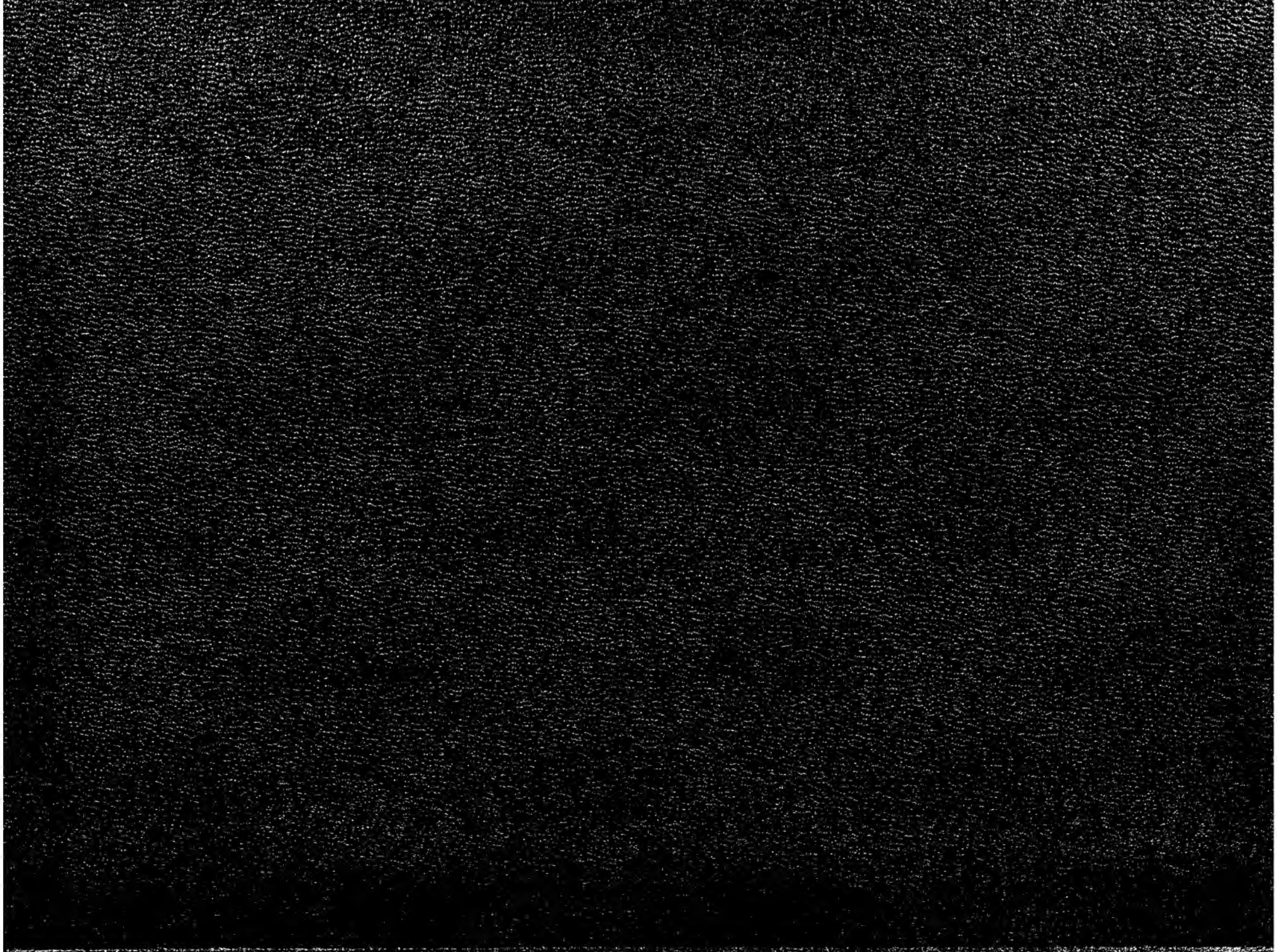

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COMPARATIVE FOOD HABITS OF BROOK TROUT (SALVELINUS FONTINALIS) AND BURBOT (LOTA LOTA) IN THE FOX RIVER, MICHIGAN

by
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A thesis submitted in partial fulfillment of
the requirements for the degree
of Master of Science
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INTRODUCTION

The interactions between an organism and its environment are exceedingly complex. A more thorough understanding of these interactions than in existence now, with detailed information on food habits and feeding habits, intraspecies competition, and other ecological aspects, will enable us to manage our sport fishery resource with better foresight and intelligence.

The purposes of this study are to investigate the food habits of a sample population of brook trout, Salvelinus fontinalis (Mitchill), and burbot, Lota lota lacustris (Walbaum), from a Michigan trout stream, and to determine whether there is evidence of overlap as to the organisms utilized as food by the two species.

Literature

Brook Trout

The food habits of the brook trout are well known, both in lakes and streams. Clemens (1928) gave an excellent review of the early literature on this subject. Metzelaar (1929), Ricker (1930), and Ide (1942), along with Clemens, all noted the changes in the food relationships of stream fish with an increase in size. Clemens (op.cit.), Lord (1933), and Needham (1930, 1938), observed the relative importance of aquatic and terrestrial forms in the diet of stream fish. Churchill (1944) noted that taste alone has an important influence upon the diet. Rawson (1941) and Cooper (1941) reported upon the feeding habits of brook trout in lakes. Hankinson (1922), Hazzard (1932),

and Schaeperclaus (1933) made important contributions to the knowledge of the life history and ecology of this sport fish.

Burbot

Much of the literature concerning food of the burbot deals with fish of a large size taken from lakes. Robins and Deubler (1955) presented what they believed to be a near exhaustive bibliography on the subject. VanOosten and Deason (1938), Rjorn (1939), and Clemens (1951) all worked on lake fish. Markun (1936), Robins and Deubler (1955), Whalls and Shetter (1956), and Beeton (1956) published information on the food habits of the smaller burbot in streams.

Collections

The trout and burbot that I examined were from collections made by the Institute for Fisheries Research, Michigan Department of Conservation, between October 5 and 8, 1952. The collections are described in an Institute Report by Dr. Gerald P. Cooper (1954). The fish were taken with both A-C and D-C shockers at eleven stations on the Fox River and on its East Branch, both a part of the Manistique River drainage system in Schoolcraft County, Michigan (Figure 1). Table I contains a summary of these collections.

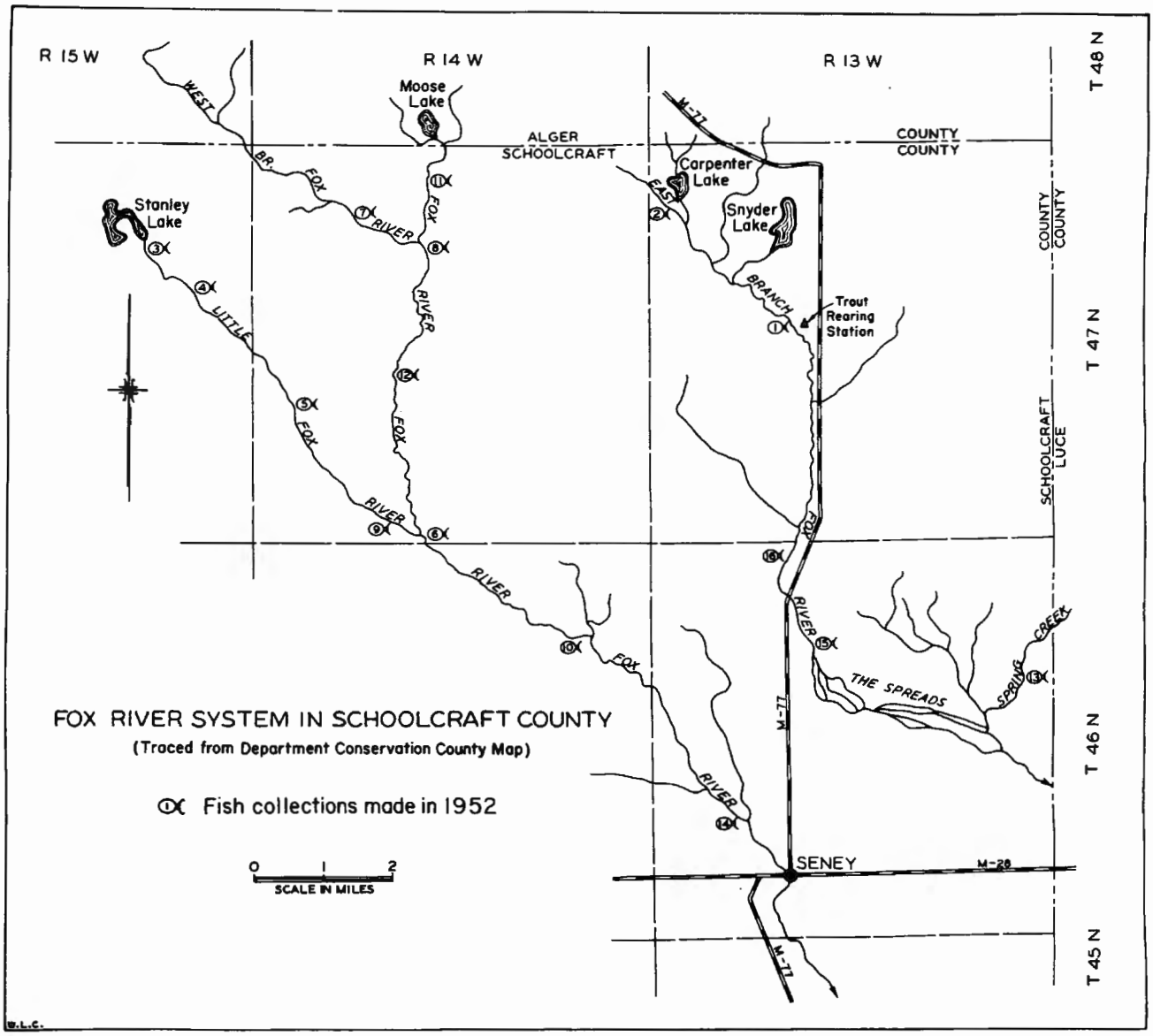

FIGURE 1. Map of Fox River system showing the locations of 11 fish collection stations. (From Cooper, 1954.)

TABLE I

SUMMARY OF SPECIMENS COLLECTED (AND ANALYZED FOR FOOD), ALL FROM FOX RIVER SYSTEM, MICHIGAN, OCTOBER 5-8, 1952.

Station number	Total number of fish collected		Total number examined		Number examined containing food	
	Trout	Burbot	Trout	Burbot	Trout	Burbot
FR-3	0	11	0	11	0	11
FR-4	15	6	15	6	15	4
FR-6	13	2	10	2	10	2
FR-7	0	1	0	1	0	1
FR-8	6	7	6	7	5	6
FR-10	19	11	11	11	11	10
FR-11	11	1	10	1	10	0
FR-12	22	12	0	12	0	11
FR-14	0	7	0	7	0	6
FR-15	4	3	4	3	4	2
FR-16	26	1	26	1	25	1
Total	116	62	82	62	80	53

POPULATION DESCRIPTION

Selective Collection Methods

Since the collection did not contain trout of more than two year-classes the fish were not divided into size-groups. It is realized that the food relationships of the trout (Clemens, 1928) and the burbot (Beeton, 1956) change with age, and this fact is taken into account in considering the relationships involved.

The two species are to be considered as a sample population, and any conclusions drawn can then apply only to this model population. It is not a random sample. Haskell (1954) stated that since it requires the same voltage on the fish to stun a large fish as a small one, a large fish, because of its greater length, may be stunned with an electrode-to-electrode voltage too low to affect a small fish. Further, Haskell (1940) did not consider shocking effective for fish under three inches, due to the difficulty in seeing them when they are stunned. Lord (1933) questioned whether shocking catches feeding and non-feeding fish without discrimination. Thus it is likely that the various age-groups present were not sampled with equal frequency.

Length Frequency Distribution

Trout

Age determinations based on scales were made by the Institute for Fisheries Research on all of the 231 brook trout originally collected. The 82 trout that I examined are all in age-groups 0 and I. The 0-trout averaged 3.8 inches and ranged from 2.7 to 4.9 inches.

The L-trout averaged 6.1 inches and ranged from 4.4 to 8.2 inches.

Burbot

The burbot were not aged. If the length frequency distribution is compared to that of Robins and Deubler (1955) it would appear that the bulk of the Fox River burbot were yearlings, ranging from 5.0 to 8.0 inches (46 fish); the next larger group, ranging from 8.0 to 10.0 inches (12 fish), correspond to Robins' two-year olds. Four burbot exceeded 10.0 inches in length and presumably were older than two years of age. These ranges also compare favorably to those of Martin (1941) for burbot in Ontario waters.

Sex Ratio and Maturity

Brook Trout

The sex and the condition of the gonads were recorded for each fish examined. Of the 82 trout sexed, 32 (46 per cent) were males and 37 (54 per cent) were females; for 13 the sex was not determined. Hazzard (1932) stated that brook trout spawn for the first time at the end of their second year of life, and then the females produce few eggs. Among the Fox River trout, 7 males of 4.5 inches and larger, belonging to age-group I, appeared to be mature; four females of this group were likely ready to spawn. Apparently the remainder, or a total of 71 fish, were immature.

Burbot

Of the fish sexed, 27 (44 per cent) were males, leaving 34 females (56 per cent) and 1 fish undetermined. All of the females over 6.5 inches (166 mm.) were mature, whereas all of those under 5.9 inches (150 mm.) were immature. The males were maturing between 5.9 and 7.0 inches (150 to 180 mm.), with all of those over 7.0 inches mature. If these stream burbot are comparable in age to those that Robins and Deubler (1955) examined, these again would be yearlings. This is in sharp contrast to the findings of Clemens (1951) to the effect that in Lake Erie the burbot became sexually mature in their third and fourth years of life when they ranged from 340 to 440 mm. in length. Robins and Deubler (1955) found that the growth in a creek population fell well behind that of a lake population, and that the creek dwellers did not mature until their third year, at a mean standard length of 9.2 inches (234.7 mm.).

Thus we are here considering a sample population composed of brook trout of two year classes and of burbot of two or more year classes, both of two stages of sexual maturity.

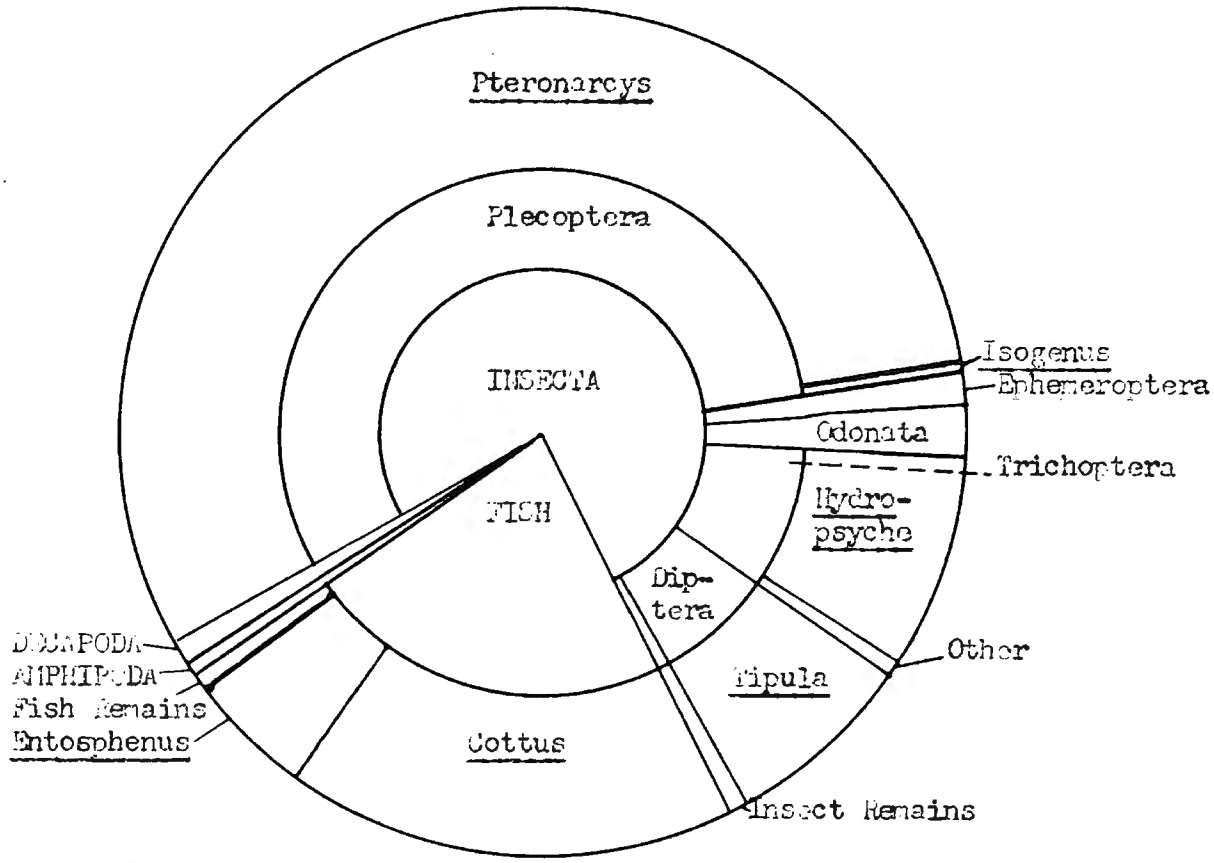

FIGURE 2a. Percentage composition of the food by observed volume, of the burbot in the Fox River.

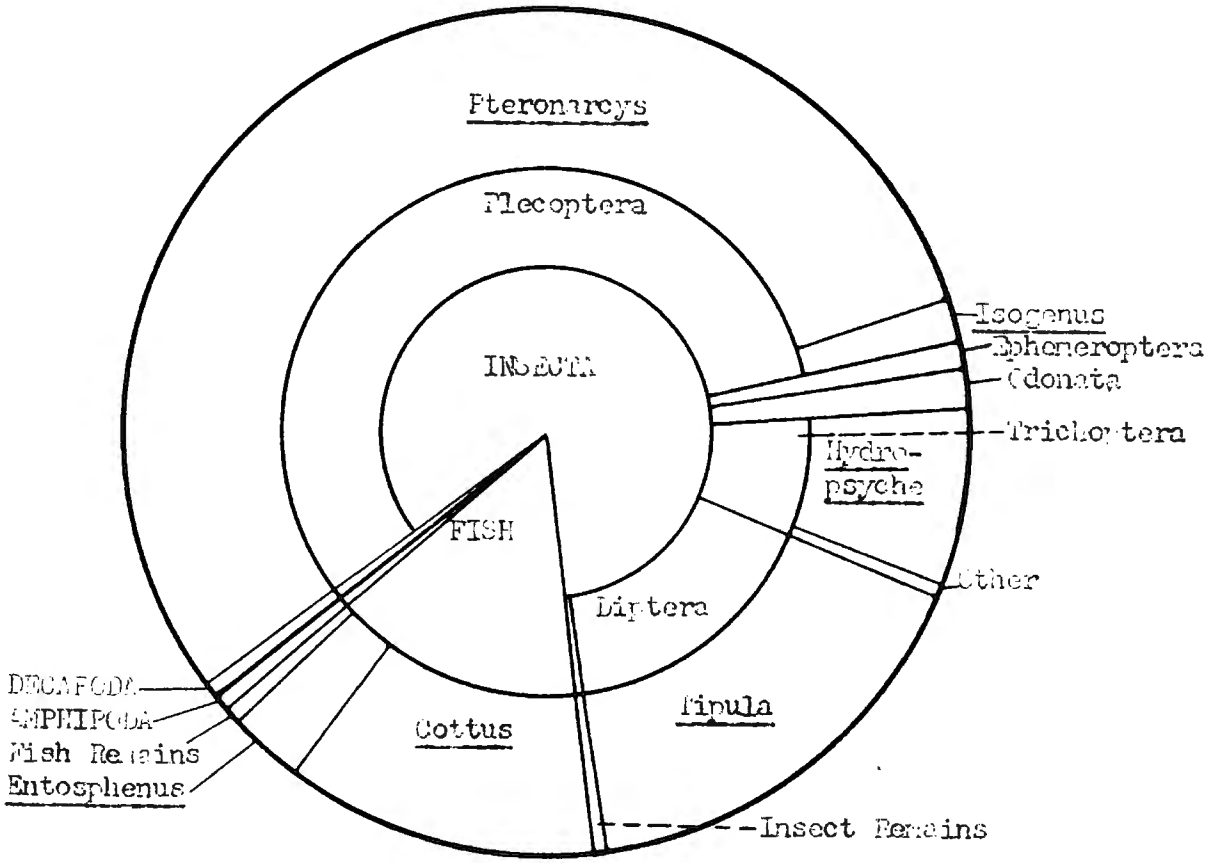

FIGURE 2b. Percentage composition of the food by restored volume, of the burbot in the Fox River.

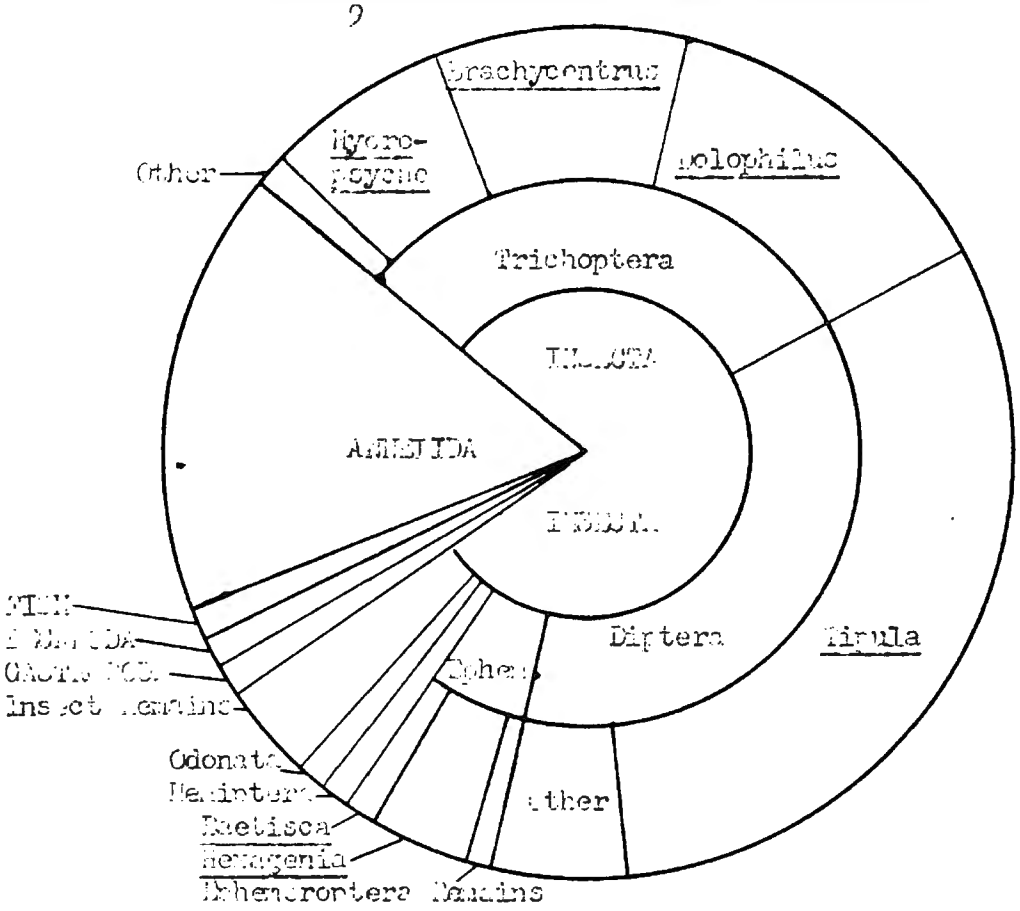

FIGURE 3a. Percentage composition of the food by observed volume, of the brook trout in the Fox River.

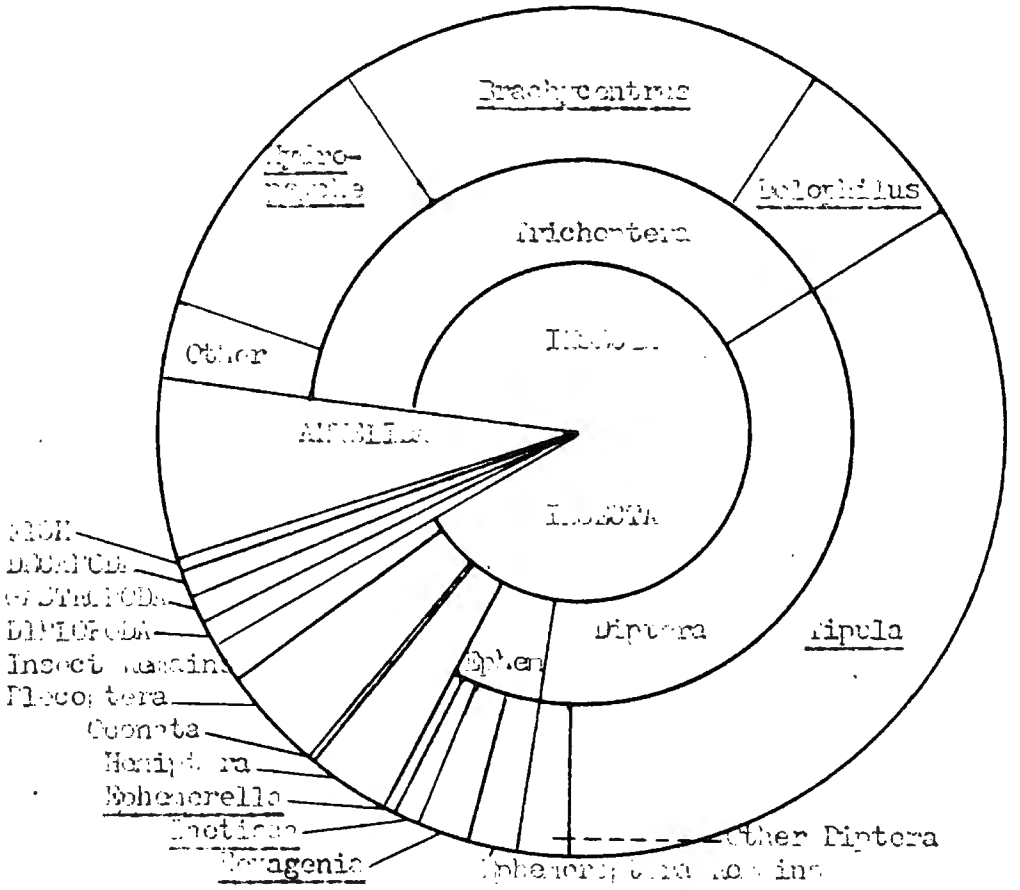

FIGURE 3b. Percentage composition of the food by restored volume, of the brook trout in the Fox River.

FOOD HABITS

Methods of Analysis

The methods employed are those described by Lagler (1956) for the study of food habits. The stomach contents only were analyzed, along with any material still in the esophagus. Upon opening each stomach, its condition, or degree of fullness relative to size, was estimated. The stomach of the burbot is tremendously distensible (Fish, 1930) and I did not feel justified in estimating the maximum distension possible. Thus the maximum employed, (i.e., the "full" condition), was that found in the most extended stomach encountered in this study.

Four basic methods were employed in the analysis: numerical, observed volumetric, reconstructed volumetric, and frequency of occurrence. Each index has obvious limitations. We must keep in mind that the food relationships pictured by these methods apply only to this sample population at the time the specimens were collected. In nature the picture is one of continual change.

Numerical method

Cooper (1941) noted that the number of food organisms is presumably the better index of the amount of effort on the part of the fish in seeking and capturing its food, while the volume of the food is presumably the better index of the amount of benefit which the fish obtains from it. It is also at least somewhat indicative of the availability of the organisms and is of value in estimating the effects of predation on them.

Volumetric method

Both observed and restored volumes were computed. For such organisms as the caddis, Hydropsyche, the restored volume is likely more indicative of the true importance than the observed volume. For example, this caddis was usually entire in numbers of 5 or less in 30 of 35 trout stomachs; always in trace amounts. Since about 6 of these are equivalent to 0.1 c.c. they were just under the minimum volume recorded in each instance, thus distorting slightly the final volume picture. The caddis, Dolophilus, on the other hand, has a head capsule which resists digestion, and the reconstruction of this form then gives a value that is too large for best indication of the organisms value as food.

Frequency of occurrence method

As in the reconstruction method, the many persisting hard parts, especially in the brook trout stomachs, may lead to distortion of the final results. The actual contents of the stomachs may represent an accumulation of certain hard parts from several feedings. Thus the averages obtained simply cannot be regarded as a typical "meal". In effect, they only describe what was found.

Condition of Stomachs

The burbot stomachs averaged 0.3 full, whereas the trout stomachs averaged 0.5 of estimated capacity. The fish had been preserved immediately after collection and the stomachs were in excellent condition. The burbot swallows its food whole (Fish,1930),

and most items were thus easily identified. Digestion is slow in the burbot, taking up to 48 hours (Robins and Deubler, 1955), and this fact, along with low water temperature and reduced metabolism, may account for the excellent condition of, and low volume of contents in these stomachs.

It should be noted that the trout were collected at the beginning of the spawning season. Lord (1933) felt that sexual excitement slowed feeding at this time. Needham (1930) stated that lowered water temperature and not sexual excitement was the cause. However, 9 (14.6 per cent) of the 62 burbot stomachs were void and only 2 or 2.4 per cent of the 82 trout stomachs were empty. Beeton (1956) found 14.2 per cent of the burbot stomachs collected from streams during August to be void.

Composition

Brook Trout

The foods of the trout and burbot are summarized in Tables 2 and 3 and in Figures 2 and 3. The most important foods eaten by the trout were caddisflies (Trichoptera), two-winged flies (Diptera), and mayflies (Ephemeroptera). Although the mayflies occurred in slightly greater numbers and more frequently than the Diptera, they composed much less of the total volume. The large crane fly larvae of the genus Tipula, which occurred in 21.3 per cent of the trout, were responsible for all but 0.4 c.c. of the total dipteran volume, the remainder of which was composed of small adult flies. Brachycentrus and Hydropsyche were the most important caddisflies.

TABLE 2. FOOD OF THE BURBOT (LOTA LOTA LACUSTRIS) IN THE FOX RIVER. Based on 53 specimens containing 21.5 c.c. of food. Oct. 5-8, 1952. Length, 134-291 mm.

FOOD ITEM I=larva, N=nymphs, A=adults	Number of ind. each	Comp. by vol. obser.	%Comp. by vol. obser.	Comp. by vol. rest.	%Comp. by vol. rest.	No. Fish cont. each	%Freq. occur.
DIPLOPODA	1	Tr.	...	Tr.	...	1	1.9
NEMATODA[1]	2	Tr.	...	Tr.	...	1	1.9
ANNELIDA	0	...	...	...	...	...	...
AMPHIPODA	23	0.1	0.5	0.2	0.6	4	7.6
DECAPODA	1	0.2	0.9	0.2	0.6	1	1.9
HYDRACARINA	0	...	...	...	...	...	...
INSECTA	296	16.3	75.8	27.7	83.2	51	96.2
Plecoptera	60	12.0	55.8	18.8	56.5	21	39.6
Pteronarcidae .							
Pteronarcys(N)	32	11.7	54.4	18.2	54.7	17	32.1
Perlodidae.....							
Isogenus (N).	28	0.3	1.4	0.6	1.8	8	15.1
Ephemeroptera...	54	0.3	1.4	0.4	1.2	19	35.9
Ephemeridae ...							
Hexagenia (N)	1	0.2	0.9	0.2	0.6	1	1.9
Baetidae	36	0.1	0.5	0.2	0.6	9	17.0
Baetisca (N).	8	0.1	0.5	0.2	0.6	2	3.8
Ephemerella (N)	1	Tr.	...	Tr.	...	1	1.9
Other (N) ...	27	Tr.	...	Tr.	...	6	11.3
Heptageniidae..	13	Tr.	...	Tr.	...	6	11.3
Heptagenia (N)	11	Tr.	...	Tr.	...	4	7.6
Other (N) ...	2	Tr.	...	Tr.	...	2	3.8
Ephem.Remains(N,A)	4	Tr.	...	Tr.	...	3	5.7
Odonata	4	0.4	1.9	0.5	1.5	4	7.6
Zygoptera (N)..	3	Tr.	...	0.1	0.3	3	5.7
Anisoptera (N).	1	0.4	1.9	0.4	1.2	1	1.9
Hemiptera	0	...	...	...	...	...	...
Corixidae (A)..	0	...	...	...	...	...	...
Other (A)	0	...	...	...	...	...	...
Hymenoptera	0	...	...	...	...	...	...
Trichoptera (L).	142	1.9	8.8	2.4	7.2	31	58.5
Hydropsychidae.							
Hydropsyche(L)	124	1.8	8.4	2.3	6.9	20	37.7
Brachycentridae							
Brachycentrus(L)	0	...	...	...	...	...	...
Philopotamidae .							
Dolophilus (L)	6	Tr.	...	Tr.	...	5	9.4
Other Trichop.(L)	12	0.1	0.5	0.1	0.3	8	15.1
Coleoptera	1	Tr.	...	Tr.	...	1	1.9
Diptera	32	1.6	7.4	5.5	16.5	20	37.7
Tipulidae	20	1.6	7.4	5.5	16.5	10	18.9
Tipula (L) ..	20	1.6	7.4	5.5	16.5	10	18.9
Other	0	...	...	...	...	...	...
Ceratopogonidae	4	Tr.	...	Tr.	...	3	5.7
Tendipedidae (L)	6	Tr.	...	Tr.	...	6	11.3
Other (A).....	2	Tr.	...	Tr.	...	2	3.8
Insect Remains .	3	0.1	0.5	0.1	0.3	3	5.7
GASTROPODA	0	...	...	...	...	...	...
FISH	13	4.9	22.8	5.2	15.6	11	20.8
Petromyzontidae[2]	5	1.0	4.7	1.0	3.0	4	7.6
Salmonid Eggs ..	0	...	...	...	...	...	...
Cottidae[3]	6	3.7	17.2	4.0	12.0	6	11.3
Fish Remains ...	2	0.2	0.9	0.2	0.6	2	3.8
TOTAL	336	21.5	100.0	33.3	100.0		

1. Metastrongylus (L)
2. Entosphemus lamotteni
3. Cottus bairdi

TABLE 3. FOOD OF THE BROOK TROUT (SALVELINUS FONTINALIS) IN THE FOX RIVER.
Based on 80 specimens containing 8.3 c.c. of food. Oct. 5-8, 1952. Length 75-177 mm.

FOOD ITEM L=larva, N=nymphs A=adults	Number of ind. each	Comp. by vol. observ.	%Comp. by vol. obser.	Comp. by vol. rest.	%Comp. by vol. rest.	No.fish cont. each	%Freq. occur.
DIPLOPODA	4	Tr.	...	0.2	1.0	3	3.8
NEMATODA[1]	6	Tr.	...	Tr.	...	6	7.5
ANNELIDA	13	1.4	16.9	1.4	6.9	11	15.0
AMPHIPODA	4	Tr.	...	Tr.	...	3	3.8
DECAPODA	1	0.1	1.2	0.2	1.0	1	1.3
HYDRACARINA	7	Tr.	...	Tr.	...	3	3.8
INSECTA	1029	6.6	79.5	18.1	89.6	78	97.5
Plecoptera	7	Tr.	...	0.8	4.0	6	7.5
Pteronarcidae							
Pteronarcys (N) .	1	Tr.	...	0.6	3.0	1	1.3
Perlodidae							
Isogenus (N).....	6	Tr.	...	0.2	1.0	5	6.3
Ephemeroptera	119	0.5	6.0	1.1	5.4	38	47.5
Ephemeridae							
Hexagenia (N).....	2	0.3	3.6	0.4	2.0	2	2.5
Baetidae.....	58	0.1	1.2	0.3	1.5	19	23.8
Baetisca (N)	11	0.1	1.2	0.2	1.0	5	5.3
Ephemerella (N)..	38	Tr.	...	0.1	0.5	9	11.3
Other (N)	9	Tr.	...	Tr.	...	6	7.5
Heptageniidae	5	Tr.	...	Tr.	...	4	5.0
Heptagenia (N)...	2	Tr.	...	Tr.	...	2	2.5
Other (N).....	3	Tr.	...	Tr.	...	2	2.5
Ephem. Remains(N,A)	54	0.1	1.2	0.4	2.0	19	23.8
Odonata	2	0.1	1.2	0.1	0.5	2	2.5
Zygoptera (N).....	2	0.1	1.2	0.1	0.5	2	2.5
Anisoptera (N).....	0	...	...	...	...	...	...
Hemiptera	46	0.1	1.2	0.6	3.0	22	27.5
Corixidae (A)	32	0.1	1.2	0.6	3.0	20	25.0
Other (A).....	14	Tr.	...	Tr.	...	5	6.3
Hymenoptera (A)	8	Tr.	...	Tr.	...	3	3.8
Trichoptera (L)	700	2.6	31.3	7.9	39.1	70	87.5
Hydropsychidae							
Hydropsyche (L) .	115	0.6	7.2	2.2	10.9	35	43.8
Brachycentridae ...							
Brachycentrus (L)	179	0.8	9.6	3.8	18.8	41	51.3
Philopotamidae							
Dolophilus (L)...	301	1.1	13.3	1.4	6.9	18	22.5
Other Trichop.(L)..	105	0.1	1.2	0.5	2.5	41	51.3
Coleoptera (L,A) ...	8	Tr.	...	Tr.	...	7	8.8
Diptera	101	3.0	36.1	7.3	36.1	35	43.8
Tipulidae	27	2.6	31.3	6.9	34.2	19	23.8
Tipula (L)	25	2.6	31.3	6.9	34.2	17	21.3
Other	2	Tr.	...	Tr.	...	2	2.5
Ceratopoginidae (L)	3	Tr.	...	Tr.	...	2	2.5
Tendipedidae (L)...	3	Tr.	...	Tr.	...	3	3.8
Other (A)	68	0.4	4.8	0.4	2.0	18	22.5
Insect Remains	38	0.3	3.6	0.3	1.5	20	25.0
GASTROPODA	7	0.1	1.2	0.2	1.0	5	6.3
FISH	7	0.1	1.2	0.1	0.5	4	5.0
Petromyzontidae[2]	...	...	...	...	...	...	...
Salmonid Eggs	7	0.1	1.2	0.1	0.5	4	5.0
Cottidae[3]	...	...	...	...	...	...	...
Fish Remains	...	...	...	...	...	...	...
TOTAL	1078	8.3	100.0	20.2	100.0		

1. Metastrongylus (L)
2. Entosphenus lamotteni
3. Cottus bairdi

The occurrence of Dolophilus in large numbers of 124, 71, and 45, in three trout belie the importance of this genus.

Other than the insects there was little of importance. A small number (13) of earthworms gave the annelids a combined total of 16.9 per cent of the volume. A number of snails (Gastropoda) and salmonid eggs, along with a few larval roundworms, millipeds, scuds, crayfish, and water mites complete the list. These same conclusions are born out by the reconstructed volumes.

It should be noted here that in general these trout depended upon a large number of small insects, mainly aquatic larvae, for their food. Clemens (1928) found that aquatic forms are the only food taken during late autumn. The above findings compared favorably with those of Needham (1930, 1938) and Lord (1933).

Burbot

Whereas the trout depended mainly upon small forms, the burbot in this population utilized a few large forms. The insects made up almost the same volume as in the brook trout, 75.8 per cent as opposed to 79.5 per cent, and occurred with about the same frequency, 96.2 per cent as against 97.5 per cent. The most important groups were Plecoptera, Trichoptera, Diptera, and Ephemeroptera. The stoneflies were responsible for 55.8 per cent of the total volume but occurred in only 39.6 per cent of the individuals, due to the fact that most of their volume is made up of a large nymph of the genus Pteronarcys. The caddisflies were again selected the most often and occurred in 58.5 per cent of the

burbot, but their volume was responsible for only 8.8 per cent of the total. Here, in the case of the Diptera, the reconstructed volume was very useful, indicating that possibly the Diptera should have been elevated to second place behind the stoneflies as far as their volume contribution was concerned. However, the soft-bodied tipulid larvae occurred in only 18.9 per cent of the burbot and thus such a move was not justified.

Aside from the insects, the fish were of major importance. While sculpins (Cottus) were found in only 11.3 per cent of the burbot, they were not restricted to the larger specimens as might be expected. Two were found in 6.0 to 7.0 inch fish, three in the 8.0 to 9.0 inch group and only one in a burbot of greater than 10.0 inches. However, since most of the burbot were under 8.0 inches in length, the sculpins actually appeared more frequently in larger specimens than in the smaller ones.

It was noted that the 62 burbot collected contained only 5 ammocetes of the American brook lamprey, Entosphenus lamotteni. If we figure the catch per hour of shocking (from Table 2, Cooper, 1954) we find that 4.6 burbot were collected per hour as opposed to 28.1 ammocetes. Thus the burbot either were not selecting this form or it was not readily available to them. Whalls and Shetter (1956) found that the ammocetes of the Michigan brook lamprey made up about 68 per cent of the volume in the food of the stream burbot 10.0 inches in length and larger. Metzelaar (1929) observed that brook trout do not feed on lamprey eels.?

Beeton (1956) found the Amphipoda or scuds to be of major importance to the burbot of all sizes. Schaeperclaus (1933) felt that the abundance of trout in brooks quite often depended upon this organism. In the Fox River system, scuds were only of minor value to both trout and burbot, along with the millipeds, roundworms, and water mites.

Evidence of Overlap in Food Habits

The fact that the particle size in part determines the availability of different organisms to the trout and burbot was well documented in the literature. The food preferences of brook trout and burbot may well differ, as illustrated by the selection of the caddis, Brachycentrus, by the brook trout. This same caddis was either rejected by or not available to the burbot. Thus in looking for evidence of overlap in the food habits of the two fish we must work at the lowest taxonomic level represented in our data.

As evidenced in Table 4, eight genera of insects were common to both the trout and burbot stomachs, but only the four genera occurring in 5 per cent or more of both fish were considered.

TABLE 4

FOOD ITEMS THAT OCCUR IN MORE THAN 5 PER CENT OF BOTH TROUT AND BURBOT CONTAINING FOOD

	Brook trout (80)			Burbot (53)		
	No.	%Vol.	%Freq.	No.	%Vol.	%Freq.
Hydropsyche	115	8.4	43.8	124	8.4	37.7
Tipula	25	31.3	21.3	20	7.4	18.9
Isogenus	6	Tr.	6.3	28	1.4	15.1
Dolophilus	301	13.3	22.5	6	Tr.	9.4
Total	447	53.0	60.0	178	17.2	62.0

The above analysis shows that the observed overlap in the food of the two populations is concerned with 4 food organisms. These organisms are selected more readily by the trout. They also provide a considerably greater share of the food of the trout, on a volume basis, than of the burbot. It is interesting to note that about 60 per cent of each of these sample populations utilize one or more of the above organisms.

FEEDING HABITS

In describing the various collection stations on the Fox, Cooper (1954) noted that food organisms were abundant only in limited muddy areas along stream banks or in silt beds behind deflectors, and that about half of all trout and burbot collected came from the later installations. At nine of eleven stations the bottom was composed of from 75 to 98 per cent shifting sand, one of the least productive of bottom types (Needham, 1938), whereas gravel constituted only 0 to 15 per cent of the bottom (Fish Collection Records, Inst. Fish. Res.).

The presence of Tipula (which often occurs in organic mud), Ephemerella (which is restricted to quiet backwaters of streams), and Hexagenia (a burrowing mayfly usually found in up to 5 cm. of mud - Pennak, 1953) indicates that both the trout and burbot frequent muddy areas to feed. However, the presence of the mayfly nymph, Baetisca obesa, which develops in cool, fairly rapid water (Burks, 1953), indicates that both species also feed in other zones.

GROWTH AND CARRYING CAPACITY

The following information from Cooper (1954) is of importance in obtaining a more complete understanding of the relationships that exist between the trout and burbot of the Fox River.

1) As compared to state-wide averages, 0-trout from the Fox were somewhat larger, while I-trout were about the same.

2) It is possible that the trout-carrying capacity of the main Fox and the Little Fox is partly taken over by the burbot.

DISCUSSION AND SUMMARY

Errington (1937) stated that the interrelationships of predation are exceedingly complex and variable, and as to how much they will ever be understood is problematical. Lagler (1944) noted that competition designates a contest between two or more organisms for one and the same thing, such as food or space in the case of fish, but that overlap in food habits is not alone evidence of such competition.

A number of authors have described the burbot as a competitor of both the lake trout and the brook trout, including VanOosten and Deason (1938), Clemens (1951), Robins and Deubler (1955), and Martin (1941). In each case an overlap in food habits has been the basis for such a conclusion.

The lack of an index to availability in this study would constitute a valid basis for criticism were it concluded that the brook trout and burbot were competitors for food in the Fox River. An overlap has been shown in the food habits of these two fish. We might well assume that the overlap might be increased if fish of the same age class or size were compared instead of two sample populations that rely on food organisms of very different size for the bulk of their food. Due to the unproductive nature of the stream bed, the burbot and trout may both feed in somewhat close quarters. All of these factors might be interpreted as indicative of competition between the trout and burbot if the growth was less than average for the region. It is above average, thus food is not likely the main limiting factor in the growth of this sample population.

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