY OF BOTTOM SPECIES LISTS, UPPER PEORIA LAKE, SUMMER 1922

2. CHANGES DOWN STREAM. NUMBER OF KINDS TAKEN

	Worms	Leeches	Pollutional midges*	Other midges*	Very tolerant snails	Less tolerant snails	Other snails	All snails	Total
Mid-channel									
Chillicothe Mile 146.5	3+	1	.0	0	1	0	0	1	5+
Rome Mile 149.3	3+	0	0	0	1	2	0	3	6+
1.5 miles above Spring Bay Mile 151.7	2	0	0	0	1	0	0	1	3+
Combined wide-water zones									
Chillicothe Mile 146.5	4+	0	1	0	1	0	0	1	6+
Rome Mile 149.3	4+	0	0	4+	1	3	0	4	12+
1.5 miles above Spring Bay Mile 151.7	4+	1	1	1+	1	4	1	6	13+

* Larvae.

SUMMARY OF BOTTOM SPECIES LISTS, UPPER PEORIA LAKE, SUMMER 1922

3. CHANGES FROM MID-CHANNEL OUTWARD INTO WIDE WATERS
NUMBER OF KINDS TAKEN

	Mid-channel	First 1500 ft.	1800–4500 ft.	All extra-channel
Rome				
Mile 149.3				
Worms	3+	4+	4+	4+
Leeches	0	0	0	0
Pollutional midges*	0	1	0	1
Other midges*	0	1	3+	4+
Very tolerant snails	1	1	1	1
Less tolerant snails	2	2	3	3
Other snails	0	0	0	0
Total	6+	9+	11+	13+
1.5 miles above Spring Bay				
Mile 151.7				
Worms	2	4+	3+	4+
Leeches	0	0	1	1
Pollutional midges*	0	1	0	1
Other midges*	0	0	2	2
Very tolerant snails	1	1	1	1
Less tolerant snails	0	1	2	4
Other snails	0	0	1	1
Total	3+	7+	12+	14+

* Larvae.

WORMS

The tube-worms (Tubificidae) and other small annelids recorded from upper Peoria Lake in 1922 included not less than five kinds, and were, along with one of the unusually tolerant snails, the conspicuous feature from the point of view of abundance, of the muds in all cross-sections. Three of the species belonged to the genus Limnodrilus, viz., *L. hoffmeisteri* Claparède; an unidentified species similar to *L. claparedeianus* Ratzel; and a species believed by Professor Frank Smith, who determined the specimens, to be new. The genus Tubifex, usually thought of as the common one in septic or polluted muds, was represented by a single species, referred with question, because of slight differences, to the European *Tubifex tubifex* (Müller). The

related family of free living worms known as Naididae was represented by small numbers of one or more undetermined species.

The species of the genera Tubifex and Limnodrilus live in tubes or burrows in the soft top ooze of stream bottoms, from which they protrude the posterior end, waving it constantly when undisturbed, as an accessory act in respiration. When very abundant these worms literally carpet the bottom with a living nap of reddish brown or deep red. This fact is the more easily visualized by those who have not seen them when it is known that they occurred in numbers as high as 60,000 per square yard in upper Peoria Lake in the summer of 1922. Such numbers amount to nearly 250 rows of 250 each in such a space, and call for a separation between individuals amounting to less than fifteen-hundredths of an inch in each direction.

The several times recorded occurrence of *Tubifex tubifex* in unusually septic situations in recent years by European writers, as about the edges of septic tanks and very near the sources of the pollution in sewage-fouled streams, seems to have led to the entire group being referred to rather indiscriminately by local authors lately as "slime worms" or "sludge worms," with little or no reference at all to the possible varying preferences or the identity of individual species. This has been no doubt largely a result of the difficult and time-consuming technique necessary in the determination of species in this group, and the extreme rarity of specialists competent to render an opinion upon them. Some of them occur quite frequently, however, in ordinary clean bottom in our inland lakes and streams; and extensive carpets of them have been observed near the edges of deep reservoirs thought clean enough to be a part of the source of a city's water supply. Even *Tubifex tubifex* has recently been reported by Muttkowski (1918) from the bottom muds of Lake Mendota; and was found, as represented by the American form as here understood, to be commonly present in the comparatively clean muds of the Illinois River at and near Havana in the early days of operations at the Illinois Biological Station.

Of the Tubificidae taken in upper Peoria Lake in 1922 far the most abundant one was not *T. tubifex* as might have been expected on the basis of recent American and European records, but *Limnodrilus hoffmeisteri*. This worm occurred at twenty-one out of twenty-three of the collecting stations in the upper lake, including all cross-sections, and like *T. tubifex* and the undescribed species of Limnodrilus was

most abundant in the two upper cross-sections, opposite Chillicothe and Rome, at the latter of which the dissolved oxygen one foot above bottom was under one part per million at stations embracing over a mile of lake-width early in August. The species was also taken, however, at a large proportion of the stations in the upper part of the middle lake and at a few in the lower.

The undescribed species of Limnodrilus had a distribution in the summer of 1922 very much like that of *L. hoffmeisteri,* being taken at nineteen out of the twenty-three upper lake stations, embracing three cross-sections; and was also taken in scattered hauls both in the middle and the lower lake. *Tubifex tubifex,* on the other hand, was taken in or just above the upper lake in 1922 only in the Chillicothe and Rome cross-sections, where it occurred at only six out of twelve stations; was not recorded at all from the eleven stations in the Spring Bay cross-section; and was recorded only once each from the middle and lower lakes.

The distinct tendency toward confinement of *Tubifex tubifex,* as here understood, to the Chillicothe and Roman cross-sections may be accepted as further confirmation of the value of that species as an indicator of bad bottom; though it is believed that the facts of outside distribution before mentioned suggest that great caution be used before basing conclusions as to the cleanness of muds upon mere occurrence, either of this or other species.

When the totals of all Tubificidae are tabulated, it is suggested that numbers may be quite as important as specific identity when we are seeking an index of the condition of the bottom muds in the small annelids. Averaging 22,400 at Chillicothe, and averaging 29,000 and ranging as high as 69,000 opposite Rome in early August, 1922, the total of all worms dropped to only 2,100 per square yard in the next 2.4 miles (cross-section 1.5 miles above Spring Bay); and to a figure of only 420 per square yard in the first cross-section in the middle lake, another 4.5 miles south. The sharp decline in the 2.4 miles between Rome and the next cross-section southward corresponded to a rise of less than two parts per million in the bottom dissolved oxygen on the round of August 9, 1922, and was proportionately more emphatic than the oxygen figures in suggesting the rapidity of improvement in the water and the muds after they spread out into the upper lake wide-waters just above Rome.

CHANGES IN ABUNDANCE OF COMMONEST SMALL BOTTOM ANIMALS IN PEORIA LAKE, 1920 TO 1922

AVERAGE NUMBERS PER SQUARE YARD

	Miles below Lake Michigan	Mud worms Tubificidae				Unusually tolerant snail Musculium transversun				Midge larvae Chironomidae				Collections averaged			
		Channel		Wide waters		Channel		Wide waters		Channel		Wide waters		Channel		Wide waters	
		1922	1920	1922	1920	1922	1920	1922	1920	1922	1920	1922	1920	1922	1920	1922	1920
Upper Lake																	
Chillicothe	146.5	14,400	4,800	27,400	960	28,800	240	63,300	0	0	2,400	216	960	1	1	2	1
Rome	149.3	48,000	480	26,910	1.200	49.200	96	38,475	16	0	1,200	438	224	1	1	8	3
1.5 mi. above Spr. Bay	151.7	2,800	9,600	2,090	240	5,760	0	7,936	24	0	48	58	0	1	1	10	1
Middle Lake																	
Mossville	154.9	48	480	468	348	768	0	1,478	3	48	48	36	42	1	1	8	4
Foot Horshor Isl.	157.4	1,560	—*	847	—	9,600	—	1,326	—	648	—	402	—	1	—	6	—
Al Fresco Park	159.3	0	480	0	24	1,500	0	583	0	24	24	51	360	1	1	13	2
Lower Lake																	
Peoria Narrows	161.0	48	0	504	0	120	0.5	24	6	72	40	36	108	1	1	2	2
Strawboard Works	161.7	—	0	—	210	—	0	—	0	—	144	—	270	—	1	—	4
Workhouse Point	162.7	72	—	36	—	0	—	16	—	0	—	108	—	1	—	6	—
Green Street	163.9	—	24	—	0	—	0	—	0	—	120	—	219	—	1	—	4
Fulton Street	164.2—	124	—	96	—	0	—	18	—	0	—	243	—	1	—	4	—
Liberty Street	164.2+	—	0	—	120	—	0	—	2	—	156	—	402	—	1	—	4
P. P U. Bridge	166.4	0	0	0	1	0	0	0	0	0	0	0	3	1	1	2	2

* The dash means no collection.

The reasons for the much greater abundance of these worms in the summer of 1922 than in the summer of 1920, when the average oxygen supply was somewhat less at the lowest than in 1922 at upper lake stations, are not clear unless we assume that the increase followed, as it might quite naturally, the bringing in with the very unusual flood of the winter and spring of 1922 of a new load of rich sediments, along with a richer bottom bacterial flora, than were present in the summer of 1920, following a more quiescent spring season. In fact, these worms do not seem to be bound to their habitat so much by a qualitative as by a quantitative food relation, deriving their sustenance as they do, without apparent selection, from the bacteria and other living and dead organic matter in the soft bottom-sediments, which they first swallow *en masse*. So far as a low oxygen supply is concerned, they seem merely able to tolerate it by virtue of their ability to store haemoglobin and to effect a mechanical aeration of their immediate surroundings, rather than to be in any true sense partial or obligate to it.

LEECHES

Two species of leeches were taken in the upper lake in the summer of 1922: the first, *Erpobdella punctata* (Leidy), in the channel opposite Chillicothe; the second, *Helobdella nepheloidea* (Graf), in the wide waters 3,600 feet eastward of mid-channel in the cross-section a mile and a half above Spring Bay. The first species mentioned was taken also in 1922 in the river at the P. P. U. Railway Bridge opposite the lower part of the city of Peoria where the pretty well aerated waters of the lower lake are being mixed with the discharge from the main sewers. *Erpobdella punctata* was noted by Baker (1922) as common at stations in the Big Vermilion River in 1918-1920 where gas bubbling was continuous in warm weather and where the mussels were dead; and by Weston and Turner (1917) as common at the upper and worst polluted stations in the Coweeset below Brockton, Massachusetts. Muttkowski (1918), on the other hand, reported *Erpobdella punctata* to be common along clean gravelly shores of Lake Mendota.

Helobdella nepheloidea, in addition to its occurrence in the upper lake above Spring Bay at stations where distinctly bad odors were recorded, was also taken in the wide waters of the middle lake opposite Mossville; in the steamboat channel and the wide waters of the lower lake opposite Fulton Street, Peoria; and, in company with *Erpobdella*

punctata, below the outlet of the lower lake at the P. P. U. Railway Bridge. We have found no definite outside records of habitats of this species. The conclusion is evidently to be drawn, with respect both to this and the other species named, that they are of rather indifferent value as an index of the condition of muds in the Illinois River.

MIDGE LARVAE

Larvae of midges occurred in our 1922 dredge-hauls from upper Peoria Lake at only eight out of the total of twenty-three stations, and failed altogether to appear at any of the channel stations. The total number of identified kinds was the same as in the summer of 1920, but three of the more pollutional species of that year were not taken at all in 1922, and the single 1922 species known to be unusually tolerant (*C. plumosus* Linn., var.) occurred only at three extra-channel upper lake stations, one each in the Chillicothe, Rome, and Spring Bay cross-sections. Undetermined species of Chironomus, Procladius, and Tanypus were taken at a few open lake stations well eastward of the channel opposite Rome and Spring Bay; and a few specimens of *Tanypus monilis* Linn., in the past reported only from cleaner situations, were taken toward the west side opposite Rome, in a haul in which tubificid worms exceeded 7,000 per square yard and unusually foul odors were noted.

In the summer of 1920 all channel hauls contained midge larvae, though the recognized more tolerant kinds then as in 1922 came from the stations outside the channel. In the middle lake and in the lower in 1922 larval Chironomidae occurred at a much larger proportion of all stations than in the upper lake, although no important increase in numbers was noted at the stations southward.

With the exception of *C. plumosus* or its varieties, and of two other pollutional species (*C. decorus* Johannsen and *Tanypus dyari* Coquillett) taken rather frequently in the summer of 1920, neither in 1922 or 1920 did numbers of chironomid larvae attain importance in Peoria Lake (Table, p. 347). The first-named species does, however, seem to bear an unusually distinct relation to pollution; as has been noted since some years ago in studies of its sister forms in Europe, where variation in the length of its ventral blood-gills has been observed to coincide more or less definitely with differences in the oxygen supply. The recent Illinois River and Peoria Lake specimens which we have referred to this species do not seem to differ very materially

except in that respect from the abundant larva formerly referred to *C. tentans* in our work of ten years or so ago at and above Havana—a form which seems to have wholly disappeared from this section of the Illinois River since some time before 1920. The practical confinement of the more pollutional kinds of midge larvae recently to the lake zones outside the channel, while to an extent perhaps a result of habitat preference unconnected with pollution, places them conveniently in those areas where the bottom receives the largest fresh supplies of rich sediment as the gage recedes after floods.

UNUSUALLY TOLERANT SNAILS

One of the most surprising facts that came out of the study of the bottom dredgings from upper Peoria Lake was the enormous multiplication at Chillicothe and in the lake opposite Rome between 1920 and 1922 of the little sphaeriid snail, *Musculium transversum* Linsley. Numbers of this small bivalve, familiar to local hunters and fishermen under the name of "duck shell", reached a hundred thousand per square yard in parts of the upper portion of the upper lake in the summer of 1922. Average numbers for all stations in cross-sections passed 51,000 at Chillicothe and 39,000 opposite Rome, these figures representing equivalents of weight valuations between 19,000 and 25,000 pounds per acre over limited areas, on the supposition that all the young and half grown lived to become adult. The distribution of the largest hauls of this little snail agreed closely with the location of the largest catches of mud worms, and also an equally abrupt average decline in the Musculium figures corresponded to the drop in worm figures already mentioned as having taken place in the two miles between the Rome cross-section and the next one south. This decline was followed by further decrease or showed little recovery in the areas sampled in the middle and lower lakes. (Table, p. 347.)

The ability of this snail to withstand low oxygen is well supported by previous evidence from the Illinois River, where it occurred in small numbers near the banks as far north as Marseilles in the summers of 1911 and 1912. Its recent extremely rapid multiplication in the worst instead of the best portion of its old range in Peoria Lake, amounting to from 50 to more than 2,000 times numbers as of the summer of 1920, may be supposed, however, to reflect quite probably some other factor than those involved in the original habitat preferences of the species. Perhaps it is true that an important consideration has

been that this snail has recently met almost no hindrance to multiplication from its greatest predatory enemy, the carp, in this poorly aerated section of Peoria Lake. The supposition that its recent distribution and abundance has been in substance inverse to that of the coarse bottom-feeding fishes is borne out by such information as we have concerning the location of the most profitable seine hauls recently above Peoria Narrows. It may also be the case that there has recently been some increase in an already relatively strong immunity in this species to the ill effects of low oxygen.

LESS TOLERANT SNAILS

It was in the group of less tolerant snails that the greatest increase in variety of the small bottom fauna of the upper lake occurred in the two years following 1920. The species included under this designation are all evidently less tolerant than *Musculium transversum*, as shown both by their greater rarity in upper Peoria Lake in 1922, and by the fact that none of them occurred quite so far north in the Illinois River in 1912 as that very tolerant species. Though less tolerant than that unusually hardy form, they are all evidently considerably more so than several other snail species (particularly *Vivipara contectoides* Binney, *V. subpurpurea* Say, *Lioplax subcarinatus* Say, and *Amnicola emarginata* Küster), all of which were common in Peoria Lake up to 1915 but have not since appeared in collections from either the upper, middle, or lower lake. Though no representative of this group could be called abundant at any upper lake station in 1922, we took then, in all, five species, all but one belonging to the Sphaeriidae, compared with a single species in 1920. The channel collections contributed two species, *Musculium truncatum* Linsley and *Pisidium compressum* Prime, against none at all in 1920; and the collections from the open lake five kinds, *M. truncatum*, *P. compressum*, *P. pauperculum* var. *crystalense* Sterki, a species of Pisidium near *P. complanatum* Sterki, and *Campeloma subsolidum* Anthony, as against the last species alone in the summer of 1920.

Of these five snails, only one, the large viviparid, *C. subsolidum*, has been previously known through published records, so far as we know, to be much more than ordinarily resistant to pollution or low oxygen. This snail was taken by us in the Illinois River in 1912 as far north as Starved Rock, or farther north than any other snail except *Musculium transversum;* and was recently reported by Miss Jewell

(1922) from the acid waters of the Big Muddy. The distribution of *Campeloma subsolidum* in upper Peoria Lake in 1922, was confined to two stations in the far east wide-waters a mile and a half above Spring Bay. Bad odors and abundant bubbling were noted at both of these stations, and the bottom dissolved oxygen was under three parts per million in July, and considerably lower in August.

While *Musculium truncatum* did not appear at all in 1920 collections from any part of Peoria Lake, in August 1922 we found it at seven out of the nine stations in the Rome cross-section, including the channel, and at one station in the upper portion of the middle lake. Numbers in the Rome cross-section ran as high as 700 per square yard, and the species was associated with Tubificidae at stations where they exceeded forty thousand. This species was found in the Illinois River channel in 1912 as far north as De Pue and Spring Valley, and seems to possess not far from as high a degree of tolerance as its more prolific coingener, *M. transversum*. It seems, in fact, to differ from it mainly at the present time in Peoria Lake as it did in the past in the cleaner waters of the Illinois, in a lesser aptitude for multiplying and occupying the capacity of its range.

Of the three species of Pisidium taken in the upper lake in 1922, *P. compressum* had much the widest distribution, occurring at six out of the total of 23 stations, compared with no records at all in 1920. It was present at three stations in the Rome cross-section, including the mid-channel station, and was associated there with Tubificidae and other annelid worms whose combined numbers exceeded 45,000 per square yard. This little shell also occurred in the upper lake in 1922 at three stations toward the west end of the Spring Bay cross-section, and extended southward into the middle lake and the upper portion of the lower. In 1912 it was taken in the channel of the Illinois at Spring Valley, De Pue, Henry, and Chillicothe.

Pisidium pauperculum, var. *crystalense* Sterki occurred in the upper lake in 1922 at only two stations, both west of the main channel in the cross-section a mile and half above Spring Bay. At one of these two hauls unusually bad odors were noted and Tubificidae and other small annelids passed 5,000 per square yard. The species was not taken in the Illinois River above Henry in the summer of 1912, and is apparently to be graded as somewhat less tolerant than *P. compressum*.

A third species of Pisidium, close to *P. complanatum* Sterki, was taken twice in the summer of 1922 in the far east wide-waters of the upper lake, once in the Rome and once in the Spring Bay cross-section. Tubificidae exceeded 6,000 per square yard at one of these stations and especially bad odors were recorded at both.

It may be mentioned here that Miss Emmeline Moore (information by correspondence) found *Pisidium compressum* and also an unnamed species near *P. abditum* Haldeman in waters of the Skaneateles outlet, New York, recently, under conditions that suggested a high degree of tolerance. It is also of interest in the present connection to recall that Juday (1908) took a species of this genus (*P. idahoense* Roper) in the deeper waters of the glacial lakes of Wisconsin, at depths where for more than two months in the year there was nearly if not complete oxygen exhaustion. These specimens were found to be quiescent under those conditions, but to revive upon being placed in well-aerated water.

Belonging to a group of snails and other bottom species still less tolerant than the Pisidia, is the little *Valvata tricarinata* Say, which we took in small numbers in August 1922 about a hundred feet from the west bank opposite Spring Bay. Here there was somewhat solider bottom than farther out in the lake, though no vegetation; and no especially bad odor was recorded. As this species is more frequently than not a shore form and more than ordinarily partial to vegetation, the question of the amount of tolerance possessed by it does not affect any conclusions already or later drawn as to the condition of the bottom muds of the great portion of upper Peoria Lake.

Middle Peoria Lake, Mossville to Al Fresco Park (Mile 154.9—159.3 below Lake Michigan)

Hydrography

The three bottom fauna cross-sections through the middle lake in the summer of 1922 began at Mossville, 3.2 miles below the last section in the upper lake, and were approximately two miles apart in all cases. The one at Mossville was 8.4 miles below Chillicothe, the one at the foot of Horshor Island 10.9 miles below, and the one opposite Al Fresco Park 12.8 miles below the first cross-section taken in 1922. The width of Peoria Lake at Mossville in August 1922 was around 4,500 feet; but had rapidly expanded to about 7,000 opposite the foot

of Horshor Island; and declined again to about 3,500 at Al Fresco Park. Mid-channel depths in the first two cross-sections were not over 13 feet, but were 18 feet opposite Al Fresco Park, where the lake is beginning to taper to the lower narrows and the current is noticeably stronger than farther northward. Extra-channel depths in the middle lake cross-sections were nearly all over seven feet, and depths of nine to ten feet were met in all three throughout a total width sweep of 2,500 to 3,000 feet. Soft mud bottom was found everywhere except in the last hundred feet next the west bank, where there was some sand or gravel.

A more readily recognizable change for the better since 1920 could be perceived in the bottom sediments of the middle lake in the summer of 1922 than was the case in the upper. Although bubbling was abundant at nearly all stations, and mild bad odors at a majority of them, no very foul odors such as were encountered in or near the channel as far south as Al Fresco Park in 1920 were noticed anywhere in the middle lake in the summer of 1922. Improvement between Mossville and Al Fresco Park, a distance of about four and a half miles, was clearly evidenced by the entire absence of foul odors and the fewness of bubbles at a number of the wide-waters stations opposite the latter place.

Replacement of vegetation does not seem to have progressed so far in the two years since 1920 in the middle as in the upper lake, a circumstance possibly having some connection with the fact that the middle lake is regularly seined. Sparse patches of Potamogeton and Vallisneria were visible near the west bank in late August and early September 1922 in the lower half of the lake, but the great weed-beds that formerly covered hundreds of acres in the upper half of the lake were as absent from the landscape as they were in 1920.

Dissolved Oxygen

There was a plentiful supply of dissolved oxygen over the greater part of the middle lake in July 1922, when on gages between 11.3 and 10.7 feet more than five parts per million were found a foot from the bottom a mile below Mossville, and nearly or more than six parts per million opposite Al Fresco Park in mid-channel samples. But before the end of the first two weeks of August, on a gage down to 10.3 feet, the mid-channel figure a mile below Mossville had dropped

to 2.2 p. p. m., and was only 3.4 p. p. m. a mile and a half above the foot of the lake. Similar mid-channel figures (2.8 p. p. m. one foot from bottom) were obtained a mile below Mossville late in August (gage 9.8 feet); and on September 13, after a slight rise, when the low figure for 1922, 1.7 p. p. m., was recorded. At Al Fresco Park on the last two dates mid-channel bottom oxygen was 5.3 and 4 p. p. m.

In the wide waters a mile below Mossville the bottom oxygen rose rapidly toward the west bank in late July 1922, topping 10.2 p. p. m., or about a part and a half above saturation, about a hundred feet from shore on July 28. But in the far east wide-waters on the same date the figures obtained a foot from the bottom ranged between 3.1 and 3.4 p. p. m., or a part to more than that lower than the channel figures. However, at this time, in the wide waters as in the channel, bottom oxygen figures rose rapidly as we proceeded down the lake, ranging between four and six parts per million opposite the foot of Horshor Island and six to more than seven opposite Al Fresco Park. On August 9, 1922, bottom figures were under 1 p. p. m. in the open lake at three stations in the cross-section a mile below Mossville, and were as high as 3 p. p. m. only at distances more than 3,000 feet east or 2,000 west of mid-channel (it will be noted that the lake is some 2,000 feet wider at low water here than directly opposite Mossville). On the same date open lake figures opposite Al Fresco Park were under 4 p. p. m. as far as 1,300 feet east of the mid-channel line, but had risen to 6.7 p. p. m. within a total of 2,000 feet.

In August 1920 appreciably lower bottom dissolved oxygen figures than any of those obtained in the summer of 1920 were recorded from the middle lake, both in its upper portion in the vicinity of Mossville and toward the lower end opposite Al Fresco Park. Then, as in 1922, there was sometimes quite rapid improvement from the channel outward into the wide waters, particularly in the lower portion. But in the second week of August 1920, figures under 1 p. p. m. were found more than 2,500 feet to the east of the mid-channel line at Al Fresco Park. Neither in 1920 nor 1922 did these extreme low figures have a very extended duration in the open lake, but were likely to be succeeded within a week or two, coincidently with a sudden increase in the green microplankton, by figures four to five parts per million higher. Even bottom dissolved oxygen figures above saturation were recorded once in 1920 from a middle lake wide-water station, late in August, though

this was in the lower part of the lake, and not above the middle as in the latter part of July 1922.

Bottom Dissolved Oxygen, Mid-channel, Middle Peoria Lake, 1920-1922
Midsummer Figures, Parts per Million

Peoria gage ft.	Mossville Mile 154.9*		1.3 miles below Mossville Mile 156.2		Foot of Horshor Island Mile 157.4		Al Fresco Park Mile 159.3		
	1922	1920	1922	1920	1922	1920	1922	1920	Dates
11.3	...	...	5.2	...	...	...	6.4	...	July 3
10.7	...	...	5.2	...	4.9	...	5.8	...	July 28
10.4	...	...	...	3.0	...	...	...	1.5	July 21-22
10.3	...	...	2.2		...	...	3.4	...	Aug. 9
10.2	...	...	1.7	...	...	...	4.0	...	Sept. 13
9.8	...	...	...	2.3	...	...	...	3.4	Aug. 6
9.8	...	...	2.8	...	...	...	5.3	...	Aug. 29
9.5	...	...	...	...	...	1.9	...	2.2; 1.5	Aug. 10-11
9.5	...	1.3	...	2.1	...	2.7	...	4.8	Aug. 25-26
9.5	...	1.2	...	...	...	1.8	...	3.7; 4.0	Aug. 27-28

* Miles below Lake Michigan.

Small Bottom Animals

The all-zone list of small bottom animals from the middle lake contained 23 species in 1922 compared with 19 from the upper lake the same season (Table 1, p. 358). Though variety of species was least both in the middle and the upper lake at the channel stations, it was there that the greatest relative increase occurred: i. e., from 8 species in the upper to 11 species in the middle lake in the same period. In the wide waters the 1922 hauls yielded in all 21 species compared with 18 from the upper lake. The increases over the upper lake lists were largely due both in the channel and in the wide waters to increased variety of the less tolerant snails and midge larvae, the first of these two groups rising to a total of 10 species for the middle lake as a whole in the summer of 1922.

Compared with 1920, there was substantially a doubling in variety of the 1922 lists, whether in channel, wide waters, or all zones combined (Table 2, p. 358). The increases over 1920 were principally due to multiplication of kinds of the less tolerant snails, which rose in the two years from one to ten species; and to the less tolerant kinds of larval midges, which increased from two kinds to five. Both the snails and the less tolerant midges showed the greatest gain in the wide waters, at the same time that the more pollutional kinds of midges fell off in representation in the extra-channel areas as compared with 1920.

The changes in the species lists of the middle lake from its upper to its lower end in 1922 were irregular in the channel, the Al Fresco Park stations showing scarcely better than those opposite Mossville, four and a half miles above (Table on p. 359). The largest variety of channel species was found in the intermediate cross-section, opposite the foot of Horshor Island, and about half way between the head and the foot of the lake. In the wide waters there was a more regular showing of improvement southward from Mossville, both the Horshor Island and the Al Fresco cross-sections yielding nearly or quite twice as many of the less tolerant snails and from three to four times as many of the less tolerant midges as were taken opposite the Mossville station.

In all three of the middle lake cross-sections of 1922 there was marked increase in variety of species as we proceeded outward into the wide waters from the steamboat channel (Table on p. 360). This improvement was mainly due in all three cross-sections to the increase in number of kinds of less tolerant snails; which rose in the Mossville section from none in the channel to three kinds in the wide waters; in the Horshor Island section from three kinds in the channel to six kinds in the wide waters; and in the Al Fresco Park section from one kind in the channel to five kinds at the extra-channel stations.

SUMMARY OF BOTTOM SPECIES LISTS, MIDDLE PEORIA LAKE, SUMMER OF 1922

1. COMPARISON WITH UPPER LAKE. NUMBER OF KINDS TAKEN

	Worms	Leeches	Pollutional midges	Other midges	Very tolerant snails	Less tolerant snails	Other snails	All snails	Total
Mid-channel									
Upper lake.....	4+	1	0	0	1	2	0	3	8+
Middle lake.....	4+	0	1	1	1	4	0	5	11+
Extra-channel or wide waters									
Upper lake.....	5+	1	1	4+	1	5	1	7	18+
Middle lake.....	3+	2	1	5+	1	9	0	10	21+
All zones.....									
Upper lake.....	5+	2	1	4+	1	5	1	7	19+
Middle lake.....	4+	2	1	5+	1	10	0	11	23+

SUMMARY OF BOTTOM SPECIES LISTS, MIDDLE PEORIA LAKE, SUMMER OF 1922

2. COMPARISON WITH 1920. NUMBER OF KINDS TAKEN

	Channel		Combined wide-water zones		All zones	
	1922	1920	1922	1920	1922	1920
Worms.....	4	3	3	3	4	3+
Leeches.....	0	0	2	1	2	1
Pollutional midges....	1	1	1	3	1	3
Other midges.....	1	1	5+	2+	5+	2+
Very tolerant snails...	1	0	1	1	1	1
Less tolerant snails...	4	0	9	1	10	1
Other snails.....	0	0	0	0	0	0
Less tolerant associated group.....	0	0	0	0	0	0
Total.....	11	5	21+	11+	23+	11+

SUMMARY OF BOTTOM SPECIES LISTS, MIDDLE PEORIA LAKE, SUMMER OF 1922

3. CHANGES DOWN STREAM. NUMBER OF KINDS TAKEN

	Worms	Leeches	Pollutional midges*	Other midges*	Very tolerant snails	Less tolerant snails	Other snails	All snails	Total
Mid-channel									
Mossville Mile 154.8	1	0	0	1	1	0	0	1	3
Foot of Horshor Island Mile 157.3	4+	0	1	0	1	3	0	4	9+
Al Fresco Park Mile 159.3	0	0	1	0	1	1	0	2	3
Combined Widewater zones									
Mossville Mile 154.8	2	1	0	1	1	3	0	4	8
Foot of Horshor Island Mile 157.3	3+	0	1	3	1	6	0	7	14+
Al Fresco Park Mile 159.3	0	1	1	4+	1	5	0	6	12+

* Larvae.

SUMMARY OF BOTTOM SPECIES LISTS, MIDDLE PEORIA LAKE, SUMMER 1922
4. CHANGES FROM MID-CHANNEL OUTWARD INTO WIDE WATERS
NUMBERS OF KINDS TAKEN

	Mid-channel	First 1500 ft.	1800-4500 ft.	All extra-channel
Mossville				
Mile 154.8				
Worms	1	2	2	2
Leeches	0	1	0	1
Pollutional midges*	0	0	0	0
Other midges*	1	0	1	1
Very tolerant snails	1	1	1	1
Less tolerant snails 1st and 2d groups combined	0	3	3	3
Other snails	0	0	0	0
Total	3	7	7	8
Foot of Horshor Island				
Mile 157.3				
Worms	4+	3+	2	4+
Leeches	0	0	0	0
Pollutional midges	1	1	1	1
Other midges	0	3+	2	3+
Very tolerant snails	1	1	1	1
Less tolerant snails 1st and 2d groups combined	3	5	2	6
Other snails	0	0	0	0
Total	9+	13+	8+	15+
Al Fresco Park				
Mile 159.3				
Worms	0	0	0	0
Leeches	0	1	0	1
Pollutional midges	1	1	1	1
Other midges	0	2	3	4
Very tolerant snails	1	1	1	1
Less tolerant snails 1st and 2d groups combined	1	4	4	5
Other snails	0	0	0	0
Total	3	9	9+	12+

* Larvae.

WORMS

Except for the irregular continuation of the decline in numbers already noticed in the upper lake, and their failure to appear at all in the collections opposite Al Fresco Park, the tubificid worms presented little of interest in the middle lake in the summer of 1922. Substantially the same list of species was found as in the upper lake, though in all cases in much smaller average numbers and with more scattered distribution. The various species of Limnodrilus, rather than *Tubifex tubifex*, led as in the upper lake in frequency; while the local form of *Tubifex tubifex* was found at only a single station in the channel opposite the foot of Horshor Island.

The absence of small annelids from the Al Fresco Park hauls is not to be taken as conclusive evidence that they were not there although noticeably improved conditions on the bottom were visible also in other respects. It is more probable that if we had increased the fraction of the Petersen dredge sample sieved for them at least small numbers of some of the species would have been found.

LEECHES

Leeches were represented in the 1922 middle lake hauls by two species, the same number as in the upper lake. One of them, *Helobdella nephcloidea* (Graf), occurred in the wide waters of the Mossville cross-section, and was also recorded in 1922 from the wide waters of the upper lake above Spring Bay. The second, *Helobdella stagnalis* (Linnaeus), although it occurred in the middle lake in 1922 only in the lower or Al Fresco Park cross-section, was one of the two commonest leeches at the more heavily polluted stations of the Coweeset just below Brockton, Massachusetts, in 1914 (Weston and Turner 1917). *Erpobdella punctata* (Leidy), which was taken in the channel at Chillicothe in 1922 and was the other common leech at the upper Coweeset hauls in 1914, was not found in middle Peoria Lake collections in the season of 1922.

MIDGE LARVAE

While a total of six species of immature midges were recorded from the middle lake in the summer of 1922, compared with five in 1920, the more distinctly tolerant or pollutional kinds were reduced in 1922 in the middle as in the upper lake from three to only one. The

one, a variety of *Chironomus plumosus* Linnaeus or a species very closely allied to it, occurred at fourteen of the thirty stations covered in the middle lake in 1922. It was, however, absent in all collections in the upper or Mossville cross-section, and reached its highest average numbers in the cross-section opposite the foot of Horshor Island, or through almost the exact center of the lake.

Chironomids of more uncertain status were represented in the middle lake hauls of the summer of 1922 by not less than five species. Of these, *Chironomus digitatus* Malloch has not before to our knowledge been recorded from any but ordinarily clean bottom. The others included a species very near *C. maturus* Johannsen, which was taken in foul muds in the lower lake both in 1922 and 1920; and an uncertain number of unidentified kinds of Chironomus, Tanypus, and Procladius.

UNUSUALLY TOLERANT SNAILS

While the snails were easily led in abundance in the middle lake as in the upper in the summer of 1922 by the unusually tolerant *Musculium transversum* Say, the figures for that species were small compared with the numbers reached by it the same season in the upper lake. The largest all-station average of a single cross-section amounted only to a little over 2,500 per square yard, or about a fifteenth of the average of the nine 1922 stations in the best upper lake cross-section (opposite Rome); and the smallest to only one sixtieth of the nine-station average of the same cross-section. Though so small compared with upper lake figures, those of the middle lake represented valuation equivalents between 200 and nearly 500 pounds per acre and made up the largest single item by weight of the whole 1922 middle lake bottom fauna.

LESS TOLERANT SNAILS

Ten other kinds of snails, all presumed to be of lesser tolerance than *Musculium transversum* but more tolerant than several species of the old fauna that have not appeared in any part of the open waters of Peoria Lake since before 1920, and all but one belonging to the Sphaeriidae, were taken in the middle lake in the summer of 1922. Numbers were small in all cases, and all recorded occurrences were at stations well away from the channel and toward the east or west margins of the lake, or, if widely distributed, in its lower portion. This number of species is just double that of the less tolerant group of snails listed from the upper lake in 1922, and compares with a

single snail species besides *M. transversum* from the middle lake in 1920. Five of these species were the same as the five already listed from the upper lake on a preceding page. This group, distinguished from the other five by the fact of occurrence above the middle lake in 1922, included one sphaeriid of the genus Musculium, one viviparid, and three species of the sphaeriid genus Pisidium, sometimes called pea-clams in the literature. The five new entrants in the 1922 lists, embracing snails whose farthest northward occurrence in 1922 was the middle lake, included three additional species of Pisidium not taken in the upper lake in 1922 or in any part of either the upper, middle, or lower lakes in 1920, and two species of Sphaerium, also not taken in the upper lake in the summer of 1922, but one of them recorded from the lower lake in 1920.

The distinction between these two groups of the less tolerant snails and their relation, in the matter of tolerance to pollution, to the other recent snail groups and to the Viviparidae and Amnicolidae apparently exterminated between 1915 and 1920 is shown in the table that follows.

Commoner Snails of Peoria Lake, 1913–1922

	Full list of species, 1922													Commoner species of 1913–1915 that have not since appeared in collections					
	Unusually tolerant species	Less tolerant, first group, taken in both upper and middle lakes in 1922					Less tolerant, second group, not taken above the middle lake in 1922					Current-loving species, taken only in swifter current in lower lake							
Figures indicate No. of collections in which each species occurred	Musculium transversum	Musculium truncatum	Pisidium compressum	P. pauperculum, var. crystalense	Pisidium sp. near complanatum	Campeloma subsolidum	Pisidium pauperculum	Pisidium species	Pisidium species	Sphaerium stamineum	S. striatinum, var. lilycashense	Pleurocera elevatum var. lewisii	Goniobasis livescens	Vivipara contectoides	Vivipara subpurpurea	Lioplax subcarinatus	Amnicola emarginata	Amnicola limosa	Somatogyrus subglobosus
Upper lake 23 colls.	23	7	6	2	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—
Middle lake 30 colls.	23	1	16	1	2	9	4	1	1	5	3	—	—	—	—	—	—	—	—
Lower lake* 18 colls.	8	—	4	1	—	3	—	—	—	2	—	—	2	—	—	—	—	—	—

* Includes Peoria Narrows and P. P. U. Bridge.

Lower Peoria Lake and Illinois River, Peoria Narrows to Peoria and Pekin Union Railway Bridge (Mile 161.0—166.4 below Lake Michigan)

Hydrography

In or adjacent to lower Peoria Lake in the summer of 1922 bottom dredgings were made at eighteen stations in four cross-sections. Collections began at the foot of Peoria Narrows, which is just above the head of the lower lake wide-waters and is not far from a quarter of a mile wide at recent low water, and ended at the P. P. U. Railway Bridge across the Illinois River about a mile and a half below the foot, which lies slightly below the center of the city of Peoria. The two intermediate cross-sections through the lake proper were opposite Workhouse Point, a little less than two miles below the Narrows; and opposite the foot of Fulton Street, a mile and a half below the first open lake cross-section and less than a mile above the lake's foot. The full width of the lake was somewhat more than a mile at the Point and considerably less than a mile opposite Fulton Street, though appreciably wider in between, during the summer months of 1922.

Though a good deal smaller, as measured either by length or width, than the upper or the middle lake, being only about three and a half miles long as compared with nearly six for the middle lake and more than six for the upper, the lower lake with its immediately contiguous areas, as here regarded, presents a visibly greater variety of habitats than either of the others, and differs from them also in several other main features. Its entire lower half is narrowed to an effectual width of much less than a mile by a long submerged but formerly wooded island on the east side, whose outside edge is only about three quarters of a mile from the Peoria water-front opposite. The effect of this is that throughout the central and lower portion of the lower lake, where our main cross-sections were made both in 1922 and 1920, the great body of moving water passes through a relatively narrow and deep prism, with depths between twelve and fourteen feet prevailing over a total width of nearly half a mile, and with, as a consequence, a greater average current everywhere in the open portion than in corresponding sections of the upper or middle lake.

The west littoral of the lower lake receives the discharge from most of the main sewers and industrial drains of a city of nearly 100,000 people, but although this is true, during the summer season

the prevailing direction of the winds and the current together seem to keep this soiling material largely confined between the channel and the bank as far as the foot of the lake, where the first extensive mixing of lake water and local sewage appears ordinarily to take place. The general orientation of both the channel and the adjacent widewaters is such, however, that in the fall of the year and occasionally during the summer season, north or slightly north of west winds may cause much more mixing of the sewage with the lake water eastward.

Soft mud bottom was met at all stations in the lower lake proper. Harder mud and shell bottom was found in midstream at the Narrows, and nearly clean sand at the P. P. U. Bridge, where the current is four to five times that in the channel opposite Workhouse Point and six to seven times midstream current measured near the middle of the middle lake in the summer of 1920.

Since the first cross-section in the lake proper was above most of the main sewers, and we confined our collecting below that place to the channel and the open lake eastward of it, no especial foul odors were recorded at any of the lower lake stations in the 1922 summer season. Bubbling was observed in abundance at most stations opposite Workhouse Point, as also at the farthest eastward stations opposite Fulton Street, but in the middle of the main channel and at most open lake stations opposite Fulton Street neither bubbles nor unusually bad odors were noted.

Little restoration of the killed-out vegetation in the southeastern part of the lower lake had occurred in the two years since 1920, the thin Potamogeton patch on the east side facing Liberty Street looking about as it did in the summer of 1920. Traces of Vallisneria were brought up by the dredge at the station nearest the west shore off Workhouse Point, but no vegetation was encountered in any other hauls.

Dissolved Oxygen

Both in the summer of 1922 and of 1920 the supply of dissolved oxygen a foot from the bottom in mid-channel at the foot of Peoria Narrows ranged between 50 and 75 per cent of saturation, numerous samples taken between the middle of July and the middle of September 1920 averaging 5.1 to 6.4 parts per million, and eight samples taken in September 1922 averaging 4.8, with a range from 3.6 to 6.2 p. p. m. Soon after the middle of July 1920 almost as high or higher

figures than at the Narrows continued in mid-channel to and below the foot of the lake. But in the first week of August 1920 the bottom oxygen dropped sharply below the Narrows from a high figure for the season of 6.4 p. p. m. to only 3.4 a mile below, and to 2.0 p. p. m. opposite Green Street, which is a mile above the foot of the lake. On the same dates a rapid rise in bottom oxygen figures from the channel eastward into the wide waters was noted a mile below the Narrows; but opposite Green Street samples showed between three and two parts per million for two fifths of a mile eastward into the open lake.

Bottom Dissolved Oxygen, Mid-Channel, Lower Peoria Lake, 1920–1922
Midsummer Figures, Parts per Million—Averages

Peoria gage ft.	Peoria Narrows Mile 161.0*		Strawboard works Mile 161.7		Green street Mile 163.9		Liberty street Mile 164.2		
	1922	1920	1922	1920	1922	1920	1922	1920	Dates
10.4	..	5.5	..	6.2	..	..	..	4.7	July 17–22
9.8	..	6.4	..	3.4	..	2.0	..	3.1	August 6
9.5	..	6.1	..	..	..	..	..	..	Aug. 24–28
9.5	..	5.1	..	..	..	..	..	..	Sept. 13
9.6	4.8	..	..	..	..	..	..	..	Sept. 1

* Miles below Lake Michigan.

Small Bottom Animals

In the two lower lake cross-sections of 1922 and those in the river immediately adjoining, there were taken in all 28 species of small bottom invertebrates, or 5 more than the total taken in the middle lake the same season and 9 more than the total from the upper. Worms, leeches, midges, and *Musculium transversum* accounted for 17 of the total of 28 species; the remaining 11 being distributed between the less tolerant snails, in the lower lake reduced to four kinds; and a miscellaneous group of seven species of Bryozoa, sponges, snails, insects, and Crustacea, all of which had their first occurrence both in 1922 and 1920 in or below Peoria Narrows.

The two main features distinguishing the 1922 lower lake fauna from that of the middle lake (Table on p. 369) were the reduction in

number from ten kinds to only four kinds of the less tolerant snails, at the same time with the first appearance below Chillicothe of seven miscellaneous small bottom animals of presumably lesser tolerance than any of the groups taken either in 1922 or 1920 in the middle or the upper lake.

The comparison of 1922 collections from the lower lake with those of 1920 (Table on p. 370) showed less dicerence than appeared either in the upper or middle lake, and suggests that this section of the lake, with its greater average current, and its long history of local pollution, has at the present time a small bottom population somewhat better adjusted to the prevailing conditions than has been the case recently in the portions of the lake above Peoria Narrows.

As we would expect from the heavy local pollution adjacent to the channel on the east side, there was a greater increase in variety in the species lists from the channel outward into the wide waters (from 2 kinds to 12 kinds in the Workhouse Point cross-section; and from 8 kinds to 17 kinds in the Fulton Street section) than either in the middle or the upper lake (Table on p. 372). This was despite the fact that the corrective action of the more rapid current in and also well outside of the channel here permits the existence of several current-loving forms that have not been found since 1915 above the lower lake; and that wind- or wave-carried local pollution has apparently reduced the number of kinds of the less tolerant Sphaeriidae in the wide waters.

The changes in the lower lake species lists down stream (Table on p. 371) were irregular and of no special significance.

Summary of Bottom Species Lists

Lower Peoria Lake, Summer of 1922

1. comparison with middle lake. number of kinds taken

	Worms	Leeches	Pollutional midges	Other midges	Very tolerant snails	Less tolerant snails	Less tolerant associated group						Combined less toler. associated group	Grand total
							Mussels	Snails	Bryozoa	Sponges	Crustacea	Other insects		
Mid-channel														
Middle lake	4+	0	1	1	1	4	0	0	0	0	0	0	0	11+
Lower lake	3+	3	0	1	1	2	1	0	1	0	1	0	3	13+
Extra-channel or Wide waters														
Middlo lake	3+	2	1	5+	1	9	0	0	0	0	0	0	0	21+
Lower lake	4+	4	3	5+	1	4	0	1	1	1	1	2	6	27+
All zones														
Middle lake	4+	2	1	5+	1	10	0	0	0	0	0	0	0	23+
Lower lake	4+	4	3	5+	1	4	1	1	1	1	1	2	7	28+

SUMMARY OF BOTTOM SPECIES LISTS, LOWER PEORIA LAKE, SUMMER OF 1922
2. COMPARISON WITH 1920. NUMBER OF KINDS TAKEN

	Channel		Combined wide-water zones		All zones	
	1922	1920	1922	1920	1922	1920
Worms	3	3	4+	2	4+	3
Leeches	3	0	4	2	4	2
Pollutional midges	0	4	3	4	3	4
Other midges	1	3+	5+	3+	5+	4+
Very tolerant snails	1	1	1	1	1	1
Less tolerant snails	2	2	4	3	4	3
Other snails	0	1	1	2	1	2
Less tolerant assoc. group	3	0	5	5	6	5
Total	13	14+	27+	22+	28+	24+

SUMMARY OF BOTTOM SPECIES LISTS, LOWER PEORIA LAKE, SUMMER 1922

3. CHANGES DOWN STREAM. NUMBER OF KINDS TAKEN

	Worms	Leeches	Pollutional midges*	Other midges*	Very tolerant snails	Less tolerant snails	Less tolerant associated group	Total
Mid-channel								
Workhouse Point Mile 161.7	1	0	0	0	0	1	0	2
Fulton Street Mile 164.2	2	3	0	0	0	0	3	8
First Wide-water zone								
Workhouse Point Mile 161.7	1	0	2	3+	1	3	0	10+
Fulton Street Mile 164.2	2	2	1	2+	1	0	3	11+
Second Wide-water zone								
Workhouse Point Mile 161.7	1	0	0	3	0	0	0	4
Fulton Street Mile 164.2	2	3	2	3	0	0	0	10

* Larvae.

SUMMARY OF BOTTOM SPECIES LISTS, LOWER PEORIA LAKE, SUMMER 1922

4. CHANGES FROM MID-CHANNEL OUTWARD INTO WIDE WATERS.

NUMBER OF KINDS TAKEN

	Mid-channel	First 1500 ft.	1800–4500 ft.	All extra-channel
Workhouse Point Mile 161.7				
Worms	1	1	1	2
Leeches	0	0	0	0
Pollutional midges*	0	2	0	2
Other midges*	0	3+	3	4+
Very tolerant snails	0	1	0	1
Less tolerant snails	1	3	0	3
Less tolerant associated group	0	0	0	0
Total	2	10	4	12
Fulton Street Mile 164.2				
Worms	2	2	2	3
Leeches	3	2	3	3
Pollutional midges	0	1	2	2
Other midges	0	2	3	5
Very tolerant snails	0	1	0	1
Less tolerant snails	0	0	0	0
Less tolerant associated group	3	3	0	3
Total	8	11	10	17

* Larvae.

WORMS

Though tubificid worms occurred at eleven out of the total of eighteen stations in the lower lake in 1922, and included four species, one of which was *Tubifex tubifex*, their numbers were generally so small as to be of no especial consequence. The commoner kinds were species of Limnodrilus, as in the upper and middle lakes, and *T. tubifex* occurred only at a single station. The comparison with the middle

and upper lake figures and with the lower lake figures for 1920, which for unknown reasons averaged even less than those of 1922, is shown in the table on page 347 preceding.

LEECHES

Four species of leeches were taken in the lower lake in the summer of 1922, which was more than were found in either the middle or upper lake in 1922 or in the lower in 1920. These four species included *Erpobdella punctata* and *Helobdella stagnalis*, both of which have been recently listed from outside of Illinois in polluted bottom; *Helobdella nephcloidea*, which was taken in the upper lake above Spring Bay in 1922 where odors were bad and bubbles were abundant; and *Dina parva*, of which we have no local or outside records from foul bottom. *Erpobdella punctata* was found only in the mixture of local sewage and lake water at the P. P. U. Bridge, below the foot of the lake, that and the occurrence in mid-channel at Chillicothe being the only records obtained anywhere in the summer of 1922. With a single exception, occurrences of the other three species were limited to the Fulton Street cross-section, where leeches were especially common in the summer of 1922 both in channel and extra-channel collections.

MIDGE LARVAE

Though average abundance of midge larvae did not go as high in the lower lake as in the upper and middle lakes in the summer of 1922, both the total number of species identified and the number known to be more than usually tolerant was greater. The three pollutional forms included the common one from the upper and middle lakes, *Chironomus plumosus*, var. as well as also typical *C. plumosus*, which was taken once opposite Fulton Street; and *C. maturus* Johannsen, which was taken at two hauls in the cross-section opposite Workhouse Point. In addition there were upwards of five or six kinds of Chironomidae of more or less doubtful position, two of them apparently less tolerant than the three above mentioned. These two were *Chironomus digitatus* Malloch, which was also taken in the middle cross-section in the middle lake in 1922, and which occurred in clean muds in Lake Mendota, studied by Muttkowski in 1918; and *Tanypus monilis* Linnaeus, found once in the Fulton Street cross-section, well to the eastward, and except for its occurrence not far from mid-channel opposite Rome in August 1922, not known to us to favor bad bottom.

UNUSUALLY TOLERANT SNAILS

Musculium transversum, the leader of the water-breathing snails in enduring low oxygen and other effects of pollution in upper Peoria Lake, continued in the lower lake to still lower levels the decline begun between Rome and Spring Bay in the summer of 1922 and showed no increase worth mentioning over 1920 abundance (Table, p. 347). The lower lake has recently had ordinarily a sufficient supply of oxygen at levels well above the bottom for the coarser commercial fishes, and is subject to little or no seining as a consequence of the almost entire absence of good landing places. Perhaps the little-restricted fish foraging may account in part for the small numbers recently found not only of this species but also of others, including mud worms and midge larvae, in the lower lake. A second circumstance that may have bearing on the recent scarcity of this snail in lower Peoria Lake is that in the period between 1913 and 1915, when bottom conditions were more nearly normal in this part of the Illinois River, the upper lake was, as in 1922, its principal stronghold. In those years the lower lake snail fauna was largely made up of species of Viviparidae and Pleuroceridae, though *M. transversum* was also taken in some hauls in moderate or small numbers.

LESS TOLERANT SNAILS

The less tolerant snails from lower lake hauls in the summer of 1922 were of only four kinds, as against ten kinds from the middle lake the same season, but no more than three from the lower lake in the summer of 1920. Three of these, *Pisidium compressum*, *P. pauperculum*, var. *crystalense*, and *Campeloma subsolidum* were present both in upper and middle lake collections in 1922, while the fourth, *Sphaerium stamineum*, had its farthest northward 1922 occurrence in the middle lake. All four of them were found in the Peoria Narrows hauls, and three of them, or all excepting the variety of *P. pauperculum*, were taken on the west beach side in the Workhouse Point cross-section. Only the two of them least reputed previously for sensitiveness, *P. compressum* and *Campeloma subsolidum*, were found in the channel or eastward of it below Peoria Narrows; and none of them was taken at stations more than 500 feet to the eastward of the mid-channel line or south of the upper and cleaner third of the lower lake. Numbers per collection or per unit of bottom area were small and relatively unimportant in all cases.

While the comparison with variety and abundance in the same group in the middle lake in 1922 was distinctly unfavorable, that with the lower lake in the summer two years before, particularly in the case of the Pisidia, was less so, and suggests moderate improvement within the limited area of best conditions in the two years. Besides taking in 1922 one more species than we did in 1920, one or the other of the two species of that genus was found at five in all of the total of eighteen stations visited in 1922; whereas in the summer of 1920 only a single species of the genus (*P. compressum*) was taken, and it was confined to a single station in the Peoria Narrows cross-section.

No explanation of the reduction in variety in this group between the middle and lower lakes recently is furnished by the comparison with our 1913 and 1915 data. In those years we took as many kinds and as great average numbers of Pisidium in the lower as in the middle lake, and more kinds of Sphaerium in the lower lake than in either the middle or upper; and found as well species of both genera at the wide-water stations in the lower half of the lower lake, where they were not taken at all either in 1922 or 1920. In view of these facts, though based in some cases on few collections, it is difficult to avoid the conclusion that local pollution has been injurious to this group in lower Peoria Lake recently.

LESS TOLERANT ASSOCIATED GROUP

A group of seven miscellaneous species having at first sight no characteristics in common except the fact that none of them was taken above the lower lake either in 1922 or 1920 completes the list of lower lake bottom animals taken by us in the season of 1922. Of this group three appeared in 1922 that were not found in collections in 1920, and three in1920 that were absent in 1922, giving us seven representatives of the lot in each summer's collections. The list included, as taken either in 1922 or 1920, the following species, embracing insects other than Chironomidae; young mussels; pleurocerid snails; sponges; bryozoans; and Crustacea:

1922 only.

Corixa species.—Peoria Narrows, in strong current.

Leptocerid (caddis) larva.—Peoria Narrows, in strong current.

Anodonta imbecillis Say.—Mid-channel, opposite Fulton Street, Peoria, in current.

1922 and 1920.

Goniobasis livescens Menke.—P. P. U. Bridge, in strong current.

Sponge species.—Peoria Narrows, in strong current, 1920; opposite Fulton Street, Peoria, 1922, 600 feet east of mid-channel, in current greater than that outside of channel in middle or upper lake.

Hyalella knickerbockeri (Bate).—In or near channel, several stations, both 1922 and 1920, in current; once in far wide-waters, 1920, near edge of smartweed bed.

Plumatella princeps var. *fruticosa* Kraepelin.—Peoria Narrows and P. P. U. Bridge in strong curent, and just outside of channel opposite Liberty Street, 1920; mid-channel and 600 feet east, opposite Fulton Street, 1922.

1920 only.

Quadrula plicata Say, *young.*—Peoria Narrows only, in strong current.

Pleurocera elevatum var. *lewisii* Lea.—Peoria Narrows and P. P. U. Bridge, in strong current.

Hydropsyche species.—Peoria Narrows and P. P. U. Bridge, a strong current.

Evidently an important consideration about this otherwise motley group is that all but one of them were confined both in 1922 and 1920 either to the swifter water at Peoria Narrows or the P. P. U. Railway Bridge, slightly above and below the lake proper; or were confined if taken in open lake cross-sections to the first 600 feet eastward of the mid-channel line, where also the current is appreciably greater than in corresponding locations in the upper and middle lakes. Besides this, the little fresh-water shrimp, Hyalella, which was found once in the east wide-waters near the edge of a smartweed bed, as also the species of Corixa, are really not bottom forms in the strict sense, being both free swimmers to a considerable extent and, in the case of the corixids, coming to the surface occasionally for air.

In favor, on the other hand, of a higher degree of tolerance in all members of this group than that possessed by the recently exterminated mussels, snails, and other bottom species of all three lakes is the fact that they have survived in recent years where so many other species have perished. Such a supposition receives support from our records from the polluted waters of the upper Illinois River obtained in the years 1911 and 1912 (Forbes and Richardson, 1913). At that time the identical species in the case of five of the 1920-1922 list

(*Quadrula plicata, Pleurocera elevatum,* var. *lewisii, Goniobasis livescens, Hyalella knickerbockeri, Plumatella princeps,* var. *fruticosa**, and species closely allied in three other cases) were taken at stations in the polluted sections of the upper Illinois where surface dissolved oxygen ranged between 1.4 and 2.7 parts per million, and where the great bulk of the normal bottom population had already been destroyed. One of the snails, also, *Pleurocera elevatum,* was one of the only two snails taken by Jewell in the acid waters of the Big Muddy River in southern Illinois in 1919 (Jewell, 1922).

Comparison of the Recent Small Invertebrate Bottom and Weed Fauna of Peoria Lake with that of 1913-1915.

GENERAL COMPARISON

Pre-1920 records of the bottom fauna, including the mussels, from the section of the Illinois River covered in the present paper were made by us at Chillicothe in the autumn of 1911 and the summer of 1912; and collections of the smaller bottom species only were made in a series of cross-sections between Chillicothe and the foot of lower Peoria Lake in the summers of 1913 and 1914 (Forbes and Richardson, 1913; Richardson, 1921). In addition to this earlier work of our own, the United States Bureau of Fisheries made a survey of the mussel resources of Peoria Lake, in connection with one of the entire Illinois River, during the years 1911 and 1912 (Danglade, 1914).

In making comparisons with these earlier records it is not possible always to be as exact as one could wish, because determinations were not carried out in as much detail in the earlier period as has been the case with more recent collections. For this reason, and also because of the necessarily very small fraction of the total bottom area covered by dredge hauls, neither our lists of the earlier nor the more recent bottom species of the lake are assumed to be as complete as they might have been with heavier programs of dredgings. Previous experience in dredging in the Illinois River and in other waters in Illinois has shown, however, that the number of bottom species that may be expected in single hauls is never very large, apparently as a consequence of a general rule that one or two or at the best a few species tend to predominate, usually with great distinctness, in a given range.

* At that time incorrectly identified.

In view of this fact, added to the generally rational and therefore explicable nature of the results, it seems not unreasonable to suppose that in the total of one hundred and fifty-two hauls in Peoria Lake between 1913 and 1922 (46 in 1913-1915, as a part of a total of 387 for the entire river; and 106 in 1920-1922) we probably obtained in both periods examples of at least most of the commoner species insofar as these are present during the summer season.

As all subdivisions of Peoria Lake were well supplied with coarse aquatic vegetation over a large portion of their area up to 1915, in order to obtain fair comparison with our 1920 and 1922 records, which were made after the old weed-beds had been destroyed, it has been necessary to exclude a good many of the less distinctly bottom forms of the pre-1920 lists. The exclusions cover a sizable assortment of free-swimming, weed-dwelling, and air-breathing species, not belonging in a proper sense to the bottom, which formerly entered in considerable numbers into bottom collections made in the shallower areas where there was more or less vegetation. Most of the excluded forms, it may be noted, have also disappeared since nine or ten years ago, along with the vegetation, over practically the entire area of Peoria Lake.

Having regard at present, then, only to the more exclusively bottom-species, both in the case of the earlier and the more recent records, we find that we took as nearly as may be calculated a total of 22 or more kinds in the upper lake in 1913-1915, of which at least 8 have since disappeared; 26 or more species in the middle lake, of which 12 have since dropped out; 43 or more species from the lower lake, of which 19 have disappeared; and from the bottom muds of all three lakes combined no less than 61 species, of which at least 23 are missing in recent collections, although recent hauls have been more than double the number of the earlier ones.

In evident contrast with the reduction of representation in the lists of more sensitive species, the tabulation (p. 383) indicates good-sized additions in all three lakes to the totals of more tolerant kinds since 1915. While a part of these apparent additions in the pollutional or tolerant column have undoubtedly taken place, especially in the Tubificidae and Chironomidae, it is probable that the more complete identification of the more recent material accounts for a part of them. It is, however, quite certain that there has been large increase in *numerical abundance* since 1915 of some of the more pollutional forms.

Of interest also is the apparent indication of a larger variety of bottom species in the lower lake than in the upper or middle lake before 1920, and a correspondingly greater loss of kinds in the lower lake species lists between 1915 and 1922. It is quite posisble that the upper and middle lakes may have been injured to a minor extent by sanitary canal pollution before 1915 and in advance of serious injury to the lower lake from the same or local causes. But this can not now be proven, and the continued existence of a healthy and varied mussel fauna (see page 385) between Peoria Narrows and Chillicothe as late as 1915, is against assuming that there had by that time been any very serious change, at least in the channel, in or quite near to which the mussel beds have always been located.

The greater variety of habitats furnished by the lower lake and its connections, already mentioned, may account for a good deal of the difference shown; and some of it may result from the greater number of lower lake bottom collections in the earlier period, including fuller special studies on the Chironomidae there than elsewhere, in the course of short visits by Malloch to Peoria in 1913 and 1911 (Malloch, 1915). But as special evidence suggesting earlier injury, particularly to the wide waters of both the upper and middle lakes, where sedimentation after the spring floods is particularly heavy, may be mentioned the noticeable absence or extreme rarity in the 1913-1915 collections of several groups of insects; such as the commoner aquatic Coleoptera; varions Odonata; and from the upper lake in particular, the common May-fly nymph of the genus Hexagenia, as well as other Ephemeridae. The limited amount of collecting in the vegetation zones before 1920 also showed much poorer results than were easily to be obtained at that time with the same amount of effort in the lakes possessing similar aquatic vegetation near Havana.

COMMONER SMALL BOTTOM ANIMALS THAT HAVE DISAPPEARED SINCE 1915

While reviewing the missing members of the old fauna, it will be recalled that the species obtained in Peoria Lake in 1922 and 1920 have already been arranged, in this and earlier papers in a descending order of tolerance without so far disclosing any that seem to have a clear title as clean bottom species. The subjoined lists may be supposed, on the contrary, to include a considerable number of kinds that fall fairly under that designation, so far as they are applicable at all

to the inhabitants of the bottom muds of our larger streams under present-day conditions.

PLANARIANS

Various unidentified species of planarians, attached to shells, bits of bark, leaves, etc., were not uncommon in Peoria Lake bottom hauls in years previous to 1920. These did not appear in any of our 1920 or 1922 bottom dredgings, or on any of a quite large number of dead mussel shells examined in the summer of 1920, although a few were noted in sediment samples caught in the relatively fast current at Peoria Narrows in August 1922 by a machine set about eighteen inches above the bottom.

BRYOZOA

While only a single species of bryozoan, *Plumatella princeps*, var. *fruticosa*, was found in Peoria Lake bottom collections in 1920 or 1922, two other species, *Paludicella ehrenbergii* Van Beneden and *Urnatella gracilis* Leidy, were common on live or dead shells in the deeper water everywhere below Chillicothe up to the summer of 1915. On many of the mussel shells examined in the summer of 1920 there were marks apparently left by the attachment of former colonies of these species.

SNAILS

The list of snails missing since 1915 includes two conspicuous cases of large and abundant kinds which were formerly so common in collections nearly everywhere in the lake that they gave their character largely to the majority of hauls made between Chillicothe and Peoria in 1913 and 1915. These were *Vivipara contectoides* W. G. Binney and *Lioplax subcarinatus* Say.

Species of snails that occurred in smaller numbers, but which seem to be of scarcely less importance as index organisms, include a second large species of Vivipara, *V. subpurpurea* Say, which was taken several times in the earlier collections, only in the middle and lower lakes, and principally in the lower. Notable also, up to 1915, was the little *Amnicola emarginata* Küster, which, although not widely distributed, occurred before 1920 in fairly large numbers over limited areas in both the middle and lower lake.

Two species of Valvata, *V. tricarinata* Say and *V. bicarinata* Lea, were formerly not far from equally common in the wide waters of the first two of the lakes. The first one was taken in a single haul

also in the summer of 1922 within less than a hundred feet of the bank at the lower end of the upper lake, but the other appeared in none of our collections from anywhere between Chillicothe and Peoria in 1920 and 1922. These two species, while evidently partial to shallow weedy waters, also habitually spread far from shore in our local bottomland lakes; occurring in lakes near Havana in 1914 and 1915 in six to nine feet of water on plain mud bottom, and in the four to seven foot depth zone in upper Peoria Lake before 1920. A species of *Amnicola* near *A. limosa* Say, partaking of the habit of the Valvatas just described, of becoming bottom or weed species at will, was taken in the shallower areas of the upper and middle lakes before 1920.

Other bottom-dwelling snails taken in Peoria Lake in 1913 and 1915 collections but since then not seen, included one or more species of the little limpet-like Ancylus, which was formerly common on shells and sticks in the deeper water near the channel; a species of Pleurocera, *P. subulare* Lea, which occurred less commonly than its more abundant congener, *P. elevatum lewisii,* which latter species still persists in small numbers in the more rapid current in the lower lake; and the comparatively large amnicolid *Somatogyrus subglobosus* Say, which was taken in small numbers only in the upper lake.

INSECTS

Among larvae and nymphs of insects which have recently disappeared entirely from open-water dredgings in all three lakes the most important are members of the family Ephemeridae, or May-flies; of several families of Odonata, or dragon-flies; and of the commonest of the midge families locally, the Chironomidae.

In 1913 and 1915 the common May-fly, *Hexagenia variabilis* Eaton, was occasional in collections from both the middle and lower lakes, but has not since been taken in the Illinois River above Havana. Specimens of two other genera of May-flies that have since failed to appear, Callibaetis and Caenis, were also taken several times in the course of the dredging before 1920 in the two lower lakes.

The principal Chironomidae that have disappeared include *Chironomus tentans* Fabricius, formerly one of the most generally distributed and abundant, and because of its large size most conspicuous of the midge larvae of Peoria Lake and other middle Illinois River situations during the summer season. Other larval midges definitely missing recently, include *Chironomus nigricans* Johannsen; one or more

species of the genus Cricotopus; and a species of the genus Orthocladius.

Several unidentified species of at least three families of dragonflies, whose nymphs have no green or other bright color*, are for the present admitted to the list of bottom forms that have disappeared from Peoria Lake since eight or ten years ago although some members of this group have recently been found to be unusually tolerant. Stickney (1922) found *Libellula pulchella* Drury very tolerant to conditions of low oxygen in recent experiments at Urbana; and Baker (1922) took the same species in the comparatively foul muds of the Big Vermilion at St. Joseph, where all the mussels had been killed. The writer took *Chromagrion conditum* Hagen and *Platythemis lydia* Drury in the Kishwaukee River below De Kalb in February 1922 in water polluted by acid wastes from steel mills to such an extent that most of the normal bottom fauna had been driven out or destroyed. The disappearance of nymphs of this group recently in the Peoria district may have been more in the nature of an indirect effect of the destruction of the vegetation, which served as headquarters for the adults, than evidence in all cases of unusual sensitiveness.

* Some green nymphs of the family Agrionidae have been excluded, as weed species, from the present comparison.

NUMBER OF SPECIES OF SMALL BOTTOM ANIMALS TAKEN IN PEORIA LAKE, 1913-1915 TO 1920-1922. ALL ZONES COMBINED; ACCIDENTAL WEED AND SURFACE FORMS EXCLUDED; NO DUPLICATIONS

	No. of collections	Species taken both in 1922–1920 and 1913–1915, or added, as unusually tolerant, since the earlier period			Total
		Group I Variously pollutional or tolerant worms, leeches, midge larvae, and snails	Group II Less tolerant associated group, as recognized in preceding pages	Group III Cleaner water group of 1913–1915, missing in all 1922–1920 collections.	
Upper lake					
1913–1915	17	9	5	8	22
1920	8	11	0	0	11
1922	23	19	1*	0	19
Middle lake					
1913–1915	13	11	3	12	26
1920	8	11	0	0	11
1922	30	23	0	0	23
Lower lake					
1913–1915	16	16	8	19	43
1920	19	17	7	0	24
1922	18	21	7	0	28
Three lakes combined					
1913–1915	46	28	10	23	61
1920–1922	106	32	10	0	42

* *Valvata tricarinata.*

ALMOST COMPLETE EXTINCTION OF AN ABUNDANT AND VARIED MUSSEL FAUNA SINCE 1913-1915

If we add to the list of exterminated small bottom animals the most of the mussels found by Danglade (1914) in Peoria Lake in 1911 and 1912, and now apparently all gone but an inconsequential number of the hardier species in the lower lake, this addition raises the total of missing bottom species from more than twenty to more than sixty kinds. Danglade listed in all, from the three lakes, a total of forty-one species, of which twenty came from Chillicothe and thirty from the middle lake. The number of kinds taken in the lower lake was not stated. The location of the most important commercial mussel beds as described by Danglade as they existed in 1911-1912, included beds above and below Rome; a mile above Spring Bay and in Spring Bay Narrows; below Mossville; and between Al Fresco Park and Peoria Narrows. The continued existence in good condition of the Mossville and Al Fresco Park beds, and of a vast bed of bluepoints. (*Quadrula plicata*) more than two miles long in the lower lake, extending from the center of the channel eastward, was verified by sketch maps furnished us as late as November 1915 by Havana pearl-hunters who spent the summer and fall of 1915 in Peoria Lake.

In the summer of 1920 and of 1922 we took with the Petersen dredge a single specimen each in the lower lake of two species, but no trace of live mussels of any kind in the waters above Peoria Narrows. We also, in July 1920, went carefully over a small boatload of mussel shells taken with a dip-net the same day by a Peoria musseler who we thought must have a market for dead shells to justify the otherwise unproductive work that he was doing. The number of shells we found alive was extremely few and all belonged to one or the other of two species, the bluepoint, *Quadrula plicata;* or the warty-back, *Quadrula pustulosa.* It is significant that both of these species were taken by us farther north in the polluted upper Illinois River in the summer of 1912 than any other mussels with the exception of one species (*Symphynota complanata*); the first having been taken at Starved Rock in company with *S. complanata;* and the second at Spring Valley.

The list of Peoria Lake mussels as of 1911-1912 that follows is as presented by Danglade (1914), except for the starring of the two unusually tolerant species of Quadrula above noted, and of the apparently hardy dwarf species of Anodonta which we took with the Peter-

sen dredge in the lower lake in the summer of 1922. The fact that the full Danglade list for Peoria Lake, inclusive of Chillicothe, of forty-one species, was only eight short of his complete list of forty-nine kinds for the entire Illinois River in 1911-1912 does not suggest that the channel areas of Peoria Lake had been seriously injured up to that time, although the Chillicothe list had already apparently suffered some reduction.

MUSSELS REPORTED BY DANGLADE (1914) FROM PEORIA LAKE, INCLUSIVE OF CHILLICOTHE, IN 1911-1912, BUT WHICH APPEAR TO HAVE SINCE BEEN COMPLETELY EXTERMINATED ABOVE PEORIA NARROWS, AND TO HAVE NEARLY ALL PERISHED IN THE LOWER LAKE

The three species of which we obtained records in the lower lake in 1920 and 1922 are starred; those taken or seen by Danglade both at Chillicothe and in the lake below there, or at Chillicothe only, are marked with a C. No. 16 was taken at Chillicothe only.

1. Quadrula granifera. C
2. Quadrula ebena. C.
3. Quadrula plena
4. Quadrula solida
5. Quadrula coccinea
6. Quadrula obliqua
7. Quadrula trigona. C
8. Quadrula rubiginosa
*9. Quadrula pustulosa. C
10. Quadrula fragosa
11. Quadrula lachrymosa. C
12. Quadrula metanevra
13. Quadrula heros. C
14. Quadrula undulata. C
*15. Quadrula plicata. C
16. Unio crassidens. C
17. Unio gibbosus. C
18. Symphynota complanata
19. Arcidens confragosus. C
20. Anodonta corpulenta
21. Anodonta suborbiculata
*22. Anodonta imbecilis
23. Strophitus edentulus
24. Obliquaria reflexa. C
25. Tritigonia tuberculata
26. Plagiola donaciformis
27. Plagiola elegans
28. Plagiola securis. C
29. Obovaria ellipsis
30. Lampsilis laevissima
31. Lampsilis gracilis. C
32. Lampsilis alata
33. Lampsilis parva
34. Lampsilis recta, C
35. Lampsilis fallaciosa. C
36. Lampsilis anodontoides
37. Lampsilis higginsi. C
38. Lampsilis orbiculata. C
39. Lampsilis ligamentina. C
40. Lampsilis luteola. C
41. Lampsilis ventricosa

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Comparison of 1922 and 1920 Species Lists, Detail

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URBANA, ILLINOIS
October, 1925

All Zones

1922: 23 stations; 3 cross-sections	1920: 8 stations; 3 cross-sections
POLLUTIONAL, MORE TOLERANT, OR DOUBTFUL	
Worms (Tubificidae and Naididae)	
Limnodrilus hoffmeisteri Claparède Limnodrilus n. sp.* Tubifex tubifex (Müller)? or var. Limnodrilus sp. like L. claparedeianus Ratzel Naididae, unidentified	At least 3 or 4 spp., unidentified
5	3+
Leeches	
Erpobdella punctata (Leidy) Helobdella nepheloidea (Graf)	One unidentified species
2	1
Pollutional or more tolerant midge larvae	
Chironomus plumosus Linnaeus, var.	Chironomus plumosus Linnaeus Chironomus decorus Johannsen Tanypus dyari Coquillett
1	3
Midge larvae of doubtful status	
Chironomus sp. or spp. Procladius sp. or spp. Tanypus sp. or spp. Tanypus monilis Linnaeus	Chironomus sp. or spp. Tanypus sp. or spp.
4+	2+
Unusually tolerant snails	
Musculium transversum Say	Musculium transversum Say
1	1
LESS TOLERANT GROUP (SNAILS ONLY)	
Less tolerant snails, first group, (upper lake, farthest northward occurrence, 1922)	
Musculium truncatum Linsley Pisidium compressum Prime Pisidium pauperculum, var. crystalense Sterki Pisidium sp. near complanatum Sterki Campeloma subsolidum Anthony	Campeloma subsolidum Anthony
5	1
CLEANER WATER OR LESS TOLERANT ASSOCIATED GROUP	
Mussels 0	*Mussels* 0
Snails Valvata tricarinata (Say) 1	*Snails* 0
Bryozoa 0	*Bryozoa* 0
Sponges 0	*Sponges* 0
Crustacea 0	*Crustacea* 0
Other insects than midges 0	*Other insects than midges* 0
Total 19+	Total 11+

* To be described by Professor Frank Smith.

Wide Waters

1922: 20 stations; 3 cross-sections	1920: 5 stations; 3 cross-sections
POLLUTIONAL, MORE TOLERANT, OR DOUBTFUL	
Worms (Tubificidae and Naididae)	
Limnodrilus hoffmeisteri Claparède Limnodrilus n. sp. Tubifex tubifex (Müller)? or var. Limnodrilus sp. like L. claparedeianus Ratzel Naididae, unidentified	At least 3 unidentified spp.
5+	3
Leeches	
Helobdella nepheloidea (Graf)	Unidentified sp.
1	1
Pollutional or more tolerant midge larvae	
Chironomus plumosus Linnaeus, var.	Chironomus plumosus Linnaeus Chironomus decorus Johannsen Tanypus dyari Coquillett
1	3
Midge larvae of doubtful status	
Chironomus sp. or spp. Procladius sp. or spp. Tanypus sp. or spp. Tanypus monilis Linnaeus	Chironomus sp. or spp. Tanypus sp. or spp.
4+	2+
Unusually tolerant snails	
Musculium transversum Say	Musculium transversum Say
1	1
LESS TOLERANT GROUP (SNAILS ONLY)	
Less tolerant snails, first group, (upper lake, farthest northward occurrence, 1922)	
Musculium truncatum Linsley Pisidium compressum Prime Pisidium pauperculum, var. crystalense Sterki Pisidium sp. near complanatum Sterki Campeloma subsolidum Anthony	Campeloma subsolidum Anthony
5	1
CLEANER WATER OR LESS TOLERANT ASSOCIATED GROUP	
Mussels 0	*Mussels* 0
Snails Valvata tricarinata Say 1	*Snails* 0
Bryozoa 0	*Bryozoa* 0
Sponges 0	*Sponges* 0
Crustacea 0	*Crustacea* 0
Other insects than midges 0	*Other insects than midges* 0
Total 18+	Total 11+

Channel

1922: 3 stations; 3 cross-sections	1920: 3 stations; 3 cross-sections
POLLUTIONAL, MORE TOLERANT, OR DOUBTFUL	
Worms (Tubificidae and Naididae)	
Limnodrilus hoffmeisteri Claparède Limnodrilus n. sp. Tubifex tubifex (Müller)? or var. Naididae, unidentified	At least 3 unidentified spp.
4+	3
Leeches	
Erpobdella punctata (Leidy)	——— ——— ———
1	0
Pollutional or more tolerant midge larvae	
——— ——— ———	Chironomus decorus Johannsen Tanypus dyari Coquillett
0	2
Midge larvae of doubtful status	
——— ——— ———	Chironomus sp. or spp. Tanypus sp. or spp.
0	2+
Unusually tolerant snails	
Musculium transversum Say	Musculium transversum Say
1	1
LESS TOLERANT GROUP (SNAILS ONLY)	
Less tolerant snails, first group, (upper lake, farthest northward occurrence, 1922)	
Musculium truncatum Linsley Pisidium compressum Prime	——— ——— ———
2	0
CLEANER WATER OR LESS TOLERANT ASSOCIATED GROUP	
Mussels 0	*Mussels* 0
Snails 0	*Snails* 0
Bryozoa 0	*Bryozoa* 0
Sponges 0	*Sponges* 0
Crustacea 0	*Crustacea* 0
Other insects than midges 0	*Other insects than midges* 0
Total 8+	Total 8+

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URBANA, ILLINOIS
October, 1925

COMPARISON OF SPECIES LISTS; MIDDLE PEORIA LAKE

All Zones

1922: 30 stations; 3 cross-sections	1920: 8 stations; 2 cross-sections
POLLUTIONAL, MORE TOLERANT, OR DOUBTFUL	
Worms (Tubificidae and Naididae)	
Limnodrilus hoffmeisteri Claparède Limnodrilus n. sp. Tubifex tubifex (Muller)? or var. Naididae, unidentified Other unidentified, immature 4+	At least 3 or 4 spp., unidentified 3+
Leeches	
Helobdella nepheloidea (Graf) Helobdella stagnalis (Linnaeus) 2	Unidentified species 1
Pollutional or more tolerant midge larvae	
Chironomus plumosus Linnaeus, var. 1	Chironomus plumosus Linnaeus Chironomus plumosus Linnaeus, var. Tanypus dyari Coquillett 3
Midge larvae of doubtful status	
Chironomus sp. near C. maturus Johannsen Chironomus digitatus Malloch Chironomus sp. or spp. Procladius sp. or spp. Tanypus sp. or spp. 5+	Chironomus sp. or spp. Tanypus sp. or spp. 2+
Unusually tolerant snails	
Musculium transversum Say 1	Musculium transcersum Say 1
LESS TOLERANT GROUP (SNAILS ONLY)	
Less tolerant snails, first group, (upper lake, farthest northward occurrence, 1922)	
Musculium truncatum Linsley Pisidium compressum Prime Pisidium pauperculum, var. crystalense Sterki Pisidium sp. near P. complanatum Sterki Campeloma subsolidum Anthony 5	Campeloma subsolidum Anthony 1
Less tolerant snails, second group, (middle lake, farthest northward occurrence, 1922)	
Pisidium pauperculum Sterki Pisidium sp. like P. sp. from L. Winnebago, Sterki Pisidium sp. unidentified, Sterki Sphaerium stamineum Conrad Sphaerium striatinum, var. lilycashense Baker 5	——— ——— ——— 0
CLEANER WATER OR LESS TOLERANT ASSOCIATED GROUP	
Mussels 0 *Snails* 0 *Bryozoa* 0 *Sponges* 0 *Crustacea* 0 *Other insects than midges* 0 Total 23+	*Mussels* 0 *Snails* 0 *Bryozoa* 0 *Sponges* 0 *Crustacea* 0 *Other insects than midges* 0 Total 11+

Wide Waters

1922: 27 stations; 3 cross-sections	1920: 6 stations; 2 cross-sections
POLLUTIONAL, MORE TOLERANT, OR DOUBTFUL	
Worms (Tubificidae and Naididae)	
Limnodrilus hoffmeisteri Claparède Limnodrilus n. sp. Naididae, unidentified Other unidentified, immature 3+	At least 3 unidentified spp. 3
Leeches	
Helobdella nepheloidea (Graf) Helobdella stagnalis (Linnaeus) 2	Unidentified species 1
Pollutional or more tolerant midge larvae	
Chironomus plumosus Linnaeus, var. 1	Chironomus plumosus Linnaeus Chironomus plumosus Linnaeus, var. Tanypus dyari Coquillett 3
Midge larvae of doubtful status	
Chironomus sp. near C. maturus Johannsen Chironomus digitatus Malloch Chironomus sp. or spp. Procladius sp. or spp. Tanypus sp. or spp. 5+	Chironomus sp. or spp. Tanypus sp. or spp. 2+
Unusually tolerant snails	
Musculium transversum Say 1	Musculium transversum Say 1
LESS TOLERANT GROUP (SNAILS ONLY)	
Less tolerant snails, first group, (upper lake, farthest northward occurrence, 1922)	
Musculium truncatum Linsley Pisidium compressum Prime Pisidium pauperculum, var crystalense Sterki Pisidium sp. near P. complanatum Starki Campeloma subsolidum Anthony 5	Campeloma subsolidum Anthony 1
Less tolerant snails, second group, (middle lake, farthest northward occurrence, 1922)	
Pisidium pauperculum Sterki Pisidium sp. unidentified, Sterki Sphaerium stamineum Conrad Sphaerium striatinum, var. lilycashense Baker 4	——— ——— ——— 0
LESS TOLERANT ASSOCIATED GROUP	
Mussels 0 *Snails* 0 *Bryozoa* 0 *Sponges* 0 *Crustacea* 0 *Other insects than midges* 0 Total 21+	*Mussels* 0 *Snails* 0 *Bryozoa* 0 *Sponges* 0 *Crustacea* 0 *Other insects than midges* 0 Total 11+

Channel

1922: 3 stations; 3 cross-sections	1920: 2 stations; 2 cross-sections
POLLUTIONAL, MORE TOLERANT, OR DOUBTFUL	
Worms (Tubificidae and Naididae)	
Limnodrilus hoffmeisteri Claparède Limnodrilus n. sp. Tubifex tubifex (Müller) or var.? Naididae, unidentified 4	At least 3 unidentified spp. 3
Leeches	
Leeches 0	*Leeches* 0
Pollutional or more tolerant midge larvae	
Chironomus plumosus Linnaeus, var. 1	Tanypus dyari Coquillett 1
Midge larvae of doubtful status	
Chironomus sp. or spp. 1	Chironomus sp. or spp. 1
Unusually tolerant snails	
Musculium transversum Say 1	——— ——— ——— 0
LESS TOLERANT GROUP (SNAILS ONLY)	
Less tolerant snails, first group, (upper lake, farthest northward occurrence, 1922)	
Pisidium compressum Prime Pisidium sp. near P. complanatum Sterki 2	——— ——— ——— 0
Less tolerant snails, second group, (middle lake, farthest northward occurrence, 1922)	
Pisidium sp. like P. sp. from L. Winnebago, Sterki Sphaerium striatinum, var. lilycashense Baker 2	——— ——— ——— 0
CLEANER WATER OR LESS TOLERANT ASSOCIATED GROUP	
Mussels 0 *Snails* 0 *Bryozoa* 0 *Sponges* 0 *Crustacea* 0 *Other insects than midges* 0 Total 11+	*Mussels* 0 *Snails* 0 *Bryozoa* 0 *Sponges* 0 *Crustacea* 0 *Other insects than midges* 0 Total 5+

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URBANA, ILLINOIS
October, 1925

COMPARISON OF SPECIES LISTS; LOWER PEORIA LAKE

All Zones

1922: 18 stations; 3 cross-sections	1920: 19 stations; 5 cross-sections
POLLUTIONAL, MORE TOLERANT, OR DOUBTFUL	
Worms (Tubificidae and Naididae)	
Limnodrilus hoffmeisteri Claparède Limnodrilus n. sp. Tubifex tubifex (Muller) or var.? New genus Other unidentified, immature	At least 3 unidentified spp.
4+	3
Leeches	
Erpobdella punctata (Leidy) Helobdella stagnalis (Linnaeus) Helobdella nepheloidea (Graf) Dina parva Moore	Erpobdella punctata (Leidy) Helobdella stagnalis (Linnaeus)
4	2
Pollutional or more tolerant midge larvae	
Chironomus plumosus Linnaeus Chironomus plumosus Linnaeus, var. Chironomus maturus Johannsen	Chironomus plumosus Linnaeus Chironomus plumosus Linnaeus, var. Chironomus maturus Johannsen Chironomus frequens Johannsen
3	4
Midge larvae of doubtful status	
Chironomus digitatus Malloch Tanypus monilis Linnaeus Chironomus sp. or spp. Procladius sp. or spp. Tanypus sp. or spp.	Chironomus crassicaudatus Malloch Palpomyia longipennis Loew? Chironomus sp. or spp. Tanypus sp. or spp.
5+	4+
Unusually tolerant snails	
Musculium transversum Say	Musculium transversum Say
1	1
LESS TOLERANT GROUP (SNAILS ONLY)	
Less tolerant snails, first group, (upper lake, farthest northward occurrence, 1922)	
Pisidium compressum Prime Pisidium pauperculum, var. crystalense Sterki Campeloma subsolidum Anthony	Pisidium compressum Prime Campeloma subsolidum Anthony
3	2
Less tolerant snails, second group, (middle lake, farthest northward occurrence, 1922)	
Sphaerium stamineum Conrad	Sphaerium stamineum Conrad
1	1
CLEANER WATER OR LESS TOLERANT ASSOCIATED GROUP	
Mussels	
Anodonta imbecillis Say	Quadrula plicata Say
1	1
Snails	
Goniobasis livescens Menke	Goniobasis livescens Menke Pleurocera elevatum, var. lewisii Lea
1	2
Bryozoa	
Plumatella princeps, var. fruticosa Kraepelin	Plumatella princeps, var. fruticosa Kruepelin
1	1
Sponges	
Unidentified species	Unidentified species
1	1
Crustacea	
Hyalella knickerbockeri (Bate)	Hyalella knickerbockeri (Bate)
1	1
Other insects than midges	
Caddis larva (Leptoceridae) Corixid nymph	Hydropsyche sp.
2	1
Total 28+	Total 24+

Wide Waters

1922: 14 stations; 4 cross-sections	1920: 14 stations; 5 cross-sections
POLLUTIONAL, MORE TOLERANT, OR DOUBTFUL	
Worms (Tubificidae and Naididae)	
Limnodrilus hoffmeisteri Claparède Limnodrilus n. sp. Tubifex tubifex (Müller) or var.? New genus Other unidentified, immature	At least two unidentified spp.
4 +	2
Leeches	
Erpobdella punctata (Leidy) Helobdella stagnalis (Linnaeus) Helobdella nepheloidea (Graf) Dina parva Moore	Erpobdella punctata (Leidy) Helobdella stagnalis (Linnaeus)
4	2
Pollutional or more tolerant midges	
Chironomus plumosus Linnaeus, var. Chironomus maturus Johannsen Chironomus plumosus Linnaeus	Chironomus plumosus Linnaeus Chironomus plumosus Linnaeus, var. Chironomus maturus Johannsen Chironomus frequens Johannsen
3	4
Midge larvae of doubtful status	
Chironomus digitatus Malloch Tanypus monilis Linnaeus Chironomus sp. or spp. Procladius sp. or spp. Tanypus sp. or spp.	Chironomus crassicaudatus Malloch Palpomyia longipennis Loew? Chironomus sp. or spp.
5+	3+
Unusually tolerant snails	
Musculium transversum Say	Musculium transversum Say
1	1
LESS TOLERANT GROUP (SNAILS ONLY)	
Less tolerant snails, first group, (upper lake, farthest northward occurrence, 1922)	
Pisidium compressum Prime Pisidium pauperculum, var. crystalense Sterki Campeloma subsolidum Anthony	Pisidium compressum Prime Campeloma subsolidum Anthony
3	2
Less tolerant snails, second group, (middle lake, farthest northward occurrence, 1922)	
Sphaerium stamineum Conrad	Sphaerium stamineum Conrad
1	1
CLEANER WATER OR LESS TOLERANT ASSOCIATED GROUP	
Mussels	
——— ——— ———	Quadrula plicata Say
0	1
Snails	
Goniobasis livescens Menke	Goniobasis livescens Menke Pleurocera elevatum, var. lewisii Lea
1	2
Bryozoa	
Plumatella princeps, var. fruticosa Kraepelin	Plumatella princeps, var. fruticosa Kraepelin
1	1
Sponges	
Unidentified species	Unidentified species
1	1
Crustacea	
Hyalella knickerbockeri (Bate)	Hyalella knickerbockeri (Bate)
1	1
Other insects than midges	
Caddis larva (Leptoceridae) Corixid nymph	Hydropsyche sp.
2	1
Total 27+	Total 22+

Channel

1922: 4 stations; 4 cross-sections	1920: 5 stations; 5 cross-sections
POLLUTIONAL, MORE TOLERANT, OR DOUBTFUL	
Worms (Tubificidae and Naididae)	
Limnodrilus hoffmeisteri Claparède Limnodrilus n. sp. Unidentified	At least 3 unidentified spp.
3	3
Leeches	
Helobdella stagnalis (Linnaeus) Helobdella nepheloidea (Graf) Dina parva Moore	——— ——— ———
3	0
Pollutional or more tolerant midges	
——— ——— ———	Chironomus plumosus Linnaeus Chironomus plumosus Linnaeus, var. Chironomus maturus Johannsen Chironomus frequens Johannsen
0	4
Midge larvae of doubtful status	
Chironomus sp. or spp.	Chironomus sp. or spp. Tanypus sp. or spp. Chironomus crassicaudatus Malloch
1	3+
Unusually tolerant snails	
Musculium transversum Say	Musculium transversum Say
1	1
LESS TOLERANT GROUP (SNAILS ONLY)	
Less tolerant snails, first group, (upper lake, farthest northward occurrence, 1922)	
Pisidium compressum Prime Campeloma subsolidum Anthony	Campeloma subsolidum Anthony
2	1
Less tolerant snails, second group, (middle lake, farthest northward occurrence, 1922)	
——— ——— ———	Sphaerium stamineum Conrad
0	1
CLEANER WATER OR LESS TOLERANT ASSOCIATED GROUP	
Mussels	*Mussels*
Anodonta imbecillis Say	
1	0
Snails	*Snails*
——— ——— ———	Pleurocera elevatum, var. lewisii
0	1
Bryozoa	*Bryozoa*
Plumatella princeps, var. fruticosa Kraepelin	
1	0
Sponges	*Sponges*
0	0
Crustacea	*Crustacea*
Hyalella knickerbockeri (Bate)	
1	0
Other insects than midges	*Other insects than midges*
0	0
Total 13+	Total 14+