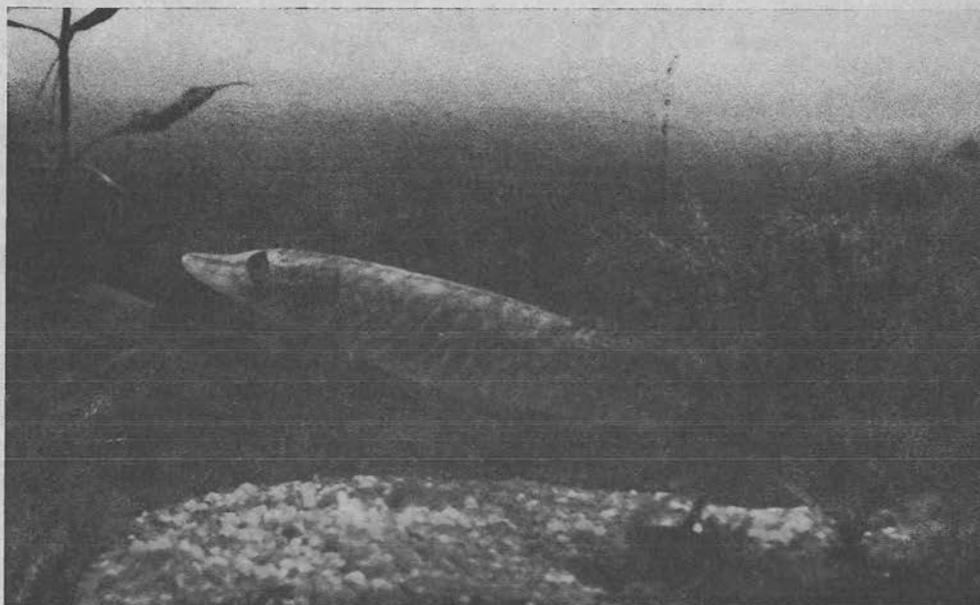


FOOD OF ANGLER-CAUGHT NORTHERN PIKE IN MURPHY FLOWAGE



DEPARTMENT OF NATURAL RESOURCES • Madison, Wisconsin • 1969

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**FOOD OF ANGLER-CAUGHT NORTHERN PIKE
IN MURPHY FLOWAGE**

By

Leon D. Johnson

Technical Bulletin Number 42
DEPARTMENT OF NATURAL RESOURCES
Madison, Wisconsin 53701

1969

ACKNOWLEDGEMENTS

I would like to acknowledge the contributions that several persons made to this project: Howard E. Snow contributed the population data on bluegills and perch in Murphy Flowage; Lyle Groth, Donald Stafford, Ingwald Tronstad and Alvin Johnson collected northern pike stomachs at the checking station; Ronald Masterjohn tabulated data; and Lyle M. Christenson, Gordon Priegel and Ruth L. Hine reviewed the report.

This research was supported in part from funds provided by the Federal Aid to Wildlife Restoration Act, under Dingell-Johnson project F-83-R.

Edited by Joyce A. Jais

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**Murphy
Flowage**

INTRODUCTION

The research described in this report was intended to provide basic information on northern pike feeding habits. Current efforts to increase populations of northern pike, *Esox lucius* (Linnaeus), are often based upon the assumption that they can control stunted panfish populations. This study was designed, in part, to determine whether or not this assumption is valid in regard to bluegills.

Do northern pike prey heavily on bluegills? If so, what size pike takes what size bluegill? What is the preferred food for northerns when prey items are related to the abundance of various forage fishes in the flowage?

The goals of this study were to find answers to these questions as well as to determine the daily and seasonal patterns of northern pike feeding. Data on successful baits used, both live and artificial, were also collected.

There have been many studies showing that northern pike are mainly piscivorous. Forbes and Richardson (1920), McNamara (1937), Frost (1954), Lux and Smith (1960), Buss (1961), Seaburg and Moyle (1964), Hunt (1965), and Lawler (1965) are some of these. There are also some unusual feeding habits reported such as the insectivorous northern pike in Lac Brochet, Quebec (Mongeau, 1955), and pike predation on waterfowl broods (Lagler, 1956).

However, this study differs in some important ways from those that preceded it. First, I worked with angler-caught fish. This enabled sampling throughout the year rather than seasonally as is the case when one relies on fyke net or seine catches. Also, it insures that all items, with the exception of the bait, were taken by the naturally feeding fish. Northern pike caught in fyke nets tend to gorge themselves on other fishes and thus complicate the analysis of their normal feeding habits.

Second, collections were made for nine consecutive years, from 1956 to 1965, which is considerably longer than similar studies have run.

And finally, I collected the entire stomach and examined its contents in order to determine the food each fish had eaten. This enables one to be certain that all items in the stomach are counted. In some of the previous studies biologists have used a stomach pump to remove the stomach contents from live fish, but all the items may not be recovered through this method.

DESCRIPTION OF THE FLOWAGE

The study was conducted at Murphy Flowage in northwestern Wisconsin as one part of an ongoing research project on warmwater fish. The Department of Natural Resources conducts a complete creel census at this flowage through the use of a compulsory free fishing permit system. Freedom from size, bag and season restrictions attracts more than the usual number of fishermen, and all fish caught must be brought to the research check station for examination.

Murphy Flowage covers 180 acres and has 6.8 miles of very irregular shoreline plus several islands. Maximum water depth is 14 feet with over 70 percent of the flowage less than 10 feet deep. The fish population includes almost all species of warmwater fish common to northern Wisconsin except the walleye, *Stizostedion vitreum vitreum*, (Mitchill) and smallmouth bass, *Micropterus dolomieu* Lacepede. The most frequently caught fish are bluegill, *Lepomis macrochirus* Rafinesque, northern pike, *Esox lucius* (Linnaeus), largemouth bass, *Micropterus salmoides* (Lacepede), and less frequently yellow perch, *Perca flavescens* (Mitchill), black crappie, *Pomoxis nigromaculatus* (LeSueur), rock bass, *Ambloplites rupestris* (Rafinesque), pumpkinseed, *Lepomis gibbosus* (Linnaeus), and brown bullhead, *Ictalurus nebulosus* (LeSueur). Occasionally brook trout, *Salvelinus fontinalis*, (Mitchill) migrate in from Hemlock Creek. Muskellunge, *Esox masquinongy* (Mitchill) have been stocked, but they survived so poorly that few have ever been caught.

PROCEDURES

Anglers caught 6,490 northern pike during the period from May, 1956 through April, 1965. I collected stomachs from 3,551 of these fish. Factors preventing a complete collection of stomachs were: 1. Inconvenience to anglers during peak rush hours when there were numerous fishermen to be checked. 2. Objections to stomach removal by the angler. (No stomachs were taken if the angler objected.) 3. Difficulties in collecting from frozen specimens during the ice fishing season. However, representative stomach collections were made in all months except October, November and April when fishing pressure declined.

Each stomach taken was wrapped in cheese cloth or placed in a perforated plastic bag and preserved in 10 percent formalin solution. A pencil notation describing the fish indicated width of jaws, total length, sex, time caught and the successful bait.

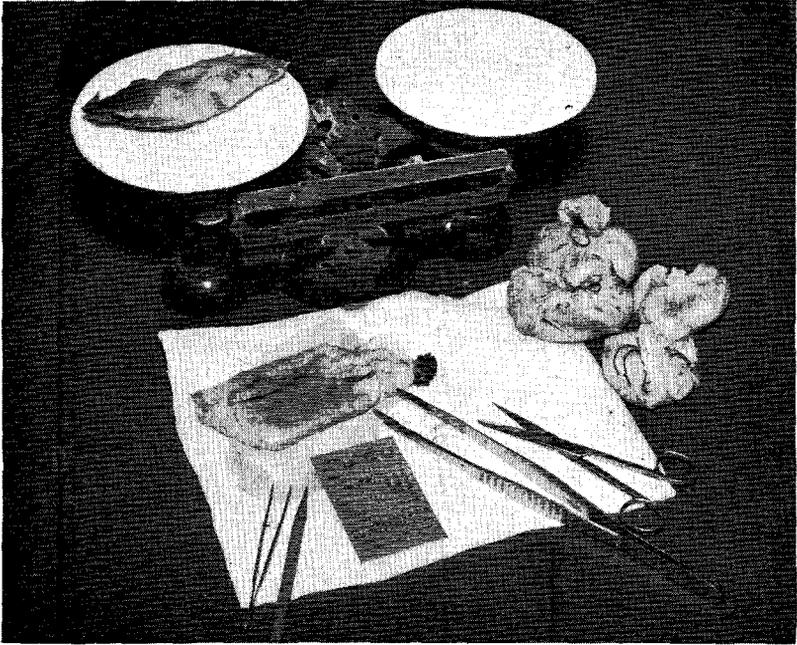


The Murphy Flowage checking station, where all fish caught in Murphy Flowage must be checked out.

Later, the food items in the stomach were counted, identified to species when this was possible, weighed on a gram balance, measured for maximum depth and classified according to stage of digestion. This was done with both whole organisms and fragments. When digestion had progressed to the point where a fish was unidentifiable it was classified as "fish remains". Minnows were recorded as bait when they had hook marks in their back, but were not considered as food items in stomachs. Unidentifiable homogeneous contents of the intestines were not tabulated.

The number of pike containing each kind of prey is expressed as the "percentage occurrence" of the prey. The percentage occurrence and the average numbers of items in the stomach are based only on the number of fish that contained food. The percentages of pike with empty stomachs were calculated separately.

Mark and recapture population estimates (Petersen method) were made of the fishes in the flowage each spring by using fyke nets and electrofishing gear and angler recaptures. Only the estimates of bluegill and perch are included in this report. Estimates of bluegills were made for each one-half-inch size group over 4.5 inches long. Perch over 6 inches were estimated in 2-inch groupings. Limitations of the fish collection gear made it impossible to work with smaller fish, although this would have been desirable.



Northern pike stomachs were wrapped in cheesecloth and preserved for later study. The partially digested bluegill on the scale was found in a 26-inch northern.

Width of the jaws in closed position provided an index to the depths of forage that could be taken by a northern pike. This was a relatively constant measurement that was made by insertion of a thin plastic ruler crosswise at the terminus of the jaws. I used measurements of closed jaws only because they could be replicated. The jaws could actually be spread to twice the measured width or more, and, therefore, fish were capable of taking larger items than this measurement would indicate.

RESULTS AND DISCUSSION

Kinds of Food

The results of the stomach analyses are presented in Tables 1 and 2. Fish were by far the most common kind of food found in the pike stomachs. Most fish species present in Murphy Flowage were represented in the stomachs at some time. Only occasionally were invertebrates found. These included crayfish, snails, earthworms, caddis larvae and Bryozoa. One stomach contained pebbles.

Bluegills, perch, minnows and crappies, in that order, were the major prey species. Actually crappies, because of their larger size, made up a slightly higher percentage of the food by weight than did minnows.

The percentages of bluegills and perch, respectively, in the pike diet are graphed both according to number of items (Fig. 1) and according to weight (Fig. 2). These figures are based on combined nine-year averages and show similar trends. The bluegill was the dominant food throughout. Perch increased slightly in importance during June, July and August and again in November, February and March. Crappies increased during the winter and declined during the summer. Fish remains increased in frequency of occurrence during the winter probably due to the slowdown in the digestive process.

The heavy use of bluegills for forage in Murphy Flowage is new. Other studies have reported that northern pike prefer cylindrical fish. Lawler (1965) reported trout-perch *Percopsis omiscomaycus* (Walbaum) and yellow perch as the main species eaten by pike in Heming Lake, Manitoba. In Lake Windermere, England *Perca fluviatilis* (Linnaeus) was the most important item in the pike diet (Allen, 1939 and Frost, 1954). However, these studies were done with lakes that had no bluegills.

In two Minnesota lakes where bluegills were present, Maple and Grove, pike still most frequently took yellow perch, according to Seaburg and Moyle (1964). Bluegills were reported to be abundant in Grove Lake. However, population estimates of perch and bluegills were not available for these lakes so their relative abundance was not known.

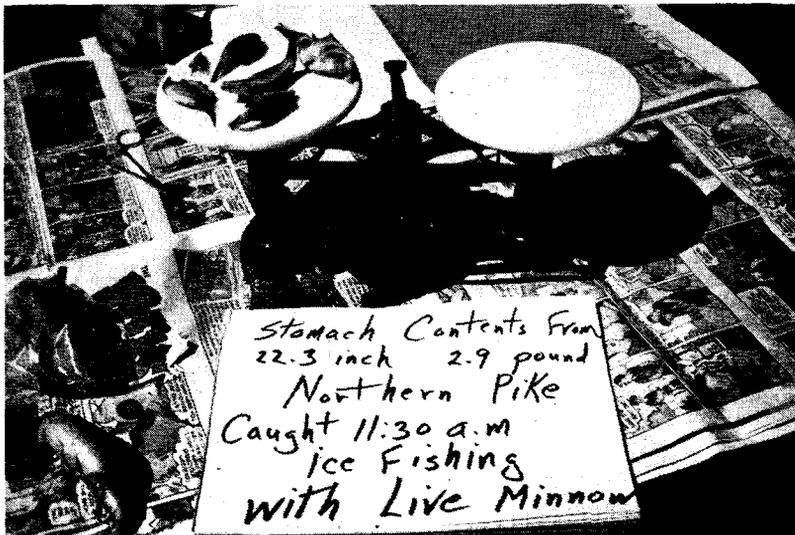


TABLE 1
Species Composition of Stomach Contents of Northern Pike, Monthly

| Species* | Percent During | | | | | | | | | | | | Combined Avg. |
|-------------------------|----------------|------|------|------|------|------|------|------|------|------|-------|------|---------------|
| | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | |
| BLUEGILS | | | | | | | | | | | | | |
| By Number..... | 36.4 | 56.0 | 52.7 | 51.6 | 75.9 | 42.9 | 53.3 | 39.2 | 41.7 | 44.6 | 57.8 | 75.0 | 50.3 |
| By Weight..... | 50.8 | 69.5 | 41.2 | 51.5 | 56.5 | 63.5 | 65.7 | 57.8 | 47.5 | 57.0 | 75.4 | 83.9 | 59.1 |
| PERCH | | | | | | | | | | | | | |
| By Number..... | 31.8 | 3.9 | 1.9 | 10.9 | 8.4 | 9.5 | 15.7 | 28.5 | 23.2 | 19.7 | 8.6 | 8.3 | 15.1 |
| By Weight..... | 27.3 | 2.4 | .6 | 9.8 | 12.4 | 14.6 | 16.8 | 22.4 | 16.8 | 16.0 | 4.8 | 5.4 | 12.6 |
| MINNOWS (Native) | | | | | | | | | | | | | |
| By Number..... | — | 14.5 | 5.7 | — | — | — | 5.1 | 4.3 | 9.5 | 7.6 | 2.6 | — | 6.5 |
| By Weight..... | — | 13.6 | 9.6 | — | — | — | 1.3 | 4.9 | 5.5 | 6.1 | 2.7 | — | 5.5 |
| CRAPPIES | | | | | | | | | | | | | |
| By Number..... | 9.1 | 9.6 | 12.3 | 12.5 | 3.6 | — | 3.4 | 2.7 | 4.2 | 1.6 | 3.4 | — | 5.1 |
| By Weight..... | 8.1 | 8.4 | 31.6 | 21.0 | 15.8 | — | 3.1 | 1.8 | 6.2 | 6.6 | 3.2 | — | 7.8 |
| LARGEMOUTH BASS | | | | | | | | | | | | | |
| By Number..... | — | — | 1.9 | — | 1.2 | — | — | — | 1.2 | 2.8 | 2.6 | — | 1.1 |
| By Weight..... | — | — | 1.3 | — | 1.0 | — | — | — | 18.1 | 1.6 | 2.0 | — | 3.4 |
| NORTHERN PIKE | | | | | | | | | | | | | |
| By Number..... | — | 0.5 | — | — | — | — | 0.6 | 1.1 | — | 0.8 | 0.9 | — | 0.5 |
| By Weight..... | — | 0.4 | — | — | — | — | 3.4 | 1.8 | — | 2.3 | 2.2 | — | 1.3 |
| BROOK TROUT | | | | | | | | | | | | | |
| By Number..... | — | — | — | — | — | — | — | 0.5 | 0.5 | — | — | — | 0.1 |
| By Weight..... | — | — | — | — | — | — | — | 0.7 | 0.3 | — | — | — | 0.1 |
| ROCK BASS | | | | | | | | | | | | | |
| By Number..... | — | — | — | — | — | — | 0.6 | — | — | 0.4 | — | — | 0.1 |
| By Weight..... | — | — | — | — | — | — | 1.3 | — | — | 1.7 | — | — | 0.5 |

TABLE 1 (Cont.)

| Species* | Percent During | | | | | | | | | | | | Combined Avg. |
|-------------------------------------|----------------|------|------|------|------|------|------|------|------|------|-------|------|------------------|
| | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | |
| FISH REMAINS | | | | | | | | | | | | | |
| By Number..... | 18.2 | 15.5 | 25.5 | 25.0 | 10.9 | 47.6 | 19.0 | 22.6 | 19.0 | 21.3 | 24.2 | 16.7 | 20.5 |
| By Weight..... | 13.8 | 5.7 | 15.7 | 17.7 | 14.3 | 21.9 | 7.8 | 10.4 | 5.4 | 8.3 | 9.7 | 10.7 | 8.8 |
| CRAYFISH | | | | | | | | | | | | | |
| By Number..... | — | — | — | — | — | — | 1.7 | 1.1 | 0.6 | 1.2 | — | — | 0.6 |
| By Weight..... | — | — | — | — | — | — | 0.5 | 0.2 | 0.2 | 0.4 | — | — | 0.2 |
| CADDIS FLY LARVAE | | | | | | | | | | | | | |
| By Number..... | — | — | — | — | — | — | 0.6 | — | — | — | — | — | 0.1 |
| By Weight..... | — | — | — | — | — | — | 0.05 | — | — | — | — | — | 0.005 |
| Total Items in all Stomachs..... | 22 | 207 | 106 | 64 | 83 | 21 | 178 | 186 | 168 | 249 | 116 | 12 | 1,412 |
| <i>n</i> | 26 | 309 | 137 | 74 | 59 | 40 | 638 | 707 | 544 | 629 | 336 | 52 | 3,551 |

*Pumpkinseed and brown bullheads are not listed here because they were found only once. Snails, earthworms and bryozoa are also omitted because of insufficient data.

TABLE 2
Percentage Occurrence of Prey, Monthly

| Species* | Stomachs Containing (Percent)** | | | | | | | | | | | | Combined Avg. |
|------------------------|---------------------------------|------|------|------|------|------|------|------|------|------|-------|------|---------------|
| | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | |
| BLUEGILLS..... | 47.1 | 58.4 | 46.1 | 41.7 | 55.6 | 46.2 | 55.9 | 38.6 | 46.2 | 46.9 | 57.1 | 66.7 | 49.6 |
| PERCH..... | 35.3 | 3.5 | 1.3 | 14.6 | 19.4 | 7.7 | 19.1 | 27.5 | 25.5 | 21.4 | 5.7 | 8.3 | 16.7 |
| MINNOWS (Native)..... | — | 14.5 | 7.9 | — | — | — | 1.3 | 4.1 | 6.9 | 7.6 | 1.9 | — | 6.2 |
| CRAPPIES..... | 11.8 | 10.4 | 14.5 | 12.5 | 8.3 | — | 4.6 | 3.5 | 4.8 | 1.8 | 3.8 | — | 5.9 |
| LARGEMOUTH BASS..... | — | — | 2.6 | — | 2.8 | — | — | — | 1.4 | 3.1 | 2.9 | — | 1.3 |
| NORTHERN PIKE..... | — | 0.6 | — | — | — | — | 0.7 | 1.2 | — | 0.9 | 1.0 | — | 0.5 |
| BROOK TROUT..... | — | — | — | — | — | — | — | 0.6 | 0.7 | — | — | — | 0.2 |
| ROCK BASS..... | — | — | — | — | — | — | 0.7 | — | — | 0.4 | — | — | 0.2 |
| FISH REMAINS..... | 23.5 | 13.9 | 32.9 | 37.5 | 27.8 | 38.5 | 20.4 | 25.7 | 15.9 | 21.4 | 21.9 | 16.7 | 22.1 |
| CRAYFISH..... | — | — | — | — | — | — | 2.0 | 1.2 | 0.7 | 1.3 | — | — | 0.8 |
| CADDIS FLY LARVAE..... | — | — | — | — | — | — | 0.7 | — | — | — | — | — | 0.09 |
| Empty..... | 34.6 | 43.9 | 44.5 | 35.1 | 39.0 | 67.5 | 76.2 | 75.8 | 73.3 | 64.4 | 68.8 | 76.9 | 67.0 |
| n..... | 26 | 309 | 137 | 74 | 59 | 40 | 638 | 707 | 544 | 629 | 336 | 52 | 3,551 |

*Pumpkinseed and brown bullheads are not listed here because they were found only once. Snails, earthworms and bryozoa are also omitted because of insufficient data.

**Percentages are based only on those pike with something in the stomach.

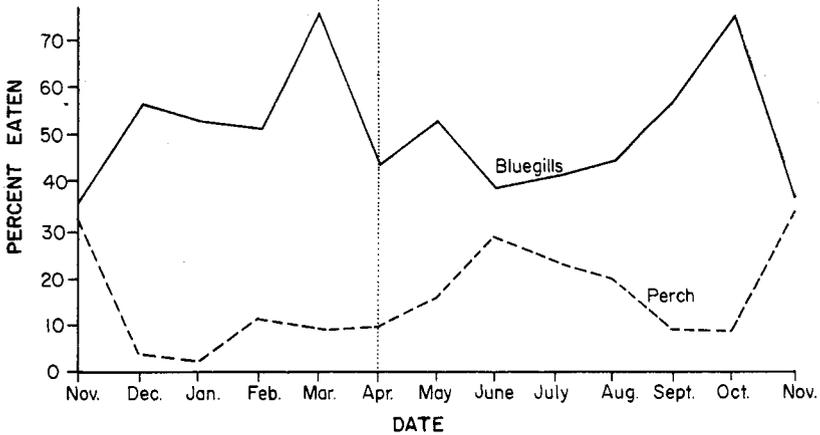


FIGURE 1. Percentage by number of bluegills and perch eaten by northern pike.

In my study, bluegills were the most frequent prey found in pike stomachs every year except 1956 when perch predominated slightly (Fig. 3). The year following this the number of stomachs containing perch was drastically reduced from the high of 31.4 percent in 1956 to only 7.0 percent in 1957.

While bluegills were the fish most frequently found in the pike stomachs, when one relates the actual numbers taken with the relative abundance of bluegills and perch in the flowage a different picture of selection emerges.

Population estimates of the bluegill and perch in Murphy Flowage from 1956 through 1964 (Howard Snow, pers. comm.) show that 4.5-

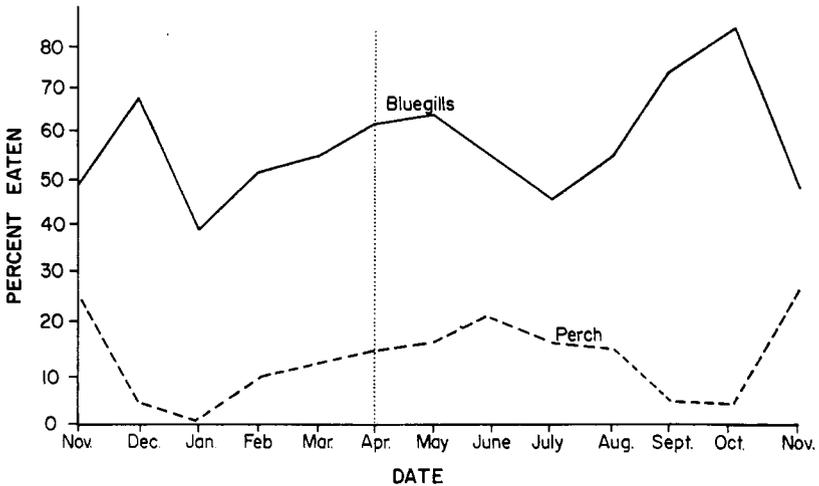


FIGURE 2. Percentage by weight of bluegills and perch eaten by northern pike.

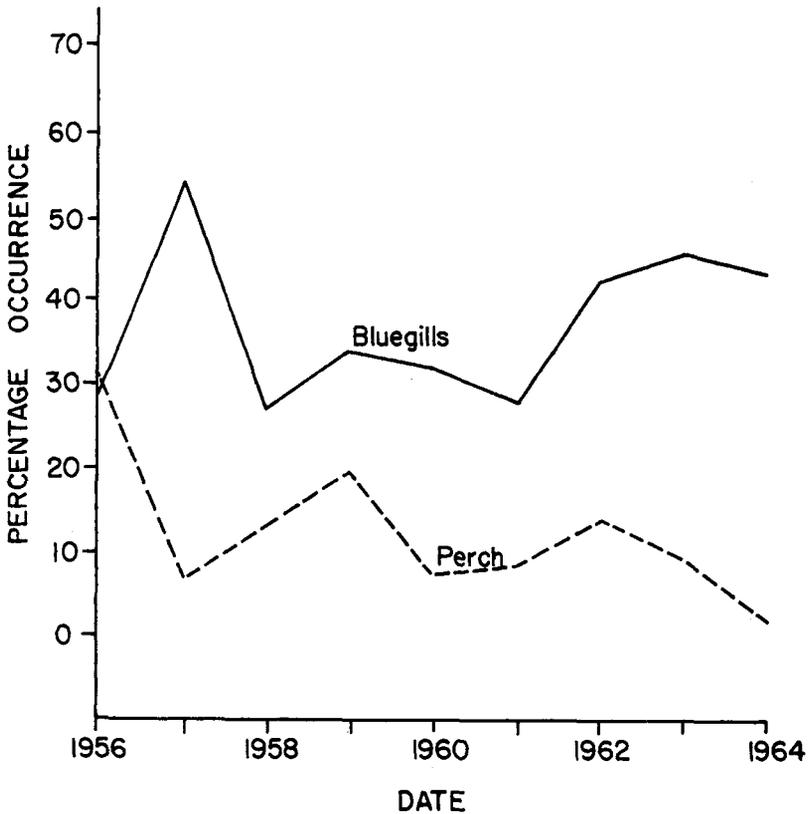


FIGURE 3. The percentage occurrence of bluegills and perch in northern pike stomachs. (Percentage occurrence is the percent of northern pike stomachs containing each kind of prey.)

inch and larger bluegills increased from a low of 122,000 in 1956 to a high of 291,000 in 1964, while perch 6.0 inches and over maintained a fairly stable population of about 10,000 which dropped to a low of 1,700 in 1964 (Fig. 4). These estimates were made for fish that were larger than those usually found in the pike stomachs. While keeping in mind that fishes utilized and fish estimated were not the same groups, these data nevertheless seem to indicate that perch were taken more frequently than bluegills in proportion to their abundance. Even though the northern pike ate large numbers of bluegills, it is doubtful that they could control bluegill populations when perch and other cylindrical fish are present. I cannot say what their effect on a bluegill population would be if cylindrical fish were not present.

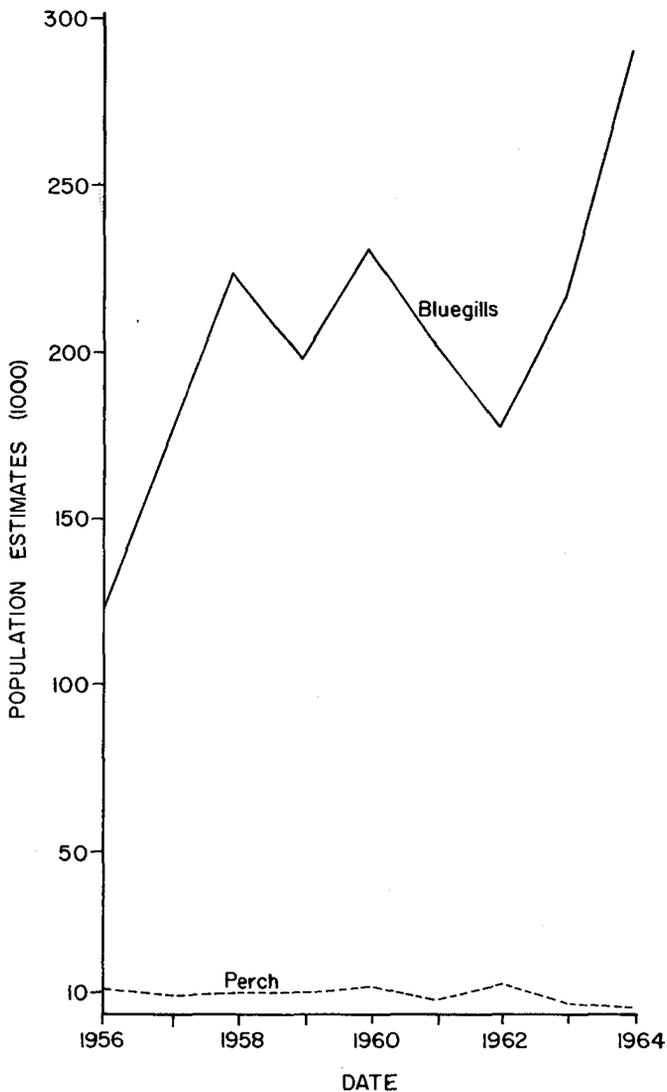


FIGURE 4. Population estimates on the relative abundance of bluegills and perch in Murphy Flowage.

Size of Fish Eaten

Depth

Body depth of a forage fish is its critical measurement. Eighty-four percent of the items found in all northern pike stomachs were between 0.5 and 1.50 inches in depth (Table 3). This is a relatively restricted range considering the variety of forage available.

TABLE 3
Relationship Between Length of Northern Pike and Body Depth of Prey in Stomach

| Length of Northern Pike (Inches) | Maximum Body Depth of Prey (Inches) | | | | | | | | | | | | n |
|-------------------------------------|-------------------------------------|-----|------|------|------|------|------|------|------|------|------|------|-------|
| | .50 | .75 | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 3.00 | 4.00 | |
| 10.0-14.9 | 62 | 15 | 15 | 8 | — | — | — | — | — | — | — | — | 13 |
| 15.0-19.9 | 23 | 24 | 26 | 13 | 9 | 2 | 2 | 1 | — | — | — | — | 531 |
| 20.0-24.9 | 7 | 17 | 25 | 17 | 16 | 7 | 7 | 2 | 1 | 1 | — | — | 605 |
| 25.0-29.9 | 4 | 8 | 25 | 14 | 13 | 8 | 18 | 2 | 6 | 1 | .5 | — | 207 |
| 30.0-35.9 | 8 | 11 | 8 | 16 | 22 | 3 | 11 | 5 | 8 | 3 | 3 | 3 | 37 |
| TOTAL | 13 | 18 | 25 | 15 | 13 | 5 | 7 | 2 | 2 | .4 | .1 | — | 1,393 |

TABLE 4
Relationship Between Length and Jaw Width of Northern Pike

| Northern Pike Length (Inches) | Average Closed Jaw Width (Inches) | | | | | | | | | | | | n | |
|----------------------------------|-----------------------------------|------|------|------|------|------|------|------|------|------|------|------|-----|-------|
| | 1.00 | 1.25 | 1.50 | 1.75 | 2.00 | 2.25 | 2.50 | 2.75 | 3.00 | 3.25 | 3.50 | 3.75 | | 4.00 |
| 10.0-14.9 | 54 | 43 | — | 3 | — | — | — | — | — | — | — | — | — | 48 |
| 15.0-19.9 | 4 | 23 | 31 | 22 | 15 | 4 | 1 | .4 | — | — | — | — | — | 729 |
| 20.0-24.9 | — | 2 | 11 | 13 | 31 | 14 | 19 | 8 | 2 | .3 | .1 | — | — | 795 |
| 25.0-29.9 | — | — | .3 | — | 7 | 7 | 30 | 16 | 33 | 2 | 6 | — | — | 335 |
| 30.0-35.9 | — | — | — | — | 4 | — | 11 | — | — | — | — | — | 26 | 11 |
| TOTAL | 3 | 10 | 16 | 13 | 19 | 9 | 13 | 6 | 8 | .5 | 1 | — | 0.4 | 1,934 |

Yet there was considerably more variation in the closed jaw width of northern pike, even within the same size group (Table 4). In the smallest group (10.0 to 15.9 inches) jaws varied only $\frac{3}{4}$ inch; but in the larger sizes the span increased to $2\frac{1}{4}$ inches (for 20.0 to 24.9-inch pike).

The relationship between the body depth of the forage fish and the closed jaw width of the northern pike is shown in Table 5. While northerns are quite capable of swallowing considerably larger prey, 95 percent of the forage consumed by the small pike (15.0 to 19.9 inches) was only 1.5 inches in depth or less. Even the largest pike (30.0 to 35.9 inches) ate this size forage 65 percent of the time. Bluegills from 2.0 to 4.5 inches long and perch under 6.5 inches long, as well as small minnows and other fishes of similar body proportions, were the ones eaten. Lawrence (1957) also considered the depth of the forage items to be a significant factor in the feeding habits of largemouth bass.

On the average, maximum depth of the food items in the stomachs was 50 to 59 percent of the average measurement of closed jaw width for all sizes of northern pike. Of all the pike stomachs containing food, 93.6 percent contained items with a depth less than the jaw width; 3.6 percent contained items that were equal in depth to the jaw width; and only 2.7 percent contained food that had a depth greater than the width of the jaws. In contrast, one 26.8-inch pike, with jaws that measured 2.9 inches wide, contained a crappie of 4.2 inches in body depth. Depth of prey in this case exceeded the jaw width of the pike by 45 percent.

Length

The length of the forage fish does not seem to be a critical factor in its being swallowed by a northern. Pike were caught with other pike protruding beyond the jaws. In such a case the forage fish was slowly swallowed as the end in the stomach was digested, until it

TABLE 5
Jaw Width of Northern Pike and Body Depth of Prey

| Length of Northern Pike (Inches) | <i>n</i> Northern Pike | Avg. Width of Jaws (Inches) | Avg. Max. Body Depth of Prey (Inches) |
|-------------------------------------|------------------------------|-----------------------------------|--|
| 10-14.9 | 48 | 1.1 | 0.6 |
| 15-19.9 | 729 | 1.6 | 0.9 |
| 20-24.9 | 795 | 2.1 | 1.2 |
| 25-29.9 | 335 | 2.7 | 1.4 |
| 30-35.9 | 27 | 3.2 | 1.5 |

TABLE 6
Weights of Forage Items for Northern Pike

| Weight of Prey (g) | Percent | | |
|--------------------|---------|-----------|----------|
| | Panfish | Game Fish | Crayfish |
| 0- 4.9 | 2 | 8 | 80 |
| 5- 9.9 | 12 | — | 20 |
| 10-14.9 | 15 | — | — |
| 15-19.9 | 14 | — | — |
| 20-24.9 | 14 | 15 | — |
| 25-29.9 | 8 | 23 | — |
| 30-34.9 | 8 | 8 | — |
| 35-39.9 | 5 | — | — |
| 40-44.9 | 5 | 8 | — |
| 45-49.9 | 4 | 8 | — |
| 50-54.9 | 2 | — | — |
| 55-59.9 | 1 | — | — |
| 60-64.9 | 2 | — | — |
| 65+ | 8 | 30 | — |

was fully consumed. One 26.2-inch pike contained the remains of another pike that had been over 13 inches long. (Original length was determined from comparison with preserved specimens.) The remains still weighed 110 grams when this pike was caught by a fisherman.

Weight

The weights of the individual forage fish were much less than one might have expected (Table 6). Although all sizes of forage were present in Murphy Flowage, 60 percent of the items in the stomachs weighed less than 25 grams. Of the bluegills eaten 52 percent weighed less than 25.0 grams, and only 8 percent weighed 65.0 grams or more.

All sizes of northern pike were physically capable of taking far larger forage items than were usually found in their stomachs. This would seem to indicate that northern pike either prefer the smaller fish or can find and capture them more readily. Unfortunately, reliable methods have not been developed for estimating the populations of these small fishes so it is difficult to determine the immediate effects of northern pike predation on a fish population.

However, this feeding habit may have a considerable influence on the growth of the pike themselves. Greater effort, and therefore greater energy might have to be expended in taking many small items rather than a few larger ones. This might result in reduced growth and smaller northern pike.

The weight of the entire contents of a pike stomach varied from zero (empty stomachs) to over 80 grams (Table 7). However, 97 percent of all stomachs contained less than 79 grams; and 53 percent contained less than 19 grams.

TABLE 7
Weight of Total Stomach Contents for Various Size Northern Pike

| Length of Northern Pike (Inches) | Percent of Stomachs Containing: | | | | | <i>n</i> |
|-------------------------------------|---------------------------------|-----------|-----------|----------|----------|--------------|
| | 1-19 g | 20-39 g | 40-59 g | 60-79 g | 80+ g | |
| 10.0-14.9 | 87 | 13 | — | — | — | 15 |
| 15.0-19.9 | 74 | 22 | 3 | 1 | — | 556 |
| 20.0-24.9 | 45 | 33 | 16 | 4 | 2 | 595 |
| 25.0-29.9 | 25 | 31 | 20 | 13 | 10 | 229 |
| 30.0-35.9 | 17 | 24 | 28 | 8 | 23 | 46 |
| TOTAL | 53 | 28 | 12 | 4 | 3 | 1,441 |

Empty Stomachs

Seasonal

Sixty-seven percent of the pike examined had empty stomachs. Even though I consistently selected only actively feeding fish by using pike caught by anglers, seasonal differences in the occurrence of empty stomachs did appear. A higher percentage of empty stomachs was found during October and from April through July (Fig. 5). There were fewer pike with empty stomachs during the winter months than at other times of the year. These findings are in agreement with studies by Lawler (1965).

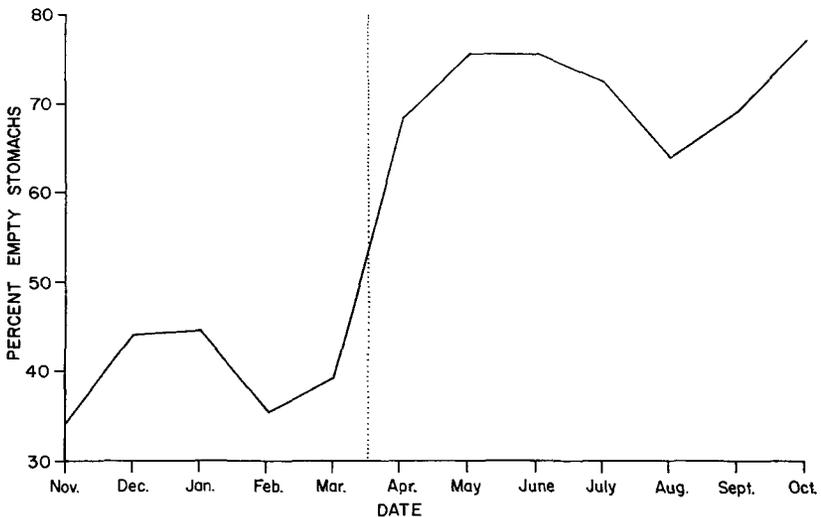


FIGURE 5. Percentage of northern pike with empty stomachs, monthly.

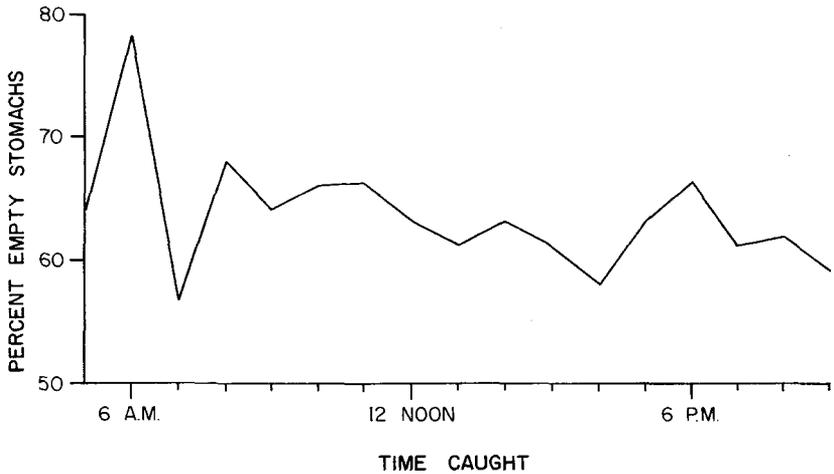


FIGURE 6. Percentage of northern pike with empty stomachs, hourly.

October coincides with the time of low forage supply and cooling but not yet cold waters. The high percentage of empty stomachs in April may have resulted from insufficient sampling but I do not think so. April is the month for northern pike spawning. Observations of pike caught in fyke nets at this season show that unspawned females do not feed, whereas the spawned out pike gorge themselves on the fish in the net. As for midsummer, fishermen recognize that northern pike are the hardest to catch at that time. It may be that pike simply do not feed normally during periods of high water temperatures; yet there was a drop in the percentage of empty stomachs in August which I cannot explain. The drop in empty stomachs during winter is probably due to the slowing of digestive processes as metabolism drops with water temperatures.

Effects of regurgitation were not established but were considered minimal. There is a remote possibility that some northern pike may have regurgitated their stomach contents in summer, particularly if they were kept alive on a fisherman's stringer. Pike removed from the water in summer or tossed on the ice in winter do not regurgitate readily, but there was no way of measuring this effect on the number of empty stomachs. Studies by Lawler (1965) indicated that there was no difference in the numbers of empty stomachs between pike caught by anglers and those captured with gill nets.

Hourly

The percentage of pike with empty stomachs is graphed on an hourly basis in Figure 6. The state of digestion of items and the number of items in the stomachs were also analysed on an hourly basis

according to the time the fish were caught (Tables 8 and 9, respectively). None of these three factors had any discernible relationship to hour of the day.

At various times of the day, 57 to 78 percent of the pike caught had empty stomachs. No digestion to almost complete digestion of stomach contents was observed for pike caught during all hours from 4 a.m. to 9 p.m. It was clear that stomachs were seldom filled to capacity: 82 percent of the stomachs contained only one item; 2 items were in 13 percent of the stomachs, and less than 1 percent of the stomachs held 5 or more items.

These data indicate that filled or empty stomachs or various stages of partial digestion are not important factors in determining the time of feeding. Feeding is continuous, at least during daylight hours. Those pike containing five or more items sometimes had stomachs distended to capacity and yet they had struck at an angler's bait. The frequency with which pike were caught during daylight, in summer or in winter, had no significant relationship with the hour (Table 10).

In the present study the greatest percentage of pike with empty stomachs or containing only one fish occurred at 6 a.m. This may account for higher catches at 7 a.m., but I cannot explain the other peaks reported by Churchill and Snow (1964). The lower fishing

TABLE 8
Percentage of Stomachs Containing Food in Various Stages of Digestion

| Hour Caught | Progress of Digestion | | | | | Remains Only | n |
|--------------|-----------------------|-----------|-----------|-----------|-----------|--------------|--------------|
| | None | 1/4 | 1/2 | 3/4 | | | |
| 4 a.m. | — | — | — | — | — | — | — |
| 5 | 25 | — | — | 25 | 50 | — | 4 |
| 6 | — | — | 33 | 67 | — | — | 3 |
| 7 | 25 | 15 | 15 | 18 | 28 | — | 40 |
| 8 | 19 | 14 | 19 | 28 | 21 | — | 43 |
| 9 | 21 | 12 | 17 | 23 | 27 | — | 52 |
| 10 | 12 | 9 | 21 | 25 | 33 | — | 67 |
| 11 | 16 | 16 | 12 | 22 | 34 | — | 74 |
| 12 Noon | 24 | 8 | 24 | 13 | 32 | — | 63 |
| 1 p.m. | 17 | 14 | 17 | 21 | 31 | — | 81 |
| 2 | 23 | 11 | 18 | 14 | 33 | — | 87 |
| 3 | 22 | 20 | 19 | 18 | 22 | — | 91 |
| 4 | 25 | 16 | 13 | 20 | 27 | — | 122 |
| 5 | 27 | 12 | 19 | 20 | 22 | — | 74 |
| 6 | 20 | 18 | 23 | 13 | 25 | — | 60 |
| 7 | 23 | 17 | 16 | 22 | 22 | — | 90 |
| 8 | 23 | 13 | 23 | 22 | 18 | — | 60 |
| 9 | 36 | 7 | 21 | 21 | 14 | — | 14 |
| 10 | — | — | — | — | — | — | — |
| TOTAL | 22 | 14 | 18 | 20 | 27 | | 1,025 |

TABLE 9
Number of Fish in Northern Pike Stomachs, Hourly

| Hour Caught | Percent of Stomachs Containing | | | | | n |
|-------------------|--------------------------------|-----------|----------|-----------|-----------|--------------|
| | 1 | 2 | 3 | 4 | 5 or more | |
| 4 a.m.----- | — | — | — | — | — | — |
| 5----- | 67 | 33 | — | — | — | 3 |
| 6----- | 100 | — | — | — | — | 4 |
| 7----- | 70 | 19 | — | — | 2 | 47 |
| 8----- | 81 | 16 | — | — | 3 | 44 |
| 9----- | 84 | 6 | 6 | 2 | 2 | 62 |
| 10----- | 80 | 12 | 5 | 1 | 1 | 75 |
| 11----- | 86 | 12 | 2 | — | — | 73 |
| 12 Noon----- | 84 | 10 | — | 2 | 3 | 59 |
| 1 p.m.----- | 73 | 20 | 6 | — | 1 | 84 |
| 2----- | 82 | 13 | 4 | 1 | — | 101 |
| 3----- | 83 | 11 | 4 | 2 | — | 102 |
| 4----- | 83 | 11 | 4 | 1 | 1 | 121 |
| 5----- | 78 | 18 | 1 | 1 | 1 | 74 |
| 6----- | 78 | 19 | 1 | 1 | — | 63 |
| 7----- | 83 | 9 | 8 | — | — | 87 |
| 8----- | 87 | 12 | — | 1 | — | 52 |
| 9----- | 85 | 15 | — | — | — | 13 |
| 10----- | 100 | — | — | — | — | 1 |
| TOTAL----- | 82 | 13 | 3 | .9 | .8 | 1,065 |

success at 1 p.m. and again at 5 p.m. is probably due to reduced fishing pressure. Anglers stop for midday and evening meals which they do not usually report as time off at the checking station.

Sex of Pike

In this study 56 percent of the northern pike examined were females (Table 11). In each of the nine years females were usually caught more frequently month by month, but ratios were sometimes reversed. I found no consistent sexual differences in pike feeding habits. Lawler (1965) also reported that there were no differences between male and female pike in the kind or quantity of their food.

Baits

Small minnows and midwater lures were the most successful baits. This was true especially of lures that approximated the size of the forage found in the stomachs. All sizes and kinds of baits caught all sizes of northern pike, but minnows and spoons tended to catch the larger ones.

The success of artificial versus live baits (usually minnows) for catching northern pike is shown in Table 12. Both types of baits were used during the summer but artificial bait predominated, which may account for its apparently greater success. Minnows were used exclu-

TABLE 10
Hourly Catch of Northern Pike

| Hour Caught | Percent | |
|-------------|------------|-----|
| | Open Water | Ice |
| 4 a.m. | .2 | — |
| 5 | .3 | — |
| 6 | 2 | — |
| 7 | 5 | .2 |
| 8 | 6 | .7 |
| 9 | 6 | 4 |
| 10 | 8 | 8 |
| 11 | 8 | 12 |
| 12 Noon | 5 | 12 |
| 1 p.m. | 6 | 13 |
| 2 | 9 | 13 |
| 3 | 8 | 16 |
| 4 | 9 | 20 |
| 5 | 6 | .9 |
| 6 | 7 | — |
| 7 | 8 | — |
| 8 | 5 | — |
| 9 | .6 | — |
| 10 | .1 | — |
| <i>n</i> | 3,247 | 586 |

sively during winter ice fishing and also had a slight edge over artificial baits in August.

Minnows were successful bait both summer and winter, whether or not the pike stomachs were filled or empty.

Pike with empty stomachs tended to take artificial baits more readily than pike with filled stomachs. This selectivity may indicate that the filled pike were more deliberate in their feeding and detected a difference between the artificial and live baits.

TABLE 11
Monthly Sex Ratio of Northern Pike Caught

| Month | Male | Female |
|-----------|------|--------|
| November | 12 | 23 |
| December | 163 | 180 |
| January | 74 | 90 |
| February | 25 | 52 |
| March | 20 | 28 |
| April | 17 | 16 |
| May | 356 | 320 |
| June | 309 | 415 |
| July | 229 | 283 |
| August | 229 | 448 |
| September | 148 | 142 |
| October | 36 | 23 |

TABLE 12
Monthly Catch and Type of Bait Used

| Month | Percent | | |
|----------------|------------|------|----------|
| | Artificial | Live | <i>n</i> |
| November..... | 7 | 93 | 27 |
| December..... | — | 100 | 446 |
| January..... | — | 100 | 119 |
| February..... | — | 100 | 55 |
| March..... | — | 100 | 34 |
| <hr/> | | | |
| April..... | 44 | 56 | 36 |
| May..... | 91 | 9 | 547 |
| June..... | 83 | 17 | 655 |
| July..... | 71 | 29 | 566 |
| August..... | 48 | 52 | 713 |
| September..... | 74 | 26 | 361 |
| October..... | 79 | 21 | 53 |
| <hr/> | | | |
| TOTAL..... | 59 | 41 | 3,612 |

Information on the baits used to catch the pike in this study is presented in Table 13. Information is lacking on which baits were unsuccessful, and the length of time required to catch a northern on a successful bait. Also there is no way of knowing if the anglers fished in the right places. Each fisherman was asked the brand name and color of the successful bait he had used, but there was no correlation between these fine distinctions and fishing success. Therefore, the data were tabulated under broader categories where differences were noted.

TABLE 13
Baits Used and Sizes of Northern Pike Caught

| Northern Pike Length | Underwater Lures | | | Surface Lures | Live Bait | | <i>n</i> |
|-------------------------|------------------|----------|-------|------------------|-----------|-------|----------|
| | Spoons | Spinners | Other | | Minnows | Worms | |
| 12.0-13.9..... | 38 | 33 | 3 | — | 8 | 17 | 60 |
| 14.0-15.9..... | 38 | 28 | 13 | 3 | 11 | 6 | 213 |
| 16.0-17.9..... | 40 | 25 | 15 | 4 | 12 | 4 | 446 |
| 18.0-19.9..... | 41 | 23 | 12 | 7 | 13 | 4 | 421 |
| 20.0-21.9..... | 33 | 20 | 14 | 7 | 22 | 3 | 297 |
| 22.0-23.9..... | 37 | 17 | 14 | 7 | 22 | 3 | 202 |
| 24.0-25.9..... | 31 | 11 | 15 | 5 | 37 | — | 127 |
| 26.0-27.9..... | 29 | 12 | 8 | 11 | 38 | 1 | 73 |
| 28.0-29.9..... | 24 | 8 | 11 | 3 | 41 | 3 | 33 |
| 30.0-31.9..... | 36 | 9 | — | 18 | 36 | — | 11 |
| 32.0-33.9..... | 50 | — | 17 | 17 | 17 | — | 6 |
| 34.0-35.9..... | — | — | — | 100 | — | — | 1 |
| 36.0-37.9..... | — | — | — | — | 100 | — | 1 |
| <hr/> | | | | | | | |
| TOTAL..... | 37 | 22 | 13 | 6 | 18 | 4 | 1,891 |

Spoons and spinners were the most successful baits (37% and 22% respectively, of all pike caught). They may also have been the baits most frequently used. The spoons included painted and shiny metal plated types which are among the oldest and best known of lures. Minnows were third (18%), probably because anglers did not use them as often. Lesser known underwater lures such as plugs, plastic minnows, etc., accounted for 13 percent of the pike caught. Surface lures were the least successful of the artificial baits (6%) although they were taken by all sizes of northern pike. Earthworms (4%) were the poorest bait even though they were probably used by more fishermen than any other, primarily for panfish.

SUMMARY AND IMPLICATIONS

Nine years of stomach contents analysis on angler-caught northern pike have shown that pike will indeed feed on bluegills. Bluegills, perch, minnows and crappies, in that order, were the major prey species of the northerns in Murphy Flowage.

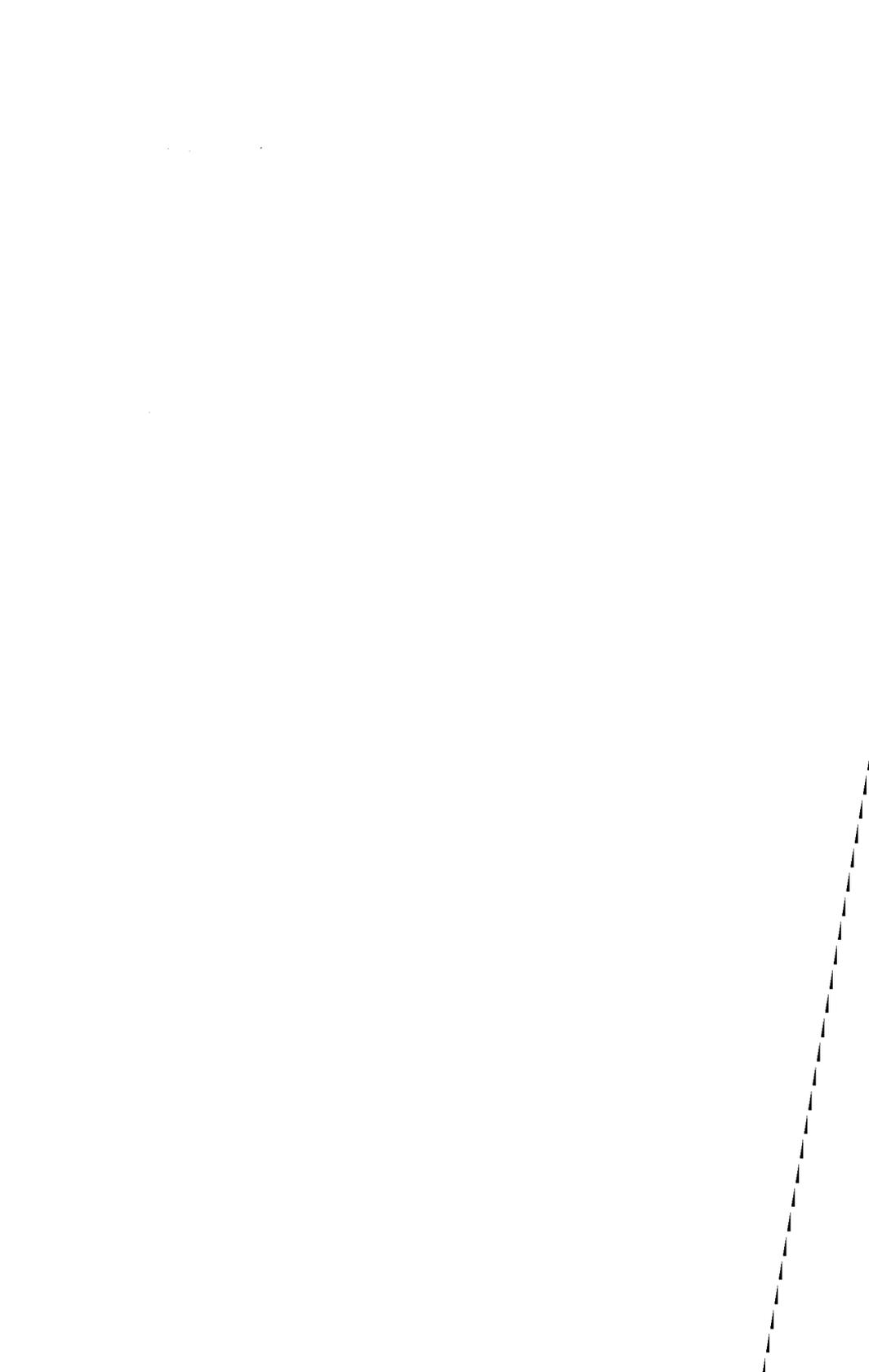
Although bluegills were the predominant prey species, a more important fact for fish management is that pike took perch more frequently than bluegills in proportion to their abundance. Assuming that this also holds in other lakes, it is very doubtful that northern pike predation can control bluegill populations when perch or other cylindrical fish are present.

All sizes of northern pike are able to take larger prey than the majority of them did. Their heavy use of small forage fishes is not immediately explainable but probably has a direct influence on the size of the pike themselves. This tendency to take small prey when it is available may result in limiting the growth of northerns in some lakes. Body depth of the forage fish is the critical dimension influencing predation.

Feeding was not related to the presence or absence of food in the stomach. Northern pike feed continuously during daylight hours, so fishermen would likely find one time of day as good as any other for catching them. Small minnows and midwater lures were the most successful baits.

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