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FOOD HABITS OF THIRTEEN SPECIES OF FISH FROM THE IMPACTED ZONE OF CANAGAGIGUE CREEK, ONTARIO

J.L. Metcalfe

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Environmental Contaminants Division
National Water Research Institute
Canada Centre for Inland Waters
Burlington, Ontario, Canada L7R 4A6

• Environment Canada

MANAGEMENT PERSPECTIVE

The bioaccumulation of contaminants by fish frequently occurs via the food chain. In order to determine the importance of this route, and to identify the components responsible, the food habits of the fish must be known in some detail. This report describes the food habits of 13 species of fish from the impacted zone of Canagagigue Creek, an industrially polluted creek in southern Ontario. The information will be used, in conjunction with data on contaminant concentrations in fish and their prey, to determine whether diet composition has any bearing on the body burdens of contaminants in Cananagagigue Creek fish. On a broader scope, we have demonstrated that the diets of fish vary considerably with season, geographic location and quality of the environment. As a result, we strongly recommend that food habits analysis should be an integral part of any food chain contamination study.

EN BREF

La bioaccumulation des contaminants par les poissons se fait souvent via la chaîne alimentaire. Afin de déterminer l'importance de cette voie, ainsi que d'identifier les composants responsables, il faut connaître avec une certaine précision les habitudes alimentaires. Le présent rapport décrit les habitudes alimentaires de 13 espèces de poissons de la zone touchée du ruisseau Canagagigue, un ruisseau pollué par l'industrie dans le sud de l'Ontario. Cette information sera étudiée, conjointement à des données sur les concentrations de contaminants dans les poissons et leurs proies, pour déterminer si la composition du régime alimentaire a un impact sur les charges corporelles de contaminants dans les poissons du ruisseau Canagagigue. A une échelle plus importante, nous avons démontré que les régimes alimentaires des poissons varient considérablement selon la saison, l'emplacement géographique et la qualité de l'environnement. Par conséquent, nous recommandons avec instance que l'analyse des habitudes alimentaires devienne une partie intégrante de toute étude de contamination de la chaîne alimentaire.

EXECUTIVE SUMMARY

In 1983, a study was undertaken to assess the importance of the food pathway as a route of uptake for contaminants by Canagagigue Creek fish. As part of the study, the food habits of 13 species of fish from the impacted zone of this industrially polluted creek were described by means of gut contents analysis. A total of 143 specimens were examined, 61 of which were collected in the spring and 82 in the fall. The species involved were: White Sucker, Shorthead Redhorse, Carp, Longnose Dace, Blacknose Dace, Creek Chub, Fathead Minnow, Bluntnose Minnow, Common Shiner, Johnny Darter, Rock Bass, Smallmouth Bass and Brook Stickleback.

Most fish species were non-selective in their food habits, and adapted readily to seasonal changes in the availability of prey. Fish collected in the spring preyed heavily on blackfly larvae, chironomid larvae and leeches. In contrast, fish collected in the fall relied less on these three items but utilized damselfly nymphs, water boatmen and plants much more significantly. These changes in diet composition reflected changes in the benthic community structure over the same time period. A wider range of prey was available in the fall, and this enabled fish to feed more selectively during this season. As a result, there was less diet similarity between species in the fall than in the spring.

In addition to prey availability, morphological and behavioural factors influenced the diets of fish. Some species were less restricted by these factors than others, and were therefore more opportunistic in their food habits. Creek chub and common shiners were the most versatile feeders, consuming up to 12 different food items each. In contrast, dace, minnows and darters, which are morphologically adapted for bottom feeding, were restricted to 1-3 items each. Rock bass, which require the cover of heavy vegetation, were restricted to vegetation-dwelling organisms, while smallmouth bass, which prefer rocky substrates, consumed mainly riffle-dwelling organisms.

Fish from Cangagigue Creek generally had less varied diets than the same species elsewhere. This is attributed to the polluted nature of the study site, which suppressed the diversity of the prey community. Caddisfly larvae, mayfly nymphs, snails, amphipods, crayfish and minnows, which are the preferred prey of our species in other areas, were rare. Under these conditions, fish were forced to choose alternate food sources. This resulted in unusual diets for several species, especially the bass.

These findings will be used, in conjunction with information on contaminant concentrations in fish and their prey, to determine the importance of the food pathway as a route of uptake for contaminants by Canagagigue Creek fish. As the diets of fish vary considerably with season, geographic location and quality of the environment, it is strongly recommended that food habits analysis should be an integral part of any food chain contamination study.

RESUME

En 1983, une étude a été entreprise pour évaluer l'importance de la voie alimentaire pour l'absorption de contaminants par les poissons du ruisseau Canagagigue. Dans le cadre de la présente étude, les habitudes alimentaires de 13 espèces de poissons de la zone de ce ruisseau touchée par la pollution industrielle ont été décrites par la technique de l'analyse du contenu des entrailles. Au total, 143 spécimens ont été examinés, dont 61 ont été recueillis au printemps et 82 à l'automne. Les espèces étaient les suivantes : e meunier noir, le suceur rouge, la car e, le naseux des rapides, le naseux noir, le mulet à corne, le tête-de-boule, le ventre-pourri, le méné à nageoires rouges, le dard noir, , le crapet de roche, l'achigan à petite bouche et l'épinoche à cinq épines.

Les habitudes alimentaires de la plupart des espèces de poissons étaient non sélectives; ces espèces s'adaptaient rapidement aux variations saisonnières de disponibilité des proies. Le régime alimentaire des poissons recueillis au printemps était constitué pour une bonne part de larves de mouches noires (50 % en poids), de larves de chironomidés (25 %) et de sangsues (9 %). Ces trois éléments étaient cependant beaucoup moins importants dans le régime alimentaire des poissons recueillis à l'automne (25 %), 19 % et 1 %, respectivement, mais ceux-ci consommaient une proportion beaucoup plus importante de nymphes de demoiselles (27 % au lieu de 1 %), de corises (7 % au lieu de 1 %) et de plantes (14 % au lieu de 1 %). Ces changements de la composition du régime alimentaire reflètent des changements de la structure de la communauté benthique pendant cette même période. Une grande variété de proires était disponible à l'automne, et ceci permettait aux poissons de se nourrir de façon plus sélective pendant cette saison. Il en résulte une moins grande différence entre les régimes alimentaires d'une espèce à l'autre à l'automne (indice moyen de chevauchement alimentaire, $\hat{C}\lambda = 0,36$) par rapport au printemps ($\hat{C}\lambda = 0,65$).

En plus de la disponibilité des proies, des facteurs morphologiques et de comportement influençaient les régimes alimentaires des poissons. Certaines espèces étaient moins restreintes par ces facteurs que d'autres, et étaient donc beaucoup plus opportunistes du point de vue alimentaire. Le mulet à corne et le méné à nageoirs rouges étaient les plus souples du point de vue alimentaire, consommant chacun jusqu'à 12 types d'aliments différents. Par contre, les naseux, les ménés et les dards noirs, qui sont morphologiquement adaptés à la recherche de la nourriture au fond, ne consommaient que de 1 à 3 types d'aliments. Le crapet de roche, qui a besoin d'une forte végétation, se limitait à des organismes habitant la végétation, alors que l'achigan à petite bouche, qui préfère les substrats rocheux, consommait principalement des organismes habitant les roches.

Les régimes alimentaires des poissons du ruisseau Cangagigue étaient généralement moins variés que ceux des mêmes espèces dans d'autres habitats. On explique ceci par la pollution du site à l'étude, qui nuisait à la diversité des communautés de proies. Les larves de phryganes, les nymphes, d'éphémères, les escargos, les amphipodes, les écrevisses et les ménés, qui sont les proies préférées de ces espèces dans d'autres habitats, sont rares. Dans ces conditions, les poissons étaient forcés de choisir d'autres sources de nourriture. Ceci entraînait les régimes alimentaires inhabituels pour plusieurs espèces, plus particulièrement pour la carpe. Ces constatations ont été utilisées, ainsi que les informations recueillies sur les concentrations de contaminants dans les poissons et leurs proies, pour déterminer l'importance de la voie alimentaire pour l'absorption des contaminants par les poissons du ruisseau Canagagigue. Comme le régime alimentaire des poissons varie d'une façon importante selon la saison, l'emplacement géologique et la qualité de l'environnement, il est fortement recommandé que l'analyse des habitudes alimentaire constitue une partie intégrante de l'étude de la contamination de toute chaîne alimentaire.

ABSTRACT

In 1983, a study was undertaken to assess the importance of the food pathway as a route of uptake for contaminants by Canagagigue Creek fish. As part of the study, the food habits of 13 species of fish from the impacted zone of this industrially polluted creek were described by means of gut contents analysis. A total of 143 specimens were examined, 61 of which were collected in the spring and 82 in the fall. The species involved were: White Sucker, Shorthead Redhorse, Carp, Longnose Dace, Blacknose Dace, Creek Chub, Fathead Minnow, Bluntnose Minnow, Common Shiner, Johnny Darter, Rock Bass, Smallmouth Bass and Brook Stickleback.

Most fish species were non-selective in their food habits, and adapted readily to seasonal changes in the availability of prey. Fish collected in the spring preyed heavily on blackfly larvae (54% by weight), chironomid larvae (25%) and leeches (9%). In contrast, fish collected in the fall relied less on these three items (25%, 19% and 1%, respectively), but utilized damselfly nymphs (27% vs. 1%), water boatmen (7% vs. 1%) and plants (14% vs. 1%) much more significantly. These changes in diet composition reflected changes in the benthic community structure over the same time period. A wider range of prey was available in the fall, and this enabled fish to feed more selectively during this season. As a result, there was less diet overlap between species in the fall (median diet overlap index, $\hat{C}\lambda$=.36) than in the spring (median $\hat{C}\lambda$=.65).

SOMMAIRE

En 1983, une étude a été entreprise pour évaluer l'importance de la voie alimentaire pour l'absorption des contaminants par les poissons du ruisseau Canagagigue. Dans le cadre de cette étude, les habitudes alimentaires de 13 espèces de poissons de la zone touchée par ce ruisseau pollué par l'industrie ont été décrites par analyse du contenu des entrailles. Au total, 143 spécimens ont été examinés, dont 61 ont été prélevés au printemps et 82 à l'automne. Les espèces étaient les suivantes : meunier noir, suceur rouge, carpe, naseux des rapides, naseux noir, mulet à corne, tête-de-boule, ventre-pourri, méné à nageoires rouges, dard noir, crapet de roche achigan à petite bouche et épinoche à cinq épines.

Les habitudes alimentaires de la plupart des espèces étaient non sélectives, et celles-ci s'adaptaient rapidement aux variations saisonnières de disponibilité des proies. Les poissons recueillis au printemps se nourrissaient surtout de larves de mouches noires, de larves de chironomidés et de sangsues. Par contre, les poissons recueillis à l'automne consommaient beaucoup moins de ces trois éléments mais utilisaient de façon beaucoup plus importante les nymphes de demoiselles, les corises et les plantes dans leur régime alimentaire Ces changements de composition du régime alimentaire reflètent les changements de la structure de la communauté benthique pendant la même période. Une plus grande variété de proies était disponible en automne, et ceci permettait aux poissons de se nourrir de façon plus sélective pendant cette saison. Par conséquent, il y avait moins de ressemblance diététique en automne qu'au printemps d'une espèce à l'autre.

In addition to prey availability, morphological and behavioural factors influenced the diets of fish. Some species were less restricted by these factors than others, and were therefore more opportunistic in their food habits. Creek chub and common shiners were the most versatile feeders, consuming up to 12 different food items each. In contrast, dace, minnows and darters, which are morphologically adapted for bottom feeding, were restricted to 1-3 items each. Rock bass, which require the cover of heavy vegetation, were restricted to vegetation-dwelling organisms, while smallmouth bass, which prefer rocky substrates, consumed mainly riffle-dwelling organisms.

Fish from Cangagigue Creek generally had narrower diet breadths than the same species elsewhere. This is attributed to the impacted nature of the study site, which suppressed the diversity of the prey community. Caddisfly larvae, mayfly nymphs, molluscs, amphipods, crayfish and minnows, which are the preferred prey of our species in other areas, were rare. Under these conditions, fish were forced to choose alternate food sources. This resulted in unusual diets for several species, especially the bass.

These findings will be used, in conjunction with information on contaminant concentrations in fish and their prey, to determine the importance of the food pathway as a route of uptake for contaminants by Canagagigue Creek fish. As the diets of fish vary considerably with season, geographic location and quality of the environment, it is strongly recommended that food habits analysis should be an integral part of any food chain contamination study.

INTRODUCTION

A study on the fate and effects of synthetic organic contaminants in Canagagigue Creek was initiated in 1980. This creek receives domestic and industrial sewage effluent from the town of Elmira, Ontario, as well as leachates from a disused chemical waste dump. The reader is referred to Carey et al. (1983) for a detailed description of stream ecology and the identification of major contaminants.

A total of 25 species of fish were found to inhabit Canagagigue Creek at various times of the year. In 1980, specimens of five species were analyzed for tissue residues of chlorophenols, which are one of the prominent groups of contaminants in the creek. The analyses revealed interspecific differences in the bioaccumulation of chlorophenols by fish. We also found that concentrations of chlorophenols in invertebrate prey species may vary by up to two orders of magnitude (Metcalfe et al., 1984). Therefore, differences in bioaccumulation among various species of fish could be due, at least in part, to their food habits.

In 1983, a study was undertaken to determine the importance of the food pathway as a route of uptake for contaminants by Canagagigue Creek fish. This study required an analysis of the food habits of the various resident fish species as well as the determination of contaminant concentrations in both fish and their prey. The contaminant aspects will be dealt with in a later report. The present report describes the food habits of 13 species of fish from the impacted zone of Canagagigue Creek, as determined by gut contents analysis. Interspecific and seasonal differences in food habits are discussed, and the diets of these fish are compared with the diets of the same species elsewhere.

MATERIALS AND METHODS

Fish Collections

Fish were collected by means of electroshocking at site CN-3 on Canagagigue Creek. This site was located 1.7 km downstream of the Elmira Water Pollution Control Plant, which was the source of sewage and synthetic organic chemicals to the creek. Fish at this site were known, from previous work (Carey *et al.*, 1983), to be highly contaminated. Collections were obtained in the spring (May 31, 1983) and fall (September 29, 1983), with sampling completed before noon on each date. Water temperature and pH at the time of collection were 11.5-12.0°C and 8.3, respectively, in the spring and 18.0-18.5°C and 7.8 in the fall. Attempts were made to collect a wide range of fish of several species on both occasions. The fish were wrapped in pre-fired (450°C) aluminum foil and frozen.

Food Habits Analysis

In the laboratory, the fish were thawed out, weighed, measured and sexed. Their internal organs (liver, gall bladder, spleen, gonads, kidneys) were removed and refrozen for separate contaminant analysis. Stomachs and intestines were weighed, then preserved in 10% buffered formalin for gut contents analysis. The "rest" fish were then refrozen.

The preserved stomachs and intestines were transferred from formalin to 70% alcohol several days prior to beginning the analysis. All gut contents were removed, sorted into taxonomic groups, then weighed wet after blotting on glass fibre filter paper to remove excess liquid. Organisms were not counted because only the contribution of each food item in terms of its biomass was important for the purpose of relating concentrations of contaminants in fish to concentrations in their food items. In any event, MacDonald and Green (1983) found that various types of measurement used to describe animal diets, including weight, number, and percent frequency of prey species, are all highly correlated, and that any one of them will adequately describe prey species importance.

Diet Overlap Calculations

Diet overlap calculations were used to compare the diets of various fish species and to describe seasonal changes in diet within a given species. The formula, taken from Pappantoniou and Dale (1982), is as follows:

$$\hat{C}\lambda = \frac{2 \sum_{i=1}^{s} x_i y_i}{\sum_{i=1}^{s} x_i^2 + \sum_{i=1}^{s} y_i^2}$$

where x_i and y_i are the proportions that food item i represents in the diets of species x and y, respectively, and s is the total number of food categories. Where seasonal changes within a species are being compared, x and y will refer to the spring and fall diets of that species, respectively. The overlap index, $\hat{C}\lambda$, can range from 0 (no overlap) to 1.0 (identical diets).

Benthic Community Structure

The structure of the benthic community at the study site was not formally described, as it was not required to satisfy the main goals of the food pathway study. However, information on the availability of prey is important for understanding the food habits of fish. Samples of potential prey items were collected for contaminant analyses along with the fish and, although not quantitative, this data provides us with an indication of the types of prey available at each time of the year.

Specimens were mainly hand-picked from rock surfaces or vegetation. The exceptions were: aquatic worms, which were obtained by sieving bottom sediment through a 700 μm mesh screen, and water boatmen, which were caught with a dip net. An approximately equal sampling effort was employed during both seasons. Table 1 shows that the benthic community was more diverse in the fall, consisting of 13 different taxa versus eight in the spring. Oligochaetes, leeches and blackfly larvae were important components during both seasons. With the exception of snails, all other organisms were more abundant in the fall. Of particular significance were damselfly nymphs and water boatmen. This assessment of the benthic composition is supported by the results of an earlier survey conducted in 1980 (Table 2). Again, the community was more diverse in the fall. A total of 23 taxa were present, as compared with only 13 in the spring. The dominant organisms were oligochaetes, blackfly larvae and chironomid larvae. The appearance of planarians, amphipods, mayfly nymphs, beetle larvae and three additional species of caddisfly larvae accounted for the increase in diversity with advancing season. The data from 1980 and 1983 are not directly comparable, as different sampling techniques were employed. The kick net used in 1980 collected a more complete sample, while hand-picking tended to be selective of the more common prey types. Also, the kick net was more efficient for obtaining chironomids, but, because sampling was done in riffles, vegetation-dwelling organisms were infrequently encountered.

Table 1. Samples of potential food items collected in the spring and fall, 1983

Organism	Common Name	Numerical Abundance	
		Spring	Fall
Oligochaeta	aquatic worms	203*	126*
Helobdella stagnalis	leech	162*	330*
Glossiphonia complanata	leech	13	55
Erpobdella punctata	leech	3	3
Dina dubia	leech	13	9
Physa sp.	snail	114	6
Zygoptera	damselfly nymphs	4	200*
Simuliidae	blackfly larvae	3155*	1356*
Anisoptera	dragonfly nymphs	0	2
Amphipoda	scuds	0	20
Corixidae	water boatmen	0	38
Hydropsychidae	caddisfly larvae	0	18
Dytiscidae	predaceous diving beetles	0	19
# taxa		8	13

*estimate from subsample

Table 2. 1980 Benthic community structure (from Carey et al., 1983)

Organism	% Numerical Abundance	
	Spring (May)	Fall (November)
Planariidae	-	<.1
Oligochaeta	15.6	15.7
G. complanata	-	.2
H. stagnalis	<.1	1.5
E. punctata	<.1	.6
Hyalella azteca	-	.2
Promenetus sp.	-	.2
Goniobasis sp.	.1	-
Sphaeriidae	.1	.2
Caenis sp.	-	.2
Baetis sp.	-	<.1
Hydropsyche sp.	.1	-
Ceratopsyche sp.	-	.2
Cheumatopsyche sp.	<.1	.2
Agraylea sp.	-	<.1
Ochrotrichia sp.	-	<.1
Oecetis sp.	-	.3
Haliplus sp.	-	.2
Peltodytes sp.	-	.2
Stenelmis sp.	-	.1
Culicidae	.1	-
Simuliidae	27.5	63.0
Chironomidae	55.3	15.5
Tabanus sp.	-	<.1
Atherix sp.	<.1	-
Limnophora sp.	<.1	-
Hemerodromia sp.	-	1.2
Nematoda	1.0	<.1
# taxa	13	23

Due to the influence of the sewage outfall 1.7 km upstream, the study area is impacted. According to the 1980 survey, the benthic community here is characterized by suppressed diversity and dominance by a few tolerant taxa (Carey et al., 1983). To illustrate the extent of impact, site CN-3 may be compared in terms of species diversity with the recovery site CN-5, which is 5.7 km further downstream. The total number of taxa occurring at CN-3 in 1980 was only 37 as compared with 72 for CN-5. The annual Shannon-Wiener species diversity indices were 1.77 for CN-3 and 3.32 for CN-5, indicating moderate pollution and clean water, respectively, according to the classifications of Wilhm and Dorris (1968).

Background information on the benthic community at the study site has been presented here in some detail because of its considerable influence on the food habits of fish in the creek. The most significant points to note are that 1) due to the influence of the sewage outfall, the selection of prey available to fish at site CN-3 is more restricted than in cleaner areas of the creek, and 2) as the benthic community establishes itself during the growing season, its diversity increases.

RESULTS

Table 3 presents the scientific and common names, and familial relationships of the 13 species of fish collected during this study. All species will be referred to by their common names in the text.

Table 3. Scientific and common names, and familial relationships of the fish species collected from Canagagigue Creek.

Family Catostomatidae (suckers)
- *Catostomus commersoni* (white sucker)
- *Moxostoma macrolepidotum* (shorthead redhorse)

Family Cyprinidae (minnows)
- *Cyprinus carpio* (carp)
- *Rhinichthys cataractae* (longnose dace)
- *Rhinichthys atratulus* (blacknose dace)
- *Semotilus atromaculatus* (creek chub)
- *Pimephales promelas* (fathead minnow)
- *Pimephales notatus* (bluntnose minnow)
- *Notropis cornutus* (common shiner)

Family Percidae (perches)
- *Esteostoma nigrum* (Johnny darter)

Family Centrarchidae (sunfishes)
- *Ambloplites rupestris* (rock bass)
- *Micropterus dolomieui* (smallmouth bass)

Family Gasterosteidae (sticklebacks)
- *Culaea inconstans* (brook stickleback)

Diets of Ten Species of Fish Collected in the Spring

Seventy-three fish, representing ten species, were collected in the spring. Sixty-one were examined for gut contents. Of the remaining 12 fish, four white suckers and one longnose dace had empty stomachs, two white suckers and two common shiners had been left intact for whole fish contaminants analysis, and two white suckers and one common shiner had been spoiled.

The food items consumed by each fish are tabulated in Appendix A. Data are presented as percent by weight of the total contents. The results are summarized in Table 4. In order to quantify the significance of each food item for each species, the proportions for individual fish were summed, then averaged. This provides a better estimate than summing the actual weights of each food item for each fish, because a large fish with a full gut containing primarily one food item could mask the preference of the species as a whole. The food habits of each species are described in detail below:

Rock Bass - This species had a varied diet consisting mainly of leeches (Hirudinea) - over 90% in three fish. Flying insects, dragonfly nymphs (Anisoptera) and water boatmen (Corixidae) were also important food items.

Table 4. Diet summaries for the ten species of fish collected in the spring

Fish Species	Number of Individuals	Food Items Present, as Average Percent by Weight																	
		Plant Tissues	Hirudinea	Gastropoda	Amphipoda	Decapoda	Unidentified Animal Remains	Ephemeroptera	Zygoptera	Anisoptera	Corixidae	Megaloptera	Trichoptera	Dytiscidae	Simulidae	Chironomidae	Tipulidae	Unidentified Flying Insects	Fish Remains
Rock Bass	6	<1	48			1	16	<1	<1	8	8		<1		3	<1		16	
Common Shiner	16	4	10						4	1		<1	3	1	70	5	1		1
Creek Chub	8	<1	20	6	<1		11							14	37	<1		12	
Fathead Minnow	3														100				
Bluntnose Minnow	1														92	8			
Blacknose Dace	2														95	5			
Longnose Dace	7														74	26			
White Sucker	13	<1	1									<1	<1		54	45			
Shorthead Redhorse	1		14						8						18	60			
Johnny Darter	4															100			

Common Shiner - Blackfly larvae (Simuliidae) were the dominant food item, being present in all 16 samples and accounting for over 90% of the contents in nine fish. Midge larvae (Chironomidae) were present in six samples, but in minute amounts. The seven fish weighing less than 20 g ate only these two items. Leeches were a significant component in three of the nine larger fish. Larvae of other insects such as caddisflies (Trichoptera), damselflies (Zygoptera) and dragonflies were also represented.

Creek Chub - Diets varied considerably among individuals. Three had ingested significant portions of leeches and three others contained 100% blackfly larvae. Predaceous diving beetles (Dytiscidae), flying insects and snails (Gastropoda) were dominant items in other individuals.

Fathead Minnow - The three specimens examined had ingested only blackfly larvae.

Bluntnose Minnow - This specimen had eaten 92% blackfly larvae and 8% midge larvae.

Blacknose Dace - Both specimens had consumed over 90% blackfly larvae, the remainder being midge larvae.

Longnose Dace - Blackfly and midge larvae were the only items present. In five fish, blackfly larvae accounted for over 80% of the contents, while midge larvae were significant in two fish.

White Sucker - White suckers fed almost exclusively on blackfly and midge larvae. In contrast with most other fish species, midges frequently made up the larger portion (six stomachs). One sucker had eaten a small amount of leeches.

Shorthead Redhorse - This large specimen had fed mainly on midge larvae (60%), with blackfly larvae, leeches and damselfly nymphs also present.

Johnny Darter - All four darters had consumed only blackfly larvae.

Diets of Eight Species of Fish Collected in the Fall

One hundred and eight fish, representing eight species, were collected in the fall. Eighty-two were examined for gut contents analysis. Of the remaining 26 fish, ten had empty stomachs, three had unidentifiable contents due to some spoilage, eight were left intact for whole fish contaminant analysis, and five had their digestive tracts frozen for separate contaminant analysis.

The food items consumed by each fish are tabulated in Appendix B. The results are summarized in Table 5. Data were treated in the same manner as for the spring sampling. The food habits of each species are described in detail below:

Rock Bass - This specimen had eaten 88% damselfly nymphs and 12% water boatmen.

Smallmouth Bass - Blackfly larvae were the dominant food item, being present in 14 of the 15 stomachs and accounting for at least 75% of the contents in nine fish. Damselfly nymphs were present in 13 stomachs and were the dominant item (over 85% of contents) in four stomachs. Mayfly nymphs (Ephemeroptera) were occasionally taken. Leeches, water boatmen, midge larvae and other fish were also represented.

Common Shiner - Several items dominated the diet of shiners. Plants were present in six of the eight stomachs, accounting for over 70% of the contents in four of them. Damselfly and blackfly larvae were each found in five stomachs, but both items usually accounted for less than 50% of the total contents. One individual had consumed mostly water boatmen. Midges, deerfly (Tabanidae) and caddisfly larvae were represented.

Table 5. Diet summaries for the ten species of fish collected in the fall

Fish Species	Number of Individuals	Food Items Present, as Average Percent by Weight																	
		Plant Tissues	Nematoda	Oligochaeta	Hirudinea	Gastropoda	Amphipoda	Copepoda & Conchostraca	Ephemeroptera	Zygoptera	Corixidae	Megaloptera	Trichoptera	Haliplidae	Dytiscidae	Simuliidae	Chironomidae & Heleidae	Tabanidae	Fish Remains
Rock Bass	1									88	12								
Smallmouth Bass	15				<1				7	27						60	<1		6
Common Shiner	8	44								14	10		1			20	4	7	
Creek Chub	10	11				6				22	36			<1	3	22			
Longnose Dace	7									1						44	55		
Carp	5	56								24	<1					20	<1		
White Sucker	22	1	<1	4	10	<1	<1	9	<1	18		<1	1	1		11	45	<1	
Brook Stickleback	14					<1			11	23						19	47		

Creek Chub - The diet of creek chub consisted of three major items: damselfly nymphs (8 stomachs), water boatmen (5) and blackfly larvae (6). Water boatmen comprised the largest percentage by weight (50% or greater) when present. Snails and plants were found in several stomachs and predaceous diving beetles and crawling water beetles (Haliplidae) were also represented.

Longnose Dace - Dace had the most restricted diet of any species. Blackfly larvae and midge larvae were consumed in approximately equal proportions, although one or the other was usually dominant in any individual. One fish had eaten a small amount of damselfly nymphs.

Carp - Carp were mainly herbivorous, with three fish consuming over 80% plant tissues. Blackfly larvae and damselfly nymphs were also present in three stomachs each, but were only significant in one stomach each. Caddisfly and midge larvae were also represented.

White Sucker - The diet of white suckers was extremely varied, with a total of 15 different items represented. Midge larvae were the dominant food item, being present in 21 of the 22 stomachs and accounting for over 50% of the contents in 11 fish. Fish in the 16.5-20.0 cm size range tended to eat almost entirely midge larvae, while fish over 26.0 cm consumed insignificant amounts. Blackfly larvae were present in 18 stomachs, but accounted for less than 10% of the contents in 13 and are therefore not considered an important food item.

The two smallest suckers (6.7 and 8.4 cm) ate over 90% zooplankton. This item was not utilized by larger suckers. Sixteen fish had consumed damselfly nymphs. They were most frequently taken by mid-sized fish (21.0-26.0 cm), being present in all seven fish in this size range and accounting for over 50% of the contents in five of them. Eight suckers, all larger than 18.5 cm, had eaten moderate amounts of the leech *Helobdella stagnalis*. Also taken occasionally by suckers were: plant tissues, nematodes, oligochaetes, snails, amphipods, mayfly larvae, Megaloptera, caddisfly larvae, crawling water beetles, and deerfly larvae.

Brook Stickleback - Sticklebacks fed mainly on midge larvae; 11 of the 14 stomachs contained them, and in seven stomachs 65-100% of the contents were midge larvae. Blackfly larvae accounted for at least 90% of the contents in three of the four stomachs which contained them. Damselfly nymphs were found in five stomachs, and in significant amounts in three. Mayflies were present in three stomachs in amounts ranging from 25-100%. One fish had eaten a small amount of snails.

Interspecific Comparisons among Species Collected in the Spring

The interspecific diet overlap indices for fish collected in the spring are presented in Table 6. Fathead and bluntnose minnows and

Table 6. Interspecific diet overlap indices ($\hat{C}_\lambda$) for fish collected in the spring

Fish Species	Rock Bass	Common Shiner	Creek Chub	Fathead Minnow	Bluntnose Minnow	Blacknose Dace	Longnose Dace	White Sucker	Shorthead Redhorse	Johnny Darter
Rock Bass	-	.18	.49	.05	.05	.02	.05	.05	.22	.01
Common Shiner	.18	-	.82	.93	.95	.95	.95	.76	.37	.06
Creek Chub	.49	.82	-	.67	.70	.69	.71	.57	.31	0
Fathead Minnow	.05	.93	.67	-	.99	1.00	.92	.68	.25	0
Bluntnose Minnow	.05	.95	.70	.99	-	1.00	.95	.75	.33	.08
Blacknose Dace	.02	.95	.69	1.00	1.00	-	.94	.72	.15	.05
Longnose Dace	.05	.95	.71	.92	.95	.94	-	.91	.56	.32
White Sucker	.05	.76	.57	.68	.75	.72	.91	-	.84	.65
Shorthead Redhorse	.22	.37	.31	.25	.33	.15	.56	.84	-	.85
Johnny Darter	.01	.06	0	0	.08	.05	.32	.65	.85	-

blacknose dace had almost identical diets ($\hat{C}_\lambda$=.99-1.00), consisting almost entirely of blackfly larvae. The diets of common shiners and longnose dace were very similar to each other and also to the above three species ($\hat{C}_\lambda$=.92-.95), as their dominant food item was also blackfly larvae. The slight increase in overlap is due to the wide diet breadth of common shiners and the higher proportion of midge larvae consumed by longnose dace.

Common shiners and creek chub also had a high degree of diet overlap ($\hat{C}_\lambda$=.82) due to the wide diet breadths (9-11 items) of both species. The dominant food item for white suckers and shorthead redhorse was midge larvae, hence the high degree of overlap ($\hat{C}_\lambda$=.84) between these two species of suckers. Shorthead redhorse consumed the greater proportion of midge larvae which leads to the highest degree of overlap of any species with Johnny darter ($\hat{C}_\lambda$=.85), which fed exclusively on midge larvae.

A moderate degree of overlap between creek chub and the four species of minnows and dace ($\hat{C}_\lambda$=.67-.71) was evident. The overlap is less than for common shiners with the same four species. Creek chub were less selective than common shiners, utilizing a number of different food sources in similar proportions. White suckers consumed blackfly larvae and midge larvae in almost equal proportions. Therefore, they moderately overlapped ($\hat{C}_\lambda$=.65-.76) with the four species that fed predominantly on blackfly larvae (common shiners, fathead and bluntnose minnows, blacknose dace) as well as Johnny darters which fed entirely on midge larvae.

Rock bass had the most unique diet. They utilized two items, leeches and flying insects, which most other species did not exploit. They all but ignored blackfly and midge larvae. The only significant overlap was with creek chub ($\hat{C}\lambda$=.49) which also consumed some leeches and flying insects.

Interspecific Comparisons among Species Collected in the Fall

The interspecific diet overlap indices for fish collected in the fall are presented in Table 7. Diet overlaps were greatest for common shiners and carp ($\hat{C}\lambda$-.94) and white suckers and stickleback ($\hat{C}\lambda$=.93). The first pair consumed almost identical proportions of plants, blackfly larvae and damselfly nymphs, in that order of importance. The second pair ate almost identical proportions of midge larvae, damselfly nymphs and blackfly larvae, again in order of importance. The overlap between the two pairs was, of course, low ($\hat{C}\lambda$=.20-.29). Midge larvae were the favoured food item of longnose dace, which explains the high degree of overlap between this species and white suckers ($\hat{C}\lambda$=.78) as well as brook stickleback ($\hat{C}\lambda$=.84).

Common shiners and creek chub had a moderate degree of overlap ($\hat{C}\lambda$=.63). They fed primarily on the same four items (plants, damselfly nymphs, water boatmen, blackfly larvae), but in different proportions. For example, shiners consumed more plants, while chub took more water boatmen. Smallmouth bass diets overlapped with those of all other species to a moderate extent. Overlap with common

Table 7. Interspecific diet overlap indices (C_λ) for fish collected in the fall

Fish Species	Rock Bass	Smallmouth Bass	Common Shiner	Creek Chub	Longnose Dace	Carp	White Sucker	Brook Stickleback
Rock Bass	-	.38	.26	.46	.01	.35	.30	.36
Smallmouth Bass	.38	-	.44	.56	.57	.44	.32	.46
Common Shiner	.26	.44	-	.63	.28	.94	.24	.29
Creek Chub	.46	.56	.63	-	.27	.49	.25	.33
Longnose Dace	.01	.57	.28	.27	-	.20	.78	.84
Carp	.35	.44	.94	.49	.20	-	.20	.26
White Sucker	.30	.32	.24	.25	.78	.20	-	.93
Brook Stickleback	.36	.46	.29	.33	.84	.26	.93	-

shiners, creek chub, longnose dace, carp and brook stickleback ranged from .44 to .57 due to the importance of blackfly nymphs and damselfly nymphs in the diets of all six species. Overlap with rock bass and white suckers was somewhat less ($\hat{C}\lambda$=.38 and .32, respectively). Unlike smallmouth bass, rock bass utilized water boatmen while avoiding blackfly larvae. White suckers fed primarily on midge larvae, which were a very minor component in the diet of smallmouth bass.

The overlap between rock bass and all other species was low due to the complete absence of blackfly larvae in their diet. Similarly, creek chub had little in common with the bottom-feeding longnose dace, white suckers and brook stickleback ($\hat{C}\lambda$=.25-.33) because chub did not eat midge larvae.

Seasonal Comparisons

The diets of the ten species of fish collected in the spring overlapped more than the diets of the eight species collected in the fall. In the spring, 50% of the $\hat{C}\lambda$ values were over .65 while the fall median was only .36. Diet overlaps were greater in the spring because most species preyed heavily on blackfly and/or midge larvae. These two items accounted for 79% of the total gut contents of all species combined. In the fall, however, no two prey items accounted for more than half of the total gut contents. Rather, four or five items were of similar importance overall, with the proportions of these items varying from species to species.

The above evidence suggests that there was a seasonal shift in the diets of Canagagigue Creek fish. However, five species were collected only in the spring and another three only in the fall, and part of this "shift" may in fact be due to species-specific differences in prey selection. To determine whether there was a truly seasonal effect, overlap between spring and fall diets was calculated for the five species collected during both seasons (Table 8). The food habits of rock bass changed significantly with season, however, it should be noted that only one individual was taken in the fall. Common shiners and creek chub selected a high proportion of blackfly larvae during both seasons, but all other prey items were different. As a result there was only a moderate seasonal overlap in both cases. In contrast, the diets of white suckers and longnose dace changed little with season. The influence of season may be further demonstrated by examining the interspecific diet overlaps among these same five species in the spring and fall (Table 9). In eight out of ten comparisons, the degree of overlap for a given species pair was lower in the fall.

Diets of Fish from the Impacted Zone of Canagagigue Creek as Compared with Previously Reported Diets for These Species

A summary of the literature on food habits of the 13 fish species of interest is presented in Table 10. This information will be used to determine whether the diets of fish from site CN-3 on Canagagigue Creek are typical or unusual for each species.

Table 8. Intraspecific seasonal diet overlap

Species	Overlap Index ($\hat{C}\lambda$) between Spring and Fall Diets
Rock Bass	.03
Common Shiner	.42
Creek Chub	.39
Longnose Dace	.84
White Sucker	.72

Table 9. Seasonal changes in interspecific diet overlap indices ($\hat{C}\lambda$) for five species of fish collected in both spring and fall

Species Pair	Spring Index Value	Fall Index Value
Rock Bass & Common Shiner	.18	.26
Rock Bass & Creek Chub	.49	.46
Rock Bass & White Sucker	.05	.30
Rock Bass & Longnose Dace	.05	.01
Common Shiner & Creek Chub	.82	.63
Common Shiner & White Sucker	.76	.24
Common Shiner & Longnose Dace	.95	.28
Creek Chub & White Sucker	.57	.25
Creek Chub & Longnose Dace	.71	.27
White Sucker & Longnose Dace	.91	.28

Table 10. Summary of literature on food habits of the 13 fish species

Species	Location	Size of Fish	Diet Composition	Method Used	Reference
Rock Bass	Lake Opinicon, Ontario	7.5 - 12.0 cm TL	Odonata-75%; Ephemeroptera-35%; Trichoptera-35%; Fish Fry-30%; Crayfish-15%	Maximum contribution as % by volume	Keast & Webb, 1966
		12.0 - 20.0 cm TL	Almost entirely crayfish and anisoptera nymphs		
	Georgian Bay	10.0 - 17.0 cm SL	Crayfish-60.4%; fish-28.5%; insects-10.2%; plants-0.9%	% by volume	Tester, 1932
	Lake Nipissing	13.0 - 10.9 cm SL	Crayfish-64.6%; fish-19.1%; insects-16.1%; plants-0.2%		
	Eastern Lake Ontario	<15.0 cm TL	Amphipoda - 81%; Trichoptera-50%; Gastropoda-19%; Decapoda-9%; Fish-3%; Chironomidae-6%	% frequency of occurrence	Elrod et al., 1981
		15.0 - 20.0 cm TL	Amphipoda-75%; Trichoptera-44%; Gastropoda-46%; Decapoda-24%; Fish-6%; Chironomidae-14%		
	Upper St. Lawrence R. at Cape Vincent	13.6 - 21.7 cm TL	Amphipoda-83%; Gastropoda-6%; Trichoptera-3%; Decapoda-3%; Fish-1%	% dry weight	Ringler and Johnson, 1983
	Upper St. Lawrence R. at Massena	12.2 - 19.6 cm TL	Fish-38%; Decapoda-28%; Trichoptera-27%; Amphipoda-7%.		
	Current and Jacks Forks Rivers, Missouri	10.0 - 25.0 cm TL	Crayfish-70%; Fish-10%, Ephemeroptera and Plecoptera-20% (spring); Crayfish-78%; Fish-11%; Ephemeroptera and Plecoptera-11% (fall).	% dry weight adjusted for calorie content	Probst et al., 1984
	Jordan Creek, Illinois	Not given	Simuliidae-52%; Baetidas-10% (spring); Corixidae-16%; Caenidae-14% (fall).	Numerical abundance	Angermeier, 1982

Table 10. **Summary of literature on food habits of the 13 fish species**
Cont'd.

Species	Location	Size of Fish	Diet Composition	Method Used	Reference
Smallmouth Bass	Perch Lake, Ontario	8.0 - 12.0 cm TL	Fish-54%; Crayfish-18%; Cladocera-20%; insects-8%	Percent by volume	Tester, 1932
	Oxtongue, R., Ontario	9.9 - 13.4 cm TL	Insects (mostly midge & caddis adults)-80%; fish-20%		
	Grand R., Ontario	Not given	Three Ephemeroptera nymphs		
	Current and Jacks Forks Rivers, Missouri	10.0 - 25.0 cm SL	Crayfish-42%; Fish-38%; Insects (mostly Ephemeroptera & Plecoptera) -20% (spring). Crayfish-51%, Fish-41%; insects (Ephemeroptera and Plecoptera)-8% (fall)	% dry weight adjusted	Probst et al., 1984
	Upper Niagara River	8.3 cm TL	Fish-48%; Caddisfly adults-12%; Amphipoda-27%	Relative importance based on % frequency of occurrence, abundance and total weight	George & Hadley, 1979
		9.6 cm TL	Fish-100%		
	Lake Nipigon, Ontario	3.0 - 3.4 cm TL	Fish-90/95%; Other-5/10% (Other includes zooplankton, Ephemeroptera, Corixidae, Chironomids)	Numerical abundance	Clemens et al., 1924
	Jordan Creek, Illinois	Not given	Simuliidae-69%; Corixidae-13% (spring); Corixidae-65%; Ephemeroptera-12% (fall)	Numerical abundance	Angermeier, 1982
Common Shiner	Squaw Creek and Des Moines R., Iowa	Wide range	Diatoms-25%; Cladophora-18%; Spirogyra-10%; Other Algae-70%; Macrophytes-42%; Bryozoa-13%; Annelida-5%; Plecoptera-3%; Ephemeroptera-21%; Corixidae-10% Trichoptera-4%; Chironomidae-11%; Other Diptera-6%; Adult Coleoptera-3%; Other Adult Insects-11%; Othe Larval insects-6%.	% occurrence	Fee, 1965

Table 10. Summary of literature on food habits of the 13 fish species
Cont'd.

Species	Location	Size of Fish	Diet Composition	Method Used	Reference
Common Shiner	Lake Edward, Quebec	Not given	Cladocera-83%; Plants-67%; Chironomids-67%; Arachnida-50%; Ephemeroptera-33%; Aphidae-33%; Psocidae-33%.	% frequency of occurrence	Leonard, 1927
Creek Chub	Quebec lakes	6.8 - 17.7 cm SL	Odonata-42%; Plants-25%; Trichoptera-19%; Ephemeroptera-17% Crayfish-13%; Arachnida-8%; Sialis -6%; Hemiptera-6%; Diptera-6%; Hymenoptera-6%; Lepidoptera-4%.	% frequency of occurrence	Leonard, 1927
	Southern Quebec lakes	5.0 - 17.0 cm FL	Chironomid larvae-1%; Other Diptera-50%; Gammarus-11%; Coleoptera Adults-16%; Ephemeroptera-14%; Anisoptera-2% (spring). Chironomid larvae-9%; Other Diptera-22%; Gammarus-25%; Coleoptera Adults-5%; Ephemeroptera-10%; Anisoptera-25% (fall).	Numerical abundance	Magnan & Fitzgerald, 1982
	Headwater streams, Albany Co., N.Y.	Adults	Blacknose Dace	Descriptive	Fraser and Emmons, 1984
	Mink R., Manitoba	9.0 - 12.9 cm SL	Fish-13/56%; Crayfish-16/32%; Other-8/29%	% of stomachs with given item dominant	Newsome and Gee, 1978
		>12.9 cm SL	Fish-0/65%; Crayfish-13/82%; Other-4/9%. (Other = Aquatic insect larvae, Molluscs, Leeches and Terrestrial Insects)		
	Adirondack Mts. brook, N.Y.	4.3 - 13.9 cm TL	Terrestrials-61/18.2% (diurnal/nocturnal); Anisoptera Nymphs-12.5/13.3%; Diptera-10.2/12.6%; Trichoptera Larvae-7.9/14.3%; Ephemeroptera nymphs-6.7/27.3%; Blacknose Dace-0/9.4%.	% dry weight	Johnson & Johnson, 1982

Table 10. Summary of literature on food habits of the 13 fish species
Cont'd.

Species	Location	Size of Fish	Diet Composition	Method Used	Reference
Creek Chub	Jordan Creek, Illinois	4.0 - 12.5 cm TL	March-April: Chironomidae-43%; Other Diptera-13%; July-August: Terrestrials-67%; Snails-22%; August-October: Terrestrials-44%; Ephemeroptera Adults-22%; October-January: Clams-33%; Diptera-22%.	Numerical composition of the two most numerous prey taxa.	Angermeier, 1982
Bluntnose Minnow	Lake Opinicon, Ontario	Not given	Bottom ooze-20/50%; Chironomid Larvae-5/30%; Cladocera-10/75%.	% by volume	Keast and Webb, 1966.
Blacknose Dace	Orwell Brook, N.Y.	Not given	Oligochaeta-0/10%; Ephemeroptera-4/9%; Trichoptera-8/12%; Megaloptera-0/5%; Coleoptera-1/7%; Chironomidae-14/56%; Other Diptera-1/23%; Terrestrials-0/25% (Range for June to September)	% dry weight	Johnson, 1982
	Blind Brook, N.Y.	1.0 - 6.0 cm	Oligochaeta-28%; Chironomidae-17% Coleoptera Larvae-9%; Other Diptera Larvae-7%; Plants-9%; Terrestrials-11%.	Numerical abundance	Rollwagen and Stainken, 1980
	Waccabuc R., N.Y.	Not given	Hydropsychidae-32.5%; Other Caddis Larvae-9.7%; Ephemeroptera-2.6%; Simuliidae-0.7%; Chironomidae-9.9%; Other Diptera-.7%; Terrestrials-10.8%; Plecoptera-24.6%; Oligochaeta -8.5%.	Numerical abundance	Pappantoniou and Dale, 1982
	Trucka Brook, N.Y.	2.9 - 8.5 cm	Ephemeroptera-45.8/60.3% (diurnal/nocturnal); Trichoptera-20.8/17.6%; Chironomidae-14.8/10.6%; other Diptera-11.3/9.7%; Terrestrials-3.3/0%.	% dry weight	Johnson and Johnson, 1982
	Elkhorn and Pease Creeks, Iowa	Not given	Chironomid Larvae - 58%	% frequency of occurrence	Noble, 1965

Table 10. Summary of literature on food habits of the 13 fish species
Cont'd.

Species	Location	Size of Fish	Diet Composition	Method Used	Reference
Longnose Dace	Waccabuc R., N.Y.	Not given	Hydropsychidae-52.7%; Ephemeroptera-25.9%; Simuliidae-2.3%; Chironomidae-4.0%; Plecoptera-9.5%; Plants-3.4%; Pelecypoda-2.3%.	% abundance	Pappantoniou and Dale, 1982
	Little Sandy Creek, Pennsylvania	4.8 - 11.8 cm TL	Simuliidae and Chironomidae-62%; Ephemeroptera-28%; Other Insecta; Oligochaeta and algae-5%.	% frequency of occurrence	Reed, 1959
	Yellowstone R., Montana	7.0 - 10.0 cm	Ephemeroptera-66%; Simuliidae-4%; Chironomidae-15%; Trichoptera-11%; Plecoptera-3%	% by volume	Gerald, 1966
Carp	Indian R., Ontario	13.5 - 25.6 cm	Cladocera-26%; Copepoda-20%; Trichoptera-4%; Diptera-28%; Mollusca-1%; Other Invertebrates-11%; Plants-2%; Debris-7%.	% by volume	Powles _et al._, 1983
	Colorado rivers	Wide range	Chironomid Larvae and Pupae-4.4/10.6%; Terrestrials-2.5/4.8%; Other Invertebrates-1.1/1.7%; Plants-21.1/38.2%; Dissolved and Detritus-27.5/51.9%.	% by volume	Eder and Carlson, 1977
White Sucker	Gamelin Lake, Quebec	<5.0 cm	Cladocera-45.8%; Copepoda-32.5%; Nauplii-18.4%; Organic Detritus-1.4%; Eggs-0.5%; Algae-0.6%; Scales-0.8%.	Numerical abundance	Lalancette, 1977
		8.5 - 23.0 cm	Cladocera-72.7%; Copepoda-20.6%; Rotifera-2.5%. Insects (mainly Diptera)-3.8%.		
	Paine Lake, Alberta	Wide range	Cladocera-33.7%; Chironomids-21.0%	% by volume	Barton, 1980

Table 10. Summary of literature on food habits of the 13 fish species Cont'd.

Species	Location	Size of Fish	Diet Composition	Method Used	Reference
White Sucker	Colorado rivers	20.0 - 30.0 cm	Chironomids-6.3/12.6%; Terrestrials-.2/5.0%; Dipteran Pupae-.8%; Simuliidae-.1/.4%; Hydropsychidae-.2/1.9%; Hyalellidae-.5/.6%; Seeds-1.7/4.8%; Aquatic Plants-2.9/3.8%; Dissolved or Detritus-31.6/70.0%; Sand-12.7/42.1%.	% by volume	Eder and Carlson, 1977
	Lake Nipigon, Ontario	5.0- 45.0 cm SL	Chironomid Larvae-25%; Ephemeroptera-20%; Molluscs-20%; Trichoptera-8%; Amphipoda-13%; Algae also important.	Numerical abundance	Clemens et al., 1924.
	St. Lawrence R.	37.6-57.7 cm TL	Amphipoda-63.8%; Leptoceridae-.6%; Chironomidae-.1%; Gastropoda-24.4%; Pelecypoda-11.1%.	% dry weight	Ringler and Johnson, 1982
Shorthead Redhorse	Lake Nipigon, Ontario	39.2-47.3 cm	Ephemeridae nymphs-76%; Chironomid Larvae-16%; Miscellaneous Animal Matter-5%; Silt-3%.	Numerical abundance	Clemens et al., 1924
Johnny Darter	Ohio lakes and streams	4.0-5.0 cm	Chironomid Larvae-72/86% (streams/lakes); Cladocera-12/2%; Copepoda -5/4%; Ephemeroptera nymphs-6/0%, Ostracoda-1/0%; Trichoptera Larvae -0/2%.	Numerical abundance	Turner, 1921
	Whitemouth R., Manitoba	1^{+}	Chronomid Larvae-70%; Ephemeroptera-15%; Trichoptera-4%; Elmidae Larvae-2%; Amphipoda-3%; Zooplankton-5%.	% by volume	Smart and Gee, 1979

Table 10. Summary of literature on food habits of the 13 fish species
Cont'd.

Species	Location	Size of Fish	Diet Composition	Method Used	Reference
Johnny Darter	White R. watershed, Indiana	Not given	Chrionomid Larvae-85%; Ephemeroptera-30%; Other Diptera-20%; Ostracoda-5%; Isopoda-5%; Odonata-5%; Neuroptera-5%; Trichoptera-10%; Fish Eggs-5%.	% frequency of occurrence	Martin, 1984
	Irvine Creek, Ontario	Not given	Chironomidae-45/90%; Ephemeroptera-5/20%; Zooplankton -0/40% (range for spring to fall).	% by volume	Paine et al., 1982
Brook Stickleback	Bog, Rennie and Brokenhead R., Manitoba	0^+ and 1^+	Zooplankton-69%; Chironomid Larvae -25%; Other-6%.	Numerical abundance	Tompkins and Gee, 1983
	Lake Nipigon, Ontario	1.8 - 4.7 cm SL	Chironomids-26%; Trichoptera-9%; Zooplankton-22%; Miscellaneous -31%.	Numerical abundance	Clemens et al., 1924

Rock Bass - Rock bass from site CN-3 preyed mainly on large bottom- and vegetation-dwelling invertebrates, especially Odonata, Corixidae and Hirudinea. Flying insects were also important in the spring. The preference of this species for large prey has been well-documented, and Odonata and Corixidae have been reported previously (Keast and Webb, 1966; Angermeier, 1982). However, leeches and terrestrials have not. Furthermore, crayfish, fish, amphipods and Trichoptera, which are important food items of rock bass in most areas, were absent from the gut contents of our specimens. Therefore, rock bass from site CN-3 have a somewhat unique diet.

Smallmouth Bass - Smallmouth bass from site CN-3 fed mainly on blackfly larvae. Damselfly nymphs were also important and mayfly nymphs were occasionally taken. Blackfly larvae were also the dominant food item of smallmouth bass in Jordan Creek, Illinois (Angermeier, 1982), and mayfly nymphs have been frequently reported. In general, however, fish appear to be the most important prey of smallmouths in other waters. According to George and Hadley (1979), fish enter the diet when bass are only 1.3 cm TL and become increasingly important as they grow. In our study, only one individual had preyed on fish. Crayfish may occasionally be important (Probst *et al.*, 1984) but they are taken much more frequently by rock bass. In the present study, neither species of bass fed on crayfish.

<u>Common Shiner</u> - Common shiners from site CN-3 were omnivorous, consuming a wide range of both plant and animal material. They were non-selective and adapted readily to seasonal changes in the availability of prey. When plant material was abundant in the fall, it was as important a food source as invertebrates. Fee (1965) also reported equal representation of plant and animal matter in the diets of shiners in Iowa, but Leonard (1927) concluded that insects were the most important food item. No other studies on common shiners were found, although Scott and Crossman (1973) described the species as omnivorous.

<u>Creek Chub</u> - The diets of creek chub at site CN-3 appeared to be typical for the species. The important food items, which included several orders of aquatic insects as well as terrestrials and leeches, have all been reported previously. The dramatic seasonal shift in food habits, which was also observed by Angermeier (1982) and Magnan and Fitzgerald (1982), demonstrates that creek chub are opportunistic. In Canagagigue Creek, chub had similar diets to common shiners, except that they consumed less plant material. Other studies confirm that plants are less important than insects in the diets of chub, and Schlosser (1983) describes the species as a "generalized insectivore".

Magnan and Fitzgerald (1982) found that the diet composition of chub in Quebec lakes was closely related to the composition of the benthic community except that chironomids were selectively avoided.

Similarly, our specimens did not feed on chironomids. Molluscs have been occasionally reported as food items for creek chub (Newsome and Gee, 1978; Angermeier, 1982). In Canagagigue Creek, chub were the only species to exploit the abundant snail population.

Creek chub were the most opportunistic of the 13 fish species investigated. No one food item accounted for more than one-third of their diet. In contrast, a dominant or preferred prey item could be easily identified for all other species.

Fathead and Bluntnose Minnows - Fathead and bluntnose minnows collected from site CN-3 in the spring had consumed almost entirely blackfly larvae. The latter had also eaten a small proportion of chironomid larvae. Neither of these bottom-feeding species has received much attention in the literature. Coyle (1930) described the food of fatheads in Ohio as being predominantly algae, although she acknowledged that earlier studies found animal matter, especially chironomids and entomostrachans, to be more important. Bluntnose minnows consume essentially the same prey items (Keast and Webb, 1966). Although blackfly larvae have not been specifically reported, their utilization by fathead and bluntnose minnows in Canagagigue Creek is consistent with the bottom-feeding habits of these fish.

Blacknose and Longnose Dace - Blacknose and longnose dace from site CN-3 fed entirely on blackfly and midge larvae. Blackfly larvae were the dominant food item in the spring, particularly for blacknose dace. As the season advanced longnose dace consumed proportionately more midge larvae. Both species have been shown, by a number of studies, to be almost entirely insectivorous. Pappantoniou and Dale (1982) found the diets of coexisting blacknose and longnose dace to be similar, and more a function of availability of prey than any differences in prey selection. Johnson (1982) states that chironomids, caddisfly larvae, and mayfly nymphs are the preferred prey of blacknose dace in environments where they are available. Several studies indicate that this is also generally true for longnose dace. However, blackfly larvae were the preferred prey of longnose dace in a Pennsylvania creek (Reed, 1959), and Gerald (1966) reported that large dace, 7.0-10.0 cm TL, were most likely to utilize this food source. Our specimens were also in this size range (6.1-9.6 cm TL). The food habits of dace in Canagagigue Creek are consistent with previous information on these benthic-foraging insectivores.

<u>Carp</u> - Small carp collected from site CN-3 in the fall had fed almost equally on plant material and insect larvae. The insect portion consisted of similar amounts of blackfly larvae and damselfly nymphs. Scott and Crossman (1973) describe carp as omnivorous, feeding on many kinds of aquatic insects, crustaceans, annelids and molluscs, as well as a variety of aquatic plants and algae. Powles (1983) found plant material to be unimportant in the diets of carp

from Indian River, Ontario. However, he noted that relative amounts of plant vs. animal material in carp from various waters is extremely variable. Eder and Carlson (1977) found, as we did, that plant material was quite significant. Dipteran larvae were an important food item in all studies, and may be the preferred insect prey. Carp from site CN-3 had a narrow diet breadth consisting of only three types of prey. Eder and Carlson (1977) discovered that young carp, in the same size range as our specimens (< 20.0 cm TL) utilized fewer alternate invertebrate food items than adult carp.

White Suckers - Chironomid larvae were important prey for white suckers at site CN-3 during both seasons. Blackfly larvae were the only other important items in the spring, while in the fall blackfly larvae and damselfly nymphs and leeches were all significant. The two smallest suckers (6.7 and 8.4 cm TL) from the fall collection had fed on zooplankton. However, two specimens of about the same size (7.3 and 7.9 cm TL) caught in the spring had consumed blackfly and midge larvae. As the latter prey were apparently abundant all year round, zooplankton may be the preferred food of small suckers when available. Lalancette (1977) found that young-of-the-year white suckers (<5.0 cm) in a Quebec lake fed almost entirely on zooplankton.

Most studies identified chironomids as the dominant food item for white suckers. Other important items included molluscs, caddisfly larvae and amphipods. Eder and Carlson (1977) also found blackfly larvae to be important in the diets of suckers from the St. Vrain River in Colorado. Damselfly nymphs and leeches have not been reported previously, and their utilization by Canagagigue Creek suckers results in a diet composition which could be considered unusual for the species. Amphipods and trichopterans were insignificant food items, and snails were not exploited despite their abundance.

Clemens (1924) noted that small suckers (<5.0 cm SL) in Lake Nipigon fed mainly on plankton, adding more of the larger bottom organisms to their diet as they grew. This trend was also true of our specimens in the fall. Suckers 17.5 cm TL consumed 1-3 items, while those 17.5-21.0 cm selected 4-5, and large specimens over 23.0 cm utilized an average of more than seven different prey. In contrast, suckers of all sizes consumed the same two items in the spring. A seasonal shift in the type of invertebrate food consumed by suckers was also reported by Scott and Crossman (1973).

Two studies described the utilization of zooplankton by adult suckers. However, zooplankton are probably only important in lake environments, particularly those with low productivity of benthic invertebrates (Lalancette, 1977). White suckers are opportunistic and capable of exploiting a wide variety of prey. As a result, diet composition varies considerably from one river or lake to another and it is difficult to define a typical diet for the species.

Shorthead Redhorse - Little information is available concerning the food habits of this species. Clemens et al. (1924) reported that redhorse ranging in size from 39.2-47.3 cm SL from Lake Nipigon ate mainly Ephemeroptera, with chironomid larvae next in importance. Our one specimen, which measured 33.0 cm TL, fed mainly on chironomid larvae, but also took blackfly and damselfly larvae and leeches. White suckers caught at the same time had been feeding exclusively on blackfly and chironomid larvae. The difference in diet composition between these two closely related species may simply be due to the larger size of the redhorse, however, competition with the much more numerous white suckers may be a factor.

Johnny Darter - Johnny darters collected from site CN-3 in the spring had fed exclusively on chironomid larvae. Four other studies also identified chironomid larvae as the dominant food item of this species. Two of these studies (Smart and Gee, 1979; Paine et al., 1982) found that diets in the spring consisted almost entirely of this prey. Although they will occasionally take other prey, especially mayfly nymphs and zooplankton, Johnny darters appear to be specialized feeders.

Brook Stickleback - Brook stickleback from site CN-3 fed mainly on chironomid larvae, but also consumed significant amounts of damselfly and mayfly nymphs and blackfly larvae. Chironomid larvae were also found to be important food items by Clemens et al. (1924) and Tompkins and Tompkins and Gee (1979). In both studies, zooplankton was important as well, and this was contrary to our findings. Blackfly larvae were not taken by sticklebacks from three Manitoba rivers, but they were also rare in the environment (Tompkins and Gee, 1979).

According to Scott and Crossman (1973), brook stickleback may feed on a wide variety of aquatic insects and crustaceans, fish eggs and larvae, snails, oligochaetes and algae. Due to this lack of selectivity, it would be difficult to define a typical diet. It appears that stickleback at site CN-3 on Canagagigue Creek were highly opportunistic, as they utilized the most readily-available prey.

DISCUSSION

Generally speaking, fish are opportunistic in their food habits. Despite inherent species-specific differences in prey preference, fish will respond to prey availability by concentrating their efforts on the most common prey types. Angermeier (1982) found that nine different species of fish in Jordan Creek, Illinois, all exploited essentially the same food resources. This non-selectivity is of particular adaptive significance for stream-dwelling fishes, as food availability in stream environments is constantly changing (Pappantoniou and Dale, 1982).

Most fish species from the impacted zone of Canagagigue Creek were non-selective and adapted readily to seasonal changes in availability of prey. Fish collected in the spring had preyed heavily on blackfly and midge larvae and also leeches. In comparison, fish collected in the fall relied less on blackfly larvae and leeches, but utilized damselfly nymphs, water boatmen and plants much more significantly. These changes in diet composition reflect changes in prey availability over the same time period. As shown in Tables 1 and 2, a wider range of prey was available in the fall. This essentially enabled fish to feed more selectively, thus leading to more distinctive diets for each species. We have demonstrated this by our observation that the degree of diet overlap between two given species was usually lower in the fall.

There are other factors which affect the food habits of fish, most notably differences in morphology and behaviour among the various species. Some species are less restricted than others and are therefore capable of being more opportunistic. Creek chub and common shiners are examples of versatile feeders. They are capable of both diurnal and nocturnal feeding, as well as surface and benthic foraging. In Canagagigue Creek, there was a higher degree of overlap between these two species in the spring ($\hat{C}\lambda$=.82) and fall ($\hat{C}\lambda$=.63) than between seasons for either species ($\hat{C}\lambda$=.42 for common shiners and .39 for creek chub). This indicates that the diets of non-selective species such as these depend mainly on the availability of prey.

According to George and Hadley (1979), rock bass feed on the largest prey they are able to swallow. This suggests that they may select prey on the basis of size rather than type. Due to body shape restrictions, rock bass are less adept at catching minnows than smallmouth bass, which are fast and powerful swimmers (Keast and Webb, 1966). A difference in habitat preference is also partly responsible for the difference in diet between rock and smallmouth bass. George and Hadley (1979) found that rock bass prefer the cover of heavy vegetation, and therefore feed on prey associated with vegetation. Damselfly and dragonfly nymphs, favoured prey of rock bass in the present study, are vegetation-dwellers. Smallmouths, on the other hand, prefer a rocky habitat. Their dominant prey in Canagagigue Creek were blackfly larvae. These organisms would be frequently encountered in riffles.

Bottom feeders such as dace, minnows and darters are much more restricted in terms of the range of prey they are able to catch. Bluntnose minnows, for example, are simply unable to get their mouths into the necessary position to pick up items from the surface (Keast and Webb, 1966). Johnny darters do not possess a swim bladder and are restricted to a microhabitat not more than 1.5 cm from the substrate (Smart and Gee, 1979). Furthermore, all darters are visual feeders (Wynes and Wissing, 1982) as are brook stickleback (Tompkins and Gee, 1982). These species are therefore unable to take advantage of the nocturnal drift. Suckers are also mainly bottom feeders. However, judging by their wide diet breadths at site CN-3 in the fall, they are more flexible than dace, minnows or darters.

The diets of most species in Canagagigue Creek were comparable to other areas. The most notable exceptions were the bass. Both species normally prey heavily on fish and crayfish. However, due to the impacted nature of the study site, potential fish prey (minnows) were only one-tenth as numerous as in cleaner areas upstream and crayfish were virtually absent (Carey et al., 1983). Under these conditions, bass were forced to choose alternate food sources, particularly leeches and damselfly nymphs.

Leeches were very abundant at site CN-3 due to nutrient enrichment. Literally hundreds have been collected by the author in only a few hours of hand-picking. Leeches have seldom been reported as a food item for fish, but in Canagagigue Creek they were utilized significantly by bass, shiners, chub and suckers. Oligochaetes were also very abundant due to the polluted conditions. However, only two out of 143 fish had consumed them. This places the concept of prey availability in a new light. Our perception of availability may differ considerably from that of a fish. Due to their burrowing habit, oligochaetes may be "invisible", or their capture may simply require too much energy output.

Fish from the impacted zone of Canagagigue Creek generally had narrower diet breadths than the same species elsewhere. An extensive survey of the literature revealed that caddisfly larvae and mayfly nymphs normally feature largely in the diets of a wide range of fish species. By contrast, these two insect orders accounted for less than 2.5% by weight of the total food items taken by our specimens. This can be attributed to the rarity of these invertebrates in the environment. Only three species of mayflies and eight of caddisflies were present at CN-3 while eight and 25 species, respectively, were present at the CN-5 recovery site (Carey et al., 1983). In terms of abundance, the differences were even more dramatic with seven versus 373 individual mayflies and 81 versus 2202 caddisflies collected per unit sampling effort. These are the two most prominent examples, but amphipods and molluscs showed a similar trend.

The structure of the fish community itself is indicative of the extent of pollution at the study site. A fish census conducted in 1980 showed that 14 species were represented at site CN-3 as compared with 18 at CN-5. Of the 13 species of interest in the present study, all but creek chub, suckers and carp were either drastically reduced in numbers or absent entirely (minnows and dace). Suckers and chub were actually more numerous at CN-3 than in cleaner areas up- or downstream, suggesting that they are more tolerant of polluted conditions.

The findings presented in this report have both a direct application to the Canagagigue Creek situation, and implications for food pathway studies in general. In the former context, the data will be used, in combination with the yet to be completed contaminant analyses, to determine whether diet composition has any bearing on the body burdens of contaminants in fish. Diet overlap indices will be used to "cluster" fish with the most similar diets. If the primary route of contaminant uptake is via the ingestion of contaminated food, then fish with the most similar diets should also have the most similar levels of toxicants in their tissues. Seasonal changes in body burdens of contaminants, if they occur, may be related to corresponding seasonal changes in prey utilization.

On a broader scope, this report points out the importance of determining the diet compositions of fish prior or concurrent to any food chain contamination study. We have demonstrated, as have many others, that diets of fish may vary considerably from one location to another. Interspecific differences in prey preference are often overshadowed by the realities of prey availability (Pappantoniou and Dale, 1982). Therefore, the published literature on fish food habits must serve only as an indiction of the types of prey "usually" consumed by the species of interest.

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APPENDIX A. Stomach Contents – May, 1983 Fish Collection

Fish Species	ID #	Sex	Total Length (cm)	Body Weight (g)	Stomach Contents (g)	Plant Tissues	Hirudinea	Gastropoda	Amphipoda	Decapoda	Unidentified Animal Remains	Ephemeroptera	Zygoptera	Anisoptera	Corixidae	Megaloptera	Trichoptera	Dytiscidae	Simuliidae	Chironomidae	Tipulidae	Unidentified Flying Insects	Fish Remains
						Food Items Consumed, as Average Percent by Weight of the Total Contents																	
Rock Bass	3	M	16.0	81.90	.70043	.8				5.9	93.2									.1			
	6	F	13.8	63.81	.72301		98.5						1.0				.3		.2				
	2	F	14.3	59.18	.87259		96.1					.7	1.8	.9	.4				.1				
	5	M	11.8	34.69	1.01598		93.1												6.4	.5			
	4	M	8.7	14.86	.23477										1.8				2.1	.6		95.5	
	1	immM	8.8	14.47	.20718									46.1	46.1				7.2	.6			
Common Shiner	7	M	15.4	56.66	.23158		57.2							14.7				12.2	1.3		14.6		
	1	M	15.0	55.48	.04378								61.4						33.2	5.4			
	2	M	15.6	54.49	.02860														50.0	50.0			
	5	M	15.5	53.35	.04088												51.6		36.8				11.6
	3	M	15.4	52.47	.21260		85.9												14.1				
	6	M	14.7	48.87	.37331														100.0				
	4	M	14.1	38.90	.07374	62.7													37.3				
	10	F	12.7	26.00	.38932											5.1			94.9				
	17	F	11.2	22.32	.08368		11.8											11.0	77.2				
	16	F	11.7	17.90	.37650														100.0				
	8	F	10.7	14.56	.15509														95.0	5.0			
	19	immF	9.1	9.73	.04810														100.0				
	9	F	9.0	8.75	.02549														97.2	2.8			
	18	immF	8.7	8.15	.06515														99.2	.8			
	11	F	6.6	2.91	.04519														100.0				
	13	F	5.3	1.31	.00400														90.0	10.0			

APPENDIX A. Stomach Contents – May, 1983 Fish Collection
cont'd.

Fish Species	ID #	Sex	Total Length (cm)	Body Weight (g)	Stomach Contents (g)	Plant Tissues	Hirudinea	Gastropoda	Amphipoda	Decapoda	Unidentified Animal Remains	Ephemeroptera	Zygoptera	Anisoptera	Corixidae	Megaloptera	Trichoptera	Dytiscidae	Simuliidae	Chironomidae	Tipulidae	Unidentified Flying Insects	Fish Remains
						Food Items Consumed, as Average Percent by Weight of the Total Contents																	
Creek Chub	2	F	15.7	47.21	1.17305	.8													99.2				
	5	M	16.0	44.34	.15353		100.0																
	8	F	13.8	31.60	.75973		50.1	3.1														46.8	
	3	immF	13.5	28.20	.29212													100.0					
	4	F	12.5	20.76	.67199														100.0				
	6	F	12.7	20.06	.27465														100.0				
	7	F	11.7	17.45	.08026			43.0	.3									9.2				47.5	
	1	F	10.5	13.95	.03431		9.7				89.6									.7			
Fathead Minnow	3	M	7.5	6.04	.05300														100.0				
	2	M	6.8	4.19	.06696														100.0				
	1	M	6.5	3.40	.00863														100.0				
Bluntnose Minnow	1	imm	7.0	3.59	.01106														92.2	7.8			
Blacknose Dace	1	F	7.7	5.76	.00920														92.4	7.6			
	2	F	7.3	4.39	.02793														98.0	2.0			
Longnose Dace	3	M	9.4	8.47	.01835														6.3	93.7			
	1	M	9.2	8.07	.05457														92.2	7.8			
	2	M	8.9	7.72	.07809														83.3	16.7			
	4	M	7.4	4.20	.00059														100.0				
	8	M	7.2	4.06	.00058														100.0				

APPENDIX A. Stomach Contents - May, 1983 Fish Collection
cont'd.

Fish Species	ID #	Sex	Total Length (cm)	Body Weight (g)	Stomach Contents (g)	Plant Tissues	Hirudinea	Gastropoda	Amphipoda	Decapoda	Unidentified Animal Remains	Ephemeroptera	Zygoptera	Anisoptera	Corixidae	Megaloptera	Trichoptera	Dytiscidae	Simuliidae	Chironomidae	Tipulidae	Unidentified Flying Insects	Fish Remains
						Food Items Consumed, as Average Percent by Weight of the Total Contents																	
Longnose	6	M	7.0	4.00	.03766														85.0	15.0			
Dace	5	M	7.3	3.96	.00138														50.0	50.0			
White	2	F	25.7	244.55	1.54400														100.0				
Sucker	1	F	25.5	235.66	2.89884	1.2	13.6									.01			58.1	27.1			
	6	F	26.1	162.18	.01660														60.2	39.8			
	7	M	23.3	139.40	.98494														99.5	.5			
	3	immF	19.8	85.52	.83484														9.3	90.7			
	9	immF	18.2	75.03	.65180														92.2	7.8			
	5	immF	19.5	73.50	.61530														81.3	18.7			
	8	M	14.1	27.72	.30412												.4		6.1	93.5			
	12	imm	12.0	21.19	.12712														.4	99.6			
	18	imm	9.7	11.38	.09661														14.8	85.2			
	11	F	10.0	10.30	.06578														3.3	96.7			
	15	imm	7.9	5.62	.06798														97.7	2.3			
	14	imm	7.3	4.45	.02802														32.9	67.1			
Shorthead Redhorse	1	M	33.0	384.00	.96055		14.1						7.6						18.0	60.3			
Johnny	1	F	5.1	1.71	.00656															100.0			
Darter	2	F	4.7	1.29	.00220															100.0			
	3	F	4.9	1.29	.01500															100.0			
	4	M	4.4	.98	.00825															100.0			

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APPENDIX B. **Stomach Contents - September, 1983 Fish Collection**
cont'd.

Fish Species	ID #	Sex	Total Length (cm)	Body Weight (g)	Stomach Contents (g)	Plant Tissues	Nematoda	Oligochaeta	Hirudinea	Gastropoda	Amphipoda	Copepoda & Conchostraca	Ephemeroptera	Zygoptera	Corixidae	Megaloptera	Trichoptera	Haliplidae	Dytiscidae	Simuliidae	Chironomidae & Heleidae	Tabanidae	Fish Remains
						Food Items Consumed, as Percent by Weight of the Total Contents																	
Common Shiner	7	imm	12.6	22.40	.49710	96.9														3.1			
	9	imm	12.7	20.92	.35200	100.0																	
	11	imm	6.1	2.05	.00557	71.6															28.4		
Creek Chub	3	F	15.4	36.12	.13252	100.0																	
	5	M	14.1	26.90	.12304					41.6				33.0						25.4			
	4	M	13.3	24.84	.15765					13.0				6.0	48.0			2.2	13.8	17.0			
	7	M	12.6	21.92	.14885									19.1						80.9			
	2	imm	12.1	20.02	.11382	10.7				4.7				27.3	54.6				2.7				
	1	imm	12.0	17.29	.39802									17.1	71.7			1.4	9.8				
	8	M	11.5	15.34	.14740									6.6	85.2					8.2			
	9	F	9.5	7.90	.06525									94.4						5.6			
	10	imm	9.2	7.77	.10700									18.2						81.8			
	11	F	8.1	5.17	.08440										100.0								
Longnose Dace	3	F	9.6	10.44	.12500															97.6	2.4		
	1	F	9.0	8.77	.08000																100.0		
	2	M	8.9	7.63	.09700																100.0		
	4	imm	6.8	3.95	.01930															96.4	3.6		
	7	imm	6.7	3.30	.02220									7.5						12.3	80.2		
	6	imm	6.3	2.61	.02500																100.0		
	8	imm	6.1	2.32	.02600															100.0			

APPENDIX B. Stomach Contents - September, 1983 Fish Collection

Fish Species	ID #	Sex	Total Length (cm)	Body Weight (g)	Stomach Contents (g)	Plant Tissues	Nematoda	Oligochaeta	Hirudinea	Gastropoda	Amphipoda	Copepoda & Conchostraca	Ephemeroptera	Zygoptera	Corixidae	Megaloptera	Trichoptera	Haliplidae	Dytiscidae	Simuliidae	Chironomidae & Heleidae	Tabanidae	Fish Remains
						Food Items Consumed, as Percent by Weight of the Total Contents																	
Rock Bass	1	M	8.4	11.35	.10020									88.1	11.9								
Smallmouth Bass	15	M	10.9	18.62	.00531									100.0									
	14	M	9.1	11.38	.51241									1.1						10.7			88.2
	11	M	8.5	10.07	.25976									97.7						2.3			
	9	F	8.8	9.79	.13634								7.2	1.1						91.7			
	5	imm	8.5	8.33	.09418									2.0						98.0			
	10	F	8.5	8.14	.09247								5.4	12.6						81.0	1.0		
	3	imm	8.0	7.83	.11893									7.8						92.2			
	2	imm	8.7	7.61	.10778															100.0			
	12	F	8.0	7.50	.09500				5.5				5.6	5.3						83.6			
	19	F	8.0	6.85	.05575									25.1						74.9			
	4	imm	7.7	6.70	.24241									16.6						83.4			
	18	M	7.8	6.28	.12628															100.0			
	8	M	7.5	5.84	.00782								84.5							15.5			
	1	M	7.5	5.80	.13659									95.4						4.6			
	17	imm	7.3	5.79	.02550									36.0						64.0			
Common Shiner	3	M	16.2	43.15	.18200									48.1			12.9			19.4		19.6	
	2	immM	15.3	42.55	.89019	72.4								2.9						24.7			
	1	immM	14.6	35.19	.27951	2.8								29.5						67.7			
	5	imm	13.1	26.87	.19285	5.8								14.8						42.0		37.4	
	4	imm	13.6	25.94	.09885									18.2	81.8								

APPENDIX B. **Stomach Contents - September, 1983 Fish Collection**
cont'd.

Fish Species	ID #	Sex	Total Length (cm)	Body Weight (g)	Stomach Contents (g)	Plant Tissues	Nematoda	Oligochaeta	Hirudinea	Gastropoda	Amphipoda	Copepoda & Conchostraca	Ephemeroptera	Zygoptera	Corixidae	Megaloptera	Trichoptera	Haliplidae	Dytiscidae	Simuliidae	Chironomidae & Heleidae	Tabanidae	Fish Remains
						Food Items Consumed, as Percent by Weight of the Total Contents																	
Carp	4	imm	16.0	80.30	.94900	99.4														.6			
	2	imm	13.2	42.68	.16422	100.0								5.4									
	1	imm	12.3	39.17	.16230									14.8			.4			94.6			
	6	imm	13.1	39.01	.68160	78.7								100.0						6.0	.1		
	7	imm	10.6	19.50	.18850																		
White Sucker	14	F	29.7	302.78	.41567			78.6	2.5					3.5			.1	1.3		8.6	5.4		
	11	F	30.3	298.09	.88800	.4	1.8	11.5	63.4				.3	6.2			4.3	.8		3.2	6.9	1.2	
	15	M	29.5	280.16	1.57900				99.1									.1			.8		
	13	F	29.0	263.14	1.54200				.3	.1				8.5			.4	1.2		56.9	32.5	.1	
	4	M	26.2	203.21	2.79100				23.7	.5			.1	54.5			12.5	.1		4.8	3.1	.7	
	5	M	25.9	190.90	.85105		.5							83.4		1.1	3.3	7.9		2.4	1.4		
	12	F	26.0	189.43	1.12750	10.9	6.5					.3		10.1			.2	1.9		7.2	62.9		
	7	M	25.0	159.36	1.85467				25.3				.1	67.5		4.3	1.3	.9		.6	.1		
	10	immF	24.5	144.57	1.28600									5.4				.5		.6	93.5		
	9	F	23.7	127.26	1.19017	.8					.2		.8	59.2			.4	2.9		28.6	7.1		
	6	F	21.0	97.30	1.08000									58.1				.8		9.2	31.9		
	20	immM	20.1	86.63	1.44400				8.5					8.9			.3			1.9	80.4		
	19	immM	18.8	74.69	1.08450				2.3					1.7				.1		44.2	51.7		
	25	imm	18.8	73.50	1.28400									2.4				.8		5.6	91.2		
	1	immM	18.4	67.33	.50021									.7			.1	.3		4.7	94.2		
	3	M	17.4	66.32	.84300															17.8	82.2		
	2	F	17.7	64.33	.81364									20.9				.3		4.3	74.5		

APPENDIX B. **Stomach Contents - September, 1983 Fish Collection**
cont'd.

Fish Species	ID #	Sex	Total Length (cm)	Body Weight (g)	Stomach Contents (g)	Plant Tissues	Nematoda	Oligochaeta	Hirudinea	Gastropoda	Amphipoda	Copepoda & Conchostraca	Ephemeroptera	Zygoptera	Corixidae	Megaloptera	Trichoptera	Haliplidae	Dytiscidae	Simuliidae	Chironomidae & Heleidae	Tabanidae	Fish Remains
						Food Items Consumed, as Percent by Weight of the Total Contents																	
White Sucker	23	imm	16.5	50.03	.64105					.7							1.3				98.0		
	24	imm	16.6	48.96	.69453									1.3						31.8	68.2		
	18	immM	15.9	39.24	.86010															1.7	97.0		
	22	imm	8.4	6.78	.07712							92.1									7.9		
	21	imm	6.7	3.42	.07600							100.0											
Brook Stickle-back	10	imm	5.1	1.48	.02004									100.0									
	9	imm	4.7	1.29	.00943								99.9								.1		
	15	imm	4.9	1.23	.01541								23.9							62.3	13.8		
	4	imm	4.8	1.21	.01331									97.8						2.2			
	2	imm	4.8	1.20	.00528					4.6				89.0							6.4		
	8	imm	4.7	1.09	.01980															92.7	7.3		
	7	imm	4.7	1.08	.01339																100.0		
	5	imm	4.6	.96	.00614								26.7								73.3		
	13	imm	4.4	.94	.00657																100.0		
	12	imm	4.6	.93	.00877															9.1	90.9		
	14	imm	4.5	.89	.00487																100.0		
	1	imm	4.6	.89	.00300															100.0			
	6	imm	4.1	.82	.00312																100.0		
	11	imm	4.3	.74	.00638									35.1							64.9		