

SEASONAL FLUCTUATIONS IN THE
BENTHIC AND PLANKTONIC COMMUNITIES
OF THE SALT RIVER, MISSOURI

A Thesis

Presented to
the Faculty of the Graduate School
University of Missouri-Columbia

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by

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May, 1977

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and hereby certify t



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Acknowledgements

During the course of this study, I have become indebted to several people for their assistance: Dr. D. H. Hazelwood, for his guidance, Dr. W. R. Enns for his aid in insect identification, Mr. Ted Postel for current limnological data, and my father, Leo T. Meierhoff, for aid in designing a one-man plankton sampling system.

However, this study would not have been possible without the tireless help from my wife, Linda, who aided in the collection, identification, and preparation of the material presented in this thesis.

This study was funded in part by the United States Army Corps of Engineers, Water Quality Section, contract DACW 43-74-C-0125.

Chapter 1

Introduction

The Salt River has been intensively studied in the past ten years due to its pending impoundment. The purpose of this study is to determine the seasonal trends in the abundance and distribution of zooplankton and macrobenthos in the Salt River. When combined with previous works, this study will provide a baseline for comparison for future studies of the Salt River after its impoundment.

Geology

Unless otherwise noted, the information on the geology, soils, and climate of the Salt River was obtained from the environmental assessment for Clarence Cannon Dam and Reservoir (Missouri Botanical Garden [hereafter referred to in reference as MBG], 1974a).

The portion of northeastern Missouri which is drained by the Salt River is characterized by a general eastward slope with its highest point in Schuyler County at 1003 ft msl. The elevation drops off sharply to an altitude of 740 to 725 ft which is maintained as an extensive upland plain. This plain occupies the entire study area except the river bottom and flood plain. As the Salt River nears its confluence with the Mississippi River, its altitude once again drops fairly sharply to

450 ft msl at its mouth.

The geology of the Salt River basin is characterized by a surface plain of dissected till, underlain by various layers of Paleozoic limestones and shales, which are in turn underlain by deeply buried Precambrian metasediments and gneissic granites. These Precambrian rocks are estimated to be greater than 1.45 billion years old, which makes them older than the nearest exposed Precambrian rocks, the St. Francis Mountains in southeastern Missouri (approximately 1.3 billion years old). After the cessation of granitic intrusion, Missouri, and the Salt River basin in particular, underwent an extended span of periodic transgressions and regressions of wide, shallow, tropical Paleozoic seas. Depending on an area's distance from the ancient shorelines, a variety of sediments were laid down; they ranged from coarse clastic sandstones at or near the beach, to finer shales immediately offshore, to fine-grained limestones well offshore. These limestones now compose the bulk of the surface rock, and are characterized by varying densities of chert nodules and extensive fossilization, especially crinoids. These rocks were laid down primarily in the Mississippian Period and are especially prominent in the Choteau and Burlington formations.

The present surface of the Salt River basin is composed of Pleistocene glacial deposits from the second (Kansan) of four glacial advances with additional recent

mantling soils and unconsolidated deposits.

The soils of the Salt River basin are composed of three series which are distributed according to elevation (United States Army Corps of Engineers [hereafter referred to in reference as Corps], 1974a). The most extensive series or association is the Putnam-Mexico-Gara, which is commonly found over much of the level upland till plains in the basin, and comprises about one-half of Monroe County. This association is characterized by a claypan layer covered by 12 to 18 in of soil developed from prairie vegetation.

The Lindley-Keswick-Hatton association, which covers about one-third of Monroe County, is found on the slopes between the upland plain and the flood plain. This association is composed of glacial till, remains of shale layers, and soil developed from oak-hickory forests.

The bottomland and terrace association is composed of 11 different soil types, all being the result of erosion and deposition from the surrounding areas. These soils are highly fertile but are accompanied by an inherent risk of flooding.

All three associations are plagued by slow permeability which increases runoff, and thereby, stream turbidity.

Vegetation

The vegetation of the Salt River basin is characterized as a combination of Prairie Peninsula and oak-hickory

forest. Due to the extensive effects of glaciation on species distribution, vegetation of the basin is more characteristic of areas to the north and east.

Vegetation associated with the river exhibits a series of successional stages away from the river:

1. The truly aquatic water willow (*Justicia americana*)
2. The semiaquatic smartweed (*Polygonum* sp.), sedge (*Eleocharis* sp.), and black willow (*Salix nigra*)
3. The herbaceous terrestrial buttonbush (*Cephalanthus occidentalis*)
4. The dominant canopy of silver maple (*Acer saccharinum*) and American elm (*Ulmus americanus*)

The remaining non-urban land is 80 to 90% agricultural (Duchrow, 1974) with corn, soybeans, and wheat the leading crops.

An extensive survey of the algae of the Salt River basin was conducted by the Missouri Botanical Garden in the summer of 1973, and a subsequent list was published (MBG, 1974b). This list more than doubled the number of algae species recorded for the state of Missouri. Characteristic successional patterns were found for the major algal divisions in northern temperate habitats. The Euglenophyta dominated the early summer flora but the Chlorophyta soon expanded to a dominant position. The

number of Chrysophyta and Cyanophyta species increased in abundance as the survey continued.

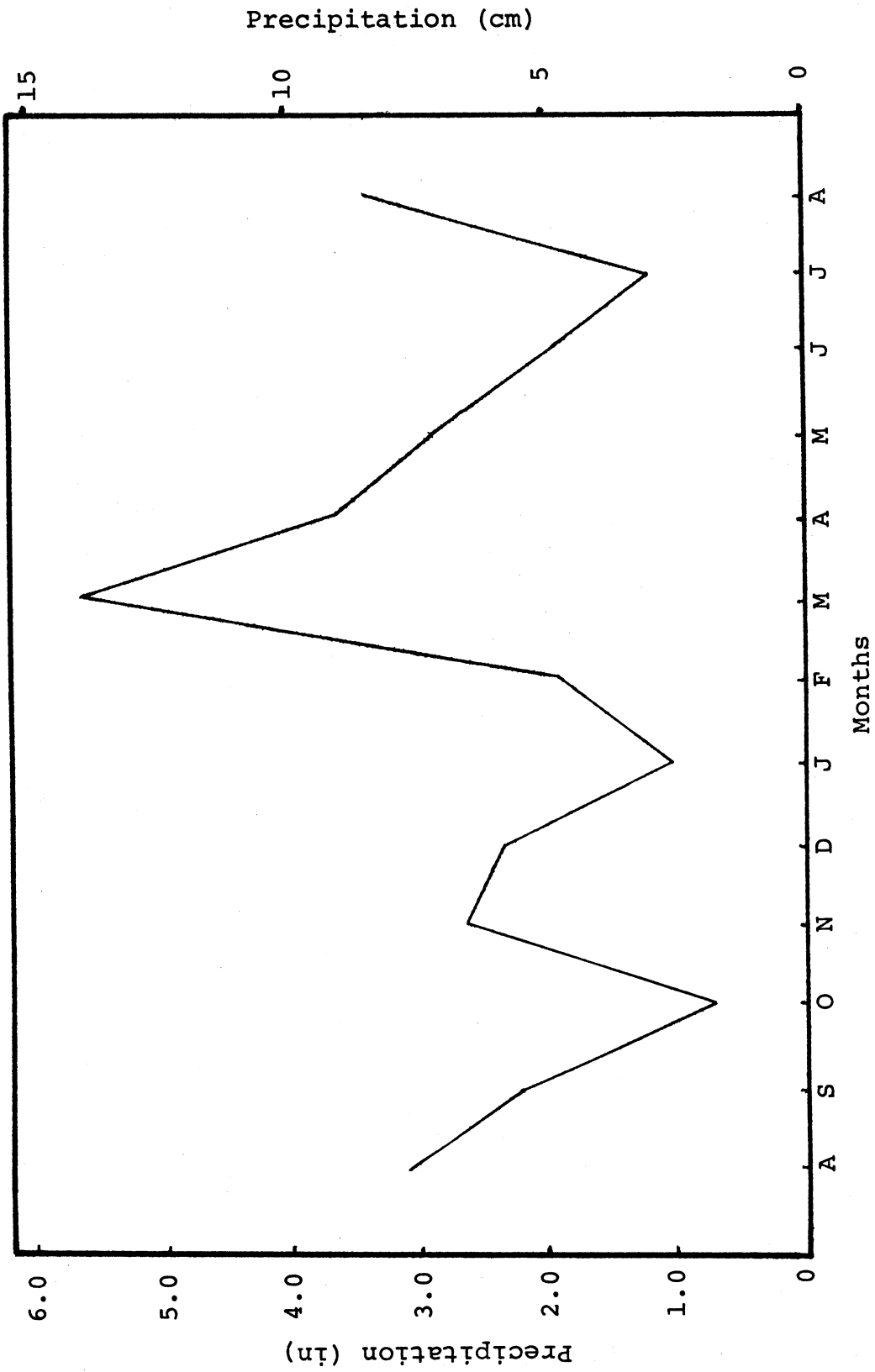
Climate

The climate of the Salt River basin is typical of the temperate central United States with hot dry summers and cold winters. Precipitation has averaged 37.1 in (94.2 cm) per year for the last 25 years as based on 29 rainfall gauges located throughout the basin (Corps, 1974a). The amount of precipitation (Figure 1) is from the National Weather Service in Moberly, Missouri, which is on the extreme western edge of the Salt River basin, and is the only recording weather station in the basin. The total of 29.48 in (74.9 cm) of precipitation from September 1975 to August 1976 shows the drought conditions present in mid-Missouri for the year.

History

Duchrow (1974) states that prior to 1800, the Salt River basin was about two-thirds forest-covered and one-third prairie; clear water and permanent flow characterized the river. With the coming of agriculture and clearing of the forests, the Salt River became silted, turbidity increased, and flow became intermittent. In 1831 the Missouri State Assembly declared the Salt River navigable to Florida, Missouri, and forbade dam construction without a permit. Monroe County, in 1834, authorized \$500 for

Figure 1.--Precipitation recorded at Moberly, Missouri
for the study period (August 1975 to August
1976)



clearing the river for navigation from Florida downstream to the county line. Late in the 1830's attempts to construct a lock and dam failed.

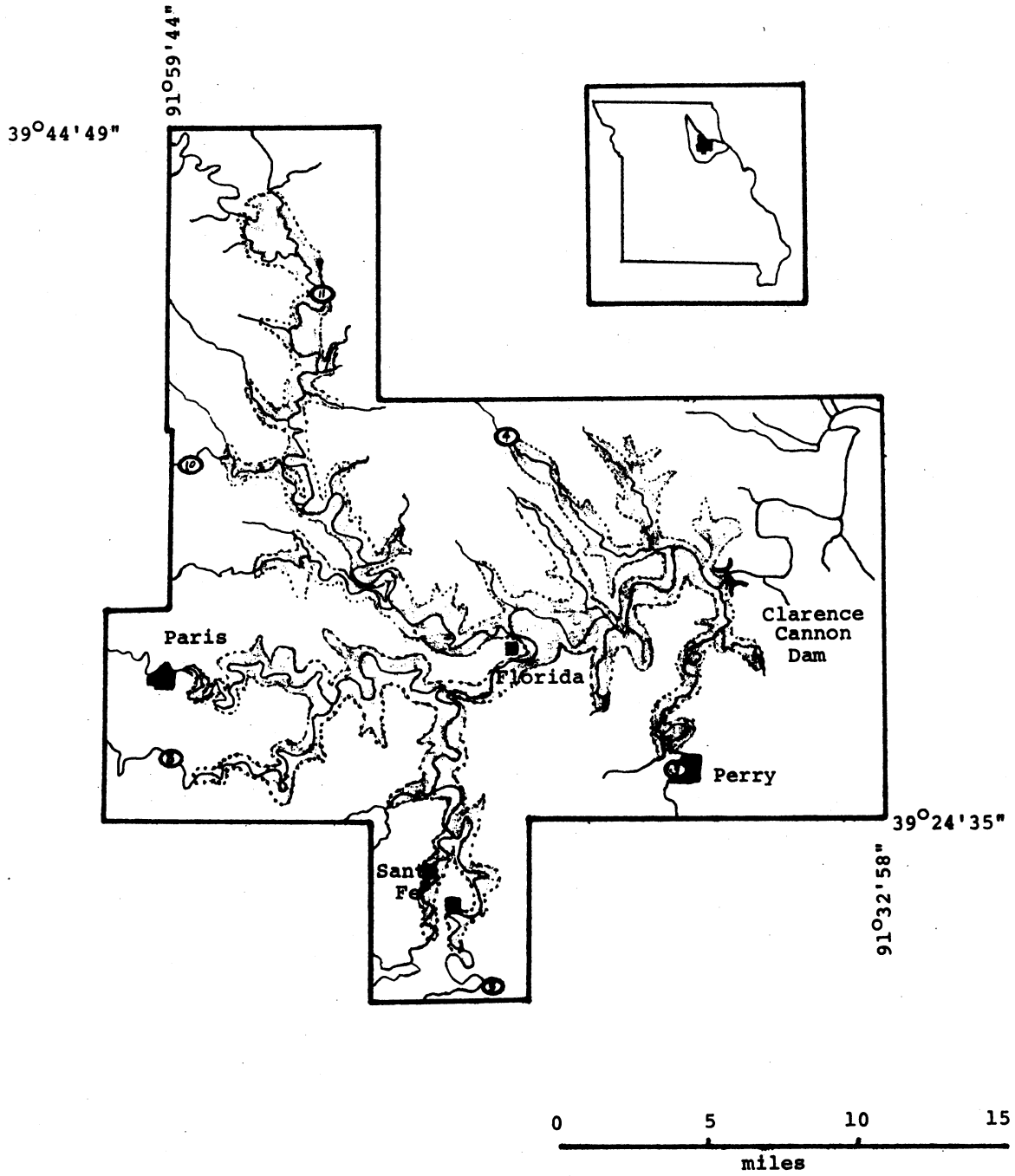
The first official notice of a dam and reservoir project in the area was in House Document #259 from the 74th Congress in 1935. Subsequent reports in May 1938 and March 1940 also included references to a flood control dam on the Salt River. Congressional authorization was given in October 1962 in Public Law 87-874 for a multiple use reservoir near Joanna, Missouri. In October 1965, the project was named in honor of the late United States Representative Clarence Cannon (Corps, 1974a).

The dam is scheduled for closing in December 1978 with an estimated cost of \$63,300,000 (Corps, 1974a). The reservoir will cover approximately 18,600 A (7526 ha) at joint use (normal) pool (606 ft msl) and 38,400 A (15540 ha) at flood pool (638 ft msl). The dam will have a general north-south axis, and, starting from the south abutment, will consist of a concrete spillway section, two hydroelectric generators, and a compacted earth-rock embankment.

Physical Description

The Salt River drains 2,318 mi² (6004 km²) within 13 counties, beginning in Schuyler and emptying in Pike (Figure 2). The river flows for approximately 200 mi (322 km) and drops 553 ft (169 m) for a gradient of about

Figure 2.--The proposed reservoir (at flood pool) on
the Salt River. The six collecting
stations are indicated.



2.8 ft/mi (.53 m/km). The habitats within the river can be divided into pools and riffles; the pools have a silt and organic ooze substrate, and the riffles have a gravel to cobble substrate. Due to the plateau-like area through which the Salt River flows for much of its length (see page 1), portions of the river are without riffles for long stretches.

The flow rate can change drastically, depending on precipitation. The highest recorded flow (at the damsite) was 96,100 cfs in April 1973, and the low was 0 cfs recorded during dry summers.

The six individual stations chosen for this study were located on fairly small tributaries of the Salt River; none had a stream order (Strahler, 1957) greater than 3. Table 1 describes the location and some of the physical characteristics of each station. These stations are all independent of each other and will be located on or near the periphery of the reservoir (Figure 2). The streams on which the stations are located can be divided into two groups: continuous flow (Stations 5, 8, and 11), and intermittent flow (Stations 3, 4, and 10). These stations are included in the twelve stations studied by Hazelwood (1974-76) and also by the United States Army Corps of Engineers (1974b).

Table 1.--Description of collection sites

	Station 3	Station 4	Station 5	Station 8	Station 10	Station 11
Topographic location	T54N, R7W SW $\frac{1}{4}$, NW $\frac{1}{4}$, SW $\frac{1}{4}$ Section 27	T55N, R8W SE $\frac{1}{4}$, NE $\frac{1}{4}$ Section 3	T53N, R8W SW $\frac{1}{4}$, NE $\frac{1}{4}$ Section 33	T54N, R10W Section 22	T55N, R10W Section 2	T56N, R9W SE $\frac{1}{4}$, NE $\frac{1}{4}$ Section 9
Quadrangle map	Perry 15 min.	Stoutsville 7 $\frac{1}{2}$ min.	Florida 15 min.	Paris West 7 $\frac{1}{2}$ min.	Goss 7 $\frac{1}{2}$ min.	Lakenan 7 $\frac{1}{2}$ min.
Stream name	Lick Cr.	Indian Cr.	South Fork of Salt R.	Elk Fork of Salt R.	Crooked Cr.	North Fork of Salt R.
Exact location	Under Mo. 154 bridge on W edge of Perry, Mo.	20 m down- stream from US 24 bridge 0.4 km WNW of In- dian Cr., Mo.	50 m down- stream from rural crossing 4.5 km SSE of Santa Fe, Mo.	20 m down- stream from Mo. 15 bridge 4.2 km S of Paris, Mo.	0.1 km down- stream from rural crossing #668, 10.7 km N of Paris, Mo.	Under US 36 bridge, 4.4 km W of Hunnewell, Mo.
County	Ralls	Monroe	Audrain	Monroe	Monroe	Shelby
Pools:	W	D	S			
	7 m	0.5 m	0.5 to 2 m	25 m	15 m	30 m
	0.5 to 1 m	Sand & clay	Silt & sand	0.5 to 1.5 m	0.5 to 2 m	1 to 3 m
	Gravel & cobble		Silt & sand	Silt & sand	Silt & detritus	Silt & cobble

Table 1. (continued)

	Station 3	Station 4	Station 5	Station 8	Station 10	Station 11
Riffles: W	1 m	30 cm	3 m	2 m	1 m	---
D	1 to 5 cm	1 cm	25 cm	20 cm	1 to 2 cm	---
S	Gravel	Gravel	Gravel	Gravel	Gravel & sand	---
Flow	Intermittent	Intermittent	Constant	Constant	Intermittent	Constant
Stream order	2	1	3	3	2	3
Algal blooms (periphytic) & Spirogyra	Hydrodictyon & Spirogyra	Spirogyra	None	Oscillatoria*	Spirogyra	None
Comments	---	---	Extensive municipal & industrial pollution **	---	Basin heavily agricultural; no municipalities **	No riffles; collapsed bridge in pool

Note. W = width, D = depth, S = substrate type.

*Not periphytic but eu planktonic.

**From United States Army Corps of Engineers. 1974a. Draft Environmental Statement.

Limnological Description

The water quality of the Salt River fluctuated greatly, usually as a result of changes in flow rates. The mean and range values for some 15 physicochemical factors for the six stations are listed in Table 2. Several studies of the water quality within the basin have been conducted in the past several years (Missouri Water Pollution Board, 1970; MBG, 1974a; Corps, 1974a, 1974b). The latter report (Corps, 1974b) was chosen as the best report because of the quantity of information published and the precision of collection. Their conclusions were that the observed values were mostly within the acceptable range for natural waters in Missouri. No distinct point sources of pollutants were found and the major contaminants came from nonpoint sources of discharges associated with the highly agricultural nature of the area.

The water quality of the Salt River includes several physicochemical factors which are of special interest: turbidity, fecal coliform bacteria, nutrients, iron, and sulfates.

The major water quality problem is excessive silt turbidity. When turbidity exceeds 25 JTUs, primary production can be significantly reduced, even in the presence of ample amounts of nitrogen, phosphate, carbon dioxide, silica, and other nutrients (Corps, 1974a). All of the stations in both this study and that above easily exceed

Table 2.--Water quality values for the Salt River, Missouri

	S T A T I O N 3		S T A T I O N 4		S T A T I O N 5				
	Min.	Avg.	Min.	Avg.	Min.	Max.			
Air Temp. (°C)	1.0	15.7	34.0	-4.0	13.5	36.0	0.0	17.0	33.0
Water Temp. (°C)	0.0	15.7	25.0	0.0	10.4	29.0	0.0	14.2	25.0
Dissolved Oxygen	5.2	9.4	13.3	7.7	11.3	15.3	5.3	9.0	13.1
pH	6.7	7.2	8.3	6.5	7.4	8.1	6.5	7.4	7.9
Carbon Dioxide	1.5	2.8	11.0	0.0	2.4	6.5	0.0	3.6	8.5
Flow (CFS)	0.0	52.0	680.0	1.0	23.0	160.0	5.0	123.0	1140.0
Turbidity (JTU)	11.0	87.2	260.0	4.0	47.4	125.0	5.0	157.5	195.0
Hardness	60.0	155.4	218.0	68.0	138.0	197.0	60.0	151.1	260.0
Alkalinity	34.0	85.3	136.0	50.0	102.2	165.0	40.0	102.3	195.0
Nitrate/Nitrite	0.05	1.01	2.4	0.0	0.9	1.4	0.0	1.12	2.6
Orthophosphate	0.0	0.07	0.18	0.0	0.06	0.18	0.0	0.1	0.21
Total Phosphate	0.06	0.17	0.55	0.01	0.11	0.29	0.03	0.19	0.43
B.O.D.	1.4	-	2.9	0.5	-	1.9	0.8	-	3.0
T.D.S.	109.9	253.5	346.0	179.0	214.4	256.0	165.0	248.4	320.0
Sulfates	19.0	70.7	110.0	20.0	41.1	64.0	14.0	64.6	158.0

Table 2. (continued)

	S T A T I O N 8		S T A T I O N 10		S T A T I O N 11		
	Min.	Avg.	Min.	Avg.	Min.	Avg.	
Air Temp. (°C)	0.0	16.7	31.0	Max.	-6.0	15.6	34.0
Water Temp. (°C)	0.0	14.1	27.0	30.0	0.0	13.4	30.0
Dissolved Oxygen	6.5	9.3	14.8	12.6	6.2	9.8	13.0
PH	6.8	7.0	7.8	7.6	6.6	7.1	7.7
Carbon Dioxide	1.5	3.3	8.0	9.5	1.5	3.7	10.0
Flow (CFS)	8.0	109.0	200.0	500.0	16.0	368.0	5700.0
Turbidity (JTU)	4.0	85.0	250.0	200.0	9.0	124.2	220.0
Hardness	66.0	161.3	286.0	202.0	54.0	125.6	214.0
Alkalinity	46.0	102.4	167.0	131.0	46.0	93.9	163.0
Nitrate/Nitrite	0.02	1.2	1.5	6.72	0.05	0.8	1.4
Orthophosphate	0.0	0.05	0.09	2.15	0.0	0.05	0.08
Total Phosphate	0.04	0.14	0.34	0.37	0.02	0.20	0.37
B.O.D.	0.8	-	4.0	5.6	0.6	-	3.9
T.D.S.	167.0	312.7	360.0	288.0	150.0	230.5	285.0
Sulfates	0.0	60.4	145.0	93.0	18.0	39.8	79.0

Note. Units of measurement are mg/l unless otherwise specified.

Min. and Max. values are from October 1972 to September 1974, Avg. value is from October 1972 to September 1975. (United States Army Corps of Engineers, 1974b.)

this value; many stations exhibited turbidity in excess of 200 JTU. Much of the turbidity is expected to settle out in the reservoir, thus improving the clarity of the Salt River below the dam. The deposition of silt, however, will cause other problems, in that the reservoir, especially its upper reaches, will become a nutrient trap since the sinking particles will absorb other materials (e.g., phosphates, nitrates, iron, etc.). Some United States Army Corps of Engineers personnel, however, are not convinced that the clay turbidity will settle out in the reservoir. They have kept water samples in the laboratory for periods in excess of three weeks without any noticeable improvement in clarity (Postel, T., 1977, Pers. Com.).

The state standard for fecal coliform bacteria was exceeded 51 times in the two-year study. The excessive amounts of these bacteria were not illegal since they occurred during storms, when runoff scoured the surrounding pastures, rather than during a period of normal flow.

The levels of nutrients fluctuate substantially, and further studies are under way to determine the probability and extent of eutrophication in Clarence Cannon Reservoir (Corps, 1974a).

The United States Army Corps of Engineers (1974a) reported that the high concentration of iron may cause taste and scale problems for potential drinking waters.

Iron may also become a limiting factor to primary (algal) production in the reservoir if other nutrients are adequate and water transparency increases. Although iron is in overabundant supply in the river now, it could be trapped by the sinking clay particles into relatively insoluble unavailable ferric (Fe^{+++}) compounds.

Even though the sulfate concentration is presently not a problem, it could present serious problems once the river is impounded. As sulfates enter the oxygen-starved hypolimnion, they will be reduced to soluble hydrogen sulfide, which when coupled with the hydrogen sulfide produced from decaying, recently flooded vegetation, will present the possibility for severe degradation of water (and possibly air) quality (MBG, 1974a).

Review of the Biotic Literature

Salt River Literature

Studies of the biota of the Salt River previous to 1969 were almost nonexistent. Duchrow (1974) states that an anonymous writer in 1883 reported that "numerous species of mayflies and stoneflies were collected in the Salt River and tributaries in Pike County in the early 1800's."

The first report of a benthic study was from Ryck and Duchrow (1973); they studied the damage to the benthos of the South Fork of the Salt River caused by a 352 m³ spill of #2 diesel fuel on March 28-30, 1972 at Mexico, Missouri. Their conclusions were that although the fish

populations downstream from the spill were severely affected initially, they quickly recovered and were present at pre-spill levels by August 9, 1972. The lack of damage to the benthic macroinvertebrates enabled the fish to return quickly since the macroinvertebrates, which form the food supply of the fish, were still present.

The oil spill was also studied by Bugbee, Walter, and Lorenz (1974). They found that in 13 days, approximately 222,000 fish were killed in the 40 km downstream to where the unabsorbed diesel fuel was finally contained. Rapid recolonization by the benthos occurred even with some fuel still present in the sediments. Based on the analysis of a series of 15 benthic samples, the spill was considered to be chronically, rather than acutely, toxic. All evidence of the spill had disappeared by February 23, 1973. They included a list of the benthic macroinvertebrates found in the South Fork of the Salt River.

Duchrow completed a report in 1974 on the water quality of the Salt River, which he surveyed by studying the benthic communities of the basin. Following extensive collecting from 33 sites in 1969 and 1970, he concluded that although major organic pollution did exist, the most prevalent source of environmental degradation was nonpoint siltation from farmland erosion. He included a list of 123 benthic macroinvertebrate taxa which are included in Appendix 2.

The Missouri Botanical Garden (1974a) completed an

environmental assessment for the Clarence Cannon Dam and Reservoir. Benthic samples were taken from 15 sites in the Salt River basin during the summer of 1973. The researchers concluded that:

1. Due to the shallow light penetration of the highly turbid water, little energy was fixed directly by algae; the major source of primary production was allochthonous detritus.
2. A late summer decrease in levels of dissolved oxygen occurred in many places in the Salt River, with an accompanying increase in the densities of animals with specialized respiratory structures (e.g., *Tubifex tubifex*, *Physa pumila*, and *Chironomus attenuatus*).
3. Relatively intolerant, lotic animals were present as well as widely tolerant, "pollution indicator" animals.

Their list of 131 benthic taxa was included in Appendix 2.

From May 1974 to November 1976, Hazelwood (1976) collected 138 benthic taxa in 130 samples (Appendix 2) and has summarized that the aquatic invertebrates were composed of the expected lotic animals (e.g., *Stenonema*, *Cheumatopsyche*, *Stenelmis*, etc.) as well as some unexpected lentic animals (e.g., Cladocera and Ectoprocta). He was not able to detect any apparent effects of either the pending impoundment or associated activities.

The fish of the Salt River have also been extensively studied for the last five years. Previously, the only study was by Purkett (1958) on the growth rates of some Salt River fish. He stated that when compared to average growth rates for 11 species, 5 grew faster than average (carp [*Cyprinus carpio*], smallmouth buffalo [*Ictiobus bubalus*], freshwater drum [*Aplodinotus grunniens*], green sunfish [*Lepomis cyanellus*], and white sucker [*Catostomus commersoni*]), 1 grew at the average rate (gizzard shad [*Dorosoma cepedianum*]), and 5 grew slower than average (river carpsucker [*Carpionodes carpio*], northern redhorse [*Moxostoma macrolepidotum*], channel catfish [*Ictalurus punctatus*], flathead catfish [*Pylodictis olivaris*], and white crappie [*Pomoxis annularis*]).

Fajen (1973) reported on attempts to establish breeding populations of spotted bass (*Micropterus punctulatus*). The results of these attempts were not conclusive. He listed 20 species of fish from the Salt River, but did not include minnows or darters (Appendix 3). In their environmental assessment, the Missouri Botanical Garden (1974a) collected 47 species of fish (Appendix 3). Hazelwood (1976) collected 48 species of fish in the Salt River in the last three years (Appendix 3).

Pflieger (1975), in his exhaustive study of the distribution of Missouri fish, lists 58 species of fish that should be present in the middle and upper reaches of the Salt River.

Plankton Literature

Studies of truly lotic zooplankton communities are not abundant: Berner (1951) included a section on the plankton of the lower Missouri River and Bothar (1975) conducted a horizontal study of the Danube River plankton. Both of these plankton communities, however, are still contaminated by lentic plankton from large upstream reservoirs. Studies of the lotic plankton in a combined lake and river system were conducted by Kofoid (1908) on the middle Illinois River, Eddy (1932) on the middle and lower Sangamon River, Chandler (1937) on a system in northern Michigan, Hooper (1947) on the headwaters (mainly) of the Yukon and Mackenzie Rivers, and Beach (1960) on the Ocqueoc River in northern Michigan. In these cases, the authors found that the lentic plankton completely dominated or eliminated any lotic plankton.

In their classic study of morphological changes in rotifers in response to predation, Gilbert and Waage (1967) found that *Brachionus calyciflorus* grew loricate spines in varying lengths as a response to the presence of *Asplanchna*. Depending on the species of *Asplanchna* that was present, the longer spines had a varying, but generally favorable, effect for *Brachionus*.

In their environmental assessment, the Missouri Botanical Garden (1974b) found 230 species of phytoplankton and periphyton in the Salt River, increasing the number of algal species collected from Missouri from 150 to 300.

However, no zooplankton was identified.

Plankton studies are not usually associated with water quality determinations because water chemistry studies can be completed faster and with less difficulty. As a result, none of the water quality studies of the Salt River attempted a plankton study. The United States Army Corps of Engineers (1974a) even went so far as to state that "The headwaters of the Salt River and its tributaries probably contain no true plankton, but rather an assemblage of detached and drifting organisms."

Benthic Literature

Compared to lotic plankton, lotic benthos has received extensive study; even the Salt River has had five studies of benthic communities (see pages 16-18). Most benthic studies are done for either fish food analysis or water quality determinations (Gersbacher, 1937). Benthic studies for water quality determinations have some advantages over other types of water quality tests because the benthos:

1. Can reflect the cumulative quality effects of water passage
2. Are relatively immobile
3. Are relatively long-lived
4. Have been analyzed into extensive systems for the indication of levels of pollution (Kolkwitz & Marsson, 1909; Gaufin & Tarzwell, 1956)

5. Have fairly specific identification keys for most species

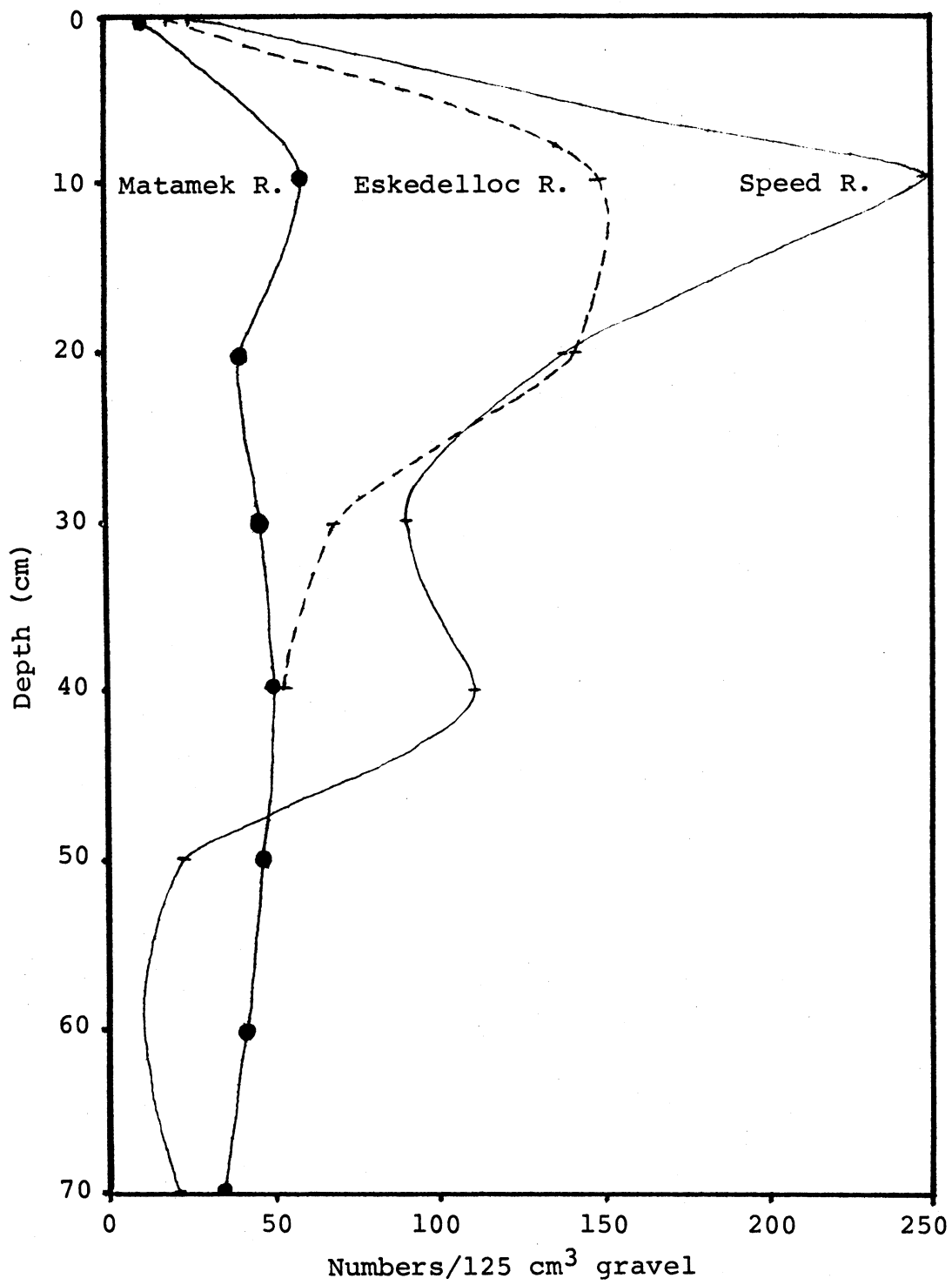
Benthic studies do have some negative aspects.

One of the worst aspects is the lack of a uniformly applicable, widely accepted method for obtaining benthic samples in streams.

The sampler designed by Surber (1937) has been the most commonly used quantitative sampler in shallow streams (Weber, 1973), but many researchers are exploring other alternatives. An increasing number of authors are shifting to some variation of an artificial substrate sampler (Macan, 1958; Coleman & Hynes, 1970; Radford & Hartland-Rowe, 1971; Bishop, 1973; Hynes, 1974; O'Connor, 1974) in order to make the samples more quantitative and to obtain a portion of the hyporheic benthos. Coleman and Hynes (1970) found that significant numbers of benthic animals live deep within the substrate (25.96% of all animals from 0 to 30.5 cm deep lived at depths from 23.9 to 30.5 cm) and that even 30 cm is still too shallow for an unbiased sample (Figure 3).

Many of the samplers suffer from physical limitations, in that they may be too bulky for easy use (the Peterson dredge), or they may be incapacitated by periods of high water (Surber, and artificial substrates, if they are scoured or buried), periods of no flow (Surber), or ice cover (artificial substrates). Also, Needham and Usinger (1956) found that 73 samples had to be taken at each site

Figure 3.--Hyporheic benthos in three Canadian
rivers (from Hynes, Kaushik, Lock, Lush,
Stocker, Wallace, & Williams, 1974)



for a 95% level of confidence as to the total numbers or densities of the species captured. Using the same data, Chutter (1972) found that 448 samples were needed to yield a sample mean within 5% of the average population density at a 95% level of confidence. Such repetitious sampling would make the quantitative use of a Surber sampler extremely rigorous.

Another drawback of benthic studies is the many substrates which are unavailable as sampling areas. Common samplers (Surber, artificial substrates, and dredges) are unuseable in such substrates as bedrock, large boulders, deep allochthonous leaf beds, and dense stands of macrophytes or algae. The samplers become either mechanically inoperative or clogged with so much vegetation that the animals are lost.

The different sampling techniques also include biases for or against the collection of certain organisms and certain habitats (Table 3). A depth limitation obviously exists for the Surber sampler and kick-nets since they are hand-held. Chutter (1972) also states that the Surber sampler should not be used in water which is deeper than 30 cm (the height of a Surber frame) since the depth increases the number of samples (595) needed for a 95% level of confidence.

Many factors contribute toward disrupting the quantitative aspects of benthic sampling techniques. These factors include: individual biases of the collector

Table 3.--Sampling method biases

	Surber sampler	Artificial substrates	Kick-net	Dredges*
Small chironomids	- (1,5,6)			
Chaoboridae	+ (2)		+ (2)	
Plecoptera	- (5)	+ (4)		-
Simuliidae	+ (3) - (6)		+ (3)	-
Hydropsychidae	- (1,6)			-
Unionidae		-	- (4)	
Attached benthos			- (4)	-
<i>Hexagenia</i>	-			+
Tipulidae	- (3)		- (3)	

Note. Numbers indicate source: 1 = Maitland, 1962; 2 = Cushing, 1963; 3 = Egglshaw, 1969; 4 = Coleman and Hynes, 1970; 5 = Radford and Hartland-Rowe, 1971; 6 = Kroger, 1972. (-) = biased against, (+) = biased for.

*Based on the bias of dredges against hard, rocky substrates.

(Needham & Usinger, 1956), insect emergence which causes the temporary disappearance of some species (Egglishaw & Mackay, 1967; Fahy, 1975), and the bias of all techniques using nets and current toward contamination of the sample by insect drift (Cushing, 1963). The major factor, however, is the non-random distribution of the benthos, which is caused by either heterogeneous occurrence of rare benthic species (Cushing, 1963; Egglishaw, 1969; Goodman, 1975), or by species preference for certain microhabitats. These preferences can be for varying depths in the substrate (Radford & Hartland-Rowe, 1971; O'Connor, 1974), varying types of substrates (Egglishaw, 1969; Brusven & Prather, 1974; Fahy, 1975), increased food availability (Egglishaw & Mackay, 1967; Egglishaw, 1969), varying water depths and velocities (Needham & Usinger, 1956; Egglishaw, 1969; Fahy, 1975), varying levels of dissolved oxygen (Sublette, 1956), and varying levels of algal growth (Hynes, 1974).

Some important groups of benthic animals can also be very difficult to identify. Such animals as oligochaetes and chironomids, both being important indicator organisms, require extra attention and time in order to make even generic identifications; these groups are usually sent to specialists for identification. Resh and Unzicker (1975) have noted that generic level identification is no longer acceptable for use within a pollution

indicator system. The variations among a number of species can place one genus into a variety of indicator categories. Some other groups (e.g., Odonota, Plecoptera, and Trichoptera) are not necessarily difficult or time consuming to identify, but not all of the identification characters occur on some of the immature nymphs or larvae, which necessitates the collection of mature nymphs or adults for identification.

Diversity Indices Literature

Diversity indices have received intensive study since the information theory was first published by Shannon and Weaver (1949). Even though no widespread agreement has emerged on which modification of the theory should be used (Pielou, 1966a; Peet, 1974), many writers in ecology use the concept. However, the term 'species diversity' still is not universally accepted (Hurlbert, 1971; Goodman, 1975) due to ambiguities in definition and application.

Chapter 2

Materials and Methods

Materials

Monthly plankton and benthos samples were taken at six stations on the Salt River (Table 1) from August 1975 through August 1976. The plankton was collected from 30 gal (114 l) of river water (twelve 2½ gal buckets) poured through a Wisconsin style plankton net and bucket of #20 mesh (68 mesh/cm [Cushing, 1963]). The water was carefully gathered so that the water was "clean" or uncontaminated with sediments from upstream. The sample was rinsed out of the plankton bucket into a 150 ml bottle with tap water. All samples were preserved in the field in approximately 10% formalin.

In the spring of 1976, a method was devised so that only one person was needed to collect the sample; previously, one person had to pour while another held the plankton net. A 5 ft (1.5 m) section of concrete reinforcing rod was bent into a "shepherd's crook," with a recurved tip on the curved end. The rod was pushed into the substrate of the river and the net was hooked over the recurved tip. This device greatly simplified the collection procedure.

The benthos was sampled with a Surber type sampler

with a coarse mesh (9 mesh/cm) bag. This coarse mesh undoubtedly allowed many small insects to pass through the net, but this loss was probably not significant in terms of biomass (Maitland, 1962). Three ft² (.2787 m²) were sampled each time since this amount is the recommended surface (Needham & Usinger, 1956; Chutter & Noble, 1966) to insure the collection of prominent members of each community. The samples were taken at random at each station (Weber, 1973), although some effort was made to sample different microhabitats (see page 26). The substrate was worked to a depth of approximately 7 cm with each sample; individual rocks were examined and cleaned by hand and tweezers. The net was picked clean with tweezers after all three samples were taken, and all organisms (along with some substrate) were fixed in approximately 10% formalin in 500 ml bottles. The insects were transferred to 70% ethanol during and after identification. Additional organisms were collected with a kick-net by random samples in leaf beds, silt banks, or emergent vegetation; these animals obviously could not be quantified. Several benthic samples were missed due to high water or ice cover. Any visible algae was also preserved along with the benthos.

Identification

Plankton

In the laboratory, the preserved plankton was rinsed

through a section of #20 mesh net to remove the formalin. The sample was then rinsed into a plastic Petri dish which was modified by scribing lines on the bottom to create a grid pattern. Occasional problems occurred when organisms (especially loricate rotifers) became trapped in the surface film; these organisms were impossible to count until they sank to the bottom of the dish. Originally, they were just poked with a fine probe until the surface film was broken, but later, a small amount of common detergent was added to the dish to decrease the surface tension. The animals were counted in each grid over one-half of the dish (using push-button laboratory counters) and the results were doubled. The other half of the dish was also examined for any unique animals or algae.

The microscope used was an American Optical Zoom dissecting binocular microscope with a variable magnification (including all attachments) from 7X to 161X. When this magnification was still inadequate, a Tiyoda compound microscope was used (magnification up to 440X). The usual magnification used for counting was approximately 33X. Standard identification texts were used (i.e., Pennak, 1953; Edmondson, 1959).

When subsampling proved necessary, a 20 ml syringe (approximately 4 mm bore) was used without a needle. The sample was diluted to 100 ml and either 10 or 20 ml

were removed with the syringe while the 100 ml total was being continuously stirred.

Benthos

All coarse substrate was examined in the field to remove all organisms and then discarded. In the laboratory, the entire sample was rinsed through a 13 mesh/cm screen to remove the formalin. The rinsed sample was then transferred to a flat glass dish and the entire sample was counted, using the A.O. Zoom dissecting microscope. Identifications were done with standard sources (i.e., Pennak, 1953; Usinger, 1956; Edmondson, 1959) aided by minor sources provided by Drs. D. H. Hazelwood and W. R. Enns. Some groups were sent to specialists for verification (Coleoptera to Dr. S. Swadener, Illinois Natural History Survey, and Astacidae to Dr. H. H. Hobbs, Smithsonian Institution). Drs. D. H. Hazelwood and W. R. Enns and the staff of the University of Missouri-Columbia Entomology Museum also aided in identification or verification. A reference collection has been maintained. A flotation process (Anderson, 1959) was attempted, but it failed due to its inability to float heavy trichopterans, fingernail clams, and snails. Since the entire sample still had to be subsequently examined, the process was abandoned in favor of sorting and counting the entire sample by hand.

Identification generally proceeded as specifically

as time and practicality permitted. In hindsight, the species identification could have been improved, especially with the chironomids and copepods, in order to make this study more meaningful.

Any encountered algae was identified to genus with a Tiyoda compound microscope, using standard texts (i.e., Smith, 1950; Prescott, 1970).

Sampling dates averaged on the 16th of each month, but varied from the 4th to the 22nd, depending on temperature, rainfall, and personal convenience.

Chapter 3

Results and Discussion

Plankton

In the thirteen month study period, 170,238 planktonic organisms from 49 different taxa were filtered from 2,010 gal (7608 l) of Salt River water. The seasonal abundance of these animals is listed in Table 4 with a complete taxonomic summary in Appendix 4. The abundances fluctuate around clearly evident plankton pulses (e.g., the rotifer *Brachionus* at Station 8 in April, the cladoceran *Bosmina* at Station 10 in January, and nauplii larvae at Station 4 in August, 1976). These pulses are, according to Welch (1952), "...sporadic, unpredictable, and frequent or infrequent."

Several unique environmental conditions probably contributed toward particular pulses.

Sometime between October 18 and November 9, 1975, a beaver constructed a dam across the South Fork of the Salt River at Station 5. The dam was built across the riffle usually sampled and raised the water level in a large upstream pool by approximately 50 cm. This temporary impoundment caused one of the largest plankton pulses that was observed at Station 5: 4,709 organisms from

Table 4.--Monthly zooplankton abundance in the Salt River, Missouri in numbers per thirty gallons

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Average
Station 3														
<i>Hydra</i>	-	-	-	3	-	-	-	-	-	-	-	-	-	0.2
<i>Bdelloidea</i>	-	-	-	-	-	-	-	-	-	-	1	-	5	0.5
<i>Filinia</i>	-	-	-	-	10	-	-	21	-	-	-	-	45	5.8
<i>Testudinella</i>	2	-	3	-	-	-	-	-	-	-	-	10	45	4.6
<i>Cephalodella</i>	-	-	-	-	-	1	-	-	99	15	1	1	-	9.0
<i>Asplanchna</i>	-	-	-	-	-	-	-	5	403	-	2	1	-	31.6
<i>Brachionus</i>	5	4	6	24	-	-	12	-	125	384	20	46	120	57.4
<i>Keratella</i>	-	-	-	-	-	1	-	1	-	-	-	-	-	0.2
<i>Platyias</i>	-	-	-	-	-	1	-	-	-	-	-	1	-	0.2
<i>Trichotrea</i>	-	-	-	-	-	-	-	-	-	2	-	-	-	0.2
loricate rotifer	-	-	-	-	1	-	-	-	-	-	-	-	-	0.1
<i>Nematoda</i>	-	-	-	-	-	-	2	-	-	-	-	1	-	0.2
<i>Naididae</i>	-	-	-	239	-	4	2	-	24	9	-	-	15	22.5
<i>Diaphanosoma</i>	5	11	-	-	-	-	-	-	1	-	-	-	-	1.3
<i>Ceriodaphnia</i>	-	-	-	122	-	-	-	-	-	-	-	-	780	69.4
<i>Daphnia</i>	-	-	-	-	-	-	-	8	21	-	-	-	-	2.2

Table 4. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Average
<i>Scapholeberis</i>	-	-	-	-	-	-	-	-	-	-	4	128	195	25.2
<i>Simcocephalus</i>	-	-	-	-	-	4	-	-	-	-	-	1	-	0.4
<i>Bosmina</i>	-	3	14	-	1	316	36	48	84	2	4	3	15	40.5
<i>Ilyocryptus</i>	-	-	-	-	-	-	-	-	-	-	-	-	60	4.6
<i>Macrothrix</i>	9	4	93	281	-	-	2	-	-	-	5	5	135	41.1
<i>Alona</i>	-	-	-	3	-	-	-	-	-	-	-	-	75	6.0
<i>Alonella</i>	-	-	41	737	3	5	5	-	1	27	-	1	-	63.1
<i>Chydorus</i>	-	4	6	239	2	268	15	2	176	132	4	6	855	131.5
<i>Leydigia</i>	-	-	-	71	-	-	-	-	-	-	2	-	45	9.1
<i>Pleuroxus</i>	-	9	-	65	1	4	-	-	-	-	14	10	240	26.4
<i>Ostracoda</i>	-	-	-	31	1	-	-	-	1	-	4	8	165	16.1
<i>Calanoida</i>	-	-	-	-	-	-	3	1	2	-	-	1	30	2.8
<i>Cyclopoida</i>	18	81	29	1052	3	9	8	10	176	93	8	52	840	183.0
nauplii	15	42	163	800	14	31	24	82	471	237	22	128	2385	339.5
<i>Harpacticoida</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	0.1
<i>Parasitengona</i>	-	-	3	-	-	-	-	-	12	3	2	11	45	5.8
<i>Podura</i>	-	-	-	-	-	-	2	-	-	5	-	22	-	2.2
<i>Sminthuridae</i>	-	-	-	-	-	-	-	-	-	-	-	6	-	0.5

Table 4. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Average
<i>Caenis</i>	-	-	-	19	-	-	-	-	-	-	5	3	-	2.1
<i>Stenonema</i>	-	2	-	-	-	-	-	-	-	-	-	-	-	0.2
<i>Isonychia</i>	-	-	-	-	-	3	-	-	-	-	-	-	-	0.2
Ceratopogonidae	-	-	-	2	-	-	-	-	-	-	-	-	15	1.3
Chironomidae	-	-	-	44	3	3	2	1	71	9	8	5	15	12.4
<i>Chaoborus</i>	-	-	-	-	-	-	-	-	-	-	-	2	-	0.2
<i>Simulium</i>	-	-	-	-	-	-	-	-	21	-	-	-	-	1.6
TOTAL	54	160	358	3730	39	650	109	179	2093	918	106	451	6125	1151.7

Station 4

<i>Hydra</i>	-	-	-	-	-	-	-	-	1	-	-	-	-	0.1
Bdelloidea	-	-	-	-	-	-	-	-	4	-	-	-	-	0.3
<i>Filinia</i>	-	-	-	-	178	-	36	74	28	-	-	-	479	61.2
<i>Testudinella</i>	3	2	2	-	-	-	-	1	1	2	-	119	27	12.1
<i>Cephalodella</i>	-	-	22	-	-	-	-	-	121	-	-	3	-	11.2
<i>Asplanchna</i>	-	-	-	-	31	4	12	-	44	-	-	1	66	12.2
<i>Brachionus</i>	17	9	4	-	-	2	-	3	368	9	-	50	66	40.6
<i>Keratella</i>	-	-	-	-	-	2	-	36	4	-	-	-	-	3.2

Table 4. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Average
<i>Platyias</i>	-	-	-	-	-	2	2	-	3	-	-	-	6	1.0
<i>Trichotrea</i>	-	-	-	3	-	-	-	-	-	-	-	-	-	0.2
loricate rotifer	-	-	-	-	16	-	-	-	-	-	-	-	-	1.2
<i>Nematoda</i>	3	-	1	-	-	-	-	-	2	-	4	-	-	0.8
<i>Naididae</i>	-	-	-	15	23	-	-	-	26	-	20	-	6	6.9
<i>Diaphanosoma</i>	2	-	-	-	-	-	-	-	-	2	-	-	2	0.5
<i>Ceriodaphnia</i>	-	-	-	-	4	-	-	-	-	-	-	-	-	0.3
<i>Daphnia</i>	-	1	-	-	14	2	23	14	121	3	-	-	-	13.7
<i>Scapholeberis</i>	-	-	-	-	-	-	-	-	1	-	3	-	-	0.3
<i>Simocephalus</i>	-	-	-	-	-	4	8	-	-	-	-	-	-	0.9
<i>Bosmina</i>	-	6	-	-	59	1042	125	37	84	39	-	60	9	112.4
<i>Macrothrix</i>	6	2	4	39	-	-	-	-	-	6	-	30	-	6.7
<i>Alona</i>	-	-	-	-	-	-	-	-	-	-	-	1	-	0.1
<i>Alonella</i>	-	14	27	19	6	41	5	1	2	6	-	4	-	9.6
<i>Chydorus</i>	2	6	11	2	8	514	6	-	15	3	-	8	24	46.1
<i>Pleuroxus</i>	-	4	-	2	3	6	-	-	1	4	-	4	6	2.3
<i>Ostracoda</i>	-	1	6	3	-	-	-	-	1	-	2	1	6	1.5

Table 4. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Average
<i>Calanoida</i>	11	-	-	-	3	8	14	4	50	-	-	8	12	8.5
<i>Lernaea</i>	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1
<i>Cyclopoida</i>	35	137	37	33	58	31	6	12	126	6	5	499	546	117.8
nauplii	24	119	31	59	53	246	62	232	176	27	14	312	1997	257.8
<i>Parasitengona</i>	-	-	-	-	-	-	-	1	3	-	7	2	2	1.2
<i>Podura</i>	-	1	-	-	-	-	2	-	8	-	-	-	-	0.8
<i>Smintthurides</i>	-	-	-	-	-	-	-	2	-	-	-	-	-	0.2
<i>Caenis</i>	-	-	-	-	3	-	-	-	-	2	6	2	-	1.0
<i>Stenonema</i>	-	3	-	3	9	-	-	-	-	-	-	-	-	1.2
<i>Chironomidae</i>	6	4	-	3	17	-	2	-	26	-	8	12	5	6.4
<i>Chaoborus</i>	-	-	-	-	-	-	-	-	-	-	-	2	18	1.5
<i>Simulium</i>	-	-	-	-	-	-	-	-	4	-	-	-	-	0.3
TOTAL	109	309	145	181	485	1906	303	417	1645	93	85	1118	3277	774.8

Station 5

<i>cercaria</i>	-	-	-	-	-	-	-	-	-	-	2	-	-	0.2
<i>Bdelloidea</i>	-	-	-	122	-	-	-	-	14	2	-	-	24	12.5
<i>Filinia</i>	-	139	19	-	3	-	74	18	18	12	-	-	90	28.7

Table 4. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Average
<i>Pedalia</i>	-	-	-	-	-	-	-	-	-	-	-	-	1503	115.6
<i>Testudinella</i>	2	-	-	110	-	-	-	-	2	-	-	2	-	8.9
<i>Cephalodella</i>	-	-	-	-	-	-	-	-	140	62	-	-	132	25.7
<i>Polyarthra</i>	-	-	-	-	-	-	-	-	-	-	-	-	54	4.2
<i>Asplanchna</i>	3	13	60	86	3	5	74	4	543	183	-	39	932	149.6
<i>Brachionus</i>	19	-	6	74	-	3	36	-	719	120	4	656	578	173.5
<i>Keratella</i>	-	-	-	-	-	-	12	6	2	29	-	-	-	3.8
<i>Platyias</i>	-	-	-	47	-	-	-	-	-	2	-	-	-	3.8
<i>Trichotrea</i>	-	-	-	281	-	-	-	-	-	3	2	-	-	22.0
loricate rotifer	-	-	-	-	8	-	-	-	-	-	-	-	-	0.6
<i>Nematoda</i>	-	-	-	-	-	-	6	1	4	-	-	-	-	0.8
<i>Naididae</i>	-	-	-	260	-	-	-	-	47	-	3	-	12	24.8
<i>Stylaria</i>	-	-	-	-	-	-	-	-	-	-	-	-	2	0.2
<i>Diaphanosoma</i>	-	4	-	-	-	-	-	-	-	-	4	72	132	16.3
<i>Ceriodaphnia</i>	-	-	-	5	-	-	-	-	-	2	-	-	5	0.9
<i>Daphnia</i>	-	-	-	-	1	-	-	3	40	-	-	-	-	3.4
<i>Scapholeberis</i>	-	-	-	-	-	-	-	-	-	-	20	34	-	4.2
<i>Simocephalus</i>	-	-	-	-	-	2	-	-	-	-	-	-	-	0.2

Table 4. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Average
<i>Hydroptilidae</i>	-	-	-	5	-	-	-	-	-	-	-	-	-	0.4
<i>Chironomidae</i>	2	3	1	131	-	1	8	1	71	12	24	6	8	20.8
<i>Chaoborus</i>	-	-	-	-	-	-	-	-	-	-	1	1	9	0.8
<i>Simulium</i>	-	-	1	21	-	-	-	-	-	-	-	-	-	1.7
TOTAL	56	297	277	4709	38	414	461	98	4182	913	285	915	5237	1375.5

Station 8

<i>Bdelloidea</i>	-	-	-	60	-	-	-	-	-	2	-	-	3	5.0
<i>Filinia</i>	2	513	4	-	7	-	27	16	455	35	-	-	1203	174.0
<i>Testudinella</i>	6	-	4	56	-	-	-	-	-	.14	-	-	-	6.2
<i>Cephalodella</i>	-	-	18	21	-	-	-	-	1886	24	53	-	-	154.0
<i>Asplanchna</i>	5	28	-	-	2	-	6	4	182	35	42	27	78	31.5
<i>Brachionus</i>	14	7	10	39	1	-	3	2	11795	208	89	43	1413	1048.0
<i>Keratella</i>	-	-	-	-	-	2	-	-	-	17	-	-	21	3.1
<i>Platyias</i>	-	-	-	-	-	-	5	-	5	-	-	-	-	0.8
<i>Trichotrea</i>	-	-	-	55	-	-	-	-	-	-	-	-	-	4.2
Nematoda	-	-	-	-	-	-	-	-	-	2	8	-	-	0.8
Naididae	-	-	10	62	-	-	3	-	5	-	11	8	-	7.6

Table 4. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Average
<i>Diaphanosoma</i>	8	6	-	-	-	-	-	-	-	-	21	-	102	10.5
<i>Ceriodaphnia</i>	-	-	1	-	-	-	-	-	-	-	-	-	-	0.1
<i>Daphnia</i>	-	-	-	-	-	-	2	1	23	2	-	-	-	2.2
<i>Simocephalus</i>	-	-	-	-	-	-	-	-	-	-	1	-	-	0.1
<i>Bosmina</i>	-	2	-	-	2	4	3	2	45	6	-	-	-	4.9
<i>Ilyocryptus</i>	-	-	-	8	-	-	-	-	-	-	1	-	-	0.7
<i>Macrothrix</i>	19	7	3	87	-	-	2	-	-	-	7	-	-	9.6
<i>Alona</i>	-	-	-	-	1	-	-	-	-	-	-	-	-	0.7
<i>Alonella</i>	6	-	6	318	4	-	11	-	-	-	16	-	-	27.8
<i>Chydorus</i>	-	-	4	2	1	2	26	-	91	54	-	-	-	13.8
<i>Leydigia</i>	-	-	-	6	-	-	-	-	-	5	-	-	-	0.8
<i>Pleuroxus</i>	2	7	39	56	-	-	2	-	-	-	47	-	18	13.2
<i>Ostracoda</i>	-	-	-	21	-	-	2	-	-	2	67	-	-	7.1
<i>Calanoida</i>	-	-	-	-	-	-	2	1	-	-	-	-	-	0.2
<i>Cyclopoida</i>	63	53	220	270	2	-	6	3	432	18	42	20	2777	300.5
nauplii	21	29	40	339	19	2	41	49	705	116	88	30	3453	379.4
<i>Parasitengona</i>	-	-	-	-	-	-	-	-	-	-	4	-	-	0.3
<i>Sminthurides</i>	-	-	-	-	-	-	-	-	-	2	-	-	-	0.2

Table 4. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Average
<i>Caenis</i>	-	-	-	-	-	-	-	-	-	-	16	-	-	1.2
<i>Isonychia</i>	15	-	-	-	-	-	-	-	-	-	4	-	-	1.5
Corixidae	-	-	1	-	-	-	-	-	-	-	-	-	-	0.1
Ceratopogonidae	-	-	-	-	-	-	2	-	-	-	1	-	-	0.2
Chironomidae	11	5	16	9	2	-	5	-	5	6	16	9	6	6.9
<i>Chaoborus</i>	5	2	-	-	-	-	-	-	-	-	4	-	5	1.2
<i>Simulium</i>	-	-	-	-	-	-	-	-	-	-	3	-	-	0.2
TOTAL	177	659	376	1409	41	10	148	78	15629	538	541	137*	9079	2217.1

Station 10

<i>Bdelloidea</i>	-	-	-	-	ns	-	-	-	-	2	3	-	-	1.4
<i>Filinia</i>	-	-	-	-	ns	50	6	5	115	-	6620	5700	156	1054.3
<i>Testudinella</i>	-	14	6	12	ns	-	-	-	35	-	7	20	-	7.8
<i>Cephalodella</i>	-	-	99	24	ns	-	-	-	575	11	-	-	-	59.1
<i>Polyarthra</i>	-	-	-	-	ns	-	-	-	-	-	-	-	5	0.4
<i>Asplanchna</i>	12	32	498	156	ns	3030	5	1	265	2	47	60	6	342.8
<i>Brachionus</i>	9	73	-	45	ns	40	-	1	3635	8	170	950	129	422.5
<i>Keratella</i>	-	-	-	-	ns	10	-	-	25	-	-	-	24	4.9

Table 4. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Average
<i>Platyias</i>	-	-	-	-	ns	30	-	-	10	-	-	-	-	3.3
non-loricata rotifer	-	-	-	-	ns	13340	-	-	-	-	-	-	-	1111.7
Nematoda	-	-	-	-	ns	-	-	-	5	-	-	-	-	0.4
Naididae	-	2	-	9	ns	-	-	-	-	-	-	10	-	1.8
<i>Diaphanosoma</i>	3	54	-	2	ns	-	-	-	-	14	70	-	-	11.9
<i>Ceriodaphnia</i>	-	-	12	8	ns	270	-	-	-	1	-	-	-	24.3
<i>Daphnia</i>	-	7	-	-	ns	60	2	2	55	-	1	-	-	10.6
<i>Bosmina</i>	-	23	-	-	ns	14910	47	1	105	8	58	-	5	1263.1
<i>Ilyocypris</i>	-	2	-	-	ns	-	-	-	-	-	-	20	2	2.0
<i>Macrothrix</i>	6	49	-	14	ns	-	-	-	-	-	1	-	-	5.8
<i>Alona</i>	-	-	-	-	ns	50	-	-	-	-	-	-	-	4.2
<i>Alonella</i>	-	11	17	102	ns	600	-	-	-	-	6	20	-	63.0
<i>Chydorus</i>	-	14	257	717	ns	11910	30	6	45	8	10	270	12	1106.6
<i>Leydigia</i>	-	-	-	24	ns	40	-	-	-	-	-	-	-	5.3
<i>Pleurocus</i>	-	63	26	-	ns	80	-	-	5	-	3	30	9	18.0
Ostracoda	-	14	47	44	ns	-	-	-	-	-	10	10	9	11.2

Table 4. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Average
<i>Calanoida</i>	-	77	-	-	ns	-	6	-	-	2	-	-	12	8.1
<i>Lernaea</i>	-	-	-	-	ns	-	-	-	-	1	-	-	-	0.1
<i>Cyclopoida</i>	19	989	270	420	ns	810	26	10	290	11	112	510	246	309.4
nauplii	5	1101	263	680	ns	1080	56	54	520	60	162	360	417	396.5
<i>Harpacticoida</i>	-	-	-	-	ns	-	-	1	-	-	-	-	-	0.1
<i>Parasitengona</i>	-	-	4	-	ns	-	-	-	-	-	-	20	2	2.2
<i>Podura</i>	-	-	-	-	ns	-	-	-	-	-	-	20	-	1.7
<i>Caenis</i>	-	2	-	-	ns	-	-	-	-	-	-	-	-	0.2
<i>Stenonema</i>	2	7	-	-	ns	-	-	-	-	-	-	-	-	0.8
<i>Isonychia</i>	1	-	-	-	ns	-	-	-	-	-	-	-	-	0.1
<i>Corixidae</i>	-	1	-	-	ns	-	-	-	-	-	-	-	-	0.1
<i>Hydropsychidae</i>	3	-	-	-	ns	-	-	-	-	-	-	-	-	0.3
<i>Chironomidae</i>	-	23	-	-	ns	-	-	1	5	-	8	30	3	5.8
<i>Chaoborus</i>	-	-	-	-	ns	-	-	-	-	-	3	-	-	0.3
<i>Simulium</i>	-	-	-	-	ns	-	-	-	5	-	-	-	-	0.4
TOTAL	50	2558	1499	2269	ns	46310 ^{**}	178	82	5700 ^{***}	118	7236	8100 ^{**}	1037	6261.3

Table 4. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Average
Station 11														
<i>cercaria</i>	-	-	-	-	-	-	-	-	-	-	1	-	-	0.1
<i>Bdelloidea</i>	-	-	-	-	-	-	-	-	180	-	-	2	2	14.2
<i>Filinia</i>	5	-	-	-	291	-	14	232	250	15	4	-	39	65.4
<i>Testudinella</i>	33	2	11	-	-	-	-	-	50	-	6	6	9	9.0
<i>Cephalodella</i>	84	-	4	-	-	-	-	-	1270	-	-	-	-	104.5
<i>Asplanchna</i>	3	-	30	6	148	13	3	104	350	15	-	34	12	55.2
<i>Brachionus</i>	198	22	28	2	32	-	-	39	3180	30	52	44	21	280.6
<i>Keratella</i>	-	-	-	-	-	-	2	2	160	2	-	-	2	12.9
<i>Platyias</i>	-	-	-	-	-	1	-	-	40	2	-	-	-	3.3
loricate rotifer	-	-	-	-	14	-	-	-	-	-	-	-	-	1.1
<i>Nematoda</i>	9	2	-	3	-	-	-	4	80	-	-	-	-	7.5
<i>Naididae</i>	6	4	2	5	-	-	-	5	100	-	-	2	-	9.5
<i>Stylaria</i>	-	-	-	-	-	-	-	-	-	-	-	1	-	0.1
<i>Diaphanosoma</i>	57	4	-	2	-	-	-	-	-	-	-	-	2	5.0
<i>Ceriodaphnia</i>	3	-	6	5	1	-	2	-	40	-	-	1	-	4.5
<i>Daphnia</i>	-	1	-	-	1	-	11	9	80	-	-	-	-	7.9

Table 4. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Average
<i>Scapholeberis</i>	-	1	-	2	-	-	-	-	10	-	-	-	-	1.0
<i>Simocephalus</i>	-	-	-	-	-	9	-	-	-	1	-	-	-	0.8
<i>Bosmina</i>	-	9	-	-	41	6077	31	26	330	18	8	-	-	503.1
<i>Ilyocryptus</i>	-	1	-	-	-	-	-	-	-	-	1	-	-	0.2
<i>Macrothrix</i>	59	9	-	21	-	-	-	-	-	-	7	-	5	7.8
<i>Alonella</i>	38	4	35	114	9	62	-	1	-	3	1	-	-	20.5
<i>Chydorus</i>	-	-	70	33	7	2917	3	30	170	5	1	8	-	249.5
<i>Leydigia</i>	-	-	-	-	-	22	-	-	-	-	-	-	-	1.7
<i>Pleuroxus</i>	6	6	120	5	5	-	-	-	-	-	-	-	2	11.1
<i>Ostracoda</i>	8	-	31	6	-	-	-	-	-	-	10	6	5	5.1
<i>Calanoida</i>	6	-	-	-	-	-	5	1	20	-	-	-	-	2.5
<i>Cyclopoida</i>	101	15	78	31	18	117	6	100	790	48	50	28	18	107.7
nauplii	87	18	158	60	97	133	33	616	2130	228	62	22	87	287.0
<i>Parasitengona</i>	2	1	-	-	-	-	2	-	-	-	-	3	-	0.6
<i>Podura</i>	-	-	-	-	-	2	2	-	-	-	-	-	-	0.3
<i>Caenis</i>	2	-	-	-	-	-	-	-	-	-	-	2	-	0.3
<i>Stenonema</i>	-	-	1	-	-	-	-	-	-	-	-	-	-	0.1

Table 4. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Average
<i>Isonychia</i>	3	-	-	-	-	-	-	-	-	-	-	-	-	0.2
Chironomidae	5	4	5	18	1	6	-	2	80	5	38	12	9	17.2
<i>Chaoborus</i>	-	-	-	-	-	-	-	-	-	-	-	1	-	0.1
<i>Simulium</i>	-	-	-	-	-	-	-	-	10	2	-	1	-	1.0
Tardigrada	-	-	-	-	-	-	-	-	10	-	-	-	-	0.9
TOTAL	715	103	579	313	665	9359	114	1171	9330	373	242	173	216	1796.3

Note. ns = no sample taken. To convert values to number/liter, divide them by 113.56.

*Inaccurate sample due to algal bloom

**1/10 subsample

***1/5 subsample

19 taxa (Table 5). The semi-lentic conditions caused significant increases in the numbers of bdelloid rotifers, the rotifer *Trichotrea*, and planktonic chironomid larvae, and also brought about one of the few times when adult cyclopoid copepods significantly outnumbered their nauplii larvae (1430 to 744). All evidence of the dam had vanished by December 20, 1975.

Another unique environmental condition occurred at Station 10 in January 1976 during a period of prolonged ice cover. The 30 gal of filtered water yielded 46,310 organisms (see pg. 43-45) or 27% of the total fauna from better than 2,000 gal. However, this pulse was composed primarily (87%) of three taxa: an unidentified non-loricate rotifer and the cladocerans *Bosmina* and *Chydorus*. No certain explanation exists for this pulse, but it could have been the result of the stimulation of algal growth by enrichment from agricultural wastes and/or chemicals. Even though approximately 5 in of ice were covered with 4 in of snow, primary production was still quite high as evidenced by the presence of a large number of algal genera (Table 5) and their abundances (Appendix 1).

Finally, on July 15 at Station 8, an inverted pulse or trough (Table 4) accompanied a phenomenal concentration of a planktonic blue-green alga (*Oscillatoria*) (Appendix 1). The algae were so dense that only 15 gal

Table 5.--Number of taxa collected from the Salt River, Missouri

	Station 3		Station 4		Station 5		Station 8		Station 10		Station 11	
	A	Z	A	B	A	B	A	B	A	B	A	B
Aug. 75	4	6	4	5	3	9	1	13	3	8	6	11
Sep. 75	4	9	0	16	2	10	2	11	8	20	3	15
Oct. 75	6	9	6	16	4	14	4	14	5	11	4	16
Nov. 75	3	16	6	11	9	19	5	16	4	15	5	8
Dec. 75	4	10	5	15	2	8	2	10	*	*	2	10
Jan. 76	6	13	10	11	4	11	4	4	15	16	7	*
Feb. 76	1	10	13	12	4	12	4	17	9	8	1	*
Mar. 76	3	10	4	11	2	12	1	8	1	10	3	4
Apr. 76	7	18	7	12	7	19	3	12	7	17	5	*
May 76	9	12	10	10	2	17	5	17	11	9	1	10
June 76	10	16	5	7	11	19	6	21	10	18	2	22
July 76	9	22	9	12	12	18	5	6	9	16	4	14
Aug. 76	6	21	5	14	3	24	4	11	8	15	3	13

Note. A = algae, Z = zooplankton, B = benthos.

*Indicates no sample taken.

(56.8 l) of river water could be filtered before the net was clogged. A regular 1/10 subsample was attempted, but failed due to the obscuring algae. A subsample was then rinsed in acetone in an attempt to clear the algae, but this subsample also proved practically uncountable. Since many blue-green algae are known to produce metabolites (Prescott, 1948), the severe reduction in numbers of algal and zooplankton taxa could have been a result of the toxicity from the metabolites produced by this species of *Oscillatoria*. The singular occurrence of this alga in such an extreme density leads one to suspect transient organic enrichment. However, the Missouri Department of Conservation received no complaints nor issued any warnings for excessive pollution on the Elk Fork in either June or July (Duchrow, R., 1977, Pers. Com.). A possible source could have been runoff from a feedlot operation (the station often has an atmosphere strongly reminiscent of swine), but data from the National Weather Service (in Moberly) indicate that the heaviest rain in the preceding two weeks was 0.21 in. This rain could not have been sufficient to produce runoff when balanced against the then prevailing drought conditions.

Several distinct trends in seasonal zooplankton abundance are evident. Throughout the 13 month sampling period, the total monthly numbers of adult cyclopid copepods and nauplii larvae are almost always closely

similar (Figure 4). Even though they come from a lotic environment, their abundances still follow the general statement of Welch (1952) as to spring and fall maxima and summer and winter minima.

Another distinct trend exists among the rotifers: *Asplanchna* versus the other small loricate rotifers (especially *Brachionus*). Since *Asplanchna* is a predator on the other rotifers (Gilbert & Waage, 1967), a classic predator-prey relationship can be shown (Figure 5). The abundances fluctuated until January 1976 when *Asplanchna* reached a dominant position and the other three genera were reduced to a subsistence level. In April, *Brachionus* and *Cephalodella* responded to the absence of *Asplanchna* in their environment with their own massive pulse. By May, all three genera were reduced to low levels, which enabled the other small loricate rotifer (*Filinia longiseta*) to successfully begin its own pulse, probably due to unutilized nutrients and a lack of predation. In short, when *Asplanchna* was present in sufficient numbers (usually greater than 10 per l), the other rotifers suffered a reduction in actual numbers. Although the relative abundances were not determined, the general predation response variations of *Brachionus* were all present (Gilbert & Waage, 1967).

The seasonal abundances of the major cladocerans (*Alonella*, *Bosmina*, and *Chydorus*) (Figure 6) seem to

Figure 4.--Copepod densities

----- = Cyclopoida

———— = nauplii

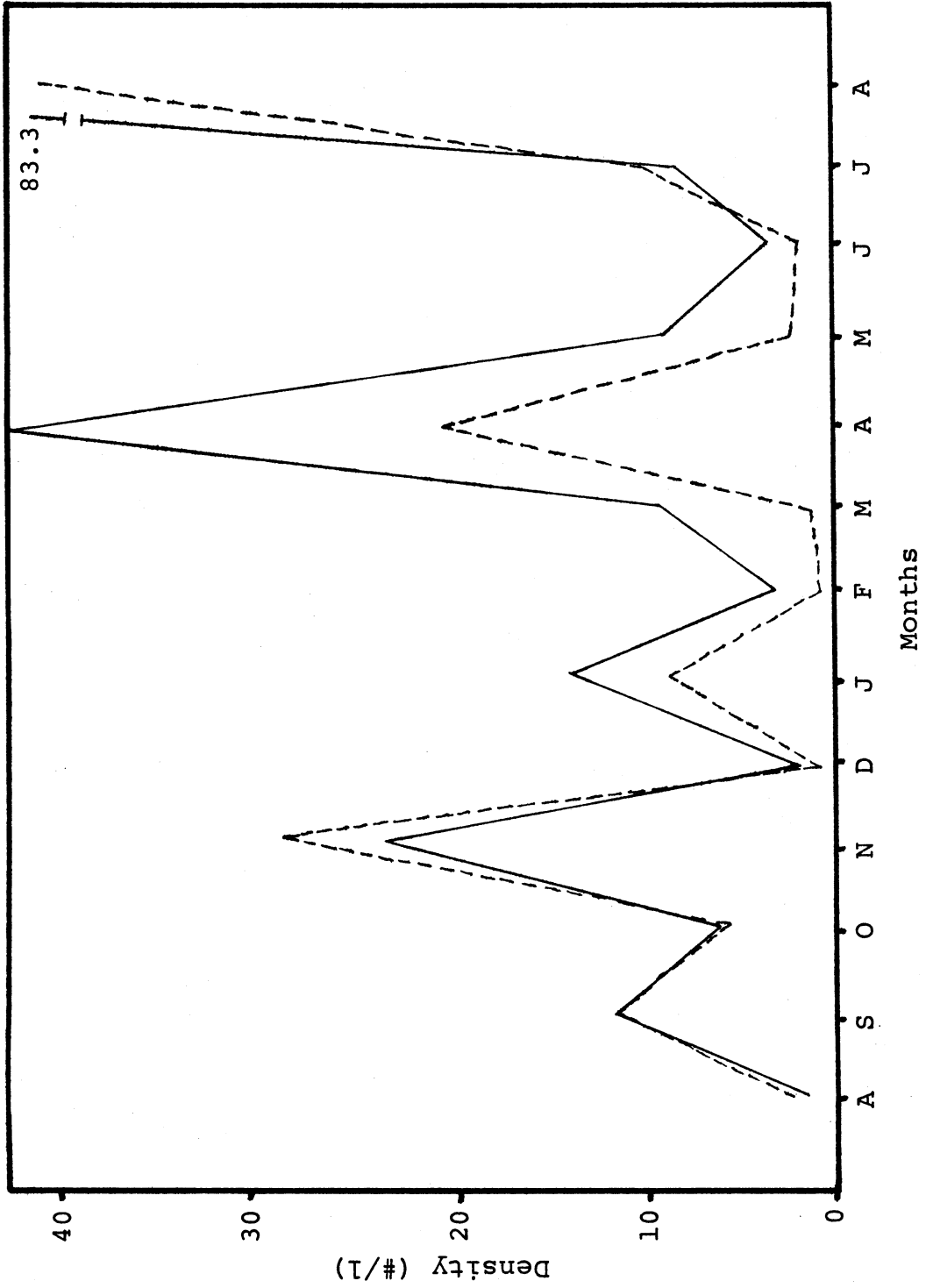


Figure 5.--Major rotifer densities

———— = *Asplanchna*
..... = *Brachionus*
----- = *Cephalodella*
++++++ = *Filinia*

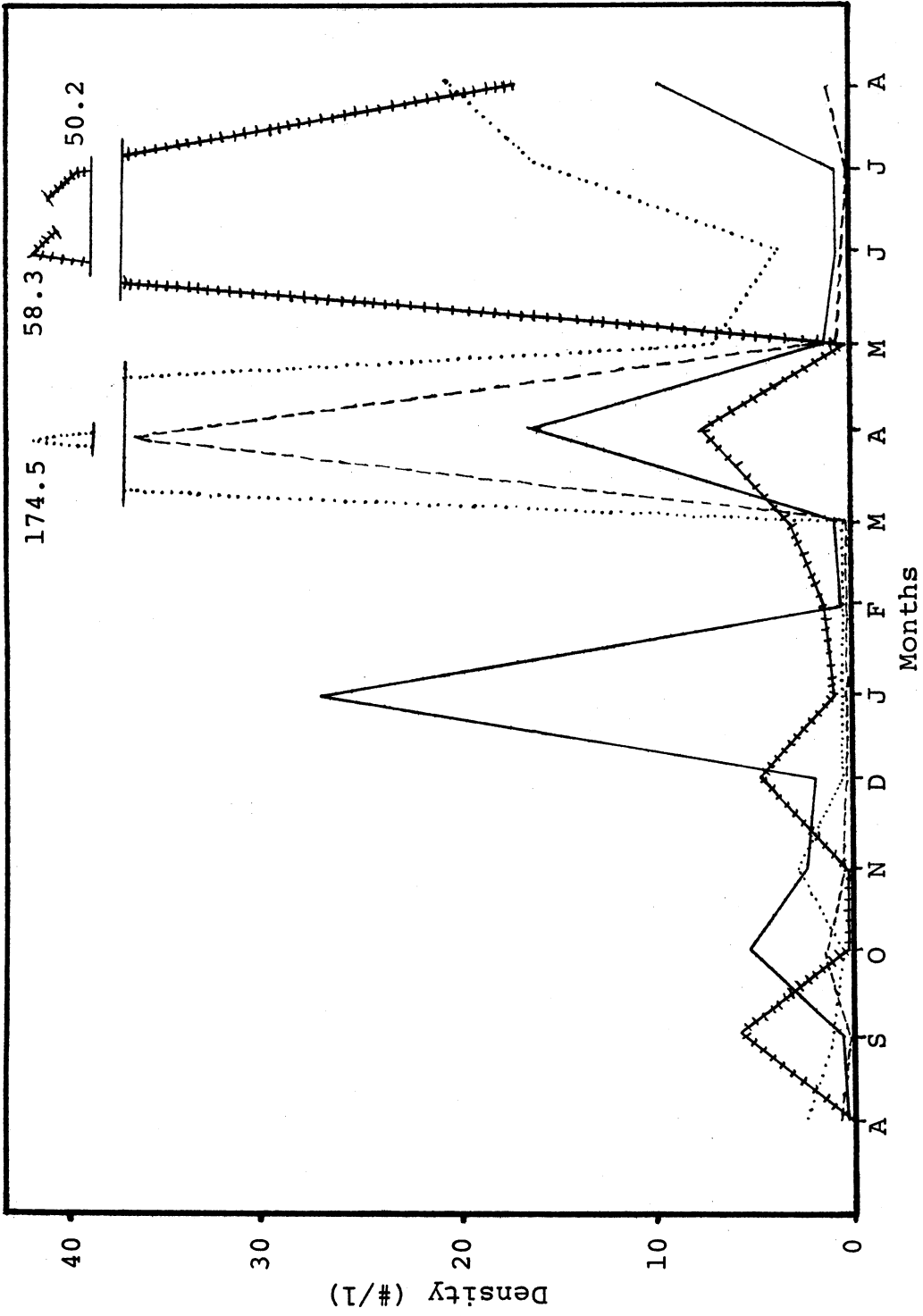
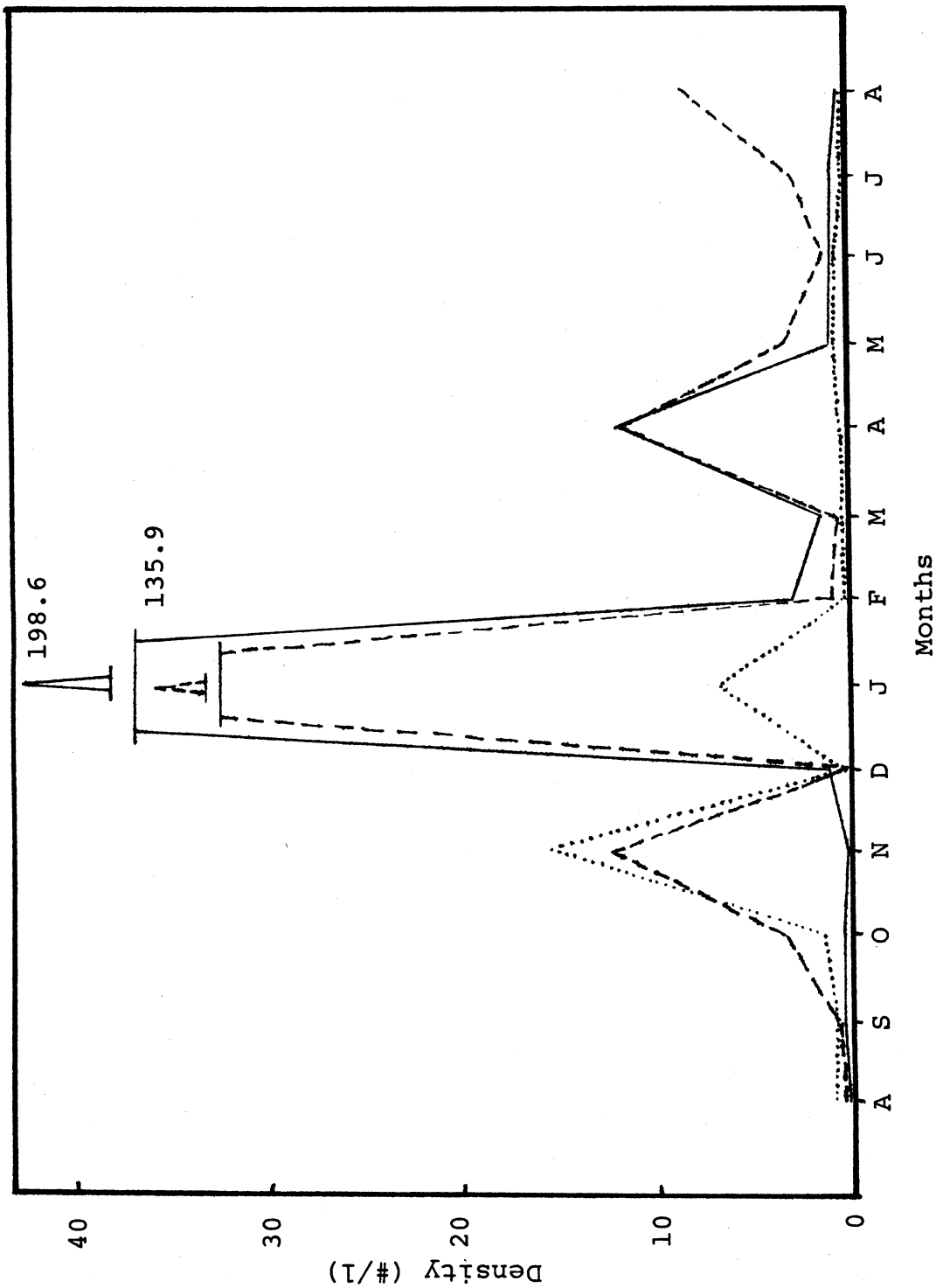


Figure 6.--Major cladoceran densities

———— = *Bosmina*

----- = *Chydorus*

..... = *Alonella*



roughly correspond to the rotifer abundances (Figure 5). This similarity could be caused in part by an increase in food potential, since rotifers and cladocerans consume the same type of food (Allan, 1976). The rotifers seem to be able to produce more plankton pulses than do cladocerans, probably because of the rotifers' higher reproductive potential and more efficient food gathering mechanism (Allan, 1976).

Abundances found in this study are comparable with those from other studies. Berner (1951) in his study on the lower Missouri River, found an average of 23.59 zooplankters per liter, which were 45.7% nematodes, 0.0% rotifers, 0.5% cladocerans, 2.9% copepods, and 19.2% nauplii. The current study yielded an average of 19.93 zooplankters per liter, which were 0.08% nematodes, 42.6% rotifers, 31.8% cladocerans, 9.1% copepods, and 14.2% nauplii.

Bothar (1975) found 16 cladocerans and 10 copepods in the Danube River which were dominated by *Bosmina longirostris*, *Moina micrura*, and *Acanthocyclops vernalis*. The maximum recorded population density was 10,250 specimens per m³. The Salt River study yielded 13 cladocerans and only four taxa of copepods, which were dominated by *Bosmina longirostris* and *Chydorus* sp. *B. longirostris* showed the highest population density with 407,804 per m³ in January 1976 at Station 10.

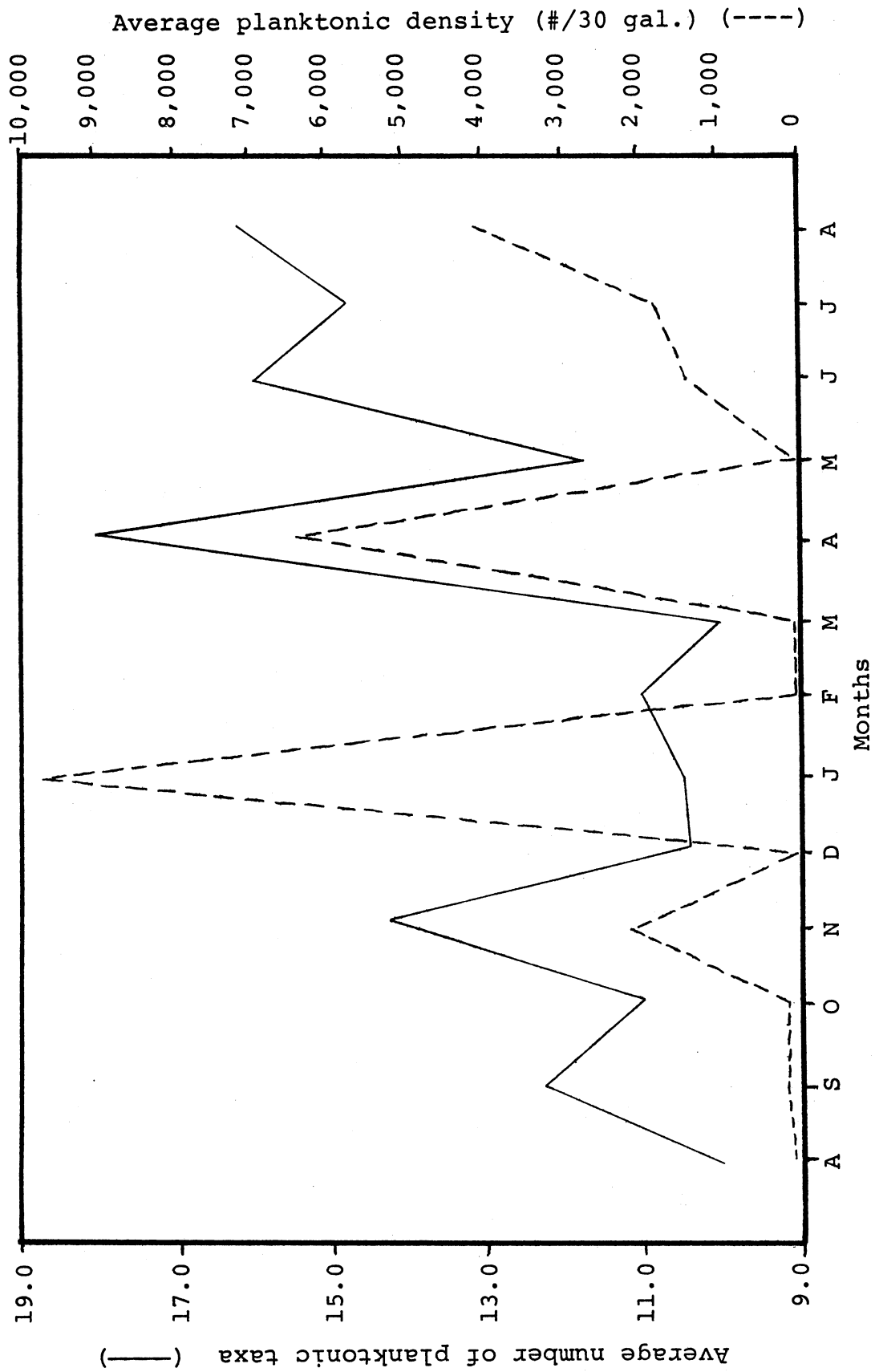
The densities in a lotic environment, however, are insignificant when compared with a lentic environment. Beach (1960) found 24 genera and 34 species of rotifers in the Ocqueoc river and lake system. The maximum pulse was approximately 12,000 rotifers per liter. The Salt River yielded 13 taxa of rotifers with a maximum pulse of approximately 145 rotifers per liter.

The monthly average densities and number of taxa collected (Figure 7) show a general correlation except for the pulse in January (especially at Station 10). The highest average monthly density was in January with 9,774 per 30 gal (86.07 per liter) and the low was in August 1975 with 194 per 30 gal (1.71 per liter).

The predominant alga genera of the river identified in this study include *Spirogyra*, *Closterium*, *Fragilaria*, *Synedra*, *Rhoicosphenia*, and *Cymbella* as plankton, and *Cladophora* and *Mougoetia* as periphyton. *Volvox*, *Ulothrix*, *Microspora*, *Tribonema*, *Navicula*, and *Oscillatoria* are present to a lesser degree. A complete listing of the genera found during the present study is contained in Appendix 1.

One thing that must be remembered when dealing with lotic plankton studies is that the collector generally is not sampling an ever-changing population, but in fact is sampling entirely different populations at each sample time. With any periodic sampling schedule, especially monthly, the flow of the Salt River has moved the previous

Figure 7.--Zooplankton population trends



plankton population well downstream and into the Mississippi River.

Benthos

In the thirteen months studied, 8,758 benthic macro-invertebrates from 110 taxa were identified from 193 ft² (17.9 m²) of river bottom sampled. A listing of the seasonal abundances of these animals can be found in Table 6 with a complete taxonomic summary in Appendix 2.

Many limitations exist for the analysis of data from this study.

Since the substrate was worked only to approximately 7 cm deep, probably less than 50% of the actual populations were sampled (Coleman & Hynes, 1970). The hyporheic benthos escaped sampling for the most part (Figure 3).

The mesh of the sampler net (9 mesh/cm) also caused some inaccuracies since small chironomids, hydropsychids, and oligochaetes were able to pass through the net. This loss undoubtedly caused an underestimate of the densities of these groups (Maitland, 1962).

Although few samples were taken in water more than 30.5 cm deep, those samples that were, probably resulted in underestimates of population densities due to current backwash of the net (Chutter, 1972).

One of the most serious limitations occurred as a result of attempting to take a sample during periods of no flow. The method used, was to place the Surber down over

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Glossiphoniidae	-	-	-	-	-	-	-	-	4	-	-	-	-
<i>Ferrissia</i>	75	29	40	11	14	47	11	7	4	-	14	22	-
<i>Gundlachia</i>	-	-	-	-	-	-	-	-	11	-	-	-	-
<i>Physa</i>	50	40	14	22	p	36	11	7	-	7	4	-	29
<i>Helisoma</i>	-	-	-	-	-	-	-	-	-	-	-	-	7
<i>Musculium</i>	54	14	7	54	-	4	-	11	14	-	11	-	-
<i>Sphaerium</i>	-	-	29	-	-	-	-	4	4	7	p	-	-
<i>Gammarus</i>	22	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cambarus</i>	-	-	-	-	4	-	-	-	-	-	-	-	-
<i>Orconectes rusticus</i>	-	-	-	p	-	-	-	-	p	-	p	p	p
<i>O. virilis</i>	p	p	-	p	-	-	-	-	p	-	-	-	p
<i>Baetis</i>	-	-	-	-	-	-	-	4	-	-	-	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Caenis</i>	18	104	11	22	25	14	158	72	86	75	40	47	61
<i>Stenonema</i>	11	65	11	65	40	25	32	57	29	32	32	14	18
<i>Ameletus</i>	-	-	-	-	-	-	-	-	4	-	-	4	-
<i>Isonychia</i>	-	-	-	-	11	-	-	22	-	11	-	-	-
<i>Tricorythodes</i>	-	-	-	-	7	-	-	-	-	-	-	-	-
<i>Argia</i>	18	4	7	-	-	-	-	-	4	-	-	-	-
<i>Enallagma</i>	-	-	-	-	-	-	-	-	4	-	-	-	-
<i>Plathemis</i>	-	-	4	-	-	-	-	-	-	-	-	-	-
<i>Perlesta</i>	-	-	-	-	-	-	-	-	11	7	-	-	-
<i>Sigara</i>	86	-	-	22	-	-	7	-	-	-	-	-	-
<i>Gerris</i>	p	-	-	-	-	-	-	-	p	p	p	p	p

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Trepobates</i>	-	7	-	-	-	-	-	-	-	-	-	-	-
<i>Merragata</i>	-	-	4	-	-	-	-	18	-	-	-	-	-
<i>Microvelia</i>	-	-	-	7	-	-	-	-	-	-	-	-	-
<i>Rhagovelia</i>	-	-	-	-	-	-	-	-	-	-	-	-	7
<i>Helichus</i>	61	22	36	P	-	-	-	4	-	7	11	-	-
<i>Dubiraphia</i>	-	-	-	-	-	-	-	-	-	-	4	4	-
<i>Stenelmis</i>	11	-	-	7	7	-	-	7	4	-	-	-	-
<i>S. larvae</i>	-	-	-	-	-	7	-	4	14	11	-	-	-
<i>Haliplus</i>	-	-	-	-	-	-	-	-	-	-	-	-	7
<i>Peltodytes</i>	18	-	-	-	-	-	-	-	-	-	-	-	-
<i>Enochrus</i>	7	-	-	-	-	-	-	-	-	-	-	7	-
<i>Tropisternus</i>	11	-	18	-	-	4	-	-	-	-	-	4	-
<i>T. ellipticus</i>	-	-	-	-	-	-	-	-	-	-	-	-	P
<i>T. mexicanus</i>	-	-	-	-	-	-	-	-	-	-	-	-	P

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Cheumatopsyche</i>	-	4	14	-	140	57	-	18	11	29	-	-	7
<i>Hydroptila</i>	-	-	-	-	-	-	-	-	-	-	-	14	-
<i>Chimarra</i>	-	-	18	-	11	-	-	-	-	-	-	-	-
<i>Psychomyia</i>	22	-	-	-	-	7	-	-	4	7	-	-	-
Chironomidae	86	83	14	50	65	32	276	61	136	93	50	50	15
<i>Simulium</i>	-	-	7	-	176	18	-	104	50	258	-	-	-
<i>Stratiomyia</i>	22	4	-	-	-	-	-	-	-	-	-	-	-
<i>Chrysops</i>	-	-	4	-	-	-	-	4	-	-	-	-	-
<i>Tipula</i>	-	-	4	-	-	4	-	-	-	-	-	-	-
TOTAL	602	771	258	307	502	255	635	438	431	599	187	176	283

Station 4

<i>Urnatella</i>	-	-	p	-	-	-	-	-	-	-	-	-	-
<i>Plumatella</i>	p	p	p	-	p	-	-	-	p	p	p	p	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Tricladida</i>	-	-	p	-	-	-	-	-	-	-	-	-	-
<i>Branchiobdellidae</i>	-	-	4	-	-	-	-	-	-	-	-	-	-
<i>Lumbriculidae</i>	-	-	-	-	-	-	-	4	-	-	-	-	-
<i>Enchytraeidae</i>	-	7	14	-	32	-	-	14	-	32	14	29	22
<i>Naididae</i>	-	-	-	-	7	-	-	-	-	18	-	-	-
<i>Chaetogaster</i>	-	-	-	-	-	-	-	-	-	-	-	-	11
<i>Stylaria</i>	-	-	-	-	-	-	-	-	4	43	-	-	7
<i>Ferrissia</i>	-	-	40	-	-	-	-	-	-	-	-	-	-
<i>Gundlachia</i>	-	-	-	-	-	-	-	-	-	-	-	-	7
<i>Lymnaea</i>	-	-	-	-	-	-	7	4	14	-	-	-	-
<i>Physa</i>	7	-	14	-	68	50	65	11	-	-	4	7	29
<i>Helisoma</i>	-	-	4	-	-	-	-	-	-	-	-	-	-
<i>Musculium</i>	-	-	7	-	22	-	-	-	-	-	-	-	-
<i>Sphaerium</i>	-	-	29	-	-	-	-	-	-	-	-	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Ceriodaphnia</i>	-	-	4	-	-	-	-	-	-	-	-	-	-
<i>Gammarus</i>	-	25	-	118	18	-	7	-	4	p	-	p	-
<i>Oreonectes virilis</i>	-	p	-	-	-	-	p	-	p	-	-	-	-
<i>Caenis</i>	-	50	14	-	176	190	255	97	75	61	97	165	72
<i>Stenonema</i>	7	29	36	18	72	86	104	32	7	43	11	25	-
<i>Ameletus</i>	-	4	-	-	-	14	-	-	-	-	-	-	-
<i>Isonychia</i>	-	-	-	-	25	14	-	-	-	-	-	-	-
<i>Argia</i>	-	25	29	22	-	-	-	-	-	7	-	-	7
<i>Enallagma</i>	-	-	-	22	-	-	-	-	4	22	p	p	7
<i>Libellula</i>	-	-	4	-	-	-	-	-	-	-	-	-	-
Capniidae	-	-	-	-	4	14	11	-	-	-	-	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Belostoma</i>	-	-	4	-	-	-	7	-	-	-	-	-	-
<i>Sigara</i>	-	-	-	-	-	-	-	-	-	-	-	-	p
<i>Gelastocoris</i>	-	4	-	-	-	-	-	-	-	-	-	-	p
<i>Gerris</i>	p	p	-	-	-	-	-	-	p	-	-	p	p
<i>Trepobates</i>	-	11	-	-	-	-	-	-	-	-	-	-	p
<i>Mesovelgia</i>	-	-	-	-	-	-	-	-	-	-	-	4	-
<i>Ranatra</i>	-	4	-	-	-	-	-	-	-	-	-	-	-
<i>Microvelia</i>	-	-	-	7	-	-	-	-	-	-	-	-	-
<i>Rhagovelia</i>	-	-	18	-	-	-	-	-	-	-	-	-	-
<i>Helichus</i>	-	-	36	7	4	4	-	7	14	-	-	-	-
<i>Stenelmis</i>	-	-	-	-	-	-	-	7	-	-	-	-	-
<i>Helophorus</i>	-	-	-	-	-	-	-	-	-	-	-	4	-
<i>Tropisternus</i>	-	-	18	-	-	-	-	-	-	-	-	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
	p	p	p	p	p	p	p	p	p	p	p	p	p
<i>Plumatella</i>	-	-	-	-	-	-	-	-	-	-	-	-	-
Tricladida	-	-	22	-	-	-	-	-	-	-	-	-	-
Nematomorpha	-	-	-	-	-	-	-	4	-	-	-	-	-
Branchiobdellidae	-	-	4	-	-	4	-	-	-	-	-	-	18
Lumbriculidae	-	-	-	-	-	-	-	4	-	-	-	-	-
Enchytraeidae	-	-	-	40	-	4	-	4	-	-	4	4	-
<i>Stylaria</i>	-	-	-	-	-	-	-	-	-	-	-	-	93
<i>Ferrissia</i>	18	29	61	7	-	-	7	-	-	11	18	40	43
<i>Gundlachia</i>	-	-	-	-	-	-	18	-	-	-	-	-	-
<i>Physa</i>	11	14	4	-	-	4	11	-	4	-	-	-	40
<i>Musculium</i>	18	22	-	22	-	7	7	-	-	-	4	36	18
<i>Anodonta</i>	-	-	-	-	4	-	-	-	-	-	-	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Ceriodaphnia</i>	-	-	-	-	-	-	-	-	-	-	4	-	-
<i>Gammarus</i>	-	-	-	-	-	-	-	-	4	p	-	p	7
<i>Asellus</i>	-	-	-	-	-	-	-	11	-	-	-	-	-
<i>Orconectes rusticus</i>	-	-	p	p	-	-	-	-	p	p	-	p	p
<i>O. virilis</i>	p	p	p	-	-	-	-	-	-	p	-	p	p
<i>Baetis</i>	-	-	-	-	-	-	-	-	-	7	-	-	-
<i>Caenis</i>	-	68	11	-	-	50	93	40	72	40	72	36	22
<i>Stenonema</i>	11	40	50	22	133	61	32	43	50	7	29	22	50
<i>Ameletus</i>	22	-	-	-	-	-	-	-	7	-	-	-	-
<i>Isonychia</i>	18	11	18	7	11	40	-	-	4	22	-	4	-
<i>Tricorythodes</i>	-	-	-	-	-	-	-	7	7	7	-	18	7
<i>Argia</i>	18	36	11	-	-	-	-	-	-	-	-	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Enallagma</i>	-	-	-	-	-	-	-	-	-	-	-	-	7
<i>Ischnura</i>	-	-	-	-	-	-	-	-	-	-	-	11	-
<i>Celithemis</i>	-	-	-	-	-	-	-	-	-	-	-	-	22
<i>Sigara</i>	194	-	22	-	-	-	-	-	-	p	-	p	-
<i>Gelastocoris</i>	-	-	-	-	-	-	-	-	-	-	-	-	p
<i>Gerris</i>	p	p	-	-	-	-	-	-	p	p	p	p	p
<i>Trepobates</i>	-	-	4	-	-	-	-	-	-	-	-	-	p
<i>Merragata</i>	7	-	-	-	-	-	-	-	-	-	-	-	-
<i>Neohaemonia</i>	-	-	-	-	-	-	-	-	-	-	-	4	-
<i>Helichus</i>	11	7	4	7	-	-	-	-	11	p	-	-	-
<i>Stenelmis</i>	43	4	-	7	4	-	-	7	7	18	-	22	32
<i>S. larvae</i>	-	-	-	-	-	57	18	14	40	18	18	25	-
<i>Dineutus</i>	-	-	-	p	-	-	-	-	-	p	p	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Gyrinus</i>	-	-	4	-	-	-	-	-	-	-	-	-	P
<i>Peltodytes</i>	-	-	-	-	-	-	-	-	-	-	-	-	18
<i>Prionocyphon</i>	-	-	-	-	-	-	-	-	-	-	-	7	-
<i>Berosus</i>	-	4	-	-	-	-	-	-	-	-	-	-	-
<i>Helocombus</i>	-	-	-	-	-	-	-	-	-	-	-	4	-
<i>Tropisternus</i>	32	-	-	-	-	-	-	-	-	-	-	-	-
<i>T. ellipticus</i>	-	-	-	-	-	-	-	-	-	-	-	-	P
<i>T. mexicanus</i>	-	-	-	-	-	-	-	-	-	-	-	-	P
<i>Cheumatopsyche</i>	-	-	72	86	40	72	29	47	32	11	36	79	22
<i>Hydropsyche</i>	255	25	-	-	-	-	-	-	7	7	-	22	-
<i>Hydroptila</i>	-	-	-	-	-	-	-	-	-	-	4	7	-
<i>Neotrichia</i>	7	-	-	-	-	-	-	-	-	-	-	-	-
<i>Athripsodes</i>	-	-	-	-	-	-	-	-	-	-	-	14	-
<i>Chimarra</i>	-	-	-	22	-	14	-	-	-	-	-	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Polycentropus</i>	-	-	-	-	-	-	-	-	4	-	-	-	-
<i>Psychomyia</i>	-	-	-	-	-	-	-	-	-	7	4	11	-
<i>Bezzia/Probezzia</i>	-	-	-	-	-	-	-	-	-	-	-	4	7
Chironomidae	140	36	-	104	32	97	162	72	83	32	104	36	32
<i>Simulium</i>	11	-	11	18	154	22	7	11	29	22	-	-	-
<i>Stratiomyia</i>	-	-	-	-	-	-	-	-	-	-	-	-	p
TOTAL	814	294	294	341	377	431	384	262	359	273	294	395	592

Station 8

<i>Hydra</i>	-	-	-	7	-	-	-	-	-	-	-	-	43
<i>Plumatella</i>	p	p	-	-	p	-	-	p	-	p	p	p	p
Nematomorpha	-	-	-	-	p	-	-	-	-	-	-	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Enchytraeidae</i>	-	-	-	-	47	-	11	14	-	22	-	-	40
<i>Naididae</i>	-	-	-	-	-	-	-	11	-	-	-	-	-
<i>Chaetogaster</i>	-	-	-	-	-	-	-	-	-	-	4	-	-
<i>Stylaria</i>	-	-	-	-	-	-	-	-	-	40	-	-	-
<i>Limnodrilus</i>	-	-	-	-	-	-	-	-	7	-	-	-	-
<i>Tubifex</i>	-	-	-	-	-	-	-	-	-	-	-	4	32
<i>Dina</i>	-	-	-	-	-	-	-	4	-	-	-	-	-
<i>Ferrissia</i>	61	25	75	29	p	4	11	7	7	29	50	-	54
<i>Gundlachia</i>	-	-	-	-	-	-	-	-	-	-	-	61	-
<i>Physa</i>	93	7	22	32	14	29	29	-	-	-	4	22	75
<i>Musculium</i>	22	11	14	32	133	32	40	14	-	11	29	29	54
<i>Sphaerium</i>	-	7	-	-	-	-	-	-	-	7	4	4	43
<i>Simocephalus</i>	-	-	-	-	-	-	7	-	-	-	-	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Orconectes rusticus</i>	P	P	P	P	-	P	-	P	P	P	P	P	P
<i>O. virilis</i>	P	-	-	-	-	-	P	-	-	P	P	P	P
<i>Baetis</i>	-	-	-	-	-	-	-	7	-	18	-	-	22
<i>Caenis</i>	-	25	29	-	97	-	22	68	65	22	22	-	118
<i>Stenonema</i>	43	14	25	61	61	68	7	23	11	7	22	7	86
<i>Isonychia</i>	22	7	22	18	140	40	-	-	4	11	-	4	-
<i>Tricorythodes</i>	7	-	-	-	-	-	-	-	-	-	-	-	-
<i>Calopteryx</i>	-	-	-	7	-	-	-	-	-	-	-	-	-
<i>Argia</i>	7	29	18	11	7	11	-	-	7	-	4	-	18
<i>Enallagma</i>	-	-	-	-	4	-	-	-	-	-	-	-	-
<i>Macromia</i>	-	-	-	-	-	-	-	-	-	-	4	4	75
<i>Perlesta</i>	-	-	-	-	-	-	-	-	4	11	-	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Sigara</i>	32	-	-	7	-	-	-	-	-	-	4	-	-
<i>Gerris</i>	p	p	p	-	-	-	-	-	p	-	p	p	p
<i>Trepobates</i>	11	18	-	-	-	-	-	-	-	-	4	7	p
<i>Merragata</i>	-	-	-	-	-	-	-	-	4	-	-	4	-
<i>Mesovelgia</i>	-	-	-	-	-	-	-	-	-	-	-	-	11
<i>Microvelgia</i>	-	4	-	7	-	-	-	-	-	-	-	-	-
<i>Helichus</i>	11	32	29	61	-	-	-	-	7	-	4	4	p
<i>Laccophilus</i>	7	4	-	-	-	-	-	-	-	-	-	-	-
<i>Stenelmis</i>	18	4	7	-	14	-	-	-	-	18	4	18	-
<i>S. larvae</i>	-	-	-	-	-	4	-	11	7	7	25	7	-
<i>Dineutus</i>	-	-	-	-	-	-	-	-	-	-	p	-	-
<i>Gyrinus</i>	-	-	p	-	-	-	-	-	-	-	-	-	-
<i>Peltodytes</i>	-	-	4	-	-	-	-	-	-	-	-	-	-
<i>Enochrus</i>	-	4	-	-	-	-	-	-	-	-	-	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Tropisternus</i>	-	11	-	-	-	-	-	-	-	-	-	-	-
<i>T. mexicanus</i>	-	-	-	-	-	-	-	-	-	-	-	-	P
<i>Cheumatopsyche</i>	61	22	22	115	251	108	7	22	14	11	61	14	40
<i>Hydropsyche</i>	61	14	-	-	-	-	-	-	-	-	-	22	-
<i>Hydroptila</i>	-	-	-	-	-	-	-	-	-	-	-	11	-
<i>Athripsodes</i>	-	4	-	-	-	-	-	-	-	-	-	4	-
<i>Chimarra</i>	-	7	-	32	40	61	-	-	4	11	-	-	-
<i>Psychomyia</i>	-	-	-	-	-	-	-	-	-	-	-	4	-
Chironomidae	341	154	40	226	148	57	75	133	36	158	75	29	201
<i>Simulium</i>	-	-	11	506	276	104	-	-	-	61	-	-	-
<i>Chrysops</i>	-	-	-	-	-	-	-	4	-	-	-	-	-
<i>Tipula</i>	-	-	-	-	-	4	-	-	-	-	-	-	-
TOTAL	797	402	316	1152	1231	520	208	319	176	441	316	255	836

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Station 10													
<i>Hydra</i>	-	-	-	-	ns	-	-	-	-	-	-	50	-
<i>Pectinatella</i>	-	p	-	-	ns	-	-	-	-	-	-	-	-
<i>Plumatella</i>	p	p	-	-	ns	-	-	-	p	p	p	p	p
<i>Tricladida</i>	-	7	7	-	ns	-	-	-	-	-	-	36	-
<i>Nematomorpha</i>	-	-	-	-	ns	-	-	-	-	p	-	-	-
<i>Lumbriculidae</i>	-	-	-	-	ns	-	-	-	-	11	-	-	-
<i>Enchytraeidae</i>	-	-	-	-	ns	-	-	-	-	50	7	7	50
<i>Naididae</i>	-	-	-	-	ns	-	-	-	-	-	-	-	18
<i>Stylaria</i>	-	-	-	-	ns	-	-	-	-	18	-	-	-
<i>Limnodrilus</i>	-	-	-	-	ns	176	-	61	-	50	-	-	-
<i>Dina</i>	-	-	-	-	ns	-	-	-	4	7	-	-	-
<i>Erpobdella</i>	-	-	-	-	ns	-	-	-	-	-	4	-	18
<i>Batrachobdella</i>	-	-	-	-	ns	-	-	-	-	-	4	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Helobdella</i>	-	-	-	-	ns	-	-	-	-	7	-	-	-
<i>Ferrissia</i>	18	11	22	-	ns	14	18	25	14	-	18	40	11
<i>Gundlachia</i>	-	-	-	-	ns	4	-	4	-	-	-	-	-
<i>Physa</i>	22	65	-	-	ns	22	-	22	-	-	-	136	18
<i>Helisoma</i>	-	-	-	-	ns	-	-	-	-	7	-	4	-
<i>Musculium</i>	50	50	-	-	ns	57	40	97	86	129	18	22	226
<i>Sphaerium</i>	-	22	-	-	ns	-	-	11	-	-	-	-	32
<i>Ceriodaphnia</i>	-	-	-	-	ns	-	7	-	-	-	-	-	-
<i>Gammarus</i>	-	-	-	-	ns	-	-	4	-	-	-	4	-
<i>Orconectes virilis</i>	p	-	-	-	ns	-	-	-	-	p	-	p	p
<i>Caenis</i>	-	50	-	7	ns	61	-	97	111	50	-	50	147
<i>Stenonema</i>	-	29	-	-	ns	29	-	14	7	32	-	-	29

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Isonychia</i>	-	47	-	-	ns	14	-	-	-	-	14	-	-
<i>Argia</i>	-	-	-	7	ns	-	-	-	-	-	-	-	-
<i>Libellula</i>	-	-	-	7	ns	-	-	4	-	-	-	-	-
<i>Plathemis</i>	-	29	-	-	ns	-	-	-	-	-	-	-	-
<i>Perlesta</i>	-	-	-	-	ns	-	-	36	104	-	-	-	-
<i>Sigara</i>	-	-	p	-	ns	-	-	-	4	-	29	-	-
<i>Gerris</i>	p	p	p	-	ns	-	-	-	p	-	p	-	-
<i>Trepobates</i>	11	11	14	-	ns	-	-	-	-	-	-	p	p
<i>Rhagovelia</i>	-	7	-	-	ns	-	-	-	-	-	-	-	-
<i>Helichus</i>	32	47	p	-	ns	-	-	11	7	22	-	4	43
<i>Laccophilus</i>	-	7	-	-	ns	-	-	-	-	-	-	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Dubiraphia</i>	-	-	-	-	ns	-	-	-	-	7	-	-	-
<i>Stenelmis</i>	-	-	p	-	ns	-	-	4	25	40	-	-	32
<i>S. larvae</i>	-	-	-	-	ns	4	-	14	32	11	29	-	22
<i>Dineutus</i>	p	-	-	p	ns	-	-	-	-	-	-	-	-
<i>Peltodytes</i>	7	-	-	p	ns	-	-	-	-	-	-	-	22
<i>Prionocyphon</i>	-	-	-	-	ns	-	-	-	4	-	-	-	-
<i>Enochrus</i>	-	-	-	ll	ns	-	-	-	-	-	-	-	-
<i>Paracymus</i>	7	-	-	-	ns	-	-	-	-	-	-	-	-
<i>Tropisternus</i>	22	14	-	7	ns	-	-	-	-	-	-	-	-
<i>Cheumatopsyche</i>	-	40	-	-	ns	57	-	40	-	-	395	43	11
<i>Hydropsyche</i>	-	-	-	-	ns	-	-	-	-	-	312	-	-
<i>Hydroptila</i>	-	-	-	-	ns	-	-	-	-	-	-	32	-
<i>Neotrichia</i>	-	-	-	-	ns	-	-	-	-	11	-	-	-
<i>Chimarra</i>	-	14	-	-	ns	7	-	-	-	-	-	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Psychomyia</i>	-	-	14	-	ns	-	-	-	-	-	-	-	-
<i>Bezzia/Probezzia</i>	-	-	-	-	ns	-	-	-	4	-	-	-	7
Chironomidae	93	886	29	-	ns	115	40	65	57	147	169	65	43
<i>Atherix</i>	-	-	-	-	ns	-	-	-	-	-	4	-	-
<i>Simulium</i>	-	-	-	-	ns	97	-	-	7	p	144	-	-
<i>Chrysops</i>	-	-	-	-	ns	-	-	11	-	7	-	-	-
TOTAL	262	1335	86	39	ns	657	104	477	402	710	1037	492	728
Station 11													
<i>Urnatella</i>	p	-	p	-	-	ns	ns	-	-	-	p	-	p
<i>Paludicella</i>	p	-	p	-	-	ns	ns	-	-	-	p	p	-
<i>Plumatella</i>	p	-	p	p	p	ns	ns	-	p	p	p	p	p

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Branchiobdellidae</i>	-	-	4	-	-	ns	ns	97	-	-	-	-	-
<i>Enchytraeidae</i>	-	-	-	-	p	ns	ns	-	p	54	4	-	-
<i>Naididae</i>	-	-	-	-	-	ns	ns	11	-	32	-	-	-
<i>Chaetogaster</i>	-	-	-	-	-	ns	ns	-	-	-	4	-	7
<i>Branchiura</i>	-	-	-	-	-	ns	ns	-	-	-	-	4	-
<i>Tubifex</i>	-	-	-	-	-	ns	ns	-	-	-	-	4	-
<i>Ferrissia</i>	18	-	14	-	11	ns	ns	-	-	-	11	14	22
<i>Physa</i>	-	4	7	524	32	ns	ns	-	-	-	-	-	18
<i>Musculium</i>	-	18	7	-	-	ns	ns	-	-	-	14	4	-
<i>Amblema</i>	-	-	-	-	4	ns	ns	-	-	-	-	-	-
<i>Ceriodaphnia</i>	-	-	-	-	-	ns	ns	-	-	-	-	-	7
<i>Simocephalus</i>	-	-	-	61	-	ns	ns	-	-	-	-	-	-
<i>Gammarus</i>	-	-	-	-	-	ns	ns	-	-	7	-	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Orconectes rusticus</i>	-	-	p	p	-	ns	ns	-	-	-	p	p	-
<i>O. virilis</i>	-	p	-	p	p	ns	ns	-	-	-	p	p	-
<i>Caenis</i>	-	-	22	7	7	ns	ns	-	-	18	4	4	-
<i>Hexagenia</i>	-	-	4	-	-	ns	ns	-	-	-	-	-	-
<i>Stenonema</i>	32	7	54	-	7	ns	ns	-	-	11	25	7	32
<i>Isonychia</i>	-	-	-	-	-	ns	ns	-	-	-	-	-	7
<i>Tricorythodes</i>	7	-	-	-	-	ns	ns	-	-	-	18	-	-
<i>Argia</i>	-	4	4	-	-	ns	ns	-	-	7	p	p	7
<i>Brachymesia</i>	-	-	4	-	-	ns	ns	-	-	-	-	-	-
<i>Sigara</i>	-	22	18	739	p	ns	ns	18	p	29	p	p	84
<i>Gerris</i>	p	-	-	-	-	ns	ns	-	p	p	-	-	-
<i>Trepobates</i>	7	4	-	-	-	ns	ns	-	-	-	14	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Helichus</i>	29	7	-	-	-	ns	ns	-	-	-	7	-	-
<i>Coptotomus</i>	-	7	-	-	-	ns	ns	-	-	-	-	-	-
<i>Hydroporus</i>	-	4	-	-	-	ns	ns	-	-	-	-	-	-
<i>Laccophilus</i>	-	4	-	-	-	ns	ns	-	-	-	-	-	-
<i>Stenelmis</i>	-	4	-	-	-	ns	ns	-	-	-	-	-	-
<i>Gyrinus</i>	-	-	-	-	-	ns	ns	-	-	-	p	-	-
<i>Peltodytes</i>	-	4	-	-	-	ns	ns	-	-	-	4	-	-
<i>Paracymus</i>	-	4	-	-	-	ns	ns	-	-	-	-	-	-
<i>Cheumatopsyche</i>	-	-	-	-	-	ns	ns	-	-	-	25	-	-
<i>Psychomyia</i>	7	-	-	-	-	ns	ns	-	-	-	-	-	-
Chironomidae	40	14	22	50	32	ns	ns	61	p	18	14	11	29
<i>Simulium</i>	-	-	-	-	-	ns	ns	-	-	-	4	-	-

Table 6. (continued)

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
TOTAL	140	104	105	1381	93	ns	ns	187	ns	176	157	47	129

Note. ns = no sample taken, p = present, but not taken in quantitative samples.

the substrate and to clean rocks and sediments into the net with one hand while sculling with the other hand to create a current to wash the animals into the net. This sculling caused an obvious loss of animals propelled around the net, but proved to be the only even somewhat feasible solution.

The type of substrate that was sampled also caused some limitations. Deep leaf and rooted macrophyte beds were avoided during sampling since they caused the Surber sampler to be ineffective. The leaf accumulations clogged the net and the macrophytes were a physical obstruction to efficient use of a Surber sampler.

Periods of low flow coupled with ice cover also caused some sampling problems by increasing the difficulty of access to the substrate since the riffles were frozen. This difficulty was a special problem at Station 11 since it is a fairly deep pool without any riffles. However, the benthos collected when stations were ice-covered did not receive any special treatment since even prolonged ice cover causes only minimal effects to benthic communities (Logan, 1963).

The same environmental conditions that affected the plankton also affected the benthos, but to a lesser degree. The beaver dam built at Station 5 caused but minor changes (increases in enchytraeids and chironomids). Since the benthic population at Station 5 was previously

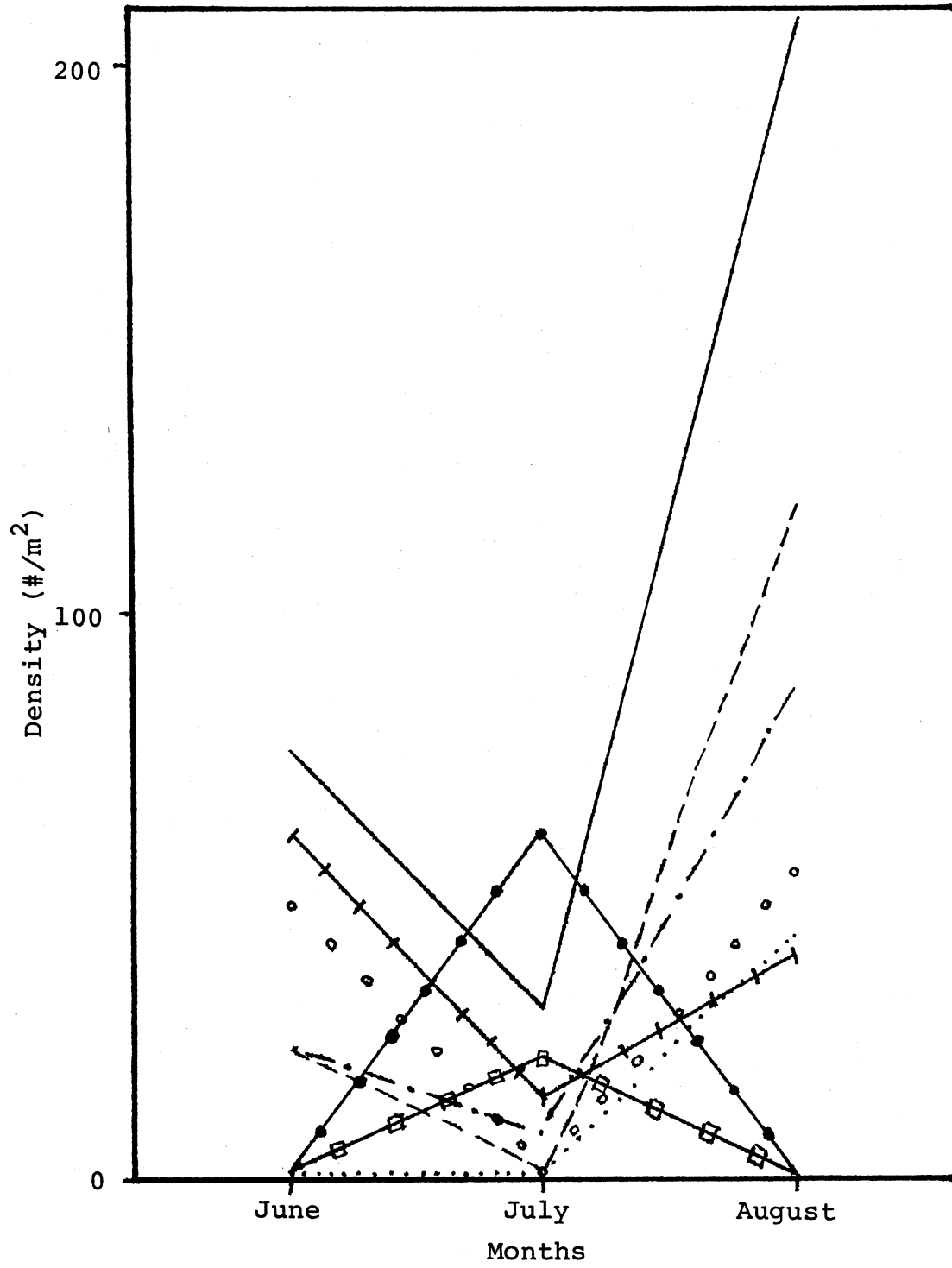
adapted to a large upstream pool, an increase in the size of the pool would not have significantly changed their environment.

The tremendous plankton pulse at Station 10 in January was not reflected by the benthos. Increases did occur in the densities of tubificids and chironomids, but most of the benthic macroinvertebrates would not have the reproductive potential to react to such a food bonanza.

The bloom of blue-green algae (*Oscillatoria*) (July 1976 at Station 8) did show a marked effect on the benthos in the initial perturbation and the later recovery by completely disrupting the benthic community (Figure 8). The toxic metabolites possibly produced by the alga may have caused some reduction in densities (e.g., the limpet *Ferrissia*, the mayfly *Caenis*, etc.), and the recovery also was probably at least partially due to the increased food supply from the decomposing algal cells. The rapid recovery (within a month) of the benthos at Station 8 was probably a result of invertebrate drift from upstream, other tributaries, and/or the ascendance of hyporheic benthos. Some aspects of this situation are difficult to explain. Given a short-lived algal bloom, one has problems explaining where the limpet *Gundlachia* came from. Eggs could not have hatched and matured fast enough to make use of the bloom, and the adults are not mobile enough to migrate to a more beneficial area. Also,

Figure 8.--Benthic densities as affected by a bloom
of *Oscillatoria*

- = chironomids
- - - - = *Caenis*
- . . . - = *Stenonema*
- + + + + = *Cheumatopsyche*
- □ □ = *Hydropsyche*
- = *Hydra*
- ○ ○ ○ ○ = *Ferrissia*
- = *Gundlachia*



one would assume that the extreme concentration of the algae would clog or destroy the filtering nets of the hydropsychids; the abundance of *Cheumatopsyche* sp. decreased in July, since they probably could not feed, but *Hydropsyche* sp. prospered during the bloom. Since the Missouri Department of Conservation lists at least eight species of *Hydropsyche* from the Salt River (Appendix 2), the one(s) that prospered during the bloom could have been omnivorous and not solely dependent on filtering nets.

Almost every station had one unique microhabitat for benthos. Station 3 had some shallow silted side pockets off of the main riffle, which often contained the larvae of the soldier fly *Stratiomyia* and the horsefly *Chrysops*, various leeches, or several hydrophilid beetles. Station 4 had a screening border of willows (*Salix nigra*) lining a pool. The exposed root network hung in the water and often produced the amphipod *Gammarus*, the damselfly *Enallagma*, or rarely, the hemipterans *Belostoma* and *Ranatra*. A shallow silted slough at Station 5 occasionally yielded some hydrophilid beetles, the dragonfly *Celithemis*, *Stratiomyia*, or the caddis fly *Athripsodes*. Stations 8 and 10 lacked any really unique microhabitats that produced different organisms. Station 11 yielded some unusual occurrences of the mayfly *Hexagenia limbata*, the dragonfly *Brachymesia furcata*, the dytiscid beetles *Coptotomus*, *Hydroporus*, and *Laccophilus*, and the hydrophilid

beetle *Paracymus*. The entoproct *Urnatella gracilis* and the ectoproct *Paludicella* were more common at this station than at any other. This station was different from the others because it was a slow-moving pool with a partially silt-covered rubble bottom from portions of a collapsed bridge.

Table 7 shows the degree of uniqueness of the fauna at each station as well as the number of taxa collected.

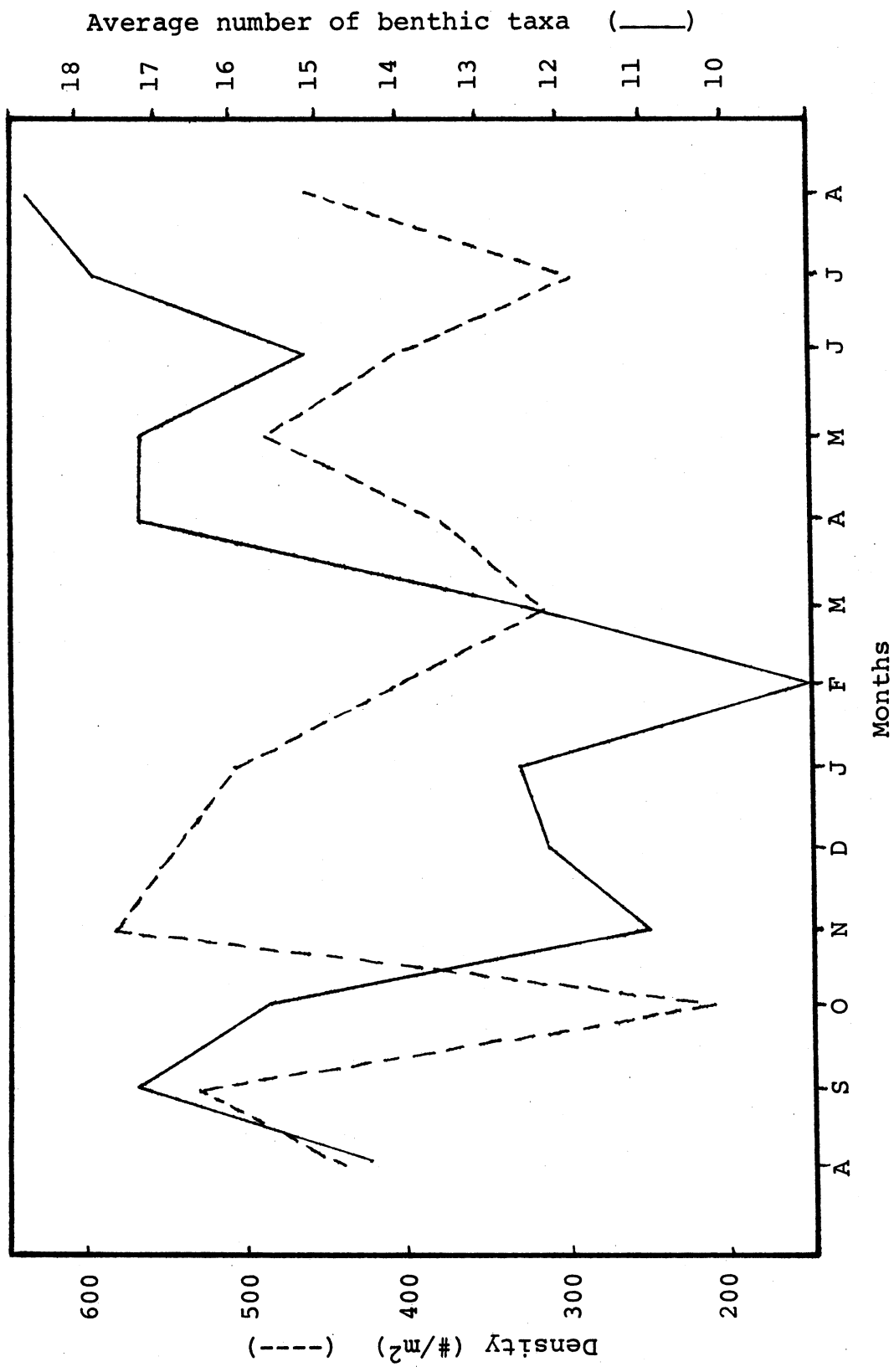
After analysis of the average density of benthos per month and the average number of taxa collected per month (Figure 9), the following conclusions can be drawn:

1. Following Logan (1963), the highest observed average density was in November with 582 animals per m².
2. The average number of taxa reached its lowest value in the winter, as animals passed the winter in their most resistant stages (e.g., statoblasts, larvae, and eggs). The highest values were reached in the summer due to a peak in primary production by algae (Appendix 1). A corresponding increase in available niches also occurred, since due to an increase in potential food sources, more marginal niches could be utilized.
3. The average density and average number of taxa are generally directly related in the warmer months and inversely related in the cooler months.

Table 7.--Taxa unique to each station

	Number of unique taxa	Total number of taxa collected	Unique taxa
Station 3	4	58	Glossiphoniidae <i>Tropisternus</i> <i>ellipticus</i> <i>Cambarus diogenes</i> <i>Haliphus</i>
Station 4	6	49	<i>Anopheles</i> <i>Lymnaea</i> <i>Helophorus</i> Capniidae <i>Belostoma</i> <i>Ranatra</i>
Station 5	9	59	<i>Chlorohydra</i> <i>Anodonta</i> <i>Asellus</i> <i>Berosus</i> <i>Ishnura</i> <i>Celithemis</i> <i>Neohaemonia</i> <i>Helocombus</i> <i>Polycentropus</i>
Station 8	2	54	<i>Calopteryx</i> <i>Macromia</i>
Station 10	5	56	<i>Pectinatella</i> <i>Erpobdella</i> <i>Batrachobdella</i> <i>Helobdella</i> <i>Atherix</i>
Station 11	5	40	<i>Amblema</i> <i>Hexagenia</i> <i>Brachymesia</i> <i>Coptotomus</i> <i>Hydroporus</i>

Figure 9.--Benthic population trends



As the number of taxa drops with the onset of winter, those insect larvae that remain year round (chironomids, and the mayflies *Caenis* and *Stenonema*, etc.) benefit from decreased competition for available food and are generally more dense than in the summer. These same insects also undergo emergence in the summer, which would tend to repress their densities.

Even though most temperate mayflies undergo emergence in the late spring or early summer, the three main genera of mayflies in the Salt River (*Caenis*, *Isonychia*, and *Stenonema*) failed to show any clear reduction in densities as a result of emergence (Figure 10). The black-fly (*Simulium*) and caddis fly (*Cheumatopsyche*) also failed to show any distinct emergence time (Figure 11). The chironomids exhibited a multitude of densities during this study. Since a myriad of chironomid species occurs in the Salt River (the Missouri Botanical Garden [1974a] records 28 species for the entire basin), no one emergence period can be expected. Even a general season cannot be defined because this author has observed year-round chironomid emergence in central Missouri.

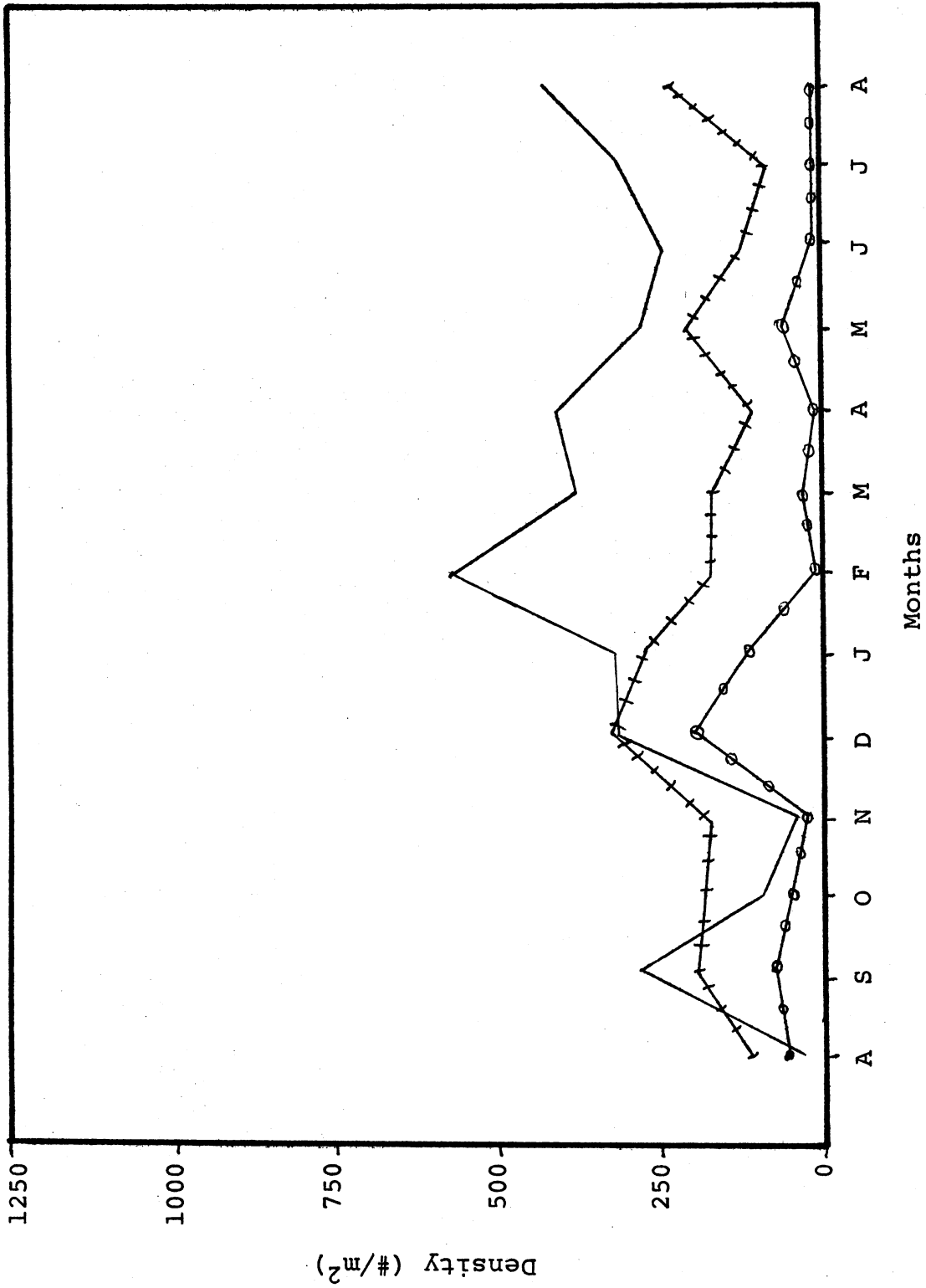
The caddis flies of the Salt River are dominated by *Cheumatopsyche* and, to a lesser extent, *Hydropsyche*. These two genera are the trichopteran best able to tolerate the highly turbid conditions of the Salt River (Roback, 1962).

Figure 10.--Selected ephemeropteran densities

———— = *Caenis*

+ + + + + = *Stenonema*

o o o o = *Isonychia*



Density (#/m²)

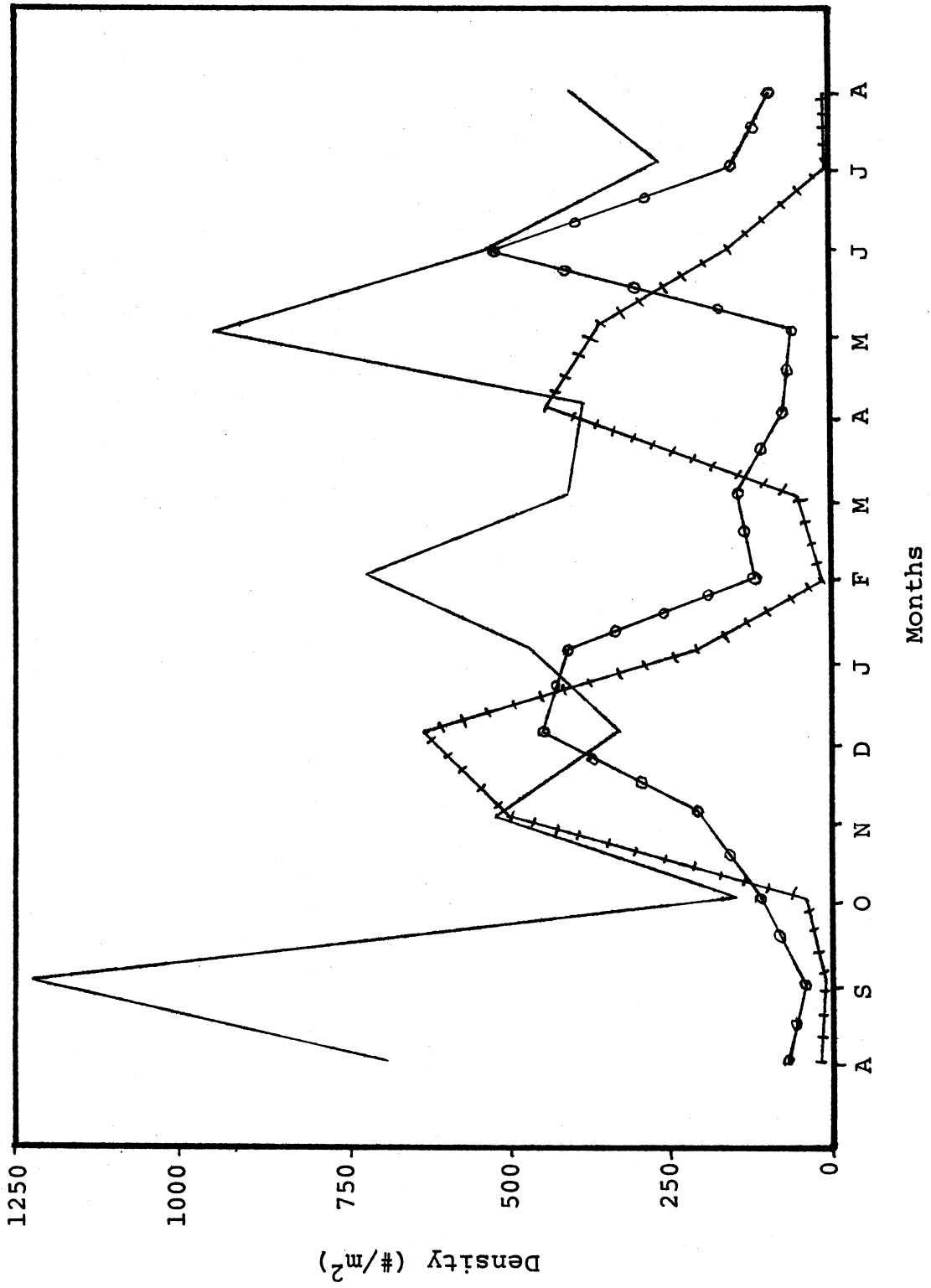
Months

Figure 11.--Selected dipteran and trichopteran densities

———— = chironomids

+ + + + = *Simulium*

• • • • = *Cheumatopsyche*



Momot and Gowing (1972) state that crayfish have evolved a seasonal migration in response to freezing temperatures; riffles are abandoned since they may become frozen solid. The crayfish of the Salt River (*Cambarus diogenes*, *Orconectes rusticus*, and *O. virilis*) appear to follow this migrational trend (Figure 12). Even with fairly equivalent collection efforts, crayfish were rarely taken during winter months.

Another observation on the crayfish of the Salt River differs from that of Page, who stated that "The elimination of *Orconectes rusticus* from all impounded areas of the Salt River system is almost certain because of the rigid preference of this crayfish for rapidly flowing water" (in Corps, 1974a). Although *O. rusticus* was not present at two stations with intermittent summer flow (Stations 4 and 10), it was present at one station with intermittent summer flow (Station 3) and also in the pool station (Station 11) which rarely had a noticeable flow (Figure 13). The preference of *O. rusticus* for rapidly flowing water does not appear to be extremely rigid.

Diversity Values

The equation used to compute diversity was that of Shannon and Weaver (1949) with the modification suggested by Pielou (1966b) as an estimate of the population

Figure 12.--Total seasonal crayfish occurrence

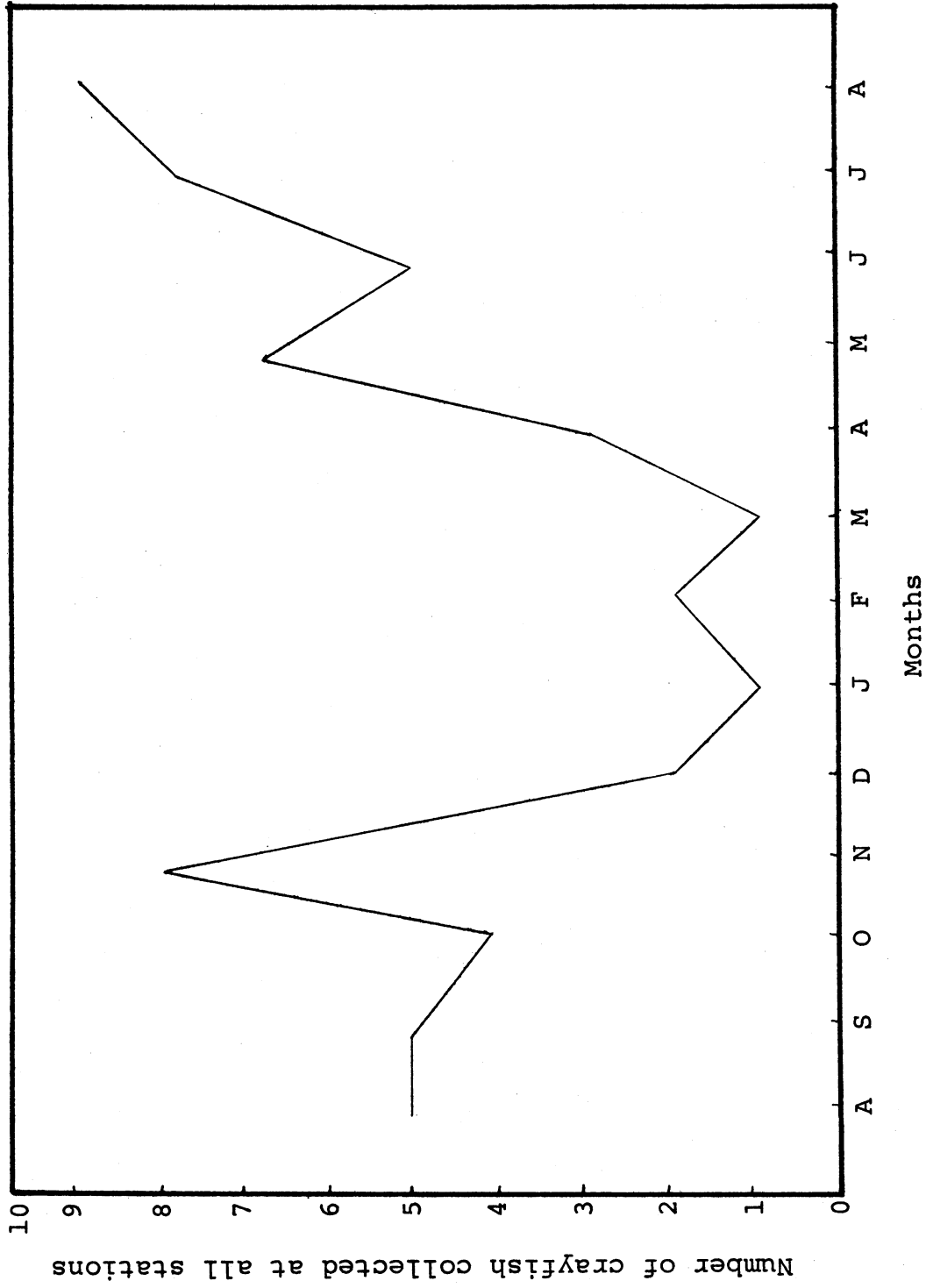
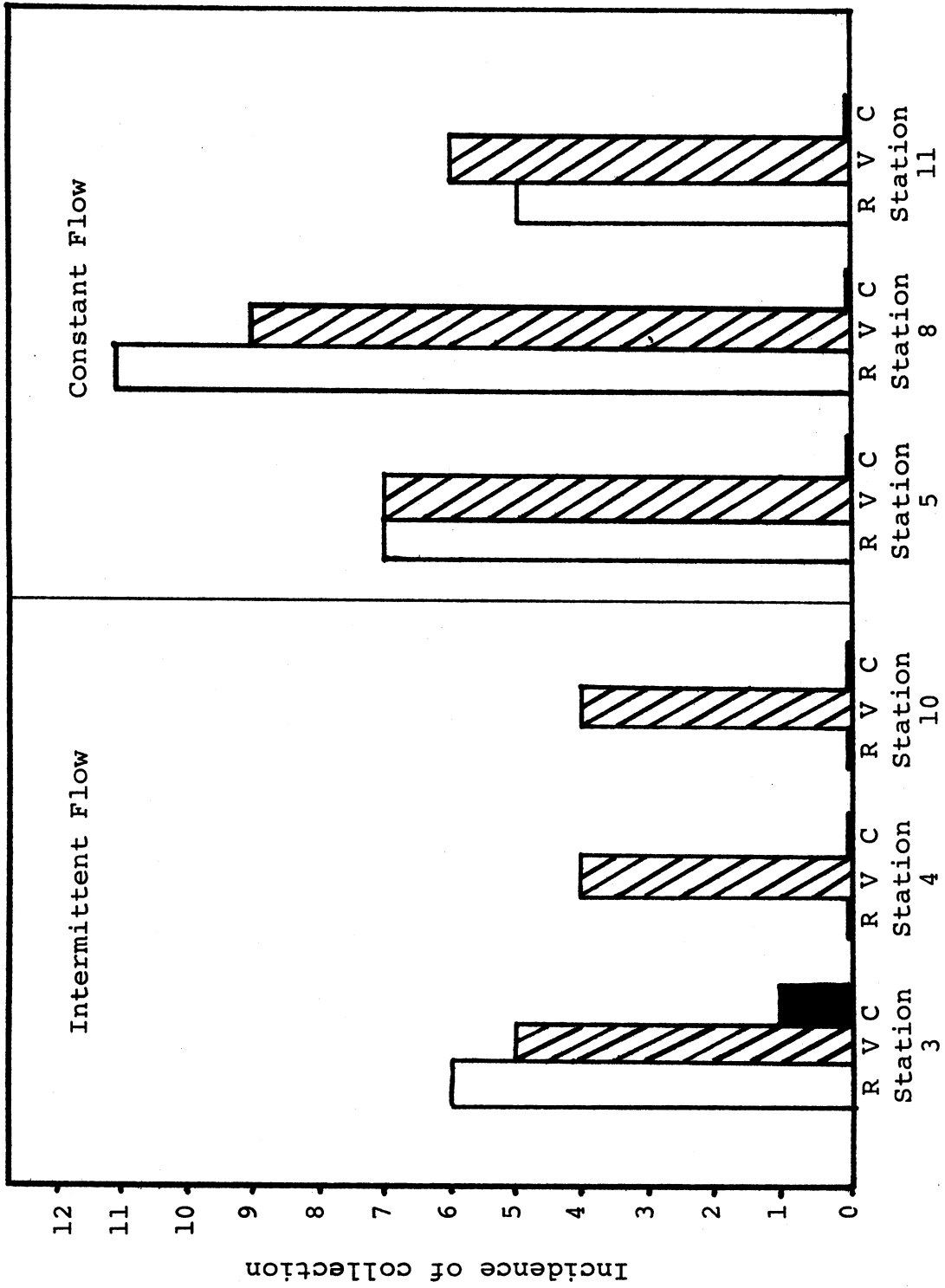


Figure 13.--Crayfish occurrence at each station

R = *Orconectes rusticus*

V = *O. virilis*

C = *Cambarus diogenes*



diversity (H''):

$$H'' = - \sum_{i=1}^S \left(\frac{N_i}{N} \right) \log_{10} \left(\frac{N_i}{N} \right).$$

The variation of H'' used by Wilhm and Dorris (1968) (\log_2 for \log_{10}) was also included in the figures for ease in interpretation. When natural logarithms are used in calculating H'' , an estimate of its variance can be made using:

$$\hat{\text{var}} (H'') = \frac{1}{N} \left[\sum_{i=1}^S \frac{N_i}{N} \left(\ln \frac{N_i}{N} \right)^2 - (H'')^2 \right] \quad (\text{Pielou,}$$

1966b).

The values were calculated on a Hewlett-Packard 65 programmable calculator, using a program designed by Dr. D. H. Hazelwood. Appendix 5 contains the H'' values for both \log_{10} and \log_2 .

The plankton populations of the Salt River are subject to sporadic pulses of varying intensity; these pulses are reflected in the diversity values for the individual populations (Figures 14 through 19). The values oscillate to varying degrees, wildly at Station 8 (Figure 17) to more subdued at Station 5 (Figure 16). Figure 20 shows the average H'' values for all stations by month. The only variation which is observed at every station is a reduction in the estimate of diversity (H'') during and after a prolonged period of ice cover in January. Since two to three inches of ice were observed on the pools

Figure 14.--Diversity estimates for Station 3

———— = plankton

+ + + + = benthos

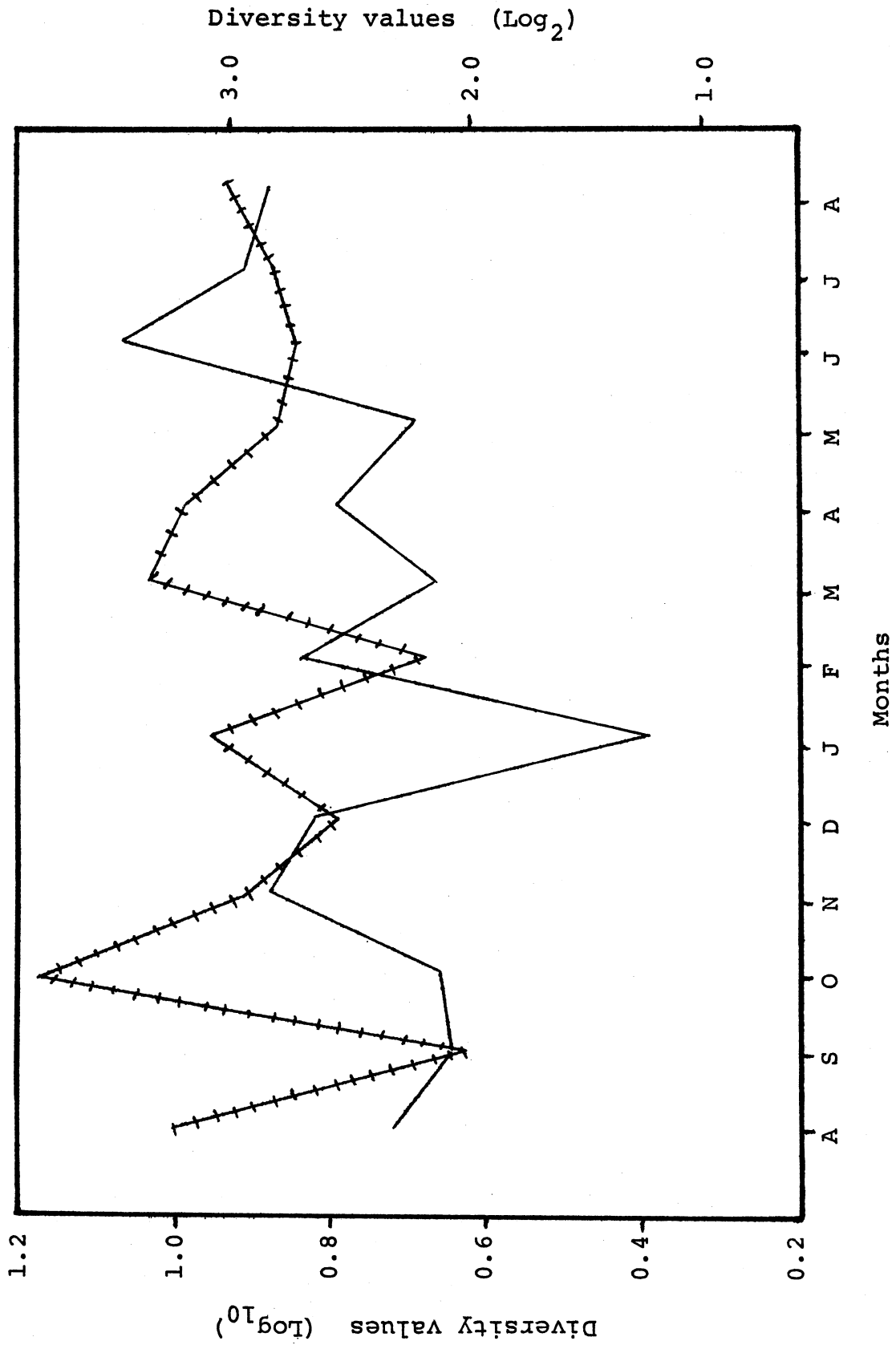


Figure 15.--Diversity estimates for Station 4

———— = plankton

+ + + + + = benthos

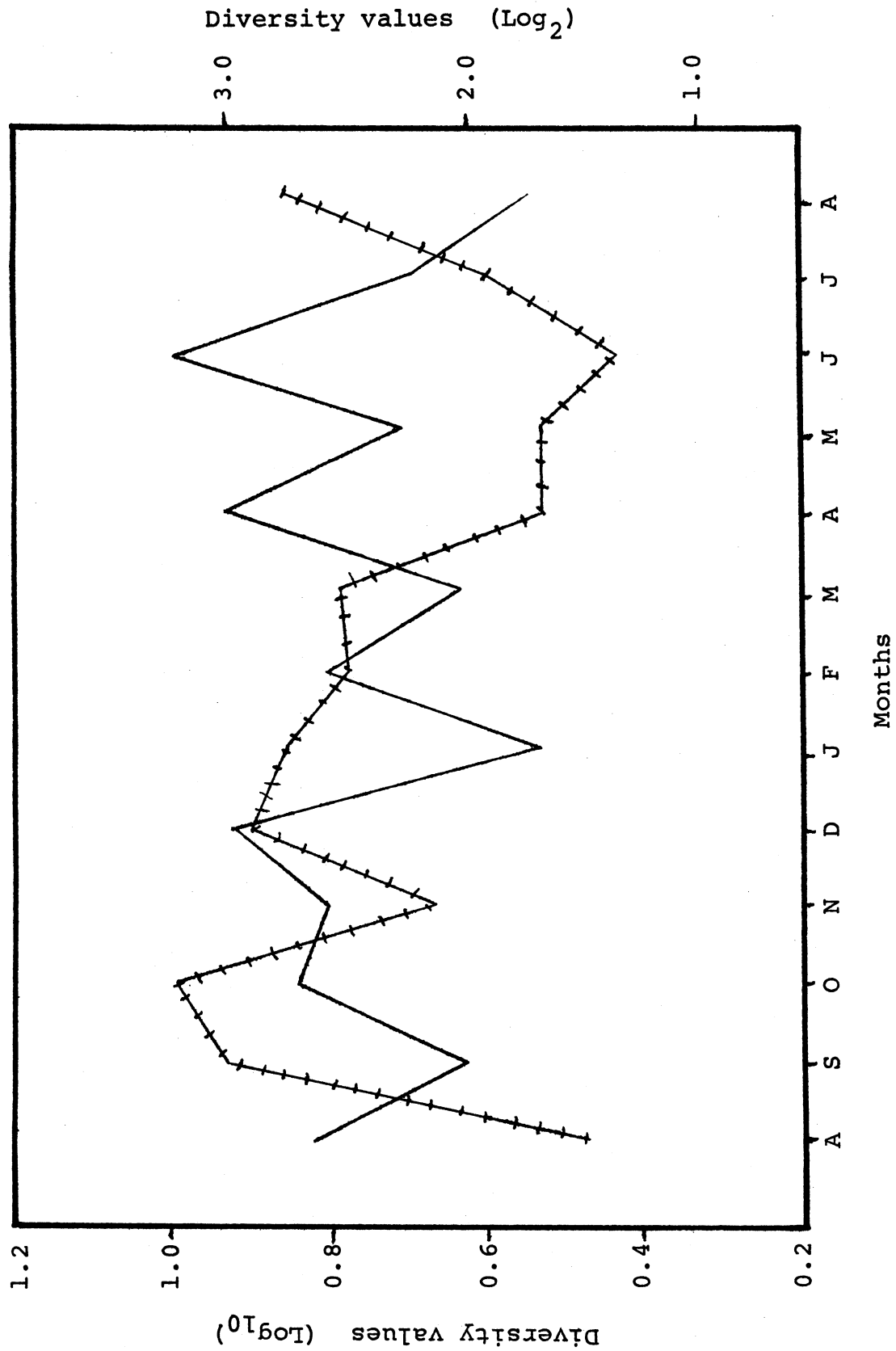


Figure 16.--Diversity estimates for Station 5

———— = plankton

+ + + + + = benthos

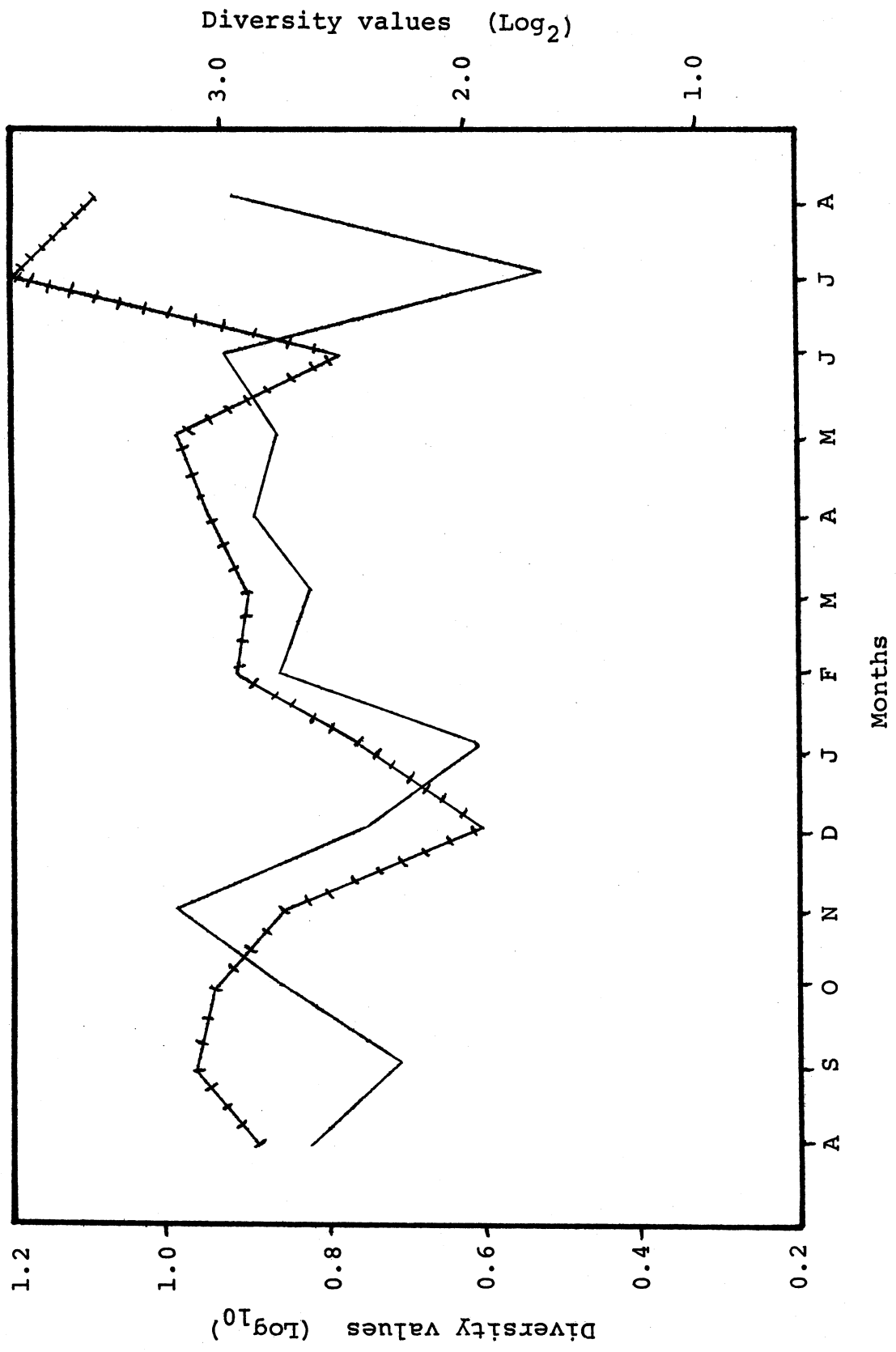


Figure 17.--Diversity estimates for Station 8

————= plankton

+ + + + = benthos

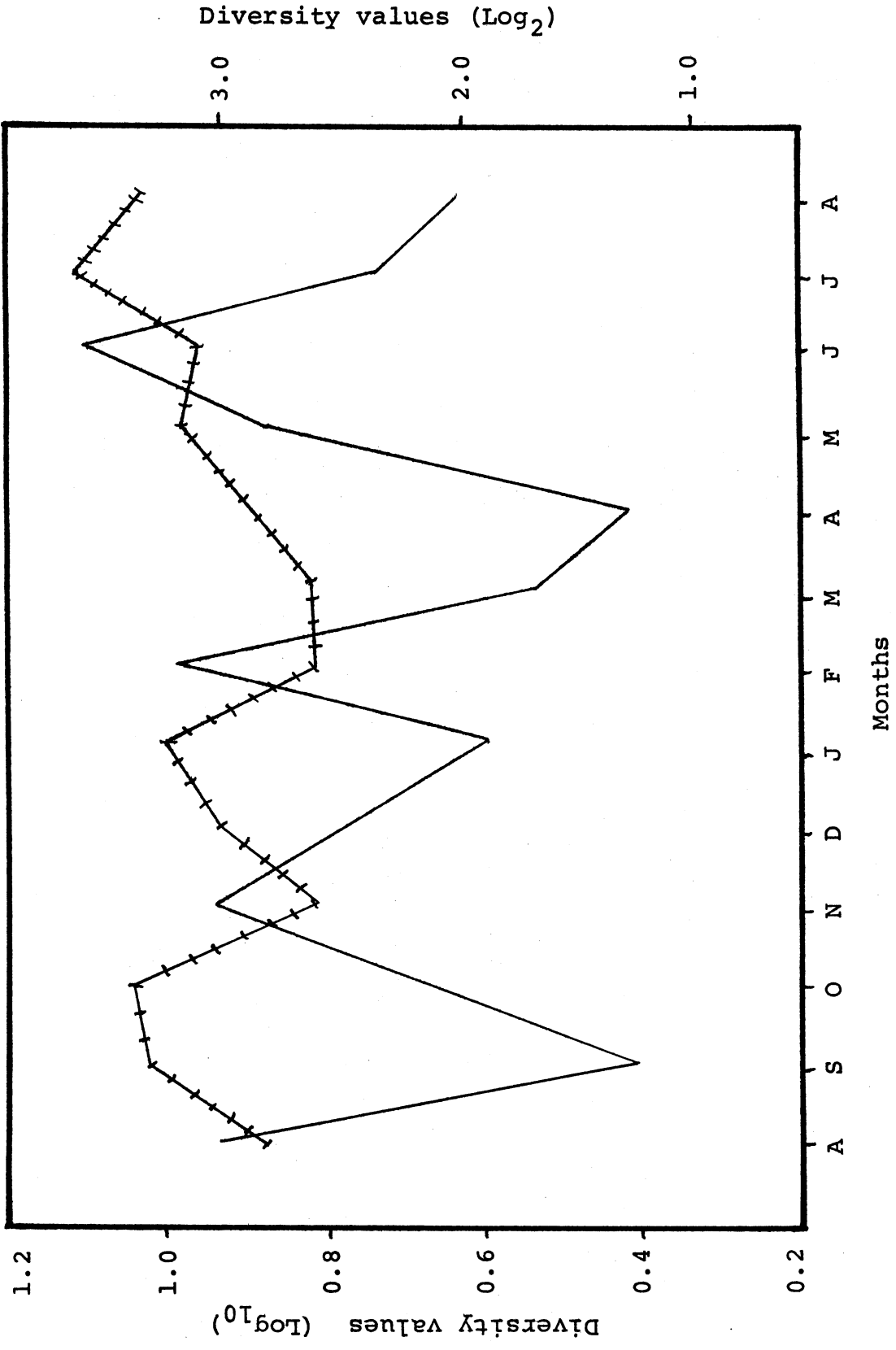


Figure 18.--Diversity estimates for Station 10

———— = plankton

+ + + + = benthos

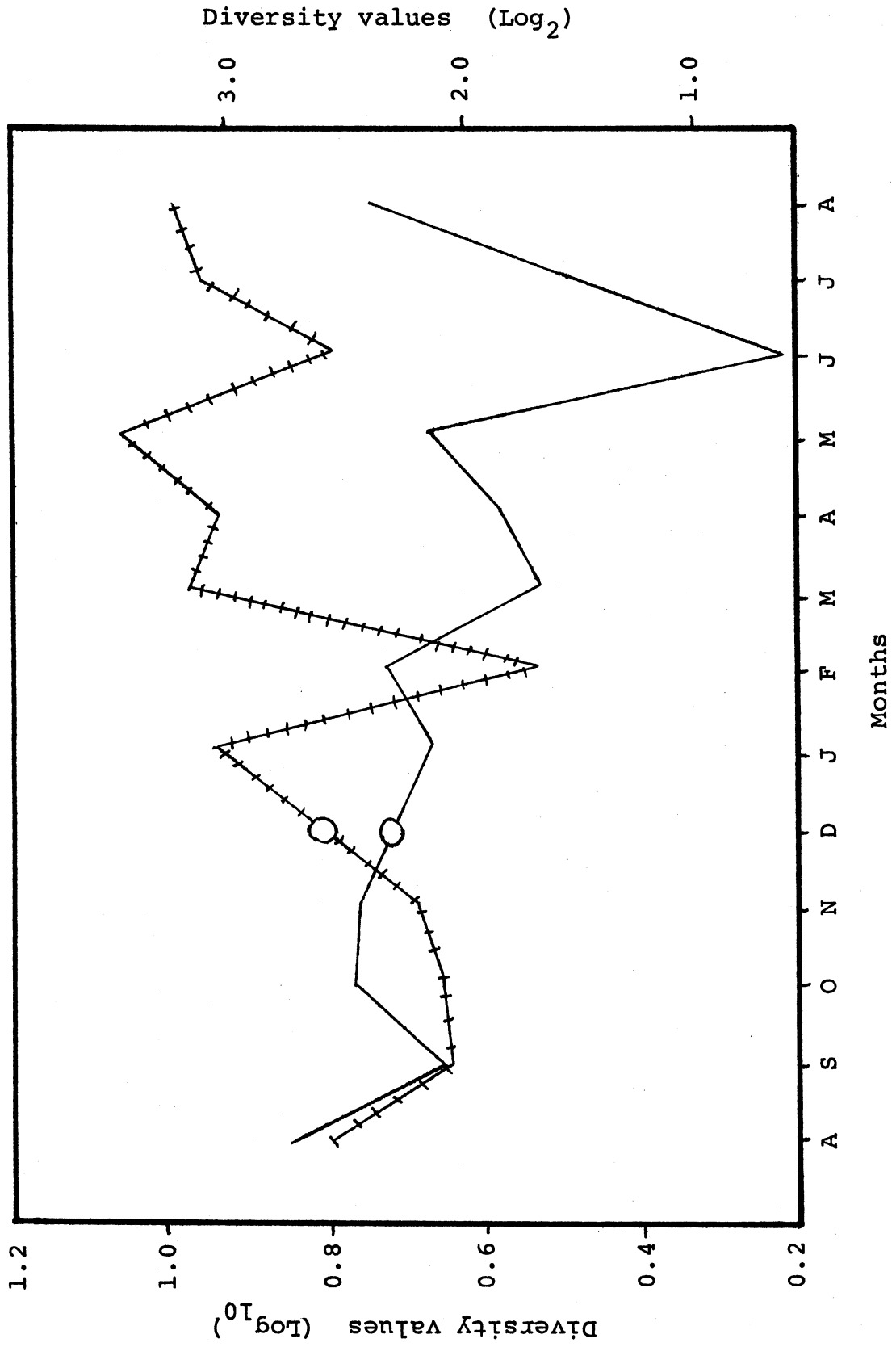


Figure 19.--Diversity estimates for Station 11

———— = plankton

+ + + + + = benthos

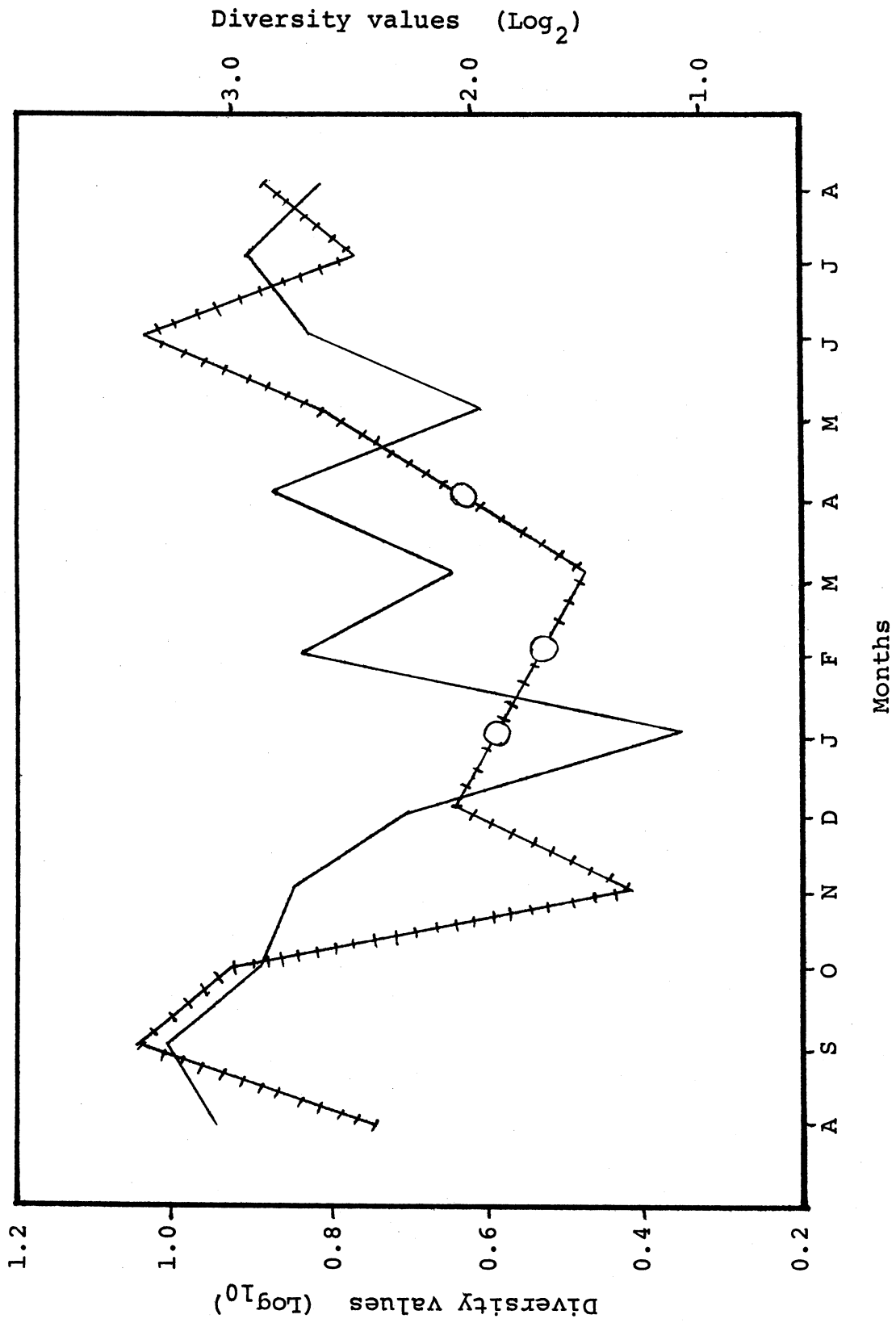
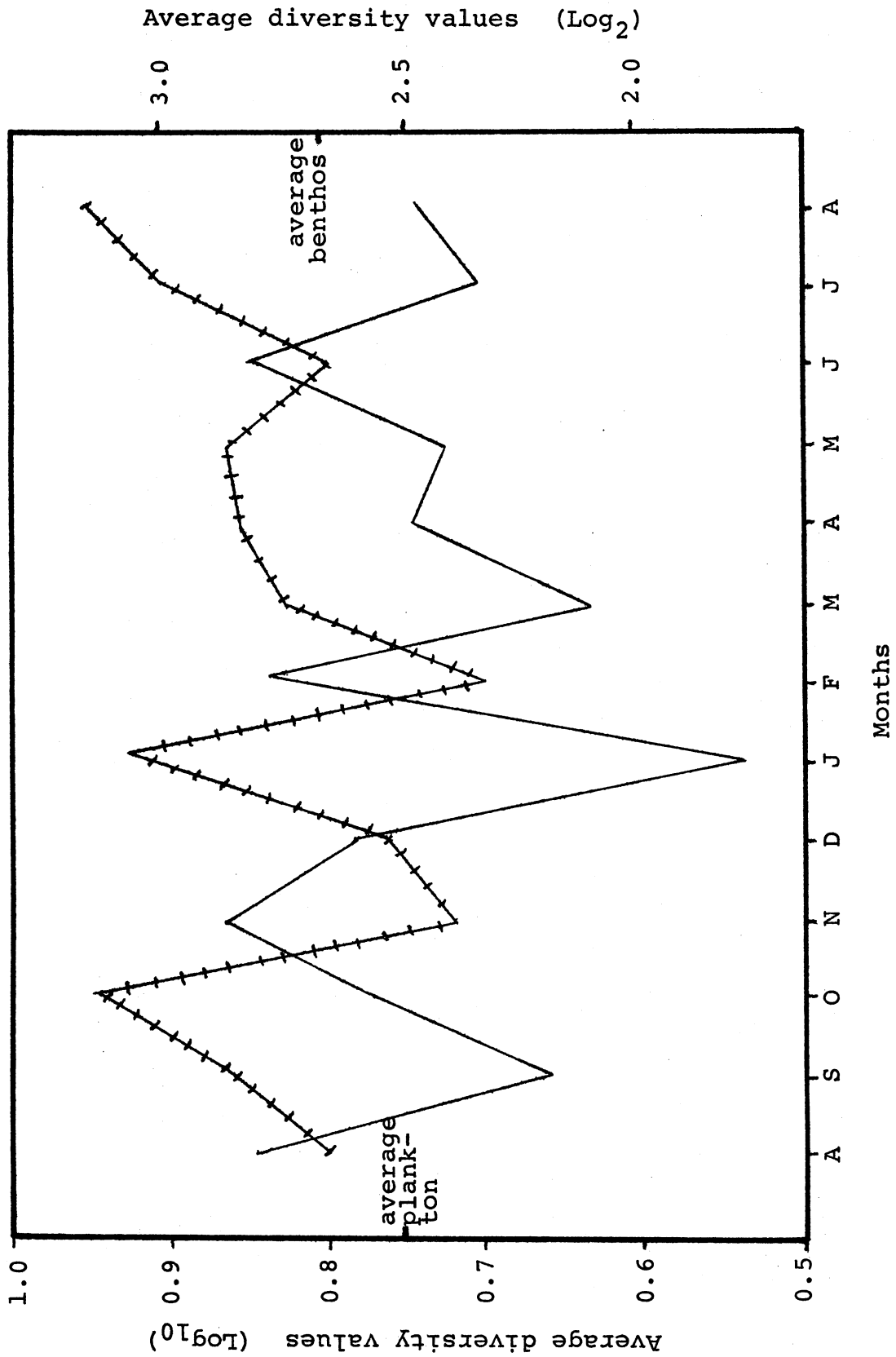


Figure 20.--Average diversity estimates for all stations

———— = plankton

+ + + + + = benthos



at all stations in December and no extended periods of thaw occurred between December 20, 1975 and January 17, 1976, the water probably underwent a depletion of oxygen and nutrients. This added stress on the organisms could have adversely affected the population diversity by eliminating those animals unable to tolerate low levels of dissolved oxygen and food abundance for long periods of time. Some animals were quite able to flourish under these conditions, as evidenced by the maximum pulse which occurred in January at Station 10 with 408 organisms/l (Table 4).

Figures 14 through 19 show that the diversity estimates for the benthic community also fluctuated, but generally not as wildly as the plankton estimates. With the exception of Station 4, the H' for the benthos exceeded those for the plankton. Since the diversity seems to be related to the number of taxa collected, the estimates should be higher for the benthos because 110 taxa were collected (as opposed to 49 planktonic taxa). However, the diversity estimates for the benthos are low because those animals collected nonquantitatively (11 genera) are not represented. The ectoproct *Plumatella* sp. is also not represented even though it may have occurred in the quantitative sample, because its presence cannot be quantified.

Station 4 (Figure 15) appears to have significant problems in addition to having the lowest average benthic

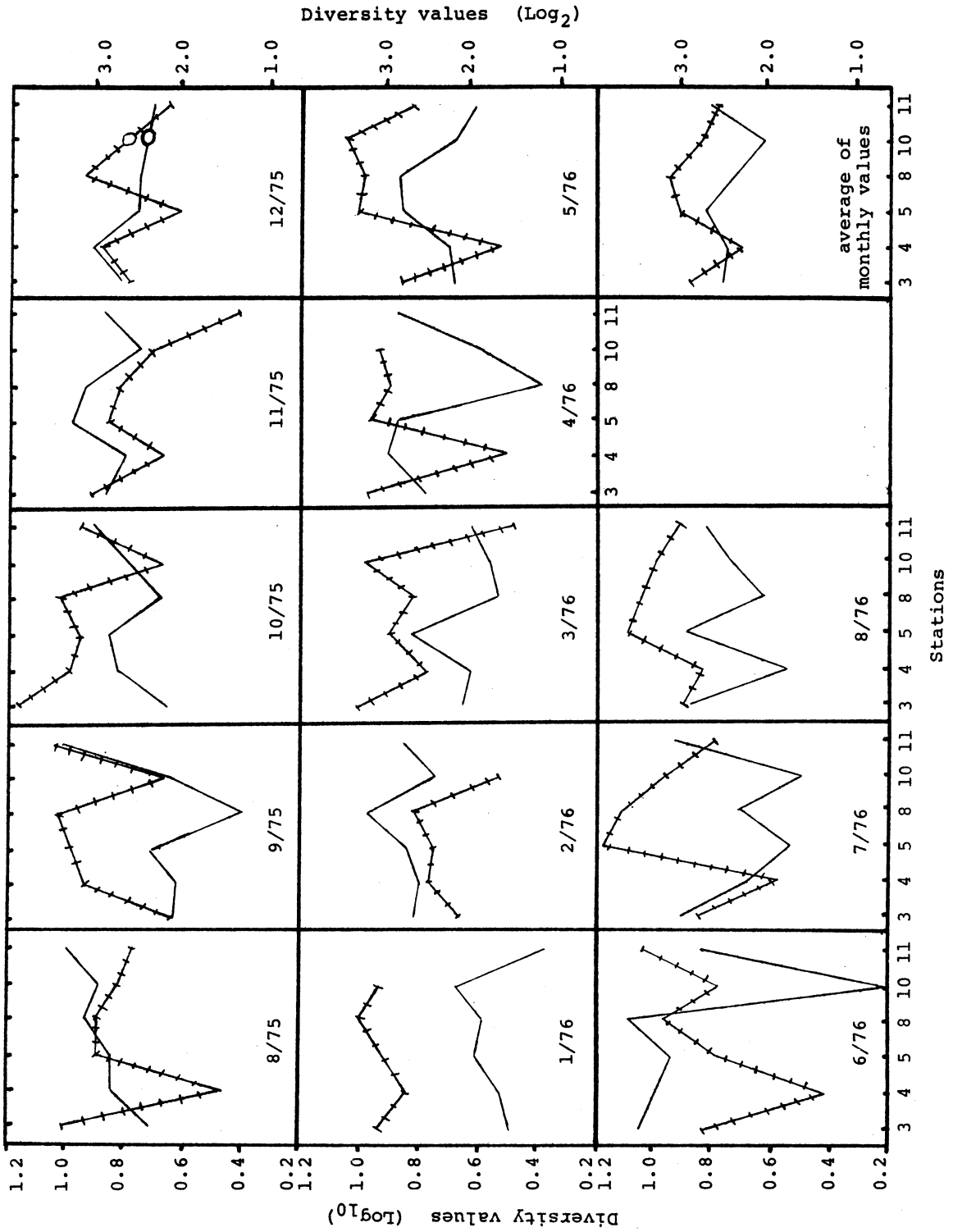
diversity (Figure 21). This station is on the smallest stream (Indian Creek) studied (average flow = 23 cfs) and usually flows intermittently throughout the summer. The United States Army Corps of Engineers (1974b) conducted a diel study at Station 4 in 1973 and found no significant hourly changes in dissolved oxygen values. From 1972 to 1975, they found an average of 11.3 mg/l of dissolved oxygen with a range from 7.7 to 15.3. In early 1975, a row of large trees on the western edge of the largest pool was cut down for power line passage. These trees had previously shaded almost all of a large pool immediately upstream from the sampled riffle. In the summers of 1975 and 1976, the pool became choked with a dense mat of a green alga (*Spirogyra*) and inhabited by enchytraeid oligochaetes and chironomids. The speculation arises that, now with increased input of solar energy, a diel oxygen pulse exists in the pool during the summer and that the benthos confined to the pool have become less diverse as less tolerant taxa are eliminated. The planktonic organisms in the pool would have sufficient oxygen during the day from photosynthesis, and could maintain themselves at night by close association with the surface film.

Wilhm and Dorris (1968) proposed that H'' (\log_2) values of less than 1.0 indicated a level of gross pollution and that values exceeding 3.0 were typical of "clean"

Figure 21.--Average monthly diversity estimates

———— = plankton

+ + + + + = benthos



water. Stations 5 and 8 both exceed 3.0 (Figure 20) as a mean monthly value, with the highest value (Station 5 in July 1976) being 3.89. The average of the H" values at Station 4 was the lowest (2.33) with the lowest single value being 1.36 (Station 4 in June 1976). Wilhm (1965) found low diversity values to be associated with diel oxygen fluctuations in a stream receiving organic wastes. Station 4, as is true of most streams in the Salt River basin, often exceeds the state standard for fecal coliform bacteria (2000 per 100 ml) after periods of moderate to heavy precipitation (Corps, 1974b). This excess is a reflection of the highly agricultural nature of the watershed. Although some of the physicochemical factors for Station 4 do little to substantiate a diel pulse (B.O.D., nitrate/nitrite, and orthophosphate), the controlling factors (dissolved oxygen, carbon dioxide, flow, and turbidity) do substantiate it (Table 2).

The only other study of the Salt River which attempted the calculation of diversity indices was that of Duchrow (1974). He claimed that since the Salt River was comparable to Ozark streams, it should have a high (greater than 4.0) benthic diversity if the river was unpolluted. The low diversity values (0.42 to 3.80) led him to state that the diversity was decreased some by organic pollution, but primarily by chronic siltation from the surrounding farmlands. Although his conclusion

is probably correct, his claim of equality of the Salt River to Ozark streams is questionable. He uses similarities in bedrock stratigraphy, riffle substrate, pH, alkalinity, hardness, and specific conductance to support his claim.

Many other factors dispute his claim:

1. The vegetation of the Salt River basin is drastically different from typical Ozark vegetation. The Salt River basin was predominantly tall grass prairie before plowing (MBG, 1974a) and is now primarily agricultural. The oak-hickory forest typical of the Ozarks covers less than 10% of the Salt River basin.
2. The primary soil types of the Salt River are more fertile than those of the Ozarks, and have developed from tall grass prairie.
3. The topography of the Salt River basin is less rugged than that of the Ozarks. Although the gradient of the Salt River averages about 2.8 ft/mi (.53 m/km), much of the river is devoid of riffles and drops much less sharply. Ozark streams usually have gradients of greater than 4 ft/mi (.76 m/km), with some streams in excess of 10 ft/mi (1.89 m/km) (Hawksley, 1976).
4. None of the Ozarks was scoured during the Pleistocene ice age. The entire Salt River basin

was buried repeatedly. This glaciation was directly responsible for changes in topography, soils, flora, and fauna.

5. The fish fauna of the Salt River is not similar to that of the Ozarks. Of 55 species of fish collected from the Salt River by three groups (Appendix 3), 45% are found statewide, 38% are not found in the Ozark region, and 16% are common to the Salt River and the Ozarks. The most common fish in the river, the red shiner (*Notropis lutrensis*) (Hazelwood, 1976), is considered to be a prairie fish exclusively (Pflieger, 1975).

Conclusions

1. The plankton diversity estimate was forced downward in the winter by a prolonged period of ice cover.
2. The argument of Duchrow (1974, 1977) that the Salt River should approach the Ozark streams in benthic diversity seems questionable. His use of the common bedrock, riffle substrate, and some chemical parameters as corroboration can be countered with dissimilar vegetation, soils, topography, historical geology, and markedly different fish populations.
3. No distinct emergence periods were noted for the aquatic insects of the Salt River.

4. A diel oxygen pulse now probably exists at Station 4 during the summer, even though the United States Army Corps of Engineers Water Quality Section did not find one in 1973.
5. The diversity estimates for the benthos at Stations 3, 5, 8, and 10 did not differ by significant amounts. The values were lowered at Station 4 by a suspected diel oxygen pulse, and at Station 11 by the absence of riffles in the sample site.
6. Even though no specific point sources of pollution have been located in the basin (Duchrow, 1974), the lower diversity estimates for the benthic community (1.36 to 2.99) indicate some degree of stress on organisms in the Salt River. However, the benthic diversity estimates commonly exceed 3.0, and, since no contaminant sources have been located, the Salt River could probably be labeled unpolluted by both the biological (Wilhm & Dorris, 1968) and legal (McKee, 1952) definitions of pollution.
7. Based on the values from this study, the benthic diversity estimates are greater than those of the plankton. The benthos never underwent the extreme density oscillations of the plankton and also was composed of more than twice as many taxa.

Summary

The zooplankton and benthos of the Salt River, Missouri were studied over a period of 13 months. The seasonal abundances and interstation distributions were determined for the study period. Other than a general depression of the zooplankton diversity estimates during prolonged periods of ice cover, no distinct conclusions can be drawn from the zooplankton data. The spatial and temporal isolation among the zooplankton samples limits their usefulness in establishment of trends.

The populations of benthic organisms were usually more stable than those of the zooplankton and were generally comparable between stations. Some variations did occur during times of unique environmental conditions. The low to medium benthic diversity estimates (indices less than 3.0) show the effects of some low level of perturbation (perhaps chronic turbidity) but enough indices were greater than 3.0 to justify the statement that the Salt River is relatively unpolluted.

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Appendix 1.--Algae collected from the Salt River, Missouri,
August 1975 to August 1976

A. NET PHYTOPLANKTON

division Chlorophyta

order Volvocales

family Volvocaceae

Eudorina sp.*Gonium* sp.*Pandorina* sp.*Volvox* sp.

Tetrasporales

Chlorangiellaceae

Characiochloris sp.

Chlorococcales

Palmellaceae

Sphaerocystis sp.

Hydrodictyaceae

Hydrodictyon sp.

Ulotrichales

Ulotrichaceae

Ulothrix sp.

Microsporaceae

Microspora sp.

Chaetophorales

Chaetophoraceae

Microthamnion sp.*Stigeoclonium* sp.

Oedogoniales

Oedogoniaceae

Oedogonium sp.

Zygnematales

Zygnemataceae

Spirogyra sp.

Desmidiaceae

Closterium sp.*Hyalotheca* sp.*Pleurotaenium* sp.

Chrysophyta

Tribonematales

Tribonemataceae

Tribonema sp.

Vaucheriales

Vaucheriaceae

Vaucheria sp.

Chromulinales

Chrysosphaeraceae

Chrysosphaera sp.

Pennales

Fragilariaceae

Fragilaria sp.*Synedra* sp.

Eunotiaceae

Eunotia sp.

Achnanthaceae

Rhoicosphenia sp.

Naviculaceae

Gyrosigma sp.*Navicula* sp.

Gomphonemaceae

Gomphonema sp.

Cymbellaceae

Cymbella sp.

Rhodophyta

Nemaliones

Chantransiaceae

Audouinella sp. (also *Rhodochorton*
or *Acrochaetium*)

Cyanophyta

Chroococcales

Chroococcaceae

Chroococcus sp.*Holopedium* sp.*Microcystis* sp.

Oscillatoriales

Oscillatoriaceae

Oscillatoria sp.*Spirulina* sp.

Nostocales

Nostocaceae

Anabaena sp.*Nostoc* sp.

Euglenophyta

Euglenales

Euglenaceae

Phacus sp.

B. PERIPHYTON

division Chlorophyta

- order Chaetophorales
 - family Chaetophoraceae
 - Chaetophora* sp.
- Cladophorales
 - Cladophoraceae
 - Basycladia* sp.
 - Cladophora* sp.
- Zygnematales
 - Zygnemataceae
 - Mougeotia* sp.
- Charales
 - Characeae
 - Nitella* sp.

Cyanophyta

- Oscillatoriales
 - Oscillatoriaceae
 - Oscillatoria* sp.

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Basidiocladia</i>	-	-	-	-	-	-	-	-	-	-	p	-	p
<i>Cladophora</i>	-	-	-	-	p	-	-	-	p	a	p	-	-
<i>Mougeotia</i>	-	-	-	-	p	p	-	-	-	-	p	-	-
<i>Oscillatoria</i>	p	p	p	-	-	-	-	-	-	-	-	-	-

Station 4

<i>Eudorina</i>	-	-	-	-	-	-	-	-	-	-	-	-	p
<i>Pandorina</i>	-	-	-	-	-	-	-	-	-	-	-	-	p
<i>Volvox</i>	-	-	-	-	-	-	-	-	v	c	-	-	-
<i>Ulothrix</i>	p	-	-	-	p	p	-	-	-	-	-	p	-
<i>Microspora</i>	-	-	-	-	-	c	-	-	-	-	-	-	-
<i>Stigeoclonium</i>	-	-	-	-	-	-	c	p	-	-	p	-	-
<i>Spirogyra</i>	-	-	p	c	p	p	p	-	c	-	-	c	-
<i>Closterium</i>	p	-	p	a	p	p	p	-	-	c	-	c	p
<i>Hyalotheca</i>	-	-	-	-	-	-	p	-	-	p	-	-	-
<i>Tribonema</i>	-	-	p	p	-	c	p	-	a	-	-	-	-
<i>Chryso-sphaera</i>	-	-	-	-	-	-	-	-	-	a	-	-	-
<i>Fragilaria</i>	-	-	-	-	-	p	p	-	p	c	-	p	-
<i>Synedra</i>	-	-	-	-	p	a	p	-	p	a	-	-	p
<i>Rhoicosphenia</i>	-	-	-	-	-	a	a	c	-	a	-	p	-
<i>Navicula</i>	-	-	-	-	-	p	a	-	-	c	-	p	-
<i>Gomphonema</i>	-	-	-	-	-	-	a	-	-	c	-	p	-
<i>Cymbella</i>	-	-	-	-	-	-	p	-	-	-	p	p	-
<i>Holopedium</i>	-	-	-	-	-	-	p	-	-	-	-	-	-

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Chaetophora</i>	-	-	p	-	-	-	-	-	-	-	-	-	-
<i>Basicladia</i>	-	-	-	-	-	-	-	-	-	-	p	-	-
<i>Cladophora</i>	-	-	-	p	p	-	p	p	c	a	c	a	-
<i>Mougeotia</i>	p	-	p	c	-	p	-	c	p	-	p	-	-
<i>Oscillatoria</i>	p	-	p	-	-	-	-	-	-	-	-	-	p

Station 5

<i>Gonium</i>	-	-	-	-	-	-	-	-	-	-	-	-	p
<i>Pandorina</i>	-	-	-	-	-	-	-	-	-	-	-	p	-
<i>Volvox</i>	-	-	-	p	-	-	-	p	a	-	-	-	-
<i>Microspora</i>	-	-	p	v	-	p	-	-	-	-	p	-	-
<i>Spirogyra</i>	p	-	p	p	-	p	-	-	p	-	p	p	-
<i>Closterium</i>	-	-	p	p	-	-	p	-	a	c	-	p	c
<i>Pleurotaenium</i>	-	-	-	p	-	-	-	-	-	-	-	-	-
<i>Tribonema</i>	-	-	-	-	-	p	-	-	-	p	p	-	-
<i>Fragilaria</i>	-	-	-	-	-	-	-	-	-	-	p	p	-
<i>Synedra</i>	-	-	-	p	-	-	-	-	p	-	p	p	-
<i>Eunotia</i>	-	-	-	-	-	-	-	-	-	-	-	c	-
<i>Rhoicosphenia</i>	-	-	-	-	-	-	p	-	-	-	p	-	-
<i>Gyrosigma</i>	-	-	-	-	-	-	-	-	-	-	-	a	-
<i>Navicula</i>	-	-	-	-	-	-	-	-	-	-	p	p	-
<i>Gomphonema</i>	-	-	-	-	-	-	-	-	-	-	p	p	-
<i>Cymbella</i>	-	-	-	p	-	-	-	-	p	-	c	c	-
<i>Chroococcus</i>	-	-	-	-	-	-	p	-	-	-	-	-	-

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Oscillatoria</i>	-	-	-	-	-	-	-	-	-	-	-	v	-
<i>Chaetophora</i>	p	p	p	-	-	-	-	-	-	-	-	-	-
<i>Bacillaria</i>	-	-	-	-	-	-	-	-	-	p	-	p	-
<i>Cladophora</i>	-	-	-	a	-	c	p	-	a	a	a	p	p
<i>Mougeotia</i>	-	-	-	p	-	-	-	-	-	-	-	-	-

Station 10

<i>Pandorina</i>	-	-	-	-	ns	c	-	-	-	-	-	-	-
<i>Volvox</i>	-	-	-	-	ns	-	-	-	p	-	-	-	-
<i>Ulothrix</i>	-	-	-	-	ns	-	p	-	-	-	-	-	-
<i>Microspora</i>	-	-	p	-	ns	a	p	-	-	-	-	p	-
<i>Microthamnion</i>	-	-	-	-	ns	-	-	-	-	-	-	-	p
<i>Stigeoclonium</i>	-	-	-	-	ns	-	-	-	-	-	-	-	c
<i>Oedogonium</i>	-	-	-	-	ns	p	-	-	-	-	-	-	-
<i>Spirogyra</i>	-	p	p	p	ns	c	p	-	p	p	p	v	-
<i>Closterium</i>	-	p	p	-	ns	p	-	-	p	-	c	p	p
<i>Hyalotheca</i>	-	-	-	-	ns	-	-	-	-	-	-	-	p
<i>Tribonema</i>	-	-	-	-	ns	v	-	-	-	c	c	p	-
<i>Vaucheria</i>	-	-	-	-	ns	-	-	-	-	-	c	-	-
<i>Chrysozphaera</i>	-	-	-	-	ns	-	-	-	-	-	p	p	-
<i>Fragilaria</i>	-	p	-	p	ns	c	-	-	-	c	-	-	p
<i>Synedra</i>	-	p	-	-	ns	a	p	-	-	c	-	-	p
<i>Rhoicosphenia</i>	-	-	-	-	ns	a	p	c	-	c	-	p	p

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Gyrosigma</i>	-	-	-	-	ns	c	-	-	-	p	-	p	-
<i>Navicula</i>	-	-	-	-	ns	p	p	-	-	c	-	p	p
<i>Gomphonema</i>	-	-	-	-	ns	-	p	-	-	c	-	-	-
<i>Cymbella</i>	-	p	-	-	ns	p	-	-	p	c	c	p	-
<i>Rhodochorton</i>	-	-	-	-	ns	-	-	-	c	a	-	-	-
<i>Holopedium</i>	-	-	-	-	ns	a	p	-	-	-	-	-	-
<i>Microcystis</i>	-	-	-	-	ns	c	-	-	-	-	-	-	-
<i>Spirulina</i>	-	-	-	-	ns	-	-	-	-	-	p	-	-
<i>Nostoc</i>	p	p	-	-	ns	-	-	-	-	-	-	-	-
<i>Phacus</i>	-	-	-	-	ns	c	-	-	-	-	-	-	-
<i>Chaetophora</i>	p	p	p	-	ns	-	-	-	-	-	-	-	-
<i>Basycladia</i>	-	-	-	-	ns	-	-	-	-	-	p	-	-
<i>Cladophora</i>	-	-	-	-	ns	-	-	-	p	a	c	-	-
<i>Mougeotia</i>	-	-	-	a	ns	-	p	-	-	-	c	-	-
<i>Oscillatoria</i>	p	p	p	-	ns	-	-	-	p	-	-	-	-

Station 11

<i>Volvox</i>	-	-	-	-	-	-	-	p	c	-	-	-	-
<i>Sphaerocystis</i>	-	-	-	-	-	-	-	-	-	-	-	-	p
<i>Ulothrix</i>	p	-	-	-	-	-	-	-	-	-	-	-	-
<i>Microspora</i>	-	-	p	-	-	p	-	-	-	-	-	-	-
<i>Spirogyra</i>	p	p	p	p	p	p	-	p	c	-	-	p	-
<i>Closterium</i>	-	p	p	p	p	-	-	p	c	-	p	p	c

	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
<i>Tribonema</i>	-	p	p	p	-	c	p	-	-	-	-	-	-
<i>Fragilaria</i>	-	-	-	-	-	p	-	-	-	-	-	-	-
<i>Synedra</i>	-	-	-	-	-	a	-	-	-	-	-	-	-
<i>Gyrosigma</i>	-	-	-	-	-	-	-	-	p	-	-	p	-
<i>Cymbella</i>	p	-	-	-	-	-	-	-	p	-	-	p	-
<i>Microcystis</i>	-	-	-	-	-	p	-	-	-	-	-	-	-
<i>Chaetophora</i>	p	-	-	-	-	-	-	-	-	-	-	-	-
<i>Basycladia</i>	-	-	-	-	-	p	-	-	-	-	-	-	-
<i>Cladophora</i>	-	-	-	-	-	-	-	-	-	p	-	-	p
<i>Mougeotia</i>	p	-	-	p	-	p	-	-	-	-	p	-	-
<i>Oscillatoria</i>	p	-	-	-	-	-	-	-	-	-	-	-	-

Note. p = present, c = common, a = abundant,
v = very abundant, ns = no sample taken.

Appendix 2.--Benthos collected from the Salt River, Missouri.

MDC = Missouri Department of Conservation

(Duchrow, 1974), MBG = Missouri Botanical Gar-

den (MBG, 1974a), UMC = University of Missouri-

Columbia (Hazelwood, 1976).

A. BENTHOS COLLECTED IN PAST STUDIES

	MDC	MBG	UMC
Cnidaria			
Hydrozoa			
Hydroida			
Clavidae			
<i>Cordylophora lacustris</i>			x
Hydrida			
<i>Chlorohydra viridissima</i>			x
<i>Hydra</i> sp.			x
Entoprocta			
Urnatellidae			
<i>Urnatella gracilis</i>			x
Ectoprocta			
Gymnolaemata			
Ctenostomata			
Paludicellidae			
<i>Paludicella articulata</i>			x
Phylactolaemata			
Lophopodidae			
<i>Pectinatella magnifica</i>			x
Plumatellidae			
<i>Plumatella</i> sp.		x	x
Platyhelminthes			
Turbellaria			
Tricladida			
Planariidae			
<i>Dugesia</i> sp.	x		
Aschelminthes			
Nematoda	x		x
Nematomorpha			x
Gordiida	x		
Annelida			
Oligochaeta			
Prospora			
Branchiobdellidae	x		x
Lumbriculidae			
<i>Eclipidrilus lacustris</i>		x	
<i>Lumbriculus variegatus</i>		x	

	MDC	MBG	UMC
Plesiopora			
Enchytraeidae			x
Naididae			
<i>Chaetogaster</i> sp.			x
<i>Dero</i> sp.		x	
<i>D. digitata</i>		x	
<i>D. nivea</i>		x	
<i>Nais simplex</i>		x	
<i>Pristina breviseta</i>		x	
<i>Stylaria proboscidea</i>			x
Tubificidae			
<i>Aulodrilus americanus</i>		x	
<i>A. pigueti</i>		x	
<i>Branchiura sowerbyi</i>		x	x
<i>Limnodrilus claparedeianus</i>		x	
<i>L. hoffmeisteri</i>		x	
<i>L. udekemianus</i>		x	x
<i>Peloscolex</i> sp.		x	
<i>P. ferox</i>		x	
<i>Tubifex tubifex</i>		x	x
Hirudinea	x		
Erpobdellidae			
<i>Dina</i> sp.			x
<i>D. microstoma</i>		x	x
<i>Erpobdella (triannulata?)</i>			x
Glossiphoniidae			x
<i>Batrachobdella picta</i>			x
<i>Glossiphonia complanta</i>		x	
<i>Helobdella fusca</i>		x	
<i>H. stagnalis</i>			x
<i>Placobdella parasitica</i>		x	
Mollusca			
Gastropoda			
Pulmonata			
Basommatophora			
Ancyliidae			
<i>Ferrissia</i> sp.	x	x	x
<i>Gundlachia</i> sp.			x
Lymnaeidae			
<i>Lymnaea</i> sp.	x		
<i>L. dalli</i>			x
<i>Stagnicola</i> sp.	x		
Physidae			
<i>Physa</i> sp.	x	x	x
Planorbidae			
<i>Helisoma</i> sp.			x
<i>Promentus</i> sp.	x		
<i>Gyraulus</i> sp.		x	

	MDC	MBG	UMC
Prosobranchia			
Mesogastropoda			
Bulimidae			
<i>Amnicola</i> sp.	x		
Pelecypoda			
Heterodonta			
Sphaeriidae	x		
<i>Musculium</i> sp.			x
<i>Pisidium compressum</i>		x	
<i>Sphaerium</i> sp.		x	x
<i>S. striatinum</i>		x	
Schizodonta			
Unionidae			
<i>Amblema</i> sp.	x		x
<i>A. costata</i>		x	
<i>Anodonta</i> sp.			x
<i>A. grandis</i>	x	x	
<i>Anodontoides</i> sp.			x
<i>Cyprogenia</i> sp.			x
<i>Elliptio</i> sp.			x
<i>Fasconia</i> sp.			x
<i>Lampsilis anodontoides</i>	x		
<i>L. ovata</i>	x		
<i>Lasmingona</i> sp.			x
<i>L. complanata</i>	x	x	
<i>Leptodea fragilis</i>	x		
<i>Ligumia</i> sp.	x		x
<i>L. nasuta</i>		x	
<i>Pleurobema</i> sp.			x
<i>Potamilis alatus</i>	x		
<i>Proptera</i> sp.			x
<i>Quadrula pustulosa</i>	x		
<i>Q. quadrula</i>	x		x
<i>Tritogonia</i> sp.	x		x
<i>Truncilla truncata</i>	x		
<i>Villosa</i> sp.			x
<i>V. lienosa</i>		x	
Arthropoda			
Arachnida			
Hydracarina	x		x
Crustacea			
Amphipoda			
Gammaridae			
<i>Gammarus</i> sp.	x		x
Talitridae			
<i>Hyalella azteca</i>	x		
Isopoda			
Asellidae			
<i>Asellus</i> sp.	x		x
<i>A. stygia</i>			x

	MDC	MBG	UMC
Decapoda			
Astacidae	x		
<i>Cambarus diogenes</i>		x	x
<i>Orconectes rusticus</i>		x	x
<i>O. virilis</i>		x	x
Branchiopoda			
Cladocera			
Daphnidae			
<i>Ceriodaphnia</i> sp.			x
<i>Simocephalus</i> sp.			x
Insecta			
Collembola			
Poduridae			
<i>Podura aquatica</i>			x
Sminthuridae			
<i>Sminthurides</i> sp.			x
Ephemeroptera			
Baetidae			
<i>Baetis</i> sp.	x		x
<i>Centroptilum</i> sp.	x	x	
<i>Pseudocloeon</i> sp.	x		
Caenidae			
<i>Caenis</i> sp.	x	x	x
Ephemeridae			
<i>Hexagenia limbata</i>	x	x	x
Heptageniidae			
<i>Heptagenia</i> sp.	x	x	
<i>Stenacron gildersleevei</i>	x		
<i>S. interpunctatum</i> (gp.)	x		
<i>Stenonema</i> sp.		x	x
<i>S. femoratum</i>	x		
<i>S. fronotale</i>	x		
<i>S. pulchellum</i>	x		
<i>S. tripunctatum</i>	x		
Leptophlebiidae			
<i>Paraleptophlebia</i> sp.	x		
Siphonuridae			
<i>Ameletus</i> sp.			x
<i>Isonychia</i> sp.	x	x	x
<i>Siphonurus</i> sp.	x		
Tricorythidae			
<i>Tricorythodes</i> sp.	x		x
Odonata			
Aeschnidae			
<i>Anax junius</i>		x	
<i>Boyeria</i> sp.	x		
Calopterygidae			
<i>Calopteryx</i> sp.			x
<i>C. maculata</i>		x	
<i>Hetaerina</i> sp.			x
<i>H. americana</i>		x	

	MDC	MBG	UMC
Coenagrionidae			
<i>Argia</i> sp.	x		x
<i>A. moesta</i>		x	
<i>A. tibialis</i>		x	
<i>Enallagma</i> sp.			x
<i>E. praevarum</i>	x		
<i>Ischnura</i> sp.	x		x
<i>I. verticalis</i>		x	
<i>Nehalennia</i> sp.	x		
Gomphidae			
<i>Dromogomphus</i> sp.			x
<i>Gomphus</i> sp.			x
<i>G. crassus</i>			x
<i>G. vastus</i>			x
<i>Ophiogomphus</i> sp.	x		
<i>Frogomphus obscurus</i>			x
Libellulidae			
<i>Brachymesia furcata</i>			x
<i>Celithemis elisa</i>		x	x
<i>Erythemis simplicollis</i>		x	
<i>Libellula cyanea</i>		x	
<i>L. flavida</i>		x	
<i>L. luctuosa</i>		x	x
<i>Plathemis lydia</i>		x	x
<i>Tetragoneuria cynosura</i>	x		
Macromiidae			
<i>Macromia</i> sp.			x
Plecoptera		x	
Nemouridae			
<i>Allocapnia</i> sp.	x		x
<i>Brachyptera</i> sp.	x		
<i>Nemoura</i> sp.	x		
<i>Taeniopteryx nivalis</i>	x		
Perlidae			
<i>Acroneuria arida</i>	x		
<i>Neoperla cymene</i>	x		
<i>Perlesta placida</i>	x		x
Perlodidae			
<i>Isogenus</i> sp.	x		
<i>Isoperla mohri</i>	x		
Hemiptera			
Belostomatidae			
<i>Belostoma</i> sp.			x
Corixidae	x		
<i>Sigara</i> sp.			x
<i>Trichocorixa kanza</i>		x	
Gelastocoridae			
<i>Gelastocoris oculatus</i>			x

	MDC	MBG	UMC
Gerridae			
<i>Gerris</i> sp.		x	x
<i>G. comatus</i>		x	
<i>G. conformis</i>		x	
<i>G. marginalis</i>		x	
<i>G. nebularis</i>		x	
<i>Limnogonus hesione</i>		x	
<i>Rheumatobates rileyi</i>		x	x
<i>Trepobates</i> sp.			x
<i>T. inermis</i>		x	
<i>T. knighti</i>		x	
Hebridae			
<i>Merragata hebroides</i>		x	x
Mesoveliidae			
<i>Mesovelia</i> sp.	x		
<i>M. mulsanti</i>		x	x
Nepidae			
<i>Ranatra</i> sp.			x
Veliidae			
<i>Microvelia</i> sp.	x		x
<i>M. americana</i>		x	
<i>Rhagovelia</i> sp.	x		x
<i>R. obesa</i>		x	
<i>Velia</i> sp.	x		
Coleoptera			
Chrysomelidae			
<i>Donacia</i> sp.	x		
<i>Neohaemonia nigricornis</i>			x
Dryopidae			
<i>Helichus</i> sp.			x
<i>H. lithophilus</i>		x	
Dytiscidae			
<i>Agabetes</i> sp.	x		
<i>Agabinus</i> sp.	x		
<i>Bidessus</i> sp.	x		
<i>Coptotomus</i> sp.			x
<i>Hydroporus</i> sp.	x	x	x
<i>Laccophilus</i> sp.	x		x
<i>L. fasciatus</i>		x	
<i>Thermonectes basilaris</i>		x	
Elmidae			
<i>Dubiraphia</i> sp.	x	x	
<i>D. quadrinotata</i>			x
<i>Macronychus glabratus</i>		x	
<i>Optioservus</i> sp.	x		
<i>Stenelmis</i> sp.	x		x
<i>S. sexlineata</i>		x	x
<i>S. vittipennis</i>		x	x
Gyrinidae			
<i>Dineutus</i> sp.			x
<i>D. assimilus</i>		x	
<i>Gyrinus</i> sp.			x
<i>G. analis</i>		x	

	MDC	MBG	UMC
Haliplidae			
<i>Haliplus</i> sp.	x		x
<i>H. borealis</i>		x	
<i>Peltodytes</i> sp.	x		x
<i>P. edentulus</i>		x	
<i>P. litoralis</i>		x	
<i>P. sexmaculatus</i>		x	
Helodidae	x		
<i>Prionocyphon</i> sp.			x
Heteroceridae	x		
Hydrophilidae			
<i>Berosus</i> sp.	x		x
<i>B. pantherinus</i>		x	
<i>B. striatus</i>		x	
<i>Dactylosternum</i> sp.	x		
<i>Enochrus</i> sp.	x	x	
<i>E. nebulosus</i>			x
<i>Helocombus</i> sp.			x
<i>Helophorus</i> sp.			x
<i>Laccobius</i> sp.	x		
<i>L. agilis</i>		x	x
<i>Paracymus</i> sp.			x
<i>Tropisternus</i> sp.	x		
<i>T. ellipticus</i>			x
<i>T. lateralis</i>		x	x
<i>T. mexicanus</i>		x	x
Psephenidae			
<i>Ectopria</i> sp.	x		
<i>Psephenus</i> sp.	x		
Neuroptera			
Corydalidae			
<i>Corydalus cornutus</i>	x		
Trichoptera			
Hydropsychidae			
<i>Cheumatopsyche</i> sp.	x	x	x
<i>Hydropsyche</i> sp.			x
<i>H. arinale</i>	x		
<i>H. betteni</i>	x		
<i>H. bifida</i> (gp.)	x		
<i>H. cuanis</i>	x		
<i>H. frisoni</i>	x	x	
<i>H. orris</i>	x	x	
<i>H. simulans</i>	x		
<i>H. slossonae</i>	x		
<i>Potamyia flava</i>	x		
Hydroptilidae	x		
<i>Agraylea</i> sp.	x		
<i>Hydroptila</i> sp.			x
<i>Neotrichia</i> sp.			x

	MDC	MBG	UMC
Leptoceridae			
<i>Athripsodes</i> sp.		x	x
<i>A. tarsi-punctatus</i>	x		
Limnephilidae	x		
<i>Limnephilus</i> sp.			x
Philopotamidae			
<i>Chimarra</i> sp.			x
<i>C. obscura</i>	x		
<i>Dolophilus shawnee</i>		x	
Psychomyiidae			
<i>Neureclipsis</i> sp.	x		
<i>Polycentropus</i> sp.			x
<i>Psychomyia</i> sp.	x		x
Rhyacophilidae			
<i>Rhyacophila</i> sp.			x
Diptera			
Ceratopogonidae			
<i>Bezzia/Probezzia</i> sp.	x	x	x
<i>Culicoides</i> sp.	x		
Chaoboridae			
<i>Chaoborus</i> sp.	x		
<i>C. americanus</i>			x
Chironomidae	x		x
<i>Ablabesmyia</i> sp.		x	
<i>Chironomus</i> sp.		x	
<i>C. attenuatus</i>		x	
<i>Clinotanypus pinguis</i>		x	
<i>Corynoneura taris</i>		x	
<i>Cricotopus bicinctus</i>		x	
<i>Cryptochironomus fulvus</i>		x	
<i>Dicrotendipes modestus</i>		x	
<i>D. nervosus</i>		x	
<i>Endochironomus nigricans</i>		x	
<i>Glyptotendipes paripes</i>		x	
<i>Harnischia</i> sp.		x	
<i>Micropsectra</i> sp.		x	
<i>Natarsia</i> sp.		x	
<i>Paralauterborniella</i> sp.		x	
<i>Polypedilum</i> sp.		x	
<i>P. ontario</i>		x	
<i>P. scalaenum</i>		x	
<i>Procladius</i> sp.		x	
<i>P. bellus</i>		x	
<i>Rheotanytarsus</i> sp.		x	
<i>Stenochironomus</i> sp.		x	
<i>Stictochironomus</i> sp.		x	
<i>Tanytarsus</i> sp.		x	
<i>Thienemanniella similis</i>		x	
<i>Tribelos jucundus</i>		x	
<i>Xenochironomus festivus</i>		x	
<i>Zavreliomyia</i> sp.		x	

	MDC	MBG	UMC
Culicidae			
<i>Aedes canadensis</i>		x	
<i>A. vexans</i>		x	
<i>Anopheles punctipennis</i>		x	x
<i>Mansonia perturbans</i>		x	
<i>Psorophora ciliata</i>		x	
<i>P. confinnis</i>		x	
<i>P. horrida</i>		x	
Deuterophlebiidae			
<i>Deuterophlebia</i> sp.	x		
Empididae	x		x
Ephydriidae			
<i>Ephydra</i> sp.			x
Muscidae			
<i>Limnophora</i> sp.	x		
Psychodidae			
<i>Psychoda</i> sp.	x		x
<i>Telmatoscopus</i> sp.		x	
Rhagionidae			
<i>Atherix variegata</i>	x		x
Simuliidae	x		
<i>Simulium</i> sp.		x	x
Stratiomyiidae			
<i>Eulalia</i> sp.	x		
<i>Stratiomyia</i> sp.			x
Tabanidae			
<i>Chrysops</i> sp.	x		x
<i>Chrysozona</i> sp.	x		
<i>Tabanus</i> sp.	x		
Tetanoceridae			
<i>Tetanocera</i> sp.			x
Tipulidae			
<i>Erioptera</i> sp.	x		x
<i>Hexatoma/Eriocera</i>	x		
<i>Pedicia/Dicranota</i>	x		
<i>Tipula</i> sp.	x		x
Total taxa collected	123	131	135

B. BENTHOS COLLECTED: AUGUST 1975 - AUGUST 1976

Cnidaria

Hydrozoa

Hydroida

Hydrida

Chlorohydra viridissima (Pallas)*Hydra* sp.

Entoprocta

Urnatellidae

Urnatella gracilis Leidy

Ectoprocta

Gymnolaemata

Ctenostomata

Paludicellidae

Paludicella articulata (Ehr.)

Phylactolaemata

Lophopodidae

Pectinatella magnifica Leidy

Plumatellidae

Plumatella sp.

Platyhelminthes

Turbellaria

Tricladida

Aschelminthes

Nematoda

Nematomorpha

Annelida

Oligochaeta

Prospora

Branchiobdellidae

Lumbriculidae

Plesiopora

Enchytraeidae

Naididae

Chaetogaster sp.*Stylaris proboscidea* (O.F.M.)

Tubificidae

Branchiura sowerbyi Bedd.*Limnodrilus udekemianus* Clap.*Tubifex tubifex* (O.F.M.)

Hirudinea

Erpobdellidae

Dina sp.*D. microstoma* Moore*Erpobdella (triannulata?)* Moore

Glossiphoniidae

Batrachobdella picta Verrill*Helobdella stagnalis* (Linnaeus)

Mollusca

Gastropoda

Pulmonata

Basommatophora

Ancylidae

Ferrissia sp.*Gundlachia* sp.

Lymnaeidae

Lymnaea dalli Baker

Physidae

Physa sp.

Planorbidae

Helisoma sp.

Pelecypoda

Heterodonta

Sphaeriidae

Musculium sp.*Sphaerium* sp.

Schizodonta

Unionidae

Amblema sp.*Anodonta* sp.

Arthropoda

Crustacea

Branchiopoda

Cladocera

Daphnidae

Ceriodaphnia sp.*Simocephalus* sp.

Amphipoda

Gammaridae

Gammarus sp.

Isopoda

Asellidae

Asellus stygia (Packard)

Decapoda

Astacidae

Cambarus diogenes Girard*Orconectes rusticus* (Girard)*O. virilis* (Hagen)

Insecta

Ephemeroptera

Baetidae

Baetis sp.

Caenidae

Caenis sp.

Ephermeridae

Hexagenia limbata (Upholt)

- Heptageniidae
 Stenonema sp.
 Siphonuridae
 Ameletus sp.
 Isonychia sp.
 Tricorythidae
 Tricorythodes sp.
 Odonata
 Calopterygidae
 Calopteryx sp.
 Coenagrionidae
 Argia sp.
 Enallagma sp.
 Ischnura sp.
 Gomphidae
 Gomphus crassus Hagen
 Libellulidae
 Brachymesia furcata (Hagen)
 Celithemis elisa (Hagen)
 Libellula cyanea Fabricius
 Plathemis lydia Drury
 Macromiidae
 Macromia sp.
 Plecoptera
 Capniidae
 Perlidae
 Perlesta placida (Hagen)
 Hemiptera
 Belostomatidae
 Belostoma sp.
 Corixidae
 Sigara sp.
 Gelastocoridae
 Gelastocoris oculatus (Fabricius)
 Gerridae
 Gerris sp.
 Trepobates sp.
 Hebridae
 Merragata hebroides White
 Mesoveliidae
 Mesovelia mulsanti White
 Nepidae
 Ranatra sp.
 Veliidae
 Microvelia sp.
 Rhagovelia sp.
 Coleoptera
 Chrysomelidae
 Neohaemonia nigricornis Kirby
 Dryopidae
 Helichus sp.

Dytiscidae

- Coptotomus* sp.
- Hydroporus* sp.
- Laccophilus* sp.

Elmidae

- Dubiraphia quadrinotata* Zimm.
- Stenelmis* sp.
- S. sexlineata* Sandn.
- S. vittipennis* Zimm.

Gyrinidae

- Dineutus* sp.
- Gyrinus* sp.

Haliplidae

- Haliphus* sp.
- Peltodytes* sp.

Helodidae

- Prionocyphon* sp.

Hydrophilidae

- Berosus* sp.
- Enochrus nebulosus* (Say)
- Helocombus* sp.
- Helophorus* sp.
- Laccobius agilis* Randall
- Paracymus* sp.
- Tropisternus* sp.
- T. ellipticus* (Leconte)
- T. mexicanus* (Leconte)

Trichoptera

Hydropsychidae

- Cheumatopsyche* sp.
- Hydropsyche* sp.

Hydroptilidae

- Hydroptila* sp.
- Neotrichia* sp.

Leptoceridae

- Athripsodes* sp.

Philopotamidae

- Chimarra* sp.

Psychomyiidae

- Polycentropus* sp.
- Psychomyia* sp.

Diptera

Ceratopogonidae

- Bezzia/Probezzia* sp.

Chaoboridae

- Chaoborus americanus* (Johannsen)

Chironomidae

Culicidae

- Anopheles punctipennis* (Say)

Ephydriidae

- Ephydra* sp.

Rhagionidae

- Atherix variegata* Walker

Simuliidae
 Simulium sp.
Stratiomyidae
 Stratiomyia sp.
Tabanidae
 Chrysops sp.
Tipulidae
 Tipula sp.

Appendix 3.--Fish collected from the Salt River,
Missouri. MDC = Missouri Department
of Conservation (Fajen, 1973), MBG =
Missouri Botanical Garden (MBG, 1974a),
UMC = University of Missouri-Columbia
(Hazelwood, 1976).

	MDC	MBG	UMC
Vertebrata			
Osteichthyes			
Lepisosteidae			
<i>Lepisosteus osseus</i> (longnose gar)	x	x	x
<i>L. platostomus</i> (shortnose gar)	x	x	x
Clupeidae			
<i>Dorosoma cepedianum</i> (gizzard shad)		x	x
Hiodontidae			
<i>Hiodon alosoides</i> (goldeneye)			x
Cyprinidae			
<i>Cyprinus carpio</i> (carp)	x	x	x
<i>Notemigonus crysoleucas</i> (golden shiner)	x	x	x
<i>Semotilus atromaculatus</i> (creek chub)		x	x
<i>Hybopsis x-punctata</i> (gravel chub)		x	x
<i>Phenacobius mirabilis</i> (suckermouth minnow)		x	x
<i>Notropis atherinoides</i> (emerald shiner)		x	x
<i>N. umbratilis</i> (redfin shiner)		x	x
<i>N. dorsalis</i> (bigmouth shiner)		x	x
<i>N. lutrensis</i> (red shiner)		x	x
<i>N. stramineus</i> (sand shiner)		x	x
<i>N. buchhanani</i> (ghost shiner)		x	x

	MDC	MBG	UMC
<i>Pimephales vigilax</i> (bullhead minnow)		x	x
<i>P. notatus</i> (bluntnose minnow)		x	x
<i>P. promelas</i> (fathead minnow)		x	x
<i>Campostoma anomalum</i> (stoneroller)		x	x
Catostomidae			
<i>Ictiobus cyprinellus</i> (bigmouth buffalo)		x	x
<i>I. niger</i> (black buffalo)		x	
<i>I. bubalus</i> (smallmouth buffalo)		x	
<i>Carpionodes carpio</i> (river carpsucker)	x	x	x
<i>C. cyprinus</i> (quillback)	x	x	
<i>Catostomus commersoni</i> (white sucker)		x	x
<i>Hypentelium nigricans</i> (northern hogsucker)	x		
<i>Moxostoma erythrurum</i> (golden redhorse)	x	x	x
<i>M. anisurum</i> (silver redhorse)	x	x	x
<i>M. macrolepidotum</i> (shorthead redhorse)		x	x
Ictaluridae			
<i>Ictalurus melas</i> (black bullhead)			x
<i>I. natalis</i> (yellow bullhead)		x	x
<i>I. punctatus</i> (channel catfish)	x	x	x

	MDC	MBG	UMC
<i>Noturus exilis</i> (slender madtom)		x	x
<i>N. flavus</i> (stonecat)		x	x
<i>Pylodictis olivaris</i> (flathead catfish)	x	x	x
Cyprinodontidae			
<i>Fundulus notatus</i> (blackstripe topminnow)			x
Poeciliidae			
<i>Gambusia affinis</i> (mosquito fish)			x
Percichthyidae			
<i>Morone chrysops</i> (white bass)	x		
Centrarchidae			
<i>Micropterus dolomieu</i> (smallmouth bass)	x	x	x
<i>M. salmoides</i> (largemouth bass)	x	x	x
<i>Lepomis cyanellus</i> (green sunfish)	x	x	x
<i>L. humilis</i> (orangespotted sunfish)	x	x	x
<i>L. macrochirus</i> (bluegill)	x	x	x
<i>Pomoxis annularis</i> (white crappie)	x	x	x
<i>P. nigromaculatus</i> (black crappie)		x	x
Percidae			
<i>Stizostedion vitreum</i> (walleye)	x	x	
<i>S. canadense</i> (sauger)		x	

	MDC	MBG	UMC
<i>Percina maculata</i> (blackside darter)		x	x
<i>P. phoxocephala</i> (slenderhead darter)		x	x
<i>P. caprodes</i> (log perch)			x
<i>Ammocrypta clara</i> (western sand darter)			x
<i>Etheostoma nigrum</i> (johnny darter)		x	x
<i>E. spectabile</i> (orangethroat darter)		x	x
<i>E. flabellare</i> (fantail darter)		x	x
Sciaenidae			
<i>Aplodinotus grunniens</i> (freshwater drum)	x	x	x
Total taxa collected	20	47	48

Appendix 4.--Zooplankton collected from the Salt River,
Missouri, August 1975 to August 1976

Platyhelminthes

Trematoda

furcocercous cercaria

Aschelminthes

Bdelloidea

Monogononta

Filiniidae

Filinia sp.*Pedalia* sp.

Testudinellidae

Testudinella sp.

Notommatidae

Cephalodela sp.

Synchaetidae

Polyarthra sp.

Asplanchnidae

Asplanchna sp.

Brachionidae

Brachionus sp.*Keratella* sp.*Platyias* sp.*Trichotrea* sp.

Unidentified loricate species

Unidentified non-loricate species

Nematoda

Annelida

Oligochaeta

Plesiopora

Enchytraeidae

Naididae

Stylaria proboscidea (O.F.M.)

Unidentified species

Arthropoda

Arachnida

Acarina

Crustacea

Branchiopoda

Cladocera

Sididae

Diaphanosoma brachyurum (Liéven)

Daphnidae

Ceriodaphnia sp.*Daphnia parvula* Fordyce*Scapholeberis aurita* (Fischer)*Simocephalus* sp.

Bosminidae

Bosmina longirostris (O.F. Müller)

Macrothricidae

Ilyocryptus spinifer Herrick
Macrothrix laticornis (Jurine)

Chydoridae

Alona intermedia Sars
Alonella sp.
Chydorus sp.
Leydigia quadrangularis (Leydig)
Pleuroxus hastatus Sars

Ostracoda

Podocopa

Copepoda

Calanoida

Centropagidae

Caligoida

Lernaeidae

Lernaea sp.

Cyclopoida

Cyclopidae

Harpacticoida

Canthocamptidae

Attheyella illinoisensis (S. A. Forbes)

Insecta

Collembola

Poduridae

Podura aquatica L.

Sminthuridae

Sminthurides aquaticus (Bour.)

Ephemeroptera

Caenidae

Caenis sp.

Heptageniidae

Stenonema sp.

Siphonuridae

Ameletus sp.

Isonychia sp.

Hemiptera

Corixidae

Sigara sp.

Veliidae

Microvelia sp.

Trichoptera

Hydropsychidae

Hydroptilidae

Coleoptera

Gyrinidae

Gyrinus sp.

Diptera

Ceratopogonidae

Bezzia/Probezzia sp.

Chaoboridae

Chaoborus americanus (Johannsen)

Chironomidae

Psychodidae

Psychoda sp.

Simuliidae

Simulium sp.

Tipulidae

Tipula sp.

Tardigrada

Eutardigrada

Macrobiotidea

Macrobiotidae

Appendix 5.--Diversity estimates (Shannon's) for the plankton and benthos of the Salt River, Missouri, collected August 1975 to August 1976. H'' = estimate of diversity (\log_{10}), H''' = estimate of diversity (\log_2), N = total number of individuals collected per sample.

A. PLANKTON

	Stations					
	3	4	5	8	10	11
August 1975						
H''	0.69	0.82	0.82	0.92	0.86	0.97
H'''	2.29	2.72	2.72	3.06	2.86	3.22
N	54	109	56	177	49	715
September 1975						
H''	0.63	0.61	0.70	0.40	0.65	1.02
H'''	2.09	2.03	2.33	1.33	2.16	3.39
N	160	309	297	659	2558	103
October 1975						
H''	0.65	0.82	0.85	0.67	0.77	0.90
H'''	2.16	2.72	2.82	2.23	2.56	2.99
N	358	145	277	376	1499	579
November 1975						
H''	0.86	0.79	0.99	0.93	0.76	0.86
H'''	2.86	2.64	3.29	3.09	2.52	2.86
N	3730	181	4709	1409	2269	313
December 1975						
H''	0.80	0.91	0.75	0.76	ns	0.71
H'''	2.65	3.02	2.49	2.52	ns	2.36
N	39	485	38	41	ns	665

	Stations					
	3	4	5	8	10	11
January 1976						
H"	0.49	0.52	0.60	0.58	0.67	0.36
H'''	1.63	1.73	1.99	1.93	2.22	1.19
N	650	1906	414	10	46310	9359
February 1976						
H"	0.81	0.79	0.84	0.97	0.73	0.85
H'''	2.69	2.62	2.79	3.22	2.43	2.82
N	109	303	461	148	178	114
March 1976						
H"	0.65	0.62	0.81	0.52	0.54	0.65
H'''	2.20	2.06	2.69	1.73	1.79	2.20
N	179	417	98	78	82	1171
April 1976						
H"	0.79	0.91	0.88	0.40	0.59	0.88
H'''	2.62	3.02	2.92	1.33	1.96	2.92
N	2093	1645	4182	15629	5700	9331
May 1976						
H"	0.68	0.69	0.85	0.86	0.67	0.61
H'''	2.26	2.29	2.82	2.86	2.23	2.03
N	918	93	913	538	118	373
June 1976						
H"	1.04	0.99	0.93	1.08	0.20	0.83
H'''	3.45	3.29	3.09	3.59	0.66	2.76
N	106	85	285	541	7236	242

	Stations					
	3	4	5	8	10	11
<hr/>						
July 1976						
H''	0.90	0.68	0.53	0.71	0.49	0.91
H'''	2.99	2.26	1.76	2.36	1.63	3.02
N	451	1118	915	137	8100	172
August 1976						
H''	0.87	0.54	0.88	0.62	0.72	0.82
H'''	2.89	1.79	2.92	2.06	2.39	2.72
N	6125	3277	5237	9079	1037	216
<hr/>						

Note. ns = no sample taken.

B. BENTHOS

		Stations					
		3	4	5	8	10	11
August 1975							
H"	1.00	0.47	0.88	0.88	0.81	0.76	
H'''	3.32	1.56	2.92	2.92	2.69	2.52	
N	168	7	227	222	73	39	
September 1975							
H"	0.62	0.92	0.96	1.01	0.65	1.04	
H'''	2.06	3.06	3.19	3.36	2.16	3.45	
N	215	68	82	112	372	29	
October 1975							
H"	1.16	0.98	0.94	1.02	0.66	0.94	
H'''	3.85	3.26	3.12	3.39	2.19	3.12	
N	72	53	82	88	24	46	
November 1975							
H"	0.90	0.65	0.85	0.80	0.69	0.43	
H'''	2.99	2.16	2.82	2.66	2.29	1.43	
N	86	75	95	321	11	385	
December 1975							
H"	0.78	0.88	0.60	0.93	ns	0.65	
H'''	2.59	2.92	1.99	3.09	ns	2.16	
N	140	137	105	343	ns	26	

		Stations					
		3	4	5	8	10	11
January 1976							
H"	0.94	0.84	0.91	1.00	0.94	ns	
H'''	3.12	2.79	3.02	3.32	3.12	ns	
N	71	186	120	145	183	ns	
February 1976							
H"	0.66	0.76	0.75	0.80	0.53	ns	
H'''	2.19	2.52	2.49	2.66	1.76	ns	
N	177	194	107	58	29	ns	
March 1976							
H"	1.00	0.77	0.89	0.81	0.98	0.48	
H'''	3.32	2.56	2.96	2.69	3.26	1.59	
N	122	56	73	89	133	52	
April 1976							
H"	0.97	0.51	0.96	0.89	0.93	ns	
H'''	3.22	1.69	3.19	2.96	3.09	ns	
N	120	145	100	49	112	ns	
May 1976							
H"	0.85	0.52	0.99	0.97	1.05	0.81	
H'''	2.82	1.73	3.29	3.22	3.49	2.69	
N	167	197	76	123	198	49	
June 1976							
H"	0.83	0.41	0.78	0.95	0.78	1.04	
H'''	2.76	1.36	2.59	3.16	2.59	3.45	
N	52	117	82	88	289	42	

	Stations					
	3	4	5	8	10	11
<hr/>						
July 1976						
H''	0.85	0.58	1.17	1.11	0.95	0.77
H'''	2.82	1.93	3.89	3.69	3.16	2.56
N	49	106	110	71	137	13
August 1976						
H''	0.90	0.83	1.08	1.03	0.98	0.89
H'''	2.99	2.76	3.59	3.42	3.26	2.96
N	79	52	165	233	203	36
<hr/>						

Note. ns = no sample taken.

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