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FOOD HABITS OF BROOK TROUT IN McGEE LAKE, 1980–82

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ABSTRACT

Excellent growth of brook trout (Salvelinus fontinalis) in 23-acre McGee Lake was attributed to their predominantly piscivorous diet. Piscivory in this lake began at a much smaller size than is typical for salmonids. Stocking brook sticklebacks to supplement food resources for brook trout should be considered as a management option for other lakes and ponds.

These conclusions were based on analyses of food habits of 745 brook trout collected during 1980-82. Length range of these trout was 3.0-18.9 inches. Trout caught by anglers during May-September provided 642 of these stomachs. Nearly all of these trout were domestic in origin, stocked as yearlings each April. The remaining 103 stomachs were from 3- to 6-inch trout collected with electrofishing gear in April and early October. Nearly all of these were wild age 0 or age I.

Forage fish, either sticklebacks (Culaea inconstans) or fathead minnows (Pimephales promelas), were the dominant food by volume, accounting for 51% of the total. They were present in 44% of all stomachs. Diptera (primarily Chronomidae) ranked second by volume (23%), but first by frequency of occurrence (57%).

Forage fish were important in brook trout diets throughout the size range sampled, including trout as small as 3-5 inches (35% of 68 stomachs in that size range contained forage fish). Volume of food/stomach generally increased with an increase in body size. Average volume/stomach was high compared to values reported in other studies of trout diets. Only 6.8% of the 745 stomachs examined were empty.

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INTRODUCTION

McGee Lake, located in southeastern Langlade County, has been managed exclusively for trout fishing since it was chemically rehabilitated in 1974. That year it was restocked with domestic brook trout*, and, since then, the lake has developed a reputation for its excellent growth of brook trout. Despite efforts to eliminate all fish in McGee Lake by the application of antimycin and rotenone in 1974, abundant populations of two forage fish species were soon reestablished. Their abundance raises the obvious biological question that will be addressed by this report: Is the excellent growth of brook trout in McGee Lake dependent on heavy use of forage fish for food?

Hunt (1979) verified McGee Lake's reputation as part of his study to assess growth, survival, and angler harvest of three strains of domestic brook trout stocked in McGee Lake, Adams Lake (Portage County), and Hazel Dell Pond (Monroe County) in the spring of 1977. Six months after being stocked, yearling brook trout of the Nashua strain increased in mean weight by 50% in Adams Lake, but by 146% in McGee Lake. During the same period, the mean weight of Assinica strain individuals increased 158% in Adams Lake, but 338% in McGee Lake. (None of the yearlings stocked in Hazel Dell Pond survived six months.)

Growth of stocked brook trout in McGee Lake during 1980-82 was also excellent (Hunt, in press), when compared with growth of wild brook trout in several nearby spring ponds that support popular sport fisheries (Carline and Brynildson 1977). Yearling brook trout (Nashua strain) stocked in McGee Lake in April 1980-82 increased in weight during the following six months by an average of 186% in 1980, 151% in 1981, and 215% in 1982. Gains in average length during the same period were 40% in 1980 (from 7.5 to 10.5 inches), 35% in 1981 (from 7.5 to 10.1 inches), and 52% in 1982 (from 6.6 to 10.0 inches). By contrast, gains in average lengths of wild yearling brook trout from spring to fall in three spring ponds near McGee Lake went from 5.0 to 6.5 inches, 4.2 to 5.1 inches, and 4.1 to 5.8 inches.

One year after the yearlings were stocked in McGee Lake, the mean length of 2-year olds was 13.2 inches in April 1981 and 12.2 inches in April 1982. The wild age II brook trout from three nearby spring ponds averaged only 6.9, 5.9, and 6.1 inches in April (Carline 1977).

It is not difficult to understand McGee Lake's popularity with anglers. The domestic yearlings in McGee Lake were larger on the average when stocked than were the wild age II trout in nearby spring ponds or streams, and by the end of the fishing season, yearlings in McGee Lake were larger than most age III wild brook trout in the region. McGee Lake also provided anglers with reasonable opportunities to catch brook trout in the 15- to 20-inch range, and each year from 1976-82 reports were heard of brook trout caught that exceeded 20 inches, although this was not verified during DNR creel census operations (Hunt, in press).

Regarding the introduction of forage fish into McGee Lake, either some brook sticklebacks and fathead minnows survived the chemical treatment or were reintroduced illegally. Although the outlet of McGee Lake is the source of Drew Creek, an artificial barrier prevents movement of fish between the lake and stream. No population estimates of these forage species have been made, but the subjective description of "abundant" could undoubtedly be verified. Schools of both species are evident along the entire shoreline.

METHODS

During the April-October periods of 1980-82, stomachs of 745 brook trout were collected; 642 were from trout caught by anglers during the May-September season, and 103 were from trout collected during electrofishing operations in mid-April and early October. The electrofishing samples were primarily trout in the 3- to 6-inch size range, since few trout of this size were available from anglers. All electrofished trout were probably wild age 0 or small wild yearlings. (There was some natural reproduction of brook trout each year in the lake, but the sport fishery was largely dependent on an annual stocking of domestic yearlings.) Few of the domestic yearlings were less than 7 inches in October, and electrofishing in April was done prior to introduction of the annual quota of 4,000 yearlings.

Stomachs were removed from angler-caught trout when anglers were interviewed at the end of their fishing trips. Date of capture and length of trout were recorded for most of these stomachs and for each trout collected with electrofishing gear. All stomachs were preserved in Formalin until they could be handled in the laboratory. Food contents in individual stomachs were classified to order by frequency of occurrence and by wet volume to the nearest 0.1 ml, based on water displacement. Forage fish in stomachs were identified as sticklebacks or fathead minnows (if recognizable as such). No other species were identifiable as food items. The only other species that could have been consumed were mudminnows (sparse in the lake) and brook trout.

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*Scientific names of fishes mentioned in this report are listed in Table 1.

RESULTS

Forage fish were found in 43.6% of the stomachs (Table 2). The only taxon of food more frequently eaten was Diptera (primarily larvae and pupae Chironomidae), which occurred in 56.5% of all stomachs examined. These two food categories also ranked 1 and 2 based on individual contributions to the total volume of food present, but forage fish as a group were by far the most dominant, accounting for 50.8% of the total volume while Diptera accounted for 23.0%. Together these two food resources comprised nearly 3/4 of all food consumed (by volume).

Ranking third by frequency of occurrence was Hemiptera (primarily aquatic Corixidae and Gerridae), which was found in 35.2% of all stomachs, but which contributed only 1.9% of the food volume, an 8th place ranking. Ranking third by volume was the order Cladocera at 6.9%. Most of the cladocerans were Daphnia sp. Only 6.8% of the 745 stomachs examined were empty.

The collective importance of the 7 major orders of insects consumed by brook trout in McGee Lake is summarized in Fig. 1, according to three size groups of trout. Insects were the most frequently consumed category in all three size groupings, but decreased in importance with an increase in predator size. Insects were present in 89%, 70%, and 65% of the stomachs represented in three size groups. However, on the basis of food volume, insects accounted for only 26% of the total from trout 3.0-6.9 inches, 23% of the total from trout 7.0-11.9 inches, and 41% of the total from trout in the 12.0-18.9 inch range. (Sample sizes in the three size groups were 103, 494, and 85, respectively.)

Forage fish in stomachs grouped by these size categories accounted for 40%, 54%, and 54% of the total food volumes, respectively. Frequency with which forage fish were consumed increased from 33% for trout in the 3.0-6.9 inch range, to 45% for trout in the 7.0-11.9 inch range, to 49% for trout over 12 inches. Sticklebacks accounted for 78% of the 117 forage fish that could be identified to species, and the remaining 22% were all fathead minnows. There was no evidence of cannibalism.

Consumption of zooplankton (Cladocera) and scuds (Amphipoda) both decreased as size of brook trout increased and no scuds (Gammarus sp.) were found in 85 stomachs from trout larger than 12 inches.

Table 3 summarizes categories of food consumed by trout grouped by 1-inch units. Particularly significant is the presence of forage fish in the diets of trout of all sizes, including 3 of 10 trout in the 3-inch group and 12 of 27 trout in the 4-inch group. Fish comprised the greatest volume of food in 11 of the 14 size groupings. In the three exceptions (3, 7, and 13-inch groups), Diptera predominated.

Crayfish (Orconectes virilis) appeared to be numerous in McGee Lake, but surprisingly few were found in the trout stomachs collected during 1980-82. Only 47 of the 694 stomachs containing food had crayfish. Trout in the 10- and 11-inch groups used this food most frequently.

The insect orders Trichoptera (caddis flies) and Ephemeroptera (mayflies), so prominent in diets of stream trout, were relatively unimportant as food for McGee Lake trout. Neither order made up much more than 1% of the food volume in any of the size groups.

DISCUSSION

Food analysis confirmed speculations that forage fish were an important component in the diet of brook trout in McGee Lake. Forage fish made up more than half of the total food volume in these stomachs, and were found in about 44% of the stomachs collected from trout ranging from 3.0-18.9 inches.

Forage Fish in the Diet of Salmonids

Growth of salmonids in other lakes and streams has often been related to the importance of forage fish in their diet. Fraser (1981) documented survival and growth of several strains of brook trout in nine small Ontario lakes and found growth was best in the lakes containing no other fish except minnows and sticklebacks, which were used extensively by the brook trout. Martin (1970) reported on long-term changes in the food habits of lake trout in Lake Opeongo, Ontario during the 1936-65 period. Growth rate, age at sexual maturity, and fecundity all improved with increased abundance of forage fish, especially cisco introduced in 1948. The spectacular success of the multi-million-dollar sport and commercial fisheries for salmon and trout in Lake Michigan is largely dependent on the rich food base of alewives that first triggered management efforts to stock the lake with salmonids in the mid-1960's. The alewives are expected to provide the bulk of the food for future introduction of salmonids at even greater densities, although some scientists are beginning to wrestle with the question of how much more stocking can be done before forage fish become depleted (Stewart et al. 1981).

Improved growth of rainbow trout, bull trout, lake trout, and brown trout has been reported in several reservoirs and lakes in the western U.S. and British Columbia following introductions of kokanee to provide a forage species. In some cases, the kokanee were large enough to also contribute to the sport fisheries (Wydoski and Bennett 1981). Kirchels and Stanley (1981) summarized several references to improved growth of salmonids in northeastern U.S. waters following introductions of forage fish, most commonly alewife or rainbow smelt. Dependence of Atlantic salmon on rainbow smelt as their principal food resource has been particularly well documented in northeastern U.S. waters (Lakey 1969).

In Stormy Lake, Wisconsin, stocked coho salmon in the 7.5- to 9.5-inch size range depended much less on forage fish than did brook trout in McGee Lake. Only 9% of 45 stomachs from coho in this size range contained forage fish (McKnight and Serns 1974). Larger coho used forage fish much more frequently. Sticklebacks were common in the diets of brown trout larger than 12 inches in a new reservoir in Great Britian, but were not found in 102 stomachs from brown trout smaller than 12 inches (Hunt and Jones 1972).

In a sample of brown trout stomachs from the Anna River in Michigan, no forage fish were found in 30 stomachs from trout less than 4 inches. Only brown trout 11.8 inches or larger were considered to be heavily dependent on forage fish (Hannuksela 1969).

The Diet of Brook Trout

The importance of forage fish in the diet of brook trout in McGee Lake tended to increase with an increase in trout size, a relationship which has been observed in many studies of salmonid food habits (Nilsson 1957; Hannuksela 1969; Brynildson and Kempinger 1970; Hunt and Jones 1972; McKnight and Serns 1974; Stauffer 1977; Strogen 1979; Johnson 1981; Garman and Nielson 1982). However, in McGee Lake, use of forage fish was much more important for small trout -- more than is typical. Even brook trout as small as 3, 4, and 5 inches used forage fish extensively. Fish were found in 35% of 68 brook trout stomachs in this size range, including 3 of 10 stomachs from trout in the 3-inch group.

Only one food habit study of brook trout corroborates extensive use of forage fish by small brook trout. Spiers (1974) reported that brook trout in Echo Lake, Maine depended on forage fish throughout the size range of 6-15 inches and found no significant increase in piscivory with an increase in predator size. However, even this study did not show a diet of prey fish by trout as small as those collected from McGee Lake during 1980-82.

In Michigan's Main au Sable River, Strogen (1979) found forage fish in only 5% of 125 brook trout stomachs in the 3.0- to 5.9-inch range, and in only 2 of 125 brown trout stomachs in this size range from the Manistee River. In a similar study in Michigan, Stauffer (1977) found no forage fish in 125 stomachs of 3.0- to 5.9-inch brown trout from the South Branch Au Sable River. He also found only 4% of 125 brown trout stomachs in this size range from the Main Au Sable River contained forage fish.

Carline and Brynildson (1977) analyzed the food contents of wild brook trout stomachs in two spring ponds located a few miles east of McGee Lake, as part of their evaluation of dredging these ponds to increase trout carrying capacity. Prior to dredging, they found no forage fish in 34 stomachs of brook trout less than 4.5 inches taken from Krause Pond. Frequency of occurrence was only 3% in 36 stomachs from brook trout measuring 4.5-6.5 inches, and only 2% in 62 stomachs from brook trout larger than 6.5 inches. During the post-dredging period, forage fish continued to be of little value in the diet of brook trout.

In Sunshine Springs, only brook trout larger than 6.5 inches were included in food habits analysis. In this pond, too, forage fish were sparse as a food item before and after dredging, but they did contribute significantly to the total weight of food, accounting for 50% of the total weight in 79 stomachs for the pre-dredging period and 55% of the total weight in 36 stomachs in the post-dredging period. (Stomachs were obtained from angler-caught trout.) In both ponds, but especially in Krause Pond, benthic invertebrates, primarily Amphipoda and Chironomidae, dominated the diets of all sizes of brook trout before and after dredging.

Crayfish (Decopoda) have been reported to be important constituents of the brook trout diet in some situations (Momot 1965; Fraser 1981; Johnson 1981), but such was not the case in McGee Lake despite what appeared to be above-normal abundance. Perhaps if forage fish were not so abundant as relatively large prey items for brook trout in McGee Lake, greater use of crayfish would occur.

Food Volume/Stomach

The relationship of increased food volume/stomach to increased body size (Fig. 2) that characterized food habits of brook trout in McGee Lake is a logical one that other investigators have also documented. However, compared to brown trout from the Manistee River (Strogen 1979) and the Au Sable River in Michigan (Stauffer 1977; Strogen 1979), brook trout in McGee Lake had higher food volume/stomach at any given size. For example, mean food volume/stomach of 3.0- to 5.9-inch brown trout was 0.12 ml for a sample from the Main Au Sable River and 0.18 ml for a sample from the South Branch Au Sable River, compared to an average volume of 0.39 ml for brook trout of this size from McGee Lake. For brown trout in the 7.0- to 9.9-inch range, Strogen reported average stomach volumes of 0.73 ml for the South Branch Au Sable River and 0.80 ml for the Lower Au Sable River. The comparable value for brook trout from McGee Lake was 0.96 ml, an average volume at least 20% greater.

MANAGEMENT CONSIDERATIONS

Chemical rehabilitation of McGee Lake in 1974 proved to be a wise management strategy to set the stage for managing the lake as a trout fishery. However, the development of a rich forage fish food base has contributed considerably to the success of that fishery, particularly to the size of trout creeled. Brook sticklebacks, in particular, have been a major component in the diet of brook trout in McGee Lake.

In Wisconsin, much more attention has been devoted to enhancing the physical aspects of trout habitat than to enhancing food resources for trout. Since better growth of trout in most Wisconsin lakes and spring ponds would be desirable, stocking sticklebacks to supplement food resources for brook trout should be considered as a management option, (and evaluated as well), particularly where other forage fish species are sparse and conditions allow trout to feed near shore most of the year.

TABLE 1. Common and scientific names of fishes in this report.

Common Name	Scientific Name
Alewife	*Alosa pseudoharengus*
Cisco	*Coregonus artedii*
Coho salmon	*Oncorhynchus kisutch*
Kokanee	*Oncorhynchus nerka*
Rainbow trout	*Salmo gairdneri*
Atlantic salmon	*Salmo salar*
Brown trout	*Salmo trutta*
Brook trout	*Salvelinus fontinalis*
Lake trout	*Salvelinus namaycush*
Bull trout	*Salvelinus confluentus*
Rainbow smelt	*Osmerus mordax*
Mudminnow	*Umbra lima*
Fathead minnow	*Pimephales promelas*
Brook stickleback	*Culaea inconstans*

TABLE 2. Food composition in the stomachs of 694 brook trout collected from McGee Lake during May-October, 1980-82.*

Food Category	% of Stomachs Containing Item	% of Total Food Volume**
Forage Fish	43.6	50.8
Diptera	56.5	23.0
Hemiptera	35.2	1.9
Miscellaneous[a]	15.0	1.3
Cladocera	14.1	6.9
Amphipoda	8.1	3.7
Decopoda	7.0	5.8
Coleoptera	5.5	0.3
Gastropoda	4.4	0.4
Oligochaeta	4.3	2.2
Odonata	3.8	3.5
Ephemeroptera	2.0	0.1
Hymenoptera	2.0	0.1
Trichoptera	1.9	0.2

*51 stomachs of the 745 sampled were empty (6.8% of total).

**Total volume was 968 cc.

[a]Includes unidentified invertebrate parts and vegetation.

TABLE 3. Composition of food in 682 brook trout from McGee Lake, collected during May-October periods of 1980-82.*

	Inch Group**													
	3		4		5		6		7		8		9	
Food Category	% Freq.	% Tot. Vol.	% Freq.	% Tot. Vol.	% Freq.	% Tot. Vol.	% Freq.	% Tot. Vol.	% Freq.	% Tot. Vol.	% Freq.	% Tot. Vol.	% Freq.	% Tot. Vol.
Fish	30	16.2	44	35.7	29	46.5	31	38.1	36	34.4	44	47.3	45	62.2
Diptera	50	41.2	70	20.3	65	15.5	83	19.4	68	37.5	51	25.8	45	14.0
Hemiptera	40	25.0	48	6.3	6	3.8	49	5.8	41	2.5	36	2.5	37	2.7
Coleoptera	10	14.7	7	0.8	3	0.1	17	1.3	13	0.4	8	0.6	3	0.6
Trichoptera							6	0.9	5	0.5	2	0.3	1	0.1
Odonata	10	1.5							1	0.4	4	2.6	6	2.0
Hymenoptera	10	0.1	11	1.8	3	0.1			2	0.2			2	0.1
Ephemeroptera	10	1.3	11	0.2					5	0.4	2	0.2	4	0.2
Amphipoda			11	10.6	35	6.1	14	10.6	4	0.6	8	1.5	9	3.6
Cladocera			15	19.9	32	26.3	9	8.2	17	11.8	20	14.4	11	2.7
Decopoda			4	3.1			6	8.1	5	3.8	5	2.5	10	4.4
Gastropoda	10	1.0			3	0.1	3	0.7	8	0.7	7	0.2	5	0.7
Oligochaeta							9	3.8	7	2.1	4	1.5	6	5.2
Miscellaneous[a]	10	1.0	11	1.3	16	1.5	34	2.8	33	5.1	19	0.6	16	1.5

	Inch Group*													
	10		11		12		13		14		15		16+	
Food Category	% Freq.	% Tot. Vol.	% Freq.	% Tot. Vol.	% Freq.	% Tot. Vol.	% Freq.	% Tot. Vol.	% Freq.	% Tot. Vol.	% Freq.	% Tot. Vol.	% Freq.	% Tot. Vol.
Fish	46	61.2	43	48.6	36	48.5	42	32.6	56	50.8	75	86.4	71	95.7
Diptera	52	9.8	47	7.4	60	41.1	67	58.5	38	40.5	25	1.4	14	2.8
Hemiptera	38	1.4	50	4.4	28	0.3	18	0.3	13	0.2			14	0.2
Coleoptera	2	0.1	7	0.3			3	0.1	6	0.3				
Trichoptera							3	0.4						
Odonata	1	0.4	7	0.7	4	0.7	18	3.4	13	7.7				
Hymenoptera	2	0.7	4	0.2										
Ephemeroptera	2	0.1												
Amphipoda	10	3.7	10	1.7										
Cladocera	7	1.8	13	25.8	4	0.3								
Decopoda	11	12.8	13	9.7	8	7.7			6	0.3				
Gastropoda	6	0.1									25	12.2		
Oligochaeta	10	5.9					6	1.2					14	0.9
Miscellaneous*	15	2.1	10	1.2	8	1.4	21	3.5	6	0.2			14	0.4

*Although 694 brook trout stomachs contained food, the lengths of 12 of those was not recorded.
**Sample sizes were 10, 27, 31, 35, 76, 129, and 157 (inch groups 3-9); and 102, 30, 25, 33, 16, 4, and 7 (inch groups 10-16+), respectively.
[a]Unidentified invertebrate parts and vegetation.

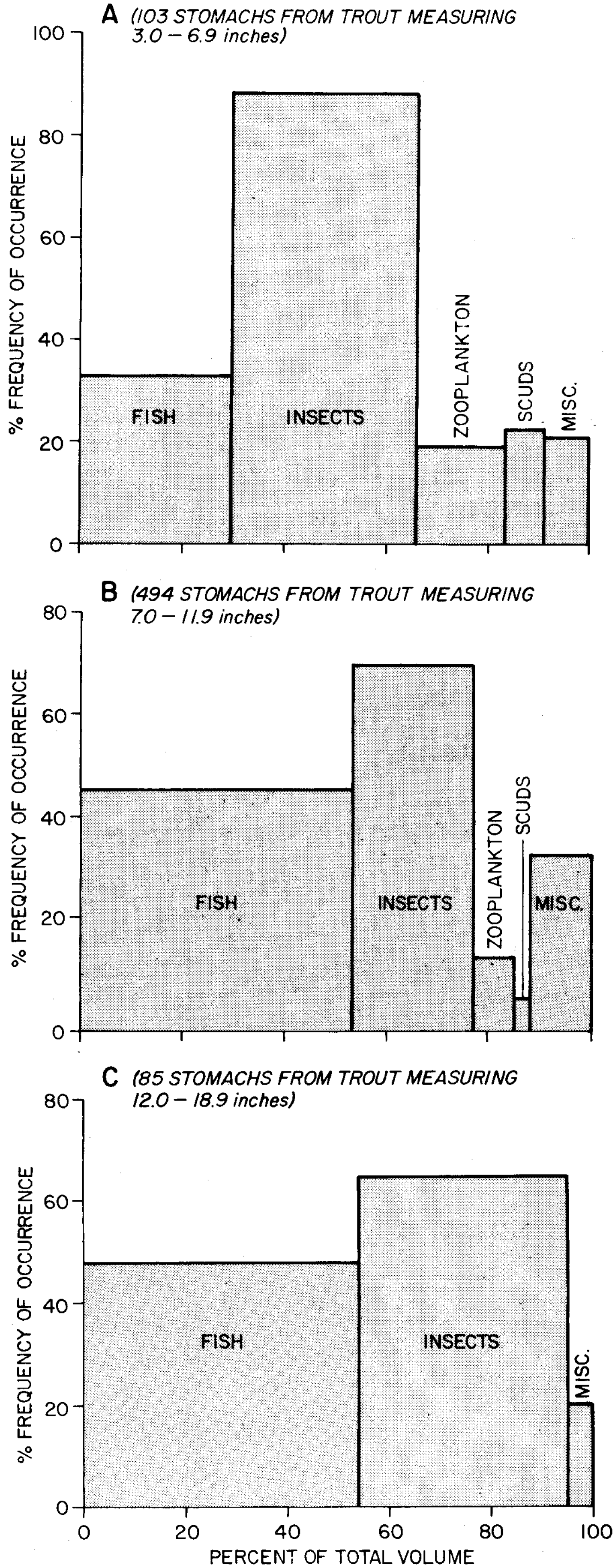

FIGURE 1. Contributions of five categories of food items to the diets of three size groups of brook trout in McGee Lake during 1980-82.

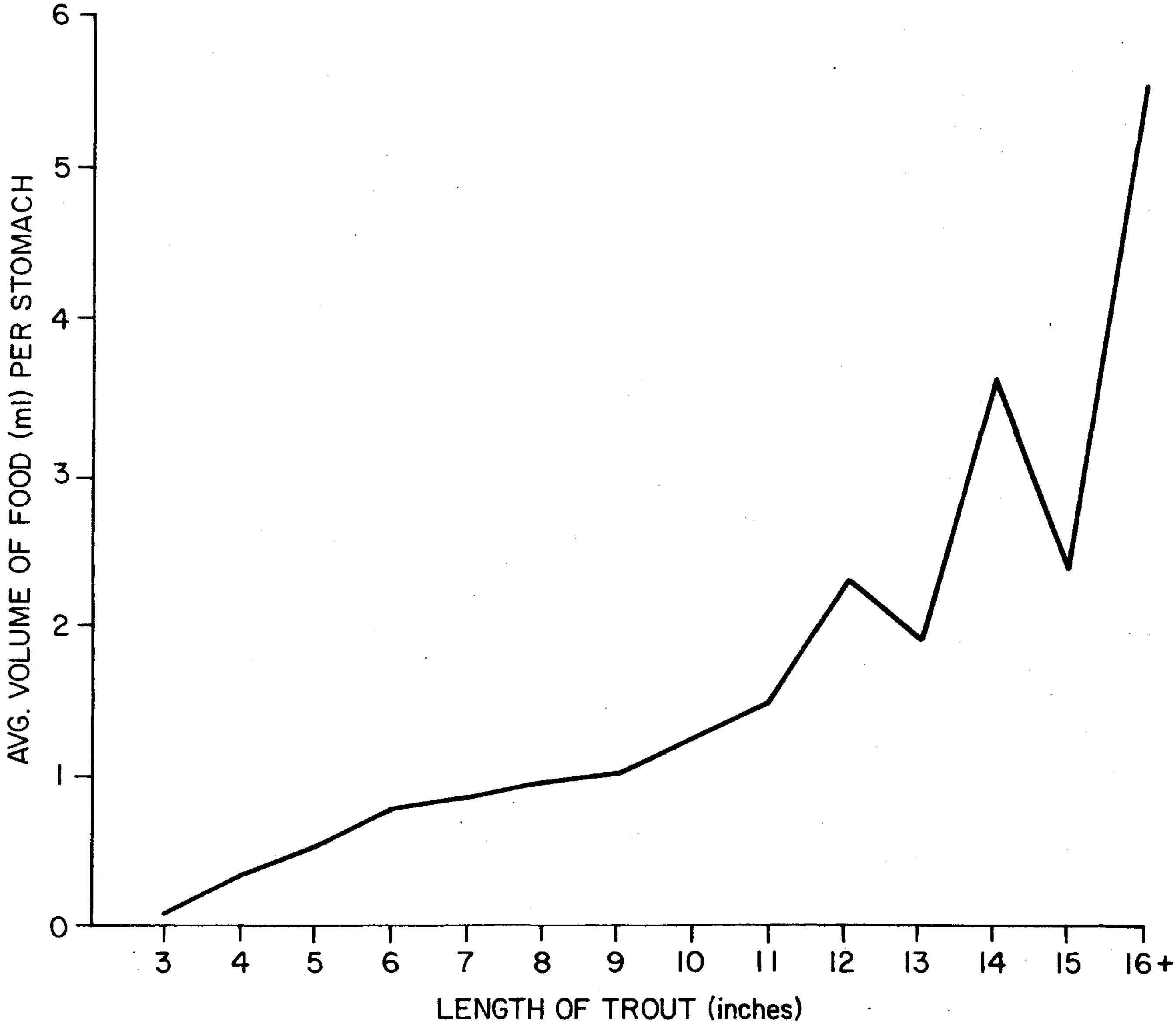

FIGURE 2. Average food volume/stomach vs total length for brook trout in McGee Lake collected during April-October, 1980-82.*

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*Based on 745 stomachs.

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