PREFACE

This study is part of a larger study involving attempts to destratify Ham's Lake and Arbuckle Reservoir. The surface area of the impoundments are 40 ha and 950 ha, respectively, while the maximum depths are 9.5 and 24 m. Changes were observed in populations of benthic macroinvertebrate and zooplankton with depth in both impoundments before and following attempts to destratify the lakes by pumping surface water to the bottom. Concomitant studies were conducted of changes in physicochemical conditions, algae, and fish. The following personnel assisted in the present project:

Carl Ferraris - Identification of most benthic macroinvertebrates collections, field collections, assistance with design and analysis.

Susan Durham - Research assistant.

Nancy McClintock - Identification of zooplankton samples, field collections.

John Parrish - Identification of two collections on Arbuckle Reservoir, field collections.

Other personnel assisting with field collections, sorting of samples, data calculation, and typing include Alan Gaulke, Mike O'Hara, Jerry Wilhm III, David Parrish, and Debbie Krawczyk.

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INTRODUCTION

Zooplankton and benthic macroinvertebrates are important trophic links between primary producers and higher organisms in many aquatic habitats. The density and distribution of zooplankton are influenced by a number of physicochemical conditions which result in vertical stratification and seasonal variation. Temperature may play a significant role in the distribution of copepods (Pennak 1953) and many cladocera reach maximum development in warmer waters (Hynes 1972). Temperature is clearly an important factor in population succession of rotifers (Wetzel 1975). High temperature may be limiting. Decrease in density of cladocera and copepods during summer has been attributed to temperature (Cowell 1970). Copepods are probably more tolerant of oxygen deficiency than cladocerans (Pennak 1953). Although some species of rotifers may tolerate reduced oxygen concentrations commonly found in the hypolimnion, others are limited in this area during stagnation (Pechlaner 1970). Although cladocera and copepods occur over a wide range in pH, correlations between pH and the composition of rotifer populations has long been recognized (Harring and Myers 1928). Few studies of the relationship between conductivity and density and distribution of zooplankton have been conducted.

The depth distribution of benthic macroinvertebrates is influenced by a number of environmental factors. The dissolved oxygen content of the water adjacent to the bottom was listed as a major limiting factor by Ruttner (1963). Benthic macroinvertebrates differ in their rate of oxygen consumption (Olson and Rueger 1968) and in their ability to withstand anoxic conditions (Walshe 1947, Pennak 1953, Thienemann 1954). A limited benthic fauna in areas below impoundments was attributed to seasonally low oxygen tension (Isom 1971). Dispersal of chironomid larvae from areas of low oxygen concentration has been reported (Bay et al. 1966, Hilsenhoff 1966). Temperature of the water near the bottom is an important factor influencing benthic macroinvertebrates by affecting respiration rates (Berg et al. 1962), glycogen content (Augenfeld 1967), length of the life cycle and emergence (Hilsenhoff 1966), and feeding rates (Hilsenhoff 1967). In addition to changes in temperature and dissolved oxygen with depth, the sediments of a lake or reservoir exhibit considerable longitudinal variation in chemical composition and texture (Welch 1952). The littoral zone contains terrestrial materials that have been modified by wave action, drift materials, and autochthonous organic materials. The sediments of the profundal zone are largely finely divided oozes. Because of the variation in environmental conditions in and over the sediments of a lake from the shore to the depths, considerable longitudinal variation exists in the diversity and abundance of benthic macroinvertebrates. The littoral zone generally supports a greater density and diversity (Muttkowski 1918, Baker 1918, Peterka 1970, Saether 1970). However, dense populations of certain species has been reported in profundal waters containing oxygen (Eggleton 1931, Sublette 1957, Mclachlan and McLachlan 1971).

Destratification and aeration result in changes in the density and distribution of populations of zooplankton and benthic macroinvertebrates (Toetz, Wilhm, and Summerfelt 1972). Artificial destratification extended the vertical depth range of zooplankton in El Capitan Reservoir, California (Fast 1971). Zooplankton density increased following aeration of a small lake in New Mexico (McNall 1971). Cladocera and copepods tended to concentrate more toward the surface during profundal aeration in Lake Bret, Switzerland (Linder and Mercier 1954). In contrast to the above observations, the vertical distribution of zooplankton was not altered significantly by destratification in a small mountain lake (Lackey 1971).

Benthic macroinvertebrates in a eutrophic lake were restricted mostly to the epilimnion prior to aeration and certain species, especially chironomids, invaded the hypolimnion after aeration (Fast 1971). Total density almost doubled. In contrast, destratification resulted in a reduction in the standing crop of benthos, especially microdrile oligochaetes and chironomid larvae, in an oligotrophic lake. Maintaining a montane lake in a destratificated condition the year around did not cause large changes in the benthic assemblage (Lackey 1971). In a sharply stratified reservoir, the macroinvertebrates increased in density and rapidly invaded the profundal zone after destratification (Inland Fisheries Branch 1970). Thus, insufficient and contrasting data exists on the effects of destratification on zooplankton and benthic macroinvertebrates. No data exists on the changes in species diversity as a result of aeration. It is the purpose of the present study to observe changes in density and diversity of zooplankton and benthic macroinvertebrates in a small and a large reservoir as a result of destratification. The following two sections in this report describe variations in Ham's Lake and in Arbuckle Reservoir. These two sections will be followed by a summary and conclusions and by recommendations.

HAM'S LAKE

Description of Lake

Ham's Lake is located in Payne County, Oklahoma, about 8 km W of Stillwater (Figure 1). The lake was built in 1965 by the Soil Conservation Service as a flood detention reservoir. The surface area is 40 ha and the volume is 115 ha-m at spillway level (Steichen 1974). The deepest part in the lake is 9.5 m and the length of the pool is about 1.3 km. The drainage area is 1470 km^2.

Ham's Lake stratifies thermally and chemically. During summer the epilimnion is supersaturated, but dissolved oxygen is depleted below 4 m (Steichen 1974). In 1973, the lake was artificially destratified by pumping surface water to the bottom. Within 2 weeks the lake was thermally destratified, but destratification of dissolved oxygen took longer.

Three stations were established for sampling populations of benthic macroinvertebrates and one for zooplankton sampling (Figure 1). Station 8 is a transect extending from the northwest part of the lake near the shore to the central pool, while Station 1 and 2 are transects in the southeast and southwest areas, respectively. Zooplankton was taken from the central pool at station 6, which is about 100 m northwest of the pump. The station numbers correspond to those used in concomitant studies of the lake.

Materials and Methods

Physicochemical Condition. Physicochemical conditions were not measured during the preliminary study in summer, 1974. In 1975 during the five collections of benthic macroinvertebrates, three measurements each of temperature, dissolved oxygen, and conductivity were made of the bottom

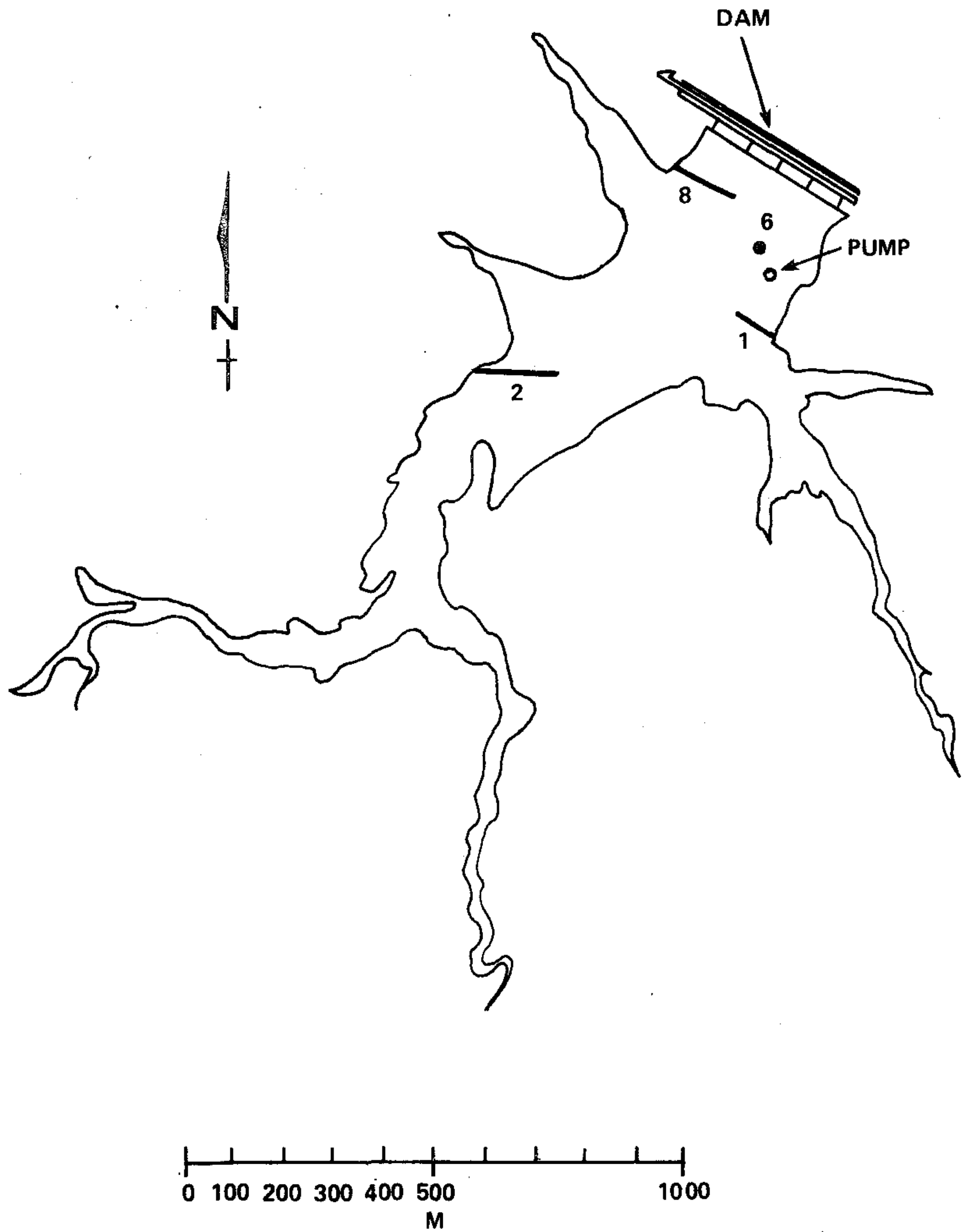

FIGURE 1. HAM'S LAKE SHOWING SAMPLING STATIONS

water at 1 m intervals from 1 to 8 m at Station 8. The bottom sediments at each depth were analyzed for pH. During the five zooplankton collections, three measurements each were made at Station 6 of temperature, dissolved oxygen, light penetration, conductivity, and pH at the surface, and at depths of 2, 4, 6, and 8 m. Temperature and dissolved oxygen were measured with a Yellow Springs Instrument Co. (YSI) Model 54 oxygen meter, which was air calibrated. Light, specific conductance, and pH were measured with a G. M. Manufacturing 268WA300 submarine photometer, a YSI model 33 salinity-conductivity temperature meter, and an Orion model 407 specific ion meter, respectively.

Benthic Macroinvertebrates. Variation with depth of population of benthic macroinvertebrates was studied at the three stations over three time periods during summer, 1974. All samples were taken after pumping began on May 13, 1974. Three samples each were taken with an EKman dredge, at depths of 1, 3, 5, and 8 m from each station on July 13, 1974. Samples were washed in a #30 U.S. standard soil series sieve and preserved in 8% formalin. The time required to sort and identify organisms necessitated reducing the number of samples during the other sampling periods. Since considerable variation existed among replicate samples, replication was not decreased. The number of stations sampled was not reduced since this was a preliminary study of the lake. Thus, during the collections on 30 Jul and 22 Aug 74, the 3 and 5 m depths were combined into a single collecting depth, 4.5m. Identification was to species when possible; otherwise, identification was to the lowest practical taxon. Nomeclature followed Pennak (1953), Brinkhurst and Jamison (1973), and Mason (1793). Identification was aided by material in Usinger (1971), Beck (1968) Beck and Beck

(1966), Brinkhurst (1964, 1965), and Brinkhurst and Cook (1966). Species diversity ($\bar{d}$) of the samples was determined by the equation of Shannon and Weaver (1963),

$$\bar{d} = -\sum_{1}^{s} (n_i/n) \log_2 (n_i/n)$$

n_i = number of individuals in the i'th taxon,

n = total numbers of individuals, and

s = total number of species.

The data collected in summer, 1974, revealed that variation among depths was considerably greater than variation among stations and that considerable variation existed among replicates. In 1975 four samples were taken from each of eight depths at Station 8. The depths were at 1 m intervals from 1 to 8 m and samples were taken on 1 Mar, 21 May, 14 Jun, 10 Jul, and 31 Jul. The latter two samples were taken after pumping operations began on 19 Jun. Samples were sorted and identified as described above.

Zooplankton. Zooplankton was not collected during the 1974 sampling. During 1975 three samples each were taken with a Juday plankton trap from the surface, 2, 4, 6, and 8 m at Station 6. Samples were collected on 12 Apr, 21 May, 12 Jun, 2 Jul, and 3 Aug. Sampling began 5 h after sunrise and were preserved in 5% formalin. In the laboratory a sample was mixed and a 1 ml subsample was withdrawn and transferred to a Sedgwick-Rafter cell. All organisms in the cell were identified and counted. Additional cells were prepared until at least 200 organisms were identified. This was shown to be an adequate sample size for estimating diversity of zooplankton by Kochsiek et al. (1971). Because of time limitations, a maximum of 10 cells were analyzed for any sample. Identification of mature organisms was to the lowest practical taxon using keys and descriptions in Ward and Whipple (1959) and Pennak (1953). Density (D) in organisms per liter was calculated from the formula,

$$D = \frac{(i)\ (c/a)}{f}$$

where,

i = number of individuals counted

c = volume of concentrated sample (in Milliliters),

a = number of Sedgwich-Rafter cells analyzed,

f = liters of water sampled.

Results

Physicochemical Conditions. Temperature, dissolved oxygen, and conductivity of the bottom water and pH of the sediments in Ham's Lake were relatively uniform at different depths at Station 8 on 1 Mar 1975 (Table 1). The concentration of dissolved oxygen decreased considerably at all depths between 1 Mar and 21 May. On 21 May an abrupt decrease in dissolved oxygen occurred between 3 and 4 m while conductivity decreased abruptly between 4 and 5 m. No consistent pattern was observed for pH of the sediments. On 14 Jun, just prior to the beginning of pumping operations, the deep water was almost devoid of oxygen and a considerable decrease in oxygen and temperature occurred between 5 and 6 m. Conductivity decreased slightly with depth. On 10 Jul, about 3 weeks after pumping began, the temperature of the bottom water was relatively uniform at all depths. The sharpest decrease in dissolved oxygen on this date occurred between 1 and 2 m. Between 14 Jun and 10 Jul, oxygen decreased in the shallow waters and increased in the bottom waters possibly as a result of pumping. The decrease in conductivity with depth that was observed on 21 May and 14 Jun was not apparent on 10 Jul.

Table 1. Physicochemical conditions* of the bottom water (ph is of the bottom sediments) over depth at Station 8 during 1975 in Ham's Lake.

Date	Water Depth (m)	Temperature (°C)	Oxygen (mg/l)	Conductivity (umhos)	pH
1 Mar	1	5.7	12.3	203	7.8
	2	5.5	11.8	205	7.5
	3	5.0	11.7	203	7.9
	4	5.4	11.3	201	7.3
	5	5.0	13.1	205	7.4
	6	5.0	9.5	202	7.3
	7	5.1	11.9	208	7.2
	8	5.2	12.5	209	8.0
21 May	1	17.8	7.8	322	6.8
	2	17.5	7.3	318	7.3
	3	17.5	8.0	320	7.3
	4	17.8	3.7	303	7.8
	5	20.4	3.1	215	7.7
	6	20.4	3.3	207	8.0
	7	20.7	3.2	188	7.1
	8	16.2	2.5	216	5.9
14 Jun	1	23.0	7.7	335	6.9
	2	22.5	7.3	330	7.4
	3	22.5	7.0	330	7.6
	4	22.5	6.1	345	7.8
	5	22.5	6.2	340	7.1
	6	19.0	0.2	337	6.8
	7	18.0	0.1	303	7.1
	8	18.0	0.1	305	6.9
10 Jul	1	30.0	6.4	396	6.9
	2	29.0	3.9	410	**
	3	29.0	3.4	432	**
	4	28.5	2.6	419	**
	5	28.5	2.6	419	**
	6	28.5	2.8	420	**
	7	28.5	2.5	420	**
	8	28.0	1.7	447	**
31 Jul	1	**	**	**	**
	2	**	**	**	**
	3	28.2	2.4	**	6.3
	4	28.0	2.5	**	7.5
	5	28.0	2.9	**	7.0
	6	28.0	2.6	**	6.9
	7	28.0	1.3	**	6.5
	*	28.0	2.3	**	7.5

* Values are means of three measurements
** Values not measured

pH was not measured on this date because of a malfunction in the meter. On 31 Jul dissolved oxygen as well as temperature was relatively uniform at all depths and values were similar to those measured on 10 Jul. A dense growth of macrophytes at 1 and 2 m on 31 Jul prevented collecting of samples of benthic macroinvertebrates and thus measurements of temperature and oxygen were not taken on this date. Malfunction of the conductivity meter prevented measurements of this parameter on 31 Jul.

Physicochemical conditions in a water column in the central pool were relatively uniform with depth on 12 Apr (Table 2). By 21 May the lake had stratified and temperature, dissolved oxygen, and conductivity decreased with depth. The largest decrease in temperature and dissolved oxygen occurred between 2 and 4 m, while conductivity decreased abruptly between 4 and 6 m. pH exhibited little vertical variation. On 12 Jun, a marked decrease in temperature and dissolved oxygen occurred between 4 and 6 m, while conductivity decreased sharply between 6 and 8 m. pH was similar at all depths except 6 m. On 3 Jul, about 3 weeks after the pumping started, temperature decreased slightly with depth. Dissolved oxygen decreased abruptly between the surface water and 2 m, but was higher at 6 and 8 m on 3 Jul than on the previous sampling date. Temperature was relatively uniform at all depths on 31 Jul. Although dissolved oxygen tended to decrease with depth, the variation between the surface water and 8 m was only 1.7 mg/l. Conductivity was similar at all depths on the last two sampling dates, while pH decreased with depth. Light intensity decreased abruptly with depth on the three dates it was measured.

Benthic Macroinvertebrates. Seventy-six species were collected from Ham's Lake during the study (Table 3). During the preliminary study, the

Table 2. Physicochemical conditions* at different depths of a water column in the central pool during 1975 in Ham's Lake.

Date	Depth (m)	Temperature (°C)	Oxygen (mg/l)	Conductivity (umhos)	pH	Light Intensity (ua)
12 Apr	Surface	13.2	9.5	297	8.0	**
	2	12.2	9.5	292	7.8	**
	4	12.0	9.1	291	7.8	**
	6	12.0	8.8	292	7.9	**
	8	11.5	8.1	301	7.6	**
21 May	Surface	22.5	7.1	328	6.9	**
	2	22.1	7.0	331	6.9	**
	4	18.4	3.6	320	7.0	**
	6	17.3	3.3	203	7.0	**
	8	16.2	1.2	215	7.0	**
12 Jun	Surface	23.5	7.9	327	8.5	9333
	2	24.0	7.8	331	8.5	182
	4	23.8	7.7	333	8.3	14
	6	19.7	1.8	317	7.7	0
	8	16.5	1.6	269	8.4	0
3 Jul	Surface	30.0	6.8	403	8.1	11,467
	2	27.0	4.1	410	7.8	243
	4	27.0	3.1	410	7.6	75
	6	26.5	2.7	410	7.5	0
	8	26.5	2.3	403	7.5	0
31 Jul	Surface	29.3	4.1	395	8.1	11,333
	2	28.5	3.1	395	7.8	58
	4	28.5	3.1	398	7.6	1
	6	28.0	3.0	400	7.5	0
	8	28.0	2.4	400	7.5	0

* Values are means of three measurements
** Values not measured

shallow waters were characterized by a few common species and many rare species, while the deep waters had one or two abundant species and few rare species (Appendix, Tables A1 - A3). Most of the dominant organisms were midges. At 1 m midges of the genus Procladius were generally the most common invertebrate. The midge Tanytarsus sp. was common at the shallow-water depth of Station 8 and 2, while the midges Chironomus sp. and Tanypus sp. were generally common at Stations 8 and 1. At the middle depths (3, 4.5, 5 m), Procladius sp. was generally the most common taxon, but was less abundant than at 1m. Chironomus sp. and Tanypus sp. tended to increase in density during the summer at the middle of Stations 1 and 2. The mayfly Hexagenia limbata occurred on 13 Jul, and the phantom midge generally was not common at the middle depths. At 8 m considerable change in dominance occurred during the summer. On 13 Jul Chironomus sp. and Tanypus sp. were common, especially at Station 1. These species decreased in abundance and the density of Chaoborus punctipennis increased to extremely large numbers , especially at Station 1. Chironomus sp. was also common at 8 m on 30 Jul and 22 Aug.

Numbers of total species in the preliminary study ranged from 2 to 17 (Table 4). Total numbers of species tended to decrease with depth at all stations. The most abrupt decrease generally occurred between 1 m and the middle depths. Total number of species collected increased slightly with time at 1 m and tended to decrease at 8 m. Variation among stations was considerably less than variation among depths.

Total density ranged from 114 to 4648 individuals/m^2 (Table 5). Density of macroinvertebrates was generally greater in shallow and deep depths than at middle depths. Considerable variation in density existed among stations,

Table 3. Benthic Macroinvertebrates collected in Ham's Lake from July, 1974, to July, 1975.

Coelenterata
- Hydrozoa
  - *Hydra* sp.

Platyhelminthes
- Turbellaria
  - *Dugesia* sp.

Nematoda
  - Unidentifiable species

Annelida
- Oligochaeta
  - *Chaetogaster* sp.
  - *Dero digitata* (Müller)
  - *Nais* sp.
  - *Stylaria lacustris* (Linn.)
  - *Aulodrilus pigueti* Kowalewski
  - *Ilyodrilus* sp.
  - *Limnodrilus hoffmeisteri* Clap.
  - *L. cervix* Brinkhurst
  - *L. claparedianus* Ratzel
  - L. *udekemianus* clap.
  - *Tubifex tubifex* (O.F.M.)
  - Unidentifiable tubificid w/capilliform chaeta
  - Unidentifiable tubificid w/out capilliform chaeta

Arthropoda
- Arachnida
  - Hydracarina spp.
- Crustacea
  - Unidentifiable Astacidae
  - *Hyalella azteca* (Saussure)
- Insecta
  - Ephemeroptera
    - *Hexagenia limbata* (Serville)
    - *Caenis* sp.
    - *Cloeon* sp.
    - *Centroptilum* sp.
    - Unidentifiable Baetidae
  - Odonata
    - *Gomphus* sp.
    - *Epicordulia* sp.
    - *Macromia* sp.
    - *Plathemis* sp.
    - *Somatochora* sp.
    - *Sympetrum* sp.
    - *Ischnura* sp.
    - Unidentifiable Coenagrionidae

Table 3 (Continued)

Arthropoda (continued)
- Megaloptera
  - *Sialis* sp.
- Trichoptera
  - Unidentifiable Leptoceridae
  - *Oecetis* sp.
  - *Polycentropus* sp.
  - *Molanna* sp.
- Coleoptera
  - *Berosus* sp.
  - *Haliplus* sp.
- Diptera
  - Unidentifiable Ceratopogonidae
  - *Chaoborus punctipennis* (Say)
  - *Ablabesmyia* sp.
  - *Anatopynia* sp.
  - *Coelotanypus* sp.
  - *Pentaneura* sp.
  - *Procladius* sp.
  - *Tanypus* sp.
  - Unidentifiable Pentaneurini
  - *Chironomus* sp.
  - *Cryptochironomus abortivus* (Malloch)
  - *Cryptochironomus* sp.
  - *Dicrotendipes* sp.
  - *Endochironomus* sp.
  - *Glyptotendipes* sp.
  - *Goeldichironomus* sp.
  - *Harnischia* sp.
  - *Lauterborniella* sp.
  - *Parachironomus* sp.
  - *Paralauterborniella* sp.
  - *Phaenopsectra* sp.
  - *Polypedilum* sp.
  - *Pseudochironomus*
  - *Stenochironomus* sp.
  - *Stictochironomus* sp.
  - *Tribelos* sp.
  - Chironomini sp. A
  - Chironomini sp. B
  - Chironomini sp. C
  - Chironomini sp. F
  - *Micropsectra* sp.
  - *Rheotanytarsus* sp.
  - *Tanytarsus* sp.
  - *Cricotopus* sp.
  - *Orthocladius* sp.

Table 3 (Continued)

Arthropoda (continued)
Psectrocladius sp.
Chironomid pupae

Mollusca
Pelecypoda
Pisidium sp.
Gastropoda
Gyralus sp.
Physa sp.

Table 4. Number of species* of benthic macroinvertebrates by station and depth during summer, 1974, in Ham's Lake.

Station	Depth (m)	13 Jul	30 Jul	22 Aug
8	1	13	17	16
	3	9	-	-
	5**	7	3	10
	8	4	3	4
1	1	12	12	16
	3	8	-	-
	5**	10	6	9
	8	8	6	7
2	1	9	15	17
	3	9	-	-
	5**	9	7	10
	8	8	2	5

* Values are number of species in three Ekman dredge hauls
** Depth = 4.5 m on 30 Jul and 22 Aug
\- Sample not taken

Table 5. Density (individuals/m^2)* of benthic macroinvertebrates by station and depth during summer, 1974, in Ham's Lake.

Station	Depth (m)	13 Jul	30 Jul	22 Aug
8	1	1032	3341	1792
	3	659	-	-
	5**	315	114	543
	8	114	773	961
1	1	931	832	2810
	3	931	-	-
	5**	501	644	903
	8	1348	1677	4648
2	1	614	1532	716
	3	615	-	-
	5**	759	816	773
	8	445	129	1047

* Values are mean densities of three Ekman dredge hauls.
** Depth = 4.5 m on 30 Jul and 22 Aug.
\- Samples not taken.

Table 6. Species diversity ($\overline{d}$)* of populations of benthic macroinvertebrates by station and depth during summer, 1974, in Ham's Lake.

Station	Depth (m)	13 Jul	30 Jul	22 Aug
8	1	3.2	2.3	3.1
	3	1.8	-	-
	5**	2.6	1.0	2.5
	8	1.7	0.3	0.8
1	1	2.2	2.8	2.9
	3	1.8	-	-
	5**	2.7	1.9	2.5
	8	2.3	0.8	0.5
2	1	2.2	2.8	3.6
	3	2.8	-	-
	5**	2.7	2.0	2.6
	8	2.6	1.0	1.6

* Values are total diversity of three pooled samples
** Depth = 4.5 m on 30 Jul and 22 Aug.
\- Samples not taken.

but no consistent pattern was observed. Density tended to increase over time but this was due largely to the large numbers of Chaoborus at the 8 m depth. Since numbers of species tended to decrease with depth and minimum density occurred at middle depths, it was decided to examine the trends in species diversity.

Species diversity ($\bar{d}$) of populations of benthic macroinvertebrates varied from 0.3 to 3.6 (Table 6). Diversity tended to decrease with depth, although relatively high diversities existed at the middle depths on 13 Jul because of the build-up of a relatively large number of species, none of which were extremely abundant. Diversity was relatively high on 13 Jul at 8 m since the Chaoborus population had not yet increased to large numbers. No consistent pattern existed among stations, but diversity decreased slightly with time despite the increase in numbers of species reflecting the increase in numbers of several populations.

In 1975 three sets of samples were collected from Station 8 before starting the pump and two after. Several trends were observed in the shallow depths. (Appendix, Tables A4 - A8) On 1 Mar the annelid worms Dero digitata, Aulodrilus pigueti, and Ilyodrilus sp. were extremely abundant at 1 m (Appendix, Tables). D. digitata was rare in 1974 and the other two worms were not collected. Although D. digitata decreased in abundance with time, it continued to be the most common organism at 1 m, while the other two organisms were rare. D. digitata was also common at 2 and 3 m and tended to increase in density at 3 m. The midge Procladius sp., which was the most common organism in the shallow depths in 1974, tended to decrease with time at the shallow depths in 1975 and to increase after pumping began. The biting midge, Family Ceratopogonidae, which was rare in 1974 at the 1 m depth of Station 8, was common at the shallow depths, especially 1 m, in March and tended to decrease with time. The phantom midge Chaoborus punctipennis was also common at these depths in March and rare during the remaining times. The midge Tanytarsus sp., which was common in 1974, was common through the 13 Jun sample. The mayfly Hexagenia limbata was generally more common at 2 and 3 m than at 1 m. Sialis sp. was more common in summer than in early samples, while the reverse was true for Hexagenia limbata. Dicrotendipes sp. was abundant at 1 m on 1 Mar, while Stylaria sp. was dense at 2 m on 21 May and at 1 m on 14 Jun. Fewer species were common at the middle depths, 4 and 5 m, than at the shallow-water depths.

In the deeper areas during 1975, Chaoborus sp. was generally the most common invertebrate. The phantom midge was extremely abundant on March 1 and less abundant on other dates. Dero digitata, which was generally the most common organism in shallow water, was common in deeper waters in spring and rare in June and July. Procladius sp. and Ceratopogonidae exhibited a similar trend. They were relatively common on 1 Mar, tended to decrease through the 10 Jul sample, and increased on 31 Jul.

Total number of species taken in 1975 varied from 4 to 30 (Table 7). Numbers of species tended to decrease with depth as in 1974. A marked decrease occurred between 1 and 2 m on all dates and a second abrupt decrease between 2 and 3 m on 1 Mar. Regular changes were not observed for the 2 to 8 m depths in the March and the two May samples; however, a significant difference existed between the 2 to 4 m depths and the 5 to 8 m depths in the July samples. The range was from 10 to 17 and from 3 to 10, respectively. Species numbers tended to decrease with time at 1 m and in deeper waters. At 8 m numbers increased from 4 to 8 between the last two sampling dates.

Table 7. Numbers of species* of benthic macroinvertebrates by depth at station 8 during 1975 in Ham's Lake.

Depth (m)	1 Mar	21 May	14 Jun	10 Jul	31 Jul
1	29	30	25	20	**
2	20	7	13	13	14
3	11	11	11	15	17
4	5	10	11	11	10
5	9	9	5	4	3
6	12	8	4	5	10
7	7	9	4	6	5
8	9	7	5	4	8

* Values are numbers of species in four Ekman dredge hauls
** Samples not taken
Vertical line designates beginning of pumping (i.e. 19 Jun 75)

Table 8. Density (individuals/m^2)* of benthic macroinvertebrates by depth at Station 8 during 1975 in Ham's Lake.

Depth (m)	1 Mar	21 May	14 Jun	10 Jul	31 Jul
1	16639	9240	6038	1079	**
2	3058	1259	605	2465	959
3	1357	2229	1141	1901	2382
4	144	814	453	506	400
5	1013	647	119	194	75
6	2908	496	635	205	593
7	3197	444	851	335	495
8	5878	529	711	506	603

* Values are mean densities of four Ekman dredge hauls
** Samples not taken
Vertical line designates beginning of pumping (i.e. 19 Jun 75)

Table 9. Species diversity ($\bar{d}$)* of populations of benthic macroinvertebrates by depth at Station 8 during 1975 in Ham's Lake.

Depth (m)	1 Mar	21 May	14 Jun	10 Jul	31 Jul
1	3.3	3.0	2.9	3.3	**
2	2.9	2.0	3.0	2.6	2.8
3	2.6	2.6	2.9	3.1	2.3
4	2.0	2.7	3.2	3.0	2.7
5	1.9	2.2	2.2	2.0	1.4
6	1.6	2.8	0.5	1.5	2.6
7	1.5	2.4	0.6	1.5	1.4
8	1.5	2.2	0.6	0.8	2.1

* Values are total diversity of four pooled samples
** Samples not taken
Vertical line designates beginning of pumping (i.e. 19 Jun 75)

Density ranged from 75 to 16,639 individuals/m^2 (Table 8). The maximum was almost twice any other density value and was due largely to segmented worms. Although no consistent pattern between density and depth was observed, minimum density generally occurred in middle depths as was noted in 1974. Maximum density occurred at 1 m on the first three sampling dates. Density tended to decrease with time and the values in summer 1974 and 1975 were similar to each other.

Species diversity ($\bar{d}$) varied from 0.5 to 3.3 (Table 9) which was similar to the range observed in 1974. Diversity generally decreased with depth reflecting the reduction in numbers of species with depth and the large populations of one or two species in deeper areas. Decrease in diversity was not marked in the spring samples; however, a large reduction was observed below 5 m on 14 Jun. The diversity increased in the deeper waters after destratification. Significant changes in diversity over time was not observed at the shallow and middle depths.

Zooplankton. Twenty-five taxa of zooplankton were taken from Ham's Lake during the five time periods (Table 10). Most species were taken from most of the depths and few species were consistently abundant (Appendix, Tables A9-A13). The highest density was the rotifer *Conochilus* sp. at the surface and 2 m depths on 21 May. This plankter was relatively abundant at these depths during the two subsequent sampling periods but rare during the first and last periods. A fairly large concentration of the cladoceran *Ceriodaphnia lacustris* was taken from the shallow depths on 21 May and 12 Jun. Ostracods were relatively common at 2 m on 2 Jul and at 8 m on 3 Aug. The rotifer *Keratella* sp. and the copepod *Diaptomus pallidus* were often common at the surface and at 2 m. The copepod *Mesocyclops edax* and

Table 10. Zooplankton collected in Ham's Lake from April to August, 1975.

Rotifera

Ploima

Brachionus sp.
Kellicottia sp.
Keratella sp.
Lecane sp.
Monostyla sp.
Trichocerca sp.
Asplanchna sp.
Polyarthra sp.
Synchaeta sp.

Flosculariaceae

Filinia sp.
Hexarthra sp.
Conochilus sp.

Unidentifiable species

Arthropoda

Cladocera

Diaphanosoma leuchtenbergianum Fischer
Daphnia ambigua Scourfield
Daphnia parvula Fordyce
Ceriodaphnia lacustris Birge
Bosmina longirostris (O.F. Müller)
Kurzia latissima (Kurz)
Unidentifiable chydoridae

Ostracoda

Unidentifiable species

Copepoda

Diaptomus pallidus (Bottom)
Cyclops bicuspidatus Claus
Mesocyclops edax (S. A. Forbes)
Nauplii
Copepodites

Diptera

Chaoborus sp.

the cladoceran Bosmina longirostris exceeded 10 individual/l at the surface on 12 Jun and at the surface and 2m on 2 Jul. Hexarthra sp., a rotifer, was absent or rare on all dates until 3 Aug and tended to increase in density with depth on that date.

Total number of species varied from five to sixteen (Table 11). The small number of species taken on 12 Apr was probably influenced by low water temperatures. Although a consistent relationship was not noted between depth and number of species as was observed for benthic macroinvertebrates, fewer species were found at 6 and 8 m on 21 May and 12 Jun possibly reflecting the limited oxygen concentrations (Table 2). The number of species increased between 12 Jun and 2 Jul at 4, 6, and 8 m; however, it is not possible to associate this with destratification since the numbers decreased abruptly between 2 Jul and 3 Aug despite little change in oxygen concentration.

Total density ranged from 38 to 503 individuals/l (Table 12). The increase in numbers of species which occurred between 12 Apr and 21 May was accompanied by an increase in density. An abrupt decrease in density occurred between 2 and 4 m on 21 May and between 4 and 6 m on 12 Jun. These decreases were accompanied by concomitant decreases in dissolved oxygen concentration (Table 2). An abrupt decrease occurred between 2 and 6 m on 2 Jul. Although density increased at 6 and 8 m after pumpint started, it decreased between 2 Jul and 3 Aug. Density was relatively uniform over depth on 3 Aug.

Species diversity ($\bar{d}$) of zooplankton varied from 1.5 to 2.9 (Table 13). Although diversity of benthic macroinvertebrates tended to decrease with depth, this pattern was not observed with zooplankton. The abrupt decrease in dissolved oxygen that occurred between 2 and 4 m on 21 May and between

Table 11. Number of species* of zooplankton by depth at Station 6 during 1975 in Ham's Lake.

Depth (m)	12 Apr	21 May	12 Jun	2 Jul	3 Aug
Surface	6	15	13	12	10
2	9	15	15	15	7
4	6	16	13	14	9
6	5	13	10	16	6
8	7	13	11	13**	9**

* Values are numbers of species in three Juday plankton trap samples
(** Only two samples analyzed)
Vertical line designates beginning of pumping (i.e. 19 Jun 75)

Table 12. Density (numbers/1) of zooplankton by depth at Station 6 during 1975 in Ham's Lake.

Depth (m)	12 Apr	21 May	12 Jun	2 Jul	3 Aug
Surface	50	362	229	384	72
2	94	505	299	476	58
4	38	241	267	206	54
6	54	226	75	177	37
8	47	236	68	171**	98**

* Values are mean densities of three Juday plankton trap samples
(** Only two samples analyzed)
Vertical line designates beginning of pumping (i.e. 19 Jun 75)

Table 13. Species diversity ($\bar{d}$)* of populations of zooplankton by depth at Station 6 during 1975 in Ham's Lake.

Depth (m)	12 Apr	21 May	12 Jun	2 Jul	3 Aug
Surface	1.5	1.8	2.1	2.3	2.3
2	2.0	1.9	2.3	2.8	2.4
4	1.9	2.2	2.9	2.9	2.3
6	1.2	2.0	2.8	2.9	2.3
8	1.9	2.3	2.2	2.5**	2.2**

* Values are total diversity of three pooled samples.
(** Only two samples analyzed)
Vertical line designates beginning of pumping (i.e. 19 Jun 75)

4 and 6 m on 12 Jun was not accompanied by a decrease in diversity of zooplankton. No effects of pumping were observed in diversity of zooplankton. Minimum diversity occurred at the surface on three sampling dates, while maximum diversity occurred at 2 to 6 m on all dates except 21 May.

ARBUCKLE RESERVOIR

Description of Reservoir

Arbuckle Reservoir is located in Murray County, Oklahoma, about 9.5 km SW of Sulphur (Figure 2). The lake was impounded in 1967 to serve for municipal water supply, flood control, fish and wildlife, and recreation (Gomez and Grinstead 1973). The surface area is around 950 ha and the volume 8930 ha-m. The deepest point in the lake is over 24 m, and the length of the pool is almost 11 km. The drainage area is 326 km^2.

Three stations were established for sampling population of benthic macroinvertebrates. Station AD is a transect extending from the Rock Creek Arm to the central pool, while Station AE is a transect in the Buckhorn Creek Arm. Station A is located in the central pool near the pump. Zooplankton was taken near Station A. The station designations correspond to those used in concomitant studies of physicochemical conditions, algae, and fish.

Materials and Methods

Physicochemical Conditions. Physicochemical conditions were not measured in 1974. During the five collections of benthic macroinvertebrates in 1975, three measurements each were made of temperature and dissolved oxygen of the bottom water and pH of the bottom sediments at 1, 2, 4, 7, 11, 15, 19, and 24 m at Station AE. Samples were measured as described for Ham's Lake. The percent ash free weight of the bottom sediments was measured at each depth by gravimetric analysis. Samples were dried at 105^{o} C and muffled at 500^{o} C. During the four zooplankton sampling periods, the same variables were measured in the central pool in Arbuckle Reservoir

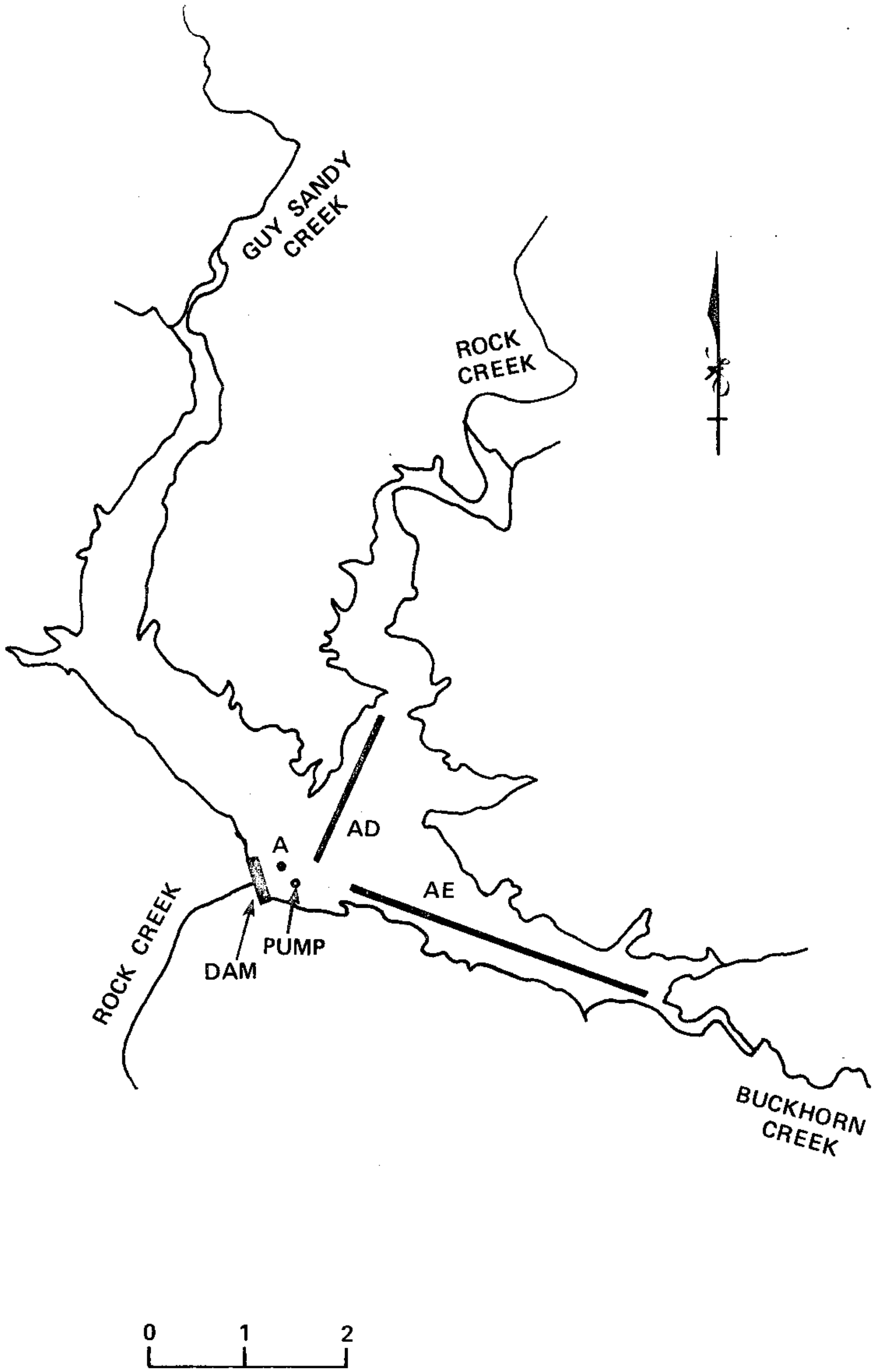

FIGURE 2. ARBUCKLE RESERVOIR SHOWING SAMPLING STATIONS

as in Ham's Lake except light intensity. Samples were taken from the surface and depths of 4, 8, 12, 16, 20, and 24 m.

Benthic Macroinvertebrates. Six samples each were taken with an Ekman dredge from 1, 5, 10, and 15 m from Stations AD and AE and six from the 24 m depth at Station A in 1974. Samples were processed as described for Ham's Lake. Since variation among depths was considerably greater than variation between Stations AD and AE, four samples each were taken from the 1, 2, 4, 7, 11, 15, 19, and 24 m depths at Station AE in 1975. Samples were taken on 25 Jan, 9 May, 22 May, 21 Jun, and 8 Aug. The latter two periods were after pumping operations began on 23 May.

Zooplankton. Zooplankton was not collected during the 1974 sampling. During 1975 three samples each were taken with a Juday plankton trap from the surface 4, 8, 12, 16, 20, and 24 m in the central pool (Station A). Collection times were approximately the same as for benthic macroinvertebrates except no sample was taken on 25 Jan. Samples were preserved and analyzed as described for Ham's Lake.

Results

Physicochemical Conditions. Temperature and dissolved oxygen of the bottom water at different depths from the central pool into the Buckhorn Creek Arm, Station AE, decreased slightly with depth on 25 Jan, while marked differences existed between shallow and deeper depths on subsequent dates (Table 14). Variations in pH and percent ash free weight were not consistent during the study. The concentration of dissolved oxygen decreased considerably at all depths between the first two sampling dates, especially in deeper waters. On May 9 a sudden decrease in oxygen content

Table 14. Temperature and dissolved oxygen of the bottom water and pH and percent ash free weight of the bottom sediments over depth at Station 7 during 1975 in Arbuckle Reservoir.

Date	Water Depth (m)	Temperature	Oxygen (mg/1)	pH	Percent Ash Free Weight
25 Jan	1	7.7	13.2	7.3	0.7
	2	7.0	13.0	7.4	5.6
	4	6.3	12.4	7.1	6.8
	7	6.1	12.2	7.4	6.3
	11	6.4	12.3	7.7	12.7
	15	6.0	12.3	7.2	5.1
	19	6.3	11.7	7.2	4.0
	24	6.5	10.7	6.2	2.0
9 May	1	21.4	9.7	7.0	5.4
	2	21.4	6.5	7.1	9.3
	4	21.0	6.8	7.1	6.9
	7	19.0	4.0	6.9	6.0
	11	18.0	5.5	7.2	1.7
	15	16.6	5.3	6.7	6.1
	19	16.2	3.5	7.0	7.5
	24	12.0	1.5	6.8	9.0
22 May	1	23.0	6.9	7.2	1.9
	2	23.0	5.4	7.3	5.3
	4	21.8	4.3	7.0	7.3
	7	21.1	4.7	7.3	5.8
	11	18.7	3.1	7.0	3.3
	15	16.5	4.4	7.0	8.9
	19	14.3	3.6	6.9	8.6
	24	13.0	1.9	6.9	10.0
22 Jun	1	27.2	7.9	7.6	1.2
	2	26.2	6.9	7.1	4.7
	4	25.3	6.4	7.1	1.9
	7	25.0	5.9	7.4	4.2
	11	23.8	2.3	7.4	2.4
	15	23.0	0.9	7.3	4.2
	19	20.5	0.1	7.1	6.7
	24	18.9	0.1	7.2	7.2
8 Aug	1	30.2	7.1	6.7	5.0
	2	29.3	5.1	6.9	6.9
	4	27.9	0.1	6.9	6.9
	7	26.1	0.1	7.1	6.6
	11	25.2	0.1	7.0	5.3

Table 14. (continued)

Date	Water Depth (m)	Temperature (^oC)	Oxygen (mg/1)	pH	Percent Ash Free Weight
8 Aug	15	25.1	0.1	7.0	5.7
	19	23.6	<0.1	6.8	8.6
	24	23.0	<0.1	6.7	9.4

* Values are means of three measurements.

Table 15. Physicochemical conditions* at different depths of a water column in the central pool during 1975 in Arbuckle Reservoir.

Date	Water Depth (m)	Temperature (°C)	Oxygen (mg/1)	Conductivity (umhos)	pH
9 May	0	24.5	6.1	395	8.4
	4	21.2	1.6	387	8.4
	8	19.0	1.4	361	8.0
	12	17.0	1.4	346	7.9
	16	15.2	1.5	348	7.8
	20	13.0	1.6	331	7.6
	24	12.0	1.5	330	7.7
23 May	0	23.4	8.2	406	8.4
	4	23.1	8.0	409	8.5
	8	21.1	5.2	410	8.1
	12	17.1	3.5	370	7.9
	16	15.9	3.8	350	8.0
	20	14.0	3.8	352	7.4
	24	13.0	1.9	352	7.5
22 Jun	0	26.0	7.3	390	8.5
	4	26.0	7.2	390	8.4
	8	24.1	3.9	390	8.2
	12	22.4	2.2	379	7.9
	16	21.0	0.2	388	8.1
	20	20.4	0.1	382	7.9
	24	18.9	0.1	285	8.0
8 Aug	0	30.1	8.0	410	8.5
	4	27.1	5.1	410	8.4
	8	25.1	<0.1	400	8.2
	12	24.9	<0.1	396	7.9
	16	24.0	<0.1	392	8.1
	20	23.5	<0.1	391	7.9
	24	23.0	<0.1	450	8.0

* Values are means of three measurements.

occurred between the 1 and 2 m depths. Temperature was relatively uniform at the 1 to 4 m depths and decreased progressively below 4 m.

By 22 May decreases in temperature occurred at successive depths below 4 m. The largest decrease in dissolved oxygen between the two sampling dates in May occurred at the 1 m depth. During June and August temperature continued to increase especially in the deeper waters, while dissolved oxygen continued to decrease. Less than 1 mg/l was measured below 11 m on 22 Jun and below 2 m on 8 Aug.

Temperature and dissolved oxygen in a water column in the central pool decreased with depth on all sampling dates (Table 15). Temperature decreased sharply with depth on 9 May. A marked decrease in dissolved oxygen occurred between the surface and 4 m depth and subsequent change was slight. Conductivity and pH decreased slightly with depth on the first three sampling dates. Dissolved oxygen content increased between 9 and 23 May, but by 22 Jun had decreased at all depths especially in deeper waters. Temperature continued to increase during the summer especially at the deeper depths. On 8 Aug less than 1 mg/l of oxygen was measured at all depths below 4 m. Conductivity was relatively uniform at all depths on 8 Aug except for a larger value at 24 m, while pH was similar in waters below 4 m.

Benthic Macroinvertebrate. Ninety-five taxa were collected in Arbuckle Reservoir during the study (Table 16). As was noted in Ham's Lake, one or two common species and many rare species were taken from the 1 m depths and the deeper depths were limited to several abundant species. Tubificids were generally common at 1 m during summer, 1974 (Appendix, Tables A14, A15). The amphipod *Hyalella azteca* was the most numerous invertebrate at 1 m at Station AE on 9 Jul, while the elmid beetle *Dubiraphia* sp. was the most

Table 16. Benthic Macroinvertebrates collected in Arbuckle Reservoir from July, 1974 to July, 1975.

Coelenterata
- Hydrozoa
  - *Hydra* sp.

Platyhelminthes
- Turbellaria
  - *Dugesia* sp.

Nematoda
- Unidentified species

Annelidia
- Hirudinea
  - Unidentified species
- Oligochaeta
  - *Chaetogaster* sp.
  - *Dero digitata* (Müller)
  - *Nais variabilis* Piguet
  - *Slavinia appendictulata* (d'Udekem)
  - *Stylaria lacustris* (Linn.)
  - Unidentifiable Naididae
  - *Aulodrilus pigueti* Kowalewski
  - *A. pleuriseta* (Piguet)
  - *Branchiura sowerbyi* Bedd.
  - *Ilyodrilus templetoni* (Southern)
  - *Limnodrilus cervix* Brinkhurst
  - *L. claparedianus* Ratzel
  - *L. hoffmeisteri* Clap.
  - *L. udekemianus* Clap.
  - *Potomothrix* sp.
  - *Tubifex tubifex* (O.F.M.)
  - Tubificid sp. A
  - Tubificid sp. B
  - Tubificid sp. C
  - Unidentifiable tubificid w/capilliform chaetae
  - Unidentifiable tubificid w/out capilliform chaetae

Arthropoda
- Arachnida
  - Hydracarina sp. A
  - Hydracarina sp. B
  - Hydracarina spp.
- Crustacea
  - *Hyalella azteca* (Saussure)
- Insecta
  - Ephemeroptera
    - *Hexagenia limbata* (Serville)
    - *H. rigida*
    - *Brachycercus* sp.
    - *Caenis* sp.

Table 16 (Continued)

Arthropoda (continued)

- Odonata
  - *Epicordulia* sp.
  - *Gomphus* sp.
  - *Libellula* sp.
  - *Ischnura* sp.
  - Unidentifiable Coenagrionidae
- Megaloptera
  - *Sialis* sp.
- Coleoptera
  - *Dubiraphia* sp.
  - *Haliplus* sp.
  - *Stenelmis* sp.
  - Unidentifiable Elmidae
  - Unidentifiable Hydroporinae
- Trichoptera
  - *Oecetis* sp.
  - Unidentifiable Leptoceridae
  - *Polycentropus* sp.
  - Psychomyiid genus A (Ross)
  - *Neotrichia* sp.
  - *Orthotrichia* sp.
  - Unidentifiable trichopteran A
  - Unidentifiable trichopteran B
- Diptera
  - *Bezzia* sp.
  - Unidentifiable Ceraptopogonidae
  - *Chaoborus punctipennis* (Say)
  - *Ablabesmyia* sp.
  - *Clinotanypus* sp.
  - *Coelotanypus* sp.
  - *Labrundinia* sp.
  - *Procladius* sp.
  - *Tanypus* sp.
  - Unidentified Pentaneurini
  - *Chironomus* sp.
  - *Cryptochironomus* sp.
  - *Dicrotendipes* sp.
  - *Endochironomus* sp.
  - *Glyptotendipes* sp.
  - *Harnischia* sp.
  - *Kiefferulus* sp.
  - *Lauterborniella* sp.
  - *Parachironomus* sp.
  - *Paralauterborniella* sp.
  - *Phaenopsectra* sp.
  - *Polypedilum* sp.
  - *Pseudochironomus* sp.

Table 16 (Continued)

Arthropoda (continued)

- *Stentochironomus* sp.
- *Stictochironomus* sp.
- *Tribelos* sp.
- *Cladotanytarsus* sp.
- *Micropsectra* sp.
- *Rheotanytarsus* sp.
- *Tanytarsus* sp.
- *Diamesa* sp.
- *Chironomini* sp. A
- *Chironomini* sp. B
- *Chironomini* sp. C
- *Chironomini* sp. F
- *Cricotopus* sp.
- *Metrionemus* sp.
- *Orthocladius* sp.
- *Psectrocladius* sp.
- *Trichocladius* sp.
- *Trissocladius* sp.
- Chironomid pupae

Mollusca

- Pelecypoda
  - *Pisidium* sp.
  - *Sphaerium* sp.
  - Unidentified Unionidae
- Gastropoda
  - *Physa* sp.

abundant at Station AD on 7 Aug. *Tanypus* sp. was common at Station AE on 7 Aug. At 5m the midge *Tanypus* sp. was generally abundant in both arms. The benthic assemblage was dominated by the phantom midge, *Chaoborus punctipennis*, at 10 and 15 m and by the tubificid worm *Aulodrilus pigueti* at the 24 m depth (Station A).

Number of species in the preliminary study ranged from two to nineteen (Table 17). As in Ham's Lake number of species tended to decrease with depth, with an abrupt decrease occurring between 1 and 5 m and generally a second sharp decrease between 5 and 10 m. More species were taken on 9 Jul than on 7 Aug.

Density ranged from 321 to 6176 individuals/m^2 (Table 18). The abundance of invertebrates was generally greater in Arbuckle Reservoir than in Ham's Lake. Density tended to increase with depth at Station AD on both sampling dates, while the minimum occurred in the middle depths at Station AE as was observed in Ham's Lake. The 24 m depth supported a large population. Thus, the relationship between density and depth differed at the two stations.

Species diversity ($\overline{d}$) ranged from 0.1 to 3.5 in summer, 1974 (Table 19). Diversity was generally higher in Ham's Lake than in Arbuckle Reservoir. As observed in Ham's Lake, diversity tended to decrease with depth although minimum diversity was observed at 10 m at Station AE on both sampling dates. These low diversities resulted from the dense population of *Chaoborus punctipennis* at 10 m. Diversity decreased with time as was observed for number of species in Arbuckle Reservoir and for diversity in Ham's Lake.

In 1975 three sets of samples were taken from Station A before pumping started on 25 May and two sets following. However, since pumping did not destratify the lake during the study period, the changes in density are due

Table 17. Number of species* of benthic macroinvertebrates by station and depth during summer, 1974, in Arbuckle Reservoir.

Station	Depth (m)	9 Jul	7 Aug
AD	1	16	15
	5	8	11
	10	8	6
	15	3	3
AE	1	19	14
	5	13	12
	10	5	2
	15	4	5
A	24	4	2

* Values are number of species in six Ekman dredge hauls.

Table 18. Density (individuals/m^2)* of benthic macroinvertebrates by station and depth during summer, 1974, in Arbuckle Reservoir.

Station	Depth (m)	9 Jul	7 Aug
AD	1	321	909
	5	1090	1006
	10	2303	3213
	15	3135	6176
AE	1	572	666
	5	495	458
	10	3091	430
	15	3133	3385
A	24	1126	6327

* Values are mean densities of six Ekman dredge hauls.

Table 19. Species diversity ($\bar{d}$)* of populations of benthic macroinvertebrates by station and depth during summer, 1974, in Arbuckle Reservoir.

Station	Depth (m)	9 Jul	7 Aug
AD	1	3.5	3.2
	5	2.0	2.3
	10	1.8	0.3
	15	0.5	0.1
AE	1	3.1	3.2
	5	3.1	2.8
	10	0.6	0.1
	15	0.6	0.7
	Total	2.0	1.9
A			

* Values are total diversity of six pooled samples; totals are of 24 pooled samples.

to seasonal environmental changes. Several species were present in large numbers (Appendix, Tables A16-A20). Stylaria lacustris, which was common in Ham's Lake, was extremely abundant on 25 Jan in Arbuckle Reservoir at 1 and 2 m and tended to decrease with time. Hyalella azteca was abundant at 1 m in winter and in the summer samples. The midge Tanytarsus sp., also common in Ham's Lake, was generally common at the 1 and 2 m depths except in August. At 2 m the midge Chironomini sp. reached a density of 4198 individuals/m^2 on 25 Jan, while the midge Cladotanypus sp. was abundant on the first two sampling dates and the segmented worm Tubifex tubifex on 22 May. During the first three sampling dates, Chironomus sp. was abundant at 2 and 4 m and Coelotanypus at 2, 4, and 7 m. The midge Procladius sp., which was common in spring in Ham's Lake, was generally common at the middle depths in Arbuckle Reservoir except in August.

The lower depths in Arbuckle Reservoir had several extremely abundant species. The segmented worm Aulodrilus pigueti attained a density of over 19,000 individuals/m^2 at 24 m on 9 May. This species was also common in shallower depths on 22 May and 21 Jun. The phantom midge Chaoborus punctipennis, the most common species in deeper waters of Ham's Lake, was abundant in Arbuckle Reservoir on 22 Jan and 8 Aug. A. pigueti and C. punctipennis were commonly collected in deeper water in summer, 1974. Although the segmented worm Dero digitata was common at several shallower depths, it reached especially large numbers at 24 m in May and June in deeper waters. This species was also commin deeper waters in spring in Ham's Lake, but rare in June and July.

Total number of species taken at a particular depth and time in Arbuckle Reservoir during 1975 varied from one to thirty (Table 20).

Table 20. Number of species* of benthic macroinvertebrates by depth at Station AE during 1975 in Arbuckle Reservoir.

Depth (m)	25 Jan	9 May	22 May	21 Jun	8 Aug
1	23	21	26	25	27
2	30	23	22	22	30
4	20	23	14	14	10
7	17	18	16	17	4
11	10	8	9	10	1
15	8	9	15	7	3
19	9	10	12	7	2
24	8	5	10	7	5

* Values are numbers of species in four Ekman dredge hauls.
Vertical line designates beginning of pumping (i.e. 25 May 75)

Table 21. Density (individuals/m^2)* of benthic macroinvertebrates by depth at Station AE during 1975 in Arbuckle Reservoir.

Depth (m)	25 Jan	9 May	22 May	21 Jun	8 Aug
1	5112	2049	7708	2236	2370
2	11580	4853	6834	3164	1615
4	2910	3427	2745	2901	1098
7	1288	2456	1348	1648	2369
11	1507	614	1001	1971	1173
15	2380	745	1444	2400	2563
19	3942	1141	7407	292	1034
24	1819	20689	7333	3497	3111

* Values are mean densities of four Ekman dredge hauls
Vertical line designates beginning of pumping (i.e. 25 May 75)

Table 22. Species diversity ($\bar{d}$)* of populations of benthic macroinvertebrates by depth at Station AE during 1975 in Arbuckle Reservoir.

Depth (m)	25 Jan	9 May	22 May	21 Jun	8 Aug
1	2.8	3.6	3.3	3.4	3.9
2	3.3	3.6	3.1	3.7	4.4
4	2.6	3.6	2.7	2.9	2.1
7	3.0	2.8	2.8	2.9	0.2
11	2.6	1.9	2.6	2.3	0
15	1.4	2.4	3.1	2.0	0.6
19	1.4	2.6	2.3	2.2	0.1
24	0.8	0.4	1.2	1.1	1.2

* Values are total diversity of four pooled samples
Vertical line designates beginning of pumping (i.e. 25 May 75)

This was similar to the range reported in Ham's Lake in 1975. As was observed in the preliminary study, number of species exhibited two sharp decreases, between 2 to 4 m and 7 to 11 m on 25 Jan. However, one significant decrease was noted on subsequent dates; between 7 and 11 m on 9 May and between 2 and 4 m on subsequent dates. Numbers decreased by 20 between 2 and 4 m on 8 Aug. Number of species tended to decrease slightly with time especially in summer at the deeper depths reflecting the almost anoxic conditions.

Density ranged from 292 to 20,689 individuals/m^2 (Table 21). The latter number was due largely to a population of the segmented worm, *Aulodrilus pigueti*. Density was generally greater than in Ham's Lake. Density was not clearly correlated with depth. Minimum diversity occurred at the middle depths, while maximum diversity occurred at 24 m on three sampling dates. Minimum density was observed in middle depths in Ham's Lake. Density tended to decrease with time although no consistent relationship was noted. This trend was also observed in Ham's Lake.

Species diversity ($\overline{d}$) ranged from zero to 4.4, both extremes occurring on 8 Aug (Table 22). The latter value was the highest measured during the entire study in the two lakes. Diversity tended to decrease with depth as was observed for numbers of species. Minimum diversity was measured at the 24 m depths during all time periods except 8 Aug. Diversity was especially low below 4 m on 8 Aug. No consistent relationship was observed between diversity and time.

Zooplankton. Twenty-four taxa of zooplankton were taken from Arbuckle Reservoir during the five time periods (Table 23). Since the lake was not destratified during the study, the trends resulted from seasonal changes.

Table 23. Zooplankton collected in Arbuckle Reservoir from May to August, 1975.

Rotifera

Ploima

Keratella sp.
Trichocerca sp. 1
Trichocerca sp. 2
Asplanchna sp.
Polyarthra sp.
Synchaeta sp.

Flosculariaceae

Filinia sp.
Hexarthra sp.
Conochiloides sp.
Conochilus sp.

Arthropoda

Cladocera

Diaphanosoma leuchtenbergianum (Fischer)
Daphnia ambigua Scourfield
Daphnia parvula Fordyce
Ceriodaphnia lacustris Birge
Bosmina longirostris (O. F. Müller)

Ostracoda

Unidentifiable species

Copepoda

Diaptomus pallidus (Bottom)
Diaptomus siciloides Lillieborg
Tropocyclops prasinus (Fischer)
Cyclops bicuspidatus Claus
Mesocyclops edax (S. A. Forbes)
Harpacticoid copepod
Ergasilus chautauquaensis Fellows
Nauplii
Copepodites

Diptera

Chaoborus sp.

As in Ham's Lake, most taxa were present at most depths and few species were consistently numerous (Appendix, Tables A21-A24). The rotifer *Conochilus* sp. was abundant at the middle depths on 9 May but was rare on all dates in subsequent samples. This species was most abundant in Ham's Lake on 21 May. Although *Keratella* sp. was generally collected throughout the study at all depths, it was most common on 22 May. This rotifer was collected throughout the study in Ham's Lake. A species of the genus *Trichocerca* was common at the surface and 2 m on 22 May and rare on other dates. This species was not taken in Ham's Lake. The cladoceran *Bosmina longirostris* was relatively common in the summer samples.

Number of species varied from three to fourteen (Table 24), which was slightly lower than the range reported for Ham's Lake. As in Ham's Lake no consistent relationship was observed between numbers of species and depth. Minimum numbers generally were collected at the surface, while maximum numbers occurred between 4 and 12 m. Numbers of species did not reflect the limiting oxygen conditions in deeper waters in Arbuckle Reservoir (Table 15).

Density ranged from 27 to 576 organisms/l (Table 25). This was similar to the range for Ham's Lake. A slight tendency existed for density to decrease with depth; however, no apparent relationship existed between density and the measured physicochemical conditions. Density tended to decrease with time.

Species diversity ($\bar{d}$) of zooplankton varied from 1.2 to 3.1 (Table 26). As in Ham's Lake, no relationship was observed between density and depth or between diversity and time. Minimum diversity was measured in the surface sample during three sampling periods.

Table 24. Number of species* of zooplankton by depth at Station A in Arbuckle Reservoir.

Depth (m)	9 May	22 May	21 Jun	8 Aug
Surface	6	9	7	6
4	13	12	12	13
8	14	10	9	11
12	14	15	10	8
16	13	11	11	8
20	9	12	10	3
24	13	9	10	6

* Values are number of species in three Juday plankton trap samples
Vertical line designates beginning of pumping.

Table 25. Density (numbers/l)* of zooplankton by depth at Station A during 1975 in Arbuckle Reservoir.

Depth (m)	9 May	22 May	21 Jun	8 Aug
Surface	39	210	84	30
4	576	200	245	177
8	362	84	127	74
12	231	167	153	43
16	242	142	208	76
20	173	143	99	27
24	178	145	135	35

* Values are mean densities of three Juday plankton trap samples. Vertical line designates beginning of pumping.

Table 26. Species diversity ($\bar{d}$)* of populations of zooplankton by depth at Station A during 1975 in Arbuckle Reservoir.

Depth (m)	9 May	22 May	21 Jun	8 Aug
Surface	1.3	1.8	2.6	1.8
4	1.8	2.3	3.1	3.0
8	1.9	2.0	2.7	2.7
12	1.8	2.8	2.9	2.5
16	1.6	2.3	2.8	2.8
20	1.4	2.6	2.7	1.2
24	2.2	2.4	2.9	1.9

* Values are total diversity of three pooled samples.
Vertical line designates beginning of pumping.

SUMMARY AND CONCLUSIONS

1. Variation with depth of the density and diversity of benthic macroinvertebrates and zooplankton were observed in two Oklahoma reservoirs undergoing destratification attempts. Samples of benthic macroinvertebrates were collected from July, 1974, through August, 1975, while zooplankton sampling began in April, 1975. Concomitant measurements were made of physicochemical variables in 1975. Arbuckle Reservoir has about 24 x the surface area, 3 x the depth, and 78 x the volume of Ham's Lake.

2. Temperature and dissolved oxygen of the water collected near the bottom at different depths during the benthic macroinvertebrate sampling in the two reservoirs were relatively uniform with depth in winter. In spring and summer dissolved oxygen progressively became more limiting in the deeper waters. Dissolved oxygen concentration increased in the bottom waters after pumping began in Ham's Lake, the smaller reservoir. No change was observed in the larger reservoir.

3. The assemblage of benthic macroinvertebrates in both reservoirs generally was composed of a few common species and many rare species in the shallow depths and of a few abundant species in the deeper waters. In Ham's Lake the midge *Procladius* sp. was the most common macroinvertebrate collected at the shallow depths in summer, 1974, while the annelid *Dero digitata* was generally the most common throughout the 1975 sampling program. Although no single species was consistently common in the shallow depths of Arbuckle Reservoir, a number of taxa were abundant during one or more time periods. The phantom midge, *Chaoborus*

punctipennis, was generally abundant in the deeper waters of both reservoirs. The annelid *Aulodrilus pigueti* was often common in the deeper waters of Arbuckle Reservoir.

4. Total number of species of benthic macroinvertebrates generally decreased with depth in both reservoirs. The most abrupt decrease generally occurred between 1 and 2 m in Ham's Lake and at deeper depths in Arbuckle Reservoir. Numbers of species generally increased slightly during summer, 1975, in Ham's Lake and decreased in Arbuckle Reservoir. The physicochemical data suggested that Ham's Lake was destratified during the summer, but that Arbuckle Reservoir was not.

5. Density of benthic macroinvertebrates was slightly greater in Arbuckle Reservoir than in Ham's Lake. No consistent pattern was noted between depth and density in either reservoir.

6. Macroinvertebrate species diversity decreased with depth in both reservoirs. Diversity in Ham's Lake was extremely low at the bottom three depths in June prior to starting the pump and increased during the summer following pumping. No significant change in diversity was observed in Arbuckle Reservoir following pumping. Diversity of benthic macroinvertebrates provided a reasonable indicator of the limiting environment of the deeper areas.

7. Most taxa of zooplankton were collected from most depths. Density or diversity was not consistently related to depth in either reservoir nor did these variables reflect the severe oxygen limitations of deeper waters in summer.

RECOMMENDATIONS

1. Species diversity ($\bar{d}$) of benthic macroinvertebrates appeared to reflect the improvement of the habitat in the deeper waters of Ham's Lake. However, since most of these species have relatively long life cycles, time may not have enabled the build-up of a larger and more diverse assemblage. It would be desirable to prevent stratification in Ham's Lake in spring, 1976, and observe the effects throughout the summer, and compare the results with data collected in 1974 and 1975.

2. Although it is useful to observe the changes at many different depths, a similarity occurred between the various shallow depths, the middle depths, and the deeper depths. Considerable variation existed among replicates at a particular depth. Thus, it is recommended that diversity of benthic macroinvertebrates be examined at fewer depths and a larger number of replications used. Total diversity, obtained by pooling all replicates taken at a particular depth, provides a more useful parameter than diversity of the individual samples.

3. The trends for populations of benthic macroinvertebrates are based on Ekman grab samples. As with most sampling devices, a certain bias is inherent. It would be useful to use additional sampling methods such as exposing Hester-Dendy artificial substrate samples. These could be exposed at different depths and thus provide data on populations inhabiting a common substrate.

4. Glycogen content, haemoglobin, oxygen consumption, feeding rate, emergence, and other functional parameters have been related to various

physicochemical conditions. Since many invertebrates were found at all depths, it would be useful to examine variation in these parameters with depth. These variations have received little attention in the literature.

5. Temperature, dissolved oxygen, and conductivity should continue to be measured in future studies. In addition, it would be useful to examine the organic content of the sediments.

6. Zooplankton density and diversity are highly variable parameters and were not consistently related to depth and variations in physicochemical conditions. I recommend that they not be measured in 1976 in Ham's Lake unless a large amount of money is available to provide a more thorough study.

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Table A1. Density (individuals/m^2) of benthic macroinvertebrates by station and depth in Ham's Lake on July 13, 1974.

	Station 8				Station 1				Station 2			
Depth (m):	1	3	5	8	1	3	5	8	1	3	5	8
Dero sp.		14										14
Aulodrilus pigueti											100	29
Limnodrilus clap.		29					29					14
Tubif. w/cap. ch.									14*			
Tubif. w/out cap. ch.	14*	29*			14*	14*	14*		43*			14*
Hyalella azteca	14											
Hexagenia limbata	72	14	57		43	86			14	172	29	
Caenis sp.					29							
Cloeon sp.					14							
Sialis sp.	72				14	14	29	14	14	57		
Leptoceridae			14	14								
Ceratopogonidae								43	14		258	
Chaoborus punctipen.							43	186	14			29
Coelotanypus sp.			43	14	14	57	43	29	29	14	57	72
Procladius sp.	258	416	86	29	560	602	158	158	229	100	43	86
Tanypus sp.	143			14	100	29	129	416		29	14	29
Pentaneurini	72	43	29				14			129	115	
Chironomus sp.	29	14	43	57	43	86	14	473		57	129	115
Cryptochironomus sp.	14							29			14	
Glyptotendipes sp.	14											
Paralauterborn. sp.	86								43			
Phaenopsectra sp.					29							
Polypedilum sp.	43	14			14	14	14			43		
Stictochironomus sp.	43											
Tribelos sp.					14							
Tanytarsus sp.	158	72	43		43	29	14		186	14		
Cricotopus sp.									14			
Chironomid pupae								14*		14*		43*

* These values included in density totals but not used in determining total number of species or species diversity since they are unidentifiable, immature forms and probably do not represent different species.

Table A2. Density (individuals/m^2) of benthic macroinvertebrates by station and depth in Ham's Lake on July 30, 1974.

	Station 8			Station 1			Station 2		
Depth (m):	1	4.5	8	1	4.5	8	1	4.5	8
Aulodrilus pigueti								14	
Limnodrilus udekemianus							14		
Tubif. w/cap. ch.					14*		14*		
Hyalella azteca							14		
Hexagenia limbata	215						244		
Caenis sp.	14						14		
Baetidae				14					
Epicordulis sp.				86					
Sialis sp.				100		14	72		
Leptoceridae	14								
Chaoborus punctipen.	29	86	731	29	43	1406			57
Coelotanypus sp.			14	14	14	14	43	100	
Procladius sp.	1492	14		316	301		387	459	
Tanypus sp.	230		14	29	100		43	100	
Pentaneurini	43						72	29	
Chironomus sp.	158	14		129	158	215		100	72
Cryptochironomus sp.							14		
Dicrotendipes sp.	14			29					
Glyptotendipes sp.						14			
Goeldichironomus sp.	14						29		
Paralauterborn. sp.	14								
Phaenopsectra sp.				29			57		
Polypedilum sp.	29			43			14		
Pseudochironomus sp.	14								
Stictochironomus sp.							14		
Chironomini sp. A	14								
Chironomini sp. B	14								
Chironomini sp. C	14			14					
Tanytarsus sp.	976				14	14	473	14	
Chironomid pupae	43*		14*				14*		

* See footnote on Table A1.

Table A3. Density (individuals/m^2) of benthic macroinvertebrates by station and depth in Ham's Lake on August 22, 1974.

	Station 8			Station 1			Station 2		
Depth (m):	1	4.5	8	1	4.5	8	1	4.5	8
Nais variabilis	57	57			14		14		
Aulodrilus pigueti		29						72	
Limnodrilus cervix					29	14			
Tubif. w/out cap. ch.	43*				29*	14*			
Astacidae							14		
Hyalella azteca							14		
Hexagenia limbata	72			29			57	14	
Caenis sp.								14	
Epicordulia sp.							14		
Macromia sp.							29		
Somatochora sp.				57					
Sialis sp.	43	14		14			29		
Leptoceridae	14						14		
Polycentropus sp.		14							
Ceratopogonidae	29			86	43	29		14	
Chaoborus punctipen.	14	172	818		43	4362	72	29	674
Anatopynia sp.	14								
Coelotanypus sp.		14		43		43	14	129	86
Pentaneura sp.				14					
Procladius sp.	473	186	14	602	215	43	72	143	57
Tanypus sp.	115		43	789	172	43		14	72
Pentaneurini				43	43				
Chironomus sp.	100	14	86	502	301	100		301	158
Cryptochir. abortivus				14					
C. sp.	43			29			43		
Dicrotendipes sp.	29						72		
Harnischia sp.	86	14		316			14		
Paralauterborn. sp.				29					
Polypedilum sp.				100	14		29		
Pseudochironomus sp.	29								
Tanytarsus sp.	502	29		57			186	43	
Orthocladius sp.	115						29		
Chironomid pupae	14*			86*					14*

* See footnote on Table A1.

Table A4. Density (individuals/m^2) of benthic macroinvertebrates by depth in Ham's Lake on 1 Mar 75.

Taxa	Depth (m) 1	2	3	4	5	6	7	8
Hydra sp.		22						
Dero digitata	4575	506	172		11	108	64	215
Nais sp.	32							
Stylaria lacustris	247	22						
Aulodrilus pigueti	3337				86	161	11	11
Ilyodrilus sp.	1388	11	22					
Limnodrilus cervix.			11					
L. claparedianus	97							
Tubif. w/cap. ch.	118*							
Tubif. w/out cap. ch.	43*	97*	54*	11*				22*
Hydracarina	32	11		11				
Hyalella azteca	527	11						
Hexagenia limbata	22	484	64	64		11		11
Caenis sp.	151	11						
Gomphus sp.		11						
Plathemis sp.	32							
Ischnura sp.	43	43						
Sialis sp.	54	11			11	22		
Oecetis sp.	140	11				11		
Berosus sp.	32							
Ceratopogonidae	2400	355	161					
Chaoborus punctipen.	118	258	355	22	560	1991	2120	4101
Coelotanypus sp.	118	118	11		108	377	549	646
Procladius sp.	312	947	420	22	204	183	334	721
Chironomus sp.	22	22			11	11	22	97
Cryptochironomus sp.		32	22		11	11	97	32
Dicrotendipes sp.	1108							
Paralauterborn. sp.	312							
Polypedilum sp.	97							
Tribelos sp.	54					11		
Micropsectra sp.	108		11			11		
Tanytarsus sp.	883	64	54	14				
Psectrocladius sp.	11				11			22
Pisidium sp.		11						
Gyralus sp.	204							
Physa sp.	22							

* See footnote on Table A1.

Table A5. Density (individuals/m^2) of benthic macroinvertebrates by depth in Ham's Lake on May 21, 1975.

Taxa	Depth (m)							
	1	2	3	4	5	6	7	8
Dugesia sp.	118							
Chaetogaster sp.	125							
Dero digitata	3530	646	700	108	301	108	54	237
Stylaria lacustris	1259					32		
Aulodrilus pigueti	86							
Ilyodrilus sp.	624							
Limnodrilus cervix	43		108	151				
L. claparedianus				11				
Tubif. w/out cap. ch.	32*		172*		11*		11*	
Astacidae	11							
Hyalella azteca	125							
Hexagenia limbata	237	172	441	231	161	86		
Caenis sp.	97							
Centroptilum sp.	11							
Gomphus sp.	11							
Sympetrum sp.	11							
Ischnura sp.	11							
Sialis sp.	22	43	172		11			
Oecetis sp.	11							
Ceratopogonidae	1216	64	377	151	54	75	54	108
Chaoborus punctipen.	11			11			65	86
Ablabesmia sp.	11							
Coelotanypus sp.	32		43	32	11	54	194	43
Procladius sp.	850	258	172	97	65	75	11	22
Chironomus sp.								11
Dicrotendipes sp.	22						11	22
Endochironomus sp.	11							
Harnischia sp.			11	11		22	11	
Lauterborniella sp.					11			
Paralauterborn. sp.	140				11			
Polypedilum sp.	22							
Pseudochironomus sp.							11	

Table A5. (Continued)

Taxa	Depth (m)							
	1	2	3	4	5	6	7	8
Micropsectra sp.	54		11					
Tanytarsus sp.	474	54	11			22	22	
Chironomid pupae	11*	11*				22*		
Pisidium sp.		11	11	11	11			
Gyralus sp.	11							
Physa sp.	11							

* See footnote on Table A1.

Table A6. Density (individuals/m^2) of benthic macroinvertebrates by depth in Ham's Lake on June 14, 1975.

Taxa	Depth (m)							
	1	2	3	4	5	6	7	8
Dugesia sp.	366							
Nematoda	11	11	11					
Chaetogaster sp.	11							
Dero digitata	2400	183	226	54	11	11	22	11
Stylaria lacustris	1141							
Aulodrilus pigueti	75		11					
Limnodrilus hoffmeist.	86		108					
Tubifex tubifex	334			75				
Tubif. w/out cap. ch.	75*		75*	75*	32*			
Hydracarina	11				11			
Astacidae	32							
Hyalella azteca	635							
Hexagenia limbata	86	86	204	43				
Gomphus sp.	11							
Coenagrionidae	11							
Sialis sp.	75	108	237	32				
Molanna sp.	11							
Ceratopogonidae	312	43	129	32	11			11
Chaoborus punctipen.		43		22	22	581	775	646
Ablabesmia sp.	32	11	11	11				
Coelotanypus sp.			43	22		32	22	32
Procladius sp.	64	54	64	22				
Tanypus sp.			22			11	32	11
Dicrotendipes sp.	22							
Harnischia sp.		11						
Parachironomus sp.	32							
Paralauterborn. sp.		11						
Polypedilum sp.	64	11						
Stenochironomus sp.	11							
Tribelos sp.	22							
Rheotanytarsus sp.	108	11		11				
Tanytarsus sp.		22						
Pisidium sp.				54	32			

* See footnote on Table A1.

Table A7. Density (individuals/m^2) of benthic macroinvertebrates by depth in Ham's Lake on July 10, 1975.

Taxa	Depth (m) 1	2	3	4	5	6	7	8
Nematoda		11						
Dero digitata	344	904	527	97	43	32	11	
Limnodrilus cervix			32					
L. hoffmeisteri	11		11					
Tubifex tubifex	97							
Tubif. w/out cap. ch.			215*	43*	11*			11*
Hydracarina	22	11						
Hyalella azteca	11							
Hexagenia limbata		161	140	32		11		
Caenis sp.	11							
Epicordulia sp.	32							
Coenagrionidae	32							
Sialis sp.	129	183	215	32				
Oecetis sp.	11						11	
Halipus sp.	22							
Ceratopogonidae	108	86	32	43		11		32
Chaoborus punctipen.		11	43	43	75	140	226	420
Ablabesmia sp.	22	118	86	11		11		
Coelotanypus sp.	11	11	32	11	54		54	32
Procladius sp.	54	710	388	161	11			
Tanypus sp.			11				22	
Chironomus sp.								11
Dicrotendipes sp.	11							
Harnischia sp.		97						
Parachironomus sp.	11		11					
Paralauterborn. sp.		22						
Phaenopsectra sp.	118							
Polypedilum sp.	11		11	11				
Tribelos sp.	11							
Tanytarsus sp.		140	97	11				
Chironomini sp. F							11	
Chironomid pupae		11*	11*					
Pisidium sp.			43	11				

* See footnote on Table A1.

Table A8. Density (individual/m^2) of benthic macroinvertebrates by depth in Ham's Lake on July 31, 1975.

Taxa	Depth (m) 1	2	3	4	5	6	7	8
Dero digitata	NS	398	1270	151	32	22		11
Aulodrilus pigueti		11	151	11		11		
Limnodrilus cervix			54	11				11
Tubif. w/cap. ch.			11*	43*				
Tubif. w/out cap. ch.			237*					
Hydracarina			11			11		
Hexagenia limbata		22	32					
Caenis sp.			11					
Sialis sp.		64	118	11		118	22	11
Ceratopogonidae			22	43	32	43	54	204
Chaoborus punctipen.		11	22	22	11	140	344	215
Ablabesmia sp.		11	22	11				
Coelotanypus sp.		54	11	32		183	64	118
Procladius sp.		172	248	43		32	11	22
Tanypus sp.		43	11					11
Pentaneurini		11						
Chironomus sp.						22		
Dicrotendipes sp.		11						
Harnischia sp.		86						
Parachironomus sp.								
Paralauterborn. sp.		11						
Polypedilum sp.			32					
Rheotanytarsus			11					
Tanytarsus sp.		54	97	22				
Pisidium sp.			11			11		

NS - Not sampled due to dense growth of aquatic macrophytes.

* - See footnote on Table A1.

Table A9. Density (numbers/l) of zooplankton by depth in Ham's Lake on 12 Apr 75.

Taxa	Depth (m) 0	2	4	6	8
Keratella sp.	11	23	6	18	3
Monostyla sp.	<1	<1			
Asplanchna sp.		<1	<1		
Polyarthra sp.	<1	1		<1	
Filinia sp.			<1		
Diaphanosoma leuch.					1
Daphnia ambigua		6	2	3	15
Daphnia parvula	1	2			1
Ceriodaphnia lacustris	<1	<1			
Bosmina longirostris			<1		
Nauplii	30*	40*	23*	22*	21*
Ostracoda		<1		<1	2
Diaptomus pallidus	2	10	4	3	2
Mesocyclops edax					<1
Copepodites	4*	10*	3*	7*	1*

* These values included in density totals but not used in determining total number of species or species diversity since they are unidentifiable, immature forms and probably do not represent different species.

Table A10. Density (numbers/1) of zooplankton by depth in Ham's Lake on 21 May 75.

Taxa	Depth (m) 0	2	4	6	8
Kellicottia sp.			<1		
Keratella sp.	9	6	14	12	13
Lecane sp.	1	<1		<1	
Monostyla sp.		3	1		<1
Asplanchna sp.	4	8	2	2	2
Polyarthra sp.	8	7	2	2	1
Filinia sp.			<1		
Conochilus sp.	215	291	92	81	73
Daphnia ambigua	3	5	2	2	4
Daphnia parvula	<1	2	<1		1
Ceriodaphnia lacustris	27	53	20	13	13
Diaphanosoma leuch.	12	7	7	2	4
Bosmina longirostris	7	4	3	1	3
Kurzia lattisima	<1				
Ostracoda	4	13	5	7	24
Nauplii	48*	58*	63*	69*	72*
Diaptomus pallidus	12	19	6	3	2
Cyclops bicuspidatus	2	3	1	<1	
Mesocyclops edax	<1	7	2	<1	1
Copepodites	9*	18*	20*	26*	23*

* See footnote on A9.

Table A11. Density (numbers/l) of zooplankton by depth in Ham's Lake on 12 Jun 75.

Taxa	Depth (m) 0	2	4	6	8
Branchionus sp.				<1	
Keratella sp.	2	3	2	3	1
Monostyla sp.	1	<1			
Asplanchna sp.	2	3	3		<1
Polyarthra sp.	5	9	11	1	1
Synchaeta sp.			<1		
Hexarthra sp.		<1	<1		
Conochilus sp.	39	93	25	8	
Unident. rotifer		<1			
Diaphanosoma leuch.	1	<1	5	<1	<1
Daphnia ambigua	<1	<1	1		<1
Daphnia parvula					
Ceriodaphnia lacustris	98	98	36	11	21
Bosmina longirostris	9	12	7	2	2
Chydoridae	<1	2			
Ostracoda	3	10	6	7	6
Nauplii	25*	28*	93*	25*	15*
Diaptomus pallidus	6	10	30	3	3
Mesocyclops edax	12	10	13	4	2
Copepodites	24*	19*	33*	10*	15*
Chaoborus					<1

* See footnote on A9.

Table A12. Density (numbers/l) of zooplankton by depth in Ham's Lake on 2 Jul 75.

Taxa	Depth (m) 0	2	4	6	8
Keratella sp.	33	16	10	4	6
Lecane sp.		1		<1	<1
Trichocerca sp.	4	2	<1	1	
Polyarthra sp.	7	5	2	<1	3
Filinia sp.	2	<1		<1	<1
Hexarthra sp.			2	<1	2
Conochilus sp.	157	88	29	26	35
Unident. rotifer	6	10	5	2	
Diaphanosoma leuch.	1	11	11	10	11
Daphnia ambigua	<1	2	<1	2	<1
Daphnia parvula		1	<1	<1	
Ceriodaphnia lacustris	18	16	6	5	5
Bosmina longirostris	28	19	3	6	2
Ostracoda	22	62	12	12	17
Nauplii	73*	164*	83*	75*	73*
Diaptomus pallidus	12	13	4	1	<1
Cyclops bicuspidatus					<1
Mesocyclops edax		6	<1	<1	
Copepodites	20*	61*	38*	31*	17*

* See footnote on Table A9.

Table A13. Density (numbers/l) of zooplankton by depth in Ham's Lake on 3 Aug 75.

Taxa	Depth (m) 0	2	4	6	8
Branchionus sp.	<1				
Keratella sp.	16	2	9	4	9
Trichocerca sp.	1		<1		<1
Asplanchna sp.			<1		
Polyarthra sp.	3	6	3	3	4
Filinia sp.	2		<1	2	5
Hexarthra sp.	12	13	16	7	25
Conochilus sp.	1	2			<1
Ceriodaphnia lacustris	<1		2		
Diaphanosoma leuch.	1	2	<1	2	6
Ostracoda	<1	15	14	8	35
Nauplii	30*	12*	6*	10*	11*
Diaptomus pallidus		2			<1
Copepodites	3*	4*	1*	<1*	3*

* See footnote on Table A9.

Table A14. Density (individuals/m^2) of benthic macroinvertebrates by station and depth in Arbuckle Reservoir on July 9, 1974.

	Station AD				Station AE				Station A
Depth:	1	5	10	15	1	5	10	15	24
Hirudinea	7								
Stylaria sp.	7								
Naidadidae									7
Aulodrilus pigueti			50			50		294	768
A. pleuriseta				22					50
Branchiura sowerbyi		36	36		7				
Limnodrilus hoffmeist.	7								
Potomothrix sp.				72					
Tubif. w/cap. ch.	7*		22*		7*				
Tubif. w/out cap. ch.	100*				14*			114*	
Hyalella azteca	29				208				
Hexagenia sp.						7			
Brachycercus sp.						7			
Caenis sp.	7								
Ischnura sp.	7				14				
Sialis sp.	7		7						
Leptoceridae					29	43			
Polycentropus sp.	50								
Companif. trichopteran					14				
Ceratopogonidae	7								
Chaoborus punctipen.	7	538	1212	940	7	43	2819	2654	265
Coelotanypus		144	265		29	172	29	64	
Procladius sp.	29	50	29		22	29	64	7	
Tanypus sp.		272	646			22	165		
Pentaneurini					7				
Chironomus sp.			36			7	14		
Cryptochironomus sp.	7	7			7	22			
Dicrotendipes					7				
Endochironomus sp.					36				
Glyptotendipes sp.					7				
Polypedilum sp.						14			
Pseudochironomus sp.	22								
Stentochironomus sp.		7							

Table A14. (Continued)

Depth:	Station AD 1	5	10	15	Station AE 1	5	10	15	Station A 24
Stictochironomus sp.	7								
Chironomini sp. A					7	22			
Chironomini sp. B					7				
Micropsectra sp.	7				7	57			
Tanytarsus sp.		29			122				
Psectrocladius sp.					7				
Chironomid pupae		7*							36*
Unionidae					7				
Physa sp.	7								

* These values included in density totals but not used in determining total number of species or species diversity since they are unidentifiable, immature forms and probably do not represent different species.

Table A15. Density (individuals/m^2) of benthic macroinvertebrates by station and depth in Arbuckle Reservoir on August 7, 1974.

	Station AD				Station AE				Station A
Depth:	1	5	10	15	1	5	10	15	24
Aulodrilus pigueti						7		179	5674
Branchiura sowerbyi	136	7			186	7	7	7	
Ilyodrilus templetoni	57		7	43				136	
Limnodrilus hoffmeist.	22								
Tubificid sp. A	86 *								
Tubif. w/cap. ch.	7*								
Tubif. w/out cap. ch.	186				115*			43*	7*
Hyalalla azteca	22								
Hexagenia limbata		22							
Gomphus sp.						7			
Sialis sp.					7				
Dubiraphia sp.	200								
Leptoceridae						14			
Polycentropus sp.	57				50				
Chaoborus punctipen.		194	3063	6076	7	108	423	3006	646
Coelotanypus sp.	14	165	122	57	43	100		14	
Procladius sp.	7	115			14	43			
Tanypus sp.		438	7		108	115			
Pentaneurini	29	7			14				
Chironomus sp.		7	7			14			
Cryptochironomus sp.	22				22				
Dicrotendipes sp.	7					7			
Harnischia sp.	7	22				7			
Paralauterborn. sp.					14				
Polypedilum sp.					14				
Pseudochironomus sp.	7								
Tanytarsus sp.	43	22			29	29			
Orthocladius sp.					29				
Unionidae		7	7		14				

* See footnote on Table A14.

Table A16. Density (individuals/m^2) of benthic macroinvertebrates by depth in Arbuckle Reservoir on 25 Jan 1975.

Taxa	Depth (m) 1	2	4	7	11	15	19	24
Hydra sp.		269		22		32	11	11
Hirudinea				43				
Dero digitata	75	75		32	97	11	22	64
Nais variabilis	97							
Slavinia append.	43							
Stylaria lacustris	2379	1420	32	11				
Aulodrilus pigueti		452	86	64			430	43
Branchiura sowerbyi			22					
Ilyodrilus temp.		32						
Limnodrilus clap.							11	
Tubifex tubifex		108	22					
Tubif. w/cap. ch.	64*	75*	11*				118*	
Tubif. w/out cap. ch.	54*	194*		11*			43*	
Hyalella azteca	807	43		11				
Hydracrina sp. A								11
Hydracrina sp. B		11						
Hexagenia limbata		97	22				32	
H. rigida	11	75						
Caenis sp.	75	11	22					
Dubiraphia sp.	11	11						
Stenelmis sp.		22						
Hydroporinae		11						
Oecetis sp.	86	43	129	97	86	11		
Psychomyiid genus A		43						
Neotrichia sp.			11					
Orthotrichia sp.				11				
Bezzia sp.	11	32	11					
Chaoborus punctipen.			22	11	323	1690	2777	1615
Clinotanypus sp.				11				
Coelotanypus sp.	11	753	829	398	172	140	22	
Procladius sp.	54	527	1152	377	560	334	140	32

Table A16. (Continued)

Taxa	Depth (m) 1	2	4	7	11	15	19	24
Tanypus sp.			11					
Chironomus sp.		226	258	75	172	151	336	32
Cryptochironomus sp.	75	172		22	32			
Dicrotendipes sp.	161	54	11					
Endochironomus sp.	11							
Paralauterborn. sp.	54	151						
Polypedilum sp.		43	22	35				
Stictochironomus sp.					22			
Tribelos sp.		11						
Chironomini sp. A		4198						
Cladotanytarsus sp.	215	990	32					
Micropsectra sp.			11					
Rheotanytarsus sp.	237							
Tanytarsus sp.	355	527	11	35	32			
Orthocladius sp.	118							
Psectrocladius sp.					11			
Trichocladius sp.	11							
Trissocladius sp.	75	140						
Sphaerium sp.	22	764	183	22		11		
Physa sp.								11

* See footnote on Table A1.

Table A17. Density (individuals/m^2) of benthic macroinvertebrates by depth in Arbuckle Reservoir on 9 May 75.

Taxa	Depth (m) 1	2	4	7	11	15	19	24
Hirudinea				11				
Dero digitata	86	140	86	22	280	151	204	1098
Slavina append.	11							
Stylaria lacustris	280	215		32	11			
Aulodrilus pigueti		22	108	11	11	258	75	19,203
Branchiura sowerbyi				43		11		
Ilyodrilus templetoni		43	22					
Limnodrilus clap.				21			54	
L. hoffmeisteri	32			43			11	
Tubifex tubifex		108	22	108				
Tubif. w/cap. ch.	97*	409*	194*	366*	54*	11*		22*
Tubif. w/out cap. ch.	194*	215*	151*	151*	75*	22*		43*
Hexagenia limbata		11	64	64			11	
Libellula sp.	11	11						
Sialis sp.		32	32					
Dubiraphia sp.	11	43	22	11				
Oecetis sp.			32		11			
Psychomyiid genus A	22	11						
Bezzia sp.	54	32	32					
Chaoborus punctipen.			161	97	32	22	151	97
Coelotanypus sp.	11	441	506	506		32	129	
Procladius sp.	54	301	614	775	97	151	409	204
Chironomus sp.	409	377	248	86		43	64	11
Cryptochironomus sp.	64		22		11	11		
Dicrotendipes sp.				11				
Harnischia sp.	43	172	291	43			11	
Polypedilum sp.	215	301	323		32			
Stenochironomus sp.			11	11				
Stictochironomus sp.	22							
Cladotanytarsus sp.	76	1119	54					
Micropsectra sp.	22	11	11					
Rheotanytarsus sp.			11					

Table A18. Density (individuals/m^2) of benthic macroinvertebrates by depth in Arbuckle Reservoir on 22 May 75.

Taxa	Depth (m) 1	2	4	7	11	15	19	24
Hydra sp.				22				
Dugesia sp.	11							
Hirudinea				11				
Chaetogaster sp.	11							
Dero digitata	581	753	22	32	43	64	1658	5221
Nais variabilis	194							
Slavina append.		11						
Stylaria lacustris	387	65		32	11	11	32	
Aulodrilus pigueti	463	2497	441	549	54	108	1378	1712
Branchiura sowerbyi		11			22			
Limnodrilus clap.								11
L. hoffmeisteri	22	32						32
Tubifex tubifex	151	549	75				657	32
Tubif. w/out cap. ch.	323*	32*					3025*	237*
Hyalella azteca	43							
Hexagenia limbata		11		11		43		
Gomphus sp.	11							
Caenis sp.	11							
Oecetis sp.	43			54				
Polycentropus sp.				22				
Sialis sp.			11					
Ceratopogonidae	32		11				11	22
Chaoborus punctipen.			22		215	151	97	11
Ablabesmia sp.	32							
Coelotanypus sp.		32	807	269	258	269	75	
Procladius sp.	237	420	86	75	247	377	377	22
Tanypus sp.		11	430				11	
Pentaneurini	54							
Chironomus sp.		689	678	65	118	226	32	11
Cryptochironomus sp.	118	86				11		11
Dicrotendipes sp.	226	43				22		
Glyptotendipes sp.	43							
Harnischia sp.	54	43			22			

Table A18 (Continued)

Taxa	Depth (m)							
	1	2	4	7	11	15	19	24
Parachironomus sp.		11				32		
Paralauterborn. sp.	118	22						
Phaenopsectra sp.						11		
Polypedilum sp.	172	204	43	22				
Rheotanytarsus sp.	3757	279	11	11				
Tanytarsus sp.	474	861	22	22		22	22	
Chironomini sp. F	21	43				86		
Metrionemus sp.	11							
Chironomid pupae	108*	32*			11*			11*
Pisidium sp.		97	86	129				
Sphaerium sp.				22		11	32	

* See footnote on Table A1.

Table A19. Density (individuals/m^2) of benthic macroinvertebrates by depth in Arbuckle Reservoir on 21 Jun 1975.

Taxa	Depth (m)							
	1	2	4	7	11	15	17	24
Hydra sp.				11				
Hirudinea	11			32				
Stylaria lacustris		11						
Slavinia append.	64							
Dero digitata	43	247	291	64	872	850	97	2540
Nais variabilis	64	11						
Aulodrilus pigueti	86	344	506	624	54	215	22	764
Branchiura sowerbyi		22						
Limnodrilus cervix								11
L. hoffmeisteri								32
Tubifex tubifex	11	75	140	64	22	1001		43
Tubif. w/cap ch.		172*						
Tubif. w/out cap. ch.	118*	21*	684*		11*	32*		32*
Hydracarina sp. A				22				
Hyalella azteca	527							
Hexagenia limbata		11	11		11			
Gomphus sp.	21							
Halipus sp.	11							
Oecetis sp.		32		22				
Psychomyiid genus A	118							
Ceratopogonidae	11	11		11				
Chaoborus punctipen.	32		43	11	280	108	118	64
Ablabesmia sp.	172	97		22				
Coelotanypus sp.		194	75	22	86		11	11
Procladius sp.		452	570	334	452	97	11	
Tanypus sp.			344	11	86	22		
Chironomus sp.		64	118	32	75	75	22	
Cryptochironomus sp.	75	151	22					
Dicrotendipes sp.	11							
Harnischia sp.		11						
Kiefferulus sp.	11							
Parachironomus sp.	11		11					
Paralauterborn. sp.	11	11						

Table A19. (Continued)

Taxa	1	2	4	7	11	15	17	24
Phaenopsectra sp.	32							
Polypedilum sp.	32	86	11		11			
Pseudochironomus sp.	11	11						
Micropsectra sp.	183	161	11	75				
Tanytarsus sp.	527	334						
Chironomini sp. A	32	280		43				
Cricotopus sp.	11							
Chironomid pupae				11*	11*			
Pisidium sp.		355	64	237				
Sphaerium sp.							11	

* See footnote on Table A1.

Table A 20. Density (individuals/m^2) of Benthic Macroinvertebrates by depth in Arbuckle Reservoir on 8 Aug 75.

Taxa	Depth (m) 1	2	4	7	11	15	19	24
Dugesia sp.	43	22						
Nematoda		22						
Hirudinea		22						
Dero digitata	172	97	11					32
Nais variabilis	22							
Stylaria lacustris	140	11				11		
Aulodrilus pigueti	140	64	43			366	22	2131
Branchiura sowerbyi	54	43		11				
Limnodrilus hoffmeist.	11							22
Tubifex tubifex	11	22	11					108
Tubif. w/out cap. ch.	398*	54*				86*	11*	43*
Hyalella azteca	452	75						
Caenis sp.	43	32						
Epicordulia sp.	11							
Coenagrionidae	11							
Elmidae		11						
Oecetis sp.	118	22						
Psychomyiid genus A		204						
Chaoborus punctipen.		64	215	2325	1173	2120	1001	775
Ceratopogonidae		11						
Ablabesmia sp.	75	43						
Coelotanypus sp.	226	118	32	22				
Labrundinia sp.	22							
Procladius sp.	86	32	527					
Tanypus sp.	11		226	11				
Pentaneurini	22							
Chironomus sp.	11							
Dicrotendipes sp.	86	86						
Glyptotendipes sp.	32	11						
Harnischia sp.		11						
Lauterborniella sp.		11						
Parachironomus sp.	54	11	11					

Table A 20. (Continued)

Taxa	Depth (m) 1	2	4	7	11	15	19	24
Phaenopsectra sp.	54	32						
Polypedilum sp.		43						
Micropsectra sp.	11	97	11					
Tanytarsus sp.		86						
Chironomini sp. A		64						
Trichocladius sp.	11							
Chironomid pupae		32*						
Pisidium sp.	43	151	11					
Sphaerium sp.		11						

* See footnote on Table A1.

Table A21. Density (numbers/l) in Arbuckle Reservoir on 9 May 75.

Species	Depth (m) 0	4	8	12	16	20	24
Keratella sp.	4	35	20	10	8	12	3
Trichocerca sp. 2			2	2	2		
Asplanchna sp.	4	42	13	20	15	9	9
Polyarthra sp.	<1	24	10	3	3	4	<1
Filinia sp.							2
Conochiloides sp.		13	13	3	<1		
Conochilus sp.	23	347	194	124	133	110	67
Diaphanosoma leuch.		1		<1			
Daphnia ambigua		11	2	<1			1
Daphnia parvula		3	3	3	3	1	4
Ceriodaphnia lacustris		3	5	2	1	<1	2
Bosmina longirostris	<1	8	4	5	2	1	2
Nauplii	5*	66*	60*	26*	36*	14*	41*
Diaptomus pallidus	<1	1	3				2
Diaptomus siciloides				7	10	6	10
Tropocyclops prasinus		10	6		<1		<1
Cyclops bicuspidatus			3	2	2	3	7
Mesocyclops edax		1	2	<1	<1		
Copepodites	2*	11*	21*	22*	26*	12*	26*

* These values included in density totals but not used in determining total number of species or species diversity since they are unidentifiable, immature forms and probably do not represent different species.

Table A22. Density (numbers/l) in Arbuckle Reservoir on 22 May 75.

Species	Depth (m)						
	0	4	8	12	16	20	24
Keratella sp.	52	31	29	35	24	26	27
Trichocerca sp. 1	1	2		10		14	
Trichocerca sp. 2	85	73	9	20	22	4	15
Asplanchna sp.	2	3	1	2	1		
Polyarthra sp.	26	22	6	13	12	13	4
Synchaeta sp.	<1					<1	
Filinia sp.	<1						<1
Conochilus sp.	2	3	1	1	3		2
Diaphanosoma leuch.		<1	1				
Daphnia ambigua				2	<1	2	<1
Daphnia parvula		1		<1		<1	
Ceriodaphnia lacustris		12	<1	1	1	<1	
Bosmina longirostris	4	8	2	5	5	5	9
Nauplii	35*	38*	29*	50*	57*	46*	37*
Ostracoda				<1			
Diaptomus pallidus		<1		1	<1	1	2
Diaptomus siciloides			1	<1			
Cyclops bicuspidatus				2		<1	22
Mesocyclops edax		1	<1	6	1	5	
Copepodites	2*	5*	5*	16*	16*	21*	26*
Chaoborus sp.					<1		

* See footnote on Table A21.

Table A23. Density (numbers/l) in Arbuckle Reservoir on 21 Jun 75.

Species	Depth (m) 0	4	8	12	16	20	24
Keratella sp.	6	18	2	10	10	9	8
Trichocerca sp. 2		<1					
Asplanchna sp.	2	4		1	<1	1	1
Polyarthra sp.	2	15	<1	7	6	3	4
Filinia sp.				<1			
Conochilus sp.	6	9					
Diaphanosoma leuch.		2			<1	<1	
Daphnia ambigua			3	<1	<1		1
Daphnia parvula					<1		<1
Ceriodaphnia lacustris		4	2	8	4	3	3
Bosmina longirostris	4	16	10	11	9	11	13
Nauplii	40*	103*	62*	64*	125*	41*	65*
Diaptomus pallidus		10	3	6	6	3	7
Tropocyclops prasinus	1	2	3	3		4	3
Mesocyclops edax	2	10	5	5	7	2	6
Copepodites	21*	52*	37*	37*	40*	22*	24*
Harpacticoid copepod			<1				
Ergasilis chautauquaensis		<1			<1	<1	

* See footnote on Table A21.

Table A24. Density (numbers/l) in Arbuckle Reservoir on 8 Aug 75.

Species	Depth (m) 0	4	8	12	16	20	24
Keratella sp.	10	14	10		7		
Trichocerca sp. 1		<1					
Trichocerca sp. 2		1	1	<1	<1		
Asplanchna sp.	<1	1	<1	<1			
Polyarthra sp.	5	12	7	<1	5	<1	
Hexarthra sp.	1	2					
Conochilus sp.	2	21	1	3	5		
Diaphanosoma leuch.		5	<1	<1	2		
Daphnia ambigua			<1				
Ceriodaphnia lacustris		4	3	2		3	
Bosmina longirostris		11	6	5	5	3	4
Nauplii	9*	47*	26*	17*	20*	13*	12*
Ostracoda	<1						
Diaptomus pallidus					3		<1
Tropocyclops prasinus		10	2	2	7	<1	3
Mesocyclops edax		2	<1				
Copepodites	3*	45*	16*	13*	21*	7*	13*
Ergasilis chautauquaensis		<1					1

* See footnote on Table A21.