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THE FOOD AND FEEDING HABITS OF THE BLUEGILL AND YELLOW PERCH IN LAKES WITH GOOD AND POOR FISHING [1]

By Percy W. Laarman and James C. Schneider

Introduction

The bluegill, *Lepomis macrochirus* Rafinesque, and the yellow perch, *Perca flavescens* (Mitchill), are found in most inland lakes in Michigan, and are the most common panfishes in the fisherman's creel. Some lakes consistently produce bluegills and perch of desirable size, whereas other lakes are plagued with populations of slow-growing fish.

Studies of bluegill diets have shown that zooplankton and aquatic insects are usually the preponderant foods (Moffett and Hunt, 1945; Scidmore and Woods, 1960; Seaburg and Moyle, 1964). Plants are also eaten frequently, and are sometimes the predominant food during the summer (Lux and Smith, 1960). In general, larger bluegills eat larger food items such as insects, whereas smaller fish take a greater proportion of zooplankton. However, Gerking (1962) found no difference in diet related to fish size in a stunted bluegill population. He did find that bluegills were selective in the size of zooplankton that was eaten.

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The yellow perch feeds primarily on zooplankton, benthos and fish, but many kinds of food may be eaten (Pearse and Achtenberg, 1921; Adams and Hankinson, 1928). In most lakes entomostraca predominate in the diet of perch up to a length of about 70 mm, insects predominate in perch 70-150 mm long, and crayfish and fish predominate in larger perch (Turner, 1920; Nurnberger, 1930; Kutkuhn, 1956). In other lakes, where cladocerans or chironomids are the principal food, there is no marked change in the diet as perch grow. When preying on cladocerans both fingerling and adult perch select Daphnia larger than 1.3 mm (Galbraith, 1967).

Laarman (1963) related growth rate of bluegills and perch to morphological and chemical characteristics of lakes in Michigan, in an attempt to classify bluegill and perch waters. He found no significant relationship between growth rate of bluegills and perch and the following parameters: lake size, mean depth, alkalinity, and turbidity.

The objective of this investigation is to determine the feasibility of using zooplankton and/or benthos as an index for classifying lakes for bluegill or perch management. For this study it is assumed that food supply in relation to feeding habits may be more significant than morphological and chemical characteristics of lakes, and may provide a better index for predicting the potential of lakes to produce desirable bluegill or perch populations.

Methods

Fisheries managers in Michigan were asked to submit names of lakes in their districts with a history of producing desirable, or undesirable, bluegill and perch populations. Lakes were selected for study on the basis of recommendations from the fisheries managers, on data from past surveys, and on lake morphology. To facilitate field work, proximity of the lakes to each other and to Ann Arbor was also considered. Marble and Gilead lakes, Branch County, were selected as representatives of good bluegill and perch lakes; Vandercook Lake, Jackson County, and Upper Brace Lake, Calhoun County, were selected as poor bluegill and perch lakes. Morphology of the lakes and data from past surveys are given in Appendix A.

Generally, 10 plankton and 20 benthos samples were taken from each lake during each collection period of 6-15 July and 7-14 September 1971. In selecting the location of stations, contour maps of the lakes were used to insure representation of various water depths. Samples were taken within each 3-meter contour interval. Approximately the same collection sites were used during both collecting periods.

Ten stomach samples from each inch-group of fish were collected when possible. Fish were collected by electrofishing gear, trap net, gill net and angling. Scale samples were taken to determine age and growth rates of the bluegills and perch.

Plankton samples were taken with a plankton net of No. 10 mesh nylon. Laboratory analyses consisted of straining the samples through a

No. 30 mesh screen. In general, this procedure separated the zooplankton greater than 1.3 mm in length from smaller organisms. The mean dry weight of zooplankton per cubic meter of water in the oxygen zone was calculated for each lake.

Organisms from the stomach samples were sorted, and frequency of occurrence was recorded. Numerical counts and length-frequencies of some food items were determined. Samples from each inch-group of fish were combined to obtain dry weights for the different food items. All samples were kept separate on the basis of the two collection periods.

Results

Bluegill

Growth rates were determined from a total of 385 fish of age groups I-VIII. July and September collections were combined to determine the average growth rate of bluegills from the four lakes (Table 1). Comparison of growth rates from each lake with the state-wide average shows the following deviations in millimeters: Marble Lake, +27; Gilead Lake, +3; Upper Brace Lake, -28; and Vandercook Lake, -10. In other words, considering all age groups, bluegills from Marble and Gilead lakes were growing faster than average and bluegills from Upper Brace and Vandercook lakes were growing at a slower rate than average.

Current annual growth was determined with back calculations from the scale samples. Gerking (1966) found that bluegill populations in northern Indiana lakes with rapid growth rates had longer growing seasons than those with slow growth rates. Our data, derived from back calculations, showed the per cent of growth occurring between the July and September collections to be as follows: Marble Lake, 23; Gilead Lake, 36; Upper Brace Lake, 23; and Vandercook Lake, 34. Therefore, populations from the good and poor lakes could not be distinguished on the basis of growth occurring in late summer.

Of fish collected in July, 16% had empty stomachs. For individual lakes the percentages were: 0 in Marble, 4 in Vandercook, 15 in Gilead, and 40 in Upper Brace. September collections were less variable: Marble, 18%; Vandercook, 18%; Upper Brace, 24%; and Gilead, 28%; for an average of 23%.

No consistent difference was found in the diet of bluegills from 50 to 244 mm long. Therefore stomach samples were combined from fish of all sizes. Young-of-the-year fish, under 50 mm, were not sampled.

The four most important food items based on dry weight and frequency of occurrence, found in the July and September stomach samples, are given in Table 2. Other organisms of lesser importance were *Chaoborus*, Copepoda, Odonata, Gastropoda and Arachnida.

The cladocerans made up a higher proportion of the diet from the "good" lakes in July. Plant material was more important in the stomach samples from the "poor" lakes. Cladocera and Chironomidae combined made up the bulk of the weight in bluegill stomachs from Marble and Upper Brace lakes in July; percentages were 76 and 85, respectively. These two organisms were much less important in September, dropping to 40% in Marble and 36% in Upper Brace. This similarity in diet between the fastest growing and the slowest growing populations of bluegills is of interest because the standing crop of cladocerans and chironomids was much greater in Marble Lake.

We sorted cladocerans from the July stomach samples to size like we sorted plankton samples. The percentages by dry weight of cladocerans (larger than approximately 1.3 mm) in the stomach samples were: Marble, 56; Gilead, 66; Upper Brace, 40; and Vandercook, 42. Large cladocerans were more abundant in stomachs from the good lakes. Cladocera of similar size found in the July plankton samples made up 94% in Marble, 94% in Gilead, 44% in Upper Brace, and 71% in Vandercook. The data suggest that bluegills of all sizes were selecting cladocerans less than 1.3 mm in length. However, this is questionable since the stomach samples contained many pieces of cladocerans, and this would inflate the percentage of small cladocerans in the stomach calculations. Cladocera were less important in the diet during September, and were not sorted by size.

The quantity of food per stomach, based just on stomachs with some food, was fairly consistent in Marble, Gilead and Upper Brace lakes. This ranged from 23 mg per stomach in Marble Lake in July to 32 mg per stomach in Upper Brace Lake in July. Collections from Vandercook Lake averaged 6 mg in July and 130 mg in September. The large amount in September was due to an unusual abundance of grasshoppers.

The preponderance of terrestrial insects in the diet of bluegills from the good lakes during September was surprising, especially in Marble

Lake where other types of organisms were also abundant. Terrestrial insects consisted of grasshoppers and Hymenoptera (mainly ants) and were found as frequently in stomachs from the good lakes as in the poor lakes. A consistent difference in the diet of bluegills from the desirable and undesirable populations was not evident.

Perch

Growth rates of perch were determined from 370 scale samples. Only 19 samples came from Vandercook Lake where perch were scarce. July and September collections were combined to obtain the averages given in Table 3.

Perch grew faster, lived slightly longer and reached a larger size in the good lakes than in the poor lakes. Many perch larger than 200 mm (about 8 inches) were found in Marble and Gilead lakes, two were found in Upper Brace Lake, and none were taken in Vandercook Lake. However, not even in the good lakes is there a large perch fishery.

Compared to the state average growth rate, perch in Marble Lake grew at an average rate to about 123 mm long, spurted to a length of about 225 mm, but then grew slowly. Perch in Gilead Lake grew more slowly than the state average at first, but once they obtained a length of 178 mm they grew rapidly the rest of their life. Perch in Upper Brace Lake grew slowly throughout life but especially after reaching about 165 mm. Perch grew slowly in Vandercook Lake also. The largest one collected was only 88 mm long and 1 year old. Perch collected from these lakes in the past showed similar growth patterns except that in 1966 perch in Gilead Lake grew rapidly throughout life.

No attempt was made to estimate the amount of growth by perch between July and September by means of back calculations from scales. The average length of perch of a given age in Marble Lake was appreciably larger in the fall than in the summer, whereas similar comparisons for the other lakes suggest that very little growth occurred in them during the same period. The likelihood of sampling bias is very great in this kind of comparison, and the suggestion that Marble Lake perch have a longer growing season is not substantiated by the data on their feeding habits: stomachs of perch collected from Marble Lake in September contained no more food than stomachs of perch collected from the other lakes.

There were no clear-cut differences between the good and poor lakes in terms of quantity of food present in perch stomachs. Between 0 and 25% of the perch stomachs collected from all lakes in July were empty; this percentage increased in September, ranging from 12 to 51%. Perch from Gilead and Upper Brace lakes had empty stomachs more often than perch from the other lakes in July; perch from the good lakes were empty more often than perch from the poor lakes in September. Marble Lake perch contained the highest average quantity of food in July; however, the medium-sized perch from Gilead Lake generally contained less food than perch from Upper Brace Lake (Table 4). In September, Upper Brace perch ate as much as perch in the good lakes. Small-sized perch from Vandercook Lake (the only size collected) contained little food during either month.

There was also little correlation between the quantity of food present in perch stomachs and the growth rates of perch of different sizes (Table 4). Small perch grew faster in Marble Lake than in the other lakes, but they contained less food than did slow-growing perch from Gilead Lake. Perch 125-174 mm long also grew most rapidly in Marble Lake, but slow-growing perch in Upper Brace Lake contained as much food. Perch 175-199 mm long grew most rapidly in Marble Lake and, this time, they also contained the most food. Large perch had the best growth in Gilead Lake, but they ate only slightly more than did large, slow-growing perch in Marble Lake. Thus, the amount of food present in perch stomachs was not a reliable indicator of growth in these populations.

There is, however, some evidence that the type of food ingested differed among size groups of perch and among lakes (Table 4). Small perch (50-124 mm long) ate a variety of foods, including snails, mayflies and amphipods. Perch from good lakes, in addition, ate small amounts of fish, whereas those from poor lakes ate some zooplankton. The diet of perch 125-174 mm long was more diverse. Principal items were crayfish, fish, snails, mayflies and other insects. Perch from Marble and Gilead lakes contained more dragonflies and mayflies (especially Hexagenia) than did perch from Upper Brace Lake. The next size group, 175-199 mm long, had a similar diet, except that midges were an important food in the good lakes but not in the poor lake. Snails, on the other hand, were important only in the poor lake. Feeding habits of large perch, 200-300 mm long, which were collected only in the good lakes, were much less diverse.

Midges, Daphnia, Leptodora and crayfish comprised 92% of their diet. Snails were not eaten. These data suggest that diets rich in dragonfly or mayfly nymphs (in medium-sized perch), and in midges, Daphnia, Leptodora or crayfish (in larger perch), may be indicative of good perch populations in lakes of this type. An abundance of snails in the stomachs of larger perch may indicate poor conditions for perch.

The midges found in the stomachs of large perch from good lakes were mostly deep-water forms of the genus Chironomus. Most of these fish were taken in gill nets at depths of 7 to 17 m where they were apparently feeding near the bottom. Dredge samples showed that the good lakes had larger populations of midges at these depths than did the poor lakes. Perhaps the abundance of these midges, most of which belonged to the group of species having four blood gills, can serve as an indicator of good perch habitat.

Three kinds of zooplankton were found in large perch from Gilead Lake. In July, large Daphnia predominated in 175-199 mm perch and they were abundant also in perch 200-300 mm long. The daphnids averaged 1.39 mm (range 0.64-2.24) and 1.47 mm (range 0.77-1.92) long, respectively. Leptodora predominated in the larger perch and in two of these it was the only food consumed. In September Leptodora, and a small Daphnia averaging 1.24 mm long (range 0.83-1.79), were the principal zooplankters in perch of 175-199 mm. Larger perch were not eating zooplankton at that time.

Leptodora, Daphnia and a few Ceriodaphnia were present in perch 200-300 mm long from Marble Lake. Daphnia and Ceriodaphnia were present in July, only, whereas *Leptodora* was present in both July and September. The *Daphnia* were of large size, averaging 1.70 mm (range 1.15-2.11). In September trace amounts of *Sida* (0.5-1.3 mm long) were found in perch of 50-124 mm.

Only small amounts of zooplankton were found in perch from Upper Brace Lake during either month. Small copepods, 0.7-1.0 mm long, were in small perch. Fingerlings 76-127 mm long ate some cladocera 0.6-2.3 mm long; the genera were *Latona*, *Ceriodaphnia*, *Sida* and *Chydorus*. Few *Leptodora* or *Daphnia* were eaten by perch of any size.

Zooplankton was unimportant to perch in Vandercook Lake in July but it comprised the bulk of the food in perch of 50-75 mm in September. Copepods, 0.4-1.0 mm long, predominated. Many species of cladocerans were consumed, including *Daphnia* spp., *Bosmina* and *Ceriodaphnia*, but they were small, 0.3-1.0 mm, and not abundant.

For all lakes, species composition of the plankton in perch stomachs bore little resemblance to that taken in plankton nets. *Daphnia* spp. were by far the preponderant large cladoceran taken in nets, whereas only small numbers of *Leptodora* were found. By contrast, *Leptodora* was disproportionately abundant in the stomachs of perch from the good lakes. Perch in Upper Brace Lake ate more of the other kinds of cladocera.

The fact that relatively low numbers of *Leptodora* were taken in the plankton net may be due partially to avoidance of the net by this organism (Wilbert Wagner, personal communication), but it is also likely that perch are selecting them because they are of large size. A high degree of food selectivity was suggested above by the observation that some fish contained only *Leptodora* whereas others taken from the same area of the lake contained primarily *Daphnia.*

Galbraith (1967) found that 82% of the *Daphnia* eaten by perch in Stager Lake were larger than 1.3 mm. We measured 471 *Daphnia* in the stomachs of 13 large perch from Gilead and Marble lakes and found that only 63% of them were larger than 1.3 mm. Perch from Marble Lake contained a high percentage (94) of large *Daphnia*, whereas perch from Gilead Lake averaged much less (55%). The *Sida* and *Latona* found in perch from Upper Brace Lake were large; 84% of them exceeded 1.3 mm.

Net Plankton

The plankton consisted mainly of cladocerans and copepods. A few *Chaoborus* were found in all the lakes, and Marble Lake contained many *Ceratium* both in July and September. A dense bloom of *Lyngbya*, a filamentous algae, occurred in Vandercook Lake during July. Since copepods generally were not important in the summer diet of bluegills or perch, only the standing crop of cladocerans was determined for each lake. Considerable variation occurred in abundance of cladocerans from different depth strata. Therefore, to determine standing crop, a weighted mean was used based on the percentage of the total lake volume (oxygen above 0.5 ppm) contained in each 3-m depth strata. The calculated standing crops are given in Table 5.

Larger standing crops of cladocerans were present in Marble Lake and, to a lesser extent, in Gilead Lake than in the poor lakes. The Cladocera population of Vandercook Lake was high in July but it was very low in September. The relatively high abundance of Cladocera in Vandercook in July was not reflected in the diet of bluegills or perch.

The majority of cladocerans collected in the plankton samples from all the lakes was _Daphnia_ spp. Upper Brace and Gilead lake samples contained some Sididae, and Marble Lake had a few _Ceriodaphnia_ spp.

As mentioned above, the percentages of cladocerans 1.3 mm and larger in the July plankton samples were as follows: Marble, 94; Gilead, 94; Upper Brace, 44; and Vandercook, 71. Comparable data for September were: Marble, 51; Gilead, 73; and Upper Brace, 28. Samples taken from Vandercook Lake in September were not sorted by size because only a few cladocerans were present.

The main differences in plankton among the four lakes were in the size of the standing crop and the average size of the cladocerans. Their species compositions were similar.

Benthos

Organisms present in the bottom fauna samples were Annelida, Amphipoda, Chironomidae, Decapoda, Ephemeroptera, Gastropoda, Megaloptera, Odonata and Trichoptera. A weighted mean based on 3-meter depth strata was used to determine the standing crop (Table 6). The standing crop of benthos was much greater in the good lakes than in the poor lakes. Marble Lake was especially rich in bottom fauna.

The average dry weight of bottom fauna in July ranged from 0.4 kg/ha in Vandercook Lake to 38.0 kg/ha in Marble Lake. In

September the range was from 3.2 kg/ha in Upper Brace to 15.7 kg/ha in Marble. Gerking (1962) found that in Wyland Lake, Indiana, with a relatively slow growing bluegill population, the standing crop of bottom fauna was 10.6 kg/ha dry weight in July and 6.1 kg/ha in August. In Connecticut and New York, 36 lakes varied from 2.0 kg/ha to 64.7 kg/ha (mean of about 14 kg/ha) dry weight of bottom fauna, based on an average of 81.4% water in living organisms (Dewey, 1941).

The two most important benthic organisms in terms of numbers and weight in each lake are given in Table 7. Chironomids were the most numerous bottom organism in Marble, Gilead and Upper Brace lakes. Gastropods were important also, by weight (shells included), in Gilead and Upper Brace lakes. Annelids predominated in Vandercook Lake. As in the plankton samples, the main difference in benthos among the lakes appears to be in the quantity of organisms rather than in kind. The good lakes had larger populations of burrowing mayflies (Hexagenia) than did the poor lakes, 0.58-0.61 per sample compared to 0.05-0.06 per sample. The good lakes also had greater populations of large midges (Chironomus) at depths of 6 or more meters than did the poor lakes; 15.2-51.1 per sample compared to 0.4-1.1 per sample.

Discussion

A simple biological index for use in classifying lakes according to their potential to produce desirable bluegill and perch populations was not evident from the data gathered. Qualitative differences in plankton and benthos were not found but there were quantitative differences.

Marble Lake, with a fast-growing population of bluegills and perch, was rich in plankton and bottom fauna. Upper Brace Lake, with the slowest-growing bluegills, ranked third in standing crop of food organisms. Vandercook Lake was extremely unproductive and it supported only small populations of bluegills and perch. The more rapid growth rate of bluegills there than in Upper Brace Lake may be due to their lower density.

The importance of terrestrial insects in the diet of bluegills complicates interpretation of the data. This phenomenon would be expected in Vandercook Lake which has a scarcity of other organisms but not in Marble Lake. The true importance of terrestrial insects in the diet of bluegills would require frequent sampling of stomachs, especially during the latter part of the summer.

A biological index based on a minimum required standing crop of cladocerans and chironomids appears as a remote possibility. September standing crops of 15 mg/m^3 dry weight of cladocerans and 1.1 kg/ha dry weight of chironomids may be necessary to maintain desirable bluegill and perch populations. For a good perch population, deep-water chironomids in excess of 6.5 million per hectare (15 per dredge sample) and shallow-water <u>Hexagenia</u> populations in excess of 200 thousand per hectare (0.5 per dredge sample) may also be necessary. Both midges and mayflies are choice food items of perch. A large population of midges in deep water would be available especially to large perch which frequent cool, deep water. Standing crops of this size are greater than the standing crops found in Upper Brace and

Vandercook lakes, slightly less than found in Gilead Lake, and much less than was present in Marble Lake. Size of the bluegill and perch populations, species composition of the fish population, and type of lake, all may alter the required standing crop of food organisms. Plankton, benthos and fish populations from many more lakes would have to be investigated to determine whether such an index is reliable.

Food habits of bluegills and perch in these lakes generally were not correlated with growth or food supply. Although no clear-cut differences between lakes were found, the following observations based on the July collection are suggestive. First, *Daphnia* made up a higher proportion of the diet of bluegills from good lakes (38-56%) than from poor lakes (16%). Secondly, plant materials (assumed to be of low food value) appeared in considerable amounts in the stomachs of bluegills from poor lakes. Thirdly, large perch from good lakes fed heavily on *Leptodora* and *Daphnia*, and lightly on chironomids, whereas the few large perch collected in a poor lake had fed heavily on snails and not at all on zooplankton and midges. More intensive sampling on these lakes and others will be necessary to substantiate these observations.

Summary

Growth and feeding habits of bluegills and perch were compared between two lakes with good fishing and two lakes with poor fishing. Also compared were the populations of benthos and zooplankton. For these studies, samples were collected during the second week of July and the second week of September 1971.

Fish had faster growth and reached a larger size in the good lakes. The good lakes were more productive in terms of standing crop of benthos and plankton. Presence or absence of any one species of invertebrate would not serve as a reliable index of fishing quality; however, Daphnia, Chironomus and Hexagenia populations were larger in the good lakes. The average size of Daphnia was also larger in the good lakes. These data suggest that, in general, September standing crops of 15 mg/m^3 dry weight of Cladocera and 1.1 kg/ha dry weight of chironomids may be necessary to maintain a desirable panfish population.

Bluegills ate a variety of foods including large amounts of terrestrial insects. There were no consistent differences in food habits of bluegills of different sizes (range 50-244 mm) and no large differences between good lakes and poor lakes in either type or quantity of food eaten. Small differences which were noted in July sampling were the higher amounts and larger size of Daphnia in the diet of bluegills in the good lakes. Bluegills in poor lakes, on the other hand, contained more plant material than did bluegills in the good lakes.

Perch also ate a wide variety of foods. In contrast to the bluegill, there were more significant differences among perch of various sizes and among lakes. Small perch, 50-124 mm long, ate mostly snails, mayflies and amphipods. Perch 125-175 mm long included crayfish and fish in their diet. Dragonflies and mayflies (especially Hexagenia) were a larger part of the diet of perch in good lakes than poor lakes. Perch larger than 175 mm collected from the good lakes fed heavily on Leptodora, Daphnia, chironomids and crayfish. The few perch of this size (i.e., over 175 mm) collected from a poor lake were feeding on fish, crayfish and snails. Comparison of the species and size composition of plankton taken in nets to that in perch stomachs suggests that perch were selecting Leptodora and large Daphnia. Of the Daphnia eaten, 63% were over 1.3 mm in length. Total amount of food in perch stomachs did not differ significantly between good and poor lakes and was not correlated with growth.

Table 1.--Average length in millimeters of bluegills from Marble, Gilead, Upper Brace and Vandercook lakes

Number of fish in parentheses. State-wide average lengths are given for comparison.

Lake	Age group							
	I	II	III	IV	V	VI	VII	VIII
Marble	86 (35)	137 (37)	175 (33)	198 (4)	218 (2)	-	-	244 (1)
Gilead	71 (13)	99 (29)	140 (36)	178 (16)	198 (7)	203 (2)	-	-
Upper Brace	55 (7)	79 (19)	104 (16)	127 (11)	152 (37)	170 (9)	185 (3)	-
Vandercook	71 (21)	104 (16)	130 (11)	155 (13)	170 (7)	-	-	-
State average	86	112	140	163	178	190	201	218

Table 2.--The four most important types of food items in stomachs of bluegills from Marble, Gilead, Upper Brace and Vandercook lakes July and September, 1971

Based on 286 stomachs with food

July			September		
Type of food item	Percentage total weight in stomach	Percentage frequency of occurrence	Type of food item	Percentage total weight in stomach	Percentage frequency of occurrence
Marble Lake					
Cladocera	56	43	Terrestrial*	51	32
Chironomidae	20	90	Chironomidae	40	74
Megaloptera	12	26	Plant	9	23
Terrestrial*	4	19	Cladocera	0.3	17
Gilead Lake					
Ephemeroptera	53	38	Terrestrial*	66	60
Cladocera	38	76	Trichoptera	28	31
Plecoptera	5	3	Chironomidae	3	64
Chironomidae	2	47	Ephemeroptera	2	2
Upper Brace Lake					
Chironomidae	69	68	Terrestrial*	32	29
Cladocera	16	44	Plant	24	54
Plant	6	60	Chironomidae	20	57
Ephemeroptera	4	36	Cladocera	16	23
Vandercook Lake					
Terrestrial*	57	35	Terrestrial*	93	62
Plant	21	38	Fish	4	3
Cladocera	16	23	Chironomidae	1	41
Chironomidae	3	69	Plant	1	28

* Terrestrial items in all lakes and both months were mostly grasshoppers and hymenopterans.

Table 3.--Average lengths in millimeters of yellow perch from Gilead, Upper Brace and Vandercook lakes

Number of fish in parentheses. State-wide average lengths are given for comparison.

Lake	Age group							
	0	I	II	III	IV	V	VI	VII
Marble	63 (3)	123 (42)	173 (47)	225 (12)	223 (10)	239 (15)	234 (2)	-
Gilead	-	94 (22)	141 (21)	178 (41)	214 (21)	248 (19)	278 (6)	269 (1)
Upper Brace	66 (2)	96 (28)	135 (15)	165 (25)	175 (18)	185 (1)	-	-
Vandercook	66 (15)	84 (4)	-	-	-	-	-	-
State average	79	117	155	178	203	229	252	272

Table 4.--Average dry weight, in milligrams per fish, of food in stomachs of yellow perch from Marble, Gilead, Upper Brace and Vandercook lakes

Number of fish examined is in parentheses. Tr = trace = less than 0.5 mg.

Size of fish and food types	July				September			
	Marble	Gilead	Upper Brace	Vandercook	Marble	Gilead	Upper Brace	Vandercook
50-124 mm	(11)	(11)	(13)	(3)	(16)	(15)	(20)	(16)
Decapoda	-	0.9	-	-	-	-	-	-
Ephemeroptera	0.1	6.8	0.4	0.6	-	1.7	0.2	-
Chironomidae	tr	0.2	tr	0.7	tr	0.1	0.3	tr
Gastropoda	1.9	0.2	0.4	-	-	0.5	tr	-
Zooplankton	-	-	0.1	tr	0.1	tr	0.5	0.5
Fish	0.4	0.4	-	-	-	0.2	-	-
Other [1]	1.2	-	0.2	0.6	0.5	2.0	1.7	-
Total food	3.6	8.5	1.1	1.9	0.6	4.5	2.7	0.5
125-174 mm	(23)	(20)	(19)	(0)	(20)	(16)	(20)	(0)
Decapoda	18.8	-	18.2	-	4.0	-	-	-
Ephemeroptera	2.4	3.9	1.9	-	0.9	1.6	0.1	-
Chironomidae	tr	0.2	tr	-	0.4	0.2	tr	-
Gastropoda	4.6	-	2.4	-	0.4	-	7.2	-
Zooplankton	tr	-	tr	-	-	-	0.1	-
Fish	tr	0.4	2.3	-	10.9	0.4	8.3	-
Other [2]	3.9	0.4	2.9	-	-	2.0	0.6	-
Total food	29.7	4.9	27.7	-	16.6	4.2	16.3	-
175-199 mm	(9)	(10)	(5)*	(0)	(12)	(10)	(13)*	(0)
Decapoda	62.5	-	7.2	-	-	-	36.2	-
Ephemeroptera	4.7	3.1	-	-	0.1	3.1	-	-
Chironomidae	5.2	7.6	-	-	0.1	3.4	-	-
Gastropoda	-	-	9.9	-	tr	-	1.3	-
Zooplankton	-	4.1	-	-	-	2.0	-	-
Fish	30.6	-	-	-	-	-	20.2	-
Other	3.1	1.7	0.9	-	28.5**	-	0.2	-
Total food	106.1	16.5	18.0	-	28.7	8.5	57.9	-
200-300 mm	(19)	(24)	(0)	(0)	(20)	(23)	(0)	(0)
Decapoda	7.7	9.4	-	-	1.3	-	-	-
Ephemeroptera	-	0.2	-	-	-	1.4	-	-
Chironomidae	45.9	tr	-	-	6.3	5.0	-	-
Gastropoda	-	-	-	-	-	-	-	-
Zooplankton	9.9	57.0	-	-	0.1	-	-	-
Fish	-	3.9	-	-	1.4	3.4	-	-
Other	0.3	0.8	-	-	0.7	0.2	-	-
Total food	63.8	71.3	-	-	9.8	10.0	-	-

[1] Primarily Amphipoda.

[2] Primarily Odonata and Trichoptera.

* Includes one 8-inch fish.

** Includes one large grasshopper.

Table 5.--Average dry weight of Cladocera per cubic meter in Marble, Gilead, Upper Brace and Vandercook lakes

Determinations based on oxygen zone only. Depth in meters at which oxygen was 0.5 ppm is given.

Lake	Month	Cladocera dry weight mg/m^3	Depth of O_2 zone, meters
Marble	July	55.9	7.0
	September	35.4	7.6
Gilead	July	25.3	11.3
	September	18.6	7.3
Upper Brace	July	8.8	7.6
	September	12.9	7.6
Vandercook	July	41.7	11.9
	September	0.4	7.3

Table 6.--Mean numbers per square meter and dry weights in kilograms per hectare of bottom fauna in Marble, Gilead, Upper Brace and Vandercook lakes

Lake	Month	Average number per square meter	Average dry weight kg/ha
Marble	July	3,169	38.0
	September	1,815	15.7
Gilead	July	1,142	20.1
	September	259	3.6
Upper Brace	July	700	4.7
	September	132	3.2
Vandercook	July	47	0.4
	September	76*	4.6*

* Gastropoda and Annelida were responsible for the increase in September.

Table 7.--The two most important benthic organisms in terms of numbers and dry weights in Marble, Gilead, Upper Brace and Vandercook lakes

Data based on mean numbers and mean dry weights per square meter

Lake and month	Bottom organism	Average number per square meter	Bottom organism	Average dry weight mg/m^2
Marble				
July	Chironomidae	1, 822	Chironomidae	2, 385
	Amphipoda	835	Ephemeroptera	603
September	Chironomidae	871	Chironomidae	970
	Amphipoda	611	Annelida	82
Gilead				
July	Chironomidae	626	Gastropoda	1, 291
	Amphipoda	384	Chironomidae	413
September	Chironomidae	217	Gastropoda	204
	Gastropoda	22	Chironomidae	115
Upper Brace				
July	Chironomidae	510	Chironomidae	404
	Amphipoda	135	Ephemeroptera	34
September	Chironomidae	75	Gastropoda	207
	Gastropoda	27	Chironomidae	102
Vandercook				
July	Annelida	35	Annelida	22
	Chironomidae	12	Chironomidae	18
September	Annelida	61	Annelida	214
	Chironomidae	7	Gastropoda	124

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Appendix A

Inventory data on the four lakes involved in this study

Good Lakes

Gilead, Branch County, T. 8 S., R. 7 W., Sec. 6, 7

52.6 ha (130 acres), maximum depth = 14.9 m (49 feet), 51%<4.6 m (15 feet)
Surface methyl orange alkalinity = 121.
Bottom types = organic, marl, sand and gravel.
Species of fish taken with gill net in 1966:
bluegill, pumpkinseed, yellow perch, black crappie, brown bullhead, grass pickerel, largemouth bass, longeared sunfish and green sunfish.
Growth rates:
bluegill > average.
black crappie > average.
yellow perch > average.
largemouth bass = average.

Marble, Branch County, T. 6, 7 S., R. 5 W., Sec. many

315.7 ha (780 acres), maximum depth = 18.3 m (60 feet), 40%<4.6 m (15 feet)
Surface methyl orange alkalinity = 148.
Bottom types = marl, muck-marl.
Species of fish taken in 1970 with fyke and trap nets:
bluegill, pumpkinseed, black crappie, yellow perch, largemouth bass, smallmouth bass, northern pike, warmouth, rock bass, lake chubsucker, white sucker, bowfin, longnose gar, brown bullhead and golden shiner.
Growth rates not available.
Size of bluegills and yellow perch taken:

Length groups					
Centimeters	10.2	15.2	20.3	25.4	30.5
Inches	4.0	6.0	8.0	10.0	12.0
Number of					
Bluegills	15	462	251	11	0
Perch	1	39	200	42	1

Poor Lakes

Vandercook, Jackson County, T. 3 S., R. 1 W., Sec. 22, 23, 26, 27

60.7 ha (150 acres), maximum depth = 12.8 m (42 feet), 37%<4.6 m (15 feet)
Surface methyl orange alkalinity not determined.
Bottom types = pulpy peat, marl.
Species of fish taken in 1963 with seine:
bluegill, black crappie, yellow perch, largemouth bass, northern pike, smallmouth bass, longnose gar, brown bullhead, white sucker, northern hog sucker, carp, golden shiner and common shiner.
Growth rates:
bluegill<average.
black crappie>average.
yellow perch<average.
largemouth bass>average.
northern pike<average.
smallmouth bass = average.

Upper Brace, Calhoun County, T. 3 S., R. 5, 6 W., Sec. 7, 12

23.3 ha (70 acres), maximum depth = 12.5 m (41 feet), 31%<4.6 m (15 feet)
Surface methyl orange alkalinity = 159.
Bottom types = mostly organic, some marl and sand.
Species of fish taken in 1966 by electrofishing:
bluegill, pumpkinseed, yellow perch, green sunfish, largemouth bass, grass pickerel, warmouth, brown bullhead, white sucker, bowfin and mudminnow.[1]
Growth rates:
bluegill<average.
yellow perch<average.
pumpkinseed<average.
largemouth bass = average.

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[1] Common names of fishes follow American Fisheries Society official list.

INSTITUTE FOR FISHERIES RESEARCH

Percy W. Laarman and James C. Schneider

Report approved by G. P. Cooper
Typed by M. S. McClure