The Food and Rate of Growth of Small-mouthed Black Bass (Micropterus dolomieu) in Rock Lake and Lake of the Woods in the District of Kenora.

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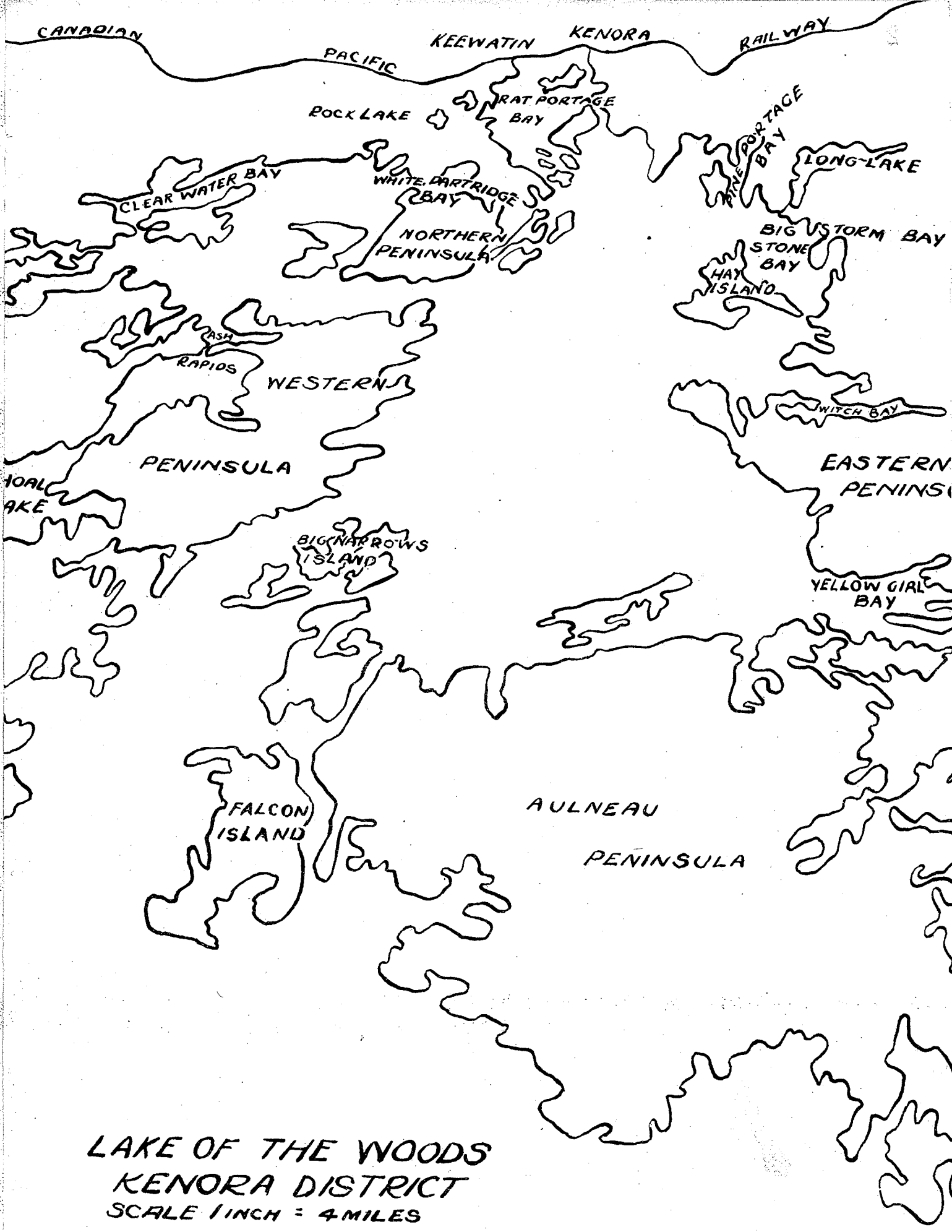
INTRODUCTION

The small mouthed black bass (Micropterus dolomieu) is one of Canada's leading game fish and, like all its near relatives, is peculiar to the North American continent. An English sporting writer, Parker Gillimore, considers it to be superior to the trout "for he is equally as good as an article of food, and much stronger and more untiring in his efforts to escape when hooked." Dr. James A. Henshall in his "Book of the Black Bass" says that a bass has the faculty of asserting himself and of making himself completely at home wherever he is placed. "He is plucky, game and brave, unyielding to the last when hooked. He has the arrowy rush and vigor of a trout, the untiring strength and bold leap of a salmon, while he has a system of fighting tactics all his own. I consider him inch for inch and pound for pound the gamest fish that swims. The royal salmon and the lordly trout must yield the palm to a black bass of equal weight."

The food and growth of bass is therefore of intense popular as well as scientific interest. This paper is based on an examination of stomachs and scales of 178 bass ranging from 3 to 16 years of age, obtained during the summer of 1933 from Lake of the Woods and Rock Lake, the latter a small separate body of water.

The fish were all caught within a distance of 30 miles from the Town of Kenora in the south east and south west directions. Some were caught at each of the following places: Rat Portage bay situated at the northern extremity of the lake, down the western outline from Poplar bay, White



LAKE OF THE WOODS
KENORA DISTRICT
SCALE 1 INCH = 4 MILES

Partridge bay and Ash Rapids, a rapids which has been blasted out for the passage of boats and has been known to flow in the opposite direction, but generally the water flows into Lake of the Woods from Shoal lake (from which Winnipeg gets its water supply.) On the eastern shore line fish were taken from Pine Portage bay, Storm bay and Yellow Girl bay. Twenty-one of the fish were caught in Rock lake about three or four miles west of Keewatin. The location of these places may be found on the accompanying map of the northern section of Lake of the Woods.

Bass are found in most suitable waters from Lake Champlain west as far as the eastern limits of Manitoba and southwards on both sides of the Appalachians from James river, Virginia, to South Carolina, and the Great Lakes to northern Mississippi and Arkansas. In Canada the Department of Fisheries has introduced bass into many waters where it is not native. Bass prefer clear water, either running streams or clear cold lakes. In the northern section of the country it is equally abundant in streams and lakes, but in the south only in cool streams with a good current. Bass have nowbeen introduced into streams in Europe and as far west as California in America.

Small-mouthed black bass were artificially introduced into Lake of the Woods and surrounding country.

Summary of Previous Literature on the Food of Black Bass.

Apart from Clemens and his colleagues (1923 and 1924) and Tester (1932) very little work has been published

on the food of bass in Ontario waters and none whatever on the food or growth of those which were introduced into Lake of the Woods.

The following summary of previous work is taken from Tester's summary, which was based partly on the tables of Adams and Hankinson, with additions of other writers.

Fry and Fingerlings.

Forbes (1880) investigated seven specimens of small mouthed bass in Illinois.

Lydell (1904) reported that as bass grow older the quantity of corixids increased.

Pearse (1920) examined 313 specimens from the western end of lake Erie, Ohio (.85 to 6.5 cm.) He refers to work done by Turner and Kraatz in other Ohio waters.

Hayford (1921) very young bass from Hackettstown station, New Jersey.

Pearse (1921) nine bass (4.6 - 5.7 cm.) from Green lake, Wisconsin.

Pearse (1921a) three small bass in Wisconsin lakes.

Moore (1922) 46 bass fry from lake George, New York.

Clemens and others (1923) 6 bass (2.6 - 3.3 cm.) from lake Nipigon, Ontario.

Clemens and others (1924) 3 specimens (3.0 - 3.4 cm.)

Greeley (1927) one bass from Genesee River System, New York.

Sibley (1927) three specimens (6 - 9.5 cm.) from lake Erie drainage basin, New York.

Rimsky-Korsakoff (1930) 16 bass (2.4 - 6.5 cm.) from

lake Champlain watershed, New York.

Sibley and Rimsky-Korsakoff (1931) 72 bass (1.7 - 3.9 cm.) from St. Lawrence watershed, New York.

Tester (1932) 86 bass fry and fingerling from lake Nipissing, Ontario.

A survey of the above literature on food shows that in order of importance the food of bass fry and fingerling consists of Cladocera, Copepods, Chironomids (midge larvae, pupae and adults), Ephemerid nymphs, Coroxids (mayfly nymphs and water boatmen respectively), aquatic insects, fish and crayfish. Tester (1932) points out a change in diet from Cladocera, Copepods and Chironomid larvae to larger insects, thence to fish and crayfish with growth. The data of most investigators confirm this sequence.

Young and Adult Bass.

Forbes (1880) examined the stomachs of 10 fish from the waters of Illinois.

Forbes and Richardson (1908), stomach contents of 3 fish from waters of Illinois were examined.

Reighard (1915) examined 8 bass from Douglas lake, Michigan.

Pearse (1918) examined 4 specimens (13.2 - 18.1 cm.) from Green lake, Wisconsin.

Pearse (1921a), 21 bass from lake Geneva, Wisconsin.

Greeley (1927) examined 13 specimens from Genesee River System, New York.

Eaton (1928), results found by Sibley - 59 bass from Finger lakes in Oswego watershed, New York.

Allen (1929), 4 bass (26.0 - 38.0 cm.) from Silver creek of the Erie-Niagara watershed, New York.

Reighard (1929) examined 3 bass (39- 42 cm.) from Whitefish lake, Michigan. In Loon lake, 1 bass (37 cm.)

Rimsky-Korsakoff (1930), stomachs of 8 bass from lake Champlain watershed, New York.

Sibley and Rimsky-Korsakoff (1931), 34 bass (7.3 - 31 cm.) from St. Lawrence watershed, New York.

Tester (1932) examined 98 adult bass from Georgian bay, 106 from lake Nipissing and 123 young and adult from Perch lake.

Summarizing the findings of the above investigators, it may be seen that in general the food of young (larger than fingerling) and adult bass consists chiefly of crayfish and fish with a smaller percentage of insects. All investigators report the presence of fish of various species. Crayfish were eaten by bass in most bodies of water examined. The percentage of insects seems to vary considerably and probably depends on the relative abundance of insects as compared with other food organisms which are present in each of the bodies of water.

LIFE HISTORY OF MICROPTERUS DOLOMIEU.

Small-mouthed black bass, like the other members of the Centrarchidae prepare nests and take care of their young from the time the eggs are deposited until the young bass can fight for themselves.

All authors on the subject state that the male bass prepares the nest. The place chosen for the nest is

usually in water 3 - 6 feet in depth in lakes, and on gravelly bottom or rock ledges adjacent to deep water. Aquatic plants may act as a screen on one side but never very near the nest, they are more often found free from vegetation, protected by fallen trees and submerged rocks, and on that side of the islands which are protected from the prevailing winds. The nests are circular saucer-like depressions with a diameter about twice as wide as the length of the fish. The bass makes these by fanning and scouring from the pebbles or rocks all the sand, silt and vegetable debris, by means of their tails and fins and by removing larger obstacles with their snouts. When the nest is ready, the male then induces the female to lay her eggs. These are then fecundated by the male and become glued to sticks and pebbles. Spawning usually takes place in June, or later in colder regions. Beeman (1924) states that spawning takes place when the water has reached a temperature of 64° F., thus the time of spawning would vary with latitude, earliness of season, and size of the body of water.

The rate of development is also dependent on temperature. During this period the nests are carefully guarded by the male parent, who remains over them, and by constant motion of his fins creates a current which keeps the eggs free from debris. The eggs usually hatch in about 14 days. After this time the vigilance of the parent increases and all suspicious and predatory intruders are driven away. This instinct of the male bass that makes him attack anything which comes near his nest leads to the destruction of many

bass by so called sportsmen who fish near nests, early in the season.

Growth of young bass from the time of hatching depends largely on warmth and food supply. The male bass stays with the fry for a period of about 40 days, constantly scouting up and down the shore, covering the distance that the young bass can travel from the nest.

From the various statements made by different investigators, it appears that the age at which fish reach maturity varies considerably in different localities.

J. S. Kingsley in his standard Natural History states that bass have been known to reach maturity as early as three years. Eastern Ontario writers say they are probably mature in their sixth summer. In Lake of the Woods it was found that most fish were not mature until their seventh summer. The lengths of these fish were around eleven inches.

The culture of small-mouthed black bass has been attempted many times with failure, but at the present time fish culturists are hopeful of success. Quoting Mr. H. H. MacKay, Director of Fish Culture in Ontario, from his paper on "The Present Status of Fish Culture in the Province of Ontario"* where he states "After many years of patient toil and disappointing results, some success appears to be on the horizon, and this success is due in the main to making provisions for the rearing of bass fry in rearing ponds entirely separate from the breeding ponds. Our results show

* Reprinted from Trans. Am. Soc. Vol. 60 (1930)

conclusively that if we desire to rear bass by the pond method, it is useless to endeavor to try and do so by leaving bass in large ponds with adults.

The food supply of the bass is of major importance, and since they will not take artificial food, the natural food in ponds must be increased by a suitable fertilizer. Horse manure and sheep manure were used this year with good results."

HISTORY OF THE BLACK BASS IN LAKE OF THE WOODS.

The first small-mouthed black bass (two carloads, approximately five hundred parent fish) were planted during 1910 in an artificial lake known as Long lake, which empties into Lake of the Woods. About three years later the Long lake dam was carried away and the fish escaped into Big Stone bay and migrated through the surrounding waters.

In 1920 a carload was shipped and the fish (220 adults) taken to Smith lake, about 25 miles south west of Keewatin.

In 1921 a carload shipment of two hundred and fifty parent fish and twenty five hundred fingerlings were sent to Keewatin. Seven adult fish were put in Rock lake, forty into Spruce lake and the remainder, including all the fingerlings, were planted in Rat Portage bay. The seven adult fish put in at this time are the only bass that have been planted in Rock lake, which before this time contained no bass.

The following list is believed to include all other plantings made in the district. All these consisted of parent

fish.

Green lake	131	
Guy lake	49	
Bob lake	49	
Flamhean lake	49	
Pritchard lake	49	
Second lake	250	
Rabbit lake	228	
Poplar lake	100	
Fox lake	60	(now a sanctuary)
Black Sturgeon lake	100	
Oussee lake	40	
Langton lake	90	
Squaw lake	352	

Some of these lakes such as Squaw lake open into Lake of the Woods. These data have been obtained from the Ontario Department of Game and Fisheries.

All the present black bass population is the result of these 36 or 37 hundred fish introduced between 1910 and 1922 and the abundance of the species shows that the environment was suitable and the food supply adequate.

MATERIALS AND METHOD.

The material upon which the present paper is based was obtained during the summer of 1933. One hundred and seventy eight specimens of small-mouthed black bass were examined, twenty-one of these being taken from Rock lake, the remainder from Lake of the Woods. All the fish were caught on hooks, either single barbed, still fishing hooks

using worms, frogs or crayfish for bait, or by the use of one or two spinners on a casting rod. As far as possible the bait which the fish took was recorded, but in many cases it was impossible. Where it was known no connection between the bait and feeding habits could be established.

Before the material was collected, small envelopes (2 in. x 3 in.) were numbered and after putting a piece of gauze and a tag bearing a corresponding number inside, they were arranged in order in a box and left handy on a shelf in the boat-house (which is situated on an island 5 miles south west of Kenora) with quart sealers containing 5 - 6% formalin. As the catches of fish came in, the date, district caught, bait used, species, length and depth of fish were recorded on the envelopes. The viscera of the fish were rolled in the gauze, tagged and dropped into a bottle of formalin. About 20 - 30 scales of the fish were removed from the lateral line region behind the operculum approximately above the ventral fins, and placed in an envelope which was then sealed.

The material was brought to the University in this way where it was examined during the next winter. Sex was determined from the reproductive organs, then the alimentary canal was cut longitudinally and emptied. The large organisms were identified with the naked eye or hand lens, smaller organisms and unidentified pieces were identified as far as possible by the use of a binocular dissecting microscope.

The scales were mounted, dry, between two slides, the ends of the slides being fastened together with gummed paper, the number of the fish from which the scales were taken was written on the paper.

In addition to the detailed work on fish scales and stomach contents, certain general features of the environment are indicated herewith, this information having been gathered both from related literature and the result of many summers spent at Lake of the Woods by the writer.

ACKNOWLEDGMENTS.

The author wishes to pay grateful acknowledgment to Professor Ferris Neave of the Zoology Department at the University of Manitoba, under whose direction this work was carried out, for his assistance in the identification of partially digested food of fishes, also for helpful suggestions and criticism and for access to his personal literature.

Also, I wish to express my appreciation of the assistance rendered by Mr. W. J. Bulman and friends in obtaining the material used.

Thanks are also due to Professor R. A. Wardle of the Zoology Department of the University of Manitoba for his suggestions and the identification of the parasites found.

FEATURES OF THE ENVIRONMENT IN LAKE OF THE WOODS.

Lake of the Woods is an International lake situated in the south west corner of the Province of Ontario, a small portion of it being in the State of Minnesota. The chief industries using power from the inflow and outflow of the lake are the Pulp Mills at both south and north ends and the Lake of the Woods Flour mill at Keewatin. A small amount of lumbering is also done but these activities do not contaminate the lake. Some commercial fishing is done for Pickerel and Whitefish.

The town of Kenora (pop. 6,766) is situated at the most northern and eastern corner, while Keewatin (pop. 1,422) is at the north west corner. Norman dam, which governs the outflow of the lake to the Winnipeg river, is in the town of Norman about midway between the above towns.

The lake is famous as a summer resort and is very accessable, as the main line of the Canadian Pacific Railway and the Transcontinental highway pass through the three towns, the highway also touching the lake at various other points.

There are several thousand islands in the lake. Exclusive of these, the area of the lake is 1,485 square miles (3,847.5 sq. kilometres). The altitude of the lake is 1,060 ft (323.02 metres). The lake drains an area of 26,750 sq. miles (69,306.81 sq. kilometres) and almost the whole area is rocky, resembling that in the immediate vicinity of the lake. The islands and the shoreline are wooded right down to the high water mark, it is from this feature that

the lake was named "Lake of the Woods." The annual precipitation is about 22.5 inches, most of which falls as snow, but the rainfall in the district of the lake is greater during the summer than that of the adjoining prairie region to the west, Lake of the Woods being in the most westerly portion of the "hardwood forest zone" which stretches across Canada south of the sub-arctic forest region and extends between the shores of lake Erie and a line from Toronto to Windsor west, joining the first prairie zone east of Winnipeg.

The country drained by Lake of the Woods contains many small lakes. The principal feeder is the Rainy river entering at the south eastern extremity. The result is that although there is considerable inflow of fresh water following the spring thaw, there is a steady supply of fresh water entering the lake all summer. The drainage area is almost entirely without settlers and the water is usually clear and free from contamination by drainage and sewage. Some of the waters entering the lake have passed through fairly extensive Sphagnum bogs and consequently contain peaty substances commonly present in such waters, this organic matter is rapidly lost in the lake. The lake bottom is mainly rock with areas of sand or mud, covered with a layer of detritus (fragments of deteriorating vegetation and animal matter).

In shallow channels between some of the islands and in many sheltered bays a rich growth of aquatic flowering plants can be found. Species of Scirpus (bulrush), Eleocharis (spike rush), Alisma (water plantain), Sagittaria (arrowhead), with Potomogeton and Ruppia (pond weeds), Lemna (duck weed),

and Zizania (wild rice), Elodea (waterweed) and Vallisneria (eelgrass) which are monocotyledons, are present in this shallow water. The dicatyledonous vegetation is represented by Myrica gale, Polygonium amphibium, species of, Castalia (white water lily), Nymphaea (yellow water lily), Ceratophyllum (hornwort), Myrophyllum (milfoils), Ranunculus (crow-foot), Pontideria (pickerel weed), Hippurus and Callitriche. The aquatic Lycopodiaceous plant Isoetes is also present. Nearly all the flowering plants have epiphytic algae on them.

The planktonic life of the lake is quite abundant although no quantitative hauls have been made. The bulk of the plankton from February till the ice breaks up is made up of animal life and consists mainly of various species of Crustacea and one Rotifer, Anurea cochlearis. The following diatoms in a normal active state are also fairly plentiful; Asterionella formosa, Synedra, Melosira granulata, Tabellaria fenestrata, and Fragilaria capucina. Stephanodiscus niagarae is rare at this time of year. Botryococcus is the only green alga found active all the year around. In May the lake is rich in diatoms, Ceratium hirundinella and various species of Pediastrum, certain Chlorophyceae, Staurastrum paradoxum, Arthrodesmus Incus, Scendesmus quadricauda and a few immature Myxophyceae are present in a small quantity. Crustaceans are rare and Rotifers plentiful at this time.

Myxophyceae reach their maximum towards the middle of the summer. From late July to early September they give a distinct color to the water.

During the summer planktonic life is at its height, organisms such as, Dinobryan, Ceratium, Anabaena, Melosira,

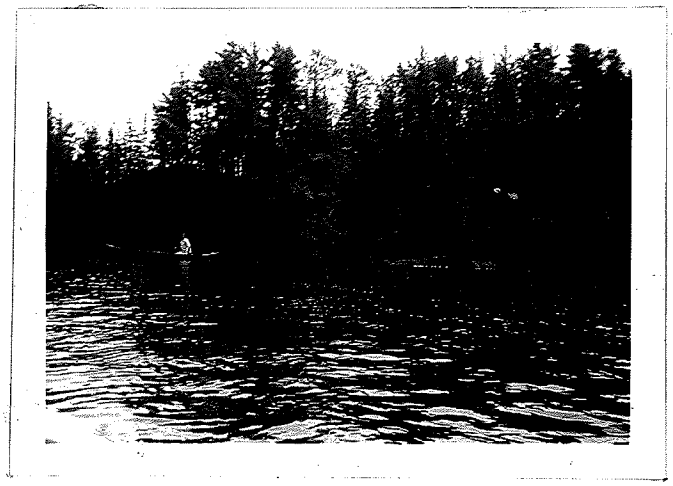
Stephanodiscus, Tabellaria, Fragillaria, Asterionella, Navicula, Gomphonema, Cymbella, Pandorina, Eudorina, Pediastrum, Spirogyra, with many others being commonly found.

Lake of the Woods is a Caledonian type of lake, Desmids being the predominating algae present in the water, this type of vegetation is typical of older lakes and generally found in Carboniferous regions, the typical Desmids found being Closterium, Pleurotaenium, Euastrum, Micrasterias, Cosmarium, Xanthidium, Arthrodesmus Incus, Staurastrum. There are several species of most of the above genera found, Spondylosium planum is also common.

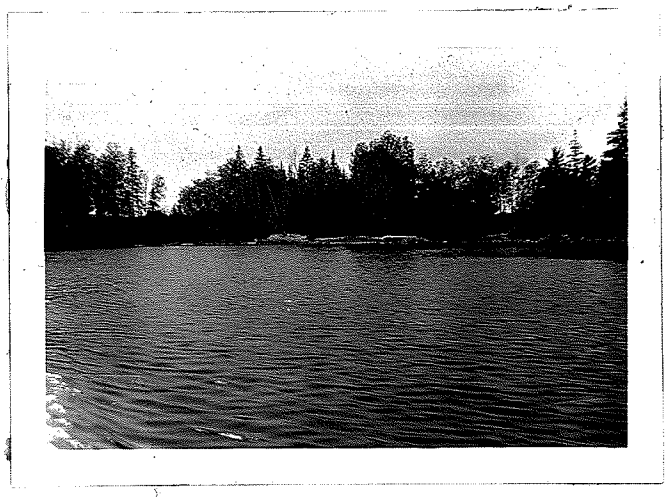
Up to the present time only a limited portion of the Lake of the Woods has been surveyed hydrographically. It is a fairly deep lake, depths of 84 ft (25.61 metres) being officially recorded. It is known by the writer that readings of 90 - 150 feet have been taken. When more intensive soundings have been made probably several parts of it will be found with depths of well over one hundred feet.

A water analysis made by Mr. A. Blakie, City Analyst, Winnipeg, shows:

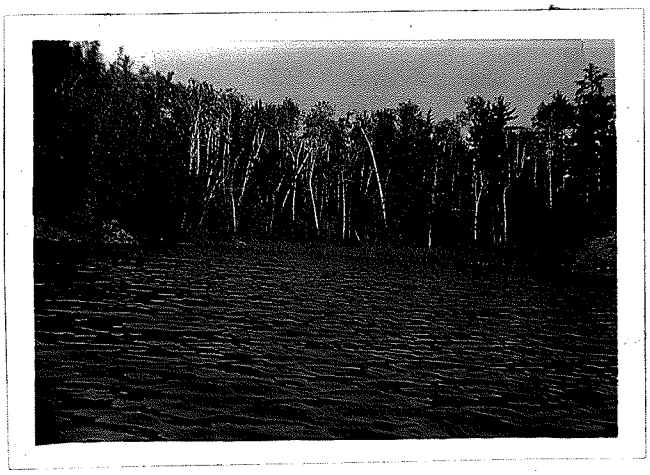
Organic matter	4.58 parts/million.
Inorganic salts	23.23 parts/million.



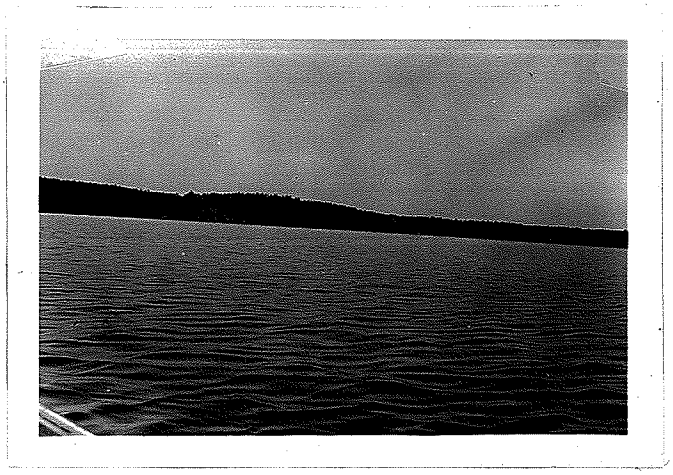
TYPICAL ROCKY SHORELINES IN LAKE OF THE WOODS.



SHORELINE SHOWING BEACH FORMATION



SHALLOW BAY SHOWING AQUATIC VEGETATION ALSO
THE CONIFEROUS GROWTH ON ROCKY SHORES AND
BIRCH AND POPLAR GROWTH ON LOW-LYING SANDY LAND



LONG STRETCH AT SHORELINE SHOWING THAT SANDY BAYS CONTAINING AQUATIC VEGETATION (AS SHOWN BELOW) ARE RELATIVELY SCARCE.

THE FOOD OF SMALL-MOUTHED BLACK BASS (MICROPTERUS DOLOMIEU) IN LAKE OF THE WOODS AND ROCK LAKE.

Introduction.

This paper is based on the examination of the stomachs of 157 black bass from Lake of the Woods, and 21 from Rock Lake. The study was extended to include the food of Pickerel (Stizostedion vitreum Mitch.) to estimate the importance of this species as a competitor of the bass for food.

LAKE OF THE WOODS.

The Food of Young Black Bass.

Thirty fish belonging in this group were examined. The lengths of these fish ranged from 13.4 centimetres (5.25 inches) to 26.7 centimetres (10.5 inches). Only three individuals were mature.

It was found that twenty-four of the fish examined (80 percent) had eaten crayfish, while only six (20 percent) had eaten fish and six (20 percent) had eaten insects.

This group, although nearly all were immature, consists of relatively large fish which show little difference in diet from the next group which are mature fish in their 7th and 8th years.

The stomachs of these fish yielded the following items: 7 fish, 57 crustacea, 12 insects. The fish included 3 perch and 4 unidentified; the crustacea consisted of 55 crayfish (Cambarus sp.) and 2 Hyalella. The insects were as follows: 2 Sialis, 2 terrestrial Coleoptera, and one each of Corixa, Dysticidae, Grasshopper, Hexagenia nymph, Ephemerid nymph, Anisoptera, Agrioxidae and Anischnae.

Throughout the paper where the number of organisms found is given, these figures were obtained by counting eyes, mouth parts, vertebral columns, etc. These parts because of their resistance to digestion would often be found when the main body of the organism was digested. In many cases, however, the organisms were quite intact and quite easy to recognize and count. Fish in particular were often unrecognizable. Only those in good condition could be identified definitely, as perch, pickerel, etc. Where unrecognizable they were put down as "miscellaneous fish."

Wickliff (1920) in his work on young bass in Lake Erie found that Copepods and Cladocerns constituted most of the first food and were found in 80 - 90 percent of the young bass, depending on the abundance of each. These animals with mayfly nymphs were important to the 4.0 centimetre stage then became less important; midge larvae and pupae, and adult insects taking their place. He also found that adult insects and fish become important as the bass increase in length and these, with crayfish, are the chief diet of bass between 4.5 - 6.5 centimetres.

The series seems to be first, Entromastacans, then as fish grow, change to Insects (larvae, pupae, then adult.) The third division of the series being crayfish and fish.

Tester (1932) found that in several Ontario lakes, the fry at first feed exclusively on Copepods, Cladocera and insects. As they increase in size they take larger organisms. The Copepods and Cladocerns decrease in importance as the insect content increases. Small midge (Chironomidae) larvae and pupae are replaced by larger larvae, nymphs and adult insects. Gradually the insects decrease in importance as fish enter into the diet. After the fry have reached a length of about 5 centimetres their food consists mainly of fish and crayfish with a small percentage of insects.

Wickliff and Tester agree very closely in their results, as do most of the other workers on young bass, such as Dr. C. L. Turner and W. C. Kraatz in Ohio waters and the other writers previously mentioned.

Though we lack data to show conclusively that young bass of Lake of the Woods feed on the same food cycles as those in other bodies of water, it is very likely they do. The occurence of the Amphipod, Hyalella in the smallest fish examined probably indicates the change of diet from Entromastacans and Insects to crayfish and fish.

Food of Adult Small-mouthed Black Bass.

First Group.

There were fifty-one specimens in their seventh and eighth summers examined. Their lengths ranging from 26.7 centimetres (10.5 inches) to 31.8 centimetres (12.5 inches).

It was found that crayfish occurred in approximately 84 percent of the stomachs, while insects occurred in 26 percent, fish occurring in 25 percent. Vegetable matter was found in 18 percent of the stomachs examined.

The following items were yielded: 30 fish, 82 crustaceans and 32 insects. Most of the fish remains found were unrecognizable apart from being teleost fishes, a few however evidently had been swallowed just before capture and were quite recognizable, 1 pickerel was identified and 5 perch. The crustaceans were all Cambarus sp. The insects included: 8 terrestrial Coleoptera, 7 Grasshoppers, 5 Dystiscidae, 4 Ephemerid nymphs, 2 Anisoptera and 1 each of Hemiptera, Carabidae, Stenodema nymph, Belostema and aquatic beetle larvae.

Dividing the food items of each class by the number of fish examined it was found that the average content of each fish of this age was, .59 fish, 1.6 crayfish and .7 insects, while one fish of the previous age had eaten theoretically, .23 fish, 1.9 crayfish and .4 insects, showing that the number of items of food eaten had increased with age.

Second Group.

Twenty-four specimens were examined, that were in their 9th and 10th summers. The lengths varied from 30.5 centimetres (12 inches) to 40.6 centimetres (16 inches.)

It was found that 78.1 percent had eaten crayfish, 33 percent fish and 16 percent had eaten insects, 8 percent had eaten vegetation of some kind. In the total stomach contents, 26 fish were found, 3 of which were pickerel,

42 Cambarus sp. and 15 Insects, including 10 Grasshoppers, 4 Hexagenia nymphs and 1 Stenodema nymph. Vegetable matter was found in only 2 fish.

The amount of food eaten by 1 fish of this group would result in being, 1.09 fish, 1.5 crayfish and .6 insects, showing another increase in amount of food eaten.

There was a marked falling off in the percentage of insects, but more noticeable was the decrease in the variety of insects eaten.

Third Group.

Only 9 specimens were examined of fish in their 11th and 12th summers. The theoretical amount of food eaten had again increased, the figures now amounting to 1.4 fish, 1.7 crayfish and .11 insects.

The lengths of these fish varied from 29.8 centimetres (11.75 inches) to 40.0 centimetres (15.75 inches.)

The data obtained showed an increase in fish as food and a great falling off of insects, but crayfish are still predominant. Crayfish were found in 88 percent of the stomachs, fish 44 percent, insects 11 percent and vegetable matter in 33 percent.

The food items found were: 13 fish, 1 pickerel, 8 shiners and 4 miscellaneous, 16 Cambarus sp. and 1 insect which was a Donacia.

Fourth Group.

The next group of fish included seven specimens ranging in length from 38.8 centimetres (15.25 inches) to 44.5 centimetres (17.5 inches), including fish from their

13th to their 15th summer. It is quite probable that lack of sufficient data may have distorted the results.

The percentage of fish eating crayfish was 88.8 percent, fish 42.8 percent, and vegetable matter 14 percent.

The items were: 6 fish, 1 pickerel and the rest unidentified, 20 Cambarus sp. and insects eaten were 7 Ephemerid nymphs by one fish.

The Percentage of Fish Eating each Category of Food in the different Age Divisions.

Table I

Food Categories	4 - 6 Summers	7 - 8 Summers	9 - 10 Summers	11 - 12 Summers	13-14-15 Summers
Crustacea	80%	84%	78%	88%	88%
Pisces	20%	28%	33%	44%	42%
Insecta	20%	26%	16%	11%	14%
Vegetation		18%	8%	33%	14%

It can be seen in the above table that the percentage of fish eating crayfish increases slightly, while the percentage of fish practically doubles itself and insects fall, with the increase of age of approximately ten years. Vegetable food varies and it is difficult to say whether this steady occurrence of vegetation in fish over six years has any bearing on the subject. Vegetation certainly has very little food value and whether the bass are eating it because they like it or by accident is hard to determine.

Food in Order of Importance.

The order of preference for various kinds of food (as indicated by the number of individuals which had taken each kind) is shown in table 2.

The number of fish feeding on crayfish (109) was over twice the number eating fish (42), only 16 fed on or

Table 2.

Food			No. of Individuals Taking Food	Number of Organisms Found
Cambarus			109	215
Fish			42	106
Pickerel	4	4		
Perch	4	6		
Shiners	1	8		
Misc.	33	88		
Vegetable Matter			16	
Grasshoppers			6	19
Terrestrial Coleoptera			5	16
Ephemerid nymphs			4	12
Hexagenia nymphs			4	7
Aquatic beetles			3	7
Odonata			3	3
Hemiptera			2	2
Neuroptera			1	2
Hyalella			1	2
Trichoptera			1	1

had eaten vegetable matter. No natural groups of insects was of general occurrence. Grasshoppers and terrestrial

Coleoptera, both of which would be caught by the fish feeding at the surface, gave the highest figures. The Ephemerid and Hexagenia nymphs (mayflies) came next while aquatic beetles, Hemiptera and Odonata followed. Neuroptera, Hyalella and Trichoptera occurred in single fish only.

Volume and Weight Percentage of Food.

Table 3.

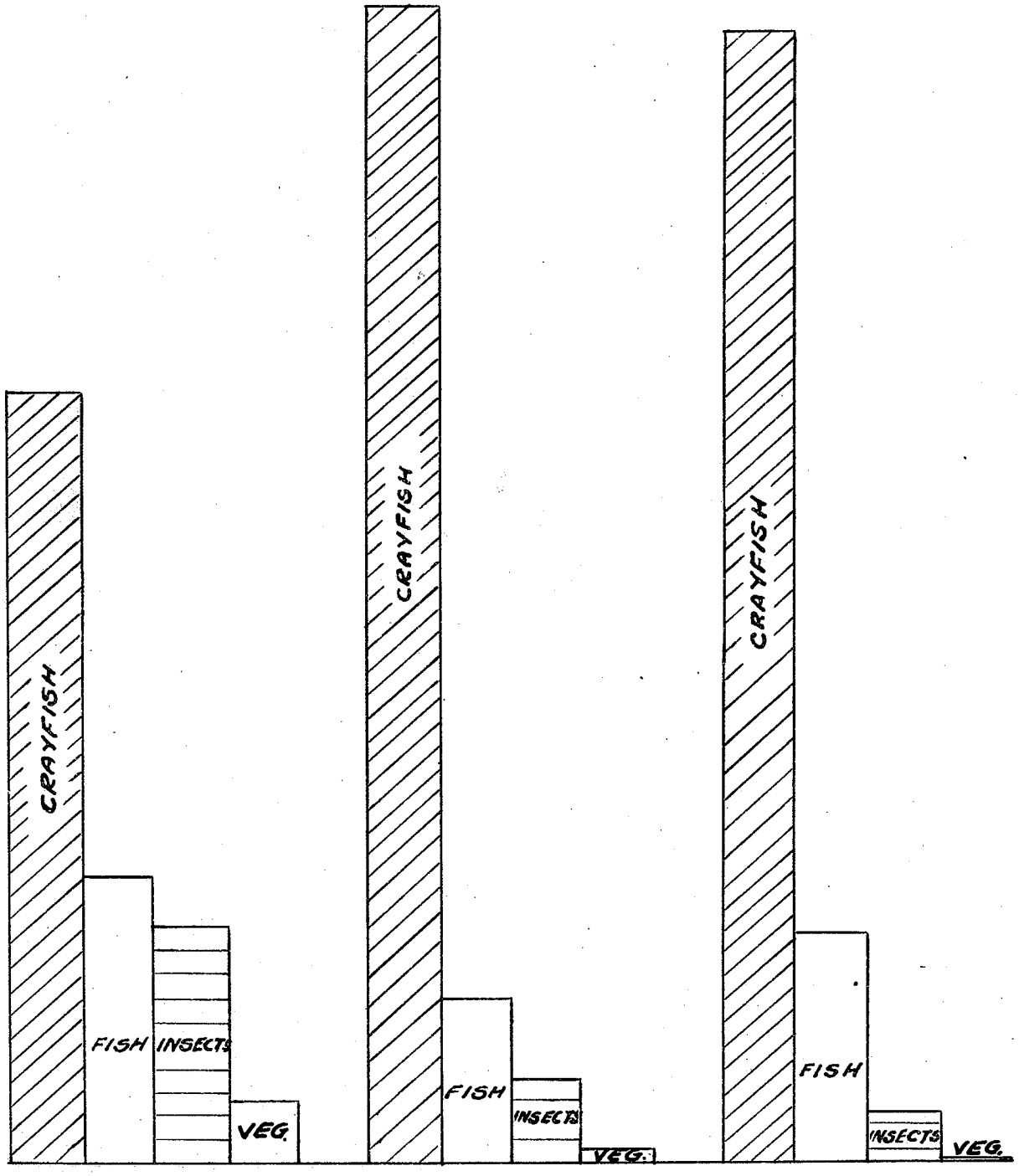
Food	Percentage by No. of Individuals	Percentage by Wet Volume	Percentage by Dry Weight
Crustaceans	54.25%	81.0%	79.3%
Fish	20.0%	11.2%	16.3%
Insects	18.25%	6.05%	3.5%
Vegetable Matter	4.0%	1.3%	.58%

The above table (3) was compiled to show the proportions of food eaten by 121 fish, the total number of fish examined which contained food.

The percentage by individuals neglects the relative size of the individual item of food, of the food constituents, therefore the results show a relatively less percentage of crayfish and the insect percentage is quite large. The crayfish percentage of 54.25%, fish 20%, insects 18.25% and vegetation 4% is decidedly out of proportion, but does still show the order of importance as fish food.

The percentage by wet volume was arrived at by placing a known volume of water in a graduated jar, and after removing excess moisture with filter paper, dropping the organisms into the jar. The volume of water displaced was

Figure 1



Percentage by Number of Individuals

Percentage by Wet Volume

Percentage by Dry Weight

measured, this representing the volume of the individuals put in. The results in this case were quite different. The crayfish rose to 81 percent of food taken, while fish fell to 11.2 percent, and insects to 6 percent. Vegetable matter was only 1.3 per cent. This method of measuring the relative importance of the classes of food gives a much more accurate account of the value of them as actual food.

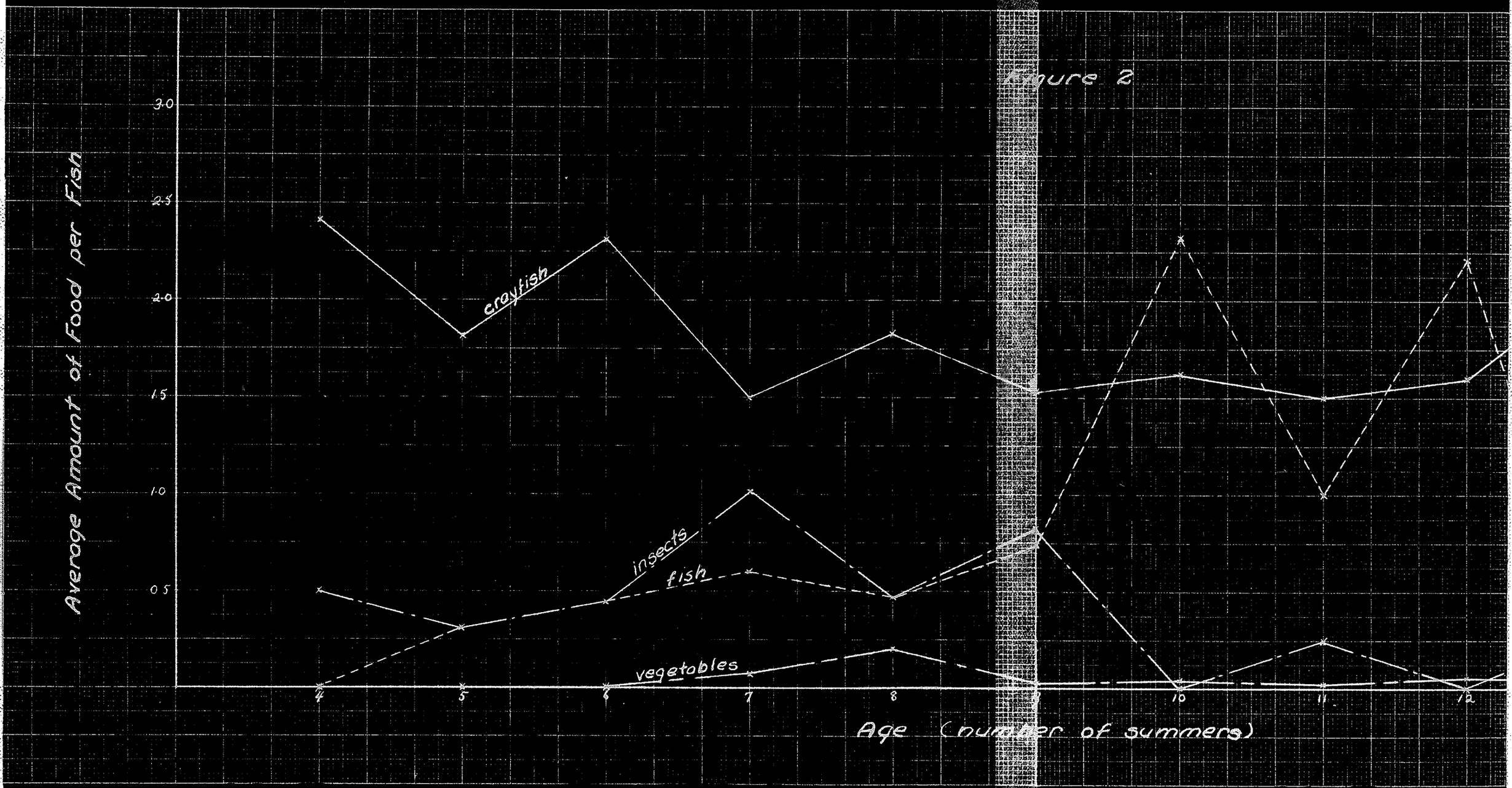
A still more important and accurate comparison is given by dry weight as there is no food value in the water contained in the flesh of animals. The figures shown were obtained by draining and removing all excess water, as above, and then placing on paper towels and putting in an oven kept at 50° C until constant weight was obtained. The material was then weighed on a balance scale. The figures obtained showed that crayfish represent 79.3 percent of the total and that fish had risen to 16.3 per cent, the importance of insects fell to 3.5 percent and vegetable matter was almost negligible, having a percentage of 0.58.

The differences in percentage is shown still more clearly in figure 1.

Relative Importance of each Food at different Ages.

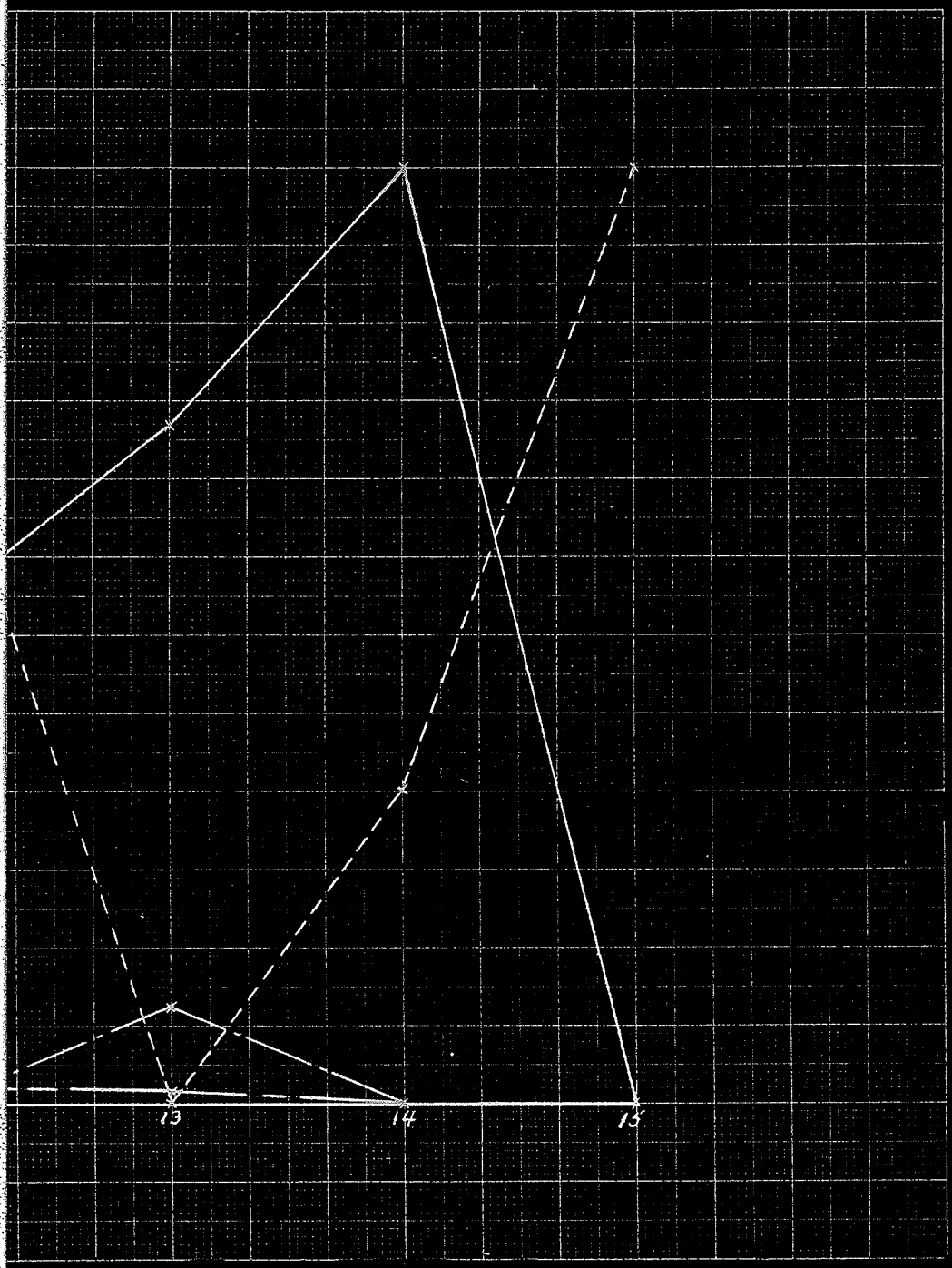
Figure 2 shows graphically the relative importance of each type of food at different ages of the fish. The age of the fish in number of summers being plotted against the average number of food items. The number of individuals eaten by the fish of the same age was divided by the number of fish examined of that age. e.g. If eighteen fish in their sixth summer ate; 42 crayfish, 7 fish and 7 insects, these

Figure 2



IF SHEET IS READ THIS WAY (HORIZONTALLY), THIS MUST BE TOP.

IF SHEET IS READ THE OTHER WAY (VERTICALLY), THIS MUST BE LEFT-HAND SIDE.



FORM 100

were then divided by 18 and a theoretical value obtained that one fish would eat 42/18 or 2.33 crayfish, 7/18 or .28 of fish and insects.

The graph up to twelve years of age shows very clearly a fairly steady value for crayfish, being slightly higher in the 4th and 6th summers. The fish line shows an upward trend and in some places rises above the crayfish. Insects show an increased importance as food with fish in their 7th summer but otherwise a steady falling off. Vegetable matter which did not appear in the fish earlier than the 7th year reaches a maximum at the 8th year, but throughout the graph remains low and of little importance.

After the twelfth year the curves become irregular which can partially be explained by the fact that so few fish were examined over this age.

Except for the great fall of fish in the 13th year and rise of crayfish in the 14th, the graph would indicate that crayfish constitute about the same value as food throughout the adult life of black bass in Lake of the Woods. On the other hand the relative amount of insect food becomes less with age and that a fish shows a marked increase.

Summary

As small-mouthed black bass increase in size they feed upon larger organisms. Even the size of crayfish found portrays this, a crayfish approximately 1.0 centimetres was found in one of the younger fish while older fish fed on crayfish ranging from 6 to 10 centimetres.

In Lake of the Woods, the Rock Bass appear to be the most important competitors for the crayfish supply. Of forty Pickerel (Stizostedion vitreum Mitch.) only 27 contained food. These twenty seven had eaten mostly fish, one alone having forty one inch and a half to two inch shiners packed in. Total fish as food numbered 74, while 31 Hexagenia nymphs were found, 2 Sialis, 3 Ephemerid nymphs, 7 Stenodema, 1 Chyronomous and Gastropod. This indicates that in this body of water the pickerel has a somewhat different diet. Crayfish not being found at all and some of the fish at any rate being different from those usually taken by the bass. Insects appear to be a much more important food item in adult pickerel than in adult bass.

From the data it can be concluded that in general, the feeding habits of the small-mouthed black bass in Lake of the Woods are similar to those found in other bodies of water by previous workers. The type of food is exactly the same, but the proportions vary. Crayfish appear to be much more important here than in any of the waters dealt with in previous literature. The importance of insects is small. Most investigators have found bass in the smaller lakes contain more insects than those of larger waters due to the tendency for these forms to be more abundant in smaller bodies of water.

Tester (1932) dealing with fish from Perch Lake and Lake Nipigon found that between a length of 20-28 centimetres (which would correspond to the 7th and 8th year categories of the present paper) the percentage volume of

crayfish fell and that of fish increased. No marked change was found in the importance of any one food during the life of the bass in Lake of the Woods, although there was a gradual and steady increase of fish as food throughout.

ROCK LAKE

Food of Young Bass.

Six fish were examined, ranging from their 4th to 6th summers and from 18.5 centimetres (7.25 inches) to 28.6 centimetres (11.25 inches.) The stomachs of these fish yielded 4 crayfish, 1 fish and 6 insects, which included 2 terrestrial Coleoptera, 1 Ephemerid, 1 Dystiscidae, 1 Agrioxidae and 1 Grasshopper. 50 percent of the fish had eaten crayfish and insects but only 1.6 percent had eaten fish.

Adult Bass.

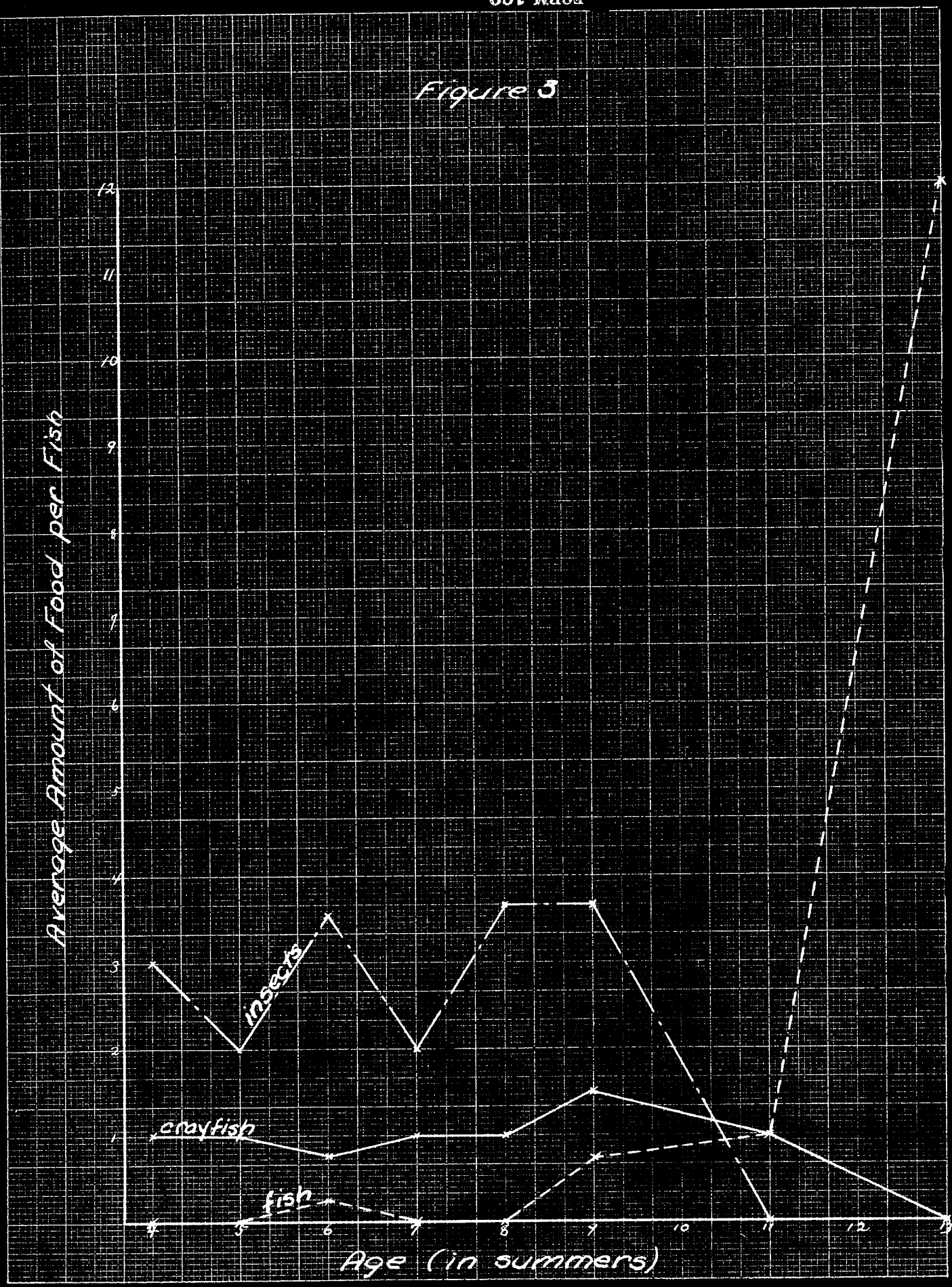
First Group

This group included the 7th and 8th summer fish, of which there were seven specimens examined ranging from 27 centimetres (10.5 inches) to 31.1 centimetres (12.25 inches) and yielded the following stomach contents: 7 crayfish and 18 insects. Although the total number of insects increased those eaten were principally terrestrial, being 7 Grasshoppers, 8 terrestrial Coleoptera and 3 Dytiscidae.

Second Group.

No fish caught in Rock Lake were in their tenth summer. Four bass in their 9th summer gave the following: 3 fish, 4 crayfish and 9 Grasshoppers. Fish, crayfish and

Figure 3



grasshoppers were each eaten by 50 percent of the fish.

Third Group.

As only 21 specimens were taken from Rock Lake the age groups were not well represented. This group includes but two fish, one in its 11th summer the other in its 13th. Their lengths were 40 centimetres (15.75 inches) and 40.6 centimetres (16 inches) respectively. These two individuals had eaten only fish, one having eaten 12 small one inch fish, the other a four inch fish.

Relative Importance of each Food at Different Ages.

In figure 3 the amount of food eaten in each category is plotted against the age of the fish. Crayfish appear as a steady diet up to the 11th year. The general contour of the curve is however very much lower than that found for Lake of the Woods bass, at no time rising above 1.5. Fish remains exceptionally low until the 8th year, then showing a continual marked increase. The insect curve is interesting in that insects seem to be the most important food item of this lake, the average number of insects eaten, in most cases, being much higher than that of any other category. Vegetable matter was not found at all in Rock Lake.

Summary.

These data agree with the general findings of other workers that fish in smaller lakes seem to eat more insects in proportion to other food.

The fish were all caught in early July when grasshoppers are found in abundance. This fact, together with the small number of specimens, may however cause some distortion in the results.

GROWTH OF SMALL-MOUTHED BLACK BASS (MICROPTERUS DOLOMIEU) IN LAKE OF THE WOODS AND ROCK LAKE.

Introduction

The same specimens were used as in the examination of stomach contents. The tables and growth curves used in this paper are based on the examination of one hundred and thirty six specimens ranging from 4.87 inches (12.5 cm.) to 17.5 inches (44.5 cm.) and twenty one specimens from Rock Lake, 7.75 inches (19.7 cm.) to 16 inches (40.6 cm.).

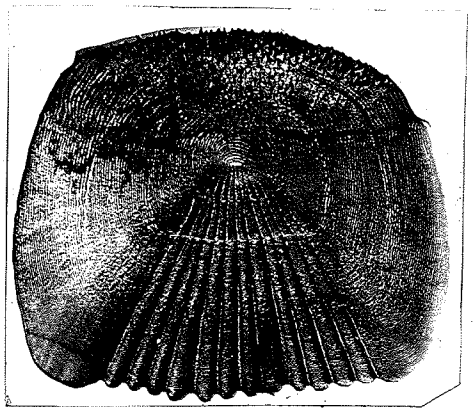
Unfortunately the standard length of all these fish was not recorded. Length in this paper refers to the total length, i.e. from the tip of the lower jaw to the fork of the tail, measured in inches. The depth was taken midway between the anterior portion of the dorsal fin and the posterior angle of the operculum.

USE OF SCALES IN DETERMINATION OF AGE.

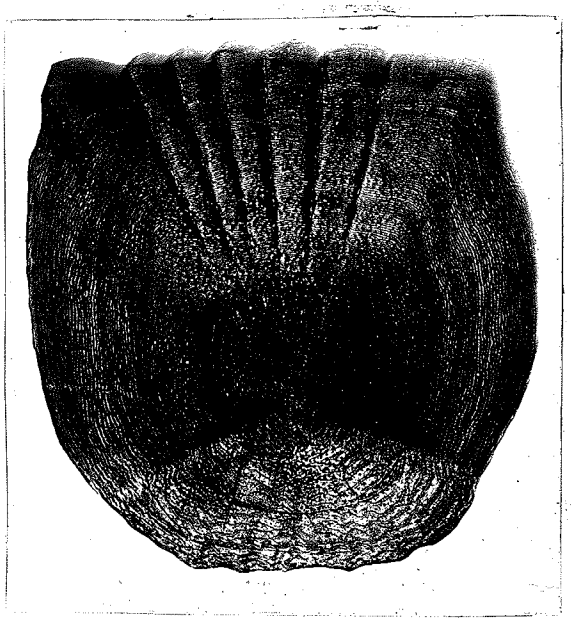
The scales of each fish were taken from their envelopes and allowed to soak in a solution of Ammonium hydroxide, then being cleaned with a brush. Sometimes it was necessary to scrape the surface lightly with a scalpel. These cleaned scales were mounted, dry, and the age of the respective fish determined in so far as it was possible.

A bass scale may be divided into four fields, anterior, posterior and two lateral fields. The posterior field is the small exposed portion of the scale, and carries characteristic rows of spines. The anterior and lateral portions are involved in the overlapping of the scales upon one another. Circuli, commonly called growth rings are concentrically arranged about the focus or nucleus which lies medially between the four fields and is the initial point of growth. The radii form a series of grooves radiating from the focus to the scalloped anterior edge of the scale. These radii are grooves which represent lines along which dentin has not been laid down and thus permit more flexibility of the scale. As bass spawn in the late spring and early summer the first circuli laid down are quite evenly spaced, temperature and food both giving good conditions for growth. Later in the year, when growth is retarded, the circuli lie closer together and growth may even stop altogether. These alternating conditions occur throughout the life of the fish. The point on the scale where growth has stopped, or just before the relatively rapid growth of the next spring starts is called an annulus or year mark. By using the scales in this way to determine the age of a fish it is assumed that as a fish grows its scales increase in size, not in numbers, and that the closeness together of the circuli does represent the slow and rapid growth of winter and summer seasons.

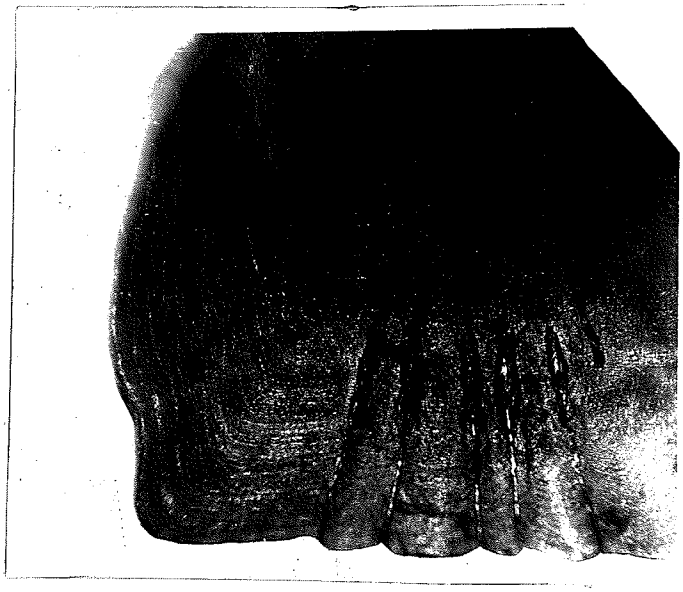
Thus the ages of the bass examined were determined by counting these annuli appearing on the scales. In

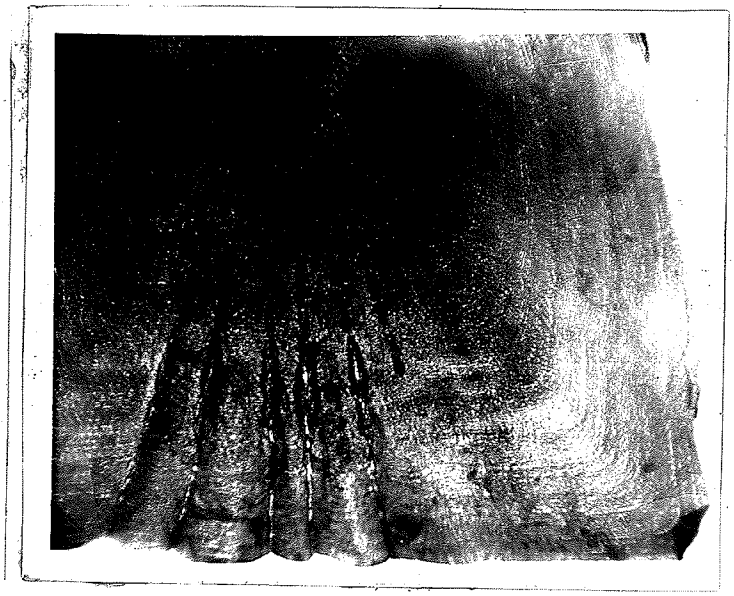


SCALE FROM A FISH IN ITS 4th SUMMER
SHOWING SPINES IN THE POSTERIOR FIELD
AND THE RADII IN THE ANTERIOR FIELD.



SCALE FROM A FISH IN ITS 8th SUMMER
SHOWING THE RELATIVE CHANGE OF SHAPE OF THE
DIFFERENT AREAS AND THE BROKEN, IRREGULAR
CIRCULI IN THE POSTERIOR FIELD, AND CUTTING
OVER CAN BE SEEN.





THE 3 ILLUSTRATIONS SHOWN ABOVE, ARE OF THE SAME SCALE. THE SCALE WAS READ TO HAVE SIXTEEN ANNULI ALTHOUGH THE ANNULI DO NOT SHOW AS CLEARLY AS DESIRED, THE FOLLOWING STATEMENTS ARE ILLUSTRATED, THAT IN THE ANTERIOR FIELD IT WAS IMPOSSIBLE TO COUNT THE ANNULUS AND THE POSTERIOR FIELD HAS NOT INCREASED IN SIZE IN PROPORTION TO THE REST OF THE SCALE.

some cases the spacing of the circuli was not definite enough to determine whether an annulus was present at a certain point. In such a scale "cutting over" was looked for. This phenomenon is believed to be caused when the scale stops growing in area and the circuli keep on forming in the anterior field. Thus when normal growth starts again a complete circulus is formed right around the anterior and lateral portions of the scale enclosing the incompleted ridges. It was evident in the black bass scales that the circuli did not all continue around the posterior field. The markings of this field being quite broken and very irregular.

Regenerated scales were frequently met with. These contain blank centres and age determination is impossible. False annuli may also be found, caused by lack of food in the middle of the rapid growing period. These, however, can generally be recognized.

In estimating the age of the fish examined, the annuli along with the indications of "cutting over" were counted. If six distinct annuli were counted and further circuli could be seen after the sixth annuli, the fish was then said to be in its seventh summer. This method of age determination was used throughout the examination of the scales.

Each slide containing seven to nine scales was checked over twice and the age determined without reference to any other measurements. After this was done the age and length were compared and in some cases where they did not

appear to agree the scales were re-read again, for two seasons, as a quick check after having done no scale reading for a few months and in order to measure the annuli of about twenty-five scales as a means of comparing scale growth and body growth.

GROWTH RATE WITH AGE

Age and Growth rate in length in the two bodies of water.

Table 4 represents the minimum, maximum and average total length of the number of fish of each age examined from Lake of the Woods.

Table 4.

In Year of Age	Number of Specimens	Total Length in Inches		
		Minimum	Average	Maximum
4th	5	4.87	5.80	7.75
5th	9	6.25	8.75	10.75
6th	22	9.75	10.65	12.50
7th	29	10.25	11.17	12.50
8th	27	11.25	12.13	13.50
9th	17	12.00	14.00	15.00
10th	7	12.50	14.39	15.50
11th	4	12.50	14.81	15.75
12th	5	12.50	14.91	15.75
13th	5	14.25	15.31	16.00
14th	3	14.50	15.50	15.75
15+	3	16.00	16.70	17.50

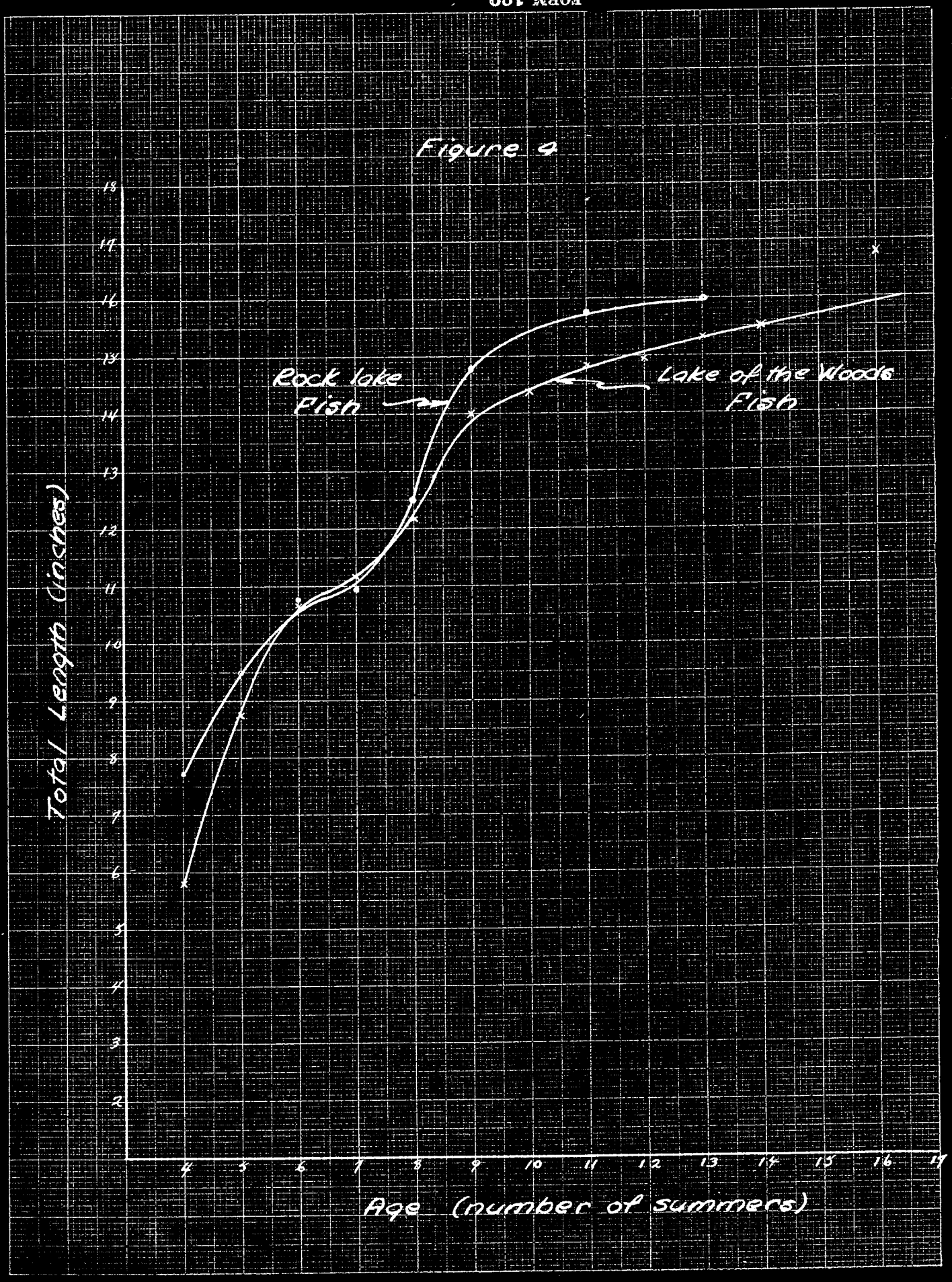
The scales of the older fish were much more difficult to read than those of the younger, the annuli being hard to determine, especially in the centre around the focus. One set of scales showed seventeen annuli quite clearly, the length of the fish being sixteen inches, while the scales from a fish an inch and a half longer could not be counted higher than fifteen years. It is quite possible that after twelve years of age the readings are only approximately correct.

From the twenty-one specimens taken from Rock lake the growth rate was found to be somewhat greater, as shown in table 5.

Table 5.

In Years of Age	Number of Specimens	Total Length in Inches		
		Minimum	Average	Maximum
4th	1		7.75	
5th	2	9.25	9.50	9.75
6th	4	10.00	10.70	11.50
7th	4	10.50	10.94	12.25
8th	4	11.25	12.50	13.25
9th	4	12.75	14.78	15.00
10th				
11th	1		15.75	
12th				
13th	1		16.00	

Figure 4



The results of the age determinations in the two bodies of water are shown in figure 4. A point of interest brought out in both bodies of water, but which has not been noted by any other investigators, is the apparent retardation of growth between the 6th and 7th years. Owing to the fact that maturation takes place around this time it can be concluded that in Lake of the Woods and Rock lake growth in length is retarded when the fish are attaining maturity.

The rapid growth in Rock lake may be caused by any or all of the following factors.

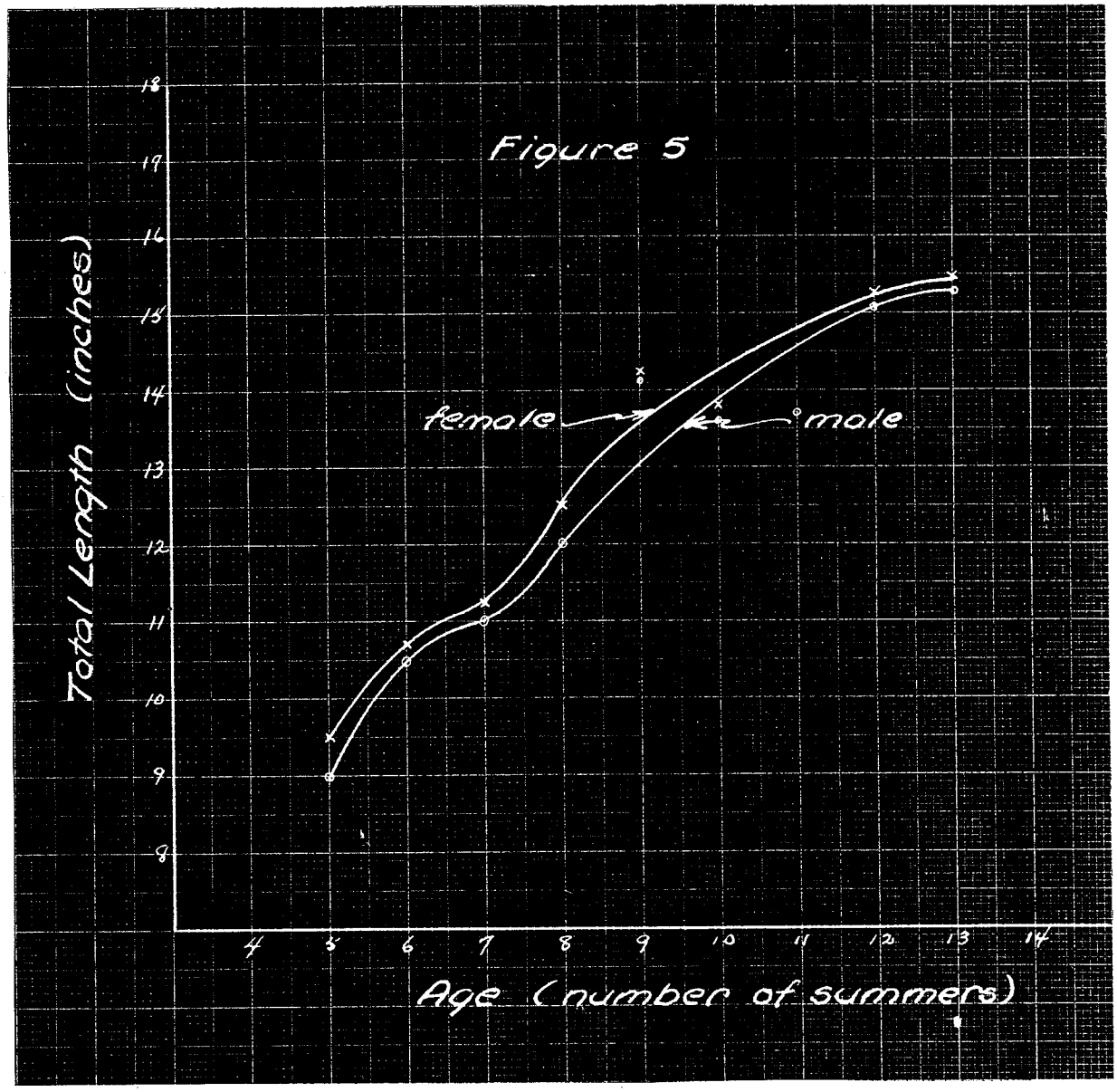
1. Rock lake is a great deal smaller than Lake of the Woods and the temperature may attain a higher maximum during the summer growth period.

2. In spite of considerable fishing in Rock lake throughout a number of years, no other species of fish has been taken from the lake by the writer, though reports of Jackfish have been heard. This suggests that competitors for food are scarce.

3. The water of Rock lake is even clearer than that of Lake of the Woods.

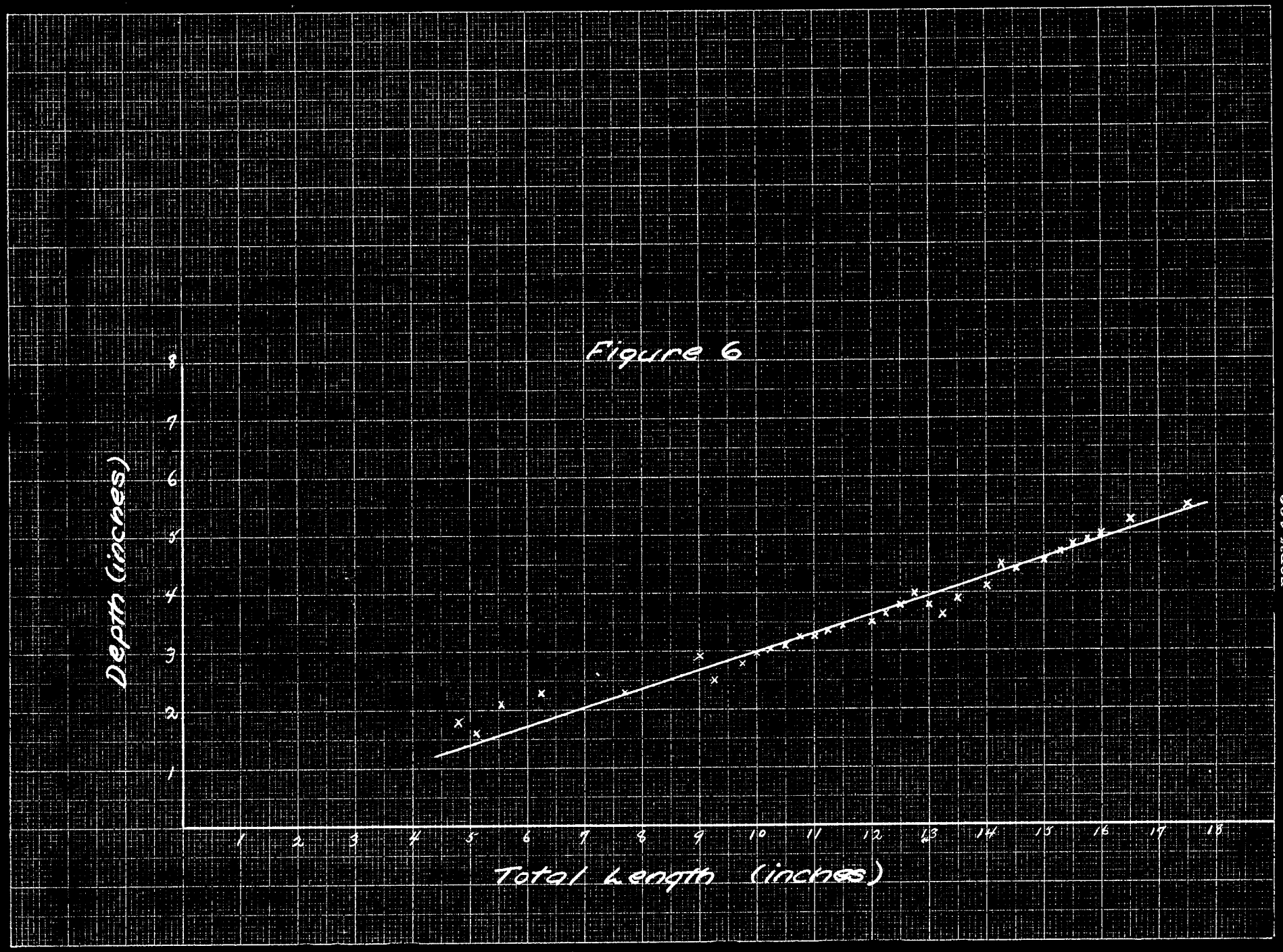
Growth rate of different sexes.

Figure 5 represents the growth rate of the different sexes. The female growth rate is slightly more rapid than that of the male. This agrees with the findings of other investigators.



Increase in Depth with Length.

Figure 6 represents the steady increase in depth of small-mouthed black bass with increased length. This may account for some of the error found in the next section,



where an attempt was made to calculate from the scales the various lengths of fish at different years of its development.

ATTEMPT TO ESTABLISH A RELATIONSHIP BETWEEN SCALE SIZE AND BODY LENGTH.

The general premise, formulated by Lea (1910) and others, that scale growth and body growth are directly proportionate, has been utilized by many workers for many species of fish as a means of calculating the length of an individual at various ages previous to capture. In some cases great accuracy is reported, in others there is considerable divergence between measured and calculated lengths.

Method and Application

The scale image from the projector was focused on a sheet of white paper and a line drawn through the focus along the antero-lateral axis to the outside edge of the scale. A strict application of the principle that scale growth and body growth are proportional would entail measuring the diameters of various annuli. In practice, however, these annuli cannot be recognized in the posterior field of black bass scales. In analogous cases many workers have utilized the distance from focus to annulus along the anterior axis as a basis for calculations. In the present case the antero-lateral axis was selected, firstly because, due to radii, it was impossible to get every annulus on a line through the centre of the anterior field, and secondly because it was thought that such a measurement might reduce

errors due to differential growth in length and width of scales. After obtaining the length of the antero-lateral axis the annuli were marked on the line and numbered and were then measured. Length of the fish at end of each year of life was then computed in accordance with the well known formula.

$$\frac{\text{Length of Annulus of year x}}{\text{Length of Scale}} = \frac{\text{Length of fish at end of year x}}{\text{Length of fish at time of capture}}$$

(Substituting "length of antero-lateral axis of annulus" for "length of scale in annulus" and "length of antero-lateral axis" for "length of scale.)

Repeating the formula for the annulus at the end of each year, the length of the fish at the end of every successive year of its life was calculated.

This procedure was carried out on the scales of twenty-seven different bass. The results, however, were not as accurate as had been hoped. The following table 6 shows the discrepancies between the length of fish at different ages as caught (called the "actual length") and that of the calculated length averages.

Table 6.

Age	Actual Length In Inches	Calculated Length In Inches	Error In Inches
1		2.72	--
2		3.88	--
3		5.06	--
4	5.80	6.22	+.42
5	8.75	7.50	-1.25
6	10.65	8.50	-2.15
7	11.17	9.45	-1.72
8	12.13	10.53	-1.60
9	14.00	11.33	-2.67
10	14.39	12.23	-2.16
11	14.81	13.12	-1.69
12	14.91	13.99	-0.92
13	15.31	14.63	-0.68
14	15.50	15.33	-0.17
15	16.00	15.29	-0.71

Except in the 4 year old fish the calculated length is always too low.

So far it has not been found possible to work out a factor that will eliminate the error. The discrepancies are probably due in part to the marked change in shape which the scale undergoes with advancing age. It may be that some measurement other than the one employed would give better results. It is evident, however, that the calculation

of body length from scales is a less simple matter in these black bass than in the case of many other fish, e.g. the lake herring (Van Oosten 1928).

Summary.

The growth rate of black bass is rapid in early life, slowing down considerably from the sixth to seventh years and then increasing, but being less rapid than before maturity.

The rate of growth was slightly higher in Rock lake than in Lake of the Woods.

The growth of female fish appears to be greater than that of the male.

The depth of the fish steadily increases with length.

Mature reproductive organs were found in fish in their seventh summer and older. The average length of this class of seventh summer fish was found to be approximately eleven inches.

PARASITES.

In the one hundred and seventy-eight Black bass examined no ectoparasites were found. The only endoparasites found in the viscera of the fish was Proteocephalus ambloplitis (Leidy 1887) found in the intestinal tract.

This parasite was found in 24.94 percent of the Black bass taken from Rock lake, and 19.10 percent of those taken from Lake of the Woods. Both waters were stocked with fish from lake Erie from which the parasite probably came.

Of the fish containing parasites 70.6 percent were females. The fact that the larval form of Proteocephalus ambloplitis is known to infect the ovary, reducing egg production and sometimes causing complete sterility may render the female more liable to infection.

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