Journal of the Arkansas Academy of Science

Volume 55 Article 18

2001

Survey of the Macrobenthic Community in Ferguson Lake, Saline County, Arkansas

John D. Rickett
University of Arkansas at Little Rock

E. P. (Perk) Floyd
U.S. Public Health Service

A Survey of the Macrobenthic Community in Ferguson Lake, Saline County, Arkansas

John D. Rickett
Biology Department
University of Arkansas at Little Rock
Little Rock, AR 72204

E.P. (Perk) Floyd
U.S. Public Health Service (ret.)
2423 E. Woodson Lateral, No. 35
Hensley, AR 72065

Abstract

One hundred thirty benthic samples were collected on 33 visits to Ferguson Lake, Saline County, Arkansas, between May 1997 and October 2000. Sediments were visually examined and described, and some were returned to the lab for sediment oxygen demand (SOD) analysis. Fourteen taxa, representing five phyla of invertebrates, were identified. In all samples, oligochaetes, chaoborids, and chironomids comprised the majority of individuals, reaching densities up to 7449, 14,208, and 8783 per m^2, respectively. When seasonally grouped, largest total abundances and greatest abundances of most taxa were collected during the winter months (December-February). A minor abundance peak occurred in July due to a mid-year generation of *Chaoborus*. Some significant differences in abundance between seasons were present. The number of taxa collected per sample was also highest in winter but not significantly different from other seasons. Community diversity indicators were lowest in summer. Sediments over most of the lake consisted of a variable thickness (1 to 4 cm) layer of woody detritus above a deeper, rich, thinly divided mix of organic muck and inorganic particulates. Too little variation in sediments existed to test for macrobenthos preferences. The SOD tests revealed a nearly complete oxygen depletion in the chamber in 24 hours.

Introduction and Study Area

Ferguson Lake is a privately-owned country club/recreation lake located in eastern Saline County, Arkansas (Fig. 1). Rickett and Floyd (1999) gave a brief history and an introductory description of the lake and reported on the morphometry and limnology of the lake. The current paper describes the macrobenthic community.

Based on characters described in the literature, Rickett and Floyd (1999) concluded that Ferguson Lake was midway between a "blackwater" environment and the more usual small watershed impoundment. We therefore called it a "brownwater" environment with several swamp-like features such as low pH, brown-colored water (humic acids), much undecomposed plant material on the sediments, and summer hypoxia immediately above the substrate.

Materials and Methods

We conducted thirty-three sampling trips between May 1997 and October 2000 and collected 65 macrobenthic samples at each of two stations in Ferguson Lake (Fig. 1). Although sampling frequency was slightly concentrated in the spring months, all months were represented. Station 1 was located in the channel of Clear Creek, approximately 400 m upstream from the dam, whereas station 2 was in mid-lake, approximately 500 m farther upstream. In a large area around station 2, the lake bottom was flat due to the long-term settling of solids, making the original channel of Clear Creek difficult to locate.

The macrobenthic community was sampled with a standard 6 x 6-inch (15.2 x 15.2-cm) Ekman grab and small amounts of sediment with organisms were preserved in FAA (15% [by volume] conc. formalin, 5% acetic acid, 15% ethanol [95%] and 65% dH_2O) for transportation to the lab. In the lab, the remaining sediment was removed with a 250-micron sieve, but at this point most of the remaining sediments were larger chunks of plant detritus. Organisms were picked from aliquots placed in petri dishes and preserved permanently in 70% ethanol. Since the area sampled by the grab encompassed approximately 232 cm^2, each count was multiplied by 43.1, and numbers/m^2 were recorded.

Sediment characteristics were visually assessed and recorded during each sampling trip. A series of 24-hour sediment-oxygen-demand (SOD) analyses were conducted to illustrate the probable major cause of the usual mid-summer hypoxia above the sediments (Rickett and Floyd, 1999). Approximately 11.3 L of sediment was collected, returned to the lab and placed, with as little disturbance as possible, in a sealable plexiglas chamber. An equal volume of lake water was added to the chamber; the chamber was sealed and a small recirculating pump was activated. A probe attached to a YSI Model 50B D.O. meter was inserted through the top with a sealed gasket, and a measurement was recorded every hour for 24 hours.

With the F-statistic, t-tests, and Mann Whitney-U tests, significant differences between the two sampling stations and between any two seasons for each of the eight "major" taxa were noted. March, April and May were considered spring; June, July and August were considered summer, and so on. Correlation of any change in taxa present in the sam-

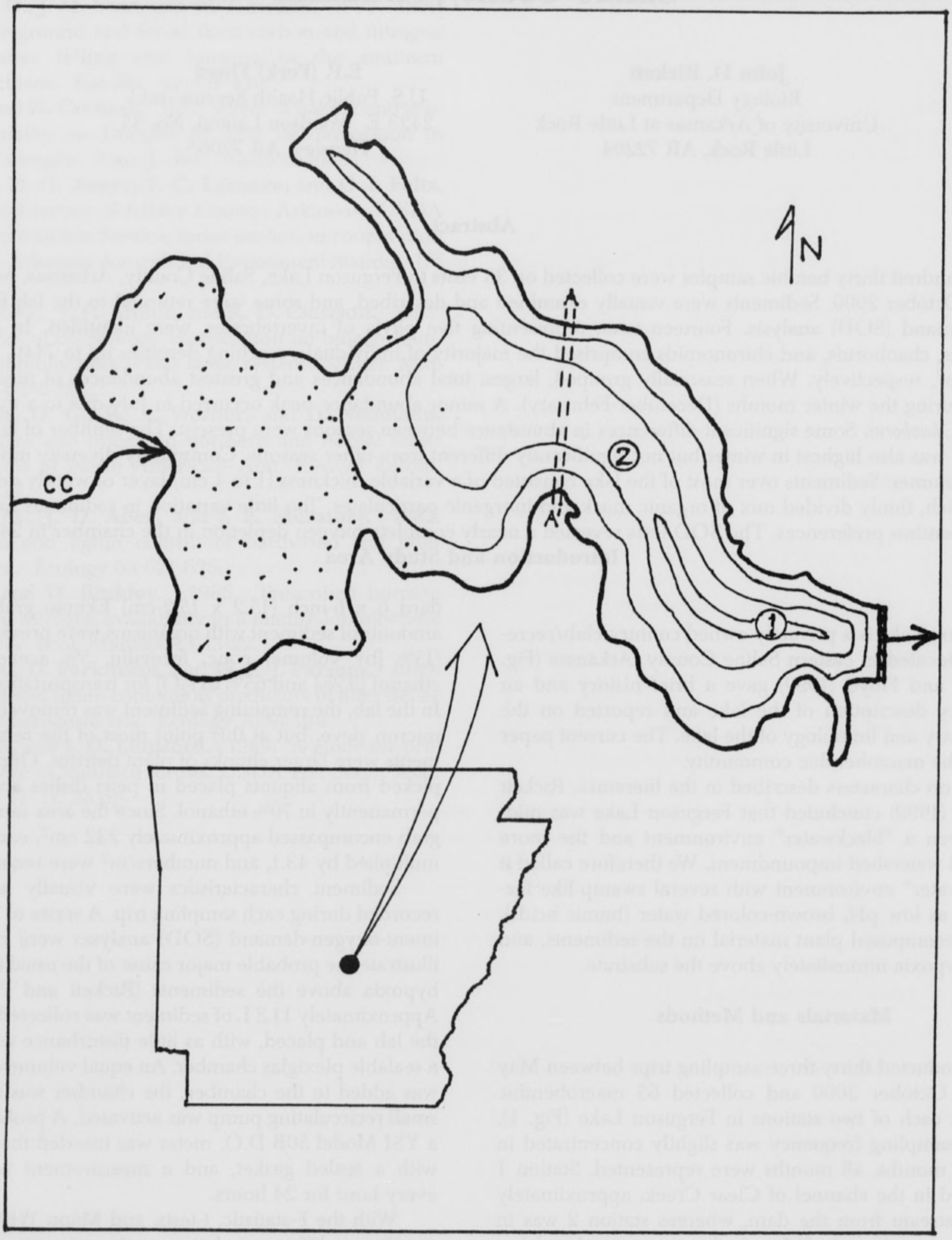

Fig. 1. Location of Ferguson Lake, Saline County, Arkansas.
Stippling: swamp dominated by tupelo gum, *Nyssa aquatica* A-A': original dam from "high" point (A) to "low" point (A')
CC: Clear Creek
Depth contours: 1 m intervals

Table 1. Benthic taxa collected in Ferguson Lake, May 1997-October 2000

(Code: N43/S2/4-30-98 = 43/m^2 organisms were collected at sta. 2 on 30 Apr 98)

Nematoda (N43/S2/4-30-98; N21.5/S2/5-19-99;
  N21.5/S1/3-21-00; N21.5/S2/4-27-00;
  N21.5/S2/10-17-00)
Nematomorpha (N21.5/S2/6-24-97; N21.5/S1/1-23-98;
  N21.5/S1/3-24-98; N21.5/S2/10-29-98;
  N21.5/S1/10-1-99; N64.5/S2/10-1-99)
Annelida
  Oligochatea
Mollusca
  Bivalvia
    Sphaeriidae
      Sphaerium (fingernail clam)
Arthropoda
  Arachnida
    Hydracarina (N43/S2/1-23-98;
      N21.5/S2/2-13-98; N21.5/S2/12-3-98)
  Copepoda
  Cladocera
  Ostracoda
  Insecta
    Ephemeroptera (mayflies)
      Caenidae
        Caenis (N21.5/S1/3-24-98)
    Trichoptera (caddisflies)
      Polycentropidae
        Nyctiophylax (N21.5/S1/4-23-98;
          N21.5/S1/4-30-98;
          N21.5/S2/5-19-98)
    Megaloptera
      Sialidae (fishflies)
        Sialis (N21.5/S1/1-23-98)
    Diptera (flies)
      Chaoboridae (phantom midges)
        Chaoborus
      Chironomidae (midges)
      Heleidae (biting midges)

ples or abundance of those present with the occasional applications of lime and fertilizer to the lake was also attempted.

Results and Discussion

Taxa and abundances.--Organisms were identified using Edmondson (1959), Edmunds (1976), Merritt and Cummins (1978), Pennak (1978), Thorp and Covich (1991), and Wiggins (1977). Fourteen taxa representing five phyla were identified (Table 1). Nematoda, Nematomorpha, Hydracarina, *Caenis* sp., *Sialis* sp. and *Nyctiophylax* sp. were seldom found and constituted small portions of the samples. The remaining eight taxa were collected frequently and are discussed later.

Of the six times Nematoda were collected, five occurred in the spring months; the other time was in October. Nematomorpha were collected three times in October and once each in January, March, and June. Water mites (Hydracarina) were collected three times in December, January, and February, whereas the caddisfly, *Nyctiophylax* sp., was collected twice in April and once in May. The fish-fly, *Sialis* sp., and mayfly, *Caenis* sp., were collected once each in January and March.

Figure 2 shows mean total numbers of organisms per sample throughout the study. Numbers exceeding 10,000 per square m were collected in February 1998, January and March 2000, whereas mid-year samples generally showed the lowest abundances. However, Figure 3 illustrates a numerical surge in July due to a mid-year generation of *Chaoborus* sp. Lowest monthly abundances occurred in May and September. Figure 4 shows the greatest abundance in winter and the lowest during the summer months due to the annual cycle of pupation and emergence of adults.

Figure 5 shows that the largest mean number of taxa per sample (8.7) was collected in March and the lowest number (5) was collected in August and September with a relatively smooth annual cycle. Figures 6 and 7 exhibit the taxonomic composition of samples by percent. The "other 1" category from Figure 6 is expanded in Figure 7 to give percents of cladocera, ostracods, heleids, and sphaeriids. The "other 2" category in Figure 7 includes the nematodes, nematomorphs, and others listed above. *Chaoborus* sp. comprised 23-91% of samples, exhibiting two distinct modes--one in August and a smaller one in January. Chironomids comprised 2-39% and exhibited a cyclic periodicity opposite that of *Chaoborus* sp., that is, when *Chaoborus* sp. comprised their largest percents, chironomids comprised their smallest. Sample components made up by oligochaetes ranged from 3-29%, and in general, followed the same pattern as that of the chironomids. The percent composition of copepods ranged between one and 18%, also showing two cycles.

Chaoborus sp. larvae were more abundant (1000-6000/m^2) than chironomid larvae (100-3200/m^2). *Chaoborus* sp. exhibited their greatest abundance in July at nearly the same time chironomids were at their lowest. Oligochaetes were most numerous (2400/m^2) in March and least abundant (100-500/m^2) from June through August. Semi-benthic copepods were most abundant (about 600/m^2) from April through June and least abundant (60/m^2) in September.

Semi-benthic cladocerans were most abundant (64/m^2) in March and absent from all samples from June through August (Fig. 7). Fingernail clams (*Sphaerium* sp.) were most abundant (150/m^2) in November and absent in September, whereas in other months the clams exhibited much irregularity of abundance. Ostracods were absent from May through August and virtually absent in April and September but exhibited a peak abundance of 504/m^2 in November (Fig. 7). Heleids exhibited low numbers (0-10/m^2) from June through August and a peak of 250/m^2 in December (Fig. 7).

The percent of samples comprised by ostracods ranged from zero in June and August to 6.3% in November (Fig. 7). The same for heleids was zero (June) to 3.5% (December), whereas cladocera were not present June through August and November and comprised 0.82% in April. The 0% in November doesn't fit the cycle and may have been due to sampling error. The month-to-month percents comprised by *Sphaerium* sp. exhibited too much irregularity to identify a pattern.

Somewhat unusual was the large number of (semi-) benthic copepods and cladocera in most of the samples. We were not able to determine if these organisms were actually on the surface of the sediment or in the water just above. The first author collected macrobenthos samples using the same methodology from Dardanelle Reservoir for many years and reported no copepods or cladocera in the samples (Rickett and Watson, 1994). In Ferguson Lake, copepods were collected in all months, but cladocera were absent during the summer months. The usually benthic ostracods (Pennak, 1978) (= eubenthos, according to Hutchinson, 1993) were also absent or nearly so from April through September. The summer absence of these latter two groups was probably due to the annual hypoxia (<1 mg/l) near the bottom of the water column (Rickett and Floyd, 1999), which was undoubtedly caused largely by a rather strong sediment oxygen demand (discussed later in this paper).

Figures 8 and 9 show seasonal percent composition of samples in the same interpretative pattern as Figures 6 and 7. *Chaoborus* sp. certainly dominated the summer samples and comprised nearly half of fall and winter samples (Fig. 8). Chironomids and oligochaetes together comprised only slightly more than 10% of the summer samples, but they

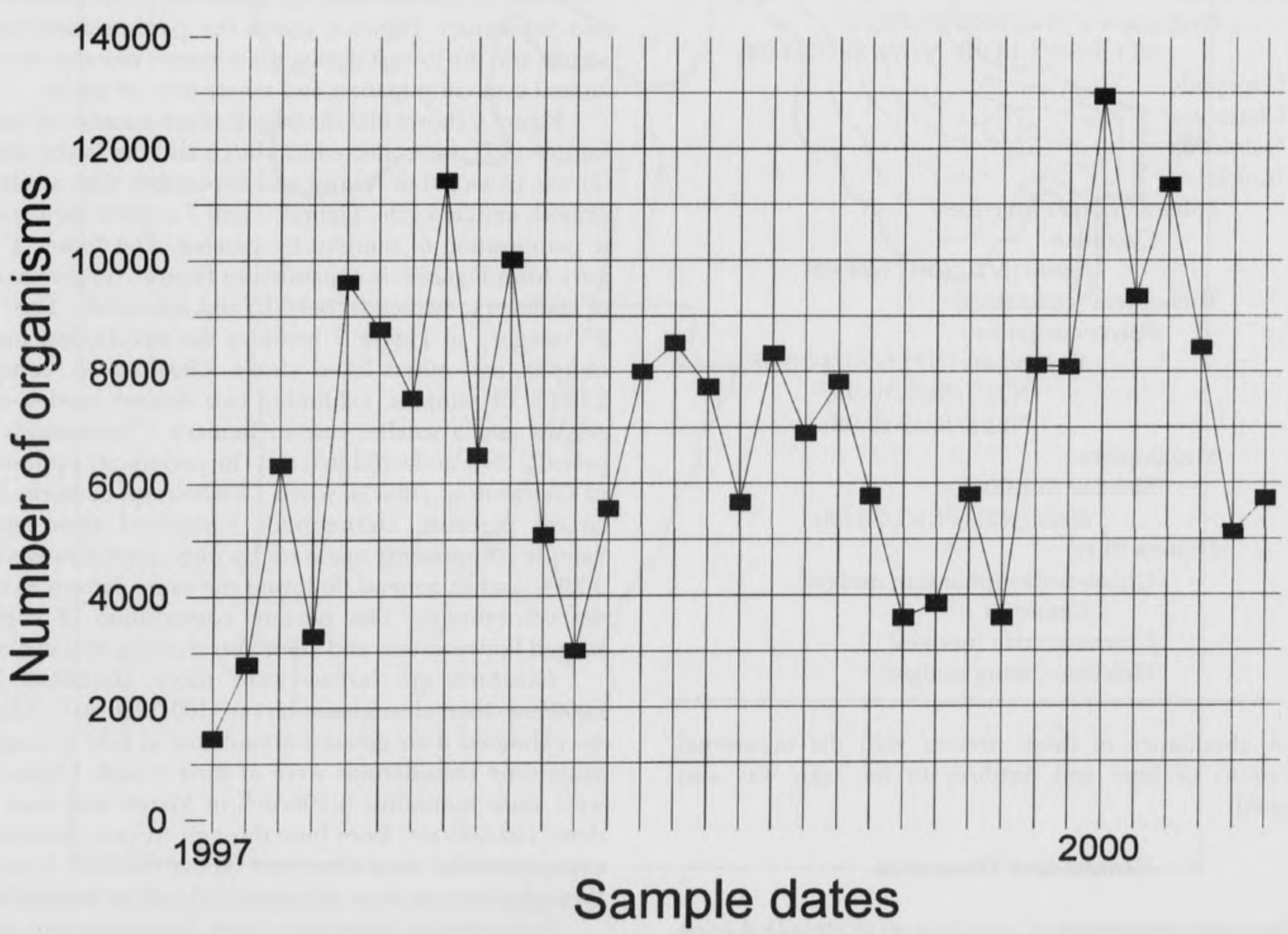

Fig. 2. Mean total numbers (per m^2) of macrobenthic organisms, Ferguson Lake, Saline County, Arkansas, 1997-2000.

omprised 40-60% in the other seasons. Copepods made up bout 5% in fall and winter samples and about 10% during pring and summer.

Ostracods comprised over half of the 5.6% made up by he remaining taxa in the fall samples and virtually none of he summer samples (Fig. 9). Cladocerans were absent and eleids virtually so in the summer samples, but *Sphaerium* p. made up about 90% of the "other" taxa from Fig. 8.

Figures 10 and 11, respectively, show monthly and seasonal variations in three popular diversity indicators--taxonomic diversity, Margalef's richness, and Shannon-Weaver heterogeneity. Taxonomic diversity was relatively low all year but highest in April and lowest during July through September. Little difference was observed among the seasons. Margalef's richness was highest in March and April and lowest in August and September. Winter exhibited, by a slight margin over spring, the highest richness, whereas summer showed the lowest. With the exception of a slight secondary peak in December, both diversity and richness exhibited a smooth, single annual cycle (high in spring and low in summer). The Shannon-Weaver heterogeneity index fluctuated considerably by month but was highest in November, April, and January and lowest in August, July, and October. When months were combined into seasons (Fig. 11), this index exhibited a smooth one-cycle-per-year fluctuation with a peak in winter (only slightly higher than in spring) and a low in summer. Shannon-Weaver heterogeneity indices for the macrobenthic community in Dardanelle Reservoir ranged mostly between 0.6 and 1.0 (Rickett and Watson, 1994).

Table 2 contains critical values for tests examining for differences between sampling stations. For six of the eight taxa, the F-statistic revealed too much (significant) internal variation to place full faith in a subsequent t-test, so Mann Whitney-U tests were also conducted. No significant differences were found between sampling stations. The t-test on

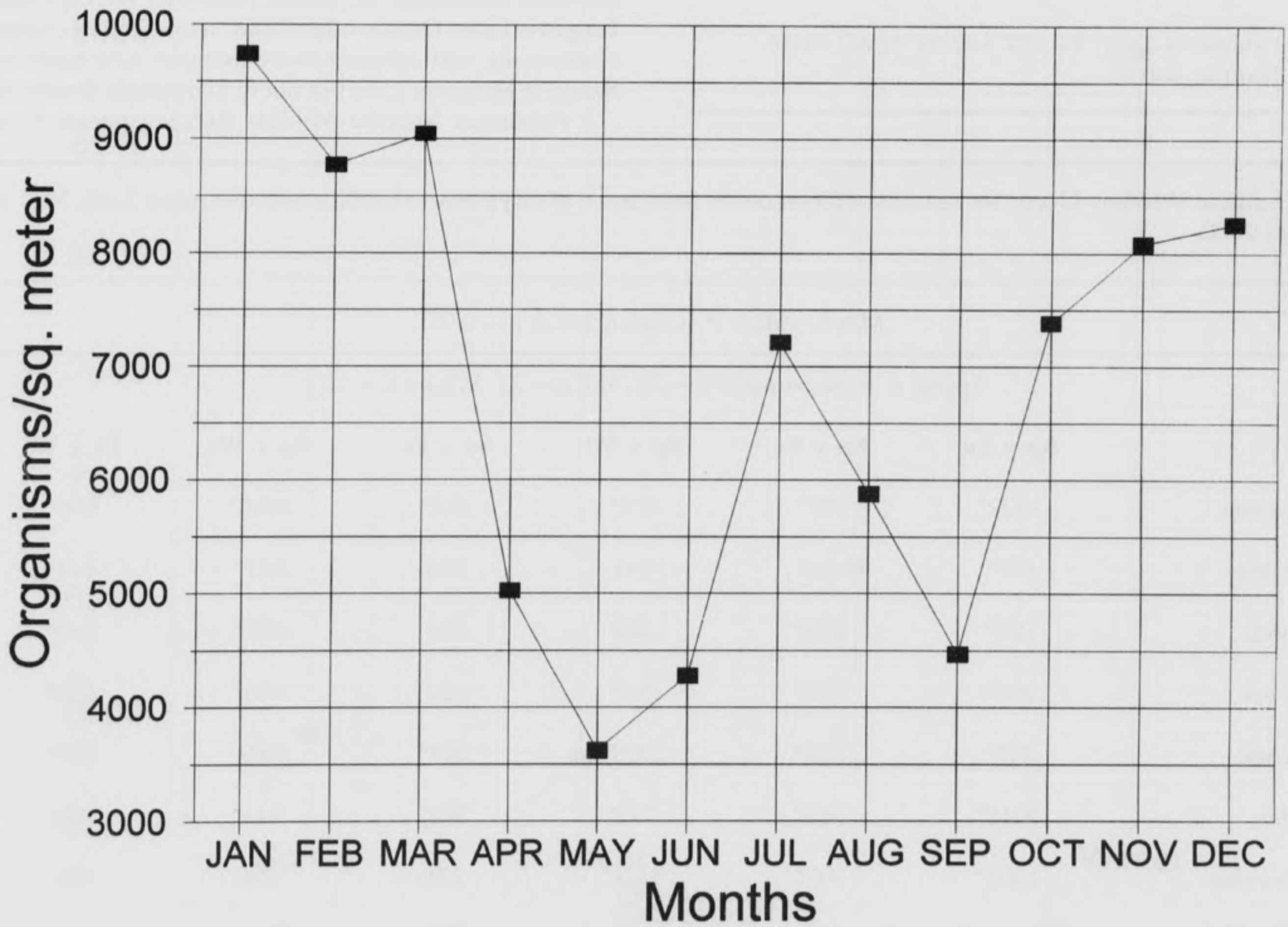

Fig. 3. Monthly mean number of organisms per square m, Ferguson Lake, Saline County, Arkansas, 1997-2000.

Table 2. Tests for significant difference between sampling stations, Ferguson Lake, Saline County, Arkansas.

taxa	F-value*	t-value*	MW-U*
Sphaeriidae	5.89**	2.30**	615
Oligochaeta	2.08**	0.32	431
Copepoda	4.79**	1.68	618
Cladocera	4.54**	0.13	551
Ostracoda	3.40**	0.78	526
Heleidae	3.57**	0.45	464
Chaoboridae	1.57	0.63	
Chironomidae	1.82	1.05	

*critical values: n-1=31; F=2.07, t=2.04, MW-U=630
**significant at p=0.05

Sphaeriidae most likely indicates a false significance. Having determined no significant difference between sampling stations overall, we then combined all samples in specified months to test for differences between any two seasons and found 36 of the 48 possible season-pairs with respect to individual taxa to be significantly different (Table 3).

The major macrobenthic taxa (oligochaetes, *Chaoborus* sp. and chironomids) present and abundance of oligochaetes in Ferguson Lake were approximately the same as in Dardanelle Reservoir, but abundances of *Chaoborus* sp. and chironomids were greater in Ferguson Lake. Margalef's richness and Shannon-Weaver heterogeneity indices between the two lakes were similar (Rickett and Watson, 1994). The total number of taxa present in Ferguson Lake was somewhat fewer than in Dardanelle Reservoir, and considerable variation occurred in the list of minor taxa between the two areas. For example, no hydras (*Hydra* sp.), bryozoans (*Urnatella* sp., *Pectinatella* sp.), snails (*Pleurocera* sp., Planorbidae), Asiatic clams (*Corbicula fluminea*), leeches (Hirudinea), amphipods (*Hyalella* sp., *Corophium* sp.), odonates (Odonata), or beetles (Elmidae) were present in Ferguson Lake. On the other hand, semi-benthic copepods, cladocerans, and ostracods were found in noticeable abundance in Ferguson Lake but not in Dardanelle Reservoir.

Wapanoca National Wildlife Refuge appears to be a

Table 3. Mann Whitney-U tests for seasonal differences in abundance of major macrobenthos taxa, Ferguson Lake, May 1997-October 2000.

MW-U values (* = significant at p = 0.05)						
Spring n = 38; Summer n = 32; Fall n = 24; Winter n = 36						
	Sp v Su	Sp v Fa	Sp v Wi	Su v Fa	Su v Wi	Fa v Wi
Oligochaeta	1032*	575*	757*	663*	1066*	598*
Sphaeriidae	637*	466	641	420	651*	444*
Copepoda	628*	1160*	579	319	621*	540*
Cladocera	864*	559*	765*	432	768*	523*
Ostracoda	797*	536*	1009*	568*	1002*	556*
Heleidae	1046*	565*	759*	582*	944*	472
Chaoboridae	1062*	707*	1121*	274	526	256
Chironomidae	1081*	485	696*	646*	1038*	444

type of aquatic habitat similar to the upper end of Ferguson Lake. Using dip nets and light traps, Harp and Harp (1980) collected many more taxa (163 taxa in four phyla, including nine orders of Insecta) than we did, but most of their collecting effort was in the littoral zone of the swampy area, whereas all of our collections were taken with an Ekman grab from sediments in or near the middle of the impoundment. A macroinvertebrate study of St. Francis Sunken Lands by Cochran and Harp (1990) yielded 243 taxa collected qualitatively with dip nets mostly in littoral zones of swampy areas. Likewise, Chordas et al. (1996) collected 219 taxa by dip nets and light traps in the White River National Wildlife Refuge. We are confident of recording many more taxa from the upper part of Ferguson Lake when time permits sampling that area.

Sediment Oxygen Demand.--The sediment was a non-uniform mix of finely-divided silt particulates and granular inorganic pieces. Overlying the sediment was a thick layer (1-4 cm) of slowly decomposing plant products (bark, tupelo and cypress foliage, and some tupelo seed pods), the accumulation of which apparently exceeded its decomposition. This detritus layer was slightly heavier at station 2 (closer to the upper end of the lake) than at station 1. The specific composition of the bottom material was also non-uniform horizontally.

SOD results are given in Figs. 12 and 13. Figure 12 shows dissolved oxygen in the chamber declined from 6.0 to 0.4mg/l in 24 hours when sediment from station 1 was tested. Correspondingly, readings over station 2 sediment declined from 7.9 to 0.5mg/l in a similar period. Except for the first hour, the rate of decline was very uniform. Figure 13 gives the amount of oxygen used per volume of sediment. During the first hour, sediment from station 2 used twice as much oxygen, and throughout the remainder of the 24-hour test, station 2 sediment continued to use slightly more oxygen than sediment from station 1.

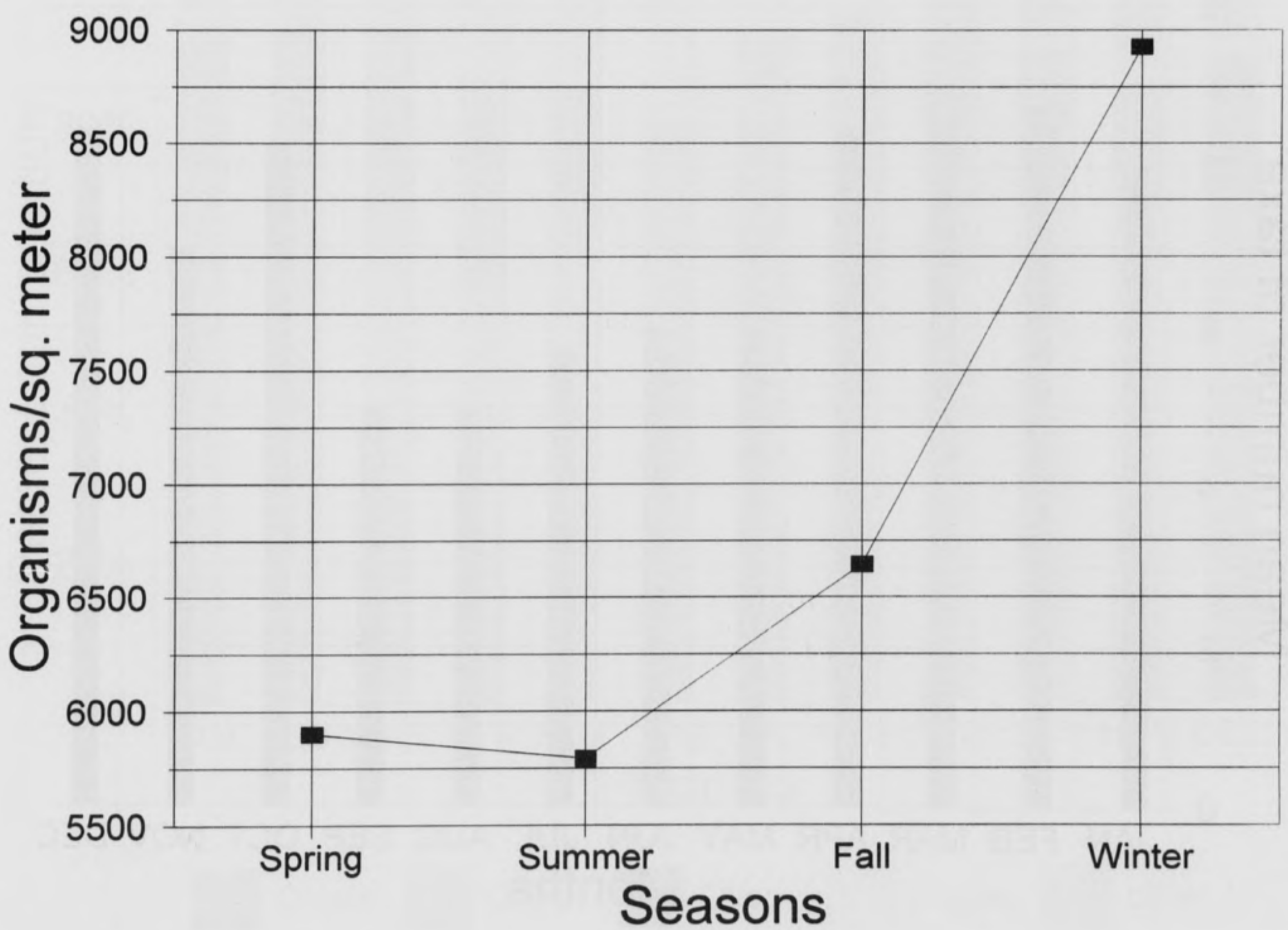

Fig. 4. Seasonal mean number of organisms per square m, Ferguson Lake, Saline County, Arkansas, 1997-2000.

Rickett and Edelman (1980) reported winter/spring SODs in Fourche Creek, Pulaski County, Arkansas to be 1.75 $g/m^2/day$, whereas summer SODs were 2.03 $g/m^2/day$, using the square measure of sediment in the chamber to represent a correspondingly representative square measure of stream sediment. If we let the 29.6 x 29.6-mm (876.16 mm^2) inside area of our SOD chamber to represent an equivalent area of Ferguson Lake substrate, we obtain 0.834 and 1.053 $g/m^2/day$ for stations 1 and 2, resepctively (mean: 0.944 $g/m^2/day$). This comparison indicates Fourche Creek sediment contained approximately twice the semi- and un-decomposed organic material as the sediment Ferguson Lake, but the water of a flowing stream would not be expected to contain as many organic acids as that of a body of standing water. The depression of pH normally associated with organic acids (such as in Ferguson Lake) would limit the rate of decomposition and therefore, the rate of oxygen consumption by the sediments.

Possible relation to lime and fertilizer applications.--During our sampling period, attempts were made by others to stimulate fish production by the addition of lime (to raise the pH) and fertilizer (to stimulate plankton production). Two hundred fifty (U.S.) tons of agricultural, slow-release lime was added during late January and early February 1998. Correspondingly, pH rose from 6.1 to 7.0 in the following two months (Rickett and Floyd, 1999), rose sharply in May to 9.7 and declined steadily back to about 6.0 by December 1998. Since early 1999 the pH has fluctuated between 6.2 and 7.0, except for slight increases above 7.0 during the summers of 1999 and 2000 (Rickett and Floyd, unpubl. data). Rickett and Floyd (1999) also noted a long-term increase in pH (6.3 [1979-1989] to 7.0 [1997-1999] not apparently associated with liming. Liming has had little or no effect on permanemtly raising the pH.

Fertilizer was applied twice. In April 1999 nine (U.S.) tons of fertilizer (assay unavailable) was applied by plane.

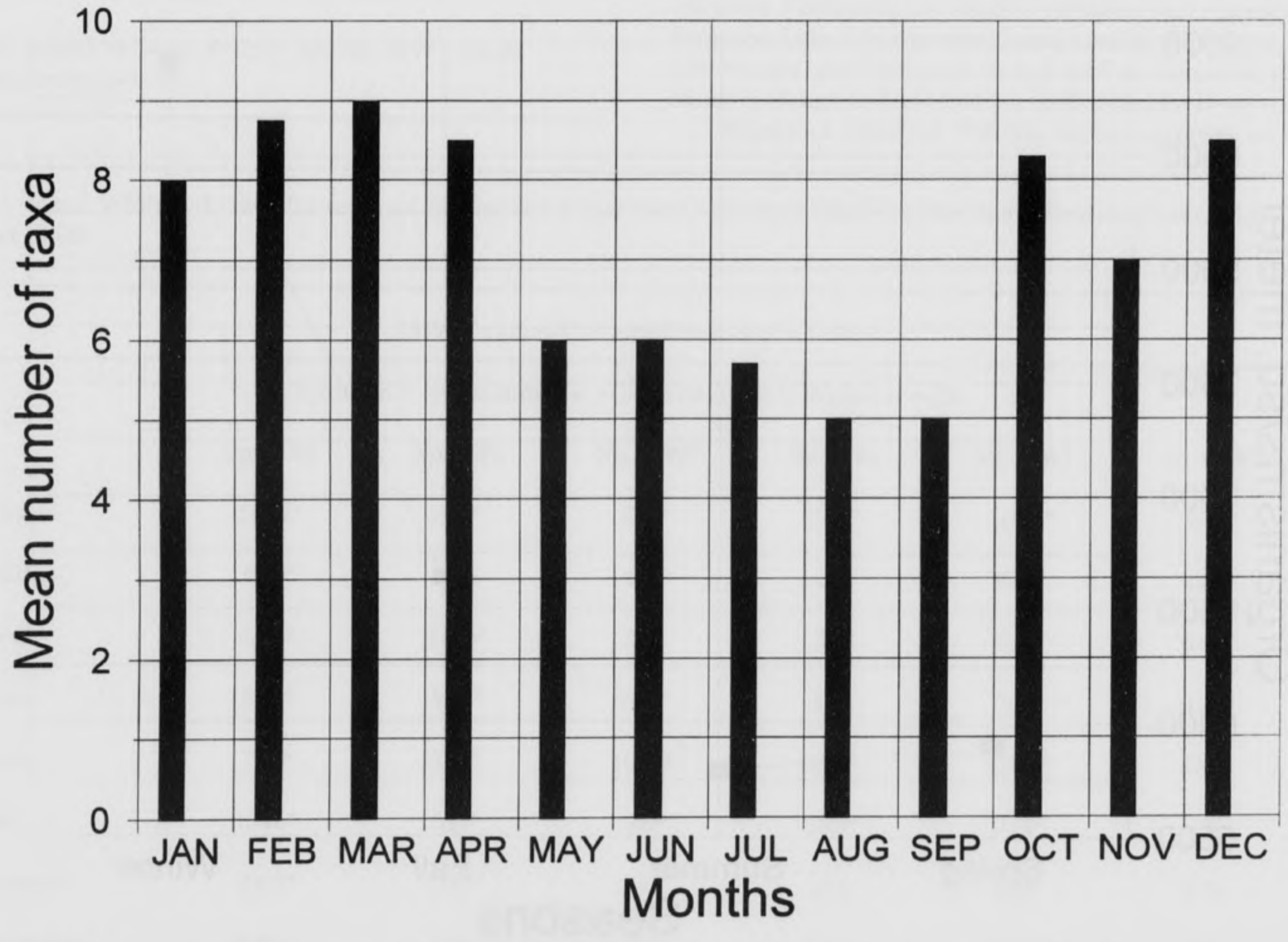

Fig. 5. Monthly mean number of macrobenthic taxa, Ferguson Lake, Saline County, Arkansas, 1997-2000.

Two days later most of it went over the spillway following a heavy rain. In April 2000 another 7.5 (U.S.) tons of fertilizer (18-46-0) was applied by plane. We would not expect fertilizer to have a direct effect on the macrobenthos community but probably on the planktonic community. A future paper will report on the plankton samples taken during this time period.

Summary

Fourteen taxa representing five phyla were collected in Ferguson Lake. Arthropoda was the most often represented phylum by taxa and numbers. *Chaoborus* sp. was the most abundant taxon followed by Chironomidae and Oligochaeta. These three taxa along with Heleidae, *Sphaerium* sp., and the semi-benthic copepods, cladocera, and ostracods comprised from 85-98% of all samples, with significant seasonal variation. All taxa exhibited seasonal cycles of abundance with lows in the summer and highs in late winter and early spring. All taxa but *Chaoborus* sp. and, perhaps, copepods demonstrated generally one high and low per year. *Chaoborus* sp. showed two highs and lows per year due to the appearance of a mid-summer generation. *Sphaerium* sp. showed the weakest seasonal cycle.

Lake sediments of silt and granular inorganics were overlain with heavy deposits of plant detritus, which apparently encouraged occupation by unusually large numbers of semi-benthic copepods, cladocerans, and ostracods. The decomposition of this detritus also caused significant hypoxia in summer in the water column 0.5 m above the sediments, and the organic enrichment of the silty/granular component was the basis of a rather strong sediment oxygen demand.

Community diversity indices (taxonomic diversity,

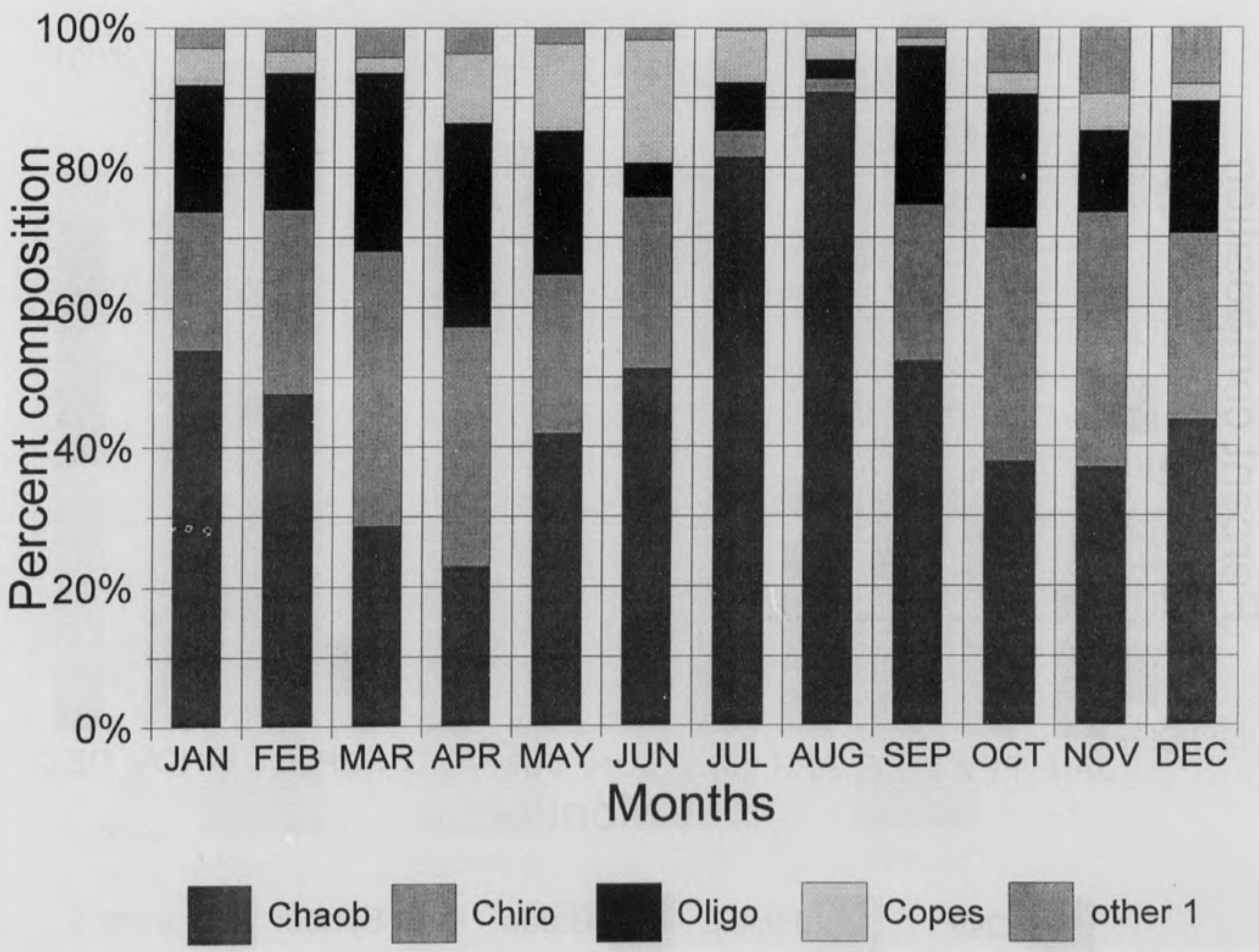

Fig. 6. Monthly taxonomic composition of samples by percent I, Ferguson Lake, Saline County, Arkansas, 1997-2000.

Margalef's richness, and Shannon-Weaver heterogeneity) indicated rather low diversity, but not significantly different diversity from other benthic communities in the region (e.g. Dardanelle Reservoir).

Literature cited

Chordas, III, S. W., G. L. Harp and **G. W. Wolfe.** 1996. The aquatic macroinvertebrates of the White River National Wildlife Refuge. Proc. Arkansas Acad. Sci. 50:42-51.

Cochran, B. G. and **G. L. Harp.** 1990. The aquatic macroinvertebrates of the St. Francis Sunken Lands in northeast Arkansas. Proc. Arkansas Acad. Sci. 44:23-27.

Edmondson, W. T., ed. 1959. Freshwater Biology, 2nd ed. John Wiley, New York.

Edmunds, G. F., Jr., S. L. Jensen and **L. Berner.** 1976. The mayflies of North and Central America. Univ. Minnesota Press.

Harp, G. L. and **P. A. Harp.** 1980. Aquatic macroinvertebrates of Wapanoca National Wildlife Refuge. Proc. Arkansas Acad. Sci. 34:115-117.

Hutchinson, G. E. 1993. Treatise on Limnology, vol. IV: The zoobenthos. John Wiley & Sons, New York, pp. 7-8.

Merritt, R. W. and **K. W. Cummins,** eds. 1978. An introduction to the aquatic insects of North America. Kendall/Hunt Publ., Dubuque, Iowa.

Pennak, R. W. 1978. Fresh-water invertebrates of the United States, 2nd ed. John Wiley & Sons, New York.

Rickett, J. D. and **P. Edelman.** 1980. An investigation of the streambed oxygen demand of Fourche Creek, Pulaski County, Arkansas. Proc. Arkansas Acad. Sci. 34:127-129.

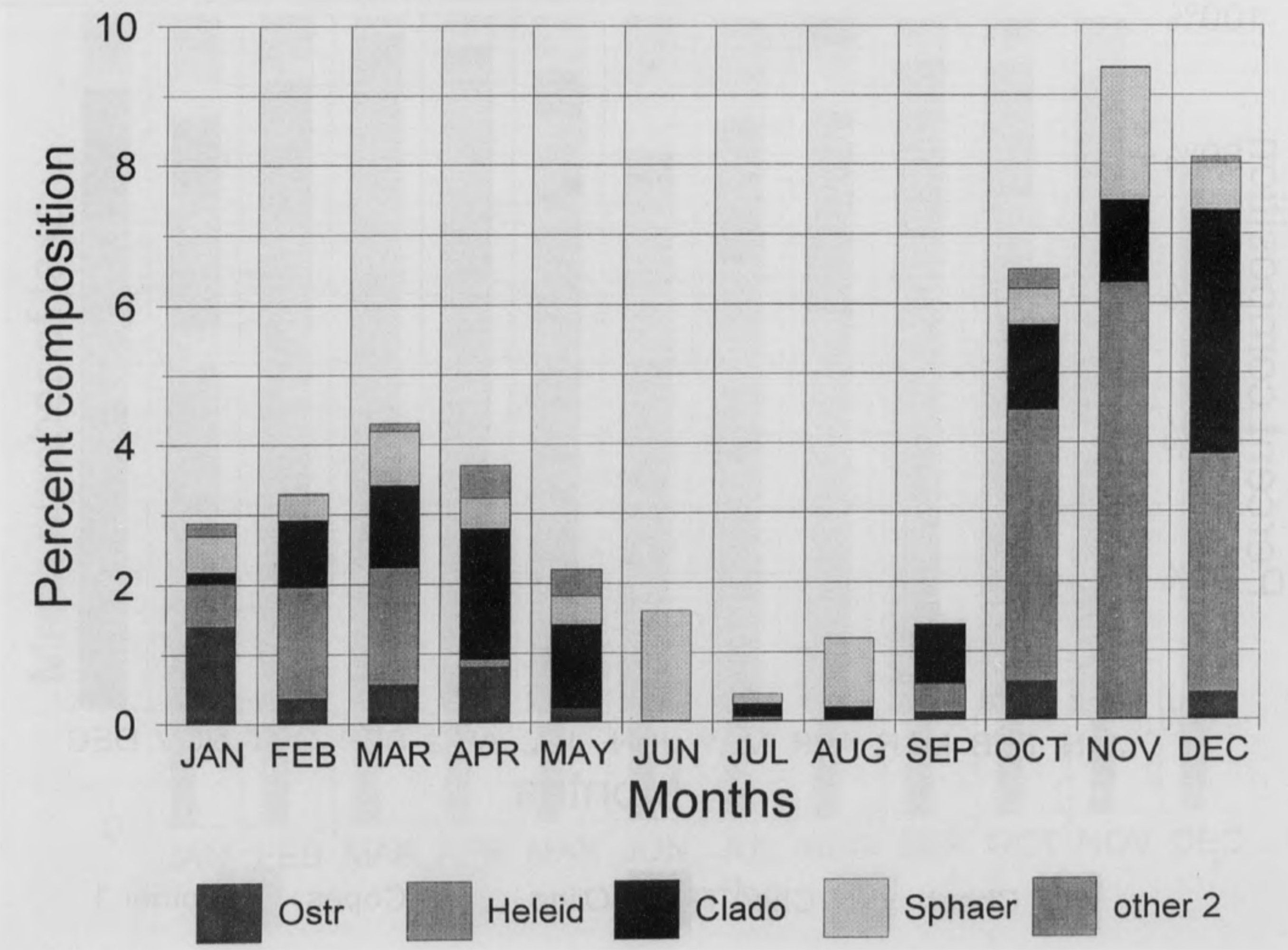

Fig. 7. Monthly taxonomic composition of samples by percent II, Ferguson Lake, Saline County, Arkansas, 1997-2000.

Rickett, J. D. and **E. P. Floyd.** 1999. Morphometry and Limnology of Ferguson Lake, Saline County Arkansas. J. Arkansas Acad. Sci. 53:101-107.

Rickett, J. D. and **R. L. Watson.** 1994. A long-term study of benthos in Dardanelle Reservoir. Proc. Arkansas Acad. Sci. 48:144-150.

Thorp, J. H. and **A. P. Covich,** eds. 1991. Ecology and classification of North American freshwater invertebrates. Academic Press, New York.

Wiggins, G. B. 1977. Larvae of the North American caddisfly genera (Trichoptera). Univ. Toronto Press.

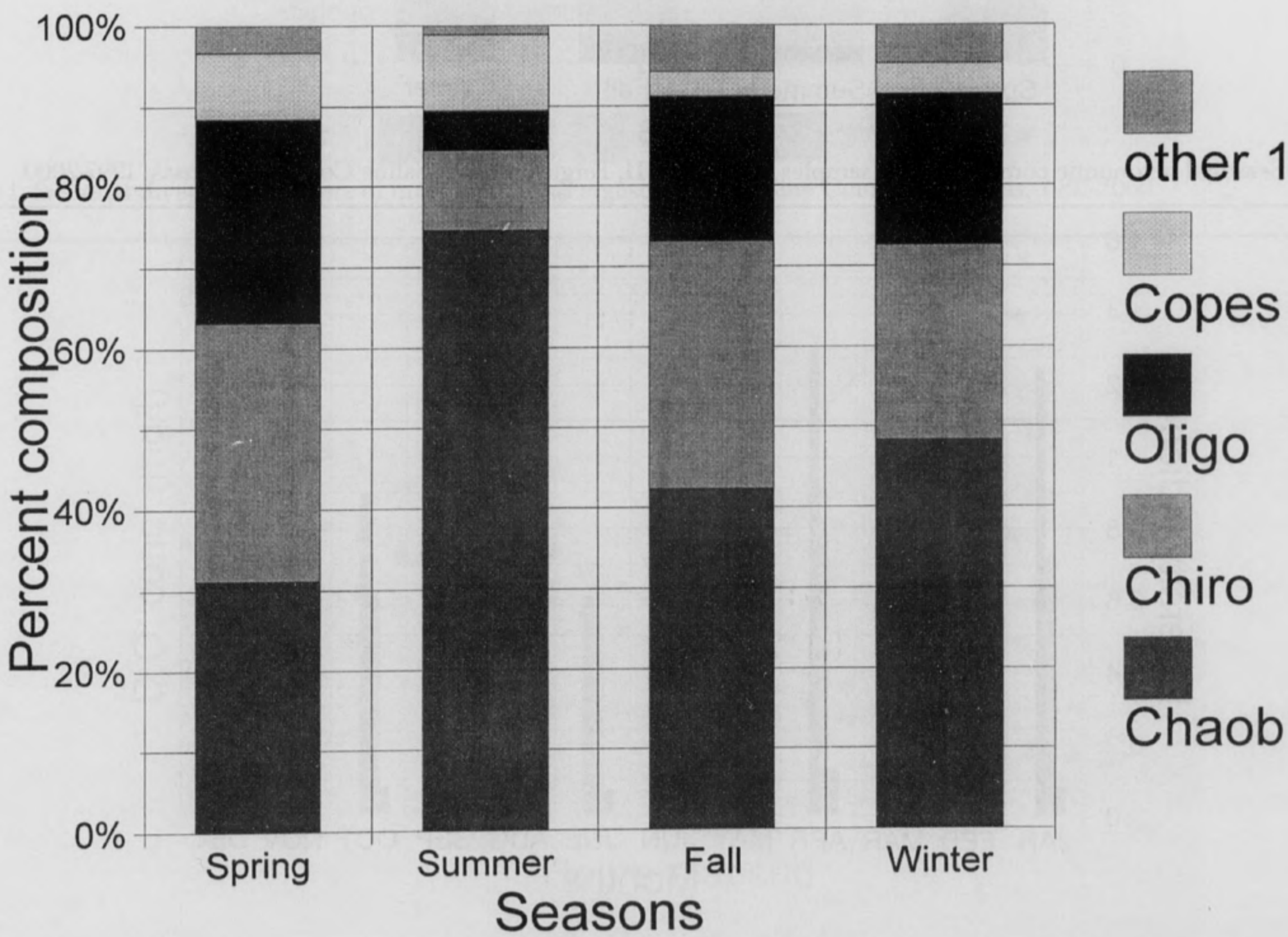

Fig. 8. Seasonal taxonomic composition of samples by percent I, Ferguson Lake, Saline County, Arkansas, 1997-2000.

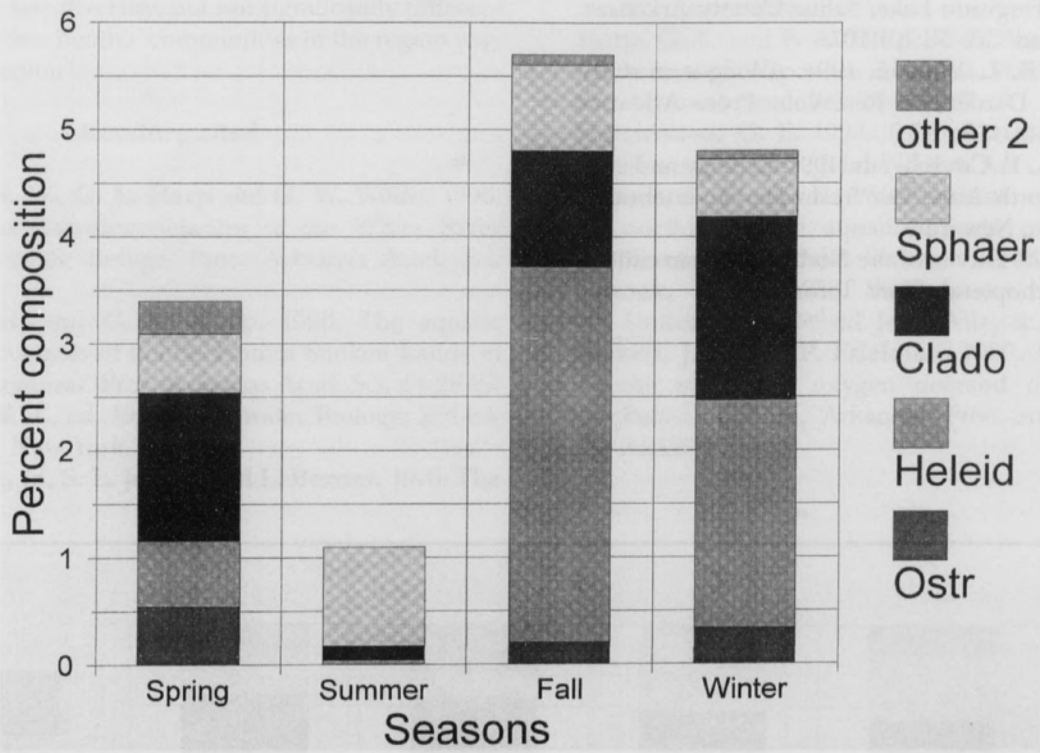

Fig. 9. Seasonal taxonomic composition of samples by percent II, Ferguson Lake, Saline County, Arkansas, 1997-2000.

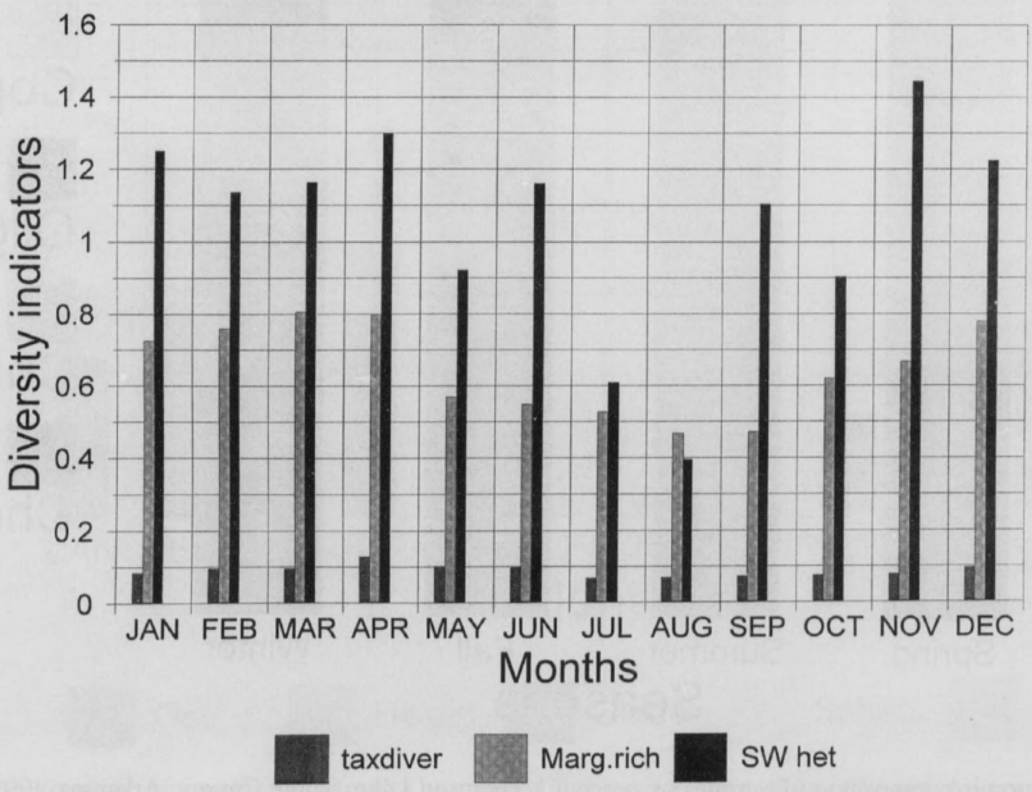

Fig. 10. Monthly diversity indicators of macrobenthos, Ferguson Lake, Saline County, Arkansas, 1997-2000.

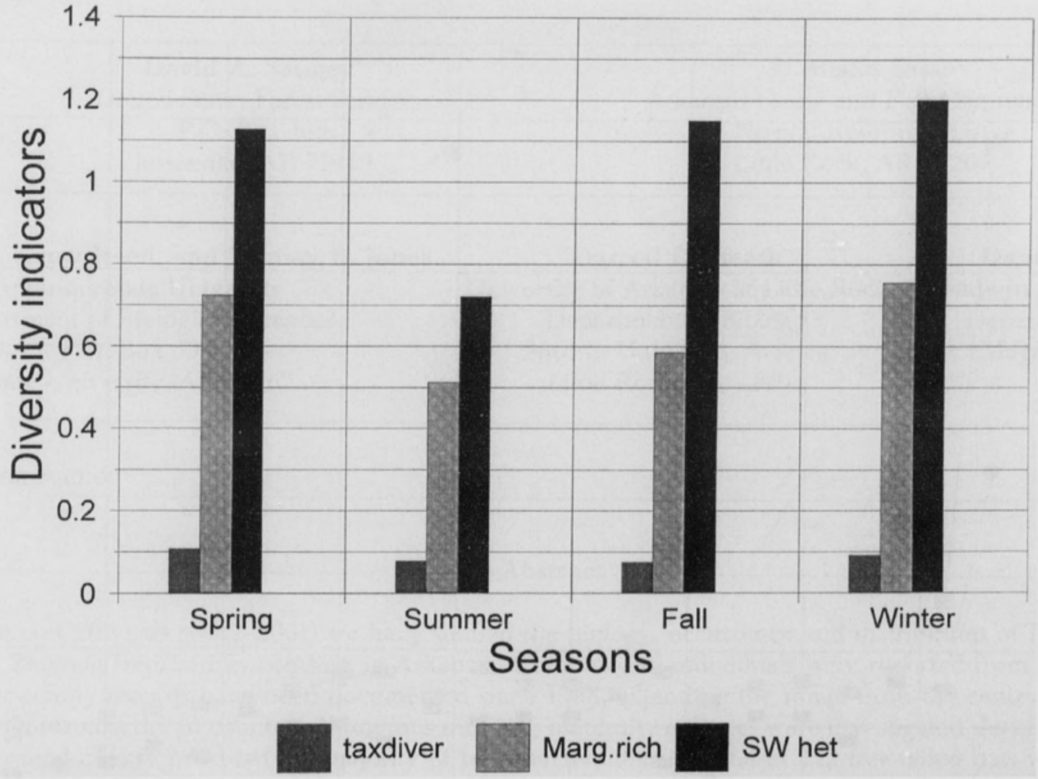

Fig. 11. Seasonal diversity indicators of macrobenthos, Ferguson Lake, Saline County, Arkansas, 1997-2000.

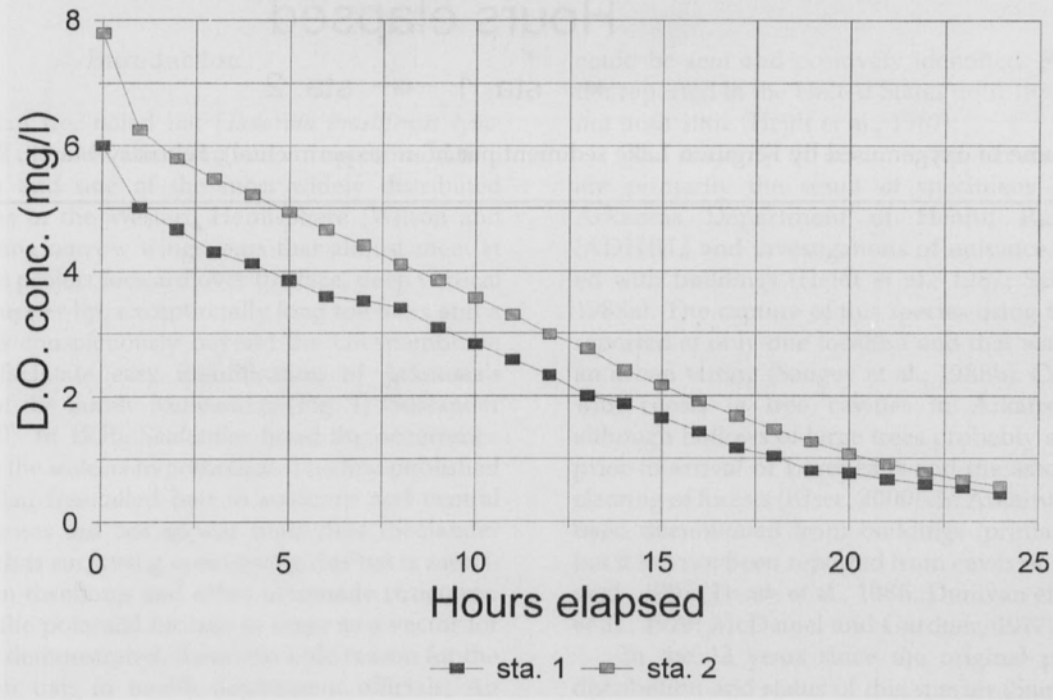

Fig. 12. Mean sediment oxygen demand (SOD) curves (experimental), Ferguson Lake sediment, February-March, 2000.

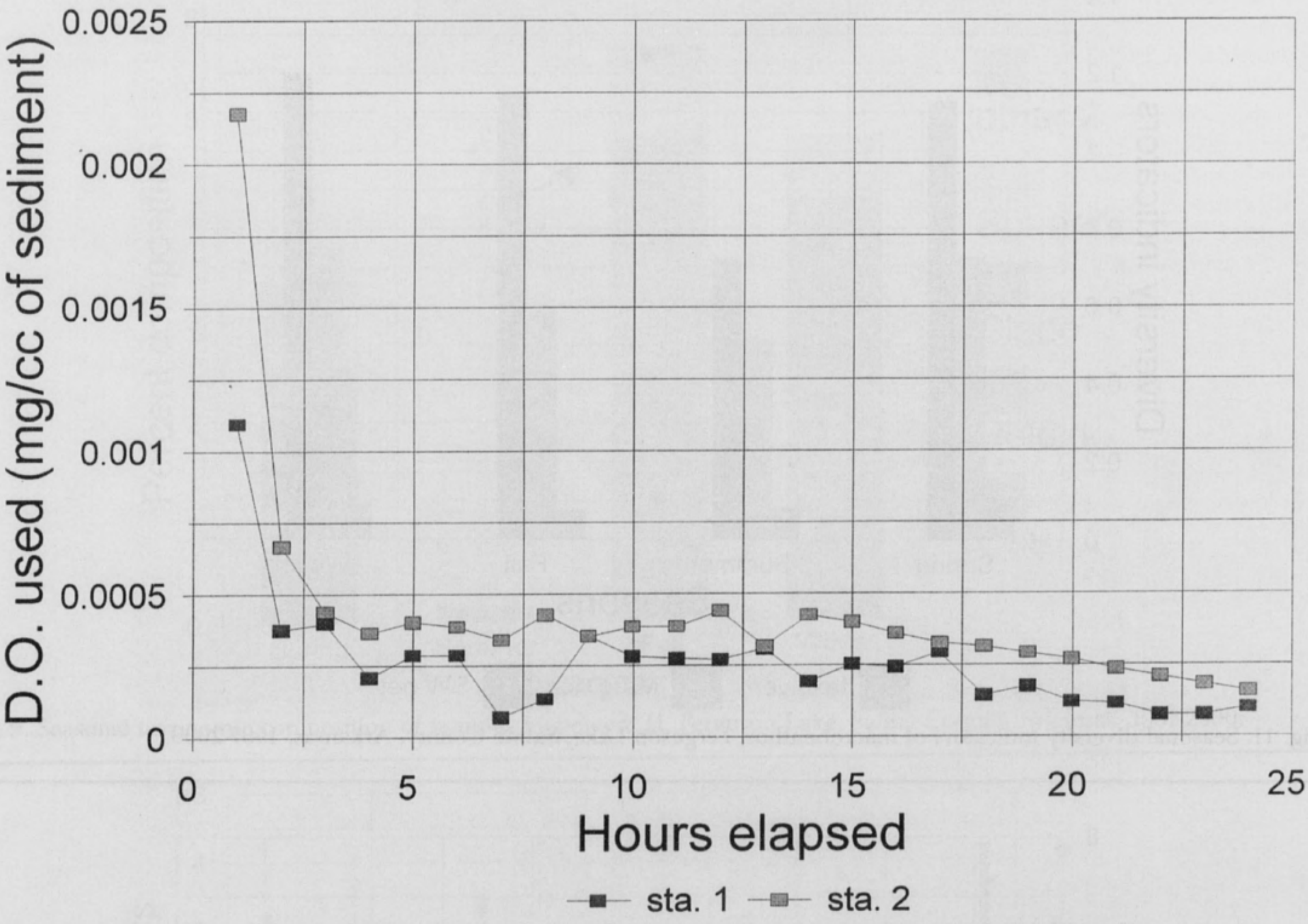

Fig. 13. Mean volume of oxygen used by Ferguson Lake sediment per hour (experimental), February-March, 2000.