As stated previously, this paper is an attempt to indicate the ecological distribution of the smaller organisms in a large lake. The distribution of these organisms is of interest not only from an ecological point of view, but also from an economic standpoint since they form the fundamental food supply of the lake. Such information will find an application in a variety of fishery problems.

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PRELIMINARY STUDIES OF THE BOTTOM FAUNA OF LAKE SIMCOE, ONTARIO

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Contents

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Introduction

During the summer of 1926, the writer carried on a biological study of the bottom fauna of Lake Simcoe. This was undertaken as a part of the plan of the Ontario Fisheries Research Laboratory for the investigation of Ontario waters. The work involved a quantitative and qualitative survey of the macroscopic bottom organisms and an examination of the food of the more important fishes. The information resulting from these phases of the work was brought together in an endeavour to throw some light on the present fish production of the lake and its future possibilities. The work was carried on in such a manner that the results were comparable to those obtained from the investigation of other lakes, more especially Lake Nipigon.

The investigation was supervised by members of the Department of Biology of the University of Toronto. I am especially indebted to Professor B. A. Bensley of that department for his advice. The field work was made possible by the active co-operation of Mr. H. H. MacKay, Biologist to the Department of Game and Fisheries of Ontario, to whom I am also greatly indebted.

Geology and Physiography

Lake Simcoe, Lat. 44° N., Long. 79° W., is the fourth largest of the inland lakes of Ontario, having an area of 280 square miles. Situated about 40 miles due north of Toronto it forms a link in that part of the Trent Valley system of waterways which empties into Georgian bay by way of Lake Couchiching and the Severn river. From an elevation of 720 feet at Lake Simcoe, the water falls to 581 feet at Georgian bay.

The depression in which Lake Simcoe is situated is part of the valley of the ancient Laurentian river (Coleman 1922). In interglacial time this river drained the Lake Huron—Georgian bay region, running south from the present Georgian bay through the Holland river valley to Scarborough just east of Toronto. Glaciers blocked this valley by piling up an interlobate moraine which forms the present height of land midway between Toronto and Lake Simcoe. In post-glacial time this valley filled with water to form a bay of the great Lake Algonquin which covered the area now occupied by Lakes Superior, Michigan and Huron and extended beyond their limits. Finally, deformation (Johnston 1916) lifted the land at the mouth of this bay, tipping the strata to leave a puddle, Lake Simcoe, cut off from Lake Algonquin. Lake Simcoe, having originated in this manner, was probably of much greater area than at present and its flood waters cut their outlet to the northwest, forming the Severn river.

Geologically, the lake lies almost wholly in the Trenton formation with its extreme north end and Lake Couchiching extending through the Black river formation into the Pre-cambrian area. The Trenton limestone is a thin, hard layer underlying the lake and covered by clays of glacial origin.

The present lake is somewhat rectangular in outline with two long finger-like bays, one on the west and one on the southwest. With the exception of these bays its shores are much exposed, a condition readily seen from the map and indicated by the fact that for its area of 280 square miles it has a shore line of only 123 miles (Prov. Govt. Chart). On the exposed shores, especially at the north end, we find evidence of violent ice action. The high, steep banks are composed of loose boulders pushed up by the ice. Violent storms sweep the lake and, crossing its diameter of roughly 15 miles, develop a considerable wave action.

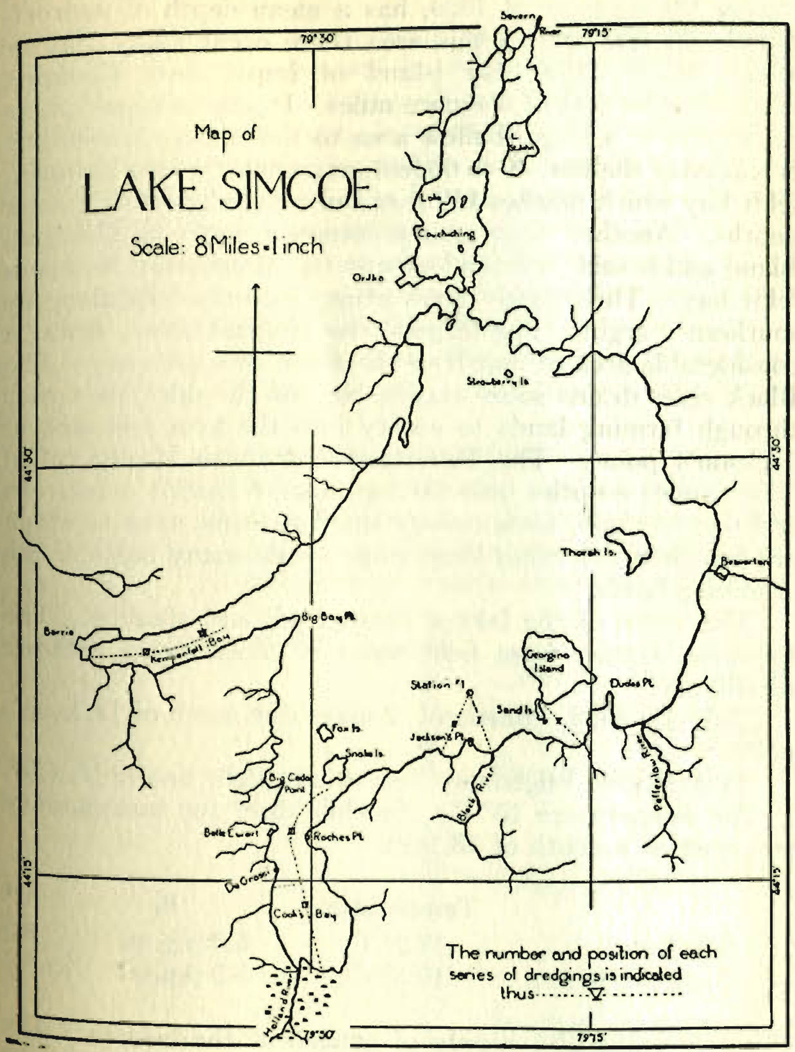

Fig. 1

The southern half of the lake, which was the part studied during the summer of 1926, has a mean depth of approximately 50 feet and in this area there occur many clay or stone shoals. The only island of importance, Georgina island, has an area of 5 square miles. It affords considerable protection to a large shallow area to the south. Cooks bay is relatively shallow, 40 to 60 feet, as compared with Kempenfeldt bay which reaches 150 feet and reputedly much greater depths. Another deep area is situated north of Georgina island and is said to extend west in the direction of Kempenfeldt bay. Three large rivers empty into the lake along its southern margin. The largest, the Holland river, drains a considerable area of marsh to the south of Cooks bay. The Black river drains some marsh, but for the most part runs through farming lands to empty into the lake just east of Jackson's point. The Pefferlaw river (also locally called Black river) empties into the bay east of Duclos point. In addition to these, some twenty small streams, most of which are less than five miles long, empty from many parts of the adjoining lands.

The water of the lake is clear, cool, and alkaline. The following extract from field notes is indicative of summer conditions:

July 15, 1926. Station I, 2 miles due north of Jackson's point.

Time 9 a.m., bright day, few clouds, light breeze N.N.W.

Air temperature 15° C. Secchi's disc* for transparency was seen at a depth of 23 feet.

	Temperature	O_2	pH
Surface...........	18.2° C.	5.6 p.p.m.	8.3
Bottom (63 ft.)....	10.3° C.	5.5 p.p.m.	8.1

There is a plentiful supply of oxygen at the bottom. The alkaline nature of the water may be accounted for by the abundance of limestone and marly clays in the region.

*A white wooden disc 20 cms. in diameter.

APPARATUS AND METHODS

The greater part of the dredging and sorting was carried out with the technique used by Adamstone (1924) on Lake Nipigon. The Ekman dredge (Birge 1922) with release was used to collect the material from an area of 81 square inches. A strong portable windlass with a 3/16 inch steel cable was used to haul the dredge. The bottom sample was transferred from the dredge to wooden trays 18"×10"×4" lined with white oilcloth. Depth was observed from a counter on the frame of the windlass and distance from shore was estimated for short distances or calculated from the speed of the boat for longer distances. Field records were kept of all observations and included notes on the character of bottom, plants brought up, etc.

The samples were washed successively through three screens of galvanized wire mosquito netting, cheese-cloth and factory cotton. The wooden frames of these screens resembled those used by Adamstone with the addition of a rim (fig. 2), which kept the screens in alignment and pre-

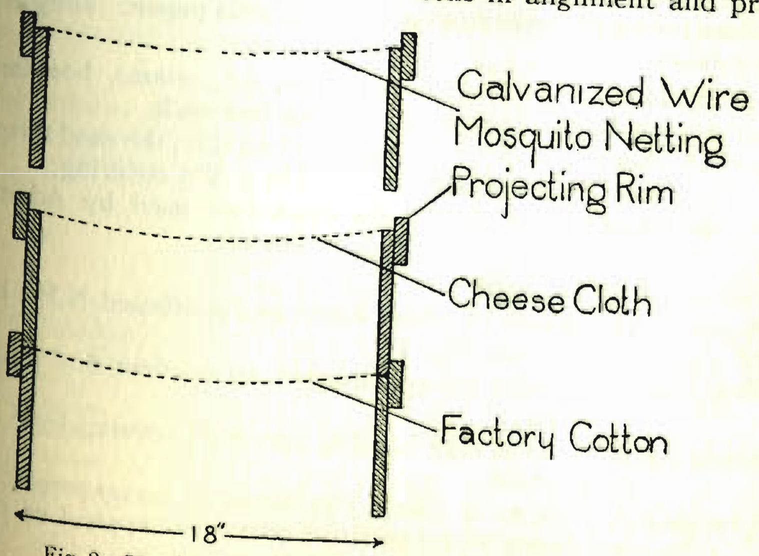

Fig. 2—Showing a sectional view of the screening arrangement.

vented the loss of material over their edges during the washing process. The materials caught by these screens were returned to the tray and taken to the laboratory for sorting, where the organisms were preserved in 70 per cent. alcohol.

The stomachs examined were taken from fish caught chiefly by gill nets, of meshes ranging from 1½ to 5 inches, and seines used in the general survey of the lake which was carried on under the direction of Mr. H. H. MacKay.

DREDGING DATA

The data obtained in dredging were recorded in tables, one of which has been included.

Each table contained the results of one series of dredgings which is a group of dredgings from a locality chosen as typical of a certain habitat or area.

Distance from shore was expressed in yards unless otherwise stated. Depth was expressed in feet. The signs indicating the character of the bottom were those used by Adamstone and defined in detail in his 1924 paper. They are as follows:

- m mud
- s sand
- c clay
- g grit (coarse sand)
- gr gravel
- r rock, *i.e.*, stones, boulders or bed rock.
- s/c sand on clay, the sand forming a thin covering.
- ma marl (not used by Adamstone).

Series I, July 14, 1926.
Begun at the mouth of Black River and continued N.W. by W. to Station I (map Fig. 1).

Dredging 1. Under bridge, brought up sawdust and plant debris.

Dredging 2-3. On a clay bar 200 yds. wide covered by 6 ft. of water.

Dredging 5. On stony area. The dredge came up empty.

" 6. Brought up greenish oozy mud typical of the deeper waters.

Dredging no	1	2	3	4	5	6	Totals
Depth in ft.	12	6	6	24	27	33	
Distance from shore in yds.	5	80	250	500	1000	2000	
Character of bottom	m.	m/c	c.	s/c	gr.	m.	
Gastropoda	9		4	4		4	21
Sphaeridae		3		2		1	6
Chironomidae	6	15	5	13		38	77
Oligochaeta	1	3	1	1		3	9
Amphipoda		3					3
Trichoptera		2		2		3	7
Hydracarina		1		1			2
Ostracoda		5		6		4	15
Totals	16	32	10	29		53	

QUANTITATIVE RESULTS

The data from all the dredgings have been analysed, and a numerical summary appears in table 1. The dry weight production has been calculated from the same data and is summarized in table 5.

TABLE 1

SHOWING THE AVERAGE NUMBER OF ORGANISMS PER UNIT AREA OF BOTTOM IN LAKE SIMCOE AND COMPARING THESE VALUES WITH THOSE OBTAINED BY ADAMSTONE (1924) ON LAKE NIPIGON.

	Lake Simcoe		Lake Nipigon
	Average number per dredging	Average number per sq. yd.	Average number per sq. yd.
All Organisms	49.5	792	875
Chironomidae	25.5	408	293
Mollusca	*8.6	138	149
Amphipoda	7.6	122	270
Oligochaeta	3.1	50	73
Ephemerida	1.4	22	21
Miscellaneous†	3.5	56	42

*8.6 Molluscs was made up of 4.7 Sphaeridae and 3.9 Gastropoda.
†Miscellaneous included Corethra, Trichoptera, Ostracoda, and Hydracarina.

It appears that bottom organisms are slightly less numerous in Lake Simcoe than in Lake Nipigon. This result may be influenced by two factors. Dredgings in Lake Simcoe are all from depths of 0-150 feet, while those in Lake Nipigon are from 0-390 feet. Adamstone (1924, p. 73) shows that in Lake Nipigon the bottom organisms are more numerous below the 150 foot level than above it. The total of 50 dredgings taken in Lake Simcoe is not enough to insure an accurate value of the bottom population. It is probable therefore, that further data will show less difference in the numbers of bottom organisms from these two lakes.

A series of drying and weighing experiments was carried out to determine the average dry weight of various individual bottom organisms. These weights were used to calculate the productivity of the bottom in dry weight per unit area. Trial weighings showed that even those organisms which dried most slowly reached a constant weight when dried for a 24-hour period in an electric oven at 53° C. Accordingly, these conditions were adopted for the remainder of the work. A large number of specimens were dried and weighed together in order to get an accurate average weight. In some cases the specimens showed such a great variation in size that it was found advisable to divide them into groups of large, medium, and small, each group being dried and weighed separately.

TABLES 2, 3 AND 4 SHOW THE DRY WEIGHT OF AVERAGE INDIVIDUALS OF THE COMMON BOTTOM ORGANISMS

TABLE 2

	Large	Medium	Small
Chironomid larvae	5.2 mgm.	1.7 mgm.	.3 mgm.
Ephemerid nymphs*	2.6 mgm.	1.4 mgm.	.2 mgm.

*The large Ephemerid nymphs which bulk so largely (table 7) in the food studies were not often encountered in the dredging. It seems that by chance we have missed the areas where they abound. If this is so, and considering that each one of these nymphs has a dry weight value of about three milligrams, it would seem that our estimate of the bottom productivity is too low.

TABLE 3

Mollusca		Av. Dry weight with shell	Shell % of total weight
Gastropoda	Amnicola, Valvata	2.9 mgm.	68%
	Physa (small)	3.5 "	54%
Sphaeridae		.64 "	82%

TABLE 4

	Av. dry weight		Av. dry weight
Amphipoda (Hyalella)	.60 mgm.	Oligochaeta	.53 mgm.
Corethra larvae	.25 mgm.	Trichoptera	.63 mgm.

These weights in general are in accordance with those found by Adamstone (1924) and Juday (1922). The Chironomid larvae of Lake Simcoe averaged 10.1 times as heavy as those from Lake Nipigon. Of these Chironomid larvae grouped as "large" the average weight for individuals from Lake Simcoe was 5.2 mgm. which is less than the average weight, 8.89 mgm., found by Juday for "large" Chironomid larvae from Lake Mendota.

Using these weights, the production of bottom organisms was calculated in pounds dry weight per acre, and these results are given in table 5.

TABLE 5

SHOWING THE AVERAGE PRODUCTION OF BOTTOM ORGANISMS IN LAKE SIMCOE, EXPRESSED IN DRY WEIGHT PER UNIT AREA.

Depth zone	Lbs. per acre	Kilograms per hectare
0- 25 ft.	11.6	13.1
25- 50 ft.	7.4	8.3
50-150 ft.	6.6	7.4
All depths	9.58	10.8

The value 9.58 pounds dry weight per acre is probably a fairly accurate average of the organisms produced on the bottom in open water as an effort was made to take dredgings from representative areas throughout the lake rather than confine them to rich or poor localities.*

A very rich bottom fauna was observed in the shallow near-shore areas, and it seemed advisable to compare it with the bottom fauna of the open water. An area 2 feet square and 10 feet from shore was marked out in a protected harbour at Jackson's Point. The bottom at this place was covered by stones of about 5 inches diameter, and the water was 14 inches deep. The fauna within this area was collected by lifting the stones and removing the organisms which clung to them. The smaller animals were lost, as were most of those which did not cling to the stones.

The dry weight of these organisms was found to be 1510 mgm. which is equivalent to 72.3 pounds per acre. This value is not necessarily an average of the shore population, as there may be richer areas in the weedy bays and poorer places on the unprotected sandy beaches. This latter type of shore is prevalent in Lake Simcoe, which suggests that the area studied was richer, rather than poorer, than the average shore area. The shore production of 72.3 pounds per acre is in striking contrast to the much smaller value of 9.58 pounds per acre in the open water. This rich shore area is of great value, but its fauna is less directly available as food for game and commercial fish than that of the deeper waters.

Lake Mendota, investigated by Muttkowski (1918) and Juday (1922), was found to yield a bottom fauna of 60 pounds dry weight per acre in the 0-1 metre zone. This zone is comparable to the shore area of Lake Simcoe, a part of which yielded 72.3 pounds per acre. The shore area of Lake Simcoe appears to be as rich as that of Lake Mendota.

*Stony bottom areas were found occasionally from which the bottom fauna could not be collected. It was thought, however, that these areas represented a small proportion of the total bottom and that the error caused by omitting them would be negligible in view of the probable error involved in our calculations. The value 9.58 is probably a minimum since error in the technique almost always resulted in a loss of organisms, causing a lower value for the bottom productivity.

In the deeper waters, Lake Simcoe yields only 9.58 pounds, while Lake Mendota's deep water (8-20 m.) gives 42.9 pounds per acre.

Lake Nipigon was found by Adamstone (1924) to yield 5.2 pounds per acre, approximately one-half the yield of Lake Simcoe. A comparison of the productivity of the same depth zones in the two lakes shows an even greater difference.

Lake Simcoe bottom from 0-150 feet yields 9.58 pounds per acre.

Lake Nipigon bottom from 0-150 feet yields 3.80 pounds per acre.

In Lake Nipigon the bottom fauna is richer (chiefly in amphipods) at depths greater than 150 feet, resulting in the average yield for all depths 0-390 feet of 5.23 pounds per acre.

Green lake, Wisconsin, investigated by Juday (1924), gave a value of 7.75 pounds per acre in the 0-1 metre zone. This lake has a comparatively unproductive shore area, but its deeper waters, 1-66 metres, yield approximately 24 pounds per acre. Green lake has an area of 12 square miles and a mean depth of 66 feet. Its bottom yield was two and one-half times that of Lake Simcoe, but in general it appears to show more resemblance to the latter than any of the other United States lakes yet studied.

Oneida lake, N.Y. studied by Baker (1916, 1918), gave the enormous yield of 245 pounds per acre. This value may be correlated with the shallowness of the lake, since South bay, the portion studied most intensively, is less than eighteen feet deep. A notable feature of the bottom fauna of this lake was the very great molluscan population.

Table 6 summarizes the production of bottom fauna in the lakes discussed above, although it is obviously difficult to compare lakes which differ so greatly in their physical characteristics. Such a table is likely to be somewhat misleading as far as their relative fish food production is concerned. For instance, the fauna of Oneida lake, being largely molluscan and made up of perhaps 75 per cent. undigestible shell material, would not have as great a food value as a fauna made up chiefly of insect larvae.

TABLE 6

SHOWING THE AVERAGE YIELD OF BOTTOM FAUNA OF VARIOUS LAKES, EXPRESSED IN POUNDS DRY WEIGHT PER ACRE.

Lakes	Pounds per acre in		Area of lake in sq. miles
	Open Water	0-1 metres	
Lake Simcoe	9.58	*72.3	280
Lake Nipigon	5.23		1,750
Green lake	†24.0	7.75	12
Lake Mendota	§42.9	§60.0	15
Oneida lake	§245.0		80

The data at hand indicate that Lake Simcoe supports a greater bottom fauna than Lake Nipigon, but considerably smaller than the smaller and more shallow United States lakes listed above.

QUALITATIVE RESULTS

The species collected belong to the groups Nematoda, Oligochaeta, Hirudinea, Crustacea, Insecta, Arachnida, and Mollusca. Although the collection contains all of the commoner species of the lake, it is by no means exhaustive, due to the limited number of dredgings. The following section contains a brief account of the species with comments on their distribution.

NEMATODA

A small number of free living nematodes were taken which have not been identified. They were unusually minute, and were all from depths of less than 35 feet.

OLIGOCHAETA

The oligochaete worms taken, number 175. They have not been identified, but they are mostly, if not all, Tubificidae.

*From a single determination.
†Approximately.
§Richardson's 1921 estimates.

Their distribution relative to depth has been worked out by means of graphs, which showed a decrease in numbers from shallow water to a minimum in the 60-90 foot area. A similar minimum, at the same depth, was found in Lake Nipigon, but in the latter the oligochaete fauna in the deeper water was much less abundant than in Lake Simcoe. This result may not be confirmed when more dredgings have been taken in the deeper water. On the other hand, these deep water dredgings were mostly from Kempenfeldt bay where, we believe, there is considerable pollution. This pollution may effect an increase in the oligochaete fauna, as it did in the Illinois river (Richardson 1921, 1925). Identification of the specimens will show whether or not they belong to the groups which Richardson designates as "tolerant" or "pollutional".

HIRUDINEA

The leeches were fairly abundant, but as yet only three species have been identified. These are *Haemopis grandis* (Verrill), *Nephelopsis obscura* Verrill, and a species of *Dina*, probably *D. parva* Moore. Two specimens of *H. grandis* were brought up on our gill nets, and two unidentified specimens were taken by dredging. All the other specimens were collected from stones along the shore.

CRUSTACEA

Cladocera: Considerable numbers of bottom or near-bottom Cladocera were brought up by the dredge, but most of them were lost in draining and washing. Of those specimens which were retained the genera *Eurycercus*, *Chydorus*, and *Daphnia* were most prominent.

Copepoda: The number of specimens taken was too small to have quantitative or distributional significance. They were *Epischura lacustris* Forbes, *Diaptomus* spp., and *Cyclops* sp. The examination of fish stomachs indicated that *E. lacustris* is very abundant and of large size.

Ostracoda: Ostracods were somewhat more plentiful than copepods, but many were lost owing to their minute size. They were taken at all depths, but occur in greater numbers at depths of more than 100 feet.

Isopoda: *Mancasellus tenax* was dredged up from depths of 10-20 feet in various parts of the lake.

Amphipoda: Two species of this order were taken, *Gammarus limnaeus* Smith and *Hyalella knickerbockeri* Bate. The former reaches a large size and is abundant along the shore areas. *H. knickerbockeri* was found to occur rather irregularly, as if in swarms, at depths of less than 20 feet. This situation showed a distinct contrast with Lake Nipigon where an amphipod, *Pontoporeia hoyi* Smith, was one of the most abundant of the deep water organisms.

Mysidacea: *Mysis relicta* Loven, occurs in the lake, having been found in several fish stomachs. It was not taken in the dredge, but thorough investigation of the deep water may reveal the habitat of this valuable food crustacean in Lake Simcoe.

Decapoda: *Cambarus virilis* Hagen. This crayfish was very abundant on the rocky shores and shoals of the southern part of the lake. It was brought up repeatedly, clinging to our gill nets, and was found in 75 per cent. of the bass stomachs examined.

INSECTA

Ephemerida: In depths down to 20 feet, ephemerid nymphs were taken in considerable numbers, but exhibited an irregular occurrence. The specimens were submitted to Dr. W. A. Clemens of the Pacific Biological Station, Nanaimo, B.C., who reported six genera. The following percentages indicate the relative abundance of each genus: *Hexagenia* 40 per cent ; *Caenis* 35 per cent.; *Ephemera* 15 per cent.; *Blasturus*, *Leptophlebia* and *Ephemerella* together 10 per cent.

Several specimens of the genus *Heptagenia* were collected from the stones along the shore. In the fish stomachs examined large specimens of *Hexagenia* were greatly predominant over the other genera (Footnote to page 84).

Trichoptera: Caddis larvae were scattered over the same range as the mayfly nymphs, but were less numerous than the latter. Their identification has not been completed. Two forms were abundant in the harbour at Jackson's Point, *Helicopsyche borealis* and *Molanna* sp.

Diptera:

Corethridae: Corethra larvae were taken in moderate numbers in six of the seven series. They show an average number of 2.0 per dredging in the 0-30 foot area and increase in a fairly regular manner to reach an average of 9.3 in the 120-150 foot area. Adamstone in three seasons took no corethra larvae in Lake Nipigon, although they have since been found in adjacent lakes.

Chironomidae: These midge larvae were by far the most abundant organisms of the bottom fauna, forming more than 50 per cent. of the total population numerically and 40 per cent. of its weight.

The chironomid larvae were identified by Professor O. A. Johannsen of Cornell University, who records the following genera and species:

1 *Chironomus plumosus*	5 *Tanytarsus* spp
2. ,, spp	6. *Tanypus* (*Ablabesymia*) sp.
3. *Chironomus* subg. *Cryptochironomus*	7. *Procladius* (sens. lat.)
4. *Chironomus* subg. *Microtendipes*	8. *Culiciodes* sp.

Chironomus plumosus is the most interesting species. It is spoken of as the giant midge, many of its larvae being 25 mm. in length and giving a dry weight of more than 5 mgm. per specimen. Of the total chironomid population in the lake *C. plumosus* makes up 16 per cent. by numbers and 54 per cent. by weight. It is the characteristic inhabitant of the aforementioned layer of ooze which appears to cover most of the bottom of Lake Simcoe at depths of more than 40 feet, but occurring at times in more shallow places.

In Lake Mendota, Muttkowski (1918) found the same species confined to the littoral area, *i.e.*, in shallow water less than 7 metres deep. It was "confined to a few rocky and gravelly areas." He cites, however, an instance of its occurrence in the "muddy depths of Lake Winnebago".

Richardson (1921, 1925) in his studies of the progress of pollution in the Illinois river, found *C. plumosus* a "pollutional" species, since it increased in the polluted areas, while less tolerant species decreased or died out completely. It does not seem probable that *C. plumosus* has any pollutional significance in Lake Simcoe. In Kempenfeldt bay, where we would expect to find pollution, *C. plumosus* was abundant, but not more abundant than in the open lake or in Cooks bay at the same depths. The chironomid larvae were found to be most numerous in the 0-30 foot area, decreasing in the 30-60 foot area, showing a substantial increase in the 60-90 foot area and a subsequent decline as the water became deeper.

It was interesting to note that when the average weight of chironomid larvae per dredging was plotted against the depth of water, there was a steady increase to a maximum in the 60-90 foot area and a subsequent steady decrease. In other words, there was no minimum in the 30-60 foot area when weight was considered instead of numbers.

The numerical distribution is quite unlike that found by Adamstone (1924) in Lake Nipigon, where there were two maxima, one in the 0-15 foot zone and a second in the 180-195 foot zone, with a minimum at 100 feet.

ARACHNIDA

The water mites (Hydracarina) are abundant in Lake Simcoe as shown both by the number taken in dredgings and

the much larger number found in fish stomachs. The specimens from these sources were sent, along with other Canadian specimens, to Dr. Ruth Marshall of Rockford College, Ill. Since Dr. Marshall intends to deal with them in a paper on Canadian hydrachnids it will be sufficient to list here those species, twelve in number, which she reports from Lake Simcoe.

Acercus torris Müller
Arrhenurus krameri Koen.
" *serratus* Marshall
" sp. (unidentified)
Hygrobates ruber Mar.
Leberta porosa Thor.
Limnesia histrionica var. *wolcotti* Pier
Mideopsis orbicularis Müll
Neumania ovata Mar.
" *teniupalpis* Mar.
Pionia pugilis Wolcott
" sp. (nov. sp.?)

MOLLUSCA

The molluscan population of Lake Simcoe compares favourably with that of most other lakes whose bottom organisms have been studied quantitatively. It is poor in molluscs as compared with Oneida lake (page 88), but it is probably as rich as Lake Nipigon. In fact, the average number of molluscs per square yard in Lake Simcoe, 138, is exactly the same as that found by Adamstone in Lake Nipigon in 1921. It is believed that the larger clams were more numerous in Lake Simcoe than in Lake Nipigon, though it is impossible to give any numerical data to bear out this statement.

Of the total molluscan fauna the Sphaeridae outnumber the Gastropoda (54 per cent. to 46 per cent.). This fact was not readily observable because the dead gastropod shells brought up in the dredge outnumbered the dead pelecypods. Dead shells were remarkably numerous in many areas. An area of at least 5 acres of shell marl, encountered in dredging series V, was covered to a depth of from 1-2½ inches with small mollusc shells. In other places large quantities of dead shells were found, but they were much more broken up than those found in series V.

The molluscs were identified by Dr. Bryant Walker and Dr. V. Sterki, to whom the writer expresses his sincere thanks. Twenty species of gastropods and fourteen pelecypods were identified by these authorities.

Gastropoda

1. *Lymnaea stagnalis appressa* Say.
2. " *emarginata* Say. (var. of form)
3. " *obrussa decampi* Streng.
4. *Planorbis antrosus striatus* Baker.
5. " *campanulatus* Say.
6. " *exacuous* Say.
7. " *deflectus* Say.
8. " *altissimus* Baker.
9. *Physa ancillaria* Say.
10. " *integra* Hald.
11. *Ferrissia parallela* Half.
12. *Amnicola limosa* Say.
13. " *emarginata* Kust.
14. " *lustrica* Pils.
15. " *walkeri* Pils.
16. *Valvata tricarinata* Say.
17. " " *perconfusa* Walker.
18. " *sincera* Say.
19. *Campeloma decisum* Say.

Pelecypoda

20. *Lampsilis luteolus* Lamark.
21. *Anodonta grandis*

*

22. *Sphaerium crassum* Sterki.
23. " *emarginatum* Prime.
24. " *sulcatum* Lamark.
25. " *stamineum* Conrad.

*A specimen of *Unio complanatus* was taken on the shore near the mouth of the Black river, but it is not included in the lake fauna since it is usually found in running water. Among the gastropods a specimen of the land form, *Helicodiscus parallelus* Say., was taken 100 yards from shore in 10 feet of water.

26. *Pisidium adamsi* (form) Prime.
27. " *compressum* Prime.
28. " *pauperculum nylanderi* Sterki.
29. " *pauperculum* Sterki.
30. " *scutellatum* Sterki.
31. " *variabile* Prime.
32. " *vesiculare* Sterki.
33. " *walkeri* Sterki.

The distribution of the gastropods relative to depth was found to show a maximum in the shallow water (1-10 feet) and a steady decline down to 45 feet. From this depth their numbers fell off rapidly until the 75 foot level was reached. The number of specimens from deeper water would not justify any statement as to their distribution.

The small pelecypods of the family Sphaeridae appear to have a maximum in the shallow water, 0-30 feet, and decrease in numbers to a fairly constant value in the deeper waters.

In a comparative summary of the bottom faunae of Lake Simcoe and Lake Nipigon it is seen that the Lake Simcoe bottom fauna is richer in quantity and possibly in variety than that of Lake Nipigon. Its lack of amphipods in the deep water is more than compensated for by its increased chironomid population. The distribution of organisms in Lake Simcoe is remarkably similar to that in Lake Nipigon in spite of the disparity in size and depth.

FOOD STUDIES

The fish for this study were caught in various parts of the lake, chiefly by the use of gill nets. The contents of their alimentary tracts were preserved in 70 per cent. alcohol. These stomach contents, representing about 10 of the common species of fish, have been examined jointly by Mr. H. H. MacKay and the author. As the resultant data will be published in a separate paper, the following statement will be confined to the bottom organism content of the stomachs examined.

Coregonus clupeaformis

The food of the whitefish is considered in detail since it is recognized as the most important of the bottom-feeding fish in Lake Simcoe. The bulk of its food belongs to three groups

Molluscs—found in 85% of the stomachs in an average quantity of 28%.
Ephemeridae—found in 63% of the stomachs in an average quantity of 23%.
Chironomidae—found in 40% of the stomachs in an average quantity of 10%.

The molluscan food of the whitefish was made up, in order of numbers, of the genera *Pisidium*, *Valvata*, *Amnicola*, *Planorbis*, and *Physa*. Though the average quantity of molluscs in the stomachs was 28 per cent. and of ephemerid nymphs 23 per cent., the mollusc content of individual stomachs was fairly constant while the ephemerid content varied from a mere trace to 95 per cent. of the whole contents. There were three less important food organisms. Ostracods were found in 60 per cent. of the stomachs in large numbers, but they were so minute that their average quantity amounted to less than 5 per cent. Hydrachnids were usually plentiful (as many as 35 were frequently found in a single stomach) occurring in 35 per cent. of the stomachs and averaging 6 per cent. of the total content. Amphipods were present in a few of the stomachs, but in negligible quantities.

Catostomus commersonii

In every case the stomachs of the common sucker which were examined, contained ephemerid nymphs and the average quantity of these nymphs was 60 per cent. of the total content. Molluscs were found in 80 per cent. of the stomachs at an average quantity of 7 per cent. Small quantities of chironomid larvae and ostracods were observed in a few stomachs.

Cyprinus carpio

The carp stomachs were not numerous enough to give quantitative data, but it was obvious that they fed largely on chironomid larvae, ephemerid nymphs, and mollusca.

Ameiurus nebulosus

A single catfish stomach examined was completely filled with ephemerid nymphs.

Perca flavescens

The yellow perch examined had fed largely upon insect larvae. Their stomachs contained:
Ephemerid nymphs in 84% of the stomachs with an average quantity of 51%.
Chironomid larvae in 23% of the stomachs with an average quantity of 5%.
Other insect remains 32% of the stomachs with an average quantity of 25%.

Crayfish, molluscs, hydrachnids and ostracods occurred in variable quantities, never large, in the perch stomachs.

Micropterus dolomieu

The small-mouth black bass were found to have consumed large quantities of crayfish. *Cambarus virilis* occurred in 60 per cent. of the stomachs in an average quantity of 14 per cent. A single stomach contained a considerable quantity of molluscs (Sphaeridae). In several specimens the stomach contents are made up largely of pleurocercoids of a tapeworm which has not been identified.

Ambloplites rupestria

The stomach of a rock bass contained two crayfish (*Cambarus virilis*).

Lota maculosa

The ling, although feeding chiefly on the ciscoes of the lake, was found to have eaten chironomid larvae, ostracods, and *Mysis relicta* of the bottom fauna.

Leucichthys sp.

The ciscoes (lake herrings) are notably plankton feeders. Data from 25 specimens indicate that they take a small quantity of bottom food as well. Of the 25 fish examined 6 contained mayfly nymphs. In one specimen these formed 20 per cent. of the contents, 6 contained chironomid larvae and 3 contained insect remains other than Ephemeridae and Chironomidae. Other specimens had eaten oligochaete worms, amphipods, and ostracods in small numbers.

The Ephemeridae which bulk so largely in the stomach contents of Lake Simcoe fish are chiefly large nymphs of the genus *Hexagenia*. Clemens and others (1924, p. 151) found that in Lake Nipigon, ephemerid nymphs were much more abundant in fish stomachs at certain seasons than at others. The abundance of these nymphs in stomachs of Lake Simcoe fish may be influenced somewhat by local or seasonal factors. Such a situation is not suggested by the data at hand. Ephemerid nymphs were as plentiful in the stomachs of fish taken in deep waters of Kempenfeldt bay on November 1, as they were in fish stomachs from shallow water south of Georgina island in mid-July.

The Mollusca form an important source of food for bottom-feeding fish in Lake Simcoe. They are mentioned under the food of the whitefish (page 96) as a very constant food supply and in this respect they resemble the Chironomidae.

The Chironomidae appear to supply a small (6%-10%) proportion of the bottom foods utilized by Lake Simcoe fish. It is quite possible that this estimate will change when more data have been accumulated. In Lake Nipigon an examination of 1,500 fish stomachs indicated that chironomid larvae were the most important source of fish food in the lake.

Cambarus virilis, the common crayfish of Lake Simcoe, is apparently abundant and an important food of the bass in the lake.

Mysis relicta was found in a small number of stomachs, chiefly of the ling. This condition is quite unlike Lake Nipigon, where *Mysis relicta* was an important food organism.

Very generally, we find that in Lake Simcoe the bottom fauna supply the major portion of the diet of the whitefish, the sucker, and the carp, that it supplies a considerable part of the food of perch and bass, and a very small part of the food used by the ling and the herring

The more important data pertaining to the food of bottom-feeding fish in Lake Simcoe are summarized and compared with figures from similar studies in Lake Nipigon and Oneida lake in table 7

TABLE 7

GIVING COMPARATIVE DATA ON THE PERCENTAGE OF BOTTOM FOODS FOUND IN THE STOMACHS OF FISHES FROM THREE LAKES.

		Lake Simcoe	Lake Nipigon	Oneida lake
Whitefish	Mollusca	28%	14%	26%
	Ephemerid nymphs	23%	5%	8%*
	Chironomid larvae	10%	28%	
C. Sucker	Mollusca	7%	20%	30%
	Ephemerid nymphs	60%	20%	21%
	Chironomid larvae	6%	25%	
Perch	Ephemerid nymphs	51%	30%	
	Chironomid larvae	10%		25%*

SUMMARY AND CONCLUSIONS

1. Lake Simcoe is a body of water, 280 square miles in area, of moderate depth and with a shoreline much exposed, except for two long bays.

2. Its waters are clear, cool, and alkaline.

3. The south end of the lake has a mean depth of 50 feet and contains numerous clay and stony shoals.

4. Where the depth is greater than 40 feet the bottom is usually covered by a layer of oozy mud 6 inches or more in depth and with often a greenish colour on its surface.

*Insect remains not divided into groups.

5. The bottom fauna is comparatively rich and varied, more so than that of Lake Nipigon, but less than in such United States lakes as Mendota and Oneida.

6. Excluding the richer shore area, the average production of bottom fauna is 9.8 pounds dry weight per acre and the average number of organisms is 778 per square yard.

7. The greater part of this fauna is made up of chironomid larvae which form 50 per cent. of the total number and 40 per cent. of the total weight. Of the Chironomidae, *Chironomus plumosus* is of special significance. In order of abundance the other main groups are Mollusca, Oligochaeta, Ephemerida, and Amphipoda.

8. The distribution of these organisms according to depth is fairly similar to their distribution in Lake Nipigon.

9. The bottom fauna form the chief food of the whitefish, the common sucker, and the carp, as well as a considerable part of the diet of bass and perch.

10. Chironomid larvae, though the most abundant organisms, are less important as a source of fish food than Ephemerida (mayflies) or Mollusca.

11. Statistics in the Annual Reports of the Ontario Department of Game and Fisheries, 1907-25, show that Lake Simcoe yields a comparatively small harvest of commercial fish, a very small harvest if we exclude the annual catch of 115 tons of carp (average for 1923-4-5). Residents on the lake complain that game fishing has become exceptionally poor. The results of this investigation indicate that there is no lack of bottom organisms. It is therefore probable that, whatever factors contribute to this situation, it cannot be attributed to a scarcity of bottom food.

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