1972

Food Habits of Fish In A Multispecies Farm Pond

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FOOD HABITS OF

FISH IN

A MULTISPECIES FARM POND

BY

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A thesis submitted
in partial fulfillment of the requirements for the
degree Master of Science, Major in
Wildlife Biology, South Dakota
State University

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This thesis is approved as a creditable and independent investigation by a candidate for the degree Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor Date

Head, Dept. of Wildlife and Fisheries Sciences Date

Abbey Pond

ACKNOWLEDGEMENTS

I would like t'o express my sincerest gratitude and appreciation to Dr. John G. Nickum for his guidance and counsel throughout all phases of the study and in the preparation of this manuscript.

I wish to thank Drs. Donald R. Progulske and Donald C. Hales for their **suggestions** and review of the manuscript. In addition, I would like to thank Mr. Richard L. Applegate for his willing assistance and thoughtful suggestions concerning the organization of data.

Thanks are extended to former graduate student Dennis G. Unkenholz for his aid and companionship during the first year of the study and to fellow graduate student, Andrew Repsys, for his help in the identification of phytoplankton.

Financial aid and supplies were provided by the South Dakota State University Agriculture Experiment Station project 7116-555. Some of the field gear used was borrowed from the South Dakota Cooperative Fishery Unit.

I would also like to thank my wife, Mary, for her help with this manuscript and for her patience and understanding during its preparation.

Appreciation is extended to the personnel of Blue Cloud Abbey for their cooperation throughout the study.

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ABSTRACT

Thomas W. Gengerke

Food habits of yellow perch, bluegill, and black crappie were studied during 1970 and 1971 in Abbey Pond, South Dakota. Aquatic insects, zooplankton, mollusks, and fish were the most frequently consumed food items by the three species.

Yellow perch led primarily on aquatic insects, zooplankton, and mollusks. Aquatic insects were dominant (by volume) in 40.0 and 61.5 percent of the **samples respectively** for **the two** years.

Zooplankton, mollusks, aquatic insects, and bryozoans were the dominant food items by volume of adult bluegills. On an annual basis aquatic insects were the most important food item in the diet.

Adult black crappies fed primarily (as indicated by number and by volume) on zooplankton and aquatic insects. Zooplankton were fed upon irregardless of their availability.

Daphnia galeata was **positively** selected while *Bosmina longirostris* and both cyclopoid and calanoid copepods were selected against by all three species of fish. With the exception of *Daphnia parvula,* which was positively selected by adult black crappies, the smaller cladocerans were generally selected against.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX

INTRODUCTION

Manipulation of fish species possessing different food habits for effective use of available food niches within aquatic ecosystems is one of the most important management techniques for maximum fish production (Tang, 1970). Results obtained from experiments on fish populations in ponds at Auburn University (Swingle, 1966), indicated that while the highest fish production of a single species was obtained by raising a plankton-feeding fish, highest total fish production per unit area could only be obtained by using a combination of species possessing different food habits. If fish are utilizing distinct food riches, competition for the food resource will not occur and higher fish
1 production may be obtained.

Knowledge of food habits and food selectivity is essential to evaluating competition. Competition for food among animals occupies a central position among all facets of the struggle for existence (Ivlev, 1961). If there **is a limiting** resource and there is competition for its utilization, one or more species would be eliminated from the system. However, if the resource is not a limiting factor, there may be competition for its utilization and at the same time coexistence of those species in competition for it. This phenomenon would allow a multispecies system to exist.

The objective of this study was to discern whether some aspect of food availability or selection might be responsible for the existence of the relatively stable multispecies system found in Abbey Pond. Specifically,it was to determine (1) the food habits of the predominant species of fish in Abbey Pond and (2) food availability in the pond.

The existence of a multispecies system in Abbey Pond makes it unique to South Dakota farm ponds which typically contain only one or two species of fish. These ponds are not as productive, are less stable, and do not provide the quality fishing associated with multispecies ponds. Overpopulated and stunted populations are characteristic of ponds dominated by one or two species of fish.

Many of the mole than 5400 ponds, (representing more than 6400 hectares), which support **fisheries in** South Dakota, do not provide stable quality fishing or desirable recreation opportunities because of this situation.

Results from this study should provide a base for improved management of farm ponds and small impoundments.

DESCRIPTION OF STUDY AREA

Abbey Pond is a 1.62 ha-impoundment on the eastern edge of the Coteau des Prairie in Grant County, South Dakota (Figure 1). It is used primarily for recreational purposes. The watershed is a mixture of crop land and pasture with all adjacent land having vegetative cover. The principal source of water for the pond is runoff.

Based on measurements made during the fall of 1970, the pond had a volume of 46,920 m^3 of water, a maximum depth of 6.09 m, a mean depth of 2.9 m, a mean slope of 9.4 percent, and a shore development of 1.7 (Figure 2). Secchi disc visibility, which approximates the depth to which 5 percent of the incident sunlight is transmitted, varied from 90 to 400 cm on the sampling dates, with a mean of 187 cm.

The pond is polymictic. Thermal stratification occurred during three **periods** in 1970 and for one **prolonged** period in 1971. Water temperatures on the **sampling** dates ranged from 1.0 to 27.0 C; pH, from 7.2 to 8.9; total **alkalinity**, from 80 to 154 mg/l; and dissolved oxygen from 0.0 mg/l at the bottom during stratification to 11.0 mg/l at the surface. Maximum values of **dissolved** oxygen occurred at 1330 hours during a 24-hour **monitoring on September** 10, 1971. **These** and other **physio-chemical** limnological characteristics (Appendix Tables 1 and 2) are comparable to values found by Schmidt (1967) for eastern South Dakota lakes.

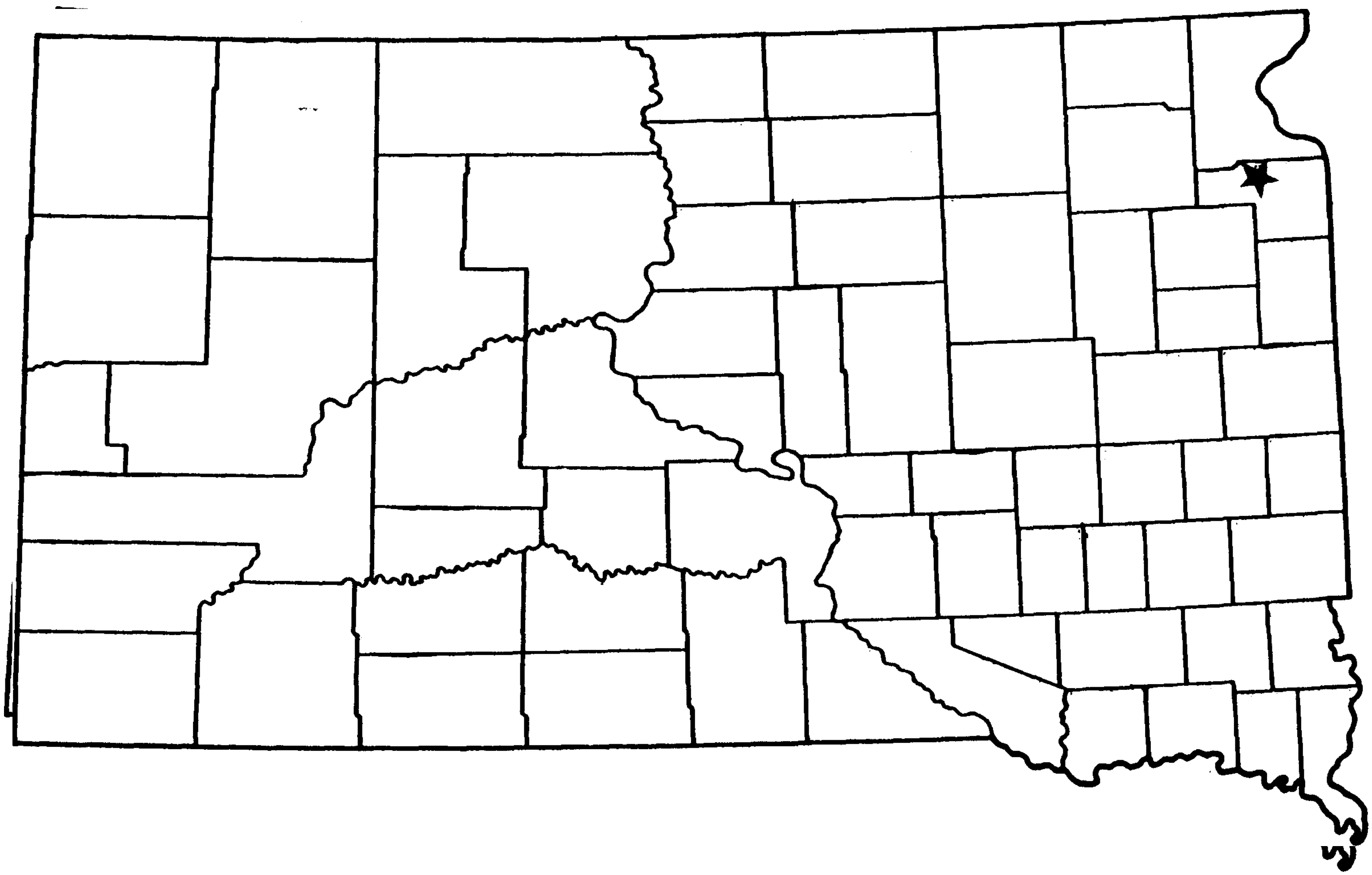

Figure 1. Location of Abbey Pond.

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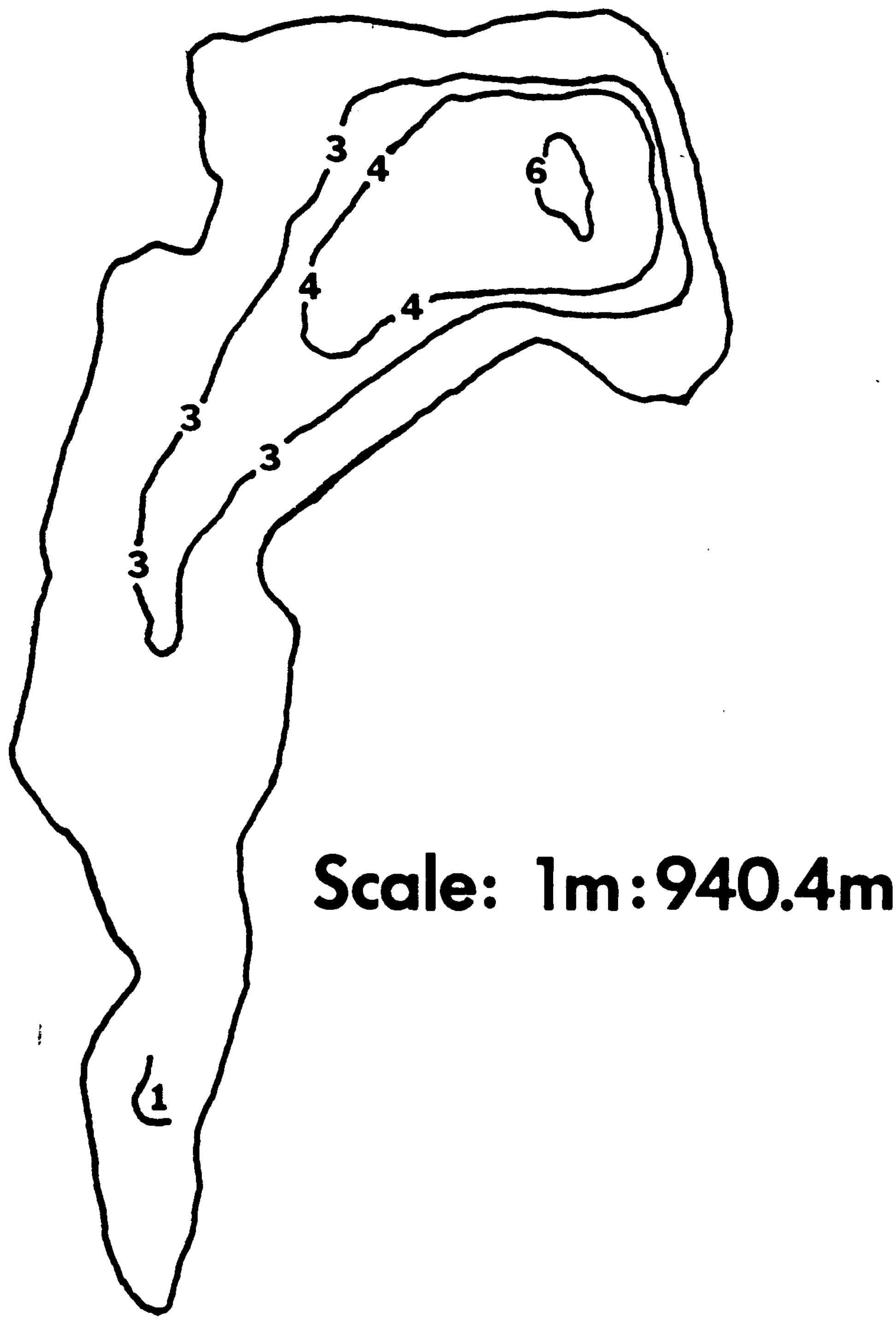

Figure 2. Bathymetric map of Abbey Pond.

The ten species of fish (Table 1) found in the pond constitute a more diverse population than is normally encountered in South Dakota ponds. Estimates made in the fall of 1970 indicated a total of 3654.9 adult fish/ha with a standing crop of 705.4 Kg/ha. Of these totals, yellow perch made up 35.3 percent by number and 20.2 percent by weight while bluegill made up 32.2 percent and 51.1 percent, respectively. Estimates made in 1968 (Thorn, 1969) and 1965 (Nickum pers. com.) were similar for total population numbers, but species composition was different and standing crops were lower (Appendix Tables 3, 4, and 5).

Phytoplankton populations were dominated by organisms in two diatom genera (*Fragilaria*; *Melosira*) and one blue-green algae (*A,hanizomenon*) (Tables 2 and 3). Diatoms predominated in June and from the middle of September through November in 1970, while blue-green algae dominated in July and August, 1970. Diatoms were dominant throughout 1971 except for a brief period of blue-green dominance in September.

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Table 1. Species of fish found in Abbey Pond[1].

Common name	Scientific name
Northern pike	*Esox lucius* Linnaeus
Black bullhead	*Ictalurus melas* (Rafinesque)
Yellow bullhead	*Ictalurus natalis* (Lesueur)
Pumpkinseed	*Lepomis gibbosus* (Linnaeus)
Bluegill	*Lepomis macrochirus* Rafinesque
Largemouth bass	*Micropterus salmoides* (Lacepede)
White crappie	*Poxomis annularis* Rafinesque
Black crappie	*Pomoxis nigromaculatus* (Lesueur)
Yellow perch	*Perca flavescens* (Mitchill)
Walleye	*Stizostedion vitreum vitreum* (Mitchill)

[1] Names according to Trans. Amer. Fish. Soc., Spec. Publ. No. 6, A list of Common and Scientific Names of Fishes from the United States and Canada, 3rd Edition, 1970.

Table 2. Phytoplankton[1] density expressed as cells x 10^3/liter and percent composition (in parentheses) in Abbey Pond during 1970.

	Date											
	6-10	6-22	7-1	7-13	8-3	8-12	8-24	9-2	9-14	10-7	10-23	11-13
Chlorophyta												
Spirogyra										T	0.1	
										(T)	(T)	
Chrysophyta												
Melosira	1.2	T[2]			0.2	T	10.7	18.6	2.9	T	T	
granulata	(4.0)	(T)[3]			(T)	(T)	(1.8)	(15.1)	(4.3)	(T)	(T)	
Fragilaria	28.9	10.2	3.0	5.7	0.6	3.3	1.4	7.0	57.6	4.8	26.4	2.3
	(95.9)	(99.6)	(13.9)	(6.0)	(1.8)	(T)	(T)	(5.6)	(84.6)	(89.3)	(99.4)	(91.6)
Cyanophyta												
Aphanizomenon			18.1	88.0	30.5	1083.6	574.5	97.4	7.5	0.4	T	0.2
			(85.4)	(93.0)	(97.2)	(99.6)	(97.9)	(79.1)	(11.0)	(8.0)	(T)	(8.3)
Anabaena			T	T								
spiroides			(T)	(T)								
Total	30.1	10.2	21.2	94.6	31.4	1087.0	586.7	123.1	68.1	5.4	26.6	2.5

[1] Organisms making up <1.0 percent of the total population (*Pediastrum duplex*, *Mougeotia*, *Closterium*, *Ceratium hirundinella*, *Navicula*, and *Cymatopleura*) were omitted from this table.
[2] Less than 100 organisms/liter
[3] Less than 1%

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Table 3. Phytoplankton[1] density expressed as cells x 10^3/liter and percent composition (in parentheses) In Abbey Pond during 1971.

	Date													
	4-16	5-1	5-21	6-11	6-23	7-9	7-19	7-27	8-9	8-19	8-31	9-10	9-20	9-29
Chlorophyta														
<u>Spirogyra</u>	2.4	0.1	0.6	0.3	1.0					0.4	0.4	T	0.2	0.1
	(17.2)	(2.8)	(11.5)	(5.1)	(T)					(1.4)	(T)	(T)	(T)	(T)
<u>Zygnema</u>	0.2		T							T	1.7	2.0	5.2	2.2
	(1.5)		(T)							(T)	(1.9)	(5.7)	(1.7)	(3.6)
Chrysophyta														
<u>Melosira granulate</u>	0.3			T	39.6	8.6	125.8	1933.9	3.0	4.5	0.8	6.5	260.3	46.5
	(2.1)			(T)	(38.7)	(57.2)	(93.8)	(96.4)	(14.9)	(16.1)	(T)	(18.5)	(87.3)	(78.3)
<u>Fragilaria</u>	10.9	4.7	4.4	5.1	61.5	6.4	7.8	60.3	15.0	8.9	69.3	0.8	17.8	9.2
	(78.7)	(96.3)	(87.3)	(94.6)	(60.2)	(42.6)	(5.7)	(3.0)	(75.3)	(32.1)	(77.9)	(2.1)	(5.9)	(15.4)
Cyanophyta														
<u>Aphanizomenon</u>		T	T				T		1.7	13.6	16.5	25.7	14.6	1.4
		(T)	(T)				(T)		(8.4)	(49.0)	(18.6)	(73.1)	(4.8)	(2.3)
<u>Anabaena spiroides</u>	T[2]				T	T	0.4	10.2	0.3	0.2	0.2	T	T	T
	(T)[3]				(T)	(T)	(T)	(T)	(1.2)	(T)	(T)	(T)	(T)	(T)
Total	13.8	4.9	5.0	5.4	102.2	15.1	134.0	2004.4	19.9	27.8	88.9	35.1	298.1	59.4

[1] Organisms making up < 1.0 percent of the total population (*Pediastrum duplex*, *Mougeotla*, *Closterium*, *Ceratium hirundinella*, *Navicula*, and *Cymatopleura*) were omitted from this table.

[2] Less than 100 organisms/liter

[3] Less than 1%

METHODS

Samples of water, zooplankton, benthos, and fish stomach contents were collected in 1970 and 1971. Intervals between sampling dates were 10 days or 2 weeks depending upon the time of year.

Water samples were taken at 1030(± 0.5) hours both years. Dissolved oxygen, pH, temperature, alkalinity, and hardness were analyzed in the field. All other chemical factors were analyzed in the lab. Determinations were made using procedures outlined in the 12th edition of Standard Methods for the Examination of Water and Wastewater (APHA, 1965) or modified in Hach Catalog No. 10. Sodium and potassium concentrations were determined by flame photometry. Organic carbon determinations were made using quantitative dichromate oxidation as described by Maciolek (1962).

Zooplankton samples were collected with a metered Miller sampler (Miller, 1961) fitted with a No. 10 net. A single horizontal pull was made on each sampling date in 1970. A double oblique tow was made on each sampling date in 1971. Samples were preserved in a 10 percent solution of formalin. Numbers of microcrustaceans were determined by counting three subsamples in a counting wheel (Ward, 1955) except in those instances where the number of organisms was so small that it was desirable to count the entire sample.

Phytoplankton samples were collected using a vertical pull with a Wisconsin plankton net fitted with a No. 20 net. Three random samples were taken on each sampling date. Samples were preserved in Lugol's solution. Numbers of organisms were determined by counting two subsamples from each sample in a Sedgwick-Rafter counting chamber at 150X.

Estimates of benthos populations were made by taking three random samples on each date with an Ekman dredge (14.8 x 15.0 cm). Material collected in 1970 was preserved in 10 percent formalin. In 1971 collected material was refrigerated and analysis completed within 24 hours. Organisms were separated from detritus using a sugar floatation technique (Anderson, 1959).

Fish were collected with trap nets fitted with 1.91 or 2.54 cm bar mesh. The nets were placed in approximately the same locations both years for **periods** of **5** to 6 hours. Captured fish were **grouped** by species into 5-cm groups and stomach contents removed.

Stomach contents were collected via a modified Seaburg (1957) stomach pump (Figure 3) and **preserved** in 10 percent formalin. Fish were **periodically** sacrificed and stomachs examined to check the effectiveness of the pump. All stomach samples from specific groups on each date were **pooled** (Borgeson, 1963). Initial analysis was done on each 5-cm **group**. **Information** gained from these analyses was consolidated to represent **young-of-the-year** or adult portions of populations. **Separating** the fish into **young-of-the-year** and adults was accomplished by **ageing** the populations and comparing these values to those reported by Thorn (1969) and in Calhoun (1966). Fish > 10 cm total length were

Figure 3. Modified Seaburg stomach pump in operating position.

considered adults in the perch and black crappie populations and those >5 cm total length were considered adults in the bluegill population. Stomach contents were examined from 280 yellow perch, 194 bluegills, 63 black crappies, 34 largemouth bass, and 17 black bullheads.

Microcrustaceans in the samples were counted utilizing the same procedures applied to zooplankton samples. The remaining organisms **were individually** counted. **The volume** of all organisms was determined **by water displacement.**

An electivity index **(Ivlev**, 1961) was calculated to describe the **selective feeding** upon **zooplankton** by fish. The index (E) was derived from the formula:

$$E = \frac{ri - pi}{ri + pi}$$

where ri represents percent composition of the item in the stomach and **pi represents percent composition** of the same item in the environment. Indices range from -1.0 (indicating negative selection or avoidance) to +1.0 (indicating **positive** selection), with 0.0 indicating random **selection.**

Keys used for the identification of organisms were: Freshwater **Biology** **(Edmonson, 1966)**, 2nd Ed.; Freshwater Invertebrates **of** the United States, Pennak (1953); Aquatic Insects of California, (Usinger, 1963); **Algae** of the Western Great Lakes Area, Prescot (1962); and The Systematics of North American Daphnia, Brooks (1957).

Population estimates for each species of fish were determined using a method described by Schnabel (1938). Fish for these estimates were collected by electrofishing with a boom-type, DC electro-shocker.

RESULTS AND DISCUSSION

Fish examined in this study appeared to adjust feeding habits in accordance with food availability. At times the three dominant species of fish appeared to be in direct competition for the food resource and at other times they utilized dissimilar items. Consumption also appeared to be a function of consumer preference.

The following discussion first deals with food availability and then with specific food habits of the dominant species of fish.

Food Availability

Zooplankton, benthic organisms, and young-of-the-year fish were the major food groups available to the fish.

Total zooplankton populations ranged from 1.1 to 498.8 organisms per liter in 1970 and from 10.0 to 305.2 organisms per liter in 1971 (Figures 4 and 5; Appendix Tables 6 and 7). Maxima in early summer and again in autumn indicated the populations were similar to diacmic populations described by Hutchinson (1967). During both 1970 and 1971, June and July peaks were dominated by Daphnia galeata Sars mendotae Birge while the fall peak was dominated by Bosmina longirostris (O. F. Muller). Cyclopoid copepods made up a substantial portion of the total population during the spring and fall pulses.

Benthos populations were dominated by chironomids, ceratopogonids, and oligochaetes. Other organisms occurred in low numbers or irregularly

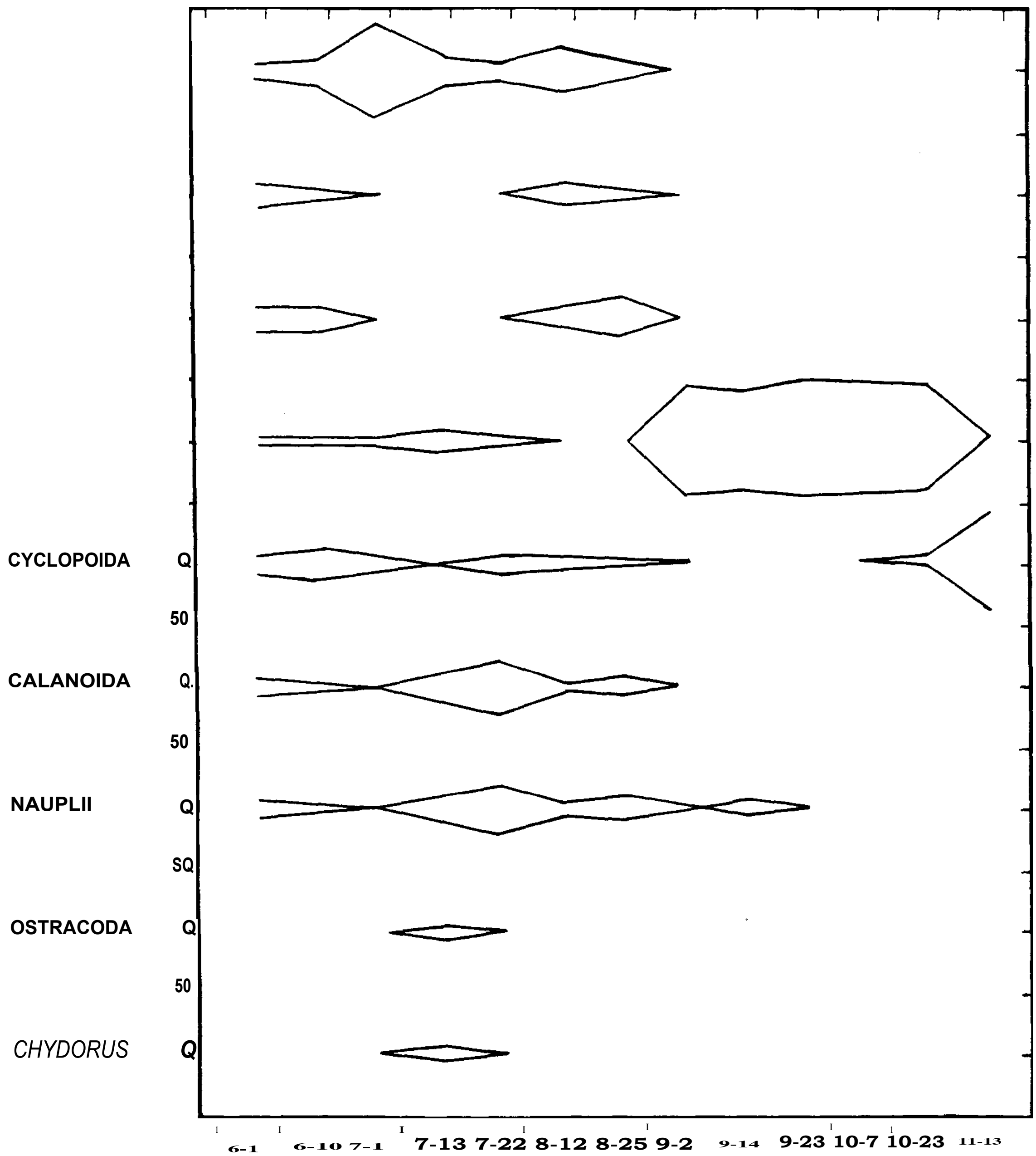

Figure 4. Zooplankton populations of Abbey Pond during 1970, expressed as percent of total population.

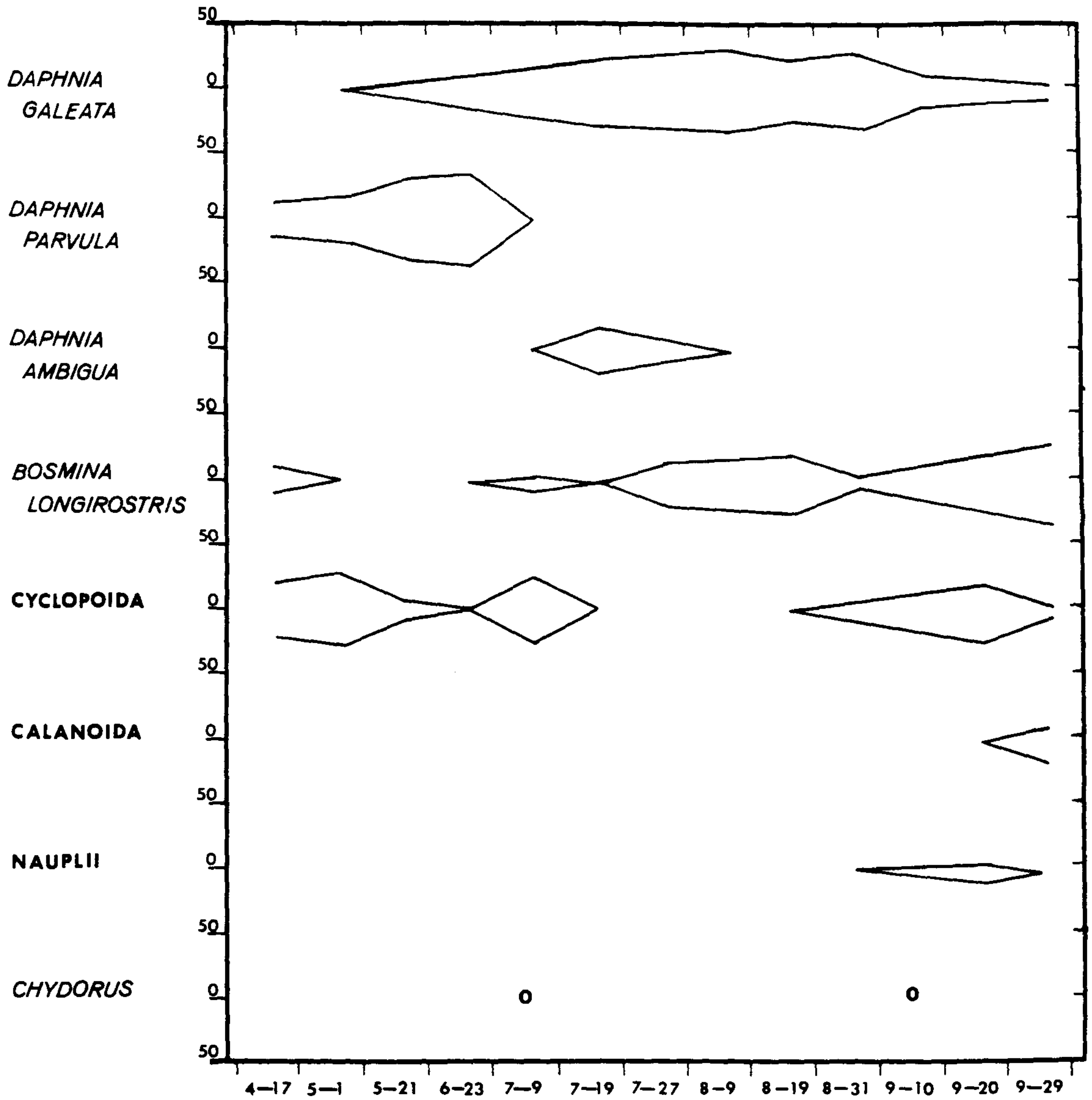

Figure 5. Zooplankton populations of Abbey Pond during 1971, expressed as percent of total population.

during the study. Peaks in yearly populations occurred in spring and late fall in 1970 and 1971 (Figure 6; Appendix Tables 8 and 9). Population levels fluctuated very little throughout the rest of the study. Differences in habitat requirements, seasonal movements, behavioral adaptations, and mobility made satisfactory quantification impossible for those organisms which occurred in low numbers or irregularly. For this reason food electivity indices could not be reliably applied to benthic organisms.

Shoreline seining indicated relatively large numbers of young-of-the-year bluegills, yellow perch, largemouth bass, and black bullheads. Young-of-the-year fish appeared around the middle of July both years.

Food Habits

Yellow Perch Aquatic insects, zooplankton, fish, and mollusks constituted the major food items by volume for adults on various sampling dates in 1970 and 1971 (Tables 4 and 5). Similar preferences were observed in yellow perch by Coots (1956). Aquatic insects were dominant (by volume) in 40.0 and 61.5 percent of the samples, respectively, for the two years. Mollusks were dominant in 13.2 and 15.2 percent and zooplankton dominated in 33.3 and 7.6 percent of the samples. Fish were dominant in 7.0 and 15.0 percent of the samples.

Zooplankton and immature aquatic insects were the dominant food items by number both years. Zooplankton appeared to be utilized more

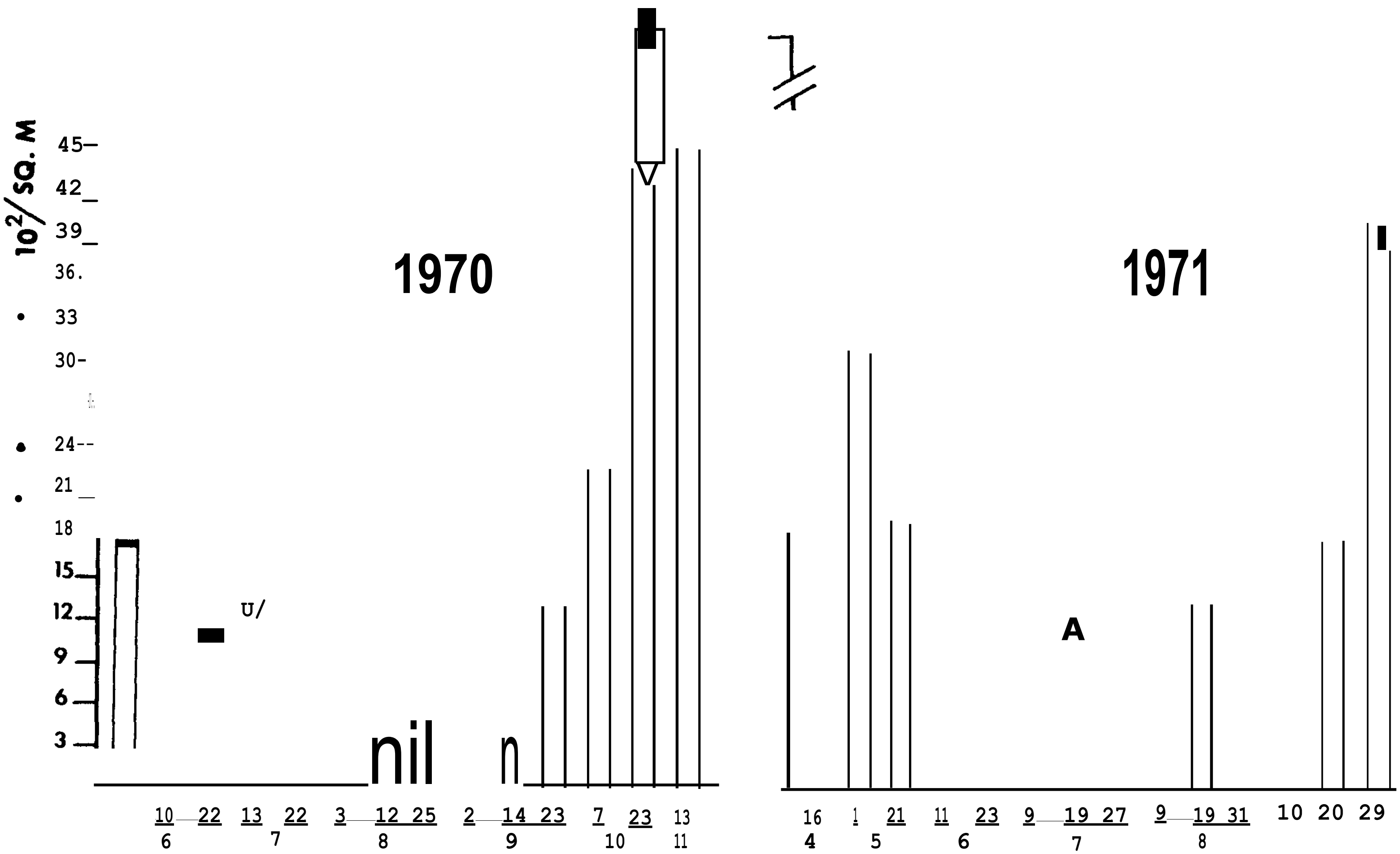

Figure 6. Total number of organisms obtained in Ekman dredge samples from Abbey Pond. Unshaded area indicates percent of total made up by the taxa Chironomidae, Ceratopogonidae, and m Oligochaeta.

Table 4. Stomach contents of adult yellow perch from Abbey Pond during 1970, expressed as percent number per stomach and **percent volume per** stomach (in parentheses).

Item		Date														
		5-25	6-1	6-10	6-22	7-1	7-13	7-22	8-3	8-12	8-25	9-2	9-14	9-23	70-7	10-23
Annelida	**Nirudinea**			T (3.1)												
Mollusca	**Gastropods**		T (4.3)	T (1.5)		T (T)		T (2.4)	T (7.6)	T (8.8)	73.7 (55.5)	3.4 (4.9)		32.6 (31.2)		
	Pelecypoda			T (T)			T (T)			T (T)	2.8 (T)	T (T)				
Arthropoda																
Crustacea																
Cladocera	**Daphnia galeata**	90.9 **(26.8)**	65.9 **(6.8)**	94.7 (38.0)	97.4 (40.6)	98.2 (69.4)	1.3 (T)	98.0 (31.9)	97.2 (53.3)	94.5 (5.0)						
	Daphnia parvula	1.4 (T)[1]	12.1 (2.4)	T (T)												
	Daphnia ambigua	1.4 (T)	10.8 (2.1)	2.8 (2.0)												
Copepoda	Cyclopoida		T (T)	T (T)	1.1 (4.9)	T (2.9)			T (T)							
	Calanoida									T (T)						
	Nauplii	T (T)	T (T)													
Amphipoda	Hyalella	T (19.7)	1.7 (11.0)	T (T)		T (1.7)	3.7 (7.4)	T (1.2)	T (17.6)	T (T)	1.8 (T)	55.8 (36.0)				
Ostracoda			T (T)	T (T)						1.0 (T)						
Arachnlda	Acari				T (T)	T (T)	T (T)	T (T)								

Continued

Table 4. **(Continued)**

Item		5-25	6-1	6-10	6-22	7-1	7-13	7-22	8-3	8-12	8-25	9-2	9-14	9-23	10-7	10-23
		Date														
Arthropoda																
Insecta																
Odonata	**Anisoptera**	T (9.8)	T (22.0)											5.3 (17.2)	10.0 (34.7)	
	Zygoptera									T (7.5)	T (T)					
Hemiptera	**Corixidae**	T (9.4)	T (7.7)	T (2.5)	T (10.1)		T (R.0)		T (2.7)	T (8.3)	1.8 (1.6)	T (1.6)		43.8 (28.9)	25.0 (10.4)	100 (100)
Trichoptera	**Limnephilidae**[2]	T (1.5)	2.1 (9.8)	T (20.0)	T (5.7)	T (1.1)	1.0 (1.9)	T (18.0)	T (T)	T (9.4)	7.7 (5.8)	23.2 (24.5)	95.8 (82.1)		55.0 (30.5)	
Coleoptera	**Dytiscidae**		T (1.2)		T (T)											
	Haliplidae		T (T)													
Diptera	**Chironomidae**	4.0 (29.6)	4.2 (19.8)	T (25.0)	T (34.8)	T (4.1)	3.7 (15.5)	T (9.6)	T (4.0)	T (T)		10.4 (14.7)				
	Ceratopogonidae	T (1.1)	2.3 (2.3)	T (T)	T (2.3)	T (4.1)	6.3 (12.2)		T (4.0)			4.6 (1.6)		5.3 (T)		
	Syrphidae										1.8 (1.6)					
Ephemeroptera	**Baetidae**	T (T)	1.1 (6.5)	T (4.4)	T (T)	T (T)	81.6 (53.7)		T (6.7)	T (T)				5.3 (T)		
Neuroptera	**Sialidae**								T (1.3)						5.0 (]0.4)	
Hymenoptera											T (T)					
Fish						T (15.8)		T (33.7)	T (T)	T (59.6)	8.8 (33.3)	2.3 (16.3)	4.3 (17.8)	5.3 (21.3)	5.0 (13.8)	
Sample size		5	7	5	10	11	6	7	16	24	17	20	4	7	5	15
Average food volume (ml)/stomach		0.5	0.6	0.6	0.3	0.2	0.3	0.1	0.2	0.4	0.3	0.1	0.3	0.2	0.3	0.1
Average food number/stomach		883.8	428.1	1501.3	1403.9	1110.3	60.6	176.2	1151.0	129.8	5.9	4.3	6.0	2.6	1.0	1.1

[1] 1.ess than 1%

[2] lncludes both organism and case

Table 5. Stomach contents of adult yellow perch from Abbey Pond during 1971, expressed as percent number per stomach and percent volume per stomach (in parentheses).

Item		Date												
		4-16	5-1	5-21	6-11	6-23	7-9	7-19	7-27	8-9	8-19	8-31	9-20	9-29
Annelida	**Hirudinea**						T							
							(T)							
Mollusca	**Gastropoda**			2.7	1.3	T	T	T	2.3	31.5	25.5			5.5
				(5.5)	(1.1)	(T)	(6.5)	(4.5)	(20.1)	(20.8)	(36.6)			(3.7)
	Pelecypoda				20.7	4.9		1.7	T		38.2		25.0	
					(12.5)	(8.1)		(20.4)	(2.5)		(36.6)		(6.0)	
Arthropoda														
Arachnida	Acari						T							1.8
							(T)							(T)
Crustacea														
Cladocera	**Daphnia galeata**		9.3				**89.9**	78.9	86.9			87.2		
			().8)				(6.4)	(7.6)	(4.0)			(8.1)		
	Daphnia parvula	3.0	**73.8**				1.0							
		(T)[1]	(45.4)				(T)							
	Daphnia ambigua		**15.9**											
			(9.7)											
	Simocephalus serrulatus							15.1						
								(6.7)						
Copepoda	Cyclopoida						T	T						
							(T)	(T)						
	Calanoida		T											
			(T)											
Amphipoda	**Hyalella**	3.0	T	26.1	9.2	14.7	3.1		T	7.8	9.1			5.5
		(1.3)	(T)	(17.2)	(2.7)	(12.1)	(13.5)		(1.2)	(1.7)	(9.1)			(1.0)
Decapoda						T								
						(T)								

Continued

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Table 5. (Continued)

Item		4-16	5-1	5-21	6-11	6-23	7-9	7-19	7-27	8-9	8-19	8-31	9-20	9-29
		Date												
Arthropoda														
Insecta														
Odonata	**Zygoptera**	1.4		4.1	7.0	T	T	T	T			T		
		(5.5)		(13.7)	(10.6)	(1.5)	(6.7)	(7.6)	(11.0)			(3,4)		
Hemiptera	**Corixidae**		T	T		T	1.3			5.2			25.0	74.0
			(2.7)	(1.4)		(2.5)	(28.5)			(5.6)			(17.2)	(88.2)
Trichoptera	**Limnephilidae** [2]		T	1.3	10.1	T	1.9	T	3.9	10.4	6.3	T		
			(13.7)	(T)	(6.8)	(T)	(34.2)	(15.2)	(48.7)	(5.7)	(12.2)	(T)		
	Hydroptilidae				1.7	2.5						T		
					(1.0)	(4.2)						(9.6)		
Coleoptera	**Dytiscidae**				1.3	T								
					(T)	(T)								
	Haliplidae				T	9.1	T							
					(T)	(15.1)	(1.0)							
Diptera	**Chironomidae**	90.9	T	63.8	11.7	44.2	T	1.4	2.9	2.6	6.3	1.4		11.1
		(70.8)	(15.2)	(56.1)	(53.1)	(36.4)	(1,0)	(10.7)	(8.4)	(1.7)	(3.0)	(12.7)		(2.6)
	Ceratopogonidae			T	28.7	20.9		T	T	5.2	4.2	10.1		
				(T)	(8.6)	(17.2)		(2.1)	(2.2)	(1.1)	(2.0)	(59.8)		
Ephemeroptera	Baetidae			T	5.7	1.5	T		T					
				(T)	(1.7)	(1.1)	(T)		(1.5)					
Fish			T	T				T		36.8		T	50.0	1.8
			(10.9)	(4.5)				(13.1)		(63.0)		(5.7)	(75.8)	(4.2)
Unknown		1.4						T						
		(22.2)						(11.3)						
Sample size		12	11	12	10	11	3	8	7	5	5	11	9	12
Average **food volume (ml)/stomach**		0.1	0.3	0.5	0.8	0.8	1.2	0.3	0.3	0.4	0.2	0.3	[3]	0.2
Average food number/stomach		5.5	652.2	36.0	22.6	70.2	522.3	192.8	93.0	7.6	9.4	153.7	0.4	4.5

[1] Less than 1%

[2] Includes both the **organism** and the case

[3] Less than 0.1 ml

and aquatic insects utilized less in 1970 than in 1971. It is possible that the greater availability of zooplankton in 1970 was responsible for this. With a decline in the zooplankton population aquatic insects were utilized more extensively during both years.

Incidence of young-of-the-year fish in stomachs increased as they became more available throughout the summer.

Electivity indices for yellow perch predation upon zooplankton indicated that Daphnia galeata was positively selected in all cases, with values ranging from +.141 to +.760 (Tables 6 and 7). That yellow perch are able to discriminate when feeding has also been suggested by Galbraith (1967). Daphnia parvula (Fordyce) and Daphnia ambigua (Scourfield) were negatively selected for on all dates except May 1, 1971. On this date the Daphnia galeata population was very low compared to those of Daphnia parvula and Daphnia ambigua and essentially not available to the yellow perch. Cyclopoid copepods were strongly selected against with values ranging from -.718 to -1.000 except on the date mentioned above. On this date the yellow perch fed more on zooplankton of all **species** than they did during any other sampling date during both years. Since the mean volume of cyclopoid copepods was greater than that of positively selected zooplankters, apparently its negative selection was not a function of size. Selection against copepods may be a function of avoidance on the part of copepods as suggested by Starostka (1970).

Table 6. **Electivity indices of adult yellow perch for zooplankton in Abbey Pond during 1970.**

	Date							
	6-1	6-10	6-22	7-1	7-13	7-22	8-3	8-12
Crustacea								
Cladocera								
Daphnia galeata	+.760	+.651	+.687	+.141	+.540	+.677	+.457	+.476
Daphnia parvula	-.207	-.910						
Daphnia ambigua	-.244	-.752						
Copepoda								
Cyclopoida	-.909	-1.000	-.952	-.945			-.993	-.718

Table 7. Electivity indices of adult yellow perch for zooplankton in Abbey land during 1971.

	Date					
	4-16	5-1	7-9	7-19	7-27	8-31
Crustacea						
Cladocera						
Daphnia galeata	+.607	+.709	+.553	+.254	+.292	+.266
Daphnia parvula		+.325	-.591			
Daphnia ambigua		+.975				
Copepoda						
Cyclopoida		+.333	-.973	-.735		

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C"

Food of young-of-the-year fish examined consisted primarily of amphipods, zygopterans, and corixids. Amphipods made up a major portion of the food volume (65.4 percent) in 1970. The remaining food volume consisted of zygopterans. Zygopterans dominated (by volume) in 1971 followed in order by amphipods and corixids. Comparison by number indicated amphipods dominated both years.

Bluegill Bluegill stomachs contained a wide assortment of aquatic organisms. Zooplankton, mollusks, aquatic insects, and bryozoans were the dominant food items by volume found in adults during 1970 and 1971 (Tables 8 and 9). Similar observations had been made by Ball (1948), Seaburg and Moyle (1964), and Swingle and Smith (1941). Gerking (1954) reported that insects were the most important food item in the diet of bluegills. On an annual basis, this is also true for bluegills in Abbey Pond. Although bryozoa were only reported from 1971 samples, it is possible that they were inadvertently discarded from the 1970 samples. Both bryozoans and aquatic insects were dominant by volume in 25.0 percent of the samples in 1971. Mollusks dominated in 33.3 and 12.5 percent and zooplankton were dominant in 16.6 and 37.5 percent of the samples in 1970 and 1971.

Sago pond weed (*Potamogeton pectinatus*, Linnaeus) occurred in 50.0 percent of the samples in 1970 and in 1 sample in 1971. Although this item contributed to the organic intake of the fish, it was difficult to determine whether it had been ingested intentionally or in conjunction

Table 8. Stomach contents of adult bluegill from Abbey Pond during 1970, expressed as percent number per stomach and **percent volume per stomach (in parentheses).**

Item		6-10	6-22	7-1	7-13	7-22	8-3	8-12	**8-25**	9-2	9-23	10-7	10-23
		Date											
Annelida	**Hirudinea**					T (T)	T (T)						
Mollusca	**Gastropoda**	T[1] (1.4)	1.7 **(23.4)**	10.9 **(24.4)**	**25.9** **(87.5)**	11.9 **(25.0)**	T **(8.0)**	3.6 **(5.3)**	60.5 **(53.1)**	75.7 (76.9)	73.4 **(75.5)**		
	Pelecypoda		T (T)										
Unknown				3.0 (T)									
Arthropoda													
Arachnida	**Acari**	T (T)	T (T)	2.8 (T)	26.1 (T)	1.2 (T)	T (T)	T (T)				**5.8** (T)	
Crustacea													
Cladocera	**Daphnia galeata**	92.7 (59.0)	**85.3** (6.0)	2.5 (T)	T (T)	16.3 (T)	97.8 (36.2)						
	Daphnia ambigua	1.2 (1.0)	T (T)										
	Daphnia parvula	3.6 (3.2)											
Copepoda	**Cyclopoida**	T (3.7)	T (T)				T (1.9)						
Amphipoda	**Hyalella**		2.5 (10.9)	63.3 **(47.0)**	2.2 **(1.8)**	33.) (23.2)	1.1 **(24.5)**	T (T)					

Continued

Table 8. (Continued)

Item		6-10	6-22	7-1	7-13	7-22	8-3	8-12	8-25	9-2	9-23	10-7	10-23
		Date											
Arthropoda													
Insecta													
Odonata	**Zygoptera**		T (1.5)	T (1.1)	T (1.8)	T (T)	T (T)	1.8 (2.6)	16.8 (14.7)				
Hemiptera	Corixidae	T (2.7)	T (2.7)	2.8 (7.8)		T (T)	T (T)				4.2 (6.3)		87.5 (87.5)
	Gerridae			T (T)									
Trichoptera	**Limnephilidae** [3]		T (6.0)	T (T)	34.5 (12.2)	2.4 (3.3)	T (5.0)	1.8 (3.5)	1.3 (1.0)	25.6 (22.9)			12.5 (12.5)
Coleoptera	**Dytiscidae**		T (2.7)	6.4 (9.5)	1.8 (3.3)	24.7 (34.7)	T (T)	**88.1** (86.3)	1.2 (T)				
	Haliplidae			2.8 (2.0)									
Diptera	**Chironomidae**	T (12.2)	3.7 (33.1)	2.1 (5.5)	**4.6** (10.0)	**6.5** (9.3)	T (17.9)		3.6 (2.1)		22.2 (18.0	94.1 X100)	
	Ceratopogonidae	T (1.4)	T (T)		T (T)	T (T)	T (2.9)						
	Syrphidae	T (7.2)											
Ephemeroptera	Baetidae	T (2.7)	2.8 (12.1)	T (T)	2.3 (2.0)	2.7 (1.1)	T (T)	1.8 (T)					
Hymenoptera		T (4.3)		T (T)			T (T)		15.6 (27.3)				
Orthoptera							T (T)						
Sago Pond weed	<u>PotamoReton pectinatus</u>	P[2]			P		P		P	P	P		
Sample size		5	]7	16	14	7	12	3	8	6	13	1	1
Average food volume (ml)/stomach		0.3	0,3	0.6	0.6	1.3	0.8	0.7	0,7	1.3	0.2	0.3	0.3
Average food number/stomach		1037,4	144.1	43.4	57.8	93.7	1823.2	36.3	20.0	1.3	9.0	17,0	8.0

[1] Less than 1%

[2] Present

[3] Includes both organism and case

Table 9. Stomach contents of adult bluegill from Abbey Pond during 197], expressed as percent number per stomach and percent volume per stomach (in parentheses).

		Date							
Item		5-]	6-11	6-23	7-19	8-9	8-19	9-10	9-20
Annelida	**Hirudinea**		T (T)						
Mollusca	**Gastropoda**	21.3 (29.4)	6.4 (13.9)		T (5.1)		T (12.5)	2.5 (T)	41.6 (29.1)
	Pelecypoda	**54.4** (50.1)	T (T)	1.5 (3.8)					
Arthropoda									
Arachnida	**Acari**	T[1] (T)	T (T)	T (T)			T (T)		2.4 (T)
Crustacea									
Cladocera	**Daphnia galeata**		**3.5** **(T)**		96.7 **(84.4)**	98.3 **(88.2)**	98.1 (66.9)		
	Daphnia ambigua				2.6 (2.2)				
	3imocephalus serrulatus				T (T)				
Copepoda	**Cyclopoida**					1.5 (8.8)			
	Calanoida						T (2.6)		
Amphipoda	**Hyalella**		2.9 (2.0)	13.0 (7.8)			T (2.4)		4.8 (1.0)

Continued

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Table 9. (Continued)

Item		Date 5-1	6-11	6-23	7-19	8-9	8-19	9-10	9-20
Arthropoda									
Insecta									
Odonata	**Zygotpera**			T	T		T	26.0	2.4
				(1.5)	(1.2)		(2.9)	(3.5)	(2.7)
Hemiptera	Corixidae		5.8	T				47.0	
			(21.1)	(2.3)				(6.3)	
Trichoptera	**Limnephilidae** [3]		T		T				
			(T)		(3.8)				
	Hydroptilidae							5.5	2.4
Coleoptera	Dytiscidae			4.7			T		16.3
				(5.8)			(4.2)		(7.5)
	Haliplidae		5.3	31.1					
			(7.6)	(13.5)					
Diptera	**Chironomidae**	23.5	66.5	65.4	T		T	8.5	T
		(20.3)	**(49.6)**	(40.3)	(T)		(6.3)	(T)	(T)
	Ceratopogonidae		4.6	T		T			
			(3.3)	(T)		(2.9)			
Ephemeroptera	Baetidae		1.1	T			T		T
			(T)	(T)			(1.8)		(T)
Hymenoptera								2.5	
								(T)	
Bryozoa	Fredericella sultana							P	P
								(88.6)	(55.1)
Sago Pond weed Wtamogeton pectinatus						P			
Unknown			1.1	T	T			8.5	27.7
			(T)	(21.1)	(1.8)			(T)	(3.0)
Sample size		1	3	8	7	1	12	17	9
Average food volume (ml)/stomach		3.0	0.8	0.8	1.2	0.3	0.5	0.7	0.0
Average food number/stomach		136.0	56.6	47.0	3191.8	1795.0	1313.3	2.0	13.0

[1] Less than 1%

[2] Present

[3] Includes both organism and case

with organisms living on or around the plants. Gerking (1962) and Etnier (1971) also expressed this same difficulty but other authors (Ball, 1948; Seaburg and Moyle, 1964; Harlan and Speaker, 1956) have indicated that bluegills intentionally ingest vegetation, especially in late summer. The incidence of sago pond weed in the stomach contents appeared to increase towards the end of both summers in Abbey Pond but this still is not conclusive evidence of intentional ingestion as other organisms (Trichoptera larvae) often associated with this vegetation were also being ingested at this time. It may be that instead of being a substitute ration as suggested by Patriarche (1949) it is serving as a transition ration, if it is a ration at all.

It appeared that bluegills fed extensively upon benthic organisms and aquatic insects, an observation also made by Dendy (1956). There was a shift from this pattern on July 19, 1971, when the bluegill diet changed to one of predominantly zooplankton. This type of change was also observed by Gerking (1962). These feeding habits persisted for one month at which time the bryozoan Fredericella sultana (Blumenbach) became the dominant food item by volume for the remainder of the sampling period. The shift to zooplankters occurred during the pulse of positively selected zooplankton (Figure 5) and during the decline of the benthos population (Figure 6). The transition from zooplankton to bryozoan occurred when the zooplankton population was declining and other components of the benthos population were at low population levels.

Bryozoans have been considered to be of little importance in the diet of fresh-water fish. Rogick (1959) mentioned that they may be eaten and Dendy (1963) observed statoblasts in bluegill stomachs but assumed that they were accidently ingested. However, Applegate (1966) found this organism to be of some importance in the diet of bluegill and longear sunfishes. He found them to be most heavily used by fish in the 5.0 - 9.9 cm (total length) groups which correspond to my adult bluegill group. The bryozoan made up 75 percent (by volume) of the bluegill diet (also comparable to values found for bluegills in Abbey Pond) at a time when other portions of the food complex were at low population levels (Applegate, pers. cam.).

The amphipod Hyalella azteca (Saussure) was an important food item in 50.0 percent of the samples during both years. Utilization varied from trace to substantial amounts. The importance of amphipods was also noted by Etnier (1971) and Gerking (1962).

Electivity indices for utilization of zooplankton by bluegills indicated Daphnia galeata to be positively selected in all cases, with values ranging from +.143 to +.685 (Table 10). This phenomenon of selecting large zooplankters when smaller zooplankters are present and even more numerous was also **observed** by Gerking (1962), Hall (1964), and Cramer (1970). **Ivlev** (1961) demonstrated the preference of predators in devouring foods of the largest possible size, with morphological features imposing a limiting and optimum size of the principally utilized prey.

Table 10. Electivity indices of adult bluegill for zooplankton in Abbey Pond, 1970 and 1971.

	1970						1971		
	6-10	6-22	7-1	7-13	7-22	8-3	7-19	8-9	8-19
Crustacea									
Cladocera									
Daphnia Raleata	+.644	+.685	+.143	+.540	+.677	+.459	+.247	+.179	+.326
Daphnia parvula	-.857								
Daphnia ambigua	-.694	+.230					-.849		
Copepoda									
Cyclopoida	-.927	-.965				-1.000		-.250	
Calanoida									+1.000

w

Mean values for the summation of all sampling dates indicated negative selection for *Daphnia parvala, Daphnia ambigua,* and cyclopoid copepods. Electivity indices for cyclopoid copepods in 1970 ranged from -.927 to -1.000. Apparently factors similar to those discussed under yellow perch food habits were responsible for the negative selection of copepods.

Young-of-the-year fish fed extensively upon *Chydorus sphaericus* (O. F. Muller) although it made up a minimal percentage of the total stomach content volume. Immature aquatic insects, specifically chironomids, limnephilids, and zygopterans, made up the largest part of the diet (by volume) in 1970. Pelecypoda contributed the largest volume of food consumed by young-of-the-year fish sampled in 1971.

Electivity indices computed for young-of-the-year consumption of zooplankton were +.913 and +.995 for *Chydorus sphaericus* and -.377 for cyclopoid copepods in 1970. Samples for 1971 gave indices of +1.000 for *Chydorus sphaericus* and +.708 for cyclopoid copepods.

Black Crappie Adult black crappie fed primarily (as indicated by number and by volume) on zooplankton and aquatic insects (Table 11). This appeared to be in contradiction to findings of Reid (1949), Huish (1957), and Harland and Speaker (1956) all of whom reported the dominance of fish in adult black crappie diets. Aquatic insects was the dominant food group by volume in 50.0 percent of the samples in 1970 and 66.6 percent of the samples in 1971. This was similar to what Stevens

Table 11. Stomach contents of adult black crappie from Abbey Pond during 1970 and 1971, expressed as percent number per stomach and percent volume per stomach (in parentheses).

		1970												1971		
		6-1	6-10	6-22	7-1	7-13	7-22	8-3	8-12	8-25	9-2	9-14	9-23	6-11	7-19	9-10
Mollusca	Gastropoda													1.8 (2.2)		
Arthropoda																
Arachnida	Acari														T (T)	
Crustacea																
Cladocera	**Daphnia** galeata		**58.3** (37.2)		100 (100)	94.2 (59.7)	97.6 **(55.5)**	99.5 (79.7)	97.9 (32.1)			55.0 (29.1)		11.1 (T)	95.2 (49.2)	
	Daphnia parvula		31.5 (36.7)			T (T)						18.5 (17.7)		1.8 (T)	1.6 (1.5)	
	Daphnia ambigua		9.3 (10.8)									21.2 (20.1)			2.1 (1.9)	
	Dosmina longirostris											1.1 (T)				
Copepoda	Cyclopoida		T[1] (1.3)			4.0 (16.3)		T (1.7)	1.0 (2.2)			3.6 (12.4)				
	Calanoida		T (T)			T (3.3)									T (1.8)	
Amphipoda	**Hyalella**		T (T)	8.9 (3.3)		T (T)		T (T)	T (T)		8.3 (2.2)		T (T)	9.2 (3.5)		2.1 (T)
Ostracoda							1.9 (T)									
Decapoda								T								

Continued

Table 11. (Continued)

Item		1970 6-1	6-10	6-22	7-1	7-13	7-22	8-3	8-12	8-25	9-2	9-14	9-23	1971 6-11	7-19	9-10
Arthropoda																
Insecta																
Odonata	**Zygoptera**		T			T		T	T		83.3		T	31.4	T	62.1
			(1.9)			(1.8)		(3.2)	(45.9)		(91.9)		(T)	(50.2)	(15.1)	(61.5)
Hemiptera	Corixidae		T	26.7		T	T	T	T		4.1		84.9	20.3	T	32.7
			(T)	**(53.5)**		**(8.3)**	(22.2)	(9.9)	(13.1)		(4.5)		(89.7)	(32.4)	(22.7)	(32.3)
Trichoptera	**Limnephilidae**[2]		T			T	T	T					6.3			
			(T)			(T)	(22.2)	(1.2)					(6.7)			
Coleoptera	Dytiscidae	12.1	T			T		T	T						T	
		(T)	(T)			(T)		(T)	(4.9)						(5.4)	
Diptera	**Chironomidae**	2.2	T	17.8		T		T			4.1	T	6.3	14.7	T	
		(20.6)	(4.0)	(2).4)		(2.5)		(T)			(1.1)	(20.1)	(2.3)	(8.0)	(1.8)	
	Ceratopogonidae	**85.6**	T	17.8		T		T	T	100				9.2		T
		(79.3)	(1.3)	(8.9)		(T)		(1.0)	(T)	(100)				(3.5)		(T)
Ephemeroptera	**Baetidae**		T	26.7		T		T					T		T	
			(3.4)	(12.5)		(5.7)		(T)					(T)		(T)	
Hymenoptera								T								
								(T)								
Fish								T								T
								(1.0)								(1.4)
Bryozoa	Fredericella sultana															F[4]
																(4.0)
Sample size		3	3	1	1	11	1	6	1	1	2	1	10	3	_	14
Average food volume (ml)/stomach		___[3]	4.1	0.1		0.4	0.2	1.0	1.2		0.4	0.3	0.5	0.4	1.8	0.3
Average food number/stomach		2.7	15540 0	2.8	37.0	1438.5	608.0	4754.2	2350.0	1.0	12.0	935.0	12.6	18.0	5622.0	8.5

'Less than 1%

[2] lncludes both organism and case

[3]Less than 0.1 ml

[4] Present

(1959) found in his study of black and white crappies. Zooplankton dominated the remaining 50.0 and 33.3 percent of the samples, respectively, for 1970 and 1971. Black crappies fed consistently upon zooplankton, regardless of whether the zooplankters were readily available or not. Zygopterans and corixids were the aquatic insects most frequently consumed.

Electivity indices of adult black crappie for zooplankton indicated positive selection for Daphnia galeata and Daphnia parvula with values ranging from +.143 to +.996 and +.300 to +1.000, respectively (Table)2). indices for Daphnia ambigua were -.375 and +.745 in 1970 and -.880 in 1971. Bosmina longirostris and both cyclopoid and calanoid copepods were strongly selected against. Apparently similar factors to those discussed under yellow perch food habits were responsible for the negative selection for copepods by black crappies. The strong negative selection for Bosmina longirostris might have been a unction of its small size. Black crappies, as with bluegill, may select large zooplankters in preference to smaller zooplankters, even when smaller zooplankters are more numerous. Ivlev demonstrated (1961) that predators prefer foods of the largest **possible size**.

Largemouth bass, White crappie, and Black bullhead Food habits of these species were observed during the study but a small sample size limits discussion of them. Both adult and young-of-the-year largemouth bass fed primarily on aquatic insects and fish, with large aquatic

Table 12. Electivity indices of adult black crappie for zooplankton in Abbey Pond, 1970 and 1971.

	1970							1971
	6-10	7-1	7-13	7-22	8-3	8-12	9-14	7-19
Crustacea								
Cladocera								
Daphnia galeata	+.484	**+.143**	+.600	+.677	+.457	+.476	+.996	+.238
Daphnia parvula	+.300		+1.000				+.957	+1.000
Daphnia ambigua	-.375						+.745	-.880
Bosmina longirostris							-.972	
Copepoda								
Cyclopoida	-.975		-1.000		-.979	-.784	+.074	
Calanoida	-.970		-.943					+1.000

insects making up the bulk of their diet in both volume and numbers (Appendix Table 10). Young-of-the-year fish fed primarily upon zygopterans (by volume) and coleopterans (by number). White crappie diets were comparable to those reported by other investigators (Marcy, 1954) and were dominated by zooplankton and corixids both by volume and by numbers. Amphipods, cyclopoid copepods, limnephilids, and immature dipterans were the predominant organisms in the diet of black bullheads.

SUMMARY AND CONCLUSIONS

Yellow perch, black crappie, and bluegill utilized all types of available food in Abbey Pond. The most frequently consumed items were aquatic insects, zooplankton, mollusks, and fish. Bryozoans were an important component (by volume) in the diet of bluegills in 1971.

Yellow perch fed primarily on aquatic insects, zooplankters, and mollusks. Zooplankton and immature aquatic insects were the dominant food items by numbers. Aquatic insects were utilized more extensively after the zooplankton population declined. Incidence of young-of-the-year fish in stomachs increased during July, August, and September. An analysis of zooplankton selectivity by yellow perch indicated *Daphnia galeata* was positively selected and cyclopoid copepods were strongly selected against.

Zooplankton, mollusks, aquatic insects, and bryozoans were the dominant food items by volume for adult bluegills. On an annual basis aquatic insects were the most important food item. The bryozoan *Fredericella sultana* became the dominant food item when the zooplankton population was declining and other components of the benthos population were at low population levels. There was positive selection for *Daphnia galeata* and negative selection for *Daphnia parvula,* *Daphnia ambigua,* and cyclopoid copepods.

' Adult black crappies fed primarily (as indicated by number and by volume) on zooplankton and aquatic insects. There was positive selection for Daphnia galeata and Daphnia parvula and negative selection for Bosmina longirostris and both cyclopoid and calanoid copepods.

Utilization of the larger zooplankters by fish increased as the zooplankton became more available. This high utilization contributed to the decline of zooplankton populations. Consistent utilization by black crappies contributed to the suppression of zooplankton populations. The zooplankton population did achieve a fall maximum primarily due to an increase in the population of Bosmina longirostris, a eutrophic species not usually associated with fall pulses.

The benthos community, including aquatic insects, was heavily utilized during all sampling periods.

Yellow perch, black crappies, and bluegills appeared to be in competition with one another because of their utilization of similar food resources. Whether this indicated competition was limiting would depend upon food availability. Apparently these species are able to maintain healthy populations regardless of this indicated competition. The use of bryozoans by bluegills in 1971 might be an indication that food availability was changing and possibly becoming a limiting factor at that time.

Analyses of species food habits did not indicate niche segregation. When species occupy a common niche, Cause's principle of competitive exclusion would be expected to operate and eliminate a species from the system. For a multispecies system, such as Abbey Pond, to exist something must prevent competitive exclusion from materializing. Where the food resource does not appear to be a limiting factor and escape cover is prevalent, such as in Abbey Pond, Gause's principle might not operate until a limiting factor is reached or introduced. Apparently such a limiting factor has not been reached in Abbey Pond.

Since food supply does not appear to be a limiting factor, it is possible that the combination of the three species is more stable than the combination of any two.

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APPENDIX

Appendix Table 1. Physical-chemical data for Abbey Pond June 1 through November 13, 1970 (chemical analyses as mg/1).

	Depth*	Date														
		6-1	6-10	6-22	7-1	7-13	7-22	8-3	8-12	8-24	9-2	9-14	9-23	10-7	10-23	11-13
Dissolved	S	10.4	4.8	6.6	7.6	5.4	3.4	3.0	4.4	6.8	7.0	8.0	5.0	4.0	5.0	11.0
Oxygen	W	9.2	4.0	6.2	4.2	3.8	4.8	3.8	2.8	6.0	4.2	7.4	4.0	3.8	4.2	10.8
	B	6.6		0.0	1.2	2.4	3.8	0.0	0.0	4.8	0.0	6.6	4.0	3.8	4.2	10.6
Temperature	S	17.5	22.0	24.0	27.0	25.0	22.5	24.0	26.5	23.0	23.0	15.0	16.0	12.0	10.0	2.0
(C)	M	16.0	15.0	20.5	23.0	23.5	22.0	23.0	23.0	21.0	22.0	14.0	16.0	12.0	9.5	2.0
	B	12.5	13.0	14.0	21.0	20.0	21.5	19.0	20.0	20.0	19.5	13.0	15.0	11.0	9.5	2.5
pH	S	7.8	7.8	8.0	7.4	8.8	8.3	8.6	8.6	8.6	8.9	8.8	8.3	8.3	8.4	8.4
	Y			7.6	8.3	8.5	8.5	8.7	8.5	8.5	8.8	8.8	8.5	8.4	8.4	8.4
	B			7.2	8.5	8.5	8.5	7.9	7.8	8.5	7.8	8.5	8.7	8.4	8.4	8.4
Secchi disc Visibility (cm)	S	95	152	200	400	200	110	215	195	145	130	230	140	150	260	210

Continued

Appendix Table 1. (Continued)

	Depth	Date														
		6-1	6-10	6-22	7-1	7-13	7-22	8-3	8-12	8-24	9-2	9-14	9-23	10-7	10-23	11-13
Total	S	126.0	104.4	115.2	122.4	109.8	91.7	97.2	118.8	115.2	118.8	127.8	128.0	122.4	129.6	130.5
Alkalinity	M			117.0	113.4	106.2	113.4	113.4	118.8	116.1	124.2	107.0	127.8	127.8	133.2	127.0
	B			118.9	109.8	104.4	124.4	127.8	136.8	124.2	136.8	131.4	127.8	127.8	133.2	132.2
Phenol-	S	0.0	0.0	0.0	0.0	19.8	0.0	0.0	10.8	8.1	14.4	14.4	0.0	0.0	7.2	1.7
phthalein	M			0.0	1.8	7.2	3.6	18.0	3.6	9.0	9.0	9.0	7.2	1.8	3.6	1.7
Alkalinity	B			0.0	7.2	7.2	3.6	0.0	0.0	4.5	0.0	7.2	11.8	1.8	1.8	1.7
Total	S	180	188	180	176	174	174	180	146	142	144	146	150	160	168	150
Hardness	M			168	156	172	174	170	144	144	140	158	142	168	158	150
	B			200	172	170	170	178	144	142	114	156	142	154	170	152
Calcium	S	167	130	130	122	108	92	112	108	104	84	104	104	116	124	134
Hardness	M			134	152	118	108	142	130	108	82	130	100	120	114	128
	B			128	160	120	98	132	118	112	86	108	120	114	130	128
Specific	S	445	420	410	480	375	400	410	415	380	438	475	500	480	495	500
Conductance	M			408	420	420	420	410	410	438	420	460	480	480	490	495
Micromhos/(cm)	B			441	409	395	418	420	415	445	425	460	480	490	495	495
Sulfate	S	170	120	125	105	135	120	115	115	140	120	120	97	95	115	110
	Y			120	110	135	105	110	120	125	120	120	115	110	93	110
	B			95	105	110	130	110	125	115	130	110	100	100	110	98
Sodium	S	6.5	6.5	6.4	9.0	4.4	4.0	4.0	9.1	9.0	9.0	9.0	9.0	9.0	9.2	9.2
	M			6.3	8.5	4.6	3.8	4.7	9.0	9.0	9.0	9.2	9.0	9.0	9.5	9.0
	B			6.7	8.5	4.6	4.0	4.8	8.9	8.9	9.0	9.5	9.0	9.0	9.2	9.0

Continued

Appendix Table 1. (Cpntinued)

	Depth	Date														
		6-1	6-10	6-22	7-1	7-13	7-22	8-3	8-12	8-24	9-2	9-14	9-23	10-7	10-23	11-13
Potassium	S	11.6	12.2	11.5	20+	11.4	11.6	11.7	11.6	12.0	11.8	12.2	12.2	12.4	12.9	12.7
	Y			11.4	10.6	11.6	10.3	11.6	11.6	12.0	11.8	11.8	12.4	12.6	12.7	12.9
	B			12.4	10.9	11.5	11.5	11.8	11.6	12.0	12.7	12.1	12.4	12.5	12.7	12.7
Total Phosphorus	S	1.4	1.2	1.0	19.0	1.4	1.4	1.1	0.62	0.62	0.40	0.59	1.23	0.69	0.31	0.12
	Y			1.3	2.0	1.4	1.4	1.7	0.68	1.13	0.61	1.02	0.69	0.18	0.37	0.12
	B			**4.8**	0.8	1.6	1.8	3.1	1.09	0.65	0.65	0.46	0.77	0.89	0.32	0.09
Chloride	S	4.0	3.5	**3.5**	**3.5**	8.0	**8.5**	8.0	9.0	9.0	10.0	10.2	10.2	11.2	10.2	12.8
	Y			**3.5**	**3.5**	10.0	7.5	8.0	**8.5**	8.0	11.0	10.7	10.7	11.7	10.7	12.2
	B			3.5	**3.5**	8.0	8.0	8.0	7.5	8.0	11.0	10.2	10.7	11.2	11.2	12.8
Total Organic Weight	S	18.98	17.91	16.75	20.17	19.45	10.92	12.29	19.47	20.25	18.02	17.74	18.36	19.19	**18.55**	18.94
	Y			14.44	22.52	27.26	8.31	17.64	**15.88**	24.21	20.66	20.78	19.81	18.31	18.19	16.61
	B			15.60	20.17	11.42	3.91	24.00	12.37	19.17	28.22	19.89	21.42	18.12	17.85	17.86
Dissolved Organic Weight	S	18,69		**13.45**	12.89			5.78	12.41	17.90	14.94	16.93	**18.82**	17.04	16.93	17.70
	Y				10.93	6.19		11.43	11.64	21.13	18.70	17.66	16.58	**16.43**	17.66	16.81
	B				2.53	**3.63**	1.60	10,87	11.51	16.09	25.42	19.36	19.27	16.24	17.85	13.57
Organic Carbon	**S**	9.49	8.95	**8.38**	10.08	9.73	5.46	6.14	9.74	10.12	9.01	8.87	9.68	9.60	9.28	9.47
	Y			7.22	11.26	13.63	4.15	8.82	7.94	12.11	10.33	10.39	9.90	9.16	9.10	8.30
	B			7.80	10.08	5.71	1.96	12.00	6.18	9.59	14.11	9.95	10.71	9.06	8.92	8.93
Organic **Energy** gcal.	S	92.21	86.97	**81.36**	97.95	**94.49**	53.04	59.70	**94.55**	98.36	87.52	86.18	84.01	93.23	90.10	92.00
	Y			70.14	109.38	132.40	40.36	**85.69**	77.11	117.61	100.33	100.91	96.22	88.94	88.37	80.68
	B			75.75	87.95	**55.49**	18.01	**116.55**	60.08	93.13	137.05	96.63	104.04	88.00	86.70	86.77

***Sampling depth**
S - surface
Y - middle
B - bottom

Appendix Table 2. 1?hysical-chemical data for **Abbey Fbnd** March 9 through **September** 29, 1971 (chemical **analyses** as mg/1).

	Depth*	3-9	4-16	5-1	5-21	6-11	6-23	7-9	7-19	7-27	8-9	8-19	8-31	9-10	9-20	9-29
Dissolved	$	1.8	10.6	5.1	6.0	5.8	5.0	5.8	4.0	3.4	6.4	6.6	5.6	6.6	7.8	8.6
Oxygen	M	4.0	9.6	5.2	6.0	0.8	2.0	0.4	3.0	3.8	6.2	5.4	5.6	6.2	7.8	8.0
		8.4	9.6	5.2	6.2	0.0	0.0	0.0	2.6	4.0	6.0	4.8	5.4	6.0	7.0	7.0
wperature		1.0	9.0	10.0	13.5	21.5	24.0	22.0	23.0	19.0	23.0	23.0	20.0	19.5	16.0	14.0
C)	4	2.5	9.0	10.0	13.5	19.0	22.0	19.0	22.0	19.0	22.0	23.0	20.0	19.0	16.0	13.0
	Q	3.5	9.0	10.0	12.5	14.0	16.0	16.0	21.0	19.0	22.0	23.0	19.0	19.0	15.0	13.0
	S		8.4	8.4	8.6	8.6	8.6	8.6	8.1	8.3	8.4	8.4	8.0	8.3	8.5	8.5
	M		8.4	8.3	8.6	8.2	8.0	8.2	8.0	8.2	8.4	8.4	8.0	8.3	8.5	8.5
	B		8.5	8.3	8.6	8.2	7.9	8.0	7.7	8.0	8.4	8.3	8.0	8.3	8.5	8.5
.ecchi disc Visibility (cm)	$	ice	120		210	170	270	90	170	170	305	170	215	220	160	150

.t inued

•pendix **Table** 2. **(Continued)**

	Depth	Date														
		3-9	4-16	5-1	5-21	8-11	6-23	7-9	7-19	7-27	8-9	8-19	8-31	9-10	9-20	9-29
Aal kalinity	S	56.0	114.8	135.7	123.5	154.0	123.5	80.0	83.5	98.0	92.2	95.7	104.0	116.0	100.0	110.0
	M	142.0	114.8	135.7	123.5	140.0	123.5	80.0	83.5	90.0	94.0	95.7	106.0	120.0	100.0	100.0
	B	188.0	114.8	116.6	123.5	142.0	135.7	147.9	88.7	92.0	94.0	92.2	108.0	120.0	100.0	100.0
enol- ,thalein :kalinity	S	0.0	8.7	1.7	7.0	30.0	20.9	12.2	0.0	2.0	3.5	1.7	0.0	2.0	10.0	10.0
	M	0.0	7.0	1.7	8.7	0.0	0.0	0.0	0.0	0.0	3.5	1.7	0.0	2.0	10.0	10.0
	B	0.0	7.0	0.0	8.7	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	2.0	10.0	10.0
.,tal ,rdness	S	70.0	176.0	182.0	182.0	184.0	186.0	138.0	132.0	160.0	138.0	164.0	140.0	134.0	140.0	160.0
	M	210.0	174.0	184.0	182.0	188.0	188.0	150.0	132.0	164.0	140.0	160.0	144.0	134.0	140.0	158.0
	B	272.0	176.0	180.0	184.0	186.0	210.0	214.0	132.0	160.0	140.0	160.0	144.0	136.0	140.0	150.0
.alcium dardness	S	54.0	116.0	118.0	128.0	126.0	134.0	120.0	118.0	118.0	94.0	106.0	86.0	86.0	100.0	106.0
	M	132.0	122.0	124.0	120.0	134.0	138.0	120.0	112.0	114.0	94.0	100.0	86.0	88.0	94.0	96.0
	B	176.0	122.0	120.0	128.0	132.0	126.0	140.0	112.0	118.0	96.0	100.0	80.0	82.0	90.0	96.0
Specific Conductance Aicromhos/(cm)	S	180	405	410	405	400	395	260	270	260	300	285	290	290	295	305
	M	450	380	400	400	400	420	245	275	265	285	285	280	280	295	295
	B	600	410	400	400	395	430	400	275	265	295	285	280	280	295	295
.ulfate	S	38	90	90	120	140	140	40	45	55	55	48	40	45	50	60
	M	95	80	88	125	140	135	43	48	60	45	42	45	45	45	55
	B	125	92	88	130	130	130	55	48	60	40	42	50	45	45	55
Sodium	S	3.0	5.0	8.0	11.0	9.8	9.0			5.0			6.0			5.0
	M	11.0	8.0	7.5	11.0	9.8	9.0			5.0			5.0			5.0
	B	13.0	8.0	7.5	9.0	9.8	9.8			4.5			5.0			4.0

Continued

Appendix Table 2. (Continued)

	Depth	Date														
		3-9	4-16	5-1	5-21	6-11	6-23	7-9	7-19	7-27	8-9	8-19	8-31	9-10	9-20	9-29
Potassium	**S**	8.3	11.6	11.1	13.8	10.7	10.5			7.8			8.0			**8.5**
	M	13.4	11.8	11.3	12.0	10.5	10.7			7.1			7.5			8.3
	B	**15.3**	11.8	11.1	11.7	10.9	12.4			7.0			7.7			**8.5**
Total Phosphorus	S	**0.88**	0.50	0.26	0.18	0.21	0.20			0.35			0.41			0.14
	M	0.48	0.37	0.28	0.17	0.36	0.42			0.36			0.38			0.17
	B	0.14	0.48	0.33	0.24	0.65	1.92			0.38			0.38			0.12
Chloride	**S**	**6.5**	11.0	**8.5**	9.5	**8.5**	10.5	6.5	6.5	6.0	7.0	6.5	6.5	8.0	8.0	7.0
	M	11.5	9.5	9.0	10.0	9.0	10.5	6.0	6.0	**5.5**	7.0	5.5	6.0	8.0	8.0	7.0
	B	13.0	9.0	9.0	10.0	9.0	10.0	**8.5**	7.0	5.0	**6.5**	5.5	**6.5**	6.5	8.0	8.5
Total Organic Weight	S	20.52	17.12	21.75	19.72	17.00	16.06			13.63			11.38			12.47
	M	**20.56**	17.77	17.77	18.20	18.36	17.92			13.71						12.24
	B	23,22	18.05	17.77	15.73	18.36	16.76			13.17			11.07			11.38
Dissolved Organic Weight	S	19.27	15.87	15.02	15.49	12.31	12.61			13.63			8.78			10.07
	M	18.90	16.93	17.44	15.41	13.15	14.13			9.30			10.84			8.69
	8	19.77	17.64	17.86	14.80	14.36	11.47			9.37			9.45			11.38
Organic Carbon	**S**	10.26	8.56	10.87	9.86	8.50	8.03			6.81			5.69			6.24
	M	10.28	8.89	8.87	9.10	9.18	8.96			6.86						6.12
	B	11.61	9.03	8.87	7.86	9.18	8.38			6.58			**5.53**			5.69
Organic **Energy** gcal.	S	99.65	83.13	105.64	95.78	82.55	78.03			66.20			55.28			60.59
	M	99.86	86.33	86.33	88.40	89.18	87.04			66.61						59.43
	B	112.78	87.69	86.33	76.40	89.18	81.40			63.95			53.75			**55.25**

***Sampling** depth

S - surface

M - middle

B - bottom

Appendix Table 3. Estimated numbers of fish and species composition by percent in Abbey Pond during 1970, 1968, and 1965.

Species	1970		1968		1965	
	Estimated Number Of Fish/Hectare	Percent Of Total	**Estimated Number** Of Fish/Hectare	Percent Of Total	Estimated Number Of Fish/Hectare	Percent Of Total
Yellow perch	1291.0	**(35.3)**	99.3	(3.1)	512.9	(15.3)
Bluegill	1180.3	(32.2)	824.8	(25.7)	1257.4	(37.7)
Black crappie	507.7	(13.8)	1666.6	(52.0)	1143.8	(34.3)
Largemouth bass	310.1	(8.4)	14.3	(0.4)		
Yellow bullhead	210.5	(5.7)	127.9	(3.9)		
Black bullhead	105.0	(2.8)	278.7	(8.7)	290.3	(8.7)
Pumpkinseed	37.5	(1.0)	30.1	(0.9)		
White crappie	12.8	(0.3)	157.6	(4.9)	126.5	(3.7)
Northern pike	P[1]	(T)[2]	2.9	(T)	P	(T)
Walleye	P	(T)				
Total	3654.9	(100.0)	3202.2	(100.0)	3330.9	(100.0)

[1] Present but not in sufficient numbers to make an estimate

[2] Less than 0.1%

P

Appendix Table 4. Estimated standing crops and percent composition (in parentheses) of fish in Abbey Pond.

Species	1970		1968		1965	
	Kilograms/Hectare	Percent Of Total	Kilograms/Hectare	Percent Of Total	Kilograms/Hectare	Percent Of Total
Yellow perch	143.0	(20.2)	14.0	(2.4)	30.3	(9.4)
Bluegill	358.5	(51.1)	133.6	(23.2)	102.7	(32.1)
Black crappie	82.7	(11.7)	273.0	(47.5)	124.7	(39.0)
Largemouth bass	79.3	(11.2)	5.1	(0.8)		
Yellow bullhead	25.9	(3.6)	25.4	(4.4)		
Black bullhead	14.8	(2.1)	84.2)	(14.6)	48.9	(15.3)
Pumpkinseed	0.9	(0.1)	2.4	(0.4)		
White crappie	P[1]	(T)[2]	26.4	(4.5)	12.1	(3.7)
Northern pike	P	(T)	8.6	(1.4)	P	(T)
Walleye	P	(T)				
Total	705.4	(100.0)	574.0	(100.0)	319.0	(100.0)

[1] Present but not in sufficient numbers to make an estimate

[2] Less than 0.1%

Cn
CM

Appendix Table 5. Estimated numbers of fish and standard error of estimates in Abbey Pond, 1970.

Species	Estimated Number of Fish in Pond	Standard Error
Perch	2090.6	± 92
Bluegill	1910.8	±315
Largemouth bass	461.8	+ 15
Black crappie	851.9	±120
Yellow bullhead	341.0	±109
Black bullhead	130.0	± 74
Pumpkinseed	61.0	± 17
White crappie	21.0	± 4

Appendix Table 6. Density per liter and percent occurrence (in parentheses) of zooplankton in Abbey Pond during 1970.

	Date												
	6-1	6-10	7-1	7-13	7-22	8-12	8-25	9-2	9-14	9-23	10-7	10-23	11-13
Crustacea													
Cladocera													
Daphnia galeata	12.3	101.6	201.9	1.6	0.9	0.4	0.2	T	0.1	1.5	0.5	0.7	
	(9.8)	(20.3)	(74.9)	(29.8)	(19.2)	(35.1)	(16.0)	(T)	(T)	(1.0)	(1.0)	(4.1)	
Daphnia parvula	27.2	85.2	0.6			0.2	0.1		0.2		0.1	0.1	0.5
	(21.7)	(17.0)	(T)			(15.7)	(5.6)		(T)		(T)	(1.0)	(1.9)
Daphnia ambigua	26.2	102.7	1.2			0.2	0.3		1.2	0.8	1.1	0.8	
	(20.9)	(20.5)	(T)			(15.7)	(27.3)		(3.1)	(1.0)	(1.4)	(4.7)	
Bosmina longirostris	10.4	18.6	18.5	1.0	0.4	0.1	0.1	3.2	29.9	151.2	68.5	13.4	1.3
	(8.3)	(3.7)	(6.8)	(17.9)	(8.4)	(5,5)	(4.7)	(86.7)	(80.2)	(98.2)	(93.3)	(83.7)	(5.0)
Chydorus			0.6	0.2		T[2]		0.2	0.1		0.2		
			(0.2)	(3.7)		(1.0)		(4.5)	(T)		(T)		
Copepoda													
Cyclopoida	21.2	119.1	38.8	0.3	0.4	0.1	0.1	0.2	1.7	0.3	2.0	0.8	20.8
	(16.9)	(23.8)	(14.4)	(4.9)	(8.4)	(8.3)	(11.3)	(4.0)	(3.1)	(T)	(2.7)	(5.1)	(81.3)
Calanoida	6.4	33.9	6.0	1.4	1.5	0.1	0.1	0.1	0.3		0.6	0.2	1.2
	(5.1)	(6.7)	(2.2)	(27.4)	(30.1)	(5.5)	(10.3)	(1.6)	(1.0)		(1.0)	(1.0)	(4.7)
Nauplii	18.3	37.1	1.8	0.5	1.7	10.0	0.2	0.1	3.8		0.5	0.1	1.7
	(14.6)	(7.4)	(1.0)	(9.2)	(34.0)	(9.2)	(21.6)	(1.6)	(10.1)		(1.0)	(1.0)	(6.7)
Ostracoda	3.0	0.5		0.3		T	T						
	(2.3)	(T)[1]		(6.2)		(1.0)	(2.8)						
Total	124.9	498.8	269.3	5.3	4.9	1.1	1.1	3.7	37.2	153.9	73.4	16.0	25.5

[1] Less than 1%

[2] Less than 0.1 organism per liter

Appendix Table 7. Density per liter and **percent** occurrence (in **parentheses)** of **zooplankton** in **Abbey Pond during** 1971.

	Date												
	4-17	5-1	5-21	6-23	7-9	7-19	7-27	**8-9**	8-19	8-31	9-10	9-20	**9-29**
Crustacea													
Cladocera													
Daphnia galeata	0.5	5.1	5.6	23.8	10.3	122.9	67.4	65.7	49.9	22.4	**8.6**	1.3	0.8
	(T)[1]	(1.6)	(10.9)	(25.7)	(28.2)	**(58.8)**	(54.7)	(60.0)	(50.3)	(57.9)	(33.9)	(12.9)	(4.0)
Daphnia parvula	29.8	115.6	35.0	65.9	1.4					0.2			
	(24.4)	(37.8)	(68.2)	(71.4)	(3.9)					(T)			
Daphnia ambigya	1.5	0.9			0.9	69.0	10.7						
	(1.2)	(T)			(2.3)	(33.0)	(8.6)						
Bosmina longirostris	26.2	**8.6**	2.8	1.3	2.2	4.3	40.9	40.5	44.7	**8.6**	7.2	4.0	12.0
	(21.5)	(2.8)	(5.3)	(1.3)	(5.9)	(2.0)	(33.2)	(37.0)	(45.1)	(22.0)	(28.5)	(39.5)	(60.6)
Chvdorus					0.5						0.3		
					(1.3)						(1.0)		
Copepoda													
Cyclopoida	56.0	174.6	7.4	1.1	18.8	12.4	1.7	2.8	4.4	6.3	**8.4**	4.1	2.2
	(45.9)	(57.2)	(14.3)	(1.1)	(51.5)	(5.9)	(1.4)	(2.5)	(4.4)	(16.3)	(33.2)	(40.5)	(10.9)
Calanoida	0.5	0.4			0.2		0.1	0.2		0.1			4.8
	(T)	(T)			(1.0)		(T)	(T)		(T)			(24.1)
Nauplii	6.1		0.2	0.2	0.1		1.8	0.3		1.2	0.7	0.7	
	(5.0)		(T)	(T)	(T)		(1.4)	(T)		(3.0)	(2.8)	(6.9)	
Ostracoda			0.3		2.1	0.2	0.4						T[2]
			(1.0)		(5.6)	(T)	(T)						(T)
Total	121.9	305.2	51.3	92.3	36.4	208.9	123.1	109.4	98.0	38.8	25.3	10.0	19.8

[1] Less than 1%

[2] Less than 0.1 organism/liter

Appendix Table 8. Benthos standing crop expressed as number of organisms per square meter and percentage of total (parentheses) in Abbey Pond during 1970.

	Date													
	6-1	6-10	6-22	7-13	7-22	8-3	8-12	8-25	9-2	9-14	9-23	10-7	10-23	11-13
Mol lusca		90												30
		(2.6)												(1.0)
Arthropoda														
Insecta														
Diptera Chironomidae	1036	540	360	360	90	165	60	15	195	151	1291	1892	5270	4369
	(62.7)	(15.7)	(32.4)	(28.5)	(10.3)	(24.4)	(16.0)	(3.8)	(23.6)	(38.6)	(96.6)	(84.3)	(91.6)	(96.9)
Ceratopogonidae	616	901	450	270	616	420	195	375	180	60	45	330	405	90
	(37.2)	(26.3)	(40.5)	(21.4)	(70.7)	(62.2)	(52.0)	(96.1)	(21.7)	(15.3)	(3.3)	(14.7)	(7.0)	(1.9)
Coleoptera		90		15	15									
		(2.6)		(1.1)	(1.7)									
Ephemeroptera		811			15		15							
		(23.6)			(1.7)		(4.0)							
Hemiptera				15										
				(1.1)										
Neuroptera							15							
							(4.0)							
Arachnida			15	15	30		90						30	
			(1.3)	(1.1)	(3.4)		(24.0)						(1.0)	
Crustacea														
Amphipoda		496												
		(14.4)												
Annelida														
Hirudinea														
Oligochaeta			285	586	105	90			450	180		30	30	15
			(25.6)	(46.4)	(12.0)	(13.3)			(54.4)	(46.0)		(1.3)	(1.0)	(T)
Total	1652	3423	1111	1261	871	675	375	390	826	391	1336	2242	5751	4504

[1]**Less** than 1%

Appendix Table 9. Benthos standing crop expressed as number of organisms per square meter and **percentage** of total (parentheses) in Abbey Pond during 1971.

	Date													
	4-16	5-1	5-21	6-11	6-23	7-9	7-19	7-27	8-9	8-19	8-31	9-10	9-20	9-29
Mollusca					60 (6.7)	15 (1.8)								
Annelida														
Oligochaeta	225 (17.4)	15 (T)[1]	15 (1.0)	45 (5.0)		**165** (20.3)	**255** **(18.8)**	**255** (17.3)	60 (7.5)		330 (28.1)	**465** (55.2)	180 (10.2)	
Arthropoda														
Insecta														
Uiptera Chlronomidae	1036 (80.2)	2686 (86.0)	1321 (70.3)	826 (93.2)	766 (86.4)	375 (46.2)	796 **(58.9)**	1111 **(75.5)**	691 **(86.8)**	1261 **(96.5)**	811 **(69.2)**	315 **(37.4)**	1516 **(86.3)**	3799 **(95.8)**
Ceratopogonidae	30 (2.3)	240 (7.6)	540 (28.7)	15 (1.6)	45 (5.0)	255 (31.4)	270 (19.9)	90 (6.1)	30 (3.7)	45 (3.4)	30 (2.5)	30 (3.5)	60 (3.4)	15 (T)
Coleoptera					15 (1.6)		15 (1.1)							
Arachnida							15 (1.1)	15 (1.0)	15 (1.8)			30 (3.5)		15 (T)
Crustacea														
Amphipoda														15 (T)
Total	1291	3123	1877	886	886	811	1351	1471	796	1306	1171	841	1756	3964

[1] l.ess than 1%

Appendix Table 10. Stomach contents of adult largemouth bass from Abbey Pond during 1970 and 1971, expressed as **percent number** per stomach and percent **volume** per stomach (in parentheses).

		1970						1971	
		6-10	6-22	7-1	7-13	7-22	8-25	5-1	8-9
Mollusca					33.3				
					(18.1)				
Arthropoda									
Crustacea									
Cladocera	Daphnia galeata	21.5	4.0						
		(T)[1]	(T)						
	Daphnia parvula	10.7							
		T							
Copepoda	Cyclopoida		4.0						
			(T)						
Amphipoda	Hvalel1a						9.0		
							(1.6)		
Insecta									
Odonata	**Zygoptera**	32.3	40.0	7.3	33.3	100	45.4		66.6
		(44.6)	(56.9)	(9.5)	(45.4)	(100)	(42.3)		**(54.5)**
Hemiptera	Corixidae		4.0	80.4	33.3			65.0	
			(5.0)	(84.0)	(36.3)			(27.0)	
Ephemeroptera	Haetidae	21.5		2.4					
		(2.1)		(T)					
Trichoptera	Limnephilidae	21.5						10.0	
		(8.5)						(8.3)	
Neuroptera	Corydalidae	21.5							
		(44.6)							
Diptera	Chironomidae							20.0	16.6
								(12.5)	(13.6)
	Ceratopogonidae			7.3					
				(1.9)					
Hymenoptera							9.0		
							(8.4)		
Fish			48.0	2.4			36.3	5.0	16.6
			(37.9)	(3.8)			(47.4)	(52.0)	(31.8)
Sample size		7	2	1	1	1	1	5	1
Average food volume (ml)/stomach		0.1	0.4	1.6	0.1	0.1	0.6	0.2	0.2
Average food number/stomach		1.3	12.5	41.0	3.0	1.0	11.0	4.0	6.0

[1] Less than 1%