HABITS OF YELLOW PERCH IN WISCONSIN LAKES

By A. S. Pearse
and
Henrietta Achtenberg

CONTENTS.

FIG. 1.—A fisherman on Lake Mendota. About 282,960 perch are caught through the ice each winter. (Photograph by L. W. Brown.)

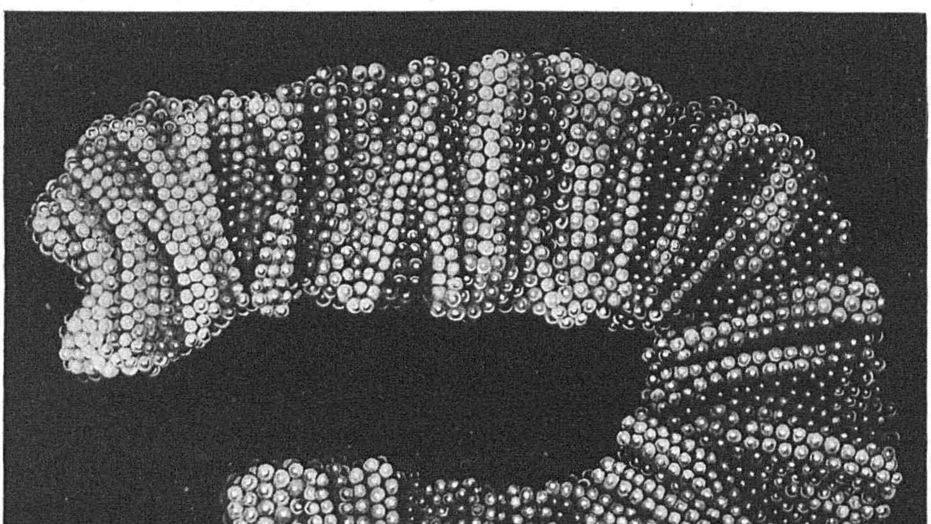

FIG. 2.—Egg string of perch. 37/61 reduction.

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INTRODUCTION.

The yellow perch, *Perca flavescens* (Mitchill), is widely distributed throughout the northeastern United States and southeastern Canada. "It is essentially a lake fish, but occurs also in running streams, most abundantly in the larger rivers and least so in creeks. * * * 'As a game fish the yellow perch can be commended chiefly on account of the fact that anybody can catch it. It can be taken with hook and line any month in the year and with any sort of bait—grasshoppers, angleworms, grubs, small minnows,

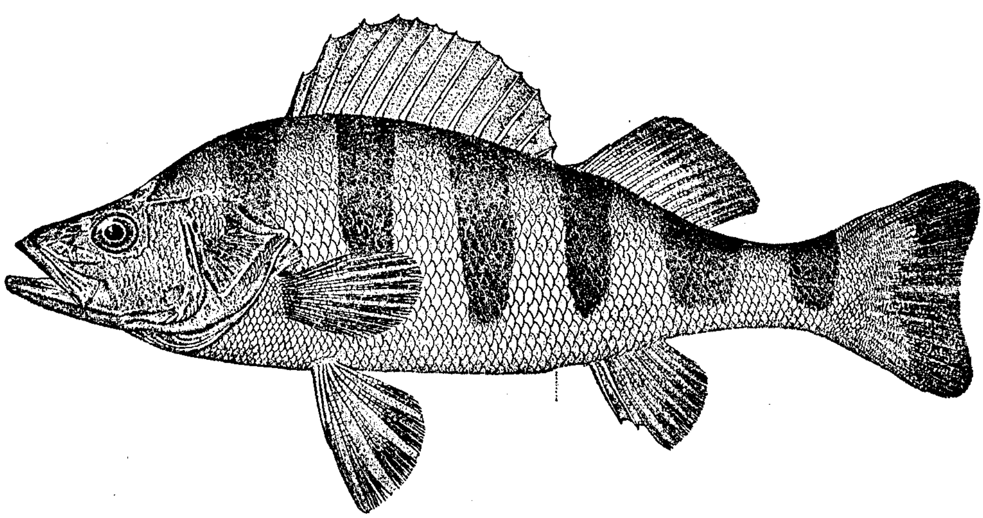

Fig. 1.—The yellow perch, *Perca flavescens* (Mitchill).

pieces of mussel, or pieces of fish; and it will even rise, and freely, too, on occasion, to the artificial fly.' * * * It is easily taken through the ice in winter."[a] Systematically the perch is related to the pikes and the darters and, like them, is largely carnivorous in its feeding habits. It belongs to a family of "highly organized, shapely, powerful, and active fishes, thoroughly equipped for a predatory life, and filling an important place in the ecological system of our inland waters."[a]

Wisconsin lakes in many localities furnish admirable habitats for perch, and those near Madison afford unusual opportunities for scientific study. The Wisconsin Geological and Natural History Survey has collected very complete data on the contour of the lake bottoms, the annual cycle of temperature changes, lake respiration, plankton,

[a] Forbes and Richardson, 1908, p. 277.

animal population of bottom, and other features which have direct application to the lakes as habitats for fish. Therefore, one who wishes to investigate fresh-water fishes in their natural surroundings can do so at Madison and know more about environmental conditions than anywhere else in America.

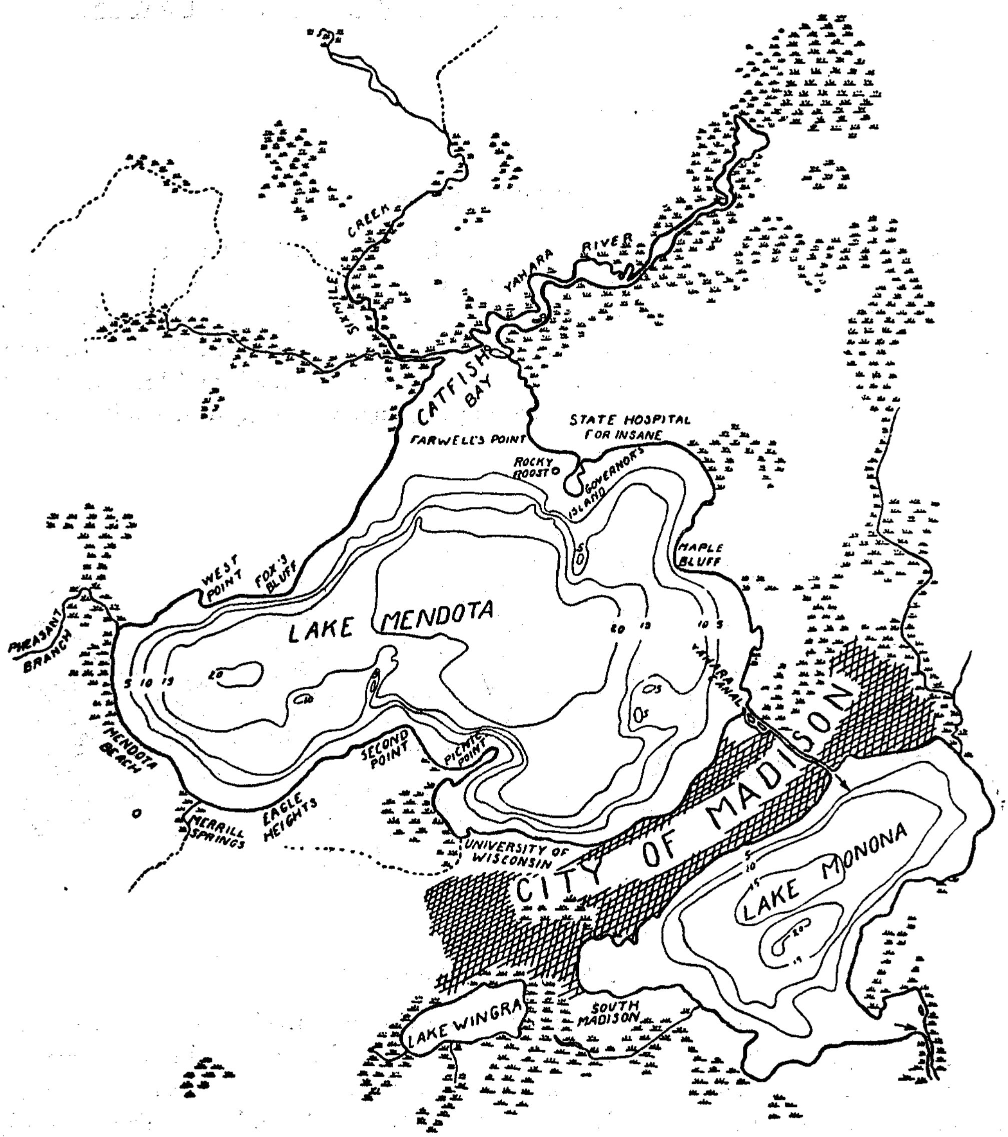

FIG. 2.—Lake Mendota and Lake Wingra, the two lakes near Madison, Wis., in which the yellow perch was chiefly studied. [For dimensions see Table 1.]

Two of the Madison lakes (fig. 2), differing as much as possible, have been utilized for perch studies. Though both of these are of glacial origin, one is large and deep, with comparatively cool waters that become stratified thermally during the summer; the other is small, shallow, has wide seasonal variations in temperature, and shows no thermal stratification during the warmer months. The two lakes are compared in Table 1.

The greatest difference of biological importance between the two lakes is probably the thermal stratification, which is characteristic of Lake Mendota during the warmer months, but which is lacking in Lake Wingra. Birge and Juday (1911) have made complete records of the seasonal changes in Lake Mendota for several years. The lake is frozen over from three to nearly five months.[a] During this period there is little difference (0 to 2.5° C.) in temperature at different depths, and there is practically no circulation; the oxygen in the deepest parts becomes gradually exhausted, and the carbon dioxide increases. Soon after the ice goes out in the spring the lake begins to circulate freely from top to bottom. The temperature and dissolved gases therefore become uniform at all depths and so continue until the temperature reaches 4° C. The water near the surface then gradually grows warmer. About the end of June a thermocline, or stratum of rapid temperature change, is established, and after that there is no mixing between the water in the upper part of the lake and that in the deeper portions. When the stratification is complete, the lower, cooler water is cut off from contact with the atmosphere, and its oxygen is gradually used up. The plankton organisms leave it, but many of the insect larvæ, molluscs, and other animals which live on or in the soft bottom mud remain in the stagnant water (Juday, 1908). The upper stratum circulates throughout the summer and, therefore, has abundant oxygen; it also grows warmer and may reach a temperature of 25° C. or more. The thermocline is usually established at a depth of about 10 m. and moves deeper as the upper stratum of warm water grows thicker in late summer. In the autumn the upper water gradually grows cooler, and, finally, about the first of October, the "autumnal overturn" takes place—the lake circulates again throughout; gases and temperatures are again uniform at all depths. This condition continues until the lake again freezes.

Lake Mendota is, then, subject to two periods of stagnation. During the winter the water is all cold, and the deepest regions may be without oxygen; during the late summer and early autumn the lake is separated into three strata, a warm circulating stratum on top, a thin middle region of rapid transition in temperature and dissolved gases, and a lower, cool, stagnant region which is without oxygen and contains considerable carbon dioxide for about three months. During the spring and the autumn overturns all parts of the lake have the same temperature and the same dissolved gases.

Lake Wingra is, of course, subject to the same external seasonal changes as Lake Mendota but does not respond in the same way. It is so shallow that the water circulates freely from top to bottom while it is not covered with ice. Its shallow basin and small total body of water make it more susceptible to short periods of changes in temperature. It warms up more rapidly in the spring and cools more quickly in the autumn than Lake Mendota.

This brief summary gives some idea of the great contrasts between the two lakes, and there are, of course, many other minor differences. However, perch are the most abundant fish in both. The point which first attracted the attention of the writers was the fact that the perch in Lake Mendota are generally a third larger than those from Lake Wingra. Furthermore, in Lake Monona,[b] which receives the water discharged from Lake Mendota, they are still larger. The questions to which answers have been sought may be formulated somewhat as follows: (1) Why are perch the most abundant

[a] The earliest freezing over recorded since 1851 was Nov. 23; the latest, Jan. 14; corresponding dates for opening in the spring were Mar. 8 and May 4.

[b] Lake Monona has not been investigated to any extent by the writers.

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fishes in these lakes? (2) Why are the perch in Lake Mendota larger than those in Lake Wingra, and why do the fish of many lakes attain a certain maximum size? (3) What effect does the stagnation of a lake like Mendota have on the activities of the fishes in it? In seeking answers to these questions we were led to make routine examinations of perch of all ages from each lake and for every week in the year; to study the migration and distribution of perch in relation to the dissolved gases in the water and to determine the gaseous content of the swim bladders; to ascertain the amount of food eaten by perch and the rate of digestion; and to investigate the breeding, enemies, and other factors which might influence the life cycle of the perch in these lakes.

During the investigation the authors were under continual obligation to the Wisconsin Geological and Natural History Survey and to the University of Wisconsin for the loan of apparatus and for assistance in other ways. Chancey Juday, in particular, gave many valuable suggestions and read the manuscript for this paper. A. R. Cahn and Dr. John Lowe furnished perch from other Wisconsin lakes for comparison and otherwise took a helpful interest in the work. Dr. R. A. Muttkowski identified the greater part of the insect remains found in the food. Miss Hattie J. Wakeman drew all the figures, with the exception of figure 1.

A few technical matters ought to be mentioned before taking up the habits of the perch. All lengths in this paper are given in millimeters and refer to the distance from the extreme anterior end to the beginning of the membranous portion of the caudal fin. Figures giving estimates of food, except where statement is made to the contrary, mean percentages by volume; + indicates an amount too small to be given a percentage value.

FOOD.

The yellow perch is more versatile in its feeding habits than its near relatives. The pikes are largely piscivorous, and the darters feed for the most part on insect larvæ, but the perch is equipped to secure almost anything edible. Its shape and structures for the capture of food are less specialized than those of other members of the family Percidæ, and it is correspondingly more versatile. The stocky body is suited to all sorts of situations; the sharp, backwardly directed teeth hold struggling animals; the slender gill rakers readily strain microscopic organisms from the water; and the activity of the swim bladder renders adjustment to various pressures comparatively easy, so that food may be sought at all depths. A perch may grub out insect larvæ from soft bottom mud, snatch crayfishes from their hiding places among the rocks alongshore, strain plankton animals from the open waters of lakes, lurk in the shore vegetation in order to capture passing fishes, or pull aquatic insects from their retreats among water plants.

Available food for perch is abundant in the two lakes investigated. Birge (1897) has shown that there may be at times more than 3,000,000 microscopic Crustacea per square meter of surface in the waters of Lake Mendota. Recent and as yet unpublished work by Birge and Juday has demonstrated the presence of more than 30,000 dipterous larvæ per square meter on the bottom of this lake, in addition to many other animals. Muttkowski (1918) counted the animals in typical habitats along the shores and computed the total numbers for the lake. He estimates that there are about 553,220,000 flatworms, 18,680,000 roundworms, 8,690,530,000 oligochætes, 103,200,000 leeches, 2,389,740,000 mollusks, 2,221,300,000 macroscopic crustaceans, 815,930,000 water mites, and 5,134,190,000 insect larvæ and adults in the shallow waters of Lake Mendota.

Aside from the myriads of pelagic animals and small fishes which may serve as food for perch, there are, then, 19,926,790,000 macroscopic animals along the shore. Though no careful studies of Lake Wingra have been made, its swampy shores and muddy, plant-covered bottom must support an equally abundant fauna suitable for perch food.

In order to determine what the perch eat in the two lakes selected for study, an attempt was made to examine 10 individuals each week for an entire year. This was easily accomplished in Lake Mendota during 1915, and many supplementary examinations were made throughout the following year. In Lake Wingra weekly examinations were made during the spring and summer, but in late autumn and winter perch

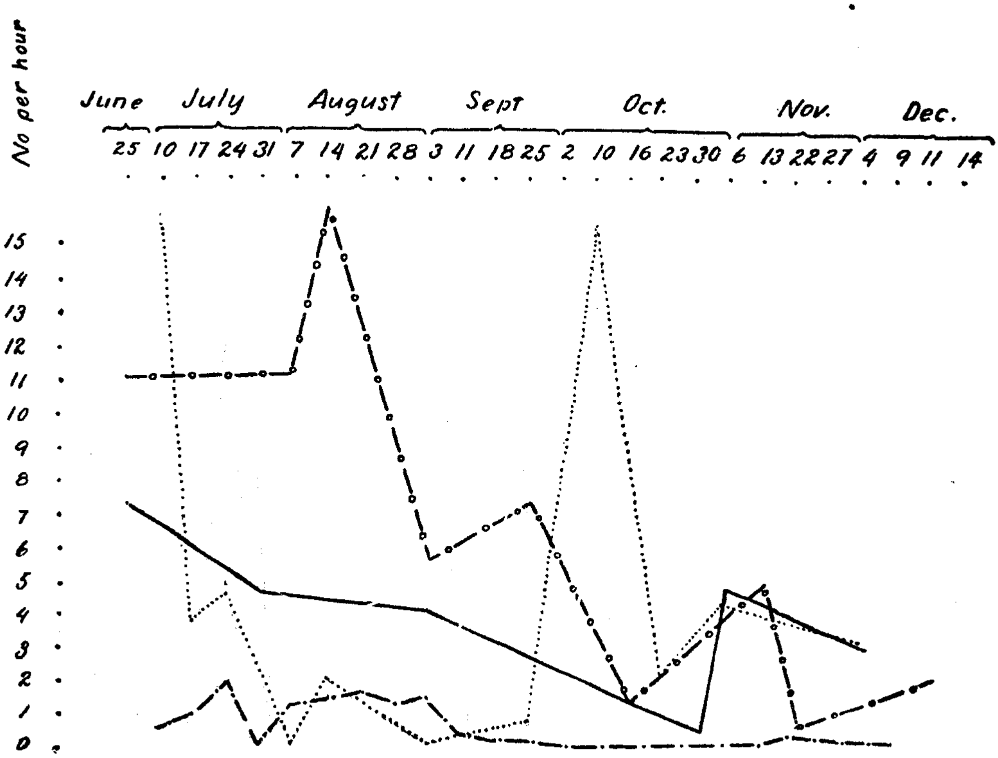


FIG. 3.—Perch caught per hour at various depths in 1-inch mesh gill nets, 3 by 75 feet, left in the water for approximately 24 hours, Lake Mendota, 1915. -.-.-.-, 0 to 5 m.; ———, 5 to 10 m.; -o-o-o-, 10 to 15 m.; . . . . . ., 15 to 24 m.

could not always be caught regularly. While the lakes were free from ice, most of the perch were caught in gill nets and were therefore of fairly uniform size, because the dimensions of the mesh selected certain classes. The current opinion among fishermen that perch are uniformly larger in Lake Mendota than in Lake Wingra was proven by the gill-net catches to be correct (Tables 2 to 5; figs. 3 to 5). In the former lake more perch were caught per hour in 1-inch mesh nets than in those of three-fourths-inch mesh; and in the latter the opposite was true. During the winter months perch were caught through the ice on hooks baited with minnows or perch eyes. At the beginning of the work in Lake Mendota most of the fishing was done east of Picnic Point, but after June 25, 1915, the routine catches recorded in Tables 2 and 3 were made directly north of the University of Wisconsin. Catches were made in all parts of Lake Wingra.

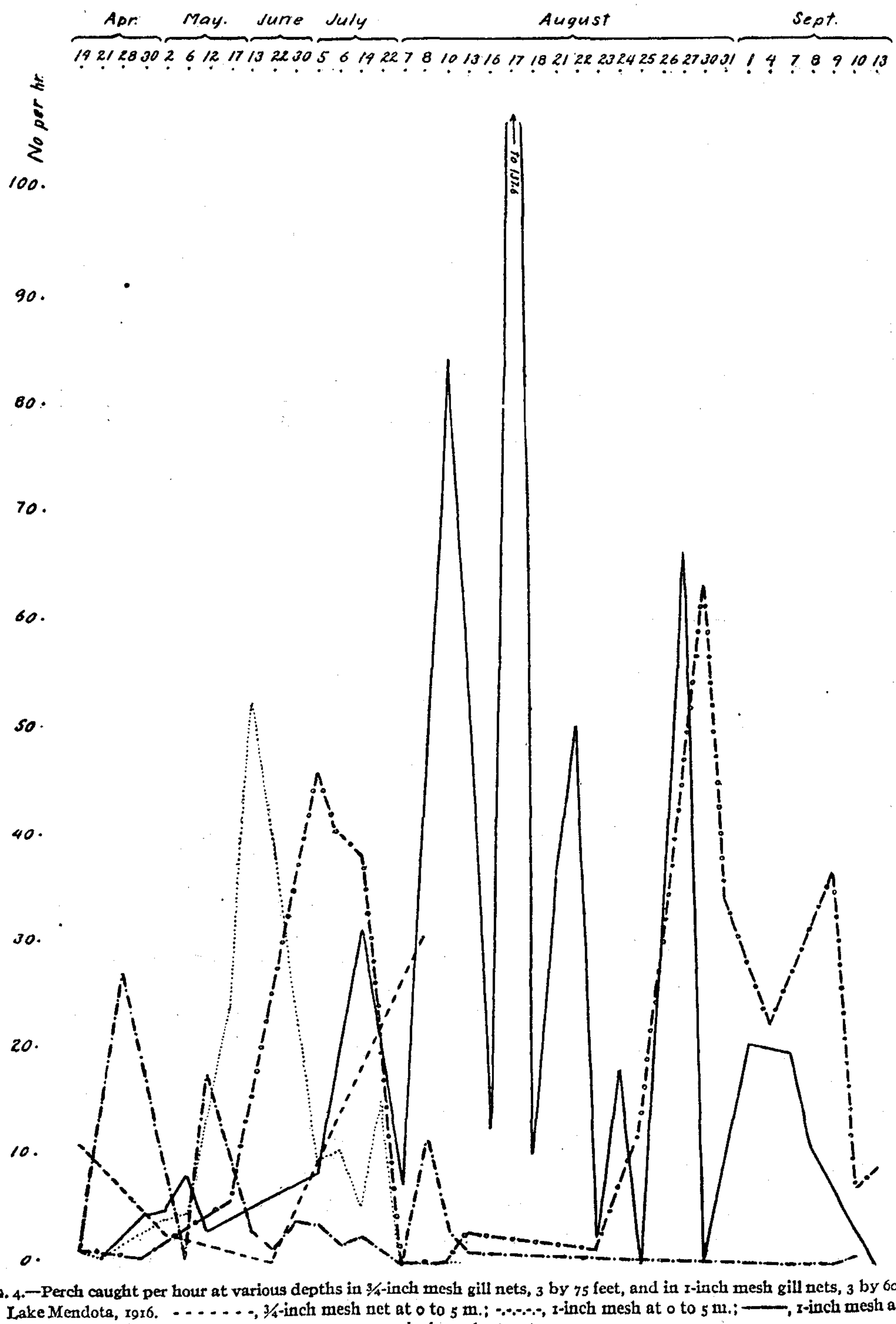


FIG. 4.—Perch caught per hour at various depths in ¾-inch mesh gill nets, 3 by 75 feet, and in 1-inch mesh gill nets, 3 by 60 feet, Lake Mendota, 1916. - - - - - - -, ¾-inch mesh net at 0 to 5 m.; -.-.-.-.-, 1-inch mesh at 0 to 5 m.; ——, 1-inch mesh at 5 to 10 m.; -o-o-o-o, 1-inch mesh at 10 to 15 m.; . . . . . .,1-inch mesh at 15 to 20 m.

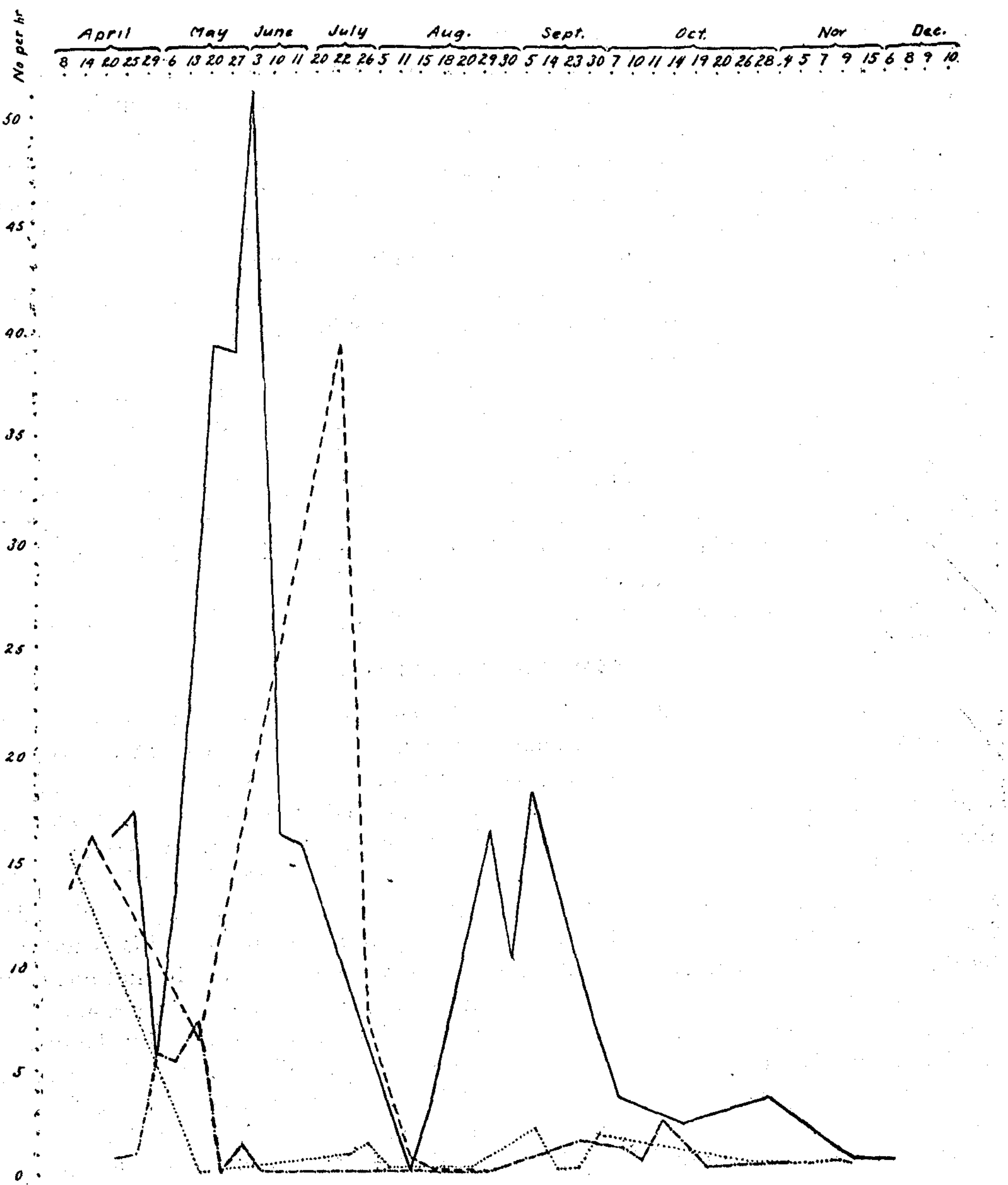


FIG. 5.—Perch caught per hour at various depths in ¾-inch mesh gill nets, 3 by 75 feet, and in 1-inch mesh gill nets, 3 by 60 feet, Lake Wingra, 1916. ———, ¾-inch mesh net at ¾ to 2 m.; - - - - - -, ¾-inch mesh at 2 to 3.5 m.; -.-.-.-.-, 1-inch mesh at ¾ to 2 m.; . . . . . ., 1-inch mesh at 2 to 3.5 m.

QUALITATIVE AND QUANTITATIVE FOOD DETERMINATIONS.

Perch were usually examined while fresh, but in a few instances they were preserved in 95 per cent alcohol before examination, as in the case of those collected in Oconomowoc Lake. In the laboratory the contents were stripped from the alimentary canal on a microscopic slide. A little water was added to the mass; it was then teased apart under a binocular microscope and after being well spread out was again examined with a compound microscope. The volume of all constituents of the food was estimated and recorded in percentages. As a rule, the larger constituents were counted, and in many instances the number of microscopic animals was also noted. It was not practicable to measure the volume of the food, because it was mixed with more or less mucous secretion, so that in the intestine it formed a cylindrical "string."

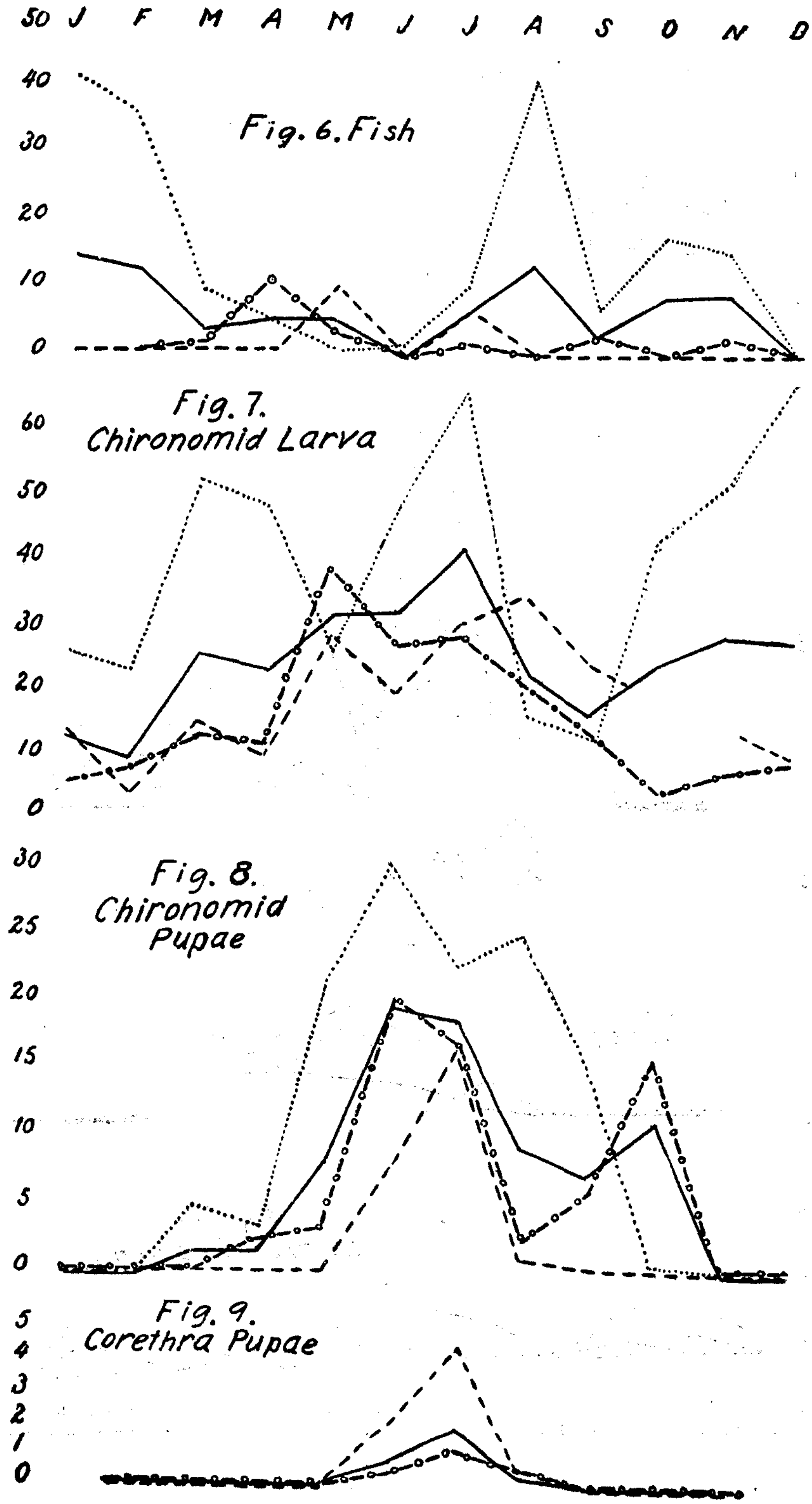
The total number of adult perch for which we made such volumetric percentage food estimates in the lakes studied was 1,147. Considering together those of various localities, habitats, and ages, the food, as a whole, was made up of 38.3 per cent insect larvæ, 21.4 per cent entomostracans, 9.5 per cent insect pupæ and adults, 6.1 per cent silt and débris, 5.5 per cent macroscopic Crustacea, 5.5 per cent plants, 4.5 per cent fish, 2.4 per cent molluscs, 1.4 per cent oligochætes, + leeches, + arachnids.

The maximum amount and number of the particular species of animals observed in the food have also been recorded, and a number of important examples are given in Table 10. No particular discussion of the different items in the food is necessary. Tables 6 to 9 show that entomostracans and insect larvæ are most important; but there is also a good representation of other animals, plants, and mud from the lake bottom.

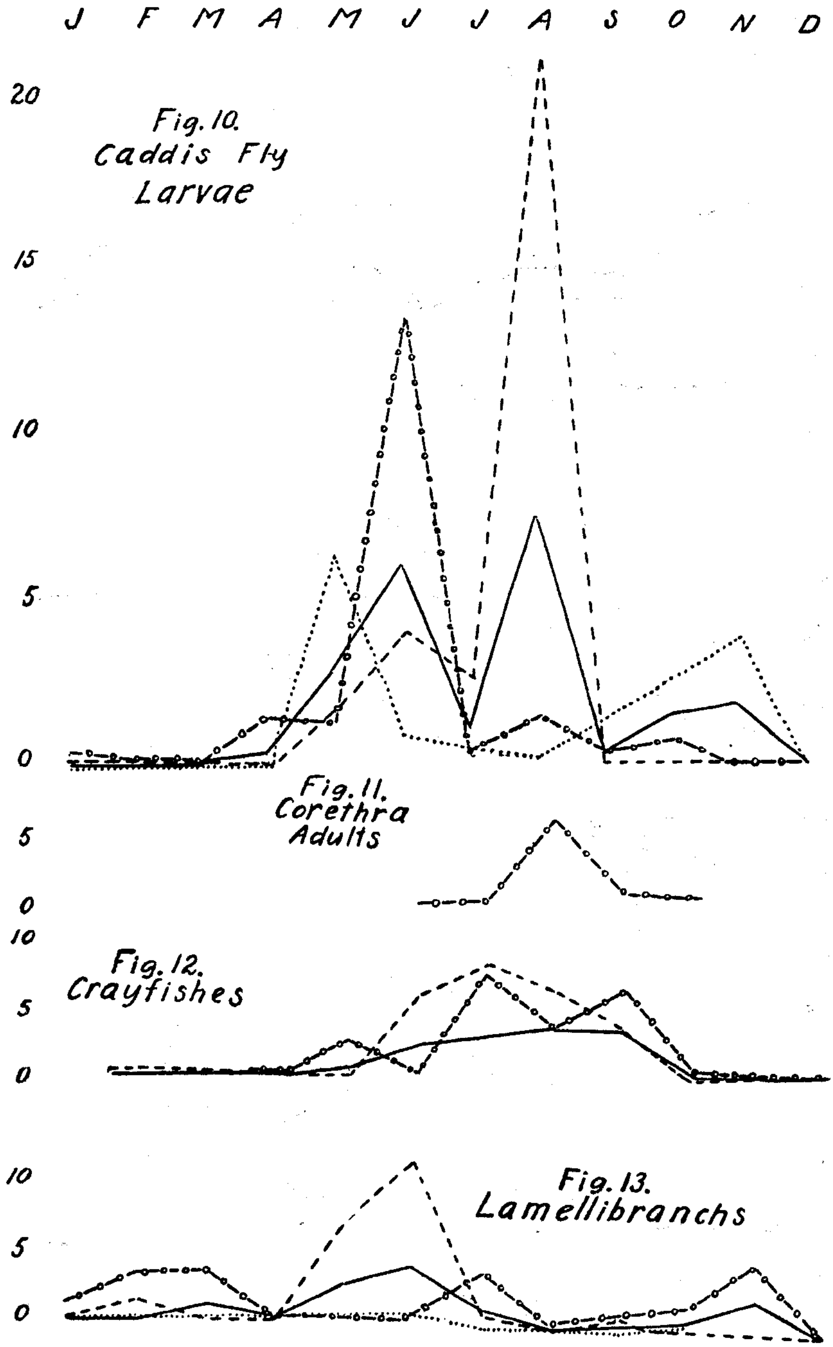
SEASONAL VARIATION.

Though the diet of perch is made up of the same general kinds of food throughout the year, there is considerable seasonal variation in all the important constituents, some of which are eaten only during certain months. The seasonal appearance of various items as constituents of perch food is represented graphically in figures 6 to 30, the curves showing the fluctuations in each throughout the year. From a study of these the annual food cycle may be outlined somewhat as follows: Perch at all seasons feed largely on or near the bottom. During the spring they come inshore, probably chiefly for breeding, and feed more or less among the aquatic vegetation. This is indicated by the rise in the percentages of plants, gastropods, Corethra larvæ, silt, and fine débris in the food at that time. In summer perch leave the deep water on account of its stagnation and feed on the bottom near the thermocline, as is indicated by the increase of chironomid larvæ, crayfishes, and midge pupæ in the diet. After the autumnal overturn the perch return to deep water and feed largely on Cladocera and Corethra larvæ. During the winter they remain in the depths of the lake, as shown by the preponderance of cladocerans, silt and débris, chironomid larvæ, and Sialis larvæ.

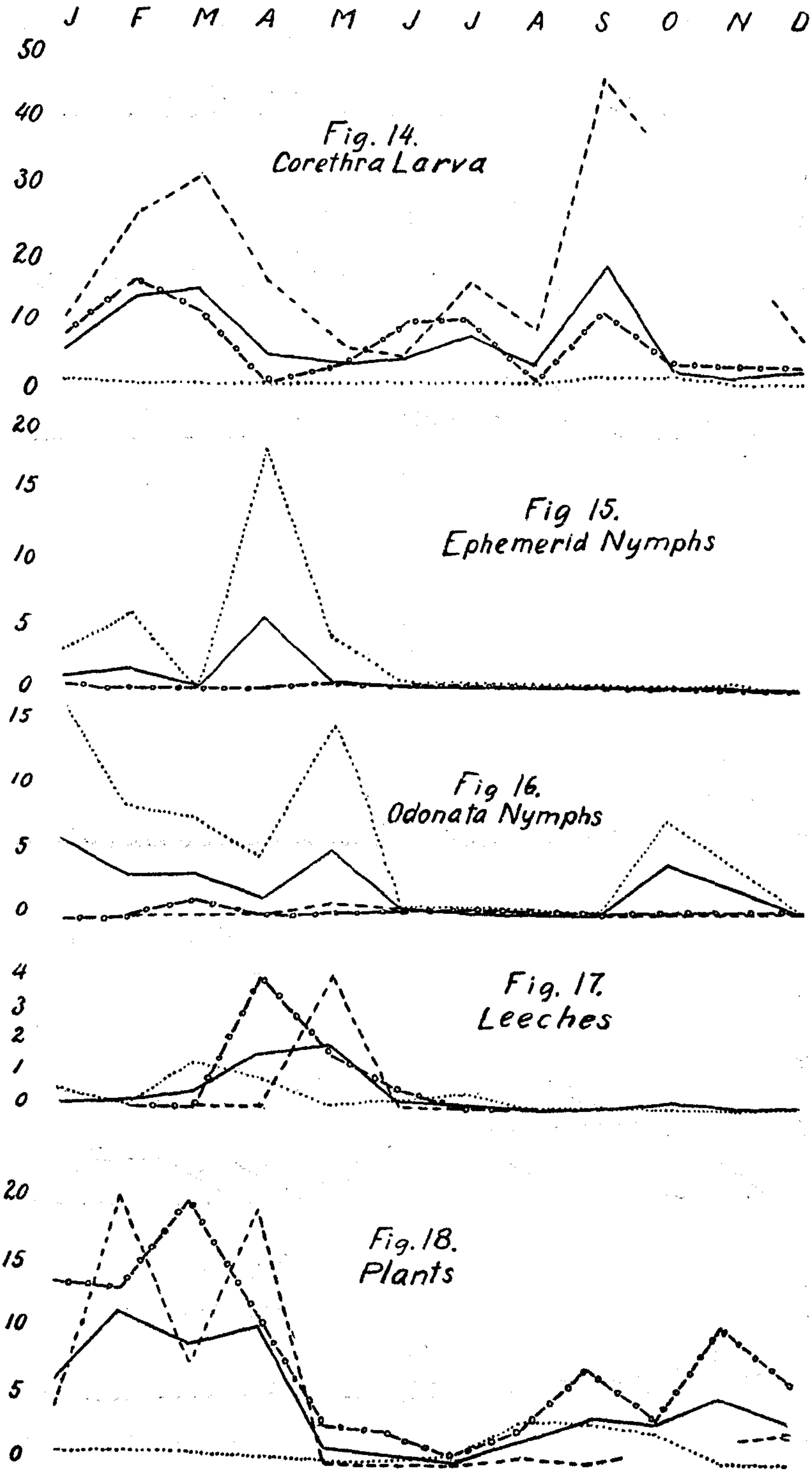
Some foods (like Corethra and chironomid adults, crayfishes, Corethra and chironomid pupæ, mites, and ostracods) were eaten only during the warmer months; some (copepods, oligochætes, algæ) were eaten throughout the year in small quantities; other foods (Corethra larvæ, chironomid larvæ, Cladocera, silt and débris, Sialis larvæ, etc.) appeared at all seasons but showed rather striking maxima during certain months. The time at which a particular food was taken in greatest quantity often coincided with



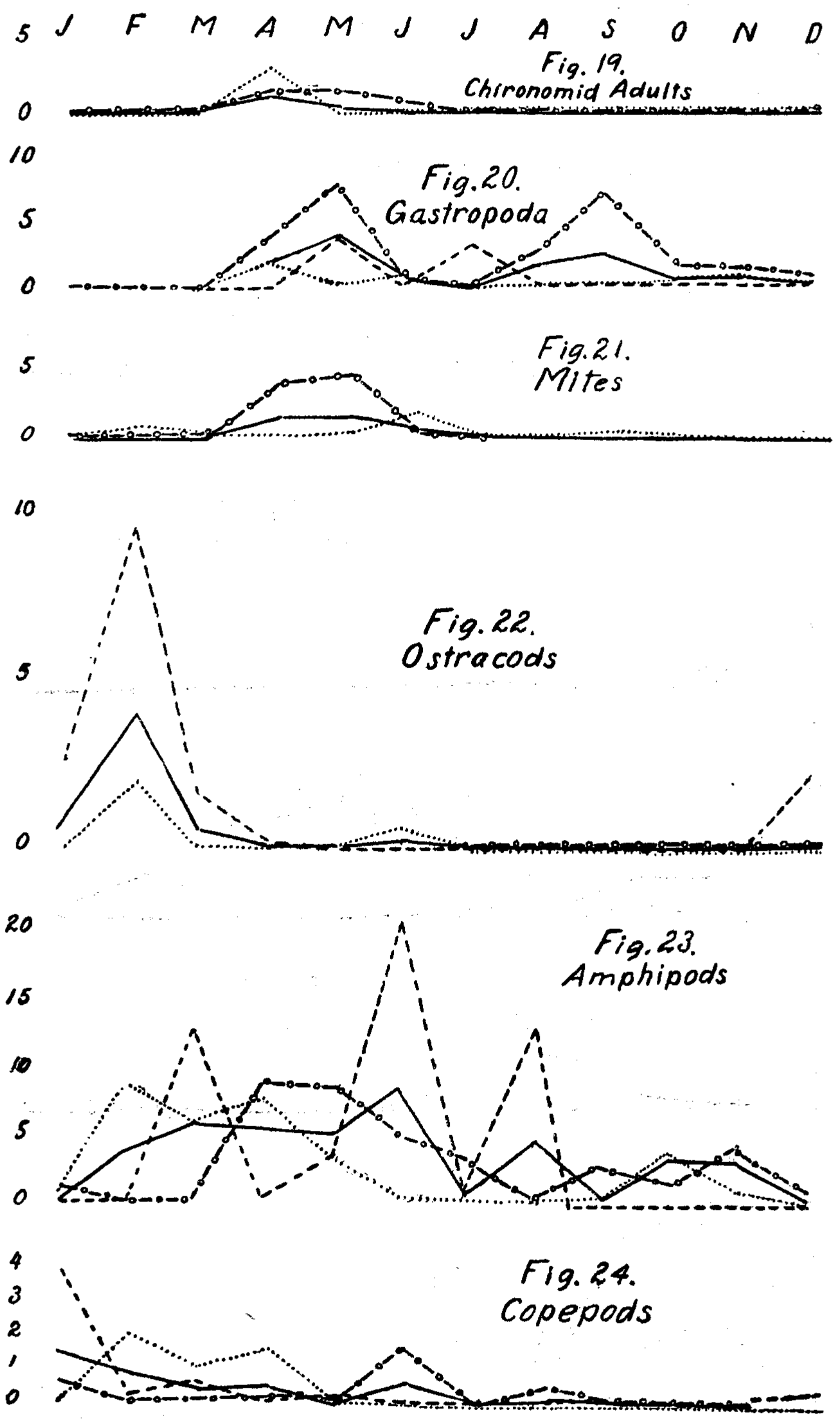
FIGS. 6 TO 9.—Percentage by volume of four constituents of perch food which increased markedly in the summer. -o-o-o-, Lake Mendota, 1915; - - - - - -, Lake Mendota, 1916; . . . . . ., Lake Wingra, 1916–17; ———, average.



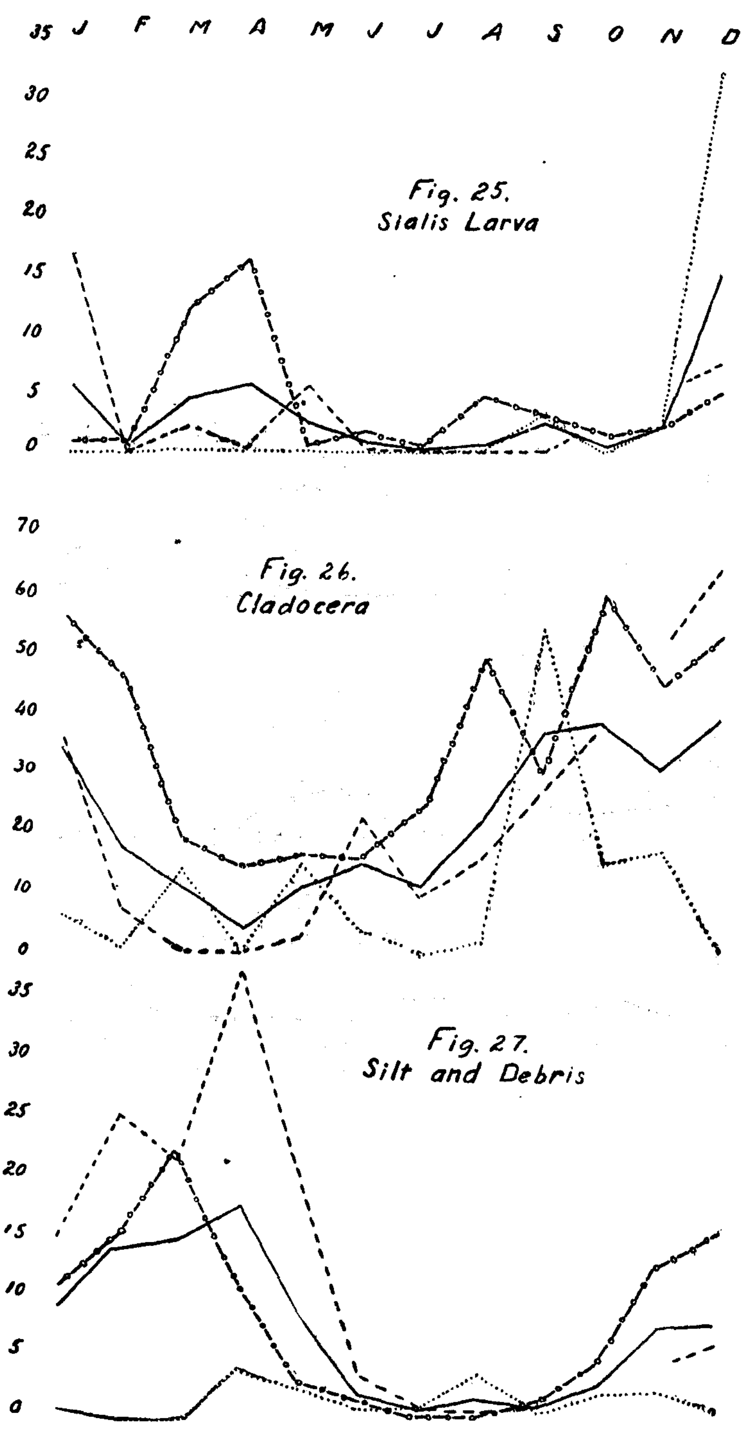
FIGS. 10 to 13.—Percentage by volume of four constituents of perch food which increased markedly during the summer. -o-o-o-, Lake Mendota, 1915; - - - - - -, Lake Mendota, 1916; . . . . . ., Lake Wingra, 1916–17; ———, average.



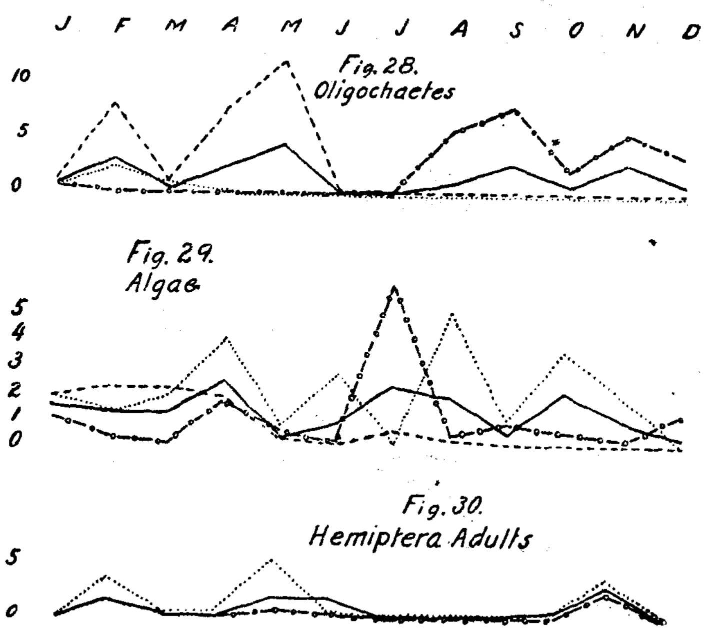
FIGS. 14 to 18.—Percentage by volume of five constituents of perch food which increased markedly during the spring or autumn. -o-o-o-, Lake Mendota, 1915;, - - - - - -, Lake Mendota, 1916; . . . . . ., Lake Wingra, 1916–17; ———, average.



FIGS. 19 to 24.—Percentage by volume of six constituents of perch food. -o-o-o-, Lake Mendota, 1915; - - - - - -, Lake Mendota 1916; . . . . . ., Lake Wingra, 1916–17; ———, average.



FIGS. 25 to 27.—Percentage by volume of three constituents of perch food which increased in amount in the winter. -o-o-o-, Lake Mendota, 1915; - - - - - -, Lake Mendota, 1916; . . . . . ., Lake Wingra, 1916–17; ———, average.



FIGS. 28 to 30.—Percentage by volume of three constituents of perch food. o-o-o-, Lake Mendota, 1915; - - - - - -, Lake Mendota, 1916; . . . . . ., Lake Wingra, 1916–17; ———, average.

its period of greatest abundance (adult midges, midge pupæ), but in other cases there was no such correlation. In the autumn the number of cladocerans in Lake Mendota increased (Birge, 1897), and the quantity eaten by perch also increased, but during the vernal cladoceran increase the opposite was true. Although copepods rivaled cladocerans in abundance at certain seasons they were never eaten in large quantities, probably because they are active, small, and do not collect in swarms to any extent, as cladocerans do.

The following list gives the number of perch out of the 1,147 examined which ate each constituent of the food; the percentage of the total which each constituent formed when it was 1 per cent or more; and the occurrence of the constituents throughout the year. All figures in parentheses mean percentage of total food by volume; figures outside parentheses indicate the number of fish eating each food.

FISH (4.5), all year:
- Fish eggs—
  - Unidentified, 2, April.
  - Cisco eggs, 1, November.
  - Perch eggs, 4, April.
  - Sucker eggs, 4, May.
- Fish remains—
  - Unidentified remains (3.9), 85, March to November.
  - Abramis chrysoleucas, 1, October.
  - Eucalia inconstans, 1, February.
  - Lepomis incisor, 6, January, February.
  - Notropis heterodon, 1, February.

INSECT LARVÆ (38.3), all year:
- Diptera larvæ (32.7)—
  - Unidentified chironomid larvæ (5), 148, all year.
  - Chironomus abbreviatus, 10, May to September.
  - C. decorus (8.3), 288, all year.
  - C. fulviventris (1.7), 86, all year.
  - C. lobiferus, 62, all year.
  - C. modestus, 3, April.
  - C. tentans (2), 28, October to February.
  - C. viridicollis, 7, October, December.
  - C. viridis, 1, August.
  - C. sp. 82 Johannsen, 1, May.
  - C. sp. 83 Johannsen, 3, May.
  - Corethra punctipennis (5.6), 329, all year.
  - Cricotopus trifasciatus, 7, April, May.
  - Orthocladius sp., 3, July, March.
  - O. nivoriundus, 2, July.
  - Palpomyia longipennis, 6, May, July.
  - Probezzia glaber, 12, April to July.
  - Probezzia pallida, 14, April to July.
  - Procladius sp., 29, March.
  - Protenthes choreus (3), 166, all year.
  - P. culiciformis, 2, August.
  - Stratiomyia sp., 1, June.
  - Tanypus sp., 37, all year.

INSECT LARVÆ—Continued.
- Diptera larvæ—Continued.
  - T. carneus, 7, April, May.
  - T. decoloratus, 6, April, May.
  - T. monilis, 20, July, November.
  - Tanytarsus dives, 15, March to May.
  - Tanytarsus sp., 2, March.
- Ephemerid nymphs (1)—
  - Mayfly sp., 32, all year.
  - Bætisca sp., 22, March to May.
  - Cænis diminuta, 9, May to September.
  - Callibætis sp., 18, April to May.
  - Ecdyurus maculipennis, 1, June.
  - Ephemerid sp., 14, May, June.
  - Heptagenia interpunctata, 1, June.
  - Siphlurus sp., 1, May.
- Odonata nymphs (1.4)—
  - Damselfly sp., 34, all year.
  - Argia sp., 1, May.
  - Enallagma antennatum, 19, May to July.
  - E. hageni, 28, March to July.
  - E. pollutum, 6, May.
  - Ischnura verticalis, 9, March to June.
  - Dragonfly sp., 7, November to July.
  - Anax junius, 2, March, July.
  - Libellula sp., 1, April.
  - Nehalenna irene, 1, April.
  - Sympetrum, 3, October.
- Trichoptera larvæ (1.5)—
  - Agraylea multipunctata, 10, June, July.
  - Hydroptila, 3, June, August.
  - Leptocella uwarowii, 17, March to September.
  - Leptocerus sp., 5, June to November.
  - Leptocerus dilutus, 7, May, August.
  - Molanna uniophila, 5, July, August.
  - Orthotrichia, 1, October.
  - Platyphylax subfasciatus, 2, May, August.
- Neuroptera larvæ (1.7)—
  - Sialis infumata (1.7), 75, all year.

INSECT LARVÆ—Continued.
- Coleoptera larvæ—
  - Carabus, 1, July.
  - Parnid, 1, March.
  - Pelocaris femoratus, 1, June.
- Hemiptera nymphs—
  - Plea minutissima, 1, July.

INSECT PUPÆ (8), all year:
- Corethra punctipennis, 12, August, September.
- Chironomus sp. (3), 128, all year.
- C. decorus (3.5), 139, April to October
- C. digitatus, 2, July.
- C. fulviventris, 18, March to May.
- C. lobiferus, 26, March to November.
- C. viridis, 1, July.
- Palpomyia sp., 4, August.
- Probezzia glaber, 2, August, September.
- P. pallida, 1, August.
- Protenthes choreus, 22, April to June.
- Tanypus sp., 7, June.
- T. carneus, 4, May.
- Tanytarsus dives, 13, March, April.

ADULT INSECTS (1.5), all year:
- Ammophila sp., 2, August, October.
- Aphodius inquinatus, 2, April, May.
- Brachonid sp., 1, July.
- Camponotus, 1, May, August.
- Carabid, 1, April.
- Chironomus sp., 13, April to November.
- C. plumosus, 2, April.
- Corethra punctipennis, 7, July, August.
- Collembolid, 1, July.
- Corixa, 40, February to November.
- Enchenopa binotata, 1, July.
- Heterocerus sp., 1, April.
- Lachnosterna, 1, May.
- Noctuid sp., 1, July.
- Platyphylas subfasciatus, 1, August.
- Sawfly, 1, April.
- Scarabæid, 1, April.

ARACHNIDA, February to September:
- Arrhenurus, 7, May.
- Atax turgidus, 2, June.
- Limnesia, 15, May to July.
- Mites, unidentified, 17, February to September.
- Spider, 1, June.

AMPHIPODA (4.3), all year:
- Dikerogammarus fasciatus, 9, February to September.
- Gammarus limnæus, 4, March.
- Hyalella azteca (4.1), 232, all year.

ISOPODA: Asellus communis, 4, February, March.

DECAPODA, (1.2), May to August:
- Cambarus propinquus, 8, May to July.
- C. virilis, 1, July.
- Crayfish, unidentified, 16, May to August.

ENTOMOSTRACA (21.4), all year:
- Cladocera (20)—
  - Acroperus, 6, June, July.
  - Bosmina, 7, July.
  - Ceriodaphnia, 13, May to August.
  - Chydorus sphæricus, 29, February to October.
  - Daphnia longispina hyalina (9.8), 215, all year.
  - D. pulex (1.2), 42, June to December.
  - D. retrocurva, 8, September.
  - Diaphanosoma, 6, July, August.
  - Eurycercus lamellatus (1.2), 95, all year.
  - Leptodora, 135, all year.
  - Pleuroxus procurvatus, 5, July, January.
- Copepoda (1.1), all year—
  - Canthocamptus, 1, June.
  - Cyclops albidus, 2, March.
  - C. bicuspidatus (1), 86, all year.
  - C. fuscus, 3, January.
  - C. leuckarti, 2, August.
  - C. viridis, 1, July.
  - Diaptomus, 1, July.
  - Nauplii, 2, June.
- Ostracoda, 52, all year.

BRYOZOA:
- Statoblast, 1, September.
- Pectenella, 3, February, August.

MOLLUSCA (2. 4), all year:
- Amnicola, 13, June to November.
- Campeloma, 10, May, June.
- Corneocyclas, 24, May to June.
- Limnæa, 2, June, October.
- Physa heterostropha, 41, all year.
- Planorbis, 12, January to October.
- Snail eggs, 1, September.
- Sphæridæ, 27, March to October.
- Sphærium occidentale, 9, January to October.
- Valvata tricarinata, 6, May.

OLIGOCHÆTA (1.4), February to September:
- Limnodrilus, 53, February to September.
- Tubifex, 2, June.

GORDIUS, 23, December to July.

HIRUDINEA, January to March:
- Unidentified leech, 11, May, July.
- Glossiphonia stagnalis, 4, January to March.
- G. complanata, 2, June.

PROTOZOA: Arcella, 1, April.

PLANTS (5.5), all year:
- Unidentified remains (4), 225, all year.
- Algæ, all year—
  - Unidentified, 7, April to September.
  - Aphanothece, 19, April, September.
  - Chara, 2, March, April.
  - Closterium, 1, April.
  - Desmids, 1, April.
  - Diatoms, 20, October to March.
  - Filamentous algæ, 121, all year.
  - Gelatinous algæ, 4, July.
  - Hydrodiction, 1, July.
  - Protococcus, 5, January, April.
  - Rivularia, 3, October.

PLANTS—Continued.
- Algæ, all year—Continued.
  - Spirogyra, 1, November.
  - Tabellaria, 1, November.
- Ceratophyllum, 1, January.
- Elodea, 5, March, September.
- Lemna, 8, May to December.
- Plant leaves, 7, May to July.
- Plant seeds, 12, May to March.
- Potamogeton, 3, May to October.
- Vallisneria, 1, October.
- Wolffia, 2, June.

$CaCO_3$ CRYSTALS, 17, February to April.[a]

SILT AND DÉBRIS (6.1), 276, all year.

QUANTITY OF FOOD CONSUMED AND RATE OF DIGESTION.

After the constituents of perch food had been ascertained and their percentages by volume determined, it became necessary, in order to gain some idea of a perch's food requirements from day to day, to find out how much it could consume in a given time and how fast digestion progressed. With such purposes in mind, a medium-sized perch (weight, 48 g.; volume, 50 c. c.) was placed in a 5-gallon spherical glass aquarium and fed all it would eat from June 19 to July 20, 1916. The results of these experiments are shown in Table 13. Similar experiments were carried out later on smaller and larger fish and are in part summarized in Tables 11 to 15. The largest perch under observation were three individuals weighing about 247 g. and having volumes of about 250 c. c. They were tested from December 18, 1916 to January 23, 1917, and ate only a few Dikerogammarus, although they were offered the same foods as smaller fishes tested at the same time (Tables 12 and 14). This agrees with the observations of Knauthe (1907), who stated that large carp usually would not eat when the temperature was below 6 to 8° C.

As to the volume of the food in proportion to the bulk of the perch eating it, we have only a few observations. Table 13 shows that a perch displacing 50 c. c. of water ate the following percentages of its own volume per hour when given more than it consumed: Damselfly nymphs, 0.3 per cent; snails, 0; minnows, 0.46 per cent; earthworms, 0.32 per cent. On January 12, 1917, a perch having a volume of 2.1 c. c. ate a minnow (*Pimephales notatus*) which had a bulk of about 0.7 c. c. Reighard (1915, p. 237) gives instances where adult perch ate other individuals of their own species which were almost as large as themselves.

The tables show that the same foods were digested more rapidly by small than by large perch and that, when fish of similar size ate at different temperatures, digestion was slower at lower temperatures. To take a concrete illustration: A perch about 62 mm. long ate seven chironomid larvæ (having a volume of 0.3 c. c.) at 2.5° C. and digested them in 43.7 hours; the same individual at 16° C. ate 0.84 c. c. of chironomid larvæ and digested them in 22 hours. A perch measuring 30 c. c. in volume ate 78 chironomid larvæ (having a volume of 4.2 c. c.), digesting them in 46.5 hours at 2.5° C. At 24° C. this perch ate 26 damselfly nymphs (no chironomid larvæ were available) having a volume

[a] On Nov. 23, 1917, calcium carbonate crystals were found in one of three perch caught at a depth of 2.5 m. in Lake Mendota.

of 2.5 c. c. and digested them in 23 hours. Taking as a basis for calculation Muttkowski's (1918) estimate of the number of chironomid larvæ in shallow water and recent studies of deep-water fauna by Birge and Juday, there are about 474,750,000,000 in Lake Mendota. The number of perch they would support may be computed roughly: A perch of medium size if eating nothing but chironomid larvæ would average about 4.2 c. c., or 78 individuals of various sizes, per day, which would amount to about 1,533 c. c., or 28,470 individuals per year. On such a basis the chironomid larvæ could support 16,675,447 perch per year.

Such methods of estimating are highly speculative at present but give some gross approximation as to the number of perch that might possibly live in Lake Mendota. After studies have been completed which are now being carried on by the Wisconsin Geological and Natural History Survey concerning the animal population of the various lake habitats and the chemical composition of animals which may serve as fish food, and after the writers have made more extensive experiments on the rate of consumption and digestion of different foods, it will be possible in a few years to speak with more authority concerning the productive capacity of lakes. Pütter (1909) has made careful studies of the food requirements of the smelt and herring, which he expresses in terms of copepods. He states that the smelt needs the following numbers of copepods daily during its first season: May 6 to 29, 124 (1 mg.); May 29 to July 29, 248 (2 mg.); July 29 to September 25, 496 (4 mg.). The herring needs: July 13 to 30, 3,300 (26.6 mg.); July 30 to September 20, 6,080 (49.9 mg.); September 20 to November 15, 4,470 (38.8 mg.). To keep in good condition the smelt would require 100 to 500 copepods daily during its growth period, and the herring 3,000 to 6,000.

Little is known concerning details of digestive processes in fishes. Denis (1912) has measured the amount and composition of urine given off by sharks and goosefishes. Knauthe (1898) states that the amount of nitrogen given off increases as the temperature of a fish rises. Greene (1914) has made interesting studies of the utilization of fat by the salmon during its migration. Pütter (1909) found that a goldfish would change the contents of its intestine more often if peristalsis was artificially stimulated by suspending fine sand in the water. He also analyzed the substance in the carp and found it to contain: Water, 78.85 per cent; dry substance, 21.16 per cent; albumen, 17.38 per cent; fat, 2.57 per cent; ash, 1.22 per cent; nitrogen, 2.91 per cent. Knauthe (1898) carried out extensive feeding experiments with carp. He states that, when no protein was fed, carp slowly became unable to digest pure starch, 10 times the usual amount of nitrogen being given off in the excreta. However, if protein was fed after a long period of exclusive carbohydrate diet, starch was again normally digested. Old fish did well when fed nothing but rice meal, and Knauthe believed this was because the proteins in the gonads were utilized. Fish died on an exclusive diet of lean meat. Ability to digest starch was lowered by deficiency of minerals in the diet. Pütter (1909) states that it was impossible to rear smelt, herring, or carp when they were fed nothing but small crustacea. About the only generalization that can be made from the facts reviewed is that some variety is apparently necessary in fish diet.

In the present work no essentially new contribution has been made to digestive processes in fishes, except for the points already reviewed relating to amounts consumed and the rate of digestion at different temperatures. These observations agree with those of Knauthe (1907) and Fibich (1905). One other interesting fact was noted. During

February, March, and April, 1916, the perch in Lake Mendota and the crappies in Lake Wingra had considerable amounts of beautifully regular calcium carbonate crystals (which were usually embedded in a brownish, amorphous matrix) in their intestines. The food of 10 perch examined on each of the following dates contained the amount of crystals indicated: February 1, 0.5 per cent; March 1, 8.1 per cent; March 29, 12.3 per cent; April 14, 1.2 per cent; April 28, 2 per cent. At the same time the crappies (*Pomoxis sparoides*) in Lake Wingra showed the following amounts: March 11, 4 per cent; March 18, 0.2 per cent; April 22, 0.2 per cent; but the intestines of the perch in Lake Wingra contained none. Two of the perch from Lake Mendota examined on March 29 contained 30 per cent of the calcium crystals. The remainder of the food in one of these consisted of 45 per cent silt and bottom débris, 5 per cent chironomid larvæ, 1 per cent Corethra larvæ, 17 per cent plant remains, 2 per cent filamentous algæ; in the other, of 35.9 per cent silt and débris, 30 per cent plant remains, 3 per cent Corethra larvæ, 1 per cent chironomid larvæ, 0.1 per cent gelatinous alga. Birge and Juday (1911, pp. 108, 171) analyzed the mud from the bottom and the crust from aquatic plants in Lake Mendota. The former contained, in percentages of dry weight, 33.21 per cent, and the latter, 47 per cent of calcium oxide. As has been previously stated, the perch feed largely inshore during February, March, and April, and the two individuals just cited, which showed a high percentage of crystals, also contained bottom mud and plant remains. The crystals may be accounted for on the supposition that calcium carbonat taken in through the mouth is dissolved in the stomach and that crystals form in t intestine as water is withdrawn during absorption.

VARIETY IN FOOD AND ADAPTABILITY IN FEEDING.

Knauthe (1907) pointed out that certain fishes, such as the trout and the p changed readily from one type of available food to another; but others, like the the smelt, and the lota, made such changes with difficulty and hence died more during scarcity of certain foods. The senior writer (1918) developed this id further in his studies of the shore fishes of Wisconsin lakes and also demonstrat different species of fishes manifest a rather marked degree of specificity in c food. Each species, even though it may be versatile, shows preferences for p foods, and some kinds of fishes select from a very limited number of foods certainly select specific foods from those available, and it is only by exa contents of their alimentary canals that preferences can be determined. foods are often apparently avoided in one lake by a particular fish, but th is eagerly eaten by it in another. As Knauthe (1907) says: "The value as food must be determined biologically even more than phenologically or

One example will illustrate the fact that different species show specifi On April 22, 1916, six species of fish were caught at the same time and Wingra, and an analysis of the food eaten gave the following results:

Ten breams (*Abramis chrysoleucas*) had eaten of *Chironomus decorus* larvæ, 3.5 per c sp.? larvæ, 2 per cent; *Cricotopus trifasciatus* larvæ, 2.6 per cent; mayfly nymphs, ronomid pupæ, 1 per cent; *Cricotopus trifasciatus* pupæ, 1.5 per cent; Hyalella, 0.1 pe 0.2 per cent; Canthocamptus, 1.5 per cent; Cyclops, 33.8 per cent; *Daphnia pul Chydorus sphæricus*, 5.1 per cent; *Bosmina longirostris cornuta*, 1.5 per cent; Physa, toria, 4.7 per cent; algæ, 0.1 per cent; flagellates, 0.2 per cent; Volvox, 0.7 per cen per cent; fine débris, 9.1 per cent.

Five crappies (*Pomoxis sparoides*) had consumed of *Chironomus fulviventris* larvæ, 24.2 per cent; mayfly nymphs, 13 per cent; Callibætis nymphs, 7.2 per cent; *Enallagma hageni* nymphs, 6 per cent; chironomid pupæ, 13 per cent; Corixa adults, 3.6 per cent; Hyalella, 3.2 per cent; ostracods, 1.3 per cent; Cyclops, 26 per cent; Daphnia, 2.6 per cent; Bosmina, 0.6 per cent; Eurycercus +; calcium carbonate crystals, 0.2 per cent.

Thirteen perch contained of fish eggs, 0.7 per cent; minnows, 8 per cent; fish remains, 7 per cent; insect larvæ, 1.5 per cent; Protenthes larvæ, 2 per cent; *Chironomus decorus* larvæ, 7.6 per cent; *C. fulviventris* larvæ, 38.2 per cent; *Probezzia pallida* larvæ, 0.5 per cent; caddisfly larvæ, 0.6 per cent; Callibætis nymphs, 7.8 per cent; *Enallagma hageni* nymph, 1.4 per cent; chironomid pupæ, 6 per cent; Hyalella, 1.5 per cent; ostracods, +; Eurycercus, 0.1 per cent; Physa, 6.5 per cent; Planorbis, 0.2 per cent; Pleurococcus, +; Chara, 1.4 per cent; fine débris, 8 per cent.

Though the perch is versatile, it selects preferred foods from the environment, and preferences apparently vary more or less at different ages, seasons, and localities. The staple articles of diet for adult perch throughout the year are chironomid larvæ and cladocerans, but with changing seasons there may be great variation in the proportions of either. Furthermore, perch of the same size caught at the same time and place have usually eaten the same kinds of food, but at times have not. As a rule the nature of the food indicates that it was secured on or near the bottom, but schools of perch are sometimes seen feeding at the surface of the lake. This is particularly true in the early morning.

Judged by the success of line fishing, feeding is largely diurnal, for few perch can 'e caught at night. This indicates also that perch depend upon their sense of sight a marked degree, and this view has been supported through the observation of lividuals fed in glass aquaria.

In order to discover whether adult perch ate different foods at various depths, parisons have been made which include all catches in Lake Mendota. These are narized in Tables 16 and 17. The first shows the percentage of food at different is; the latter, the kinds of foods which exceeded all others in volume. Both show: (1) That food is more varied in shallow water and that it consists largely onomid larvæ, Corethra larvæ, Daphnia, Corneocyclas, and bottom mud in the parts of the lake; (2) that the following foods decrease in amount eaten in from shallow to deep water—small fishes, mites, adult insects, crayfishes, copepods, snails, leeches; (3) that the following foods increase in passing llow to deeper water—insect larvæ, insect pupæ, bottom mud, Cladocera, s, oligochætes, plants; and (4) that in general the perch have eaten the a are most abundant at the depth where they are caught. This indicates not change rapidly from one stratum to another; that is, there are usually tical migrations.

that insect pupæ, largely those of midges, are eaten mostly in deep water t they are secured in the bottom mud before beginning their migration . Plants occur in greater amounts in perch from deeper water, and this cause remains of plants which have been washed loose and broken up by arranged as to be lying upon the bottom. Deposits of such plants are s for insect larvæ. The tables just cited and evidence from many other hat the perch usually feed on or near the bottom.

st in the food of perch from different depths may, perhaps, best be following specific instances where individuals were caught at the same

JULY 1, 1915.

Depth, 18.3 m.; number examined, 9. Food—*Chironomus decorus* larvæ, 21 per cent; *Protenthes choreus* larvæ, 12.4 per cent; *Corethra punctipennis* larvæ, 15 per cent; *Chironomus decorus* pupæ, 21.6 per cent; *Corethra punctipennis* pupæ, 0.5 per cent; mites, 0.1 per cent; ostracods, 0.1 per cent; *Daphnia hyalina*, 13.3 per cent; *Corneocyclas idahoensis*, 8.3 per cent; Hyalella, 0.5 per cent; Gordius (from chironomid larvæ), 6.4 per cent.

Summary.—Midge larvæ, 48.4 per cent; midge pupæ, 22.1 per cent; mites, 0.1 per cent; ostracods, 0.1 per cent; cladocerans, 13.3 per cent; clams, 8.3 per cent; amphipods, 0.5 per cent; Gordiacea, 6.4 per cent.

Depth, 15 m.; number examined, 5. Food—*Chironomus decorus* larvæ, 14 per cent; *Corethra punctipennis* larvæ, 9.4 per cent; *Protenthes choreus* larvæ, 6 per cent; *Chironomus decorus* pupæ, 33 per cent; *Protenthes choreus* pupæ, 7.6 per cent; *Daphnia hyalina*, 10 per cent; Sphaeriidæ, 14 per cent; Gordius, 4 per cent.

Summary.—Insect larvæ, 29.4 per cent; insect pupæ, 40.6 per cent; cladocerans, 10 per cent; clams, 14 per cent; Gordiacea, 4 per cent.

Depth, 4 m.; number examined, 5. Food—Minnows, 19.4 per cent; Chironomus unidentified larvæ, 5.6 per cent; *Chironomus abbreviatus* larvæ, 1 per cent; *Corethra punctipennis* larvæ, 2 per cent; *Chironomus decorus* pupæ, 1 per cent; *Cambarus propinquus*, 36 per cent; Hyalella, 9 per cent; *Eurycercus lamellatus*, 1 per cent; *Physa heterostropha*, 16 per cent; Planorbis, 0.4 per cent; leech, 9 per cent.

Summary.—Fish, 19.4 per cent; midge larvæ, 8.6 per cent; midge pupæ, 1 per cent; crayfishes, 36 per cent; amphipods, 9 per cent; cladocerans, 1 per cent; snails, 16.4 per cent; leech, 9 per cent.

MAY 12, 1916.

Depth, 0.5 m.; number examined, 5. Food—Sucker eggs, 21.8 per cent; *Chironomus decorus* larvæ, 1 per cent; *C. fulviventris* larvæ, 1.6 per cent; *Enallagma antennatum* nymphs, 3 per cent; Argia nymph, 1 per cent; *Leptocerus ancylus* larvæ, 8 per cent; *Sialis infumata* larvæ, 16.9 per cent; *Hyalella azteca*, 0.8 per cent; *Physa heterostropha*, 8 per cent; *Nephelopsis obscura*, 19 per cent; bud scale, 0.4 per cent; Lemna, 1.5 per cent; filamentous algæ, 2 per cent; sand, 13 per cent; débris, 2 per cent.

Summary.—Fish eggs, 21.8 per cent; insect larvæ, 31.5 per cent; amphipods, 0.8 per cent; snails, 8 per cent; leeches, 19 per cent; plants, 3.9 per cent; sand, 13 per cent; débris, 2 per cent.

Depth, 4 m.; number examined, 2. Food—Perch eggs, 99.7 per cent; *Chironomus decorus* larvæ, 0.1 per cent; *Sialis infumata* larvæ, 0.1 per cent.

Depth, 7 m.; number examined, 3. Food—*Chironomus decorus* larvæ, 51.6 per cent; *Protenthes choreus* larvæ, 21.7 per cent; *Corethra punctipennis* larvæ, 4.7 per cent; *Sialis infumata* larvæ, 15 per cent; *Amnicola limosa*, 1.3 per cent; leech, 5 per cent; fine mud, 0.7 per cent.

Summary.—Insect larvæ, 93 per cent; snails, 1.3 per cent; leeches, 5 per cent; mud, 0.7 per cent.

Depth, 15 m.; number examined, 3. Food—*Chironomus decorus* larvæ, 8.3 per cent; *Protenthes choreus* larvæ, 8.3 per cent; *Corethra punctipennis* larvæ, 2 per cent; *Leptocerus ancylus* larvæ, 1.3 per cent; *Sialis infumata* larvæ, 5 per cent; oligochætes, 28.3 per cent; bottom mud, 46.7 per cent.

Summary.—Insect larvæ, 24.9 per cent; oligochætes, 28.3 per cent; bottom mud, 46.7 per cent.

Depth, 17 m.; number examined, 3. Food—*Chironomus decorus* larvæ, 18.7 per cent; *Protenthes choreus* larvæ, 8.7 per cent; *Corethra punctipennis* larvæ, 1 per cent; oligochætes, 46.7 per cent; *Corneocyclas idahoensis*, 0.7 per cent; bottom mud, 24.3 per cent.

Summary.—Insect larvæ, 28.4 per cent; oligochætes, 46.7 per cent; clams, 0.7 per cent; mud, 24.3 per cent.

Except for the food of a few young perch and for the comparison (p. 319) between the examinations in Lakes Wingra and Mendota, no particular studies have been made of the perch from different lakes. It is probable that the feeding habits are rather uniform, but the food varies according to conditions in different localities.

VARIATION IN FOOD AT DIFFERENT AGES.

In order to determine what foods were eaten by young perch during the first summer after they hatched, collections were made with a minnow seine at intervals during 1916 in shallow water east of the base of Picnic Point in Lake Mendota. The results of the food examinations are summarized in Table 18. The perch were very uniform as to size, and it will be noted that the average length showed a regular increase as the season advanced. The table shows that Cyclops, other small crustaceans, and minute insect larvæ are replaced to a large extent by Hyalella and good-sized insect larvæ as the perch increase in size.

To compare the food of the perch summarized in Table 18 with the food of those from another place in Lake Mendota on a date close to one of those utilized in the usual locality, 10 small perch were collected from the mouth of Six Mile Creek on August 8, 1916. They had eaten of *Tanypus monilis* larvæ, 2.5 per cent; *Chironomous lobiferus* larvæ, 7.8 per cent; mayfly nymphs, 18.5 per cent; Bætis nymphs, 8 per cent; *Cænis diminuta* nymphs, 23.4 per cent; Corixa nymphs, 16.3 per cent; *Chironomus lobiferus* pupæ, 13.1 per cent; *Hyalella azteca*, 10.3 per cent; ostracods, +. If these results be compared with those for August 7, in Table 18, it is apparent that only three of the same items have been eaten in the two localities, yet there is general similarity. About the same types of foods are eaten in about the same proportions.

Through the kindness of A. R. Cahn we were able to examine small perch from Oconomowoc Lake. Though the individuals were more variable in size than those examined in Lake Mendota, the same food changes are evident (Table 19). Small insect larvæ and entomostracans are succeeded by larger larvæ and Hyalella.

If these two tables showing the food of small perch are compared with Table 9, which gives the results for adults, it is evident that at the close of the first summer the food of the young has become like that of adults.

RATE OF GROWTH ON DIFFERENT FOODS.

To be of most significance, the determinations of the rate of growth should be made on perch of various ages at different temperatures. Knauthe (1898) performed experiments which indicated that metabolism is more rapid in young fish than in old and that more protein food is necessary during youth. Older fish need apparently more mineral than young. Pütter (1909) says that the smelt and herring require nearly twice as much food after growing for a month. He found that a carp after two summers weighed about 500 g. and that it would increase to 1,250 g. by the middle of the next August. In this paper it has already been shown that digestion is more rapid in perch at higher temperatures (p. 313).

We have been able to test the rate of growth in perch of one size only and at one temperature. From August 19 to September 18, 1916, when the temperature of the water varied from 20 to 16.8° C., 26 small perch were placed in separate glass jars having a capacity of 4 liters each, and in lots of 3 were fed, as follows:

1. Fish liver and flour mashed and mixed together.
2. *Hyalella azteca* alive.
3. Plankton fresh from Lake Mendota. It consisted of Daphnia, 95 per cent; Leptodora, 4.5 per cent; algæ, chiefly Lyngbya, 0.5 per cent.
4. Earthworms alive.

5. Insects—Corixa, Plea nymphs, Notonecta nymphs, damselfly adults, crickets, midges.
6. *Chironomus decorus* larvæ alive.
7. Fish cut into small pieces.
8. "Normal" diet, consisting of all the kinds of food fed under 1 to 6, but no single one in large enough quantity to give complete satisfaction by itself. The two jars in which these fish were kept contained also Elodea.
9. Starved.

The fish ate all classes of food readily except the insects. Although Corixa and other varieties which occurred in perch of similar size in nature were offered, they were never taken in any quantity and were often refused altogether. The practice with all the foods was to change the water each morning and in midafternoon to add a fresh supply of food, which exceeded what might be eaten before the next day.

The results of these experiments are given in Table 20. The foods would come in the following order, as judged by the rate of gain in weight and volume: Earthworms, Entomostraca, chironomid larvæ, amphipods, fish, "normal," liver, and flour. The three perch fed adult insects lost almost as much as those which had nothing. It will be noted that there is no correlation between the gains in weight and volume. It is difficult to understand why the three "normal" individuals which were fed a variety did not gain as much as others which received only one kind of food during the entire month. Perhaps the extra energy required to digest a variety more than compensated for the diversity of chemical substances obtained.

COMPARISON OF FOOD OF PERCH IN LAKE MENDOTA AND IN LAKE WINGRA.

The fact that perch are individually smaller in Lake Wingra than in Lake Mendota is probably due to a number of causes, but one would naturally turn first to differences in food for an explanation of such variance. In Table 21 the various foods eaten by the perch in each lake is given by months. The averages show that fish, insect larvæ, insect pupæ, adult insects, isopods, and copepods are eaten in greater amounts in Lake Wingra than in Lake Mendota; the opposite is true of mites, crayfishes, amphipods, ostracods, cladocerans, snails, clams, leeches, oligochætes, plants, silt and débris, and $CaCo_3$ crystals. In all but two months in Lake Wingra, insects as larvæ, pupæ, or adults form half, or more than half, of the food. In Lake Mendota the months are equally divided, as regards the particular foods eaten in maximum amounts, between Cladocera and insect larvæ.

An examination of figures 6 to 29 will show many other minor differences in details between the two lakes. Among the insects the chironomids do not differ much, but Wingra excels in chironomid pupæ and in odonate and mayfly nymphs. Among the cladocerans the amount of Leptodora was about the same in the two lakes (4.6 to 4.7 per cent); Daphnia was in excess in Mendota (20.9 to 4.8 per cent), and Eurycercus in Lake Wingra (0.1 to 30.3 per cent).

Another difference between the perch in the lakes under consideration is shown in Table 22, which demonstrates that there are two seasons in Wingra when many of the perch have little or no food in them and only one in Mendota. The empty perch in April are doubtless due to the neglect of feeding on account of breeding. The fasting period in Wingra during August and September has no counterpart in Mendota and is equally characteristic of both sexes. It is probably due to the continued high temperature, from which there is no escape, as there is in Mendota, and to the extreme turbidity of the water. In late summer the water in Lake Wingra is murky with myriads of algæ. The perch are pale in color and apparently in poor condition.

The chief respect in which the perch of Wingra differ from those in Mendota, in regard to food, is (1) that they eat more insect larvæ and less of entomostracans, (2) that through most of the year they apparently feed more among water plants, and (3) that they have longer periods when little or no food is eaten.

COMPARISON OF FOOD OF PERCH AND CRAPPIE IN LAKE WINGRA.

From February to November, 1916, the food of crappies (*Pomoxis sparoides*) from Lake Wingra was studied, and the results for the nine months may be compared with those for perch. The total percentages of foods eaten by both was as follows, the perch being placed first in each case: Fish, 12.7 to 8.8; insect larvæ, 52.8 to 25.5; insect pupæ, 11.4 to 7.9; adult insects, 1.3 to 4.8; mites, 2 to +; amphipods, 0.3 to +; clams, 0.05 to 0; leeches, 0.2 to +; oligochætes, 0.1 to 0; plants, 3 to 0.4; débris, 1.2 to 1. In other words, the perch eats more of fish, insect larvæ, insect pupæ, mites, amphipods, snails, clams, leeches, oligochætes, plants and débris; the crappie more of adult insects, ostracods, copepods, cladocerans. These proportions clearly indicate that perch feed largely on or near the bottom, while crappies hunt more toward the surface and among water plants.

The structure of the crappie is more specialized than that of the perch and would indicate greater adaptation to particular conditions. Its mouth is more upturned, suggesting feeding toward the surface of the water, and the body is more compressed, indicating a habitat among aquatic vegetation. A full account of the observations on the crappies of Lake Wingra has already been published (Pearse, 1919).

RESPIRATION.

A perch must obtain the oxygen necessary for its metabolic activities from the water in which it lives. Water free to absorb gases from the atmosphere will contain about 35 per cent oxygen, 65 per cent nitrogen, and a trace of carbon dioxide. The total amount of gas which may be absorbed varies with the temperature of the water. At 0° C. a liter of water, when the pressure is 760 mm., can absorb 41.14 c. c. of oxygen, 1,796.7 c. c. of carbon dioxide, and 20.35 c. c. of nitrogen. At 20° C. the amounts will be: Oxygen, 28.38 c. c.; carbon dioxide, 901.4 c. c.; and nitrogen, 14.03 c. c.; at the boiling point of water none of the gases will be absorbed. When there are many living plants present, the amount of oxygen may rise above the saturation point; when oxygen is used up (decomposition, respiration, etc.), it may fall much below saturation or even be absent altogether. A perch, then, normally lives in water which may vary greatly in its gaseous content at different seasons.

Supersaturation with oxygen appears to offer no particular difficulties for fish, but when this gas is scanty there may be trouble in obtaining a sufficient supply for respiratory needs; yet some species are able to live in water containing a very small amount. Winterstein (1908) states that 0.7 c. c. of oxygen per liter was enough to sustain life in *Leuciscus erythropthalmus*, but when the amount was decreased as low as 0.4 to 0.5 c. c., death ensued. Most fishes show signs of distress when the oxygen is 1 to 4 c. c. per liter. In natural bodies of water the carbon dioxide usually increases as the oxygen decreases, but in amounts such as occur in nature its presence does not appear to be particularly detrimental, provided enough oxygen is also present. Winterstein (1908), however, thinks that fishes are affected by the presence of carbon dioxide, because some species succumb when its tension is only 8 to 12 per cent of the total pressure of gases; but he also found that in two instances as much as 144.7 and 204.6 c. c. per liter were required to overcome Leuciscus. Shelford and Allee (1913) conclude that the narcotic effect of carbon dioxide is more important for fishes than its action as an acid. Various species tested by them were affected injuriously when the amount present was from 5 to 37.5 c. c. per liter.

As a rule, four factors are of chief importance for the normal respiration of fishes: (1) Sufficient oxygen for metabolism, (2) lack of enough carbon dioxide to be injurious, (3) favorable temperature, and (4) proper reaction (salinity or acidity) of water. Though oxygen and carbon dioxide are the only gases which usually affect the respiratory activities of fishes, others may be of some importance at times. Methane and ammonia sometimes occur in certain restricted localities, and are injurious; nitrogen may, if present in unusual amount, give rise to the gas disease (Marsh and Gorham, 1905). But troubles from such gases are of rare occurrence. Gardner and Leetham (1914) have shown that a trout uses twice as much oxygen for respiration if the temperature of the water about it is raised from 10 to 20° C. Wells (1913) found that fish died more quickly in alkaline than in acid water when gas conditions were poor. Marsh (1910) asserts that fish will not live in well-aerated distilled water and that they are very susceptible to dilute solutions of mineral acids.

The respiration of fishes, then, requires reasonably pure water of proper chemical reaction and with a sufficient supply of oxygen. The experiments of Shelford and Allee (1913, 1913*a*) have demonstrated that fishes respond to the conditions in their environment in such a way as to spend most of their time in the optimum. Fishes are able to discriminate variations in the gas content of the water, and when placed in a graded series usually spend the most time where conditions are best. They are apparently more stimulated to turn away from unfavorable regions by the presence of carbon dioxide than by deficiency in oxygen, some turning back upon encountering 1.5 c. c. of carbon dioxide per liter. "We have in the experiments good evidence that fishes turn back from waters high in carbon dioxide and low in oxygen with precision and vigor. Also that if they enter such localities, they can not behave normally and may soon die."[a] Wells (1913) also has shown that fishes are most active when in water containing a scanty supply of oxygen and has demonstrated (1915) that a number of fresh-water species select slightly acid water in preference to that which is alkaline. He also asserts (1913) that the future will show that the reactions of fishes are of more importance than their resistance to unfavorable conditions. Death after reaching the vital limit is unusual, but the avoidance of conditions which may mean death is of frequent occurrence. The behavior of fishes is such that it would usually keep them in optimum conditions; yet Juday and Wagner (1908) found that lake trout commonly entered deep waters which contained so little oxygen that they could not live in them for any length of time. Paton (1902) also observed that brook trout which were kept in water containing very little oxygen were able to survive for some time by remaining inactive on the bottom and thus reducing their metabolism to a minimum. This brings us to the resistance of fishes to a marked deficiency in oxygen or to an unusually large amount of carbon dioxide.

[a] Shelford and Allee, 1913, p. 251.

Packard (1905, 1907, 1908) kept top minnows, *Fundulus heteroclitus*, in oxygen-free water and found that they were able to live about three hours. He believes that these fishes must get oxygen from other sources than the atmosphere. His experiments support Mathews' (1905) theory of respiration, which supposes that the oxygen of the atmosphere acts as a depolarizer and combines with nascent hydrogen produced during metabolism. If oxygen can be replaced by some other substance which will neutralize hydrogen, its presence is not necessary. Packard found that he could prolong the life of Fundulus in water which contained no oxygen by injecting carbohydrates into the body cavity. Wells (1913) determined that abundant oxygen and carbon dioxide was less injurious to fishes than a very small amount of both gases or than much carbon dioxide and little oxygen. He says (p. 345): "Oxygen in large amounts (10 c. c. per liter) antagonizes the detrimental effects of high carbon dioxide (50 c. c. per liter)." He also found that the most active fishes succumbed to a large amount of carbon dioxide before more sluggish individuals, and that oxygen deficiency was more quickly fatal when the water was alkaline than when it had an acid reaction. The observations just reviewed, then, indicate (1) that fish are able to live for some time in water without oxygen; (2) that lack of oxygen is generally more injurious than excess of carbon dioxide; and (3) that gas conditions unfavorable for respiration are more quickly fatal in water with an alkaline reaction.

The general resistance which fishes show to suffocation is in many species assisted materially by the use of the swim bladder as a storage reservoir for oxygen. This organ apparently serves various functions and in different fishes may be used as a lung, an organ for making sounds, a hydrostatic organ, and as a respiratory reservoir. Woodland (1911) proved the hydrostatic function by weighing fish after subjecting them to different pressures. The use of the bladder as a storage reservoir for oxygen has been the subject of a number of investigations. Tower (1902), for example, studied a number of marine fishes and found there were three gases present—oxygen, carbon dioxide, and nitrogen; that the amount of carbon dioxide might increase a little (0.25 per cent) during suffocation, but that it was usually 0.06 to 0.1 per cent of the total gases; and that the deeper the water from which fishes were taken, the higher the proportion of oxygen (in some fishes captured at considerable depths the gas in the bladder was practically all oxygen). Bridge (1891) showed that the secretion of gases into the swim bladder was under the control of the nervous system; and he found that there was usually an increase in the amount of carbon dioxide when the fish died of suffocation. The Cambridge Natural History states that in general the amount of oxygen in the bladder is less in fresh-water fishes than in those from the ocean. In fishes like the perch, in which the swim bladder has no duct connecting it with the outside, its functions are confined to storing reserve oxygen and regulating the specific gravity of the body (hydrostatic function). Finally, the density of the water in which fishes live affects respiratory activities. As pressure grows greater on account of increase in depth, the ability of the water to absorb gases is also increased. Furthermore, the comparative "hardness" or "softness" of water not only affects the density, but has a marked influence on the pressure of the gases present in solution. Sumner (1906) asserts that the membranes of fresh-water fishes are highly adapted to resist changes in density. There is an "irreducible minimum" of salts in the blood which is not released even when the surrounding water has a very low salt content. Garrey (1905) found the osmotic pressure of blood of marine fishes was about half that of sea water.

With this brief review of facts gleaned from literature on the respiration of fishes, the discussion will now be turned to the discoveries made during the present investigations in regard to the respiratory activities of the perch in Lake Mendota.

During the summer of 1915 it was noticed that many fish caught in gill nets in Lake Mendota were dead, and that there was a greater mortality in the region of the thermocline and below it than above (fig. 31; Table 2). Of 2,194 perch caught, 343 were dead and 1,154 alive above the thermocline; 610 dead and 87 alive below. This

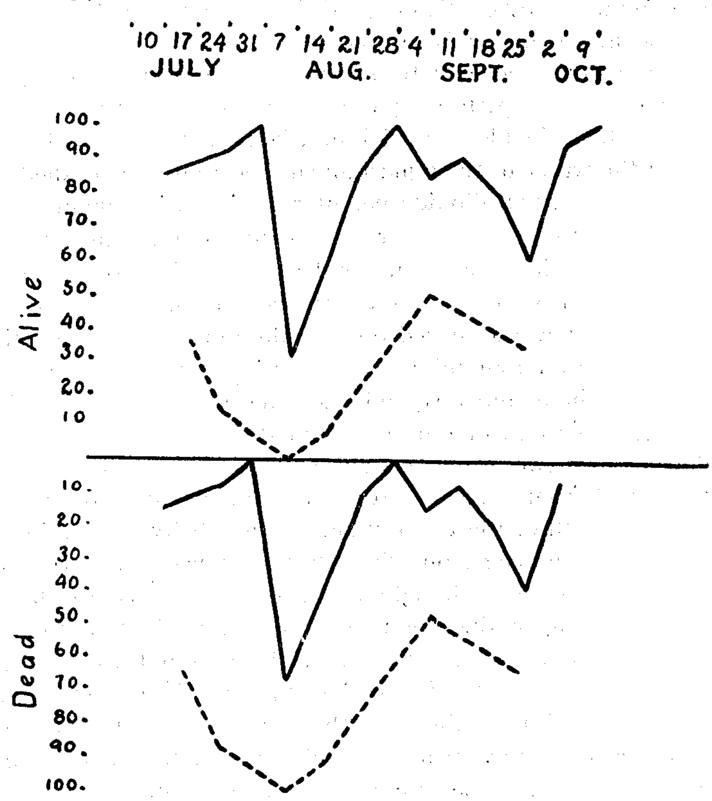


FIG. 31.—Percentage of perch caught alive or dead in gill nets above and below the thermocline, Lake Mendota, 1915. ——, above thermocline; - - - - - -, below thermocline.

indicated that perch commonly entered water which contained too little oxygen for respiration. During the summer of 1916 careful observations were again made, and the same results were obtained. Though perch were usually most abundant immediately above the thermocline, large catches often occurred just below it, where there was no oxygen.

The next problem was to discover how long perch could live in the oxygen-free water below the thermocline. Accordingly, from August 30 to September 4, 1916, when the amount of oxygen at a depth of 13.5 m. was 0.05 c. c. per liter and the carbon dioxide was 5 c. c. per liter, perch were let down into the stagnant region and left for various periods of time. The results of the experiments are shown as follows:

Hours submerged.	Perch used.	Perch surviving.	Hours submerged.	Perch used.	Perch surviving.
0.5 to 1	6	5	2 to 2.5	6	2
1 to 1.5	2	2	3	6	0
1.5 to 2	6	2	4	6	0

It will be observed that some perch lived for over two hours, but that none survived for three. This suggested that perch might be able to enter the lower waters of the lake with impunity to take advantage of the abundant food supply there, coming up above the thermocline at intervals to breathe.

This possibility made it necesary to observe the behavior of perch in water from below the thermocline. On September 4 water was pumped up from 13.5 m. (oxygen, 0.06 c. c. per liter; carbon dioxide, 5 c. c.) into a large aquarium on the deck of a boat. Samples taken from the water in the aquarium showed that it contained about 0.3 c. c. of oxygen and 5 c. c. of carbon dioxide per liter. Nine fish, caught in a gill net half an hour before at a depth of 11.6 m., were placed in the aquarium and their behavior observed for two hours. They were compared at intervals with perch caught at the same time and place, which were kept in a large cage at the surface of the lake. One of the fish in the stagnant water turned on its side and became immobile (except for respiratory movements) after four minutes. After half an hour several were lying on their sides, but after an hour and forty minutes one individual was still right side up and, though inactive, appeared to be in normal condition.

On the following day two perch, caught an hour before at 11.7 m., were again placed in water pumped from 13.5 m. into a glass aquarium, and their behavior was observed for an hour. Both of these individuals turned belly up within a few seconds; one floated at the top of the cage, but the other at times was at the bottom and at times at the top. At intervals both righted themselves, moved the fins, and wiggled about actively. After being in the stagnant water for an hour both were taken out and placed in the lake just below the surface. Half an hour later both had recovered, were right side up, and apparently in good condition. Two hours later both were released and swam away. During the time the perch were in the stagnant water the rapidity of their respiratory movements was observed, and the results, showing the number of respiratory movements per minute, are given as follows:

Time.	No. 1.	No. 2.	Time.	No. 1.	No. 2.	Time.	No. 1.	No. 2.
10.03	46	46	10.17	43	48	10.41	34	35
10.05	....	56	10.25	52	53	10.49	32	28
10.07	41.2	48	10.27	41	....	10.55	25	28
10.09	....	45	10.33	....	43	10.57	21	33
10.11	46	....	10.35	0	39	11.00	20	31
10.13	47	47	10.38	0	35			

One individual stopped making respiratory movements for over two minutes in the midst of the experiment. In general, the rate of respiration decreased, but when the fish were placed in the lake again the rate rapidly increased. The rate of those in the stagnant water was considerably less than that of those observed simultaneously in a cage in the open lake. But the water from 13.5 m. was cool (15° C.), and it would therefore be expected that the perch would respire at a slower rate than when in surface water (21.6° C.). In order to determine the normal rate of respiratory movements at different temperatures two healthy perch were observed in the laboratory on November 29, and the results are summarized as follows:

Temperature (degrees centigrade)	8	16	20	25
Movements per minute	24.1	38.5	45.6	59.3

The data indicate that the rapidity of the respiratory movements of the fish placed in stagnant water was not materially increased or decreased by such treatment.

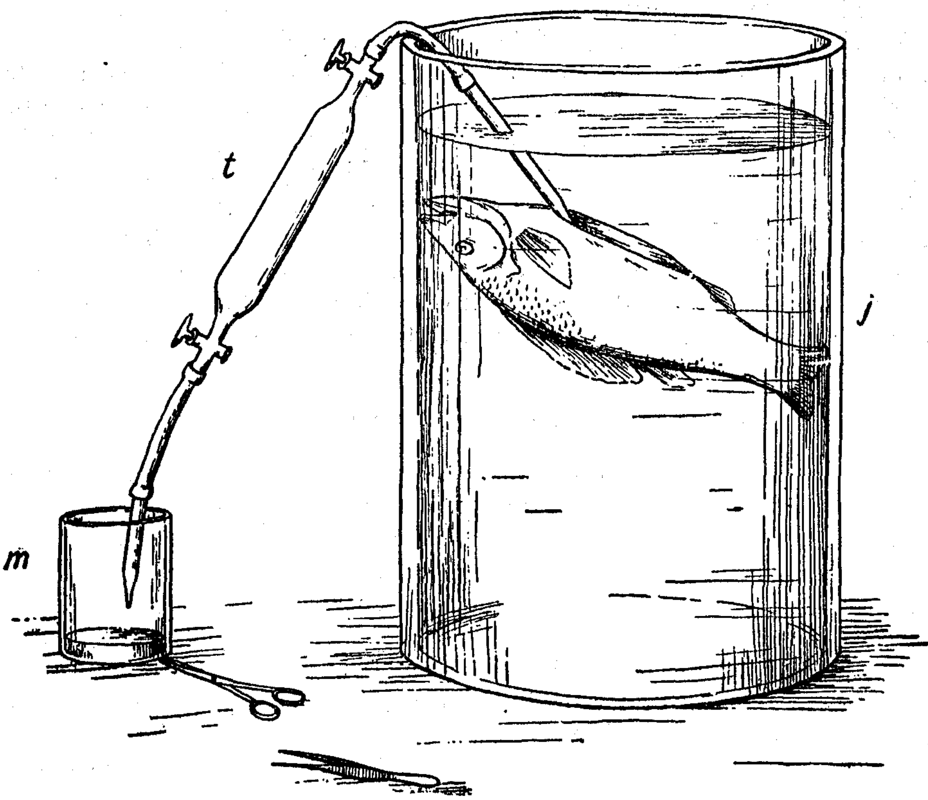


FIG. 32.—Collecting tube and method of collecting gas from perch swim bladders. *j*, jar full of stagnant water continually pumped from depths of lake; *m*, small vessel for collecting mercury; *t*, collecting tube filled with mercury.

The experiments described show that perch in Lake Mendota commonly enter the stagnant water below the thermocline and that they may remain there for an hour or two without suffocating. These facts suggested that perch might make use of the oxygen in the swim bladder while in the stagnant areas, and experiments were performed which showed the supposition to be correct. From August 23 to September 24, 1916, fishes were lowered in wire cages to depths varying from 12 to 13.5 m. The amount of oxygen at such depths was about 0.05 c. c. per liter and the carbon dioxide, 5 c. c. per liter. The perch were allowed to remain for varying lengths of time in the stagnant water and then were pulled quickly (10 seconds) to the surface and placed in a large jar of water pumped from the same depth at which they had been submerged. They were opened as soon as possible under water and the gas in the bladder siphoned out into a mercury-filled collecting tube (fig. 32) of 5 c. c. capacity. The samples were carried into the laboratory in the collecting tubes and analyzed with a Haldane apparatus, the oxygen being absorbed with 10 per cent alkaline pyrogallol and the carbon dioxide with 10 per cent potassium hydroxide. Every time samples were taken from perch which had been submerged in deep water, two or three control individuals which had been in a fish car at the surface were also tested. The details of the results of the analyses are shown in Table 23, and a summary is given in Table 24. Though considerable variation is shown, the latter table indicates that the oxygen in the bladder was used up while the perch were in the stagnant water, but the carbon dioxide did not increase.

From the studies in Lake Mendota the following facts have been ascertained: (1) Perch commonly go into the stagnant water below the thermocline, where there is only a fraction of 1 per cent of oxygen per liter; (2) they may remain there for two hours or more without suffocating, but it is doubtful if they would feed for more than a few minutes; (3) when perch invade water which does not contain sufficient oxygen for respiration they apparently draw to some extent on the reserve in the swim bladder; (4) if through the action of the bladder as a hydrostatic organ a perch is adjusted to pressure conditions above the thermocline, it will, if it invades the lower regions where it is overcome by lack of oxygen and excess of carbon dioxide, tend to float up into levels where gas conditions are more favorable.

REPRODUCTION.

It has already been pointed out that the perch in Lake Wingra are generally of smaller size than those in Lake Mendota. This backwardness in growth, however, does not appear to retard the attainment of sexual maturity (Table 25). Judging by the measurements made on individuals from a school of young perch which remained near the base of Picnic Point (fig. 2) during the summer of 1916 (Table 18), and by observations on the gonads of half-grown perch at various seasons, the authors believe that perch may become sexually mature in Lake Mendota at the end of two years of growth. Meek (1916), speaking of conditions in Europe, says: "The perch appears to become mature when it is three years old."

After a perch attains sexual maturity the gonads in both sexes pass through a regular cycle of seasonal changes. After spawning is completed, the gonads remain small until late summer and then increase very rapidly in size for a month or more. By September they are almost as large as in the spring. The growth of the gonads, then, takes place for the most part in the summer, when food is most abundant, and there is little change in size during the winter months. By November, perch caught in deep water (18 to 20 m.) will often shed eggs when brought to the surface. Such individuals are, of course, not completely "ripe" but emit eggs on account of the decrease in pressure. Prof. C. L. Turner (1919) has made a careful study of the volumetric and cytological changes in perch gonads at Milwaukee, and his paper gives detailed information concerning the annual reproductive cycle.

The spawning season in Lake Wingra comes earlier than in Lake Mendota. This is due largely to the fact that the ice goes out sooner and the smaller volume of water warms up more rapidly. Figures 3 to 6 show that the period of activity associated with the migration of perch into shallow water for spawning came nearly a month earlier in Lake Wingra. In the spring of 1916 the ice left Lake Wingra March 20 and Lake Mendota April 8. The temperature just below the surface on April 18 was 10.6° C. in Lake Wingra and 4.6° C. in Lake Mendota. Our observations agree with those of Forbes and Richardson (1908), who state that the spawning of perch takes place in April and May, when the temperature of the water is 7 to 10° C.[a] Compared with other species of fishes and amphibians which lay eggs in the spring, the perch spawn rather early. During the spring of 1916 the following sequence was observed in Lake Mendota: April 12, the swamp-tree frog, *Corophilus nigritus*, was singing in the swamps along shore; April 20 to May 7, perch were spawning; May 2, the larvæ of the orl fly, *Sialis infumata*, were migrating on shore; May 12, suckers, *Catostomus commersonii*, were spawning; May 30, crappies and dogfishes were frequenting bare spots alongshore; and June 19, crappies in Lake Wingra were spawning. When most of the perch in Lake Mendota were spawning, the majority of those in Lake Wingra were already spent. In the autumn also the gonads of the perch in the smaller lake were noticeably earlier in reaching the large size characteristic of the cooler months, and this is again correlated with the earlier cooling of the lake.

Perch come into shallow water alongshore to breed. The males precede the females and remain longer on the spawning grounds. This means that there are many more males than females in shallow water from the middle of April until the early part of May.[a] For example, on April 28, 1916, a 1-inch mesh gill net, pulled from a depth of less than 3 m., contained 380 perch, and all but four were ripe males (Table 26). There were three ripe females and one immature male. On May 2 and 12 there was still a great preponderance of males in the nets set in shallow water, but on later dates the sexes became more or less similarly distributed at all depths. The males evidently came inshore and remained during the entire spawning season; the females left deep water for only a short time to lay their eggs. Meek (1916, p. 281) records similar behavior for the plaice: "Results appear to show that the males appear first at the spawning ground and remain during the season, whereas the females depart shortly after the ova are shed." Abbott (1878) states that perch go in pairs to the spawning beds. In our gill-net catches a ripe female was often surrounded by several males. This indicates that a female may be attended by more than one male.

Breeding instincts appear to dominate feeding instincts at the time of spawning. Table 22 shows that about 6 per cent of the individuals captured during the breeding season contained no food, and it was mostly the males that were empty. Another difference in feeding activities was noted between the sexes. The fishermen on Lake Mendota have stated on various occasions that they always caught more females than males when fishing in deep water through the ice with hook and line. The following observations support this view: December 29, 1916, 13 m., 40 females, 0 males; Decem-

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[a] On May 7, 1920, at 4.25 p. m., the writer set two 4 by 75 gill nets, tied end to end, at a depth of 2.7 m. on the south shore of Lake Mendota. At 10.45 a. m. on May 8 the 1½ inch mesh net contained a rock bass and a pickerel. The 1-inch mesh net at 8.15 a. m. on May 8 had caught 921 ripe male perch, 10 ripe female perch, 9 spent female perch, 4 female perch which had whitish eggs in their ovaries, and 1 mud puppy. The food of the last consisted of crayfishes, 92; Physa heterostropha, 4; plant remains, 2; Leptocella larva and case, 1; perch eggs, 1. The water temperature (first figure in each set indicating depth in meters; second, degrees centigrade) was as follows: 0, 11; 1, 10.8; 3, 10.4; 4, 10; 5, 9.7; 6, 8.1; 7, 7.2; 8, 7.1; 10, 6.9; 13, 6.5; 15, 6.4; 18, 6.1; 20, 5.8; 23.5, 5.6.

ber 30, same place, 38 females, 2 males; January 4, 1917, 15 m., 5 females, 3 males; January 6, same place, 9 females, 7 males; January 8, same place, 34 females, 7 males; January 25, 18 m., 28 females, 10 males. These facts indicate that the females feed more actively during the winter or that they exceed the males in numbers in the deeper parts of the lake.

The egg string deposited by a perch which had been kept for several months in a running-water aquarium is shown in Plate LXXXIII, figure 2. This contained 2,650 eggs and was deposited on May 1, 1916, when the water temperature was 12° C. A string was also laid by another individual in the same aquarium on April 18. Forbes and Richardson (1908) mention a string recorded in one of the laboratories of this Bureau which measured 88 inches in length and weighed 41 ounces after the water had been drained from it. The strings swell very rapidly and harden somewhat after leaving the body of the female. They are often thrown over stones, plants, or other objects in the water. Gorham (1912) states that they may be attached to willow roots. The same authority says that eggs hatch in 8 to 10 days and that the small fry hide in nooks alongshore until they appear in schools as fingerlings. Hankinson (1908) and Reighard (1915) mention seeing schools of small perch in shallow water, and the latter notes that there may be small fishes of other species with them. On August 23, 1916, a school of about a thousand young perch was observed near our dock just north of the University of Wisconsin, and it remained in that locality for over a week.

Meek (1916, p. 290) says of the European perch: "The larva measures about 5 mm. when hatched, and in the course of a year the young attains a length of 6 cm., and in two years about 13 cm." We have already noted that perch hatched in the spring of 1916 in Lake Mendota had attained by August 30 a length of 68 mm., without the tail fin, and that perch less than 130 mm. long were sexually mature (Table 25).

MIGRATIONS.

The perch in lakes frequent various localities at different times. In general, migrations are correlated with the changes accompanying the rhythmical sequence of day and night or with those associated with seasonal succession. In order to secure data on the numbers of perch at different depths, fishing was carried on simultaneously at various levels. The catch per hour in a gill net gives a fair idea of the number of perch present, but rather wide seasonal variations are to be expected. Fishes will not be captured unless they are moving, and the lesser activity accompanying lower temperatures will cause smaller catches. Another means the authors have used for judging the number of fishes present in any locality is by the catch per hour with hook and line. During stormy weather the number of perch secured in Lake Wingra from a drifting rowboat with hook and line often exceeded that taken in gill nets, probably because the shallowness of the lake made it inexpedient for the fishes to move about much in windy weather. Neither gill nets nor hooks give accurate data as to the actual numbers present. However, they do give information which is of value for judging comparative numbers when they are used simultaneously at various depths.

An examination of Tables 2 to 5 and 27 shows several points of interest in regard to the abundance of fishes at various seasons, and it is possible to make a number of generalizations from the data presented. In Lake Mendota the course of the annual migration is pretty definite. In the winter most of the perch are in deep water. As soon as the lake is free from ice there is a migration inshore for spawning, but the perch soon return to deep water and remain there until the lack of oxygen drives them into shallower regions. As soon as the autumnal overturn renews the oxygen the perch return for the most part to the depths of the lake. Less marked migrations of the same general type also take place in Lake Wingra, but there is no stagnation period in the summer. Figures 33 and 34 bring out a point which has already been discussed to some extent under food and respiration; that is, though the perch are obliged to live above the thermocline from August to October, they descend at intervals into the cool, stagnant region below, probably to take advantage of the abundant food there. Wells (1915) has pointed out that fishes generally prefer water which has a slightly acid reaction to

DEPTH—METERS	JUNE 5	6	19	26	JULY 3	10	17	24	31	AUG. 7	14	21	28	SEPT. 4	11	18	25	OCT. 2	9	16	23	30	NOV. 6	13	20	22	27	DEC. 4	9	11	14
3	23					13	3		1														0		0		†		2		1
4			6	4				42				40	30	34	10	5*	1*		0*						0						
5										26																					
6																		66				12									
7									115																						
8																															
9																															
10		89		32	176									96																	
11		69																													
12		88								180	209			138						31										47	
13					267					87														20* 94							
14											180						175		89												
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16						203				4*	46																	41			
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FIG. 33.—Perch caught in gill nets set at various depths, Lake Mendota, 1915. The curve indicates the thermocline. All nets used were 1-inch bar mesh. * indicates a net 4 by 50 feet which caught only one-fifth as many perch as the other nets used, which measured 3 by 75 feet. Nets were left in the water about 24 hours. The ice left the lake April 9 to 11; the fall overturn took place October 9 and 10.

that which is neutral or alkaline. Of course, such behavior would tend to keep perch in deep water or near the bottom vegetation. Gurley (1902) is an ardent advocate of temperature as the controlling factor in the seasonal migrations of fishes, but in Lake Mendota it can have but slight influence. The perch come into shallow water in spring, when the temperature is low, uniform at all depths, and the same as that which has prevailed for several months; in autumn they descend into deep water when the temperatures are again uniform throughout the lake. The food and the net and line catches both indicate that the perch remain on or near the bottom and in as deep water as possible throughout the year. The migrations into shallow water are to spawn and to escape stagnant conditions during the summer.

One other possibility remained to be tested, however. During the period of stagnation in the lower water the perch might remain on the bottom in the region of the thermocline or spread out over the whole lake to feed on the plankton organisms in the water containing oxygen. The latter alternative seemed improbable from the fact that it is easiest to catch perch near the bottom at any season, but it was decided to perform an experiment to find out. Accordingly, on August 10, 1916, four 1-inch mesh, 3 by 60 feet, gill nets were set north of the University of Wisconsin in Lake Mendota. At this time the thermocline was well established at a depth of 9 meters, and the gaseous content of the water (according to titrations by the Winkler method; Birge and Juday, 1911) at certain depths was as follows: At 18 m.—Oxygen, 0.01 c. c. per liter; carbon dioxide,

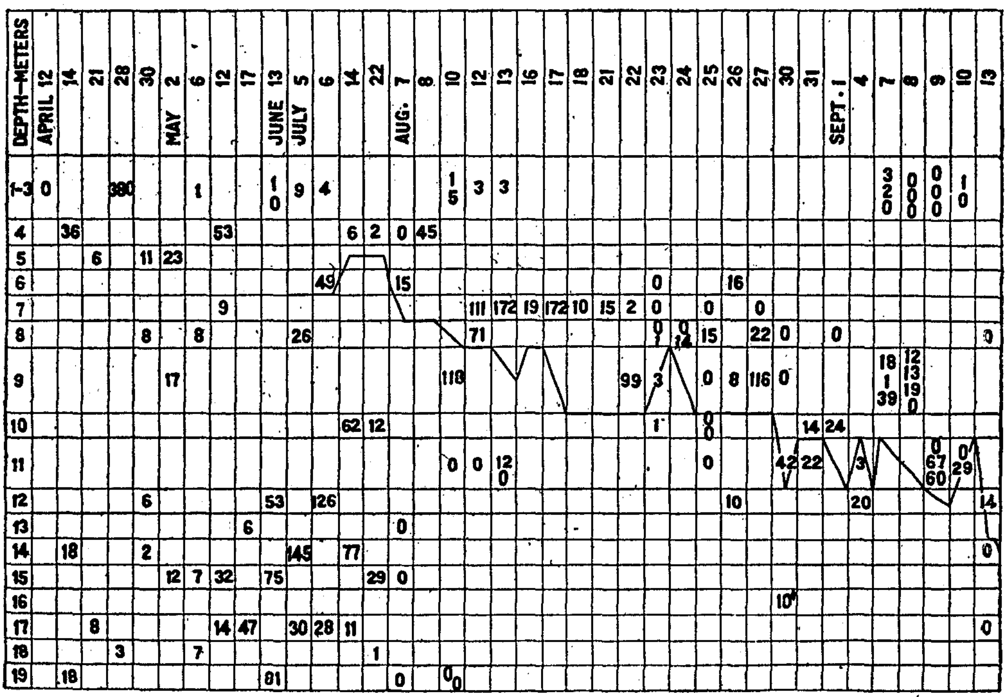

FIG. 34.—Perch caught in 3 by 60 feet, 1-inch bar mesh gill nets, Lake Mendota, 1916. Nets were left in the water for various periods of time, but those set on any particular day were left for the same length of time, and the catches for that day at different depths are therefore comparable. The curve represents the thermocline. The ice left the lake on April 8; the fall overturn occurred October 5 to 10. † indicates 10 perch caught at 16 m. in about 2 minutes while washing net.

10.31 c. c. At 14.5 m.—Oxygen, 0.01 c. c.; carbon dioxide, 4.1 c. c. At 13 m.—Oxygen, 0.02 c. c.; carbon dioxide, 4.17 c. c. At 6.6 m.—Oxygen, 4.49 c. c.; carbon dioxide, 0 c. c. One net was set at 19.2 m. on the bottom; another was set where the water was 19 m. deep, but the net was fastened to eight weighted 11 m. lines, so that it floated just above the thermocline; a third was set on the bottom where the water was 8 to 9.2 m. deep; the fourth was set on the bottom at a depth of 3 m. All of these nets were set at right angles to the shore line and were placed in a straight line from deep to shallow water. They were left in the water three hours (9.45 to 10.30 a. m. to 12.45 to 1.30 p. m.). Nothing but perch was taken in the nets, and the catches were as follows: On bottom at 19.2 m., 0; at a depth of 8 m. above bottom 19 m. deep, 0; on bottom at 8 to 9.2 m., 118 (49 alive, 69 dead; males, 42 dead, 17 alive; females, 27 dead, 32 alive); on bottom at 3 m., 5 (all alive; 3 males, 2 females). This experiment indicates that perch are bottom fishes at all seasons. The observations of Hankinson (1908), Reighard (1915), and Meek (1916), in other lakes make it apparent that this condition is general.

Meek (1916) states that perch are more sluggish in winter. The gill-net and line catches for both lakes support his view (Tables 2 to 5 and 27). The catches in Lake Wingra indicate, however, that cool or stormy weather does not interfere with feeding if food is available. On windy days, when the gill nets caught little, the usual numbers of fish were captured from a drifting boat on hooks. The fishes in this shallow lake were apparently ready to eat if food was present but were unable or unwilling to move about much during storms.

On several occasions schools of perch were observed at the surface. This occurred once at 10 p. m. on Lake Wingra and was observed several times from 5 to 7.30 a. m. in Lake Mendota during the warmer months. As such schools were usually observed during early morning hours, it was thought that there might be a daily migration which would take the perch into shallow water at night and into deep water during the day. Such a migration could not, however, be very extensive, because perch caught at depths

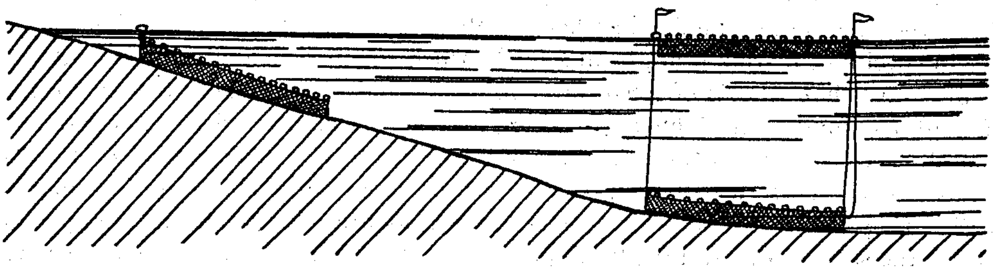

FIG. 35.—Positions of gill nets set to determine the comparative numbers of perch at different depths.

of more than 10 m. were apparently unable to make rapid modifications in their swim bladders so as to become adjusted to surface conditions. When kept in shallow aquaria such deep-water perch, though apparently in good condition, often floated belly up at the surface for two or three days.

It was possible, however, that there might be rhythmical migrations, a few meters in extent, with the changes accompanying day and night. Gill nets were accordingly set to discover if such were the case. They were arranged to catch fish at the surface and on the bottom, so as to give opportunity for comparing the numbers present in two or more situations, and were examined at the end of 4-hour periods for 24 hours. On August 12, 1916, three nets were set in Lake Mendota (fig. 35). One floated at the surface; another was on the bottom directly beneath it at a depth of 7.5 m. (just above the thermocline); another was inshore from the other two and on the bottom at 2.9 m. The catches for this and two other similar experiments are shown in Tables 28 to 30.

It will be noted—

1. That there were never many perch caught in shallow water near shore.

2. That in the bottom net just above the thermocline the catches in the early morning hours (1 to 3 a. m.) were usually the smallest. For the three experiments the average catches were as follows: From 12 m. to 4 p. m., 43; 4 p. m. to 8 p. m., 56; 8 p. m. to 12 p. m., 37; 12 p. m. to 4 a. m., 12; 4 a. m. to 8 a. m., 41; 8 a. m. to 12 m., 41.

3. That the only time when perch were caught in the surface net was at 5 a. m.

These results indicate that perch migrate from the region of the thermocline toward the surface during the night, but the number of observations is small and should be extended. In the experiment summarized in Table 30, where the deep net was exactly on the thermocline, not a single perch was caught during the early morning hours.

All catches in Tables 28 and 30 marked with an *e* were taken ashore; all others were thrown back as soon as they were removed from the net. It will be noted that, when the fish were not put back, the next catch was not appreciably smaller. The first catch in each experiment should have been larger, if all other conditions were the same, for the nets remained in the water exactly 4 hours. Pulling a net and the removal of the fish occupied from 2 to 25 minutes, which would make the periods of time for the various catches after the first somewhat less than 4 hours. The fact that as many fish were caught during the next 4 hours, when an entire catch was removed from that region of the lake, as when they were put back indicates that, though perch keep to a particular depth, which varies somewhat with the time of day, they do not remain in one locality, but continually swim along the shore.[a]

One other aspect of the migratory activities of perch remains to be considered. This is their habit of swimming in schools. Meek (1916) states that soon after hatching certain species of marine fishes form schools which retain their unity for several years. He also says that schools of fresh-water fishes are much more likely to mix; fishes of different ages, and even of different species, may keep together. Schools of perch have been observed at various times in shallow water in the two lakes under consideration in this paper. These usually consisted of fish of about equal size—large, medium, or small. They have been seen alongshore, among aquatic plants, and in the open lake both at the surface and at a depth of 3 or 4 m. For example, during the latter part of August, 1916, a school of about a thousand young perch remained alongshore in one locality, just north of the University of Wisconsin, for more than a week. Hankinson (1908, 1916) and Reighard (1915) report similar schools of young perch in Michigan lakes. Catches in gill nets also indicate that perch swim in schools when in deep water. A net set in one spot and examined at intervals might catch nothing for several hours and then be filled in a few minutes (Table 30). A similar thing often happened when fishing with a hook and line. Furthermore, a 60-foot gill net might have 50 or 75 perch in one end and not a single individual in the other. All these observations signify that perch swim in schools throughout life.

ENEMIES AND PARASITES.

PREDATORY ENEMIES.

In the Wisconsin lakes perch pay the penalty for exceeding other fishes in abundance by being preyed upon by a number of predacious animals. Among the fishes the pickerel (*Esox lucius*) appears to be the species which most commonly feeds upon perch. During the year 1916 the following records were secured from Lake Mendota:

[a] During the summer of 1917 additional evidence was secured which supports this view. Nine hundred and sixty-six perch were caught in gill nets at three stations in Lake Mendota. An aluminum tag was fastened to the dorsal fin of each, and they were then returned to the lake. Although fishing with nets was continued for a total of 33 days at the three places, only one of the tagged fishes was caught a second time.

Date.	Length of pickerel (millimeters).	Perch eaten.	
		Number.	Size (millimeters).
April 17	730	1	185
April 25	755	1	200
June 12	164	3	95
August 23	362	1	140
Do	400	1	105

The remains of perch have also been found in largemouth black bass (*Micropterus salmoides*) caught in Lake Mendota. Dogfishes (*Amia calva*) were often caught in gill nets in shallow water, and in many cases they were near perch which had been previously captured in the net. Such occurrences indicate that dogfishes may feed upon perch, but the authors have never found them in the alimentary canal. The gar (*Lepisosteus osseus*), doubtless, also feeds on young perch. Hankinson (1908) found pickerel feeding on perch and also mentions an 8-inch perch as occurring in the wall-eyed pike (*Stizostedion vitreum*). Forbes and Richardson (1908) state that 75 per cent of the food of the lota (*Lota maculosa*) is made up of perch. Reighard (1915) reports perch feeding on each other.

Besides finny enemies, perch are probably often beset by other predators; for instance, water snakes, garter snakes, and bullfrogs may catch the young alongshore. Turtles often eat perch caught in nets, and probably feed upon them when they have a chance under natural conditions.

A. R. Cahn has furnished observations on birds which eat perch. In Wisconsin he has found the following feeding on perch: Herring gull, common tern, black tern, American merganser, red-breasted merganser, great blue heron, green heron, black-crowned night heron, loon, horned grebe. He states that the following also probably eat perch: Double-crested cormorant, white pelican, other species of gulls and grebes, and the bald eagle. Fisher (1893, p. 32) reports the fishhawk as feeding on perch; Eaton (1910, p. 137) mentions the kingfisher. The senior writer on June 10, 1916, saw a crow pick a crappie (*Pomoxis sparoides*) from the surface of Lake Wingra. Though the fish in this instance struggled actively and finally escaped, the crow may at times be more successful in its aquatic forays and capture fishes from the water. Probably such carnivorous mammals as the otter and mink at times capture perch.

Among the predatory animals mentioned the only ones which commonly follow the perch into deep water are the pickerel (Reighard, 1915) and the lota. The latter does not occur in either of the lakes discussed in this paper but is important in the Great Lakes and some other smaller bodies of water. The majority of the perch in Lake Mendota are therefore free from attack by predacious enemies during most of the year, except for an occasional pickerel.

PARASITES.

While the routine weekly examinations of perch were made primarily for the purpose of ascertaining the nature of the food, after March, 1915, a careful record was kept of the presence of parasites. This record is doubtless incomplete; the numbers are too small rather than too large. For example, many of the intestinal distomes were doubtless overlooked, because the food was stripped from the intestines, and they may have remained attached to its wall. The commonest intestinal distome, *Bunodera nodulosa*, lives in the bile ducts and gall bladder during early stages, but no regular examinations were made to discover its presence at seasons when it was not in the intestines. Every parasite observed was not identified as to species, but practically all, if not all, will fall in the list which follows. No routine record was kept of the occurrence of the skin parasite, *Diplostomulum cuticola*.

The results of the routine examinations for parasites are summarized in Tables 31 and 32. Nematodes were never present as intestinal parasites during December; in Lake Mendota they were most abundant in summer; in Lake Wingra, from March to May and from August to November. In Lake Mendota no trematodes were found in the intestines during September, October, and November; and in Lake Wingra none were found at any season. The cysts of larval proteocephalid tapeworms were prevalent in the liver, and often in the peritoneum elsewhere, during every month of the year. Larval proteocephalids were most abundant in the intestine from March to May in Mendota but were irregularly distributed through the year in Wingra. Acanthocephalans were most abundant in spring in both lakes. Leeches and adult tapeworms were uncommon and irregular in their occurrence.

The most striking difference in regard to parasites between the perch of Lake Mendota and those of Lake Wingra is in the complete absence of intestinal trematodes from the latter. This may be due to the absence of a proper intermediate host in Lake Wingra. The following list includes all the parasites known to occur in the perch from Wisconsin lakes:

PROTOZOA.

Henneguya wisconsinensis Mavor and Strasser.—This myxosporidian was first described from specimens taken from the urinary bladder of a male perch caught in Lake Mendota and examined on April 15, 1915. During the present investigations no examinations for this parasite have been made.

CESTOIDEA.

Proteocephalus pearsei La Rue.—Specimens of larval cestodes, cestode larval cysts, and adult tapeworms were sent to Dr. G. R. La Rue, of the University of Michigan, who was kind enough to describe them (1919). One of the larval cysts was found in the body muscles on October 13, 1916.

TREMATODA.

Bunodera luciopercae (O. F. Müller).—This fluke was common in the intestines, particularly in the cæca, in perch collected from Lake Mendota but was absent from those collected from Lake Wingra. It has previously been reported in the perch from this country by Stafford (1904) at Montreal, Canada, and by Marshall and Gilbert (1905) from the lakes near Madison, Wis.

Clinostomum marginatum (Rudolphi).—This trematode was observed twice in the perch from Lake Mendota. On September 25, 1915, a cyst containing a nearly mature specimen was found beneath the skin in the flesh at the base of the tail. On January 10, 1917, the gills of 20 perch, which had been caught at a depth of 17 m., were examined and one small larval cyst was discovered, embedded in a gill filament. These isolated observations, of course, give no idea of the prevalence of this parasite in Wisconsin.

Diplostomulum sp.—This skin parasite was observed now and then in the lakes near Madison and was always more abundant in the young fish than in adults. It was very prevalent in the perch from Oconomowoc Lake. An idea of the difference in infection in perch from two Wisconsin lakes may be gained from the following statistics:

Fourteen perch, collected from Lake Mendota, near the base of Picnic Point, August 24, 1916 (length—maximum, 69; minimum, 52; average, 61 mm.), were infected to the degree shown by the following "number of infected individuals—total number of parasites—average" figures: Tail, 5-5-3.5; fins, 0; head, 8-16-1.1; ventral region, 9-18-1.3; dorsal region, 14-15-1; whole body, 14-55-4.

Thirty-nine individuals collected on July 17 and August 8, 1916, in Oconomowoc Lake (length—maximum, 98; minimum, 35; average, 55.1 mm.), showed: Tail, 25–53–1.3; fins, 24–79–2; head, 26–98–2.5; ventral region, 31–132–3.3; dorsal region, 25–123–3.1; whole body, 38–490–12.9.

(?) *Allocreadium isoporum* Looss.—One specimen, which is apparently referable to this species, was found in the intestine of a perch collected in Oconomowoc Lake, August 14, 1916.

Crepidostomum cornutum (Osborn).—Eight specimens were found in a perch caught in Lake Mendota at a depth of 18 m., January 10, 1918.

ACANTHOCEPHALA.

Neœchinorhynchus cylindratus (Van Cleave).—This was the common acanthocephalan found in perch. Sometimes it occurred in great numbers. In one instance a couple of hundred were found in the intestine of a single perch.

Echinorhynchus thecatus Linton.—One specimen, which is apparently referable to this species, was saved from a perch 60 mm. long caught on August 24, 1916, in a minnow seine east of Picnic Point.

NEMATODA.

Dacnitoides cotylophora Ward.—Specimens of the nematodes from perch intestines were probably of this species.*

HIRUDINEA.

Piscicola punctata (Verrill).—This was the species of leech usually found on the perch in the lakes investigated.

Placobdella parasitica (Say).—One individual of this species was found attached to a perch caught in Lake Wingra October 28, 1916. Our thanks are due to Prof. J. P. Moore, who identified it.

INSECTA.

Psephenus sp.—On July 22, 1916, a perch, caught at a depth of 15 m. in Lake Mendota, had a "water penny" attached to its body just behind the right pectoral fin. This beetle larva must, therefore, be recorded as an accidental commensal or parasite.

GENERAL DISCUSSION AND CONCLUSIONS.

The investigations on the perch in the two lakes selected for study have been described, and it is now time to return to the problems it was hoped they would solve: (1) To account for the abundance of perch compared to other species of fish; (2) to determine why perch have a particular maximum size in certain lakes and why they are larger in some lakes than in others; and (3) what effect stagnation has on the activities of fishes.

The perch appears to be more abundant than other species of fish because it is versatile and not too specialized. Though it has certain specificities of behavior, such as the habit of usually feeding on or near the bottom, it is able, more than any other fish with which it is associated, to invade all habitats. It may feed on the enormous quantities of plankton in the pelagic regions; it is at home among aquatic vegetation; and it may grub out the animals embedded in such great numbers in the soft bottom mud or even largely subsist for a time on the mud itself. Its chief advantage over the common shore fishes is in its ability to forsake the shore, with its stores of food dependent chiefly on the aquatic vegetation, and invade the depths of the lakes, where the chief source of food is the soft sedimentary bottom deposits rich in organic constituents.

The perch has rivals in each of the habitats where it seeks food, but it is an able competitor of them all. In shallow waters it may capture mollusca as well as the pumpkinseed, littoral plankton as well as the silversides or bream, insects and their larvæ as well as the bass, crayfishes as well as the dogfish, small minnows as well as the gar. In the open lake the perch's chief competitors for food are the cisco and the white bass, but neither of these fishes excels it in ability to strain plankton from the water. In the deeper regions of lakes the perch must contend with the vegetarian and bottom-feeding sucker, cottid, and carp, and with the predacious pickerel and lota. The sucker, cottid, and carp are real rivals when it comes to bottom feeding, for they are especially able to take advantage of the nourishment in the bottom mud.[a] They are also better protected, by reason of their size, from the attacks of the predacious deep-water fishes; but their large size, on the other hand, limits their numbers, and they can never compare with the perch in this respect. These bottom feeders are limited, however, in times of scarcity or when they are driven into shallow water by stagnant conditions in the depths. They can not then feed as well as the perch in pelagic or littoral regions.

Perch are, then, more abundant in lakes than other kinds of fishes because they are of intermediate size and because they are better able to secure food from all available habitats and at all seasons of the year.

There are probably a number of factors which cause perch to attain a certain characteristic maximum size in different lakes. This is a phenomenon which is not confined to perch alone but has been noted in other fishes. It is apparent, for example, in the ciscoes in various Wisconsin lakes, and has been observed in other localities in various parts of the earth. Petersen and Jensen (1911) state that the plaice in a certain estuary ceased to grow for two-thirds of a year, whereas some which were transplanted quadrupled in size during the same period of time. They believe that the discrepancy in this instance was due to differences in food. The present authors believe that their comparison of the habits of perch and their conditions of life in Lake Wingra and in Lake Mendota have shed some light on the causes for such contrasts, and they feel that they can, at least in part, give specific reasons why the perch are smaller in the former lake.

The shallowness of Lake Wingra is probably the chief cause for the small size of its perch. The limitation of perch to a stratum of water 3 m. in thickness, between the air above and soft muddy bottom below, causes many unfavorable conditions. Winds stir up the whole body of water; thus movement and feeding are often made difficult or impossible. Knauthe (1907) has made the generalization that in two ponds of equal capacity in other ways the quieter one will be the more productive for rearing fish.

On account of the shallowness of the water in Lake Wingra there are wider and more rapid variations in temperature. The water is all warm in summer; there is no possibility of retreat into cool, quiet depths; and consequently the perch in this lake pass through a period in late summer when little food is eaten (Table 22). In winter, the perch in Lake Wingra move about very little and hence feed less than those in Lake Mendota (Tables 2 to 5, 22, and 27; figs. 3 to 5). Though oxygen was always present in quantities sufficient for respiration, many of the fish caught in gill nets in Lake Wingra died during the warmer months, when the water was murky with algæ and other organic or sedimentary products.

The perch in Lake Wingra, on account of the earlier warming of the water, breed before those in Lake Mendota, when the season is less advanced and food is less

[a] The importance of this deposit as a source of food has been pointed out in a masterly way by Petersen and Jensen (1911).

abundant. They also mature the gonads earlier in the autumn, in part during the hottest weather when food is readily available but when feeding conditions are unfavorable. Perch hatching in Lake Wingra have less desirable conditions for feeding during their growth period.

There are two conditions which appear to be more favorable to the perch in Lake Wingra. One of these is the fact that there is abundant oxygen for respiration at all depths during the summer when feeding is active. The other is the entire absence of trematode intestinal parasites. These two factors, however, appear to be of little importance compared with those cited in the preceding paragraphs, which are more favorable in Lake Mendota. The differences between the perch in the two lakes in regard to the constituent elements in the food are probably not important in determining maximum size. As has been stated, the perch in Wingra eat more of insect larvæ and less of Entomostraca than those in Mendota; but there is no reason to believe that such differences would account for the discrepancies in size.

The chief generalization to be made from the comparisons between Lake Wingra and Lake Mendota is that, at least in temperate regions, a deep lake is a far better habitat for most fishes than a shallow one and will usually be more productive. There is no doubt that some fishes, such as the crappie, are peculiarly adapted to shallow-water habitats, as shown by the senior author in a report (1919) compiled from studies, extending through an entire year, of the abundant crappies in Lake Wingra. But though there are such special cases and though more extensive studies in different types of lakes will doubtless bring new facts to light, the authors believe their first statement will, in general, hold good. Of course, a deep lake without suitable breeding grounds and with a scanty fauna would have few fishes, but even under such circumstances it would excel a shallow lake with similar characteristics.

One other problem remains for solution, and, though the results presented in this paper do not solve it, they may help to do so. This is the determination of the factors controlling the productiveness of lakes of various types and sizes. An understanding of this may in time give man the power to control and increase production.

An attempt has been made to gain some idea of the productiveness of Lake Mendota in terms of the total number of perch caught from its waters per year. Daily counts were made of the number of fishermen on the eastern half of the lake from January 8 to February 27, 1917, at 10 a. m. and 3 p. m. At intervals trips were made around the lake to ascertain how long each man had been fishing and the number of perch caught. The number of fishermen averaged 19.1 in the morning and 31 in the afternoon. Their catch per hour averaged 23.6. Estimating that each man counted fished three hours, and that one-fourth of the fishermen (not counted) were on the west end of the lake, the total average catch per day for all fishermen would be 2,358. There is more fishing for perch in winter than in summer. Probably the number of perch caught per day when there is no ice is about one-fourth that during the winter. This means that 2,358 perch are caught per day for four months and 589 per day for eight months. From such speculation it may be estimated that 424,540 perch are caught each year from Lake Mendota. Judging by the other fishes taken in gill nets and by our general knowledge of conditions, it is estimated that the total annual catch of other species by fishermen is about as follows: Pickerel (*Esox lucius*), 2,208; white bass (*Roccus chrysops*), 615; rock bass (*Ambloplites rupestris*), 613; silver bass or crappie

(*Pomoxis sparoides*), 183; largemouth black bass (*Micropterus salmoides*), 305; pumpkinseed (*Eupomotis gibbosus*), 428; bluegill (*Lepomis incisor*), 1,238.

This gives a rough approximation of the number of food fishes caught in Lake Mendota each year and may serve as a standard for lakes of similar size, depth, and situation. The old fishermen claim that many more fish were caught 15 years ago and state that a single man sometimes secured over 800 perch in a day. At present the usual catch of a professional fisherman, fishing through the ice with a line and two hooks, is from 200 to 400 per day.

Lake Wingra not only has smaller perch, but fewer of them. This is clear from the catch per hour in gill nets (Tables 2 to 5; figs. 3 to 5). The reasons for lesser size have already been discussed, and apparently the same reasons set a smaller limit to numbers. The differences between the sizes and numbers of perch in the two lakes are due to variations which interfere with growth and allow fewer individuals to survive in Lake Wingra.

SUMMARY.

1. The habits of perch in a small, shallow, and muddy lake were compared with those of perch in a neighboring large, deep, and clean lake. Perch were the most abundant fishes in both, but, in proportion to the size of the lake, there were more in the larger lake.

2. The perch is a versatile feeder but usually gets its food on or near the bottom. The percentage by volume of the foods eaten by 1,147 adults was as follows: Chironomid larvæ, 25.2; cladocerans, 22.1; Corethra larvæ, 6.4; silt and bottom débris, 6; chironomid pupæ, 5.9; fish, 5.2; amphipods, 3.6; Sialis larvæ, 3.4; caddisfly larvæ, 2.1; oligochætes, 1.5; crayfishes, 1.5; odonate nymphs, 1.4; clams, 1.2; algæ, 1.2; snails, 1.1; ephemerid nymphs, 0.9; calcium carbonate crystals, 0.5; leeches, 0.4; hemipterous adults, 0.3; mites, 0.3; chironomid adults, 0.2; Corethra adults, 0.2; Corethra pupæ, 0.2; copepods, 0.1; ostracods, 0.09.

3. There are more or less marked seasonal variations in all constituents of the perch's food. In general, foods are eaten in proportion to their abundance and availability; but this is not always the case.

4. An adult perch eats about 7 per cent of its own weight each day. Digestion is three times more rapid in summer than in winter.

5. Perch do not take any abundant food but select certain things. There are daily and seasonal variations. Individuals feeding in shallow water eat a greater variety than those from greater depths. Perch contain food which is available at the depths where they are caught, which indicates that extensive vertical migrations are infrequent.

6. Food varies with age. During youth there is a change from Cyclops and other entomostracans to Hyalella and insect larvæ. At the end of the first summer the food of young perch is much like that of adults.

7. As judged by the rate of increase in young perch when fed on a single food the following varieties rank in the order given, the best being first: Earthworms, entomostracans, chironomid larvæ, amphipods, fish, small amounts of various foods, liver and flour, adult insects.

8. In the small lake investigated insects were the most important constituent of the food. In the larger lakes insects and entomostracans were equally important.

9. Compared with the crappie, the perch eats a greater variety and shows other specificities of behavior.

10. Though perch are able to recognize the proportions of oxygen and carbon dioxide in water, they enter regions where conditions are unfavorable for respiration and may remain in oxygen-free water for as much as two hours without dying. When in water without oxygen perch use part of the oxygen in the swim bladder.

11. Perch may become sexually mature in two years. In the smaller lake investigated they generally become mature when of much smaller size than do those in the larger lake.

12. During the spawning season the males come into shallow water and remain for some time. The females remain on the spawning grounds only long enough to breed.

13. Except during the spawning season and when the deeper water is stagnant, most of the perch in the large lake remain in deep water through the year. In the smaller lake similar migrations take place.

14. There appears to be an upward migration at night.

15. Perch swim more or less in schools throughout the year and apparently do not remain in one locality but move along the shore.

16. Perch have many predacious enemies. The pickerel and lota are important.

17. Perch are very generally infected with parasites. Those in the two lakes investigated contained cestodes and cestode larvæ (one or more species), trematodes (5), acanthocephalans (2), nematodes (1). Leeches and an insect larva were found on the outside of the body.

18. Perch are more abundant in inland lakes than other species because they are more versatile.

19. Large inland lakes will generally contain more fishes per unit of volume than those of smaller size.

20. Judging by the data presented in this paper the reason why the fishes in certain inland lakes attain a rather small maximum size is because there are various adverse conditions which prevent growth. In the present instance food does not appear to be as important as other factors, such as shallowness, exposure to wind, etc.

TABLES.

TABLE 1.—COMPARISON OF LAKE MENDOTA AND LAKE WINGRA, EACH 258.8 M. (849 FEET) ABOVE SEA LEVEL.

Lake.	Length.		Breadth.		Area.		Maximum depth.		Mean depth.		Shore line.	
	Kilometers.	Miles.	Kilometers.	Miles.	Square kilometers.	Square miles.	Meters.	Feet.	Meters.	Feet.	Kilometers.	Miles.
Mendota.....	9.5	5.8	7.4	4.5	39.4	15.2	25.6	84	12.1	39.6	32.4	20.1
Wingra.......	2.6	1.6	1.4	.8	2.17	.79	4.25	14	1.6	5.3	7.3	4.5

TABLE 2.—TOTAL AND COMPARATIVE NUMBER OF PERCH CAUGHT IN GILL NETS SET AT VARIOUS DEPTHS IN LAKE MENDOTA, JULY 2 TO DEC. 14, 1915, WITH NOTES ON THE AMOUNTS OF OXYGEN AND CARBON DIOXIDE PRESENT.[a]

Date.	Depth net set (meters).	Cubic centimeters of gases per liter.		Number of perch caught.						
							Average per hour at—			
		O.	CO_2.	Alive.	Dead.	Total.	0–5 m.	5–10 m.	10–15 m.	15–24 m.
June 5	3.0					23				
June 6	10.0					89				
	11.0					69				
	12.0					88				
June 19	4.0					6				
June 26	4.0					4				
	10.0					32				
July 3	9.5					176		7.3		
	12.9					267			11.1	
July 10	3.5			11	2	13	0.5			
	16.5					203				8.4
	18.3					175				7.2
July 17	3.0			3	0	3	.1			
	18.5	0.96	6.22	30	59	89				3.7
July 24	4.0			39	3	42				
	15.5	.36	6.76	16	89	105				4.3
	18.5	.16	7.65	1	6	7				.3
July 31	3.0			1	0	1				
	7.1			112	3	115				
	18.6	.55	4.59	0	0	0				
	[b] 23.1	.1	5.1	0	0	0				
Aug. 7	5.0			25	1	26				
	11.8	4.62	0.0	32	148	180			7.5	
	13.0	3.14	0.0	32	55	87			3.6	
	[b] 16.3	.06	4.74	0	4	4				.1
Aug. 14	12.0	.03	0.2	10	199	209			8.7	
	13.6	.06	4.13	9	171	180			7.5	
	15.6	.04	4.89	9	37	46				2.0
	[b] 18.5	.04	4.74	0	2	2				.08
Aug. 21	4.0			35	5	40	1.6			
Aug. 28	4.0			30	0	30	1.2			
Sept. 4	4.0			33	1	34	1.4			
	10.0	5.02	0.0	83	13	96		4.0		
	12.3	1.77	3.31	102	26	138			5.7	
	[b] 18.5	.00	11.92	1	1	2				.08
Sept. 11	4.0			9	1	10	.4			
Sept. 18	[b] 4.0			4	1	5	.2			
Sept. 25	[b] 3.5			1	0	1				
	14.5	2.32	6.29	93	82	175			7.3	
	16.7	.04	5.67	6	13	19				.8
	18.6	.008	7.14	1	1	2				.08
Oct. 2	5.5			62	4	66		2.5		
Oct. 9	[b] 4.5			0	0	0				
	14.3	6.60	.51	89	0	89			3.7	
	16.7	6.63	1.31	201	0	201				8.3
	19.0	6.86	.25	167	0	167				7.0
Oct. 16	11.7			31	0	31			1.3	
Oct. 23	19.0			54	0	54				2.2
Oct. 30	6.0			12	0	12		.5		
Nov. 6	3.5			0	0	0				
	18.5			94	0	94				4.0
	[b] 18.5			17	0	17				.7
Nov. 13	[b] 13.0			20	0	20			.8	
	13.0			94	0	94			4.0	
Nov. 20	4.0			0	0	0				
	3.0			0	0	0				
Nov. 22	14.6			23	0	23			.5	
Nov. 27	3.5			7	0	7	.2			
	3.5			1	0	1				
Dec. 4	16.3			41	0	41				1.7
	21.0			32	0	32				1.3
Dec. 9	3.5			2	0	2				
Dec. 11	12.5			47	0	47			2.0	
Dec. 14	3.5			1	0	1				

[a] All nets used were 1-inch bar mesh, measuring 3 by 75 feet, except those marked [b], which were ¾-inch bar mesh, measuring 4 by 50 feet. For some reason the latter caught only one-fifth as many perch as the former, as is demonstrated by the catches on Nov. 6 and 13.

[b] See note under [a].

TABLE 3.—PERCH CAUGHT PER HOUR AND PER DAY IN GILL NETS, LAKE MENDOTA, 1916.

Date.	Depth set (meters).	Cubic centimeters of gases per liter.		Gill nets.			Number of perch caught.		
		CO_2.	O.	Time set.	Time pulled.	Hours in water.	Total.	Average per hour.	Average per 24 hours.
Apr. 12	1 – 3	...	...	...	...	...	0	...	...
Apr. 14	19	...	...	...	...	24	18	0.7	...
	14.5	...	...	...	...	24	18	.7	...
	3.7	...	...	...	...	24	36	1.5	...
Apr. 21	17.3	...	...	5 p.m.	7 a.m.	14	8	.5	12
	5	...	...	5 p.m.	7 a.m.	14	6	.4	9.6
Apr. 28	[a]18.2	...	...	4.45 p.m.	6.30 a.m.	13.7	14	1.0	24.0
	18.2	...	...	4.45 p.m.	6.30 a.m.	14	3	.2	4.8
	[a]3 – 1.8	...	...	4.45 p.m.	6.30 a.m.	14	163	11.6	278.4
	3 – 1.8	...	...	4.45 p.m.	6.30 a.m.	14	380	27.0	648.0
Apr. 30	14.5	...	...	6.50 a.m.	10.05 a.m.	3.2	2	.15	3.6
	12.5	...	...	7.05 a.m.	10.14 a.m.	3.1	6	.3	7.2
	8.5	...	...	7.16 a.m.	10.20 a.m.	3	8	.5	12.0
	5	...	...	7.25 a.m.	10.32 a.m.	3.2	11	3.6	86.4
May 2	15	...	...	1.53 p.m.	4.53 p.m.	3	12	4.0	96.0
	9.5	...	...	2.08 p.m.	5.08 p.m.	3	17	5.1	134.4
	4.7– 4.5	...	...	2.18 p.m.	5.20 p.m.	3	23	7.6	182.4
	[a]4.5– 4.1	...	...	2.22 p.m.	5.16 p.m.	3.1	18	6.0	144.0
May 6	18	...	...	6.38 a.m.	9.38 a.m.	3	7	2.3	55.2
	15	...	...	6.51 a.m.	9.51 a.m.	3	7	2.3	55.2
	7.7	...	...	7.00 a.m.	8.00 a.m.	1	8	8	192
	1.5– 3	...	...	7.14 a.m.	9.10 a.m.	2	1	.5	12.0
May 12	17	...	...	5.12 a.m.	8.12 a.m.	3	14	4.6	110.4
	15	...	...	5.20 a.m.	8.21 a.m.	3	32	10.6	254.4
	7	...	...	5.31 a.m.	8.36 a.m.	3	9	3.0	72.0
	4 – 3.1	...	...	5.41 a.m.	8.42 a.m.	3	53	17.6	422.4
May 17	17	...	...	12.01 a.m.	2.00 a.m.	2	47	23.5	364.0
	13	...	...	12.13 a.m.	2.13 a.m.	2	6	3.0	72.0
June 13	19	...	...	8.19 a.m.	11.19 a.m.	3	81	27.0	648.0
	15.5	...	...	8.33 a.m.	11.35 a.m.	3	75	25.0	600.0
	12	...	...	8.43 a.m.	11.44 a.m.	3	53	17.6	422.4
	2.5– 3	...	...	8.57 a.m.	11.57 a.m.	3	1	.3	7.2
	3 – 3.5	...	...	9.01 a.m.	12.05 a.m.	3	0	0	0
July 5	17	...	...	10.42 a.m.	1.53 p.m.	3.1	30	9.6	230.4
	14	...	...	10.51 a.m.	2.00 p.m.	3.1	145	45.8	1,099.2
	8.5	...	...	11.07 a.m.	2.05 p.m.	3	26	8.6	206.2
	3 – 3.6	...	...	11.20 a.m.	2.11 p.m.	2.8	9	3.2	76.8
July 6	17	...	...	11.00 a.m.	1.46 p.m.	2.7	28	10.1	242.4
	12	...	...	11.10 a.m.	1.56 p.m.	2.7	126	40.5	972
	6.3	...	...	11.20 a.m.	2.03 p.m.	2.7	49	17.8	427.2
	3.1	...	...	11.30 a.m.	2.10 p.m.	2.6	4	1.4	33.6
July 14	17	5.944	1.601	8.35 a.m.	10.35 a.m.	2.0	11	5.5	132.0
	14.3	4.544	3.835	9.08 a.m.	11.08 a.m.	2	77	38.5	924.0
	9.6	3.527	8.131	9.48 a.m.	11.48 a.m.	2	62	31.0	744.0
	4.1	...	...	10.14 a.m.	12.14 p.m.	2	6	2.0	48.0
July 22	18.3	5.234	.123	7.27 a.m.	9.33 a.m.	2.1	1	.5	12.0
	15	4.280	.242	8.14 a.m.	10.14 a.m.	2.0	29	14.5	348.0
	10.5	4.125	1.778	8.44 a.m.	10.44 a.m.	2.0	12	6.0	144.0
	4.5	...	...	9.10 a.m.	11.10 a.m.	2	2	1.0	24.0
Aug. 7	18.6	10.314	.015	8.45 a.m.	10.45 a.m.	2	0	0	0.0
	15.2	4.125	.015	9.15 a.m.	11.18 a.m.	2	0	0	0.0
	13.3	4.177	.024	9.43 a.m.	11.44 a.m.	2	0	0	0
	6.3	0.0	4.493	9.30 a.m.	11.35 a.m.	2	15	7.5	180.0
	3.6	...	...	11.53 a.m.	1.53 p.m.	2	0	0	0
Aug. 8	3.8– 3.3	...	...	...	...	[b]4	45	11.2	268.8
	[a]3.8– 3.3	...	...	...	...	[b]4	122	30.5	732
Aug. 10	19	...	...	9.45 a.m.	12.45 p.m.	3	0	0	0
	19.2	...	...	10.00 a.m.	1.02 p.m.	3	0	0	0
	8 – 9.2	...	...	10.18 a.m.	1.18 p.m.	3	118	39.3	943.2
	3	...	...	10.30 a.m.	1.40 p.m.	3	5	1.6	38.4
	3.1– 2.5	...	...	8.35 a.m.	12.33 p.m.	4	1	.25	6
	11	...	...	9.00 a.m.	1.00 p.m.	4.0	0	0	0
Aug. 12	7.7– 7.2	...	...	9.12 a.m.	1.18 p.m.	4.1	111	27.0	648
	2.5– 3.1	...	...	12.33 p.m.	4.30 p.m.	4.0	3	.7	16.8
	11	...	...	5.00 p.m.	9.10 p.m.	4.1	0	0	0
	7.2– 7.7	...	...	5.18 p.m.	9.18 p.m.	4.0	71	17.7	424.8
Aug. 13	2.5– 3.1	...	...	9.00 p.m.	1.20 a.m.	4.3	1	.2	4.8
	11	...	...	9.10 p.m.	1.32 a.m.	4.3	0	0	0
	7.2– 7.7	...	...	9.18 p.m.	1.43 a.m.	4.5	24	5.3	127.2
	2.5– 3.1	...	...	1.20 a.m.	5.00 a.m.	3.6	1	.3	7.2
	11	...	...	1.32 a.m.	5.10 a.m.	4.2	12	2.8	67.2
	7.2– 7.7	...	...	1.43 a.m.	5.18 a.m.	3.5	72	20.5	492.0
	2.5– 3.1	...	...	5.00 a.m.	8.30 a.m.	3.5	1	.2	4.8
	11	...	...	5.10 a.m.	9.00 a.m.	3.8	0	0	0
	7.2– 7.7	...	...	5.18 a.m.	9.18 a.m.	4.0	76	19	456

[a] All nets marked with this sign were ¾-inch mesh, bar measure, 3 by 75 feet. All other nets were 1-inch mesh, 3 by 60 feet.
[b] Nets set in Catfish Bay.

TABLE 3.—PERCH CAUGHT PER HOUR AND PER DAY IN GILL NETS, LAKE MENDOTA, 1916—Continued.

Date.	Depth set (meters).	Cubic centimeters of gases per liter.		Gill nets.			Number of perch caught.		
		CO_2.	O.	Time set.	Time pulled.	Hours in water.	Total.	Average per hour.	Average per 24 hours.
Aug. 16	7.5–6.5	....	....	8.15 a. m.	9.40 a. m.	1.5	19	12.6	302.4
Aug. 17	6 –8	....	....	8.15 a. m.	9.30 a. m.	1.2	172	137.6	3,442.4
Aug. 18	6.5–7	....	....	8.15 a. m.	9.15 a. m.	1	10	10.0	240
Aug. 21	6.5–7.7	....	....	8.10 a. m.	8.35 a. m.	.5	15	36.0	864
Aug. 22	6.5–7	....	....	8.00 a. m.	10.20 a. m.	2.3	2	.8	19.2
	9	....	....	10.40 a. m.	12.35 p. m.	2.0	99	49.5	988.0
Aug. 23	8 –7	....	....	8.00 a. m.	8.50 a. m.	.8	0	0	0
	9	....	....	8.55 a. m.	9.47 a. m.	1.8	3	1.6	38.4
	10	....	....	9.53 a. m.	10.23 a. m.	.75	1	1.3	31.2
	6.5–6	....	....	12.30 p. m.	1.30 p. m.	1.0	0	0	0
	8.2	....	....	1.35 p. m.	2.35 p. m.	1.0	1	.1	24.0
	8.5	....	....	2.40 p. m.	3.30 p. m.	.8	0	0	0
Aug. 24	7.5	....	....	8.15 a. m.	9.00 a. m.	.75	14	18.6	446.4
	7	....	....	8.25 a. m.	9.15 a. m.	.8	0	0	0
Aug. 25	8.5–7	....	....	8.00 a. m.	9.28 a. m.	1.5	0	0	0
	7.5	....	....	8.10 a. m.	9.23 a. m.	1.2	0	0	0
	7 –8.5	....	....	8.20 a. m.	9.35 a. m.	1.2	0	0	0
	11.5–10.5	4.950	.09	9.40 a. m.	10.30 a. m.	.8	0	0	0
	10 –7.5	....	....	9.44 a. m.	10.33 a. m.	.8	0	0	0
	7.5–6.2	....	....	9.47 a. m.	10.36 a. m.	.8	0	0	0
	10 –9	....	....	10.40 a. m.	12.00 m.	1.3	0	0	0
	7.5–11	....	....	12.10 p. m.	2.00 p. m.	1.2	15	12.5	150
Aug. 26	12	4.383	.049	6.10 a. m.	7.35 a. m.	1.4	10	7.1	170.4
	9	....	....	6.10 a. m.	7.30 a. m.	1.3	8	6.1	146.4
	6	....	....	6.10 a. m.	7.25 a. m.	1.2	16	13.3	212.8
Aug. 27	9	....	....	6.15 a. m.	7.35 a. m.	1.3	116	89.2	1,140.8
	8	....	....	6.14 a. m.	7.55 a. m.	1.6	22	13.8	331.2
	7	....	....	6.12 a. m.	8.04 a. m.	1.8	0	0	0
Aug. 30	9.5–8.3	....	....	6.23 a. m.	7.04 a. m.	.66	0	0	0
	8.3–7.3	....	....	6.29 a. m.	7.08 a. m.	.66	0	0	0
	11.2	....	....	7.20 a. m.	7.58 a. m.	.66	42	63	1,512
Aug. 31	10.8–11.2	....	....	6.22 a. m.	7.30 a. m.	1.16	14	12	248
	11.2–11.5	....	....	6.25 a. m.	7.25 a. m.	1.0	22	22	528
Sept. 1	8	....	....	6.24 a. m.	7.30 a. m.	1.1	0	0	0
	10	....	....	7.35 a. m.	8.44 a. m.	1.16	24	20.6	494.4
Sept. 4	11.5–11.6	....	....	6.30 a. m.	7.45 a. m.	1.25	3	2.4	57.6
	11.6–11.7	....	....	6.34 a. m.	7.38 a. m.	1	20	20	480
Sept. 7	9.5	....	....	9.43 a. m.	1.43 p. m.	4.0	1	.2	4.8
	(a)	....	....	9.49 a. m.	1.52 p. m.	4.0	0	0	0
	3 –2.6	....	....	10.10 a. m.	2.04 p. m.	4.0	3	.7	16.8
	9.5	....	....	1.45 p. m.	5.37 p. m.	4.8	18	9.8	235.2
	(a)	....	....	1.52 p. m.	5.48 p. m.	4.0	0	0	0
	3 –2.6	....	....	2.06 p. m.	5.55 p. m.	3.8	2	.4	9.6
	9.5	....	....	5.43 p. m.	9.47 p. m.	4.0	39	9.7	232.8
	(a)	....	....	5.48 p. m.	10.08 p. m.	4.6	0	0	0
	3 –2.6	....	....	5.55 p. m.	10.18 p. m.	4.3	0	0	0
Sept. 8	9.5	....	....	10.06 p. m.	1.47 a. m.	3.6	12	3.2	76.8
	(a)	....	....	10.10 p. m.	1.44 a. m.	3.5	0	0	0
	3 –2.6	....	....	10.20 p. m.	2.13 a. m.	3.9	0	0	0.2
	9.5	....	....	1.45 a. m.	5.38 a. m.	3.9	13	3.3	79.2
	(a)	....	....	2.05 a. m.	5.48 a. m.	3.7	0	0	0
	3 –2.6	....	....	2.15 a. m.	6.03 a. m.	3.8	0	0	0
	9.5	....	....	5.41 a. m.	9.43 a. m.	4.0	19	4.7	112.8
	(a)	....	....	5.50 a. m.	9.55 a. m.	4.1	0	0	0
	3 –2.6	....	....	6.05 a. m.	10.10 a. m.	4.1	0	0	0
	9.5	....	....	9.50 a. m.	1.43 p. m.	3.9	0	0	0
Sept. 9	11 –11.5	....	....	11.15 a. m.	3.07 p. m.	3.9	60	15.3	367.2
	(a)	....	....	11.25 a. m.	3.25 p. m.	4.0	0	0	0
	3.1–2.3	....	....	11.45 a. m.	4.00 p. m.	4.3	0	0	0
	11	....	....	3.25 p. m.	7.15 p. m.	3.16	67	21.1	506.4
	(a)	....	....	3.26 p. m.	7.33 p. m.	4.1	0	0	0
	3.2	....	....	4.02 p. m.	7.42 p. m.	3.6	0	0	0
	11	....	....	7.30 p. m.	11.15 p. m.	3.75	0	0	0
	(a)	....	....	7.35 p. m.	11.20 p. m.	3.75	0	0	0
	3.2	....	....	7.45 p. m.	11.32 p. m.	3.75	0	0	0
Sept. 10	11	....	....	11.17 p. m.	3.06 a. m.	3.8	0	0	0
	(a)	....	....	3.12 a. m.	7.06 a. m.	3.9	39	10	240
	(a)	....	....	3.17 a. m.	7.20 a. m.	4.0	1	.2	4.8
	3.2	....	....	3.29 a. m.	7.37 a. m.	4.1	0	0	0
	11	....	....	7.17 a. m.	11.15 a. m.	4.0	29	7.2	172.8
	(a)	....	....	7.23 a. m.	11.23 a. m.	4.0	0	0	0
	3.2	....	....	7.38 a. m.	11.45 a. m.	4.1	1	.2	4.8
Sept. 13	17.5	....	....	1.55 p. m.	3.25 p. m.	1.5	0	0	0
	14.5	....	....	2.10 p. m.	3.40 p. m.	1.5	0	0	0
	12.1	....	....	2.19 p. m.	3.49 p. m.	1.5	14	9.3	223.2
	8.7–7.5	....	....	2.27 p. m.	3.57 p. m.	1.5	0	0	0

[a] Surface.

TABLE 4.—FISHES CAUGHT PER HOUR IN GILL NETS, LAKE WINGRA, 1916.[a]

Date.	Temperature (degrees centigrade).	Gill nets.			Perca flavescens.	Esox lucius.	Lepomis incisor.	Pomoxis sparoides.	Lepisosteus osseus.	Micropterus dolomieu.	Micropterus salmoides.	Abramis crysoleucas.	Cyprinus carpio.	Eupomotis gibbosus.	Amia calva.	Ameiurus nebulosus.
		Depth set (meters).	Size mesh (inches).	Hours in water.												
Apr. 8	......	2	¾	4	13.7	0	0	0	0	0	0	0	0	0	0	0
		2	1	4	.7	.5	0	0	0	0	0	0	0	0	0	0
		2	2	4	0	0	0	0	0	0	0	0	0	0	0	0
		2	1	2.2	15	0	0	0	0	0	0	0	0	0	0	0
		2	2	2.2	0	1	0	0	0	0	0	0	0	0	0	0
Apr. 14	......	2	{¾ and 1}	.5	16	0	0	0	0	0	0	0	0	0	0	0
Apr. 20	10.6	.7	¾	1.3	17.3	0	0	0	0	0	0	0	0	0	0	0
		1	1½	4.2	0	1.3	2	1.3	0	.6	0	0	0	0	0	0
		.7	2	4.2	0	0	0	0	0	0	0	0	0	0	0	0
		1	1	4.2	.9	4	4	0	0	0	0	0	0	0	0	0
Apr. 22	......	3	1½	.2	0	4	0	0	0	0	0	0	0	0	0	0
		1.5	¾	1.1	15	0	0	0	0	0	0	11	0	0	0	0
		1	1½	1.6	0	0	0	0	0	0	0	0	0	0	0	0
		1	1	4.6	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1½	3	0	3	.6	1.6	0	0	.6	0	0	0	0	0
		1.5	¾	3.5	0	0	0	0	0	0	.1	0	0	0	0	0
		1.5	1	3.5	.9	0	.5	0	0	0	0	0	.3	0	0	0
		1.5	1	3.5	0	0	0	0	0	0	0	0	0	0	0	0
Apr. 29	......	2	1	1.4	0	0	0	0	0	0	0	0	0	0	0	0
		2	1½	.5	0	0	0	0	0	0	0	0	0	0	0	0
		1	¾	1.6	5.6	.8	0	0	0	0	0	0	0	0	0	0
		2	1	2.3	0	0	0	0	0	0	0	0	0	0	0	0
		2	1½	2.1	0	0	0	0	0	0	0	0	0	.5	0	0
		2	¾	2.1	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1½	.4	0	0	0	0	0	0	4	0	0	2	0	0
		1.5	1	.4	0	0	2	0	0	0	0	0	0	0	0	0
		1	1½	1.2	0	0	0	0	0	0	0	0	0	0	0	0
		1	1	1.2	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1½	1.2	0	0	0	0	0	0	0	0	0	0	0	0
		1.2	1	1.2	0	0	0	0	0	0	0	0	0	0	0	0
May 6	......	1	¾	3.1	13.7	0	.3	0	0	0	0	1.1	0	.3	.3	0
		1	1	3.2	0	0	.3	0	0	0	0	.3	0	0	.3	0
		1	1½	3.5	0	0	0	.3	0	0	0	0	0	0	.5	0
		1	1	.7	5.2	0	1.2	0	0	0	0	0	0	0	0	0
		1	1½	1.7	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1½	.5	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1	1	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1	1	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1½	1	0	0	0	2	0	0	0	0	0	0	0	0
		1.5	1	.6	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1½	.6	0	0	0	0	0	0	0	0	0	0	0	0
May 13	16	2	1½	2.3	0	0	0	0	0	0	0	0	0	0	0	0
		2.5	1	3.5	0	0	0	0	0	0	0	0	0	0	0	0
		2	¾	2	6.5	0	0	0	0	0	0	0	0	0	0	0
		1	1	1.3	0	1	0	1	0	0	0	0	0	0	0	0
		1	1½	1	0	0	0	0	0	0	0	0	0	0	2	0
		1	1½	1.5	0	0	0	0	0	0	0	0	0	0	0	0
		1	1	1.3	7.1	0	0	.8	0	0	0	0	0	0	0	0
		1	1½	1.3	0	0	0	1	0	0	0	0	1	0	0	0
May 20	......	1	1½	1.7	0	0	0	0	0	0	0	0	0	0	0	0
		1	1½	.5	0	0	0	2	0	0	0	0	0	0	0	2
		1.5	1½	.3	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1½	1.3	0	0	0	0	0	0	0	0	0	0	0	0
		1	1	1.6	0	0	0	0	0	0	0	0	0	0	0	0
		1	1	2	0	0	0	0	0	0	0	0	0	1	0	0
		1.5	¾	1	16	0	0	0	0	0	0	0	0	0	0	0
		1.5	¾	.5	10	0	0	0	0	0	0	5	0	1	0	0
		1.5	¾	1	13	0	0	4	0	0	0	0	0	1	0	0
May 27	26	1	1½	1.5	0	0	0	0	0	0	0	0	0	0	0	0
		1	1½	1.3	0	0	0	0	0	0	1.3	0	0	0	0	0
		1	1½	1.5	0	.6	.6	.6	0	0	1.3	0	0	0	0	0
		1	1	1.5	0	0	1.3	0	0	0	0	0	.6	0	0	0
		1	1	1.5	0	0	1.3	0	0	0	.6	0	0	0	.6	0
		1	1	1.5	1.3	0	0	0	0	0	0	0	.6	0	0	0
		1	1	2.5	0	0	0	0	0	0	0	0	0	0	0	0
		1	¾	1.6	37.8	0	.6	0	0	0	0	0	0	0	0	0
June 3	......	1	¾	1	21	0	2	1	0	0	0	0	0	1	1	0
		1	¾	1.2	8.8	0	.8	0	0	0	0	0	0	0	0	0
		1	¾	.3	12	0	0	0	0	0	0	0	0	0	2	2
		1	¾	.3	9	0	4	0	0	0	0	0	0	0	0	0
		1	1	1.1	0	0	0	0	0	0	0	0	0	0	0	0
		1	1	.5	0	0	0	0	0	0	0	0	0	0	0	0
		1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
		1	1½	.7	0	0	0	0	0	0	0	0	6.4	1.2	1.2	0
		1	1½	1.3	0	0	0	0	0	0	0	0	5.6	.8	0	2.4
		1	1½	1	0	0	0	0	0	0	0	0	0	0	0	0
		1	¾	.8	1.2	0	0	0	0	0	1.2	0	0	0	0	0
		1	1	.6	0	0	0	0	0	1.5	0	0	0	0	0	0

[a] In all nets the mesh sizes were bar measure. The 1-inch mesh nets were 60 feet long; all others, 75 feet long.

TABLE 4.—FISHES CAUGHT PER HOUR IN GILL NETS, LAKE WINGRA, 1916—Continued.

Date.	Temperature (degrees centigrade).	Gill nets.			Perca flavescens.	Esox lucius.	Lepomis incisor.	Pomoxis sparoides.	Lepisosteus osseus.	Micropterus dolomieu.	Micropterus salmoides.	Abramis crysoleucas.	Cyprinus carpio.	Eupomotis gibbosus.	Amia calva.	Ameiurus nebulosus.
		Depth set (meters).	Size mesh (inches).	Hours in water.												
June 10	20.5	2	1½	2.2	0	0	0	.4	0	0	0	0	0	0	0	0
		1	1	1	0	0	1	0	0	0	0	0	0	0	0	0
		1.5	¾	.7	8	0	0	0	0	1.2	0	5.2	0	0	0	0
		1.5	¾	.5	8	0	0	0	0	0	0	8	0	0	0	0
June 17	......	1	¾	1.3	8.8	0	0	.8	0	0	0	0	0	.8	0	0
		1	¾	2	10.5	0	0	0	0	0	0	0	0	0	.5	0
		1.5	1	1.1	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1	2.1	0	0	1.4	.4	0	0	0	0	0	0	0	0
		1.5	1½	1	0	0	0	0	0	0	0	0	0	0	1	0
		1.5	1½	2.3	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1	1.5	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1	1.5	0	0	0	0	0	0	0	0	0	1.3	0	0
		1.5	1	1.5	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1	.7	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1½	.5	0	0	0	0	0	2	0	0	0	0	0	0
		1.5	1½	1.7	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	1½	1.5	0	0	0	0	0	0	0	0	0	0	0	0
July 22	30	1.8	1½	2.1	0	0	.8	0	0	0	0	0	0	0	0	0
		2.4	1	2.2	.7	0	0	0	0	0	0	0	0	0	0	0
		3.1	¾	2	39	0	0	0	0	0	0	0	0	0	0	0
July 26	29.4	2.4	¾	1.8	8.2	0	0	0	0	0	0	0	0	0	0	0
		3.1	1	2.1	0	0	0	0	0	0	0	0	0	0	0	0
		3.7	1½	2.3	0	0	0	0	0	0	.6	0	0	0	0	0
		3.1	¾	1.6	1.2	0	0	0	0	0	0	0	0	0	0	0
		2.4	1	1.6	1.2	0	0	0	0	0	0	0	0	0	0	0
		2.2	1½	1.6	0	0	0	0	0	0	0	0	0	0	0	0
Aug. 5	......	2.7	¾	2.8	2.9	0	0	0	0	0	0	0	0	0	0	0
		2.7	1	2.8	0	0	0	0	.3	0	0	0	0	0	0	0
		2.7	1½	2.8	0	0	.3	.7	0	0	0	0	0	0	0	0
Aug. 11	26	2.9	¾	1.5	0	0	.6	.6	0	0	.6	0	0	0	0	0
		2.9	1	1.4	0	0	0	0	0	0	0	0	0	0	0	0
		3	1½	1.3	0	0	.7	0	.7	0	0	0	0	.7	0	0
		3.5	¾	1.7	0	0	0	0	0	0	0	0	0	.5	0	0
		3.3	1	1.7	0	0	0	0	0	0	0	0	0	0	0	0
		3.1	1½	1.5	0	0	0	0	0	0	0	0	0	1.2	0	0
		1.5	1½	1	0	0	0	1	0	0	0	0	0	3	0	0
		1.5	1	1	0	0	0	0	0	0	0	0	0	0	0	0
		2.5	¾	1	0	0	0	0	0	0	0	0	0	0	0	0
Aug. 15	......	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0
		2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
		2	1	1	0	0	0	0	0	0	0	0	0	0	0	0
		3.5	1	.7	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	¾	1.7	0	0	0	0	0	.5	0	0	0	0	0	0
		1.5	¾	.9	.9	0	0	1	0	0	0	0	0	0	0	0
		3.5	¾	.7	0	0	0	0	0	0	0	0	0	0	0	0
		1.5	¾	1	3	0	0	0	0	0	0	0	0	0	0	0
Aug. 19	26.8	1	1	13	2.4	0	0	0	.8	0	0	0	0	0	0	0
Aug. 20	......	2.8	1½	3.2	0	0	0	0	0	.7	0	0	0	0	0	0
		2.8	1	3	0	0	0	0	0	0	0	0	0	0	0	0
		2.8	¾	2.7	.3	0	0	0	0	0	0	0	.3	0	0	0
Aug. 29	......	1	¾	5	5	0	0	0	0	0	0	0	0	0	0	0
		1.5	1	4.8	0	0	0	.6	0	0	0	0	0	0	0	0
		2	1½	4.8	0	0	0	0	0	0	0	0	0	0	0	0
Sept. 5	......	1	¾	4.9	7	0	0	0	0	0	2.3	0	0	.7	0	0
		2	1	4.3	.4	.4	0	0	0	.5	0	0	0	0	0	0
		3	1½	4.5	0	0	0	0.2	0	0	0	0	0	1	0	0
Sept. 14	19.9	2	¾	4.1	3.3	0	0	0	0	0	0	0	0	0	0	0
		2.5	1	4.1	0	0	0	0	0	0	0	0	0	0	0	0
		3	1½	4	0	0	0	0	0	0	0	0	0	0	0	0
Sept. 23	14.5	3	1½	1.6	0	0	0	0	0	0	0	0	0	0	0	0
		2	1	1.4	0	0	0	0	0	0	0	0	0	0	0	0
		1.1	¾	1.3	1.6	0	0	0	0	0	0	0	0	0	0	0
		1	¾	2.6	0	0	0	0	0	.4	0	0	0	0	0	0
		1.5	1	2.6	.8	0	0	0	0	0	0	0	0	0	0	0
		2	1½	2.6	0	0	0	0	0	0	0	0	0	.8	0	0
Sept. 30	13.5	1.5	¾	4.3	1.7	0	0	0	0	0	0	0	0	0	0	0
		2	1	4	.5	0	0	0	0	0	0	0	0	0	0	0
		2.5	1½	3.7	0	0	0	0	0	0	0	0	0	0	0	0
Oct. 7	14.8	.7	¾	4.8	1.7	0	0	0	0	.2	0	0	0	.2	0	0
		1.5	1	4.5	.4	0	0	0	0	0	0	0	0	0	0	0
		2.5	1½	4.3	0	0	0	0	0	0	0	0	0	0	0	0
Oct. 10	14.2	1	1	2	.5	0	0	0	0	0	0	0	0	0	0	0
		1	1	1.7	0	0	0	0	0	0	0	0	0	0	0	0
		2	1½	1.7	0	0	0	0	0	0	0	0	0	0	0	0
		1	1½	1.7	0	0	0	0	0	0	0	0	0	0	0	0
Oct. 11	13.7	1.7	1	3.2	1.3	0	0	0	0	0	0	0	0	0	0	0
		2.5	1½	3.1	0	0	0	0	0	0	0	0	0	0	0	0
Oct. 12	......	1.7	1	14.8	.07	0	0	0	0	0	0	0	0	0	0	0
		2.5	1½	14.7	0	0	0	.07	0	0	0	0	0	0	0	0

TABLE 4.—FISHES CAUGHT PER HOUR IN GILL NETS, LAKE WINGRA, 1916—Continued.

Date.	Temperature (degrees centigrade).	Gill nets.			Perca flavescens.	Esox lucius.	Lepomis incisor.	Pomoxis sparoides.	Lepisosteus osseus.	Micropterus dolomieu.	Micropterus salmoides.	Abramis crysoleucas.	Cyprinus carpio.	Eupomotis gibbosus.	Amia calva.	Ameiurus nebulosus.
		Depth set (meters).	Size mesh (inches).	Hours in water.												
Oct. 14	12.3	1.7	1	48	.02	0	0	0	0	0	0	.02	.02	0	0	0
		2.5	1½	48	0	0	0	.06	0	0	0	0	.04	.02	0	0
		2.5	1½	3	0	0	0	0	0	0	0	0	0	0	0	0
		.8	¾	3	2.1	0	0	0	0	0	0	0	0	0	0	0
Oct. 20	8.5	1.6	1	31.8	.1	0	0	0	0	0	0	0	0	0	0	0
		3	1½	31.5	0	0	0	0	0	0	0	0	0	0	0	0
		3.3	2	31.1	0	.03	0	0	0	0	0	0	0	0	0	0
Oct. 28	4.1	2	1	48	.3	0	0	0	0	0	0	0	0	0	0	0
		3	1	47.5	0	0	0	0	0	0	0	0	.02	0	0	0
		3	2	47.5	0	0	0	0	0	0	0	0	0	0	0	0
Oct. 31	6.5	2	1	71.7	.08	0	0	0	0	0	0	0	.01	0	0	0
		3	1	71.9	0	0	0	0	0	0	0	0	.02	0	0	0
		3	2	71.9	0	0	0	0	0	0	0	0	0	0	0	0
		1.4	¾	.6	3.3	0	0	0	0	0	0	0	0	0	0	0
Nov. 4	7	2	1	96	.03	0	0	0	0	0	0	0	0	0	0	0
		3	1	96	0	0	0	0	0	0	0	0	0	0	0	0
		3	2	95.9	0	.01	0	0	0	0	0	0	0	0	0	0
		1.5	1	2.7	.6	0	0	0	0	0	0	0	0	0	0	0
		2	1½	2.4	0	0	0	0	0	0	0	0	0	0	0	0
		3	2	2.5	0	0	0	0	0	0	0	0	0	0	0	0
		1	¾	2.5	2.4	0	0	0	0	0	0	0	0	0	0	0
Nov. 5	......	1.5	1	19	.2	0	0	0	0	0	0	0	0	0	0	0
		2	1½	19	0	0	0	0	0	0	0	0	0	0	0	0
		3	2	19	0	0	0	0	0	0	0	0	0	0	0	0
Nov. 7	7.2	3	1	49	.1	0	0	0	0	0	0	0	0	0	0	0
		3	1½	49	0	0	0	0	0	0	0	0	0	0	0	0
		3	2	49	0	0	0	0	0	0	0	0	0	0	0	0
Nov. 9	8	3	1	48	.3	0	0	0	0	0	0	0	0	0	0	0
		3	1½	48	0	0	0	0	0	0	0	0	0	0	0	0
		3	2	48	0	0	0	0	0	0	0	0	0	0	0	0
Nov. 11	6.7	3.5	1	47.5	.2	0	0	0	0	0	0	0	0	0	0	0
		3.5	1½	47.5	0	0	0	0	0	0	0	0	0	0	0	0
		3.5	2	47.5	0	.02	0	0	.02	0	0	0	0	0	0	0
		1	¾	2	.5	0	0	0	0	0	0	0	0	0	0	0
Dec. 7[a]	......	1.5	¾	20.4	0	0	0	0	0	0	0	0	0	0	0	0
Dec. 8	3.8	1.5	¾	26	.03	0	0	0	0	0	0	0	0	0	0	0
Dec. 9[a]	2.2	1.5	¾	21.3	0	0	0	0	0	0	0	0	0	0	0	0

[a] Lake Wingra froze over on Nov. 15, but opened up again; it did not freeze over for the winter until Dec. 10.

TABLE 5.—PERCH CAUGHT PER HOUR AND PER DAY IN GILL NETS, LAKE WINGRA, 1916.[a]

Date.	Temperature (degrees centigrade).	Gill nets.					Perch caught.		
		Depth set (meters).	Size mesh (inches).	Time set.	Time pulled.	Hours in water.	Total.	Average per hour.	Average per 24 hours.
Apr. 8		2	¾	7.00 a. m.	11.00 a. m.	4	55	13.7	329
		2	1	7.00 a. m.	11.00 a. m.	4	3	.7	18
		2	2	7.00 a. m.	11.00 a. m.	4	0	0	0
		2	1	11.45 a. m.	2.30 p. m.	2.2	33	15	360
		2	2	11.45 a. m.	2.30 p. m.	2.2	0	0	0
Apr. 14		2	¾ and 1			.5	8	16	384
Apr. 20	10.6	.7	¾	7.00 a. m.	8.25 a. m.	1.3	26	17.3	415
		1	1½	6.50 a. m.	11.00 a. m.	4.2	0	0	0
		.7	2	6.50 a. m.	11.00 a. m.	4.2	0	0	0
		1	1	6.50 a. m.	11.00 a. m.	4.2	4	.9	22
Apr. 22		3	1½	7.10 a. m.	7.20 a. m.	.2	0	0	0
		1.5	¾	7.10 a. m.	8.15 a. m.	1.1	16	15	360
		1	1½	7.15 a. m.	8.50 a. m.	1.6	0	0	0
		1	1	7.20 a. m.	12.00 m.	4.6	0	0	0
		1.5	1½	9.00 a. m.	12.00 m.	3	0	0	0
		1.5	¾	8.00 a. m.	11.30 a. m.	3.5	0	0	0
		1.5	1	8.00 a. m.	11.30 a. m.	3.5	3	.9	22
		1.5	1	8.00 a. m.	11.30 a. m.	3.5	0	0	0
Apr. 29		2	1	11.45 a. m.	1.00 p. m.	1.4	0	0	0
		2	1½	7.45 a. m.	8.10 a. m.	.5	0	0	0
		1	¾	6.35 a. m.	8.15 a. m.	1.6	9	5.6	134
		2	1	6.35 a. m.	8.50 a. m.	2.3	0	0	0
		2	1½	8.10 a. m.	10.15 a. m.	2.1	0	0	0
		2	¾	8.10 a. m.	10.15 a. m.	2.1	0	0	0
		1.5	1½	7.45 a. m.	8.00 a. m.	.4	0	0	0
		1.5	1	7.45 a. m.	8.00 a. m.	.4	0	0	0
		1	1½	10.30 a. m.	11.45 a. m.	1.2	0	0	0
		1	1	10.30 a. m.	11.45 a. m.	1.2	0	0	0
		1.5	1½	10.30 a. m.	11.45 a. m.	1.2	0	0	0
		1.2	1	10.30 a. m.	11.45 a. m.	1.2	0	0	0
May 6		1	¾	6.30 a. m.	9.35 a. m.	3.1	42	13.7	329
		1	1	6.30 a. m.	9.45 a. m.	3.2	0	0	0
		1	1½	6.30 a. m.	10.00 a. m.	3.5	0	0	0
		1	1	10.15 a. m.	11.00 a. m.	.7	4	5.2	125
		1	1½	10.15 a. m.	12.00 m.	1.7	0	0	0
		1.5	1½	11.30 a. m.	12.00 m.	.5	0	0	0
		1.5	1	12.00 m.	1.00 p. m.	1	0	0	0
		1.5	1	10.00 a. m.	11.00 a. m.	1	0	0	0
		1.5	1½	10.00 a. m.	11.00 a. m.	1	0	0	0
		1.5	1	1.00 p. m.	1.35 p. m.	.6	0	0	0
		1.5	1½	1.00 p. m.	1.35 p. m.	.6	0	0	0
May 13	16	2	1½	6.45 a. m.	9.00 a. m.	2.3	0	0	0
		2.5	1	7.00 a. m.	10.30 a. m.	3.5	0	0	0
		2	¾	7.00 a. m.	9.00 a. m.	2	13	6.5	156
		1	1	11.30 a. m.	12.45 p. m.	1.3	0	0	0
		1	1½	10.30 a. m.	11.30 a. m.	1	0	0	0
		1	1½	11.30 a. m.	1.00 p. m.	1.5	0	0	0
		1	1	12.45 a. m.	2.00 p. m.	1.3	9	7.1	170
		1	1½	12.45 p. m.	2.00 p. m.	1.3	0	0	0
May 20		1	1½	6.47 a. m.	8.30 a. m.	1.7	0	0	0
		1	1½	8.40 a. m.	9.12 a. m.	.5	0	0	0
		1.5	1½	9.12 a. m.	9.28 a. m.	.3	0	0	0
		1.5	1½	9.28 a. m.	10.50 a. m.	1.3	0	0	0
		1	1	6.53 a. m.	8.35 a. m.	1.6	0	0	0
		1	1	8.43 a. m.	10.40 a. m.	2	0	0	0
		1.5	¾	6.58 a. m.	7.58 a. m.	1	16	16	384
		1.5	¾	8.45 a. m.	9.18 a. m.	.5	5	10	240
		1.5	¾	9.35 a. m.	10.30 a. m.	1	13	13	312
May 27	26	1	1½	8.00 a. m.	9.30 a. m.	1.5	0	0	0
		1	1½	6.45 a. m.	8.00 a. m.	1.3	0	0	0
		1	1½	9.30 a. m.	11.00 a. m.	1.5	0	0	0
		1	1	7.00 a. m.	8.30 a. m.	1.5	0	0	0
		1	1	8.30 a. m.	10.30 a. m.	1.5	0	0	0
		1	1	10.00 a. m.	11.30 a. m.	1.5	2	1.3	31
		1	1	11.30 a. m.	2.00 p. m.	2.5	0	0	0
		1	¾	7.20 a. m.	9.00 a. m.	1.6	63	37.8	907
June 3		1	¾	6.53 a. m.	7.55 a. m.	1	21	21	504
		1	¾	7.55 a. m.	9.10 a. m.	1.2	11	8.8	211
		1	¾	9.10 a. m.	9.30 a. m.	.3	4	12	288
		1	¾	9.30 a. m.	9.52 a. m.	.3	3	9	216
		1	1	7.00 a. m.	8.05 a. m.	1.1	0	0	0
		1	1	9.15 a. m.	9.45 a. m.	.5	0	0	0
		1	1	8.15 a. m.	9.15 a. m.	1	0	0	0
		1	1½	7.25 a. m.	8.10 a. m.	.7	0	0	0
		1	1½	8.10 a. m.	9.25 a. m.	1.3	0	0	0
		1	1½	10.30 a. m.	11.30 a. m.	1	0	0	0
		1	¾	10.35 a. m.	11.25 a. m.	.8	1	1.2	29
		1	1	10.40 a. m.	11.20 a. m.	.6	0	0	0

[a] In all nets the mesh sizes were bar measure. The 1-inch mesh nets were 60 feet long; all others, 75 feet long.

TABLE 5.—PERCH CAUGHT PER HOUR AND PER DAY IN GILL NETS, LAKE WINGRA, 1916—Contd.

Date.	Temperature (degrees centigrade).	Gill nets.					Perch caught.		
		Depth set (meters).	Size mesh (inches).	Time set.	Time pulled.	Hours in water.	Total.	Average per hour.	Average per 24 hours.
June 10	20.5	2	1½	6.43 a. m.	8.42 a. m.	2.2	0	0	0
		1	1	6.57 a. m.	7.58 a. m.	1	0	0	0
		1.5	¾	7.05 a. m.	7.48 a. m.	.7	6	8	192
		1.5	¾	7.48 a. m.	8.15 a. m.	.5	4	8	192
June 17		1	¾	5.50 a. m.	7.03 a. m.	1.3	11	8.8	211
		1	¾	7.03 a. m.	9.00 a. m.	2	21	10.5	252
		1.5	1	6.10 a. m.	7.20 a. m.	1.1	0	0	0
		1.5	1	7.20 a. m.	9.30 a. m.	2.1	0	0	0
		1.5	1½	6.32 a. m.	7.32 a. m.	1	0	0	0
		1.5	1½	7.32 a. m.	9.45 a. m.	2.3	0	0	0
		1.5	1	10.00 a. m.	11.30 a. m.	1.5	0	0	0
		1.5	1	10.00 a. m.	11.30 a. m.	1.5	0	0	0
		1.5	1	11.30 a. m.	1.00 p. m.	1.5	0	0	0
		1.5	1	1.00 p. m.	1.45 p. m.	.7	0	0	0
		1.5	1½	9.45 a. m.	10.15 a. m.	.5	0	0	0
		1.5	1½	10.15 a. m.	12.00 m.	1.7	0	0	0
		1.5	1½	10.30 a. m.	12.00 m.	1.5	0	0	0
July 22	30	1.8	1½	6.58 a. m.	9.03 a. m.	2.1	0	0	0
		2.4	1	6.50 a. m.	9.00 a. m.	2.2	2	.7	16
		3.1	¾	6.40 a. m.	8.45 a. m.	2	78	39	936
July 26	29.4	2.4	¾	7.12 a. m.	9.03 a. m.	1.8	15	8.2	196
		3.1	1	6.50 a. m.	9.03 a. m.	2.1	0	0	0
		3.7	1½	6.40 a. m.	8.59 a. m.	2.3	0	0	0
		3.1	¾	9.20 a. m.	11.00 a. m.	1.6	2	1.2	29
		2.4	1	9.20 a. m.	11.00 a. m.	1.6	2	1.2	29
		2.2	1½	9.20 a. m.	11.00 a. m.	1.6	0	0	0
Aug. 5		2.7	¾	6.40 a. m.	9.30 a. m.	2.8	8	2.9	70
		2.7	1	6.40 a. m.	9.30 a. m.	2.8	0	0	0
		2.7	1½	6.40 a. m.	9.30 a. m.	2.8	0	0	0
Aug. 11	26	2.9	¾	9.00 a. m.	10.30 a. m.	1.5	0	0	0
		2.9	1	9.04 a. m.	10.30 a. m.	1.4	0	0	0
		3	1½	9.10 a. m.	10.30 a. m.	1.3	0	0	0
		3.5	¾	10.50 a. m.	12.25 p. m.	1.7	0	0	0
		3.3	1	10.53 a. m.	12.25 p. m.	1.7	0	0	0
		3.1	1½	10.55 a. m.	12.25 p. m.	1.5	0	0	0
		1.5	1½	1.31 p. m.	2.30 p. m.	1	0	0	0
		1.5	1	1.35 p. m.	2.35 p. m.	1	0	0	0
		2.5	¾	1.42 p. m.	2.40 p. m.	1	0	0	0
Aug. 15		2	1	8.45 a. m.	10.45 a. m.	2	0	0	0
		2	1	11.00 a. m.	12.00 m.	1	0	0	0
		3.5	1	12.30 p. m.	1.15 p. m.	.7	0	0	0
		2	1	1.40 p. m.	2.40 p. m.	1	0	0	0
		1.5	¾	9.05 a. m.	10.50 a. m.	1.7	0	0	0
		1.5	¾	11.05 a. m.	12.00 m.	.9	1	.9	22
		3.5	¾	12.35 p. m.	1.20 p. m.	.7	0	0	0
		1.5	¾	1.40 p. m.	2.40 p. m.	1	3	3	72
Aug. 19	26.8	1	1	7.35 a. m.	8.40 a. m.	13	32	2.4	26
Aug. 20		2.8	1½	5.10 a. m.	8.20 a. m.	3.2	0	0	0
		2.8	1	5.22 a. m.	8.18 a. m.	3	0	0	0
		2.8	¾	5.35 a. m.	8.12 a. m.	2.7	1	.3	7
Aug. 29		1	¾	6.05 a. m.	11.00 a. m.	5	25	5	120
		1.5	1	6.10 a. m.	11.03 a. m.	4.8	0	0	0
		2	1½	6.15 a. m.	11.05 a. m.	4.8	0	0	0
Sept. 5		1	¾	6.15 a. m.	11.10 a. m.	4.9	35	7	168
		2	1	6.22 a. m.	11.00 a. m.	4.3	2	.4	10
		3	1½	6.28 a. m.	10.55 a. m.	4.5	0	0	0
Sept. 14	19.9	2	¾	6.15 a. m.	10.20 a. m.	4.1	13	3.3	79
		2.5	1	6.20 a. m.	10.25 a. m.	4.1	0	0	0
		3	1½	6.26 a. m.	10.28 a. m.	4	0	0	0
Sept. 23	14.5	3	1½	6.15 a. m.	7.50 a. m.	1.6	0	0	0
		2	1	6.24 a. m.	7.50 a. m.	1.4	0	0	0
		1.1	¾	6.32 a. m.	7.50 a. m.	1.3	2	1.6	38
		1	¾	8.10 a. m.	10.45 a. m.	2.6	0	0	0
		1.5	1	8.14 a. m.	10.50 a. m.	2.6	2	.8	19
		2	1½	8.18 a. m.	10.55 a. m.	2.6	0	0	0
Sept. 30	13.5	1.5	¾	6.30 a. m.	10.45 a. m.	4.3	7	1.7	31
		2	1	6.45 a. m.	10.42 a. m.	4	2	.5	12
		2.5	1½	6.55 a. m.	10.38 a. m.	3.7	0	0	0
Oct. 7	14.8	.7	¾	6.23 a. m.	11.08 a. m.	4.8	8	1.7	31
		1.5	1	6.32 a. m.	11.04 a. m.	4.5	2	.4	10
		2.5	1½	6.43 a. m.	11.00 a. m.	4.3	0	0	0
Oct. 10	14.2	1	1	2.00 p. m.	3.57 p. m.	2	1	.5	12
		1	1	4.07 p. m.	5.50 p. m.	1.7	0	0	0
		2	1½	2.10 p. m.	3.55 p. m.	1.7	0	0	0
		2	1½	4.09 p. m.	5.50 p. m.	1.7	0	0	0
Oct. 11	13.7	1.7	1	1.55 p. m.	5.09 p. m.	3.2	4	1.3	31
		2.5	1½	2.00 p. m.	5.06 p. m.	3.1	0	0	2
Oct. 12		1.7	1	5.09 p. m.	7.55 a. m.	14.8	1	.07	0
		2.5	1½	5.06 p. m.	7.50 a. m.	14.7	0	0	0

TABLE 5.—PERCH CAUGHT PER HOUR AND PER DAY IN GILL NETS, LAKE WINGRA, 1916—Contd.

Date.	Temperature (degrees centigrade).	Gill nets.					Perch caught.		
		Depth set (meters).	Size mesh (inches).	Time set.	Time pulled.	Hours in water.	Total.	Average per hour.	Average per 24 hours.
Oct. 14	12.3	1.7	1	7.55 a. m.	7.50 a. m.	48	1	.02	.5
		2.5	1½	7.50 a. m.	10.50 a. m.	3	0	0	0
		2.5	1½	7.50 a. m.	7.45 a. m.	48	0	0	0
		.8	¾	7.45 a. m.	10.45 a. m.	3	6	2.1	50
Oct. 20	8.5	1.6	1	8.10 a. m.	4.00 p. m.	31.8	3	.1	2
		3	1½	8.20 a. m.	3.50 p. m.	31.5	0	0	0
		3.3	2	8.30 a. m.	3.40 p. m.	31.1	0	0	0
Oct. 28	4.1	2	1	8.25 a. m.	8.30 a. m.	48	13	.3	7
		3	1	8.35 a. m.	8.10 a. m.	47.5	0	0	0
		3	2	8.43 a. m.	8.15 a. m.	47.5	0	0	0
Oct. 31	6.5	2	1	8.30 a. m.	8.15 a. m.	71.7	6	.08	2
		3	1	8.10 a. m.	8.03 a. m.	71.9	0	0	0
		3	2	8.15 a. m.	8.08 a. m.	71.9	0	0	0
		1.4	¾	8.05 a. m.	8.43 a. m.	.6	2	3.3	79.2
Nov. 4	7	2	1	8.15 a. m.	8.12 a. m.	96	3	.03	.7
		3	1	8.03 a. m.	8.05 a. m.	96	0	0	0
		3	2	8.08 a. m.	8.00 a. m.	95.9	0	0	0
		1.5	1	8.30 a. m.	11.10 a. m.	2.7	2	.6	14
		2	1½	8.32 a. m.	11.08 a. m.	2.4	0	0	0
		3	2	8.35 a. m.	11.08 a. m.	2.5	0	0	0
		1	¾	8.57 a. m.	11.20 a. m.	2.5	6	2.4	57
Nov. 5	....	1.5	1	11.10 a. m.	6.05 a. m.	19	4	.2	5
		2	1½	11.08 a. m.	6.05 a. m.	19	0	0	0
		3	2	11.08 a. m.	6.05 a. m.	19	0	0	0
Nov. 7	7.2	3	1	6.35 a. m.	7.40 a. m.	49	7	.1	3
		3	1½	6.35 a. m.	7.40 a. m.	49	0	0	0
		3	2	6.35 a. m.	7.40 a. m.	49	0	0	0
Nov. 9	8	3	1	8.10 a. m.	8.00 a. m.	48	16	.3	8
		3	1½	8.10 a. m.	8.00 a. m.	48	0	0	0
		3	2	8.10 a. m.	8.00 a. m.	48	0	0	0
Nov. 11	6.7	3.5	1	8.40 a. m.	8.05 a. m.	47.5	10	.2	5
		3.5	1½	8.40 a. m.	8.05 a. m.	47.5	0	0	0
		3.5	2	8.40 a. m.	8.05 a. m.	47.5	0	0	0
		1	¾	8.40 a. m.	10.40 a. m.	2	24	.5	12
Dec. 7[a]	....	1.5	¾	12.00 m.	8.25 a. m.	20.4	0	0	0
Dec. 8	3.8	1.5	¾	8.52 a. m.	10.47 a. m.	26	1	.03	.7
Dec. 9[a]	2.2	1.5	¾	10.50 a. m.	8.06 a. m.	21.3	0	0	0

[a] Lake Wingra froze over on Nov. 15, but opened up again; it did not freeze over for the winter until Dec. 10.

TABLE 6.—FOOD OF 499 ADULT PERCH IN LAKE MENDOTA, 1915, SHOWN BY MONTHS.

[All figures referring to food indicate percentage by volume; + means a trace.]

Month.	Perch. Number examined.	Perch. Average length (millimeters)	Fish.	Chironomid larvæ.	Corethra larvæ.	Probezzia larvæ.	Ephemerid nymphs.	Caddisfly larvæ.	Odonate nymphs.	Sialis larvæ.	Unidentified larvæ.	Chironomid pupæ.	Corethra pupæ.	Chironomid adults.	Corethra adults.	Winged ants.	Sialis adults.
January	40	166.6	......	3.3	7.5	......	0.5	0.2	......	0.6	0.1	......	......	......	......	......	......
February	37	166.2	......	5.2	15.5	......	......	......	......	1.0	......	......	......	......	......	......	......
March	39	165.1	0.2	10.2	11.1	......	......	......	1.0	11.5	......	......	......	......	......	......	......
April	26	170.7	10.2	9.0	.3	......	......	1.3	......	16.0	......	2.1	......	1.5	......	......	......
May	56	171.0	3.8	35.6	3.1	0.4	1.1	1.3	......	.7	......	3.4	......	1.5	......	......	......
June	49	161.2	......	24.6	8.3	.8	.7	13.3	.2	1.5	.2	20.3	0.3	.7	......	......	0.7
July	64	164.7	1.5	26.0	9.2	......	.1	.3	......	.3	.4	16.7	1.0	......	......	......	......
August	41	163.0	......	18.0	1.6	.1	......	1.2	......	4.4	......	2.4	.3	......	6.0	......	......
September	39	165.8	3.3	11.7	10.6	......	......	.4	......	3.4	......	6.5	......	......	.3	0.6	......
October	50	164.8	......	2.8	3.6	......	.1	.6	......	1.5	......	15.7	......	......	......	......	......
November	37	172.3	2.6	5.6	2.2	......	......	+	......	2.1	......	.1	......	......	......	......	......
December	21	165.4	.5	7.2	2.6	......	......	......	......	5.0	......	......	......	......	......	......	......
Average	......	166.3	1.8	13.3	6.3	.1	.2	1.6	.1	4.0	.1	5.6	.1	.3	.5	.1	.1

Month.	Corixa adults.	Unidentified adult insects.	Mites.	Amphipods.	Crayfishes.	Ostracods.	Copepods.	Cladocera.	Gastropods.	Lamellibranchs.	Leeches.	Oligochætes.	Filamentous algæ.	Algæ.	Plants.	Fine débris.	Sand and stones.
January	......	......	......	1.0	......	......	0.6	56.3	......	1.5	......	0.8	1.0	......	13.7	10.2	......
February	......	......	......	......	......	......	......	45.2	......	3.6	......	......	.1	0.2	12.9	14.6	......
March	......	......	......	......	......	......	......	18.6	......	3.5	......	......	......	......	18.7	21.7	......
April	......	......	3.8	8.8	......	......	.1	14.0	3.6	.3	3.7	......	......	1.5	10.6	10.8	......
May	0.4	+	4.0	8.3	2.4	......	......	16.1	7.1	.1	1.4	......	.4	......	2.6	2.5	......
June	......	0.2	.2	4.8	......	......	1.5	16.3	.6	.4	.5	......	......	......	1.7	1.0	......
July	......	......	......	2.9	7.4	......	......	24.4	......	3.9	......	......	......	5.8	.6	......	0.1
August	......	......	......	.6	3.6	0.1	.3	49.0	2.5	.2	......	5.3	.1	.3	2.4	......	.2
September	......	......	......	2.5	6.8	.1	.1	30.6	6.5	1.0	......	7.4	.6	......	6.7	1.1	.2
October	......	......	......	1.8	.6	......	.1	60.2	1.4	1.4	.4	1.7	.1	.4	3.1	4.0	......
November	2.3	......	......	3.9	......	.1	......	45.6	1.1	4.4	......	5.1	.1	......	9.7	12.7	......
December	......	......	......	1.1	......	.3	.4	54.7	1.0	......	......	3.3	1.0	......	6.6	15.5	......
Average	.2	+	.7	3.0	1.7	.1	.3	36.0	2.0	1.7	.5	2.0	.3	.7	7.4	7.8	+

TABLE 7.—FOOD OF 188 ADULT PERCH IN LAKE MENDOTA, 1916, SHOWN BY MONTHS.

[All figures referring to food indicate percentage by volume; + means a trace.]

Month.	Perch.		Fish eggs.	Fish.	Chironomid larvæ.	Corethra larvæ.	Ephemerid nymphs.	Caddisfly larvæ.	Odonate nymphs.	Sialis larvæ.	Chironomid pupæ.	Corethra pupæ.	Coleoptera adults.
	Number examined.	Average length (millimeters).											
January	10	172.8	......	......	10.8	10.4	......	......	......	16.5	......	......	......
February	10	166.0	......	......	1.8	25.8	......	......	......	......	......	......	......
March	10	159.4	......	......	12.5	31.9	......	......	......	2.0	......	......	......
April	39	167.2	......	......	7.3	15.4	......	......	......	......	......	......	......
May	32	170.7	9.6	......	25.5	5.9	......	1.4	1.1	5.5	......	......	......
June	16	163.8	......	......	17.3	4.1	+	3.7	.5	......	7.8	1.8	......
July	33	167.1	......	6.0	27.2	16.2	......	2.6	......	......	16.5	4.1	0.1
August	14	157.1	......	......	32.0	7.7	......	21.0	......	......	1.2	.3	......
September	10	167.1	......	......	21.8	46.0	......	......	......	......	.1	......	......
December	14	169.0	......	......	8.1	7.0	......	......	......	7.8	......	......	......
Average	......	166.0	1.0	0.6	16.4	17.0	+	2.9	.2	3.2	2.6	.6	+

Month.	Unidentified adults.	Crayfishes.	Amphipods.	Ostracods.	Copepods.	Cladocera.	Gastropods.	Lamellibranchs.	Leeches.	Oligochætes.	Algæ.	Plants.	Silt and débris.	$CaCO_3$ crystals.
January	......	......	......	2.5	3.6	35.1	......	......	......	1.0	1.7	4.0	14.4	......
February	......	......	......	9.3	.2	7.0	0.2	1.5	......	7.5	2.0	19.6	24.5	0.5
March	......	......	12.2	1.6	.5	......	......	......	......	1.0	2.0	7.0	21.2	8.1
April	......	......	.7	.1	......	......	......	......	......	6.9	1.7	18.7	36.8	9.3
May	......	......	3.1	......	.2	3.0	3.2	7.2	3.7	12.0	.3	.2	20.0	......
June	0.3	6.2	21.3	......	+	22.2	+	11.5	.1	+	......	+	3.2	......
July	.9	8.2	1.7	......	......	10.0	2.8	1.1	+	......	.5	+	1.0	......
August	......	6.7	12.6	......	.1	16.7	......	......	......	......	.2	.3	.3	......
September	......	3.5	......	......	.1	26.3	......	.4	......	+	......	.2	1.1	......
December	......	......	......	2.1	.2	65.7	......	......	......	......	......	2.1	6.3	......
Average	.1	2.5	5.2	1.6	.5	18.6	.6	2.2	.4	2.8	.8	5.2	12.9	1.8

TABLE 8.—FOOD OF 350 ADULT PERCH IN LAKE WINGRA, 1916–17, SHOWN BY MONTHS.

[All figures referring to food indicate percentage by volume; + means a trace.]

Month.	Perch.		Fish.	Chironomid larvæ.	Corethra larvæ.	Ephemerid nymphs.	Caddisfly larvæ.	Odonate nymphs.	Hemiptera nymphs.	Sialis larvæ.	Chironomid pupæ.	Chironomid adults.	Coleoptera adults.	Hemiptera adults.
	Number examined.	Average length (millimeters).												
March	16	131.7	8.7	48.2	0.3	0.9	......	7.2	......	......	5.0	......	......	0.1
April	47	134.8	4.5	45.5	......	17.9	......	3.7	......	......	3.5	2.7	1.0	.3
May	40	129.4	......	24.6	......	4.2	6.0	13.9	......	......	21.7	......	......	4.7
June	40	130.3	1.0	46.8	......	1.9	.7	.2	4.4	......	30.4	......	......	.5
July	47	138.8	10.3	62.6	.1	......	.3	.2	......	......	22.9	......	......	......
August	21	133.3	41.9	14.4	.5	......	......	......	......	......	25.3	......	......	......
September	39	144.5	7.4	10.1	.7	......	1.0	......	......	3.6	15.6	......	......	......
October	31	155.6	17.7	41.2	1.1	.2	2.4	7.0	......	......	.9	......	......	.6
November	26	155.7	16.0	48.2	......	.9	3.5	3.2	......	2.3	......	......	......	3.5
December	2	141	......	64.0	......	......	......	......	......	32.5	......	......	......	......
January	16	149.2	41.5	25.8	1.2	3.0	......	16.6	......	......	......	......	......	......
February	25	154.4	35.3	21.3	......	5.2	......	7.8	......	......	......	......	......	4.0
Average	......	141.6	15.4	37.7	.3	2.9	1.2	5.0	.4	3.2	10.4	.2	.1	1.1

Month.	Unidentified adult insects.	Mites.	Amphipods.	Isopods.	Ostracods.	Copepods.	Cladocera.	Gastropods.	Lamellibranchs.	Leeches.	Oligochætes.	Algæ.	Plants.	Silt and débris.
March	......	......	5.8	......	......	0.8	13.1	......	......	1.2	1.2	1.8	0.6	......
April	......	......	7.4	......	......	1.3	.6	1.7	......	.7	......	3.9	.3	3.2
May	......	0.1	3.6	......	......	......	13.8	.1	......	......	......	.7	.1	2.0
June	......	1.8	.2	......	0.6	......	3.9	.8	0.5	.1	......	2.5	.3	.4
July	......	......	.2	......	+	+	+	......	......	.3	+	.1	.5	.5
August	......	......	......	......	......	......	2.0	......	......	......	......	4.7	2.8	3.4
September	......	.2	.2	......	......	.1	54.7	......	......	......	......	1.0	2.9	.5
October	1.3	......	3.2	......	+	......	16.1	.1	.1	......	......	3.4	2.3	1.1
November	......	......	1.7	......	.1	+	17.5	.5	......	......	......	1.7	......	1.8
December	......	......	......	......	......	......	1.5	......	......	2.0	......	......	......	......
January	......	......	1.0	......	......	......	5.4	......	......	.6	......	2.0	1.0	.6
February	......	.2	8.9	4.2	1.9	2.1	.4	......	......	......	1.7	1.2	.8	......
Average	.1	.2	2.7	.3	.2	.4	10.8	.3	.1	.4	.2	1.9	.9	1.1

TABLE 9.—MEAN OF FOODS EATEN BY PERCH IN LAKE WINGRA, 1916–17, AND IN LAKE MENDOTA, 1915–16.

[Boldface indicates maximum for month and for average; italics, the next largest amount. Figures indicate percentage of food by volume; + means a trace.]

Food.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
Fish and fish eggs	*13.8*	11.8	3.0	4.9	4.5	0.3	5.9	14.0	3.6	8.9	9.3	0.2	6.8
Chironomid larvæ	13.3	9.4	**23.6**	**20.6**	**28.6**	**29.6**	**38.6**	*21.5*	14.5	*22.0*	*26.0*	*26.4*	**22.9**
Corethra larvæ	6.4	*13.8*	*14.4*	5.2	3.0	4.1	8.5	3.3	*19.1*	2.4	1.1	3.2	7.0
Ephemerid nymphs	1.2	1.7	.3	6.0	1.8	.9	0.0	0.0	0.0	.1	.3	0.0	1.0
Caddisfly larvæ	.1	0.0	0.0	.4	2.9	5.9	1.1	7.4	.5	1.5	1.8	0.0	1.8
Odonate nymphs	5.5	2.6	2.7	1.2	5.0	.3	.1	0.0	0.0	3.5	1.6	0.0	1.9
Sialis larvæ	5.7	.3	4.5	5.3	2.1	.5	.1	1.5	2.3	.8	2.2	15.1	3 4
Chironomid pupæ	0.0	0.0	1.7	2.9	8.4	*19.5*	*18.7*	9.6	7.4	8.3	+	0.0	6.4
Corethra pupæ	0.0	0.0	0.0	0.0	0.0	.7	1.7	.2	0.0	0.0	0.0	0.0	.2
Corethra adults	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	.1	0.0	0.0	0.0	.2
Chironomid adults	0.0	0.0	0.0	1.4	.5	.2	0.0	0.0	0.0	0.0	0.0	0.0	.2
Hemiptera adults	0.0	1.3	0.0	.1	1.7	.2	0.0	0.0	0.0	.3	2.9	0.0	.5
Other insects	0.0	0.0	0.0	.5	.1	.1	.3	0.0	.2	.4	0.0	0.0	.1
Mites	0.0	0.0	0.0	1.3	1.4	.7	0.0	0.0	.1	0.0	0.0	0.0	.3
Amphipods	.7	3.0	6.0	5.6	5.0	8.8	1.6	4.4	.9	2.5	2.8	.4	3.5
Isopods	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.1
Crayfishes	0.0	0.0	0.0	0.0	.8	2.1	5.2	3.4	3.4	.3	0.0	0.0	1.3
Ostracods	.8	3.7	.5	+	0.0	.2	+	+	+	+	.1	.8	.5
Copepods	1.4	.8	.4	.5	.1	.5	+	.1	.1	+	+	.2	.3
Cladocera	**32.3**	**17.6**	10.6	4.9	*11.0*	14.1	11.5	**22.6**	**37.2**	**38.2**	**31.6**	**40.6**	*22.7*
Gastropods	0.0	.1	0.0	1.8	3.5	.5	.9	.8	2.2	.8	.8	.3	1.0
Lamellibranchs	.5	1.7	1.2	.1	2.4	4.1	1.7	.1	.5	.8	2.2	0.0	1.3
Leeches	.2	0.0	.4	1.5	1.7	.2	.1	0.0	0.0	.1	0.0	.7	.4
Oligochætes	.6	3.1	.7	2.3	4.0	+	+	1.8	2.5	.9	2.6	1.1	1.6
Algæ	1.2	1.1	1.3	2.4	.3	.8	2.1	1.7	.3	1.9	.9	0.0	1.2
Plants	6.2	11.1	8.8	9.9	1.0	.7	.4	1.8	3.3	2.7	4.9	2.9	4.5
Silt and débris	8.4	13.0	*14.3*	*16.9*	8.2	1.5	.5	1.3	1.0	2.6	7.3	7.3	6.9
$CaCO_3$ crystals	0.0	.2	2.7	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.5

TABLE 10.—LARGEST NUMBER OF VARIOUS SPECIES OF ANIMALS FOUND IN A SINGLE PERCH AS A CONSTITUENT OF THE FOOD, 1915–16.

Date.	Locality.	Size of perch (millimeters)	Chief food constituent.			Other food constituents expressed in per cent of total food.
			Kind.	Number eaten.	Per cent of total food.	
Apr. 22, 1915	Lake Wingra	178	Minnows	4	90.0	Fish remains, 10.
May 8, 1916	East of Picnic Point, Lake Mendota.	164	Chironomus fulviventris larvæ.	105	30.0	Mites, 24; crayfish, 35; plant remains, 5; débris, 5; mayfly nymph, 1.
May 27, 1916	Lake Wingra	133	Damselfly nymphs	45	92.5	Filamentous algæ, 5; plant remains, 2; mayfly nymphs, 5.
Mar. 20, 1915	North of University of Wisconsin, Lake Mendota.	144	Procladius larvæ	77	45.0	Aphanothece, 10; Corethra larvæ, 20; fine silt and débris, 5; plant remains, 20.
June 5, 1915	do	172	Corethra larvæ	150	100.0	
Do	do	162	Leptocella uwarowii larvæ.	40	95.0	Chironomid cases and larvæ, 5.
June 12, 1915	do	170	Chironomid pupæ	300	97.0	Chironomid cases, 3.
Sept. 4, 1915	do	178	Camponotus adults	1,000	25.0	Insect remains, 5; Chironomus decorus pupæ, 5; Leptodora, 30; Daphnia hyalina, 35.
May 8, 1915	East of Picnic Point, Lake Mendota.	164	Mites	89	24.0	Chironomus fulviventris larvæ, 30; crayfish, 35; plant remains, 5; débris, 5; mayfly nymph, 1.
June 13, 1916	North of University of Wisconsin, Lake Mendota.	153	Hyalella	610	80.0	Chironomid larvæ, 2; chironomid pupæ, 8; caddisfly larvæ, 10.
Feb. 1, 1916	Northeast of Picnic Point, Lake Mendota.	156	Ostracods	595	93.5	Corethra larvæ, 3; Chironomus decorus larvæ, 2; Rivularia, 0.5; plant remains, 1.
Aug. 28, 1915	North of University of Wisconsin, Lake Mendota.	162	Leptodora	800	95.0	Daphnia hyalina, 2; Corethra adults, 3.
July 24, 1915	do	168	Daphnia hyalina	3,644	100.0	
Nov. 27, 1915	do	172	Amnicola limosa	32	27.0	Hyalella, 64.5; Leptodora, 27; caddisfly larvæ, 1; chironomid larvæ, 0.3; filamentous algæ, 0.2.
Aug. 28, 1915	do	160	Physa heterostropha	195	99.9	Spartina, 0.1
July 3, 1915	do	173	Sphæridæ	119	50.0	Daphnia hyalina, 10; chironomid larvæ, 10; chironomid pupæ, 30; Amnicola, 1.
Jan. 17, 1915	do	186	Oligochætes	20	30.0	Sialis infumata, larvæ, 0.5; fine débris, 15; plant remains, 50.

TABLE 11.—RATE OF DIGESTION OF VARIOUS FOODS AT A NEARLY UNIFORM TEMPERATURE, 16.6° C.[a]

Temperature (degrees centigrade).	Food eaten.	Time in hours until first feces.		
		Shortest.	Longest.	Average.
16.5	Chironomid larvæ	5.0	7.0	6.0
16.3	Entomostraca	4.5	6.8	5.4
16.8	Earthworms	7.16	23.0	19.2
16.8	Hyalella	5.5	24.0	8.4
16.5	Liver and flour	3.25	23.0	[b] 15.8
17.0	Fish	24.0	24.0	[c] 24.0

[a] 10 perch were used; minimum weight, 1.9 g.; maximum weight, 4.67 g.; average weight, 2.85 g. When possible, as with chironomid larvæ and earthworms, the rate of digestion was computed from the time the fish began to eat; in a few cases (Entomostraca), from the time the food was placed in the dish. The experiments extended from Sept. 16 to Oct. 2, 1916.
[b] Not eaten by 5 individuals.
[c] Not eaten by 3 individuals.

TABLE 12.—RATE OF DIGESTION OF VARIOUS FOODS AT TEMPERATURES OF ABOUT 3 AND 18° C.[a]

Date.	Temperature (degrees centigrade).	Food eaten.		Average rate of digestion (hours).
		Kind.	Number.	
Jan. 24, 1917	2.5	Chironomid larvæ	3	43.7
Do	18.0	.....do	16	22.0
Jan. 17, 1917	2.5	Corethra larvæ	(?)	47.5
Jan. 15, 1917	18.0	.....do	(?)	23.0
Dec. 18, 1916	3.5	Dikerogammarus	3	64.0
Jan. 8, 1917	2.5	Earthworms	1	39.0
Do	17.0	.....do	1	18.4
Jan. 22, 1917	2.5	Liver and flour	0	....
Jan. 1, 1917	2.5	Minnows	1	43.3
Do	20.5	.....do	1	16.4
Dec. 26, 1916	4.5	Snails	0	....

[a] 2 experiments were conducted simultaneously, using 2 perch in each case, averaging 28 g. in weight. When possible, as with chironomid larvæ and earthworms, the rate of digestion was computed from the time the fish began to eat; in a few cases (Corethra larvæ), from the time the food was placed in the dish.

TABLE 13.—RATE OF DIGESTION OF VARIOUS FOODS AT TEMPERATURES VARYING FROM 23 TO 26° C.[a]

Date.	Temperature (degrees centigrade).	Food eaten.					Average rate of digestion (hours).
		Kind.	Number.		Volume (c. c.).		
			Total.	Per hour.	Total.	Per hour.	
June 19, 1916	23	Damselfly nymphs	24	1.5	2.5	0.15	31.7
July 20, 1916	26	Earthworms	5	.2	2.0	.16	20.0
July 5, 1916	23	Minnows	13	.57	5.2	.23	22.5

[a] In this experiment 1 perch weighing 48 g. was used.

TABLE 14.—RATE OF DIGESTION OF VARIOUS FOODS AT TEMPERATURES VARYING FROM 2.5 TO 4.5° C.[a]

Date.	Temperature (degrees centigrade).	Food eaten.		Average rate of digestion (hours).
		Kind.	Number.	
Jan. 24, 1917	2.5	Chironomid larvæ	50	46.5
Jan. 15, 1917	2.5	Corethra larvæ	(?)	48.0
Dec. 18, 1916	3.0	Dikerogammarus	13	64.0
Jan. 8, 1917	2.5	Earthworms	0	....
Jan. 22, 1917	2.5	Liver and flour	0	....
Jan. 1, 1917	2.5	Minnows	6	67.3
Dec. 26, 1916	4.5	Snails	0	....

[a] In this experiment 2 perch, weighing respectively 31 and 24 g., were used.

TABLE 15.—RATE OF DIGESTION AT DIFFERENT SEASONS, AS JUDGED BY INTERVAL BETWEEN EATING AND FIRST APPEARANCE OF FECES.

[Summary of data presented in Tables 11 to 14.]

Date.	Temperature (degrees centigrade).	Fish used.		Food eaten.		Average rate of digestion (hours).
		Number.	Average weight (grams).	Kind.	Number.	
Oct. 2, 1916	16.5	10	2.8	Chironomid larvæ	6	6.0
Jan. 24, 1917	2.5	2	2.8	....do	3	43.7
Do	18.0	2	2.8	....do	16	22.0
Do	2.5	2	27.5	....do	50	46.5
Jan. 17, 1917	2.5	2	2.8	Corethra larvæ	(?)	47.5
Jan. 15, 1917	18.0	2	2.8	....do	(?)	23.0
Do	2.5	2	27.5	....do	(?)	48.0
June 19, 1916	23.0	1	48.0	Damselfly nymphs	24	31.7
Dec. 18, 1916	3.0	2	2.8	Dikerogammarus	3	64.0
Do	3.0	2	27.5	....do	13	64.0
Sept. 29, 1916	16.3	10	2.8	Entomostraca	(?)	5.4
Sept. 20, 1916	16.8	10	2.8	Earthworms	1	19.2
Jan. 8, 1917	2.5	2	2.8	....do	1	39.0
Do	17.0	2	2.8	....do	1	18.4
July 20, 1916	26.0	1	48.0	....do	5	20.0
Jan. 8, 1917	2.5	2	27.5	....do	0	....
Sept. 25, 1916	16.8	10	2.8	Hyalella	(?)	8.4
Sept. 22, 1916	16.5	10	2.8	Liver and flour	(?)	15.8
Jan. 22, 1917	2.5	2	2.8	....do	0	....
Do	2.5	2	27.5	....do	0	....
Sept. 27, 1916	17.0	10	2.8	Minnows	1	24.0
Jan. 1, 1917	2.5	2	2.8	....do	1	43.3
Jan. 5, 1917	20.5	2	2.8	....do	1	15.4
July 5, 1916	23.0	1	48.0	....do	13	22.5
Jan. 1, 1917	2.5	2	27.5	....do	6	67.3
Dec. 26, 1916	4.5	2	2.8	Snails	0	....
June 30, 1916	24.0	1	48.0	....do	0	....
Dec. 26, 1916	4.5	2	27.5	....do	0	....
Oct. 10, 1916	17.0	10	2.8	Fish	....	24.0

TABLE 16.—PERCENTAGE OF VARIOUS FOODS EATEN BY 715 ADULT PERCH CAUGHT AT VARIOUS DEPTHS AND AT ALL SEASONS IN LAKE MENDOTA DURING 1915 AND 1916.

Depth at which caught (meters).	Fish.	Silt and débris.	Insect larvæ.	Insect pupæ.	Insect adults.	Mites.	Crayfishes.	Hyalella.	Ostracods.	Cladocera.	Copepods.	Snails.	Clams.	Oligochætes.	Leeches.	Plants.
0 to 10	5.3	4.1	33.0	4.0	1.0	1.9	7.0	9.5	0.4	21.2	0.4	3.1	0.7	1.0	1.0	3.6
10 to 15	0	9.5	38.1	8.7	.1	0	1.7	5.0	.1	27.1	.3	.2	1.6	2.5	0	3.6
15 to 20	0	11.6	37.4	8.4	.1	0	0	.8	.4	27.0	.1	0	3.4	3.4	0	7.6
Mean	1.8	8.4	36.1	7.0	.4	.6	2.9	5.1	.3	25.1	.2	1.1	1.9	2.3	.3	4.9

TABLE 17.—NUMBER OF TIMES A PARTICULAR FOOD FORMED THE LARGEST ITEM, BY VOLUME, IN ALL PERCH CAUGHT AT THE SAME TIME AND DEPTH.[a]

[Percentages refer to numerical ratios, not to volume of food.]

Depth (meters).	Fish.	Silt and débris.	Insect larvæ.	Insect pupæ.	Insect adults.	Crayfishes.	Hyalella.	Cladocera.	Snails.	Oligochætes.	Plants.	Total records.
0 to 5	2	....	12	1	....	3	3	10	1	1	1	33
Per cent	6	....	36	3	....	9	9	30	3	3	3	....
5 to 10	....	....	11	....	1	1	1	4	....	....	....	18
Per cent	....	....	56.6	....	5.6	5.6	5.6	22.4	....	....	....	....
10 to 15	....	3	13	3	....	....	1	10	....	....	....	29
Per cent	....	10.4	44.8	10.4	....	....	3.5	34.5	....	....	....	....
15 to 20	....	4	14.5	.5	....	....	....	13	....	....	1	33
Per cent	....	12	43.5	1.5	....	....	....	49	....	....	3	....

[a] 687 adult perch caught during 1915 and 1916 in Lake Mendota are included.

TABLE 18.—FOOD OF SMALL PERCH COLLECTED IN SHALLOW WATER EAST OF BASE OF PICNIC POINT IN LAKE MENDOTA, 1916.

[All figures referring to food indicate percentage by volume; + means a trace.]

Date.	Perch. Number examined.	Perch. Average length (millimeters).	Chironomus sp. larvæ.	C. fulviventris larvæ.	C. digitatus larvæ.	Procladius larvæ.	Orthocladius larvæ.	Tanypus decoloratus larvæ.	Tanypus monilis larvæ.	Plea minutissima larvæ.	Damselfly nymphs.	Mayfly nymphs.	Bætis nymph.	Cænis diminuta nymphs.	Agraylea multipunctata larvæ.	Enallagma hageni nymph.	Enallagma antennatum nymph.
July 7	10	29.6	....	1.6	....	....	....	6.9	....	0.1	....	....	+	....	....	....	....
July 19	9	36.8	1.1	9.1	....	0.9	....	3.7	....	....	....	....	....	....	....	5.5	....
Aug. 7	10	50.4	....	16.2	....	....	....	....	....	....	....	24.5	....	....	....	....	4.5
Aug. 24	10	61.4	2.5	1	2	....	0.4	....	7.5	....	3	....	....	1	25.5	....	....

Date.	Corixa nymphs.	Chironomid pupæ.	Chironomid adults.	Hyalella azteca.	Ostracods.	Cyclops.	Nauplii.	Daphnia.	Chydorus sphæricus.	Eurycercus lamellatus.	Acroperus.	Ceriodaphnia.	Bosmina longirostris cornuta.	Pleuroxus procurvatus.	Filamentous algæ.	Plants.
July 7	1.5	....	0.1	15.3	0.1	43.3	2.7	0.1	8.9	11.8	0.2	0.1	6.5	0.5	....	....
July 19	....	....	....	55.4	2.5	.2	....	....	.7	17.2	....	4.6	....	.3	....	....
Aug. 7	.3	....	....	39.6	.8	.4	....	.5	....	....	....	13.9	....	....	0.9	0.2
Aug. 24	....	1	....	50.8	....	.3	....	....	....	....	....	....	....	....	....	1

TABLE 19.—FOOD OF SMALL PERCH COLLECTED ALONG NORTH SHORE OF OCONOMOWOC LAKE, 1916.

[All figures referring to food indicate percentage by volume; + means a trace.]

Date.	Perch. Number examined.	Perch. Average length (millimeters).	Insect larvæ.	Chironomous sp. larvæ.	C. lobiferous larvæ.	C. fulviventris larvæ.	Orthocladius larvæ.	O. nivoriundus larvæ.	Palpomyia larvæ.	Tanypus sp. unknown larvæ.	Tanypus monilis larvæ.	Tanytarsus larvæ.	Procladius larvæ.	Cricotopus trifasciatus larvæ.	Probezzia glaber larvæ.	Cænis diminuta nymphs.	Dragonfly nymphs.	Damselfly nymphs.	Enallagma antennatum nymphs.
June 14	13	57.8	....	8.4	....	....	....	....	....	....	....	....	0.3	....	3.4	....	....	....	7
July 15	10	47.3	1	.3	....	....	....	0.5	....	2	7.3	2.0	....	....	....	....	....	....	....
July 17	10	46.2	2.5	.2	....	0.2	....	....	....	....	3.7	....	....	....	....	1.4	3.0	3.5	....
Aug. 8	10	66.1	....	....	....	....	....	....	3.5	2.0	4.9	....	....	....	....	.3	....	....	....
Aug. 14	10	48.5	4.3	.5	1.0	6.0	0.5	....	1.0	2.6	6.3	....	....	1.0	....	1.0	....	....	....

Date.	Sialis infumata larvæ.	Caddisfly larvæ.	Agraylea larvæ.	Chironomid pupæ.	Palpomyia pupæ.	Crayfishes.	Hyalella azteca.	Ostracods.	Cyclops.	Ceriodaphnia.	Bosmina longirostris cornuta.	Eurycercus lamellatus.	Daphnia.	Pleuroxus.	Diaphanosoma.	Acroperus.	Chydorus sphæricus.	Physa.	Filamentous algæ.
June 14	....	....	....	4.7	....	....	18.7	0.3	32.7	....	....	0.5	18.8	....	....	....	2.3	0.6	1.4
July 15	....	....	....	2.0	....	....	42.8	....	10.4	1	1.5	10.0	1.5	0.9	1.5	9.1	2.6	.8	.6
July 17	....	1.0	....	1.2	....	....	37.3	+	....	....	....	....	36.1	....	9.0	....	.1	....	.5
Aug. 8	6.0	....	0.3	.5	....	20	61.8	.2	....	....	....	....	....	....	....	....	.3	....	....
Aug. 14	....	....	28.0	.7	3.3	....	13.1	+	7.0	+	.3	....	.1	....	22.0	....	.5	....	.3

TABLE 20.—LOSS AND GAIN IN PERCH FED DIFFERENT FOODS FROM AUG. 19 TO SEPT. 18, 1916.

Food.	Number of perch fed.	Aug. 19		Sept. 18.		Per cent gain.		Per cent loss.	
		Average weight (grams).	Average volume (cubic centimeters).	Average weight (grams).	Average volume (cubic centimeters).	Weight (grams).	Volume (cubic centimeters).	Weight (grams).	Volume (cubic centimeters).
Liver and flour	[a] 3	2.104	2.40	2.501	2.46	19.89	2.5	.....	.....
Hyalella	3	1.856	1.76	2.296	2.3	23.70	30.68	.....	.....
Entomostraca	3	2.683	2.71	3.874	3.65	43.49	34.68	.....	.....
Earthworms	3	1.856	1.68	2.726	2.9	46.87	72.62	.....	.....
Insects, adult	3	2.152	2.07	1.643	1.7	.....	.....	23.65	13.04
Chironomid larvæ	3	2.099	2.00	2.836	2.9	35.11	45.0	.....	.....
Fish	3	1.944	1.91	2.380	2.45	22.42	20.41	.....	.....
Normal	2	3.232	3.20	3.850	3.9	19.12	21.87	.....	.....
Starved	[b] 3	1.205	1.26	.861	.76	.....	.....	28.54	39.68

[a] 1 died Sept. 6 on account of fouling of water. [b] 1 died Sept. 11.

TABLE 21.—COMPARISON OF FOODS EATEN BY ADULT PERCH IN LAKE WINGRA AND IN LAKE MENDOTA, SHOWN BY MONTHS.

[The figures are percentages by volume and + means a trace; 350 perch were examined in Lake Wingra from March, 1916, to February, 1917. In Mendota, 499 were examined in 1915 and 188 in 1916. To obtain averages given for Lake Mendota the figures for 1915 were multiplied by 3 and averaged with those for 1916.]

LAKE WINGRA.

Month.	Fish and eggs.	Insect larvæ.	Insect pupæ.	Adult insects.	Mites.	Crayfishes.	Isopods.	Amphipods.	Ostracods.	Copepods.	Cladocera.	Snails.	Clams.	Leeches.	Oligochætes.	Plants, algæ.	Silt and débris.	$CaCO_3$ crystal.
January	41.5	46.6	.....	.....	.....	.....	.....	1.0	.....	.....	5.4	.....	.....	0.6	.....	3.0	0.6	.....
February	35.3	34.3	.....	4.0	0.2	.....	4.2	8.9	1.9	2.1	.4	.....	.....	.....	1.7	2.0	.....	.....
March	8.7	56.6	5.0	.1	.....	.....	.....	5.8	.....	.8	13.1	.....	.....	1.2	1.2	2.4	.....	.....
April	4.5	67.1	3.5	4.0	.....	.....	.....	7.4	.....	1.3	.6	1.7	.....	.7	.....	4.2	3.2	.....
May	.....	48.7	21.7	4.7	.1	.....	.....	3.6	.....	.....	13.8	.1	.....	.....	.....	.8	2.0	.....
June	1.0	54.0	30.4	.5	1.8	.....	.....	.2	.6	.....	3.9	.8	0.5	.1	.....	2.8	.4	.....
July	10.3	63.2	22.9	.....	.....	.....	.....	.2	+	+	+	.....	.....	.3	+	.6	.5	.....
August	41.9	14.9	25.3	.....	.....	.....	.....	.....	.....	.....	2.0	.....	.....	.....	.....	7.5	3.4	.....
September	7.4	15.4	15.6	.....	.2	.....	.....	.2	.....	+	54.7	.....	.....	.....	.....	3.9	.5	.....
October	17.7	51.9	.9	1.9	.....	.....	.....	3.2	+	.....	16.1	.1	.1	.....	.....	5.7	1.1	.....
November	16.0	58.1	.....	3.5	.....	.....	.....	1.7	.1	.....	17.5	.5	.....	.....	.....	1.7	1.8	.....
December	.....	96.5	.....	.....	.....	.....	.....	.....	.....	.....	1.5	.....	.....	2.0	.....	.....	.....	.....
Average	15.4	50.6	10.4	1.6	.2	.....	.3	2.7	.2	.4	10.8	.3	.1	.4	.2	2.7	1.1	.....

LAKE MENDOTA.

Month.	Fish and eggs.	Insect larvæ.	Insect pupæ.	Adult insects.	Mites.	Crayfishes.	Isopods.	Amphipods.	Ostracods.	Copepods.	Cladocera.	Snails.	Clams.	Leeches.	Oligochætes.	Plants, algæ.	Silt and débris.	$CaCO_3$ crystal.
January	.....	18.6	.....	.....	.....	.....	.....	0.8	0.6	1.4	51.0	.....	1.1	.....	0.9	11.7	11.3	.....
February	.....	23.2	.....	.....	.....	.....	.....	.....	2.3	.1	35.7	0.1	3.1	.....	1.9	15.2	17.1	0.1
March	0.2	37.0	.....	.....	.....	.....	.....	3.1	.4	.1	13.9	.....	2.6	.....	.3	16.3	21.6	2.0
April	7.7	25.6	1.6	1.1	2.8	.....	.....	6.8	.....	.1	10.5	2.7	.2	2.8	1.7	14.2	17.3	2.3
May	5.3	41.5	2.6	1.4	3.0	1.8	.....	7.0	.....	.1	12.8	6.1	1.9	2.0	3.0	2.1	6.9	.....
June	.....	43.4	17.9	.8	.1	1.6	.....	8.9	.....	1.1	17.8	.5	3.2	.4	+	1.3	1.6	.....
July	2.6	38.7	18.7	.3	.....	7.6	.....	2.6	.....	.....	20.8	.7	3.2	+	.....	4.9	.3	.....
August	.....	34.2	2.4	4.5	.....	4.4	.....	3.6	.1	.1	40.9	1.9	.2	.....	4.0	2.2	.2	.....
September	2.6	36.5	4.9	.7	.....	6.0	.....	1.8	.1	.1	29.5	4.9	.9	.....	5.6	5.1	1.3	.....
October	.....	8.6	15.7	.....	.....	.5	.....	1.8	.....	.1	60.2	1.4	1.4	.4	1.7	3.5	4.0	.....
November	1.5	10.0	.1	2.3	.....	.....	.....	3.9	.1	.....	45.6	1.1	4.4	.....	5.1	9.7	12.7	.....
December	.4	16.8	.....	.....	.....	.....	.....	.8	.8	.3	57.5	.8	.....	.....	2.5	5.5	13.2	.....
Average	1.7	27.8	5.3	.9	.5	1.8	.....	3.4	.4	.3	33.0	1.7	1.9	.5	2.2	7.6	9.0	.4

TABLE 22.—COMPARISON OF NUMBER OF PERCH EXAMINED FROM LAKE WINGRA AND FROM LAKE MENDOTA WHICH CONTAINED LITTLE OR NO FOOD, SHOWN BY MONTHS.

[Figures in parentheses indicate per cent of total catch.]

LAKE WINGRA, 1916.

Month.	Temperature (degrees centigrade).	Females.			Males.		
		Number caught.	Number nearly empty.	Number empty.	Number caught.	Number nearly empty.	Number empty.
January	....	14	0	0	2	0	0
February	....	16	0	0	0	0	0
March	....	7	0	0	9	0	0
April	10.6	25	0	0	28	0	8(15)
May	21.0	39	0	1(2)	1	0	0
June	20.5	28	0	0	11	0	0
July	29.6	23	0	0	19	0	0
August	26.3	15	0	5(12)	25	0	11(27)
September	15.9	21	2(5)	0	21	8(20)	1(5)
October	10.8	18	0	0	12	0	0
November	7.3	4	0	0	5	0	0
December	....	0	0	0	1	0	0

LAKE MENDOTA, 1915-16.

Month.	Temperature (degrees centigrade).	Females: Number caught.	Females: Number nearly empty.	Females: Number empty.	Males: Number caught.	Males: Number nearly empty.	Males: Number empty.
January	0.6	26	0	0	20	0	0
February	1.0	28	1(2)	0	16	0	0
March	2.2	22	0	0	37	0	0
April	3.8	28	0	4(6)	33	0	10(16)
May	9.8	49	1(1)	0	23	1(1)	0
June	14.4	28	2(2)	0	14	0	0
July	19.2	47	0	0	46	1(1)	0
August	19.3	29	0	1(2)	25	0	1(2)
September	17.2	32	0	0	13	0	0
October	13.4	22	0	0	28	0	0
November	4.9	25	0	1(2)	11	0	0
December	1.8	15	0	0	15	0	0

TABLE 23.—GAS CONTENT OF SWIM BLADDERS OF PERCH.[a]

Date.	Depth (meters).	Time left in oxygen-free water.		Gases in swim bladder.			Respiration quotient $\left(\frac{CO_2}{O_2}\right)$	Cubic centimeters of gases in water per liter.	
		Down.	On deck.	Per cent CO_2.	Per cent O_2.	Per cent N_2.		CO_2.	O_2.
Aug. 23	(b)			2.03	53.76	44.21	0.03		
	(b)			.68	44.64	54.68	.01		
	(b)			.71	51.12	48.17	.01		
	(b)			.91	47.83	51.26	.02		
Aug. 24	(b)			.24	50.97	48.79	.004		
	(b)			.33	41.17	58.50	.008		
	(b)			.108	44.51	55.39	.002		
	12	32 minutes	3 minutes	.833	28.12	71.05	.003	4.38	0.11
	12	do	7 minutes	.41	22.35	77.24	.02	5.51	.06
	12	42 minutes	3 minutes	.175	37.30	62.53	.005		
	12	do	6 minutes	.099	28.18	71.73	.003		
Aug. 26	(b)			.42	38.26	61.31	.01		
	(b)			.65	13.74	85.62	.04		
	13	1 hour	2 minutes	1.21	7.87	90.92	.15	4.64	.03
	13	do	5 minutes	.4	11.06	88.55	.03	4.12	.06
	13	do	8 minutes	.43	14.69	84.88	.03		
	13	do	10 minutes	.14	12.3	87.36	.01		
	13	1.5 hours	3 minutes	.211	24.24	75.50	.008		
	13	do	6 minutes	.31	19.66	80.03	.01		
	13	do	9 minutes	.31	22.51	77.18	.01		
	13	do	11 minutes	.11	17.90	81.99	.005		
Aug. 30	(b)			.64	18.51	80.85	.03		
	13.5	2 hours	6 minutes	.12	.73	99.15	6.08	7.21	.05
	13.5	do	9 minutes	.170	4.08	95.74	.04	5.98	.05
Aug. 31	(b)			.21	8.0	91.78	.03		
	13.5	1.1 hours	1 minute	.43	37.06	62.50	.01	5.67	.07
	13.5	do	8 minutes	.24	5.8	93.96	.04	5.15	.07
	13.5	2 hours	4 minutes	.21	4.17	95.62	.05		
	13.5	do	6 minutes	.044	28.21	71.75	.001		
	13.5	do	9 minutes	.05	27.09	72.86	.001		
	13.5	do	12 minutes	.26	20.51	79.23	.01		
Sept. 2	c 2			.33	28.24	71.43	.01	1.03	5.72
	2			.89	25.93	73.18	.03	1.54	4.87
	2			.62	34.12	65.26	.02		
	2			.71	25.65	73.64	.02		
	2			.24	32.43	67.33	.00		
	2			.25	25.06	74.68	.01		
Sept. 4	(b)			2.73	28.65	68.63	.09		
	(b)			.78	29.61	69.61	.02		
	d 13.5	½ hour	1 minute	1.20	24.78	74.02	.04		
	d 13.5	do	6 minutes	.25	25.31	74.44	.01		
	d 13.5	do	8 minutes	.43	9.96	89.61	.04	5.02	.24
	d 13.5	1 hour	6 minutes	3.0	14.19	82.81	.2		
	d 13.5	do	8 minutes	1.09	11.20	87.71	.1		

[a] Some individuals had been near the surface of Lake Mendota; others had been in the stagnant water below the thermocline, where there was practically no oxygen.
[b] Surface.
[c] These individuals were caught at a depth of less than 2 m. in University Bay.
[d] These individuals were kept on the deck of a boat in stagnant water pumped from 13.5 m.

TABLE 24.—PERCENTAGE OF GASES IN THE SWIM BLADDERS OF PERCH.[a]

Depth (meters).	Number of perch.	In stagnant water (hours).	Average CO_2.	Most CO_2.	Least CO_2.	Average O_2.	Most O_2.	Least O_2.	Average N_2.	Most N_2.	Least N_2.	Respiration quotient $\left(\frac{CO_2}{O_2}\right)$
Surface	21	....	0.81	3.0	0.11	36.21	53.76	8.0	62.97	91.98	44.21	0.02
12 to 13	5	½	.62	1.20	.25	22.10	28.12	9.6	77.27	89.61	71.05	.03
13	2	¾	.14	.17	.09	32.74	37.30	28.18	67.13	77.24	71.05	.004
13	8	1	.74	3.0	.14	14.27	37.06	5.8	84.83	93.96	62.50	.05
13	4	1½	.27	.31	.11	21.08	24.24	17.90	78.67	81.99	75.50	.01
13	6	2	.14	1.26	.04	14.16	28.21	.73	85.72	99.15	71.75	.01

[a] Some individuals were examined as soon as taken from surface water; others, after being left in the stagnant water below the thermocline.

TABLE 25.—SIZE OF PERCH AT SEXUAL MATURITY IN LAKES WINGRA AND MENDOTA, MARCH TO OCTOBER, 1916.

Lake.	Perch examined.		Size of perch (millimeters).		
	Number.	Sex.	Maximum.	Minimum.	Average.
Wingra	162	Male	178	113	134.9
Do	158	Female	180	118	137.7
Mendota	74	Male	187	115	156.6
Do	95	Female	201	120	167.6

TABLE 26.—SEX OF PERCH EXAMINED FROM VARIOUS DEPTHS OF LAKE MENDOTA DURING 1916.

Date examined.	Depth (meters).	Total catch.	Males.			Females.		
			Immature.	Ripe.	Spent.	Immature.	Ripe.	Spent.
Apr. 28	18	[a] 6	1	0	0	4	1	0
Do	3	[a] 380	1	376	0	0	3	0
Apr. 30	14.5	2	0	0	0	0	0	2
Do	12.5	6	0	0	0	0	3	3
Do	8.5	8	0	1	0	0	5	2
Do	5.0	11	0	8	0	0	0	3
May 2	15.0	12	0	0	0	1	7	4
Do	9.5	17	0	7	0	0	5	5
Do	4.5	23	0	22	0	0	0	1
May 6	18.0	7	0	1	0	0	1	5
Do	15.0	7	0	0	0	0	0	7
Do	7.7	8	0	3	0	0	0	5
Do	2.0	1	0	0	0	0	0	1
May 12	17.0	14	3	3	0	0	0	8
Do	15.0	32	0	11	0	2	0	18
Do	7	9	0	5	0	1	0	3
Do	3.5	53	1	51	0	0	0	1
Do	.5	5	0	0	0	1	0	4
May 17	17.0	47	4	12	2	1	0	27
Do	13.0	6	0	2	4	0	0	0
Do	4.5	0	0	0	0	0	0	0
July 13	19.0	81	0	1	51	0	0	29
Do	15.5	75	0	0	45	0	0	30
Do	12.0	53	0	0	18	0	0	35
Do	2.7	1	0	0	0	0	0	1
Do	3.2	0	0	0	0	0	0	0

[a] These nets remained in the water 14 hours; all others, 3 hours.

TABLE 27.—FISHES CAUGHT PER HOUR ON HOOKS AND LINES BAITED WITH MINNOWS, LAKE WINGRA, 1916–17.[a]

Date caught.	Temperature (degrees centigrade).	Depth (meters).	Number of hooks used.	Time (hours).	Perca falvescens.	Pomoxis sparoides.	Lepomis incisor.	Lepososteus osseus.	Micropterus salmoides.	Eupomotis gibbosus.
June 10	20.5	2–3	3	2.2	0	23.6	0.4	0.4	0	0
June 19	30.0	2–3	3	3.2	0	2.7	0	0	0	0
July 22		2–3	4	1.2	25.0	3.3	20.8	0	0	0
Do		2–3	4	3.3	4.5	.9	12.1	0	0	0
July 26	29.4	2–3	2	1.4	2.8	0	0	0	0	0
Do		3.1	2	2.5	0	1.2	.8	0	0	0
Aug. 5		2.8	3	4.0	.5	0	0	0	0	0
Aug. 20	27.0	3–2.5	1	2.4	0	.4	0	0	0	0
Aug. 29	26.8	1–2	3	3	0	0	0	0	0	0
Sept. 5			3	2.6	0	.3	0	0	0	0
Sept. 14	19.9		3	1.9	0	3.4	0	0	0	0
Sept. 23	14.5		3	3.4	3.2	0	0	0	0	0
Sept. 30	13.5		3	2.7	2.2	0	0	0	0	0
Oct. 7	14.8		3	3.7	0	0	0	0	0	0
Oct. 10	14.2		3	2.9	1.0	0	0	0	0	0
Oct. 11	13.7		3	.6	1.6	0	0	0	0	1.6
Oct. 14	12.3		2	2	2.1	0	0	0	0	0
Oct. 28	6.5		3	.7	1.4	0	0	0	0	0
Nov. 4	7.0		3	1.8	2.7	0	0	0	0	0
Nov. 11	6.7		3	1.0	0	0	0	0	0	0
Nov. 18		1.5	3	.5	0	0	0	0	0	0
Nov. 25		.8	3	1.2	0	0	0	0	0	0
Dec. 2	2.5		3	2.7	0	0	0	0	0	0
Dec. 23		1.5	3	3	0	0	0	0	0	0
Dec. 30		1.3	3	3	0	0	0	0	0	0
Jan. 2		1.0	3	.6	0	0	0	0	0	0
Do		2	2	1	2	0	0	0	0	0
Jan. 6		2	2	1	0	0	0	0	0	0
Jan. 20		1	3	2.5	0	0	0	0	0	0
Jan. 27		1	5	1.3	0	0	0	0	0	0
Do		2.5	2	2.1	2.5	0	0	0	0	0

[a] The lake froze over on Nov. 15; opened on Nov. 28; froze over again Dec. 10.

TABLE 28.—PERCH CAUGHT IN THREE 1-INCH MESH, 3 BY 60 FEET, GILL NETS, LAKE MENDOTA, AUG. 12 AND 13, 1916.[a]

2.9 m.[b]		7.5 m.[c]		Surface.[d]	
Time net in water.	Number.	Time net in water.	Number.	Time net in water.	Number.
8.35 a. m. to 12.33 p. m.	[e] 1	9.12 a. m. to 1.18 p. m.	[e] 112	9.00 a. m. to 1.00 p. m.	0
12.33 p. m. to 4.30 p. m.	3	1.18 p. m. to 5.18 p. m.	82	1.00 p. m. to 5.00 p. m.	0
4.30 p. m. to 9.00 p. m.	1	5.18 p. m. to 9.18 p. m.	71	5.00 p. m. to 9.10 p. m.	0
9.00 p. m. to 1.20 a. m.	1	9.18 p. m. to 1.43 a. m.	24	9.10 p. m. to 1.32 a. m.	0
1.20 a. m. to 5.00 a. m.	1	1.43 a. m. to 5.18 a. m.	72	1.32 a. m. to 5.10 a. m.	12
5.00 a. m. to 8.30 a. m.	1	5.18 a. m. to 9.18 a. m.	76	5.10 a. m. to 9.00 a. m.	0

[a] Thermocline at 8 to 9 m.; strong northeast wind.
[b] Set on bottom near shore.
[c] Set on bottom out in the lake.
[d] Set above the net set at 7.5 m.
[e] Taken ashore; all others were thrown back as soon as they were removed from the net.

TABLE 29.—PERCH CAUGHT IN THREE 1-INCH MESH, 3 BY 60 FEET, GILL NETS, LAKE MENDOTA, SEPT. 7 AND 8, 1916.[a]

2.8 m.[b]		9.5 m.[c]		Surface.[d]	
Time net in water.	Number.	Time net in water.	Number.	Time net in water.	Number.
10.10 a. m. to 2.04 p. m.	3	9.43 a. m. to 1.43 p. m.	1	9.49 a. m. to 1.52 p. m.	0
2.04 p. m. to 5.55 p. m.	2	1.43 p. m. to 5.37 p. m.	18	1.52 p. m. to 5.48 p. m.	0
5.55 p. m. to 10.18 p. m.	0	5.37 p. m. to 9.47 p. m.	39	5.48 p. m. to 10.08 p. m.	0
10.18 p. m. to 2.13 a. m.	0	9.47 p. m. to 1.47 a. m.	12	10.08 p. m. to 1.44 a. m.	0
2.13 a. m. to 6.03 a. m.	0	1.47 a. m. to 5.38 a. m.	13	1.44 a. m. to 5.48 a. m.	0
6.03 a. m. to 10.10 a. m.	0	5.38 a. m. to 9.43 a. m.	19	5.48 a. m. to 9.55 a. m.	0
....	....	9.43 a. m. to 1.43 p. m.	0	....	....

[a] Thermocline at 10.5 m.; strong northwest wind decreasing to moderate.
[b] Set on bottom near shore.
[c] Set on bottom out in the lake.
[d] Set above net set at 9.5 m.

TABLE 30.—PERCH CAUGHT IN THREE 1-INCH MESH, 3 BY 60 FEET, GILL NETS, LAKE MENDOTA, SEPT. 9 AND 10, 1916.[a]

2.7 m.[b]		11.2 m.[c]		Surface.[d]	
Time net in water.	Number.	Time net in water.	Number.	Time net in water.	Number.
11.45 a. m. to 4.00 p. m.	0	11.15 a. m. to 3.07 p. m.	[e] 60	11.25 a. m. to 3.25 p. m.	0
4.00 p. m. to 7.42 p. m.	0	3.07 p. m. to 7.15 p. m.	67	3.25 p. m. to 7.33 p. m.	0
7.42 p. m. to 11.32 p. m.	0	7.15 p. m. to 11.15 p. m.	0	7.33 p. m. to 11.20 p. m.	0
11.32 p. m. to 3.27 a. m.	0	11.15 p. m. to 3.06 a. m.	0	11.20 p. m. to 3.15 a. m.	0
3.27 a. m. to 7.37 a. m.	0	3.06 a. m. to 7.06 a. m.	[e] 39	3.15 a. m. to 7.20 a. m.	[e] 1
7.37 a. m. to 11.45 a. m.	0	7.06 a. m. to 11.15 a. m.	29	7.20 a. m. to 11.23 a. m.	0

[a] Thermocline at 10 to 11 m.; brisk south-southeast wind.
[b] Set on bottom near shore.
[c] Set on bottom out in the lake.
[d] Set above net set at 11.2 m.
[e] Taken ashore; all others were thrown back as soon as they were removed from the net.

TABLE 31.—PERCH INFECTED BY CERTAIN PARASITES IN LAKE MENDOTA, 1915–16, SHOWN BY MONTHS.

[Numbers in parentheses indicate percentage infected of total catch for a single month.]

Month.	Perch.		Parasites.						
	Number examined.	Number infected.	Nematodes in intestine.	Trematodes in intestine.	Tapeworm cysts in liver, peritoneum, etc.	Adult tapeworms in intestine.	Larval proteocephalids in intestine.	Acanthocephala.	Leeches (Piscola).
1915.									
March	41	27(66)	....	11(27)	20(50)	11(27)	4(10)	9(22)	....
April	28	24(86)	2(7)	....	15(53)	....	6(21)	4(14)	....
May	45	30(67)	10(22)	1(2)	16(35)	1(2)	2(4)	11(24)	....
June	60	28(47)	13(21)	....	16(32)	....	1(2)	5(10)	....
July	66	44(66)	13(20)	1(1)	42(96)	1(1)	....	1(1)	....
August	57	43(75)	10(22)	11(25)	29(72)	11(19)	....	....	....
September	43	38(90)	9(22)	....	35(87)	....	....	....	....
October	53	48(90)	10(20)	....	47(92)	....	2(4)	5(10)	....
November	37	36(97)	4(10)	....	32(86)	....	....	5(13)	....
December	36	27(75)	....	1(3)	20(55)	1(3)	....	....	1(3)
Average	46.6	34.5(76)	7.1(14)	2.5(3.8)	27.2(57.8)	2.5(5.2)	1.5(4.1)	4.0(9.4)	0.1(.3)
1916.									
January	10	10(100)	....	1(10)	10(100)	....	....	....	....
February	10	10(100)	1(10)	4(40)	9(90)	....	....	1(10)	....
March	20	19(95)	....	7(35)	18(90)	....	2(10)	5(25)	....
April	41	39(95)	....	24(60)	37(90)	....	1(2)	4(10)	....
May	29	25(86)	1(3)	11(38)	24(82)	....	2(7)	3(10)	....
June	16	15(94)	6(37)	1(6)	11(68)	....	....	....	....
July	33	32(97)	4(12)	....	31(94)	....	....	1(3)	....
August	15	15(100)	4(26)	1(6)	15(100)	....	1(6)	....	....
September	10	10(100)	2(20)	....	10(100)	....	....	....	....
December	15	12(80)	....	7(46)	12(80)	....	....	1(6)	....
Average	19.9	18.7(94.7)	1.8(11)	5.6(24)	17.7(80.4)	0	.6(2.5)	1.5(6.4)	0
Average for both years	33.2	26(85.3)	4.4(14.6)	4(14)	22.4(69)	1.2(2.6)	1(3.3)	2.7(7.9)	+(.1)

TABLE 32.—PERCH INFECTED BY CERTAIN PARASITES IN LAKE WINORA, 1916–17, SHOWN BY MONTHS.

[Numbers in parentheses indicate percentage infected of total catch for a single month.]

Month.	Perch.		Parasites.					
	Number examined.	Number infected.	Nematodes.	Tapeworm larval cysts.	Tapeworms in intestine.	Proteocephalid larvæ.	Acanthocephala.	Leeches.
1916.								
March	17	13(76)	2(11)	11(65)	....	....	3(17)	....
April	54	49(90)	1(2)	49(90)	1(2)	1(2)	14(26)	....
May	41	38(92)	3(7)	38(92)	....	....	3(7)	....
June	40	34(85)	....	34(85)	....	....	2(5)	....
July	48	42(87)	....	42(87)	....	....	....	....
August	41	38(92)	1(2)	38(92)	1(2)	4(10)	2(5)	....
September	41	39(95)	7(17)	39(95)	....	....	1(2)	....
October	31	29(93)	1(3)	29(93)	....	2(6)	....	2(6)
November	26	23(84)	1(3)	23(88)	....	1(3)	....	....
December	2	0	....	....	....	....	....	....
1917.								
January	15	15(100)	15(100)	....	....	....	....	....
February	16	16(100)	16(100)	....	....	....	1(6)	....
Average	31	27(83)	1.3(2.7)	30(82)	.1(.3)	.7(1.7)	2.1(5.1)	.2(1)

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