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LARGE-SCALE OPERATIONS MANAGEMENT TEST OF USE OF THE WHITE AMUR FOR CONTROL OF PROBLEM AQUATIC PLANTS

Report 1

BASELINE STUDIES

Volume III

The Plankton and Benthos of Lake Conway, Florida

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LARGE-SCALE OPERATIONS MANAGEMENT TEST OF
USE OF THE WHITE AMUR FOR CONTROL OF
PROBLEM AQUATIC PLANTS

Report 1: Baseline Studies

Volume I: The Aquatic Macrophytes of Lake Conway, Florida

Volume II: The Fish, Mammals, and Waterfowl of Lake Conway, Florida

Volume III: The Plankton and Benthos of Lake Conway, Florida

Volume IV: Interim Report on the Nitrogen and Phosphorus Loading Characteristics of the Lake Conway, Florida, Ecosystem

Volume V: The Herpetofauna of Lake Conway, Florida

Volume VI: The Water and Sediment Quality of Lake Conway, Florida

Volume VII: A Model for Evaluation of the Response of the Lake Conway, Florida, Ecosystem to Introduction of the White Amur

Volume VIII: Summary of Baseline Studies and Data

Report 2: First Year Poststocking Results

Report 3: Second Year Poststocking Results

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Monthly monitoring of the phytoplankton, periphyton, zooplankton, and benthic invertebrates of Lake Conway, Florida, indicates that no serious water quality problems were present prior to introduction of the Chinese Grass Carp (Ctenopharyngodon idella) for the biological control of aquatic macrophytes. The phytoplankton community is dominated by green algae (Chlorophyta) during most of the year, with the exception of summer and early fall when blue-greens (Cyanophyta) become abundant. Maximum algal abundance (predominately

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PREFACE

The work described in this volume was performed under Contract No. DACW39-76-C-0076 between the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss., and the University of Florida, Gainesville. The work was sponsored by the U. S. Army Engineer District, Jacksonville, and by the Office, Chief of Engineers, U. S. Army.

This is the third of eight volumes that constitute the first of a series of reports documenting a large-scale operations management test of use of the white amur for control of problem aquatic plants in Lake Conway, Florida. Report 1 presents the results of the baseline studies of Lake Conway; subsequent reports will present the annual poststocking results.

This volume was written by Messrs. Roger Conley, Eldon C. Blancher II, Floor Kooijman, and Charles Ferrick and Drs. Jackson L. Fox and Thomas L. Crisman of the Department of Environmental Engineering Sciences of the University of Florida.

The work was monitored at WES in the Mobility and Environmental Systems Laboratory (MESL) by Mr. R. J. Theriot under the general supervision of Mr. W. G. Shockley, Chief, MESL, and Mr. B. O. Benn, Chief, Environmental Systems Division (ESD), and under the direct supervision of Mr. J. L. Decell, Chief, Aquatic Plant Research Branch (APRB), ESD. The ESD and APRB are now part of the recently organized Environmental Laboratory of which Dr. John Harrison is Chief.

Director of WES during the period of the contract was COL J. L. Cannon, CE. Technical Director was Mr. F. R. Brown.

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BASELINE STUDIES

The Plankton and Benthos of Lake Conway, Florida

PART I: INTRODUCTION

1. In recognition of the need to supplement the traditional chemical and mechanical techniques of aquatic vascular plant control, the U. S. Army Corps of Engineers has increased its research support of the study of biological control agents. The largest and most comprehensive study of the efficacy of the white amur or grass carp (*Ctenopharyngodon idella*) as a weed control agent is being conducted at Lake Conway, Florida.

2. Florida, with its long growing season and abundance of fresh water and nutrients, is plagued by aquatic weeds. Lake Conway typifies the weed problem found in an urban chain of lakes in Florida. Furthermore, the physical characteristics of Lake Conway facilitate the confinement of the fish within the study area. Lake Conway is a 750-ha system of five connected pools south of Orlando (Figure 1). In recent years, *Hydrilla verticillata*, a submersed aquatic vascular plant, has formed thick growths in several areas of the system. *Vallisneria* and *Potamogeton*, also submersed vascular plants, are additional nuisances in this particular chain of lakes. The Lake Conway system has a small watershed with few inflowing or outflowing streams. The shoreline is heavily urbanized and unlikely to change much in the future.

3. The overall study has been designed by the Corps of Engineers to assess the impact of the fish on the weed population as well as on nontarget biological, chemical, and physical parameters. Originally, limnological data were to be gathered for 1 year prior to the introduction of the fish and for 2 years after stocking. The prestocking investigation was extended several months longer than a year to allow the hatchery-reared fish to attain a greater size. The grass carp was

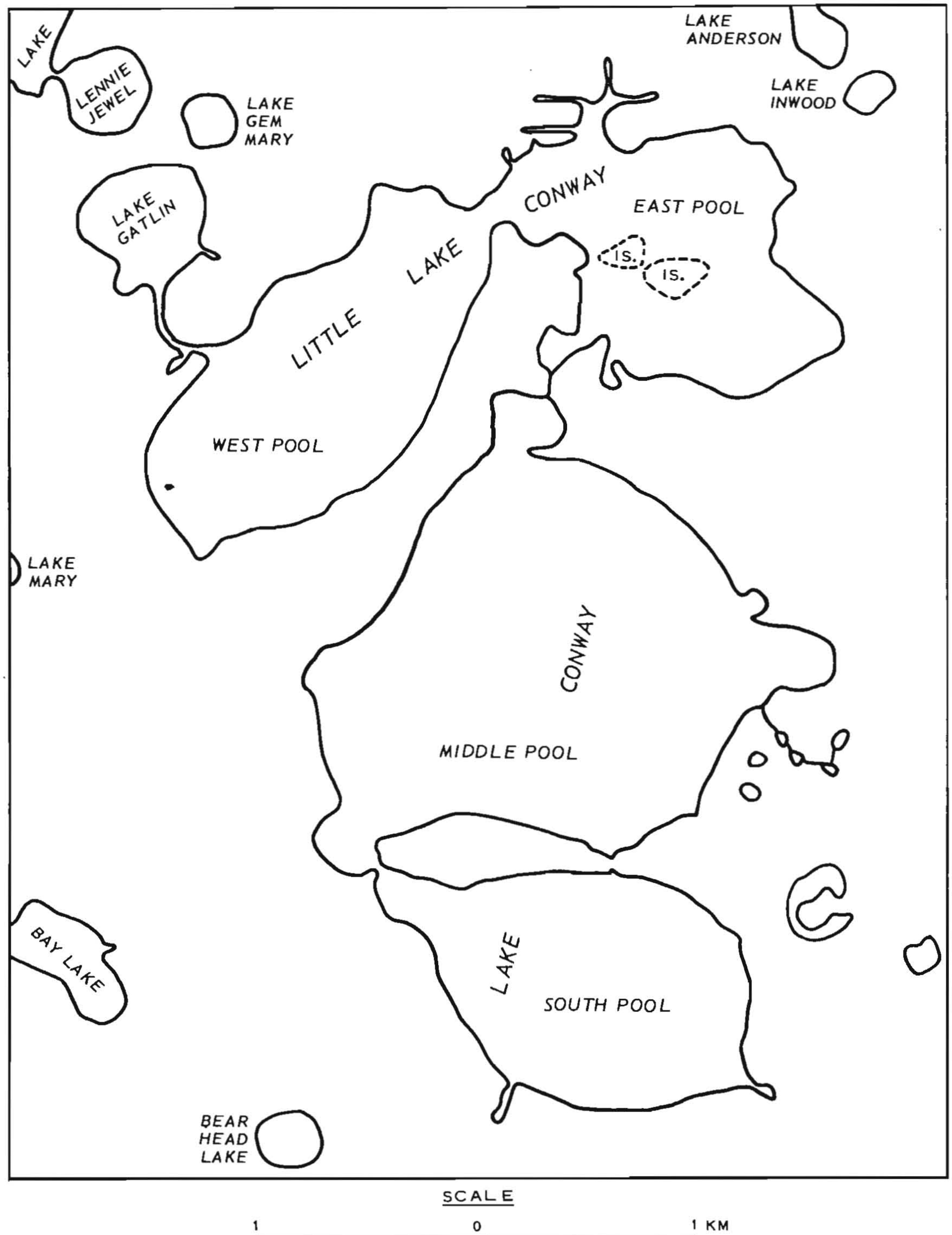

Figure 1. Lake Conway system

introduced in September 1977. Poststocking monitoring is in progress and will continue for at least 2 years.

4. This report contains baseline data on the phytoplankton, zooplankton, periphyton, and benthic invertebrates collected from April 1976 to August 1977. Other groups have been assessing other parameters for roughly the same period of time. These include the University of Florida's Center for Wetlands, which has been collecting productivity data and constructing systems models; the Florida Game and Freshwater Fish Commission (fish, aquatic birds, and mammals); the Florida Department of Natural Resources (aquatic plants); the Orange County Pollution Control Agency (physical and chemical parameters of lake water and sediment); and the University of South Florida (herpeto-fauna).

5. The grass carp is a large (up to 50-kg) cyprinid fish that is herbivorous as an adult and consumes great quantities of aquatic weeds. It is also an exotic and will be the largest fish within the system. The objective of the study is to assess the impact of the fish on selected nontarget groups of plants and animals.

6. The consumption of the macrophytes by the fish might cause an increase in nutrient availability to the algae. Because algae, both periphyton and phytoplankton, have rapid growth rates and respond quickly to fluctuating environmental conditions, they are sensitive indicators of a lake's biotic response to such changing conditions. Zooplankton are important both because they eat algae (thereby influencing density and relative species composition) and because they are in turn eaten by fish and invertebrate predators. Most fish are dependent on zooplankton as a food source at some stage of their life cycle, especially as fry.

7. Benthic communities (plant and animal) are also an important component of a lake ecosystem. Periphyton in Lake Conway may not only contribute significantly to the primary productivity of the lake but also serve as food for littoral invertebrates. Periphyton is favored in Lake Conway because of the availability of large stands of aquatic macrophyte surfaces to serve as substrata for growth.

8. Surveys of benthic invertebrates are also sensitive to changes

in water quality. They are good indicators of dissolved oxygen stress because they are fairly long-lived (compared to plankton) and are found at or near the bottom where low dissolved oxygen is most apparent. Because they are a major component of the diet of fish, the composition of the benthic invertebrate community can influence higher trophic levels. Thus, the planktonic, periphytic, and benthic communities are of great importance in lakes, and many types of ecological changes can be detected and documented through their study.

PART II: METHODS OF SAMPLING

Plankton Samples

9. Monthly plankton samples were collected at littoral (<3-m depth) and limnetic (>3-m) stations in each of the five pools of the Lake Conway system. During the first 12 months a total of 16 littoral and 5 limnetic stations were sampled. From April through August 1977, both phytoplankton and zooplankton were collected at 13 littoral and 10 limnetic stations, while zooplankton was also sampled at 5 additional limnetic stations.

10. For phytoplankton, littoral areas were sampled with a Van Dorn or Kemmerer bottle at a depth of 1 m. At deep stations, a 5.1-cm centrifugal pump with a 10-m flexible plastic hose was used to sample at depths of 1 m, middepth (generally 4 m), and within 1 m of the lake bottom (usually 7 m). Samples were preserved with 5 percent tetraborate-buffered formalin.

11. After settling in Utermohl chambers, phytoplankton were identified to species level on an inverted microscope at a magnification of 400 diameters. Generally, 200 to 400 individuals were identified and enumerated with colonies counted as individual algae. To help identify the diatoms as to species, preparations were cleared by heat and 30 percent hydrogen peroxide, then mounted in Hyrax. Major taxonomic references included those of Prescott (1962), Patrick and Reimer (1966), Whitford and Schumacher (1969), and Tiffany and Britton (1952).

12. Zooplankton samples were collected at all stations by the vertical haul technique with a U. S. Standard No. 10 (153-μm mesh size) plankton net. This technique consists of lowering a weighted net to slightly above the bottom and returning it to the surface at a constant rate. Data obtained by this method provide zooplankton data on an areal and volumetric basis. Since October 1976, additional samples for dry weight analysis (No. 10 mesh) and nauplii and rotifer abundance (No. 20 mesh, 60 μm) were collected at one deep station in each pool. Zooplankton samples were rinsed from the plankton net into 60-ml sample

bottles and preserved with either 70 percent ethyl alcohol (April 1976 through September 1976) or 10 percent formalin (October 1976 through August 1977). In the laboratory, aliquots were placed in shallow dishes and identified using a stereoscopic dissecting microscope at a magnification of 20 to 50 diameters. Taxonomic keys by Edmondson (1959) and Pennak (1953) were used for species identifications.

13. Monthly averages for all plankton were computed by averaging separately the littoral and limnetic stations for each pool. The mean for each pool weighted these two averages by the proportion of lake surface represented by the littoral and limnetic zones in that pool. Finally, a grand mean for the lake was calculated as the mean of the five pool averages.

Periphyton Samples

14. Commercial periphyton samplers (Design Alliance Corp.) containing eight vertically positioned glass slides were placed at six littoral stations throughout the lake from July 1976 to July 1977. The samplers were placed at each station every three months. With the exception of South Pool, samplers in each pool were placed both near the surface (6 cm) and at a depth of 1 m within or near areas of aquatic macrophytes. Only samples from 6 cm were taken from South Pool. At each station, the samplers were secured to permanent objects in the lake. Care was taken to prevent shading. Stolen or disturbed samplers were replaced once. Data gaps are due to the sampler being disturbed or stolen a second time.

15. Slides were left in the water from 9 to 25 days. At the end of each exposure period, half of the slides from each sampler were placed in 100 ml of 90 percent acetone and stored in the dark at 4°C. Later, the extracted samples were spectrophotometrically (Beckman DB) analyzed for chlorophyll a using the phaeophytin correction method (Environmental Protection Agency (EPA) 1973). The other half of the slides were preserved in a 5 percent solution of neutralized formalin. The growth from these slides was then scraped off with a razor blade,

and after thorough mixing, aliquots of varying volumes were removed and filtered through glass fiber filters for subsequent dry weight (105°C) and ash-free dry weight (500°C) analyses.

16. Additional aliquots of 0.5 ml were placed in specially designed counting chambers for counting and identification. Strip counts were made with a minimum count of 200 at a magnification of 400 diameters using a Unitron inverted microscope. The taxonomic keys of Prescott (1962), Patrick and Reimer (1966), and Tiffany and Britton (1952) were used to aid in identification.

17. In addition to the glass slide samples, periphyton were also collected from the macrophytes at each of the six locations. A plastic bag was lowered over each macrophyte sampled and fastened. The material enclosed within the bag was then clipped free from the roots or remaining parts and preserved in a 5 percent solution of neutralized formalin. In the laboratory, the surface area of the macrophyte parts was determined by placing a piece of transparent plastic graph "paper" over the plant and then estimating the area covering the plant material. The plant parts were then placed in a Waring blender and homogenized at high speed for 5 minutes. The mixing dispersed the attached periphyton into solution and made microscopic identification and counting possible. The technique used followed that described earlier for the glass slide regrowth counts.

18. The surface area to net weight ratio was determined for *Potamogeton*, *Vallisneria*, and *Nitella*. Since the Florida Department of Natural Resources has determined the biomass and areal distribution of the macrophytes in each pool, this ratio will enable the calculation of comparable periphyton data for the entire lake system.

Benthic Macroinvertebrate Samples

19. Duplicate bottom samples were taken bimonthly at 21 stations (distributed over the five pools of the Lake Conway system) by means of a petite Ponar grab (sampling area, 0.25 ft^2 = 0.023 m^2). Samples were sieved in the field through a U. S. Standard No. 30 sieve

(0.595-mm mesh) and fixed in 5 percent formalin with rose bengal. The dye stains the living organisms just prior to death and makes it easier to see and pick the organisms from the detritus and sediment in the sample. After sorting, the organisms were transferred to ethyl alcohol, examined microscopically (magnification 7 to 200 X) and counted and identified (generally to species level) using the keys of Pennak (1953), Edmondson (1959), Beck (1976), and Brinkhurst (1974), among others. Diversities were calculated using Shannon-Weaver's formula (EPA 1973). To determine biomass, the samples were transferred to water and left for 24 hours to counteract the dehydration of the organisms in alcohol. Standing water was then removed and the wet weights were determined. The samples were dried at 80°C for 12 hours and incinerated at 550°C for 1-1/2 hours to obtain dry weights and ash-free dry weights, respectively.

PART III: RESULTS AND DISCUSSION

Phytoplankton

20. Phytoplankton communities were very diverse, especially during spring and summer. The Shannon-Weaver diversity index (EPA 1973) was usually over 3.0 and often exceeded 4.0. The seasonal distribution of individuals among major taxa averaged for all pools is shown in Figure 2. During most of the year green algae (Chlorophyta) were dominant. The greens comprised roughly 30 percent of the total during most of the year, while blue-greens varied from 10 percent during winter 1977 to about 70 percent during summer of that year. Diatoms (Chrysophyta, Bacillariophyceae) were fairly constant (15 percent) but tended to be a slightly greater fraction of the phytoplankton occurrence in late spring or early summer. Cyclotella stelligera, a centric diatom, was the most

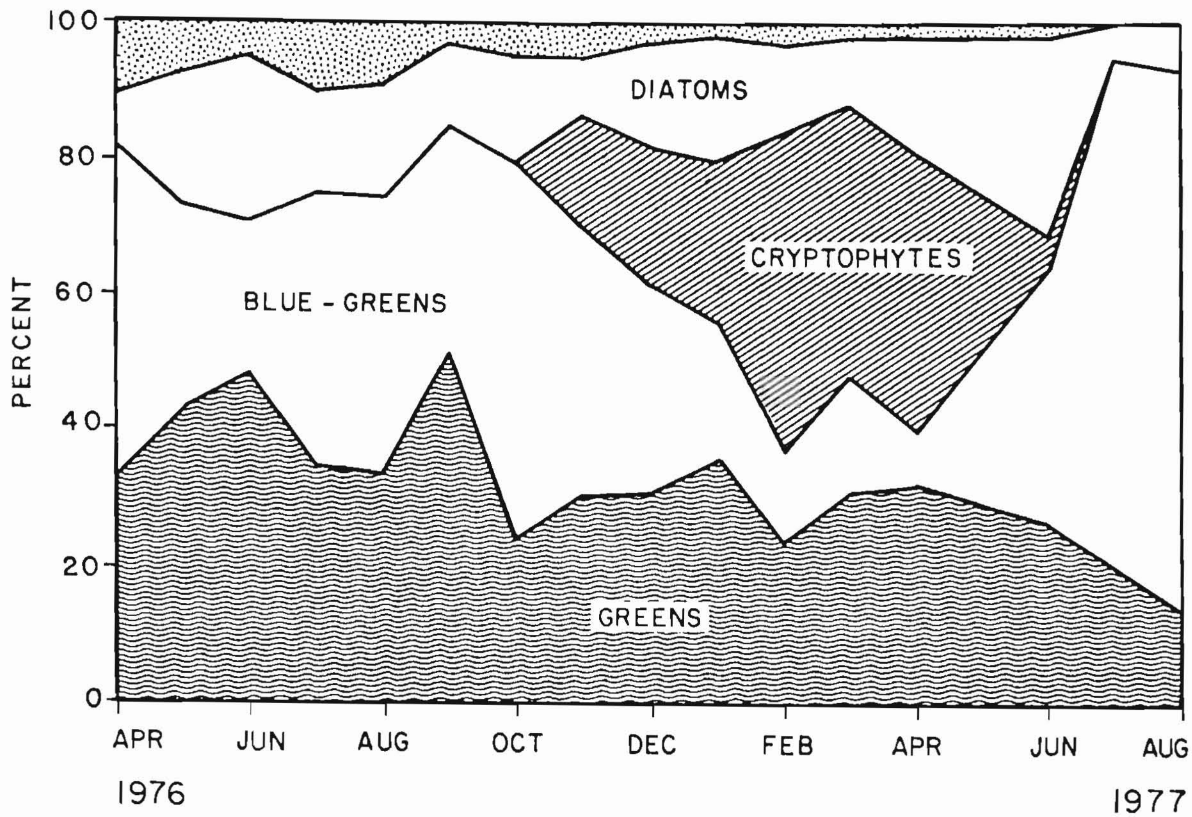

Figure 2. Seasonal distribution of phytoplankton, major taxa averaged for all pools

predominant diatom, but two pennate forms, *Achnanthes minutissima* and *Synedra rumpens*, were also common. During winter 1977, *Chroomonas minuta* and two other cryptomonads were abundant. The remainder of the algae included Pyrrophyta, Euglenophyta, and nondiatom Chrysophyta.

21. The species listed in Table 1 are those that composed over 10 percent of total algae in samples collected before August 1977. Green algae were clearly dominant. Although this group was characterized by a great number of species (over 110), a majority of these species were represented by few individuals at any particular time. On the other hand, blue-greens were much less diverse (approximately 40 species) with species tending to be common when present.

22. Figure 3 shows the average monthly abundance of phytoplankton for the Middle and West Pools. Both pools displayed highest abundances

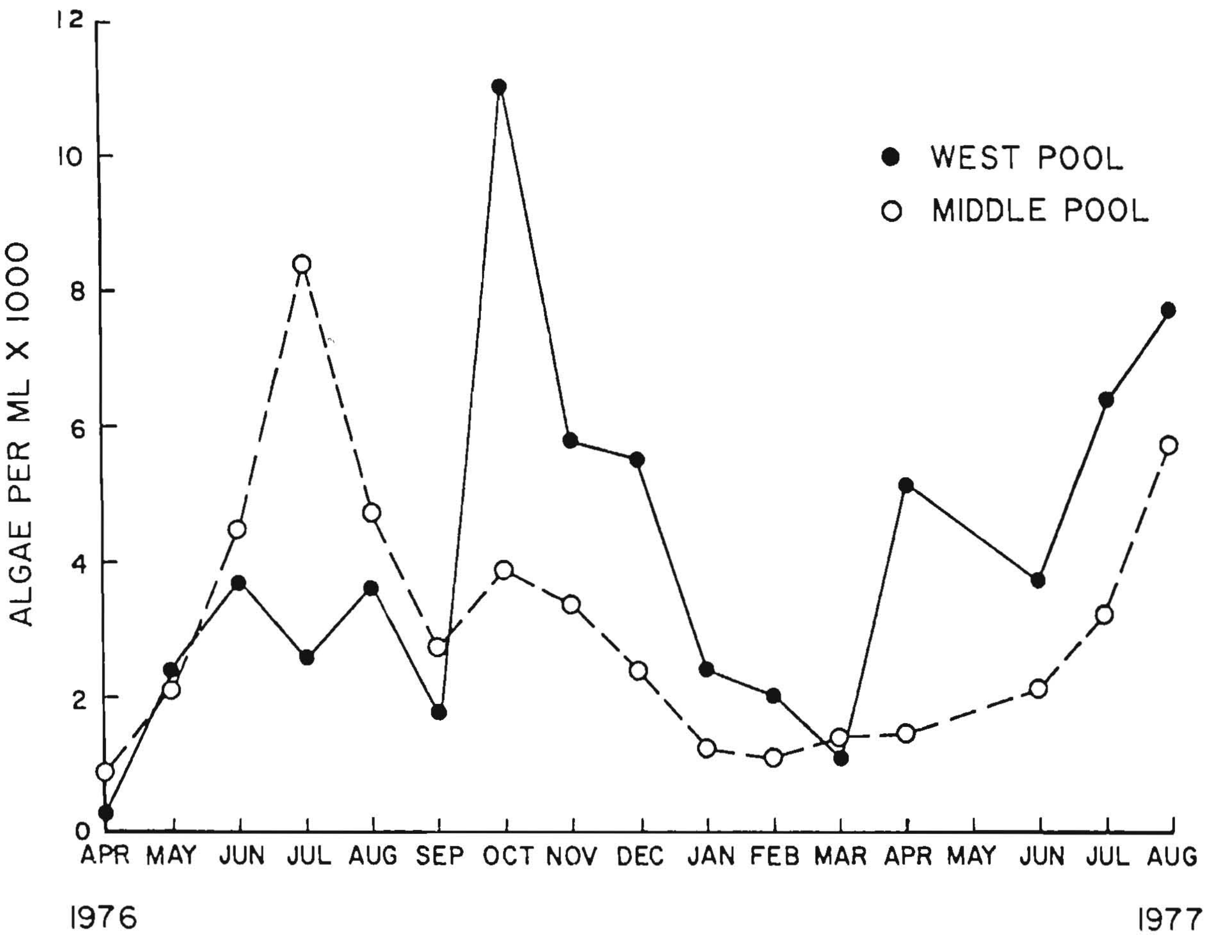

Figure 3. Average monthly abundance of phytoplankton, Middle and West Pools

in midsummer and late fall 1976. Density was low in winter but rose again in late summer 1977. This seasonal pattern is similar for all pools but substantial differences in abundance between pools were observed. Lake Gatlin and the northern pools were generally found to be more eutrophic with larger algal populations than the southern pools. The relative size and, to a lesser extent, the timing of phytoplankton peaks differ between pools. The fall 1976 bloom of algae was the principal yearly peak in all pools but Middle, where maximum abundance occurred in spring 1976.

23. The maximum algal abundance was in fall 1976 for most pools and was due to blooms of filamentous blue-green algae (*Oscillatoria limnetica*, *O. angustissima*, *Lyngbya limnetica*, and *Spirulina laxissima*). The blooms were due to the high nutrient concentrations associated with the late fall breakdown of lake stratification. The lake thermally stratifies during the summer. The temperature change rarely exceeds 1°C per metre of depth, but summer water temperatures often exceed 30°C at the surface. At these high temperatures greater density differences exist per degree than is true for cooler more northern lakes and result in more stable stratification for a given thermal profile. Hypolimnetic oxygen deficiency was evident in July and August of both 1976 and 1977. Nutrients released under anoxic conditions become available in the photic zone when mixing occurs in the fall. Algal blooms do not occur in the spring as in some northern lakes because Lake Conway is monomictic (one mixing per year) and is of sufficiently high temperature during the winter (minimum surface temperature around 13°C) to remain well mixed.

24. Another potential source of nutrients in the fall is associated with the dieback of large populations of submersed aquatic macrophytes. Very little is known about this relationship at present, but the receding plants are often covered with dense populations of periphyton, especially such filamentous genera as *Spirogyra*, *Ulothrix*, and *Oedogonium*. The increased importance of these genera during this period is suggestive of nutrient release from vascular plants as an important process in nutrient dynamics.

25. The phytoplankton are of rather low abundance and high diversity. The species present are common for central Florida and indicate a large variety of green algae (including desmids), which are often considered indicators of oligotrophic conditions. The lake has generally high transparency with a Secchi disc reading of 4 to 6 m in winter and 1.5 to 2 m in summer. Nevertheless, signs of eutrophy are also clearly in evidence; namely, large macrophyte populations and fall blooms of blue-green algae.

Zooplankton

26. To date, 6 copepod, 14 cladoceran, and 23 rotifer species have been identified from Lake Conway (Table 2). At any particular time, 2 to 4 species of copepods and cladocerans and 1 to 3 rotifers were encountered. Shannon-Weaver diversity in the individual samples was low (0.8 to 2.46) when compared to the phytoplankton and benthic invertebrate populations. However, low zooplankton diversity is characteristic for Florida (Nordlie 1976) and North America lakes in general (Pennak 1962).

27. All of the zooplankton species encountered during this study (Table 2) have been collected from other Florida lakes (Nordlie 1976; Confer 1971; Maslin 1969; Cowell et al. 1975).

28. Areal abundance of total zooplankton for the Conway system is presented in Figure 4. Generally zooplankton abundance numbered 10^5 individuals per square metre of surface area for all pools. Generally, an increase in numbers was observed from south to north through the pools (Table 3). Seasonal trends were evident with greater abundance of animals occurring during the warmer months. Within-pool variation was greatest in Lake Gatlin. This pool displayed some of the highest and lowest abundances of any pool measured. A precipitous drop in zooplankton numbers was noted in all pools from May through July of 1977. This decrease may be attributed in part to increased predation or decreased food supply during that period.

29. All three major groups of zooplankton considered in this

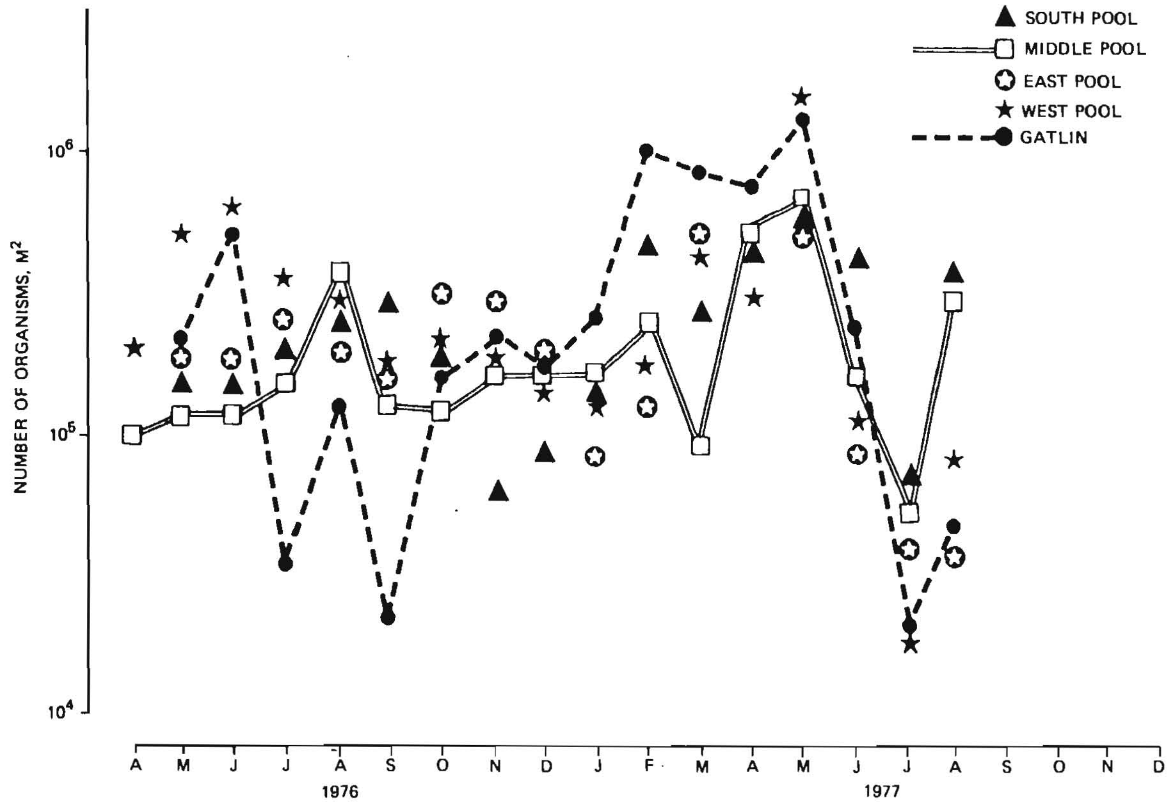

Figure 4. Areal abundance of total zooplankton, Lake Conway system

investigation were present in significant numbers in all pools throughout the year. For illustration, abundances and seasonal trends of copepods, cladocerans, and rotifers are presented for the West and Middle Pools of Lake Conway (Figure 5). Abundances of copepods and cladocerans throughout the system were on the order of 10^5 per square metre, whereas rotifers generally ranged slightly lower from (10^4 to 10^5 per square metre), reaching peaks of 10^6 per square metre in some pools. Distinct seasonal trends were not evident for all groups, but generally higher abundances were noted in spring and early summer.

30. In comparing 17-month averages of areal abundances of the major taxa in each pool, some interesting trends develop (Table 3). Copepods composed over 50 percent of total zooplankton in the South and

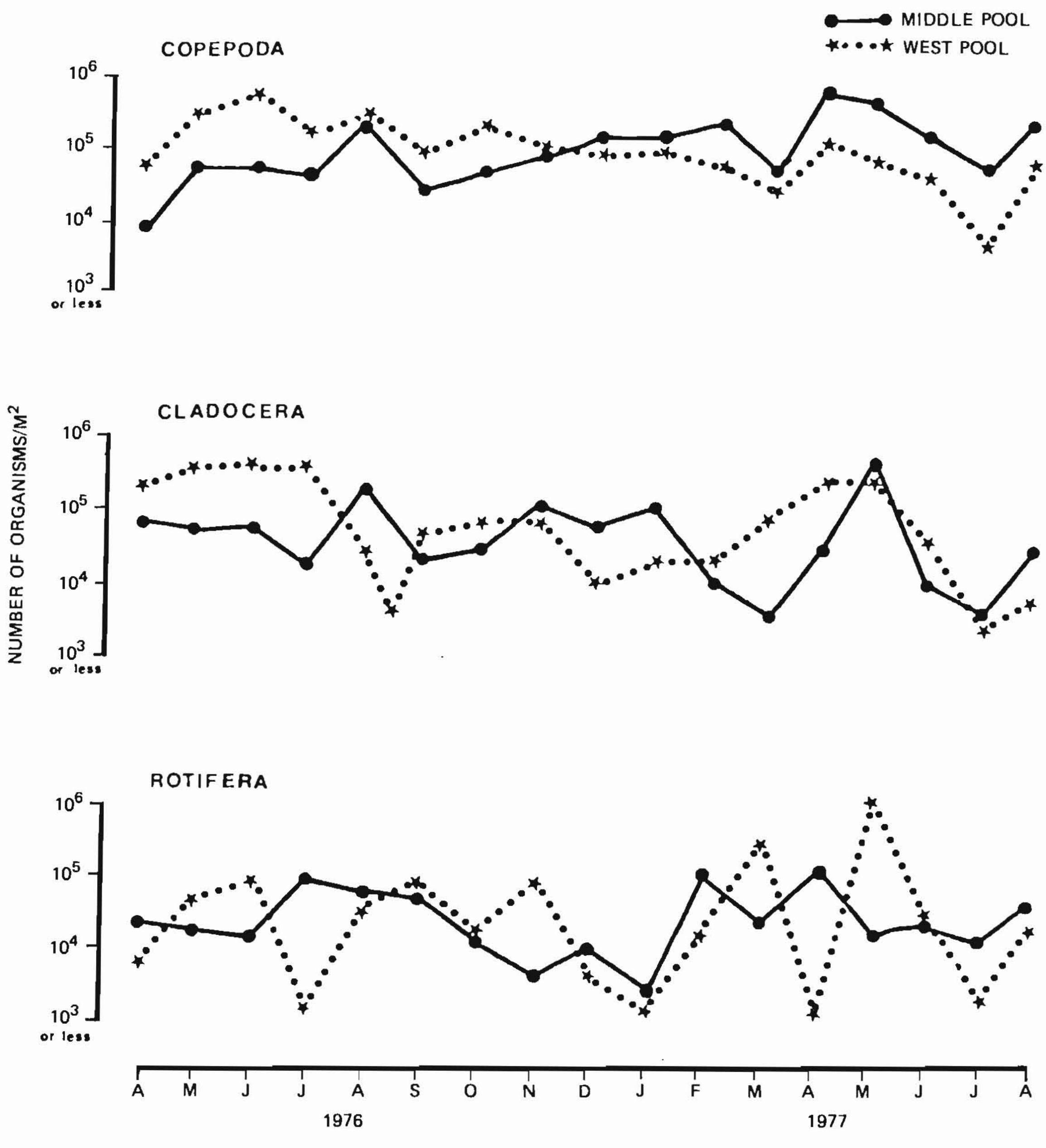

Figure 5. Abundance of major taxa of zooplankton in Middle and West Pools

Middle Pools, with cladocerans and rotifers of decreasing importance. In the East and West Pools copepods, cladocerans, and rotifers were codominant. Fifty-three percent of the total zooplankton in Lake Gatlin were cladocerans.

31. A zooplankton community represents an equilibrium of growth, reproduction, competition between individual species for available resources, and predation pressures. Opportunistic species with high rates of increase are favored in rapidly changing environments while others utilize strategies which are adaptive in more constant conditions (Allan 1976). Rotifers and cladocerans have short life cycles, are rather unspecialized feeders, and develop large transitory populations. Copepods, on the other hand, exhibit longer life cycles. Highly eutrophic lakes are usually dominated by small herbivorous zooplankton (rotifers and cladocerans) (Hrabacek et al. 1961; Brooks 1969; Cowell et al. 1975) whereas oligotrophic systems are typified by large populations of copepods (Allan 1976). The decrease in numbers of copepods, evident as one moves north through the pools, is associated with an increase in trophic state. A concomitant rise in cladoceran abundance is indicated but seems to lag in the East and West Pools. Perhaps a larger increase is not observed due to increased invertebrate predation in these pools.

32. Total zooplankton in eutrophic lakes number on the average 4 to 5×10^5 organisms per square metre or greater (Patalas and Salki 1973; Cowell et al. 1975) and range on the order of 1 to 2×10^5 organisms per square metre in oligotrophic lakes. Total abundance of zooplankton in the Lake Conway system (approximately 2 to 4×10^5 per square metre) is comparable to that of mesotrophic lakes in general.

Periphyton

33. Production (or net recruitment) rates calculated from the 6-cm and 1-m glass slide regrowth data for the five pools have been expressed in terms of dry weight (Figure 6), ash-free dry weight (Figure 7), and chlorophyll a (Figure 8). The values were determined by

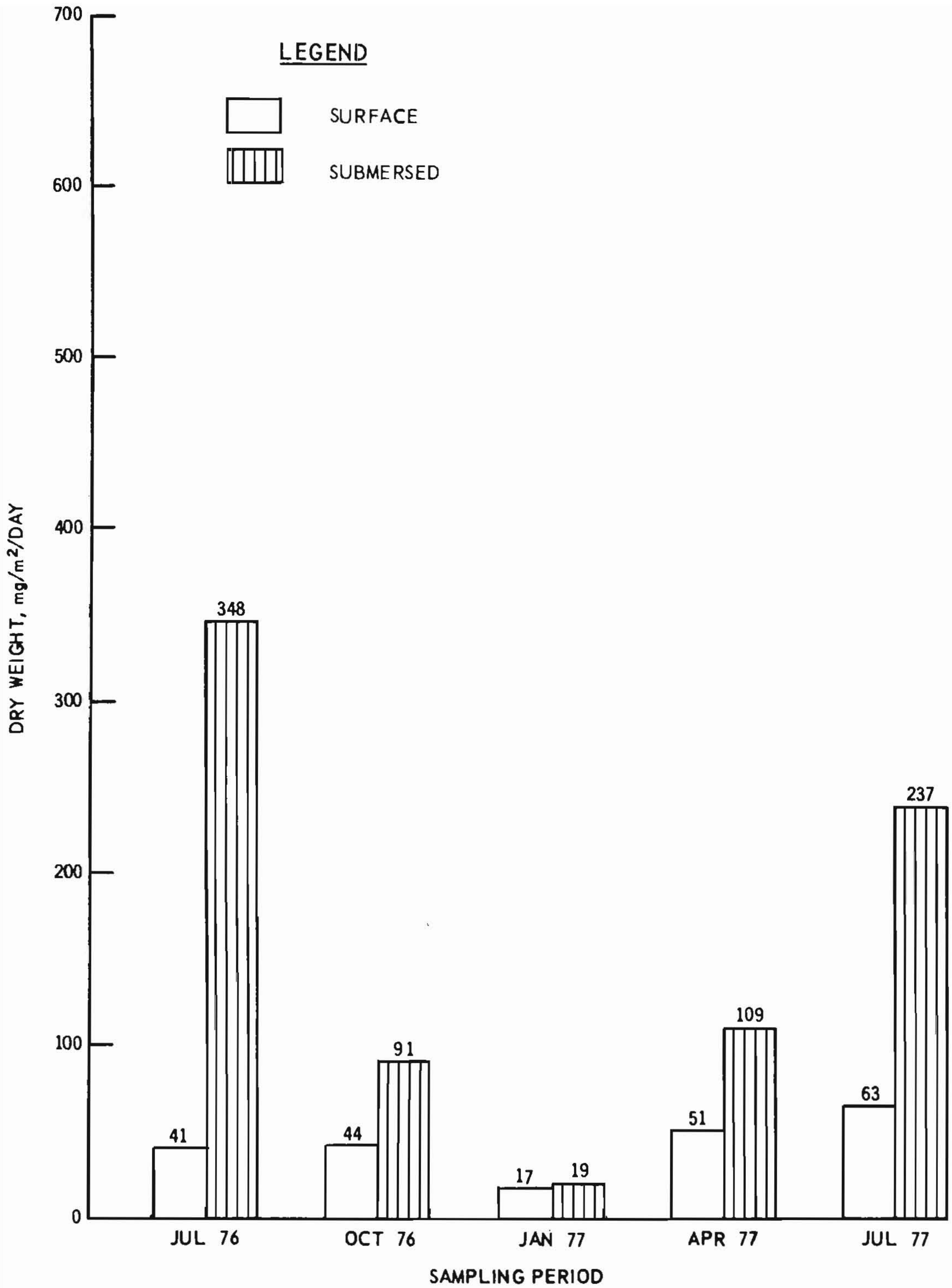

Figure 6. Dry weight production (average for the six stations) on 6-cm and 1-m slides

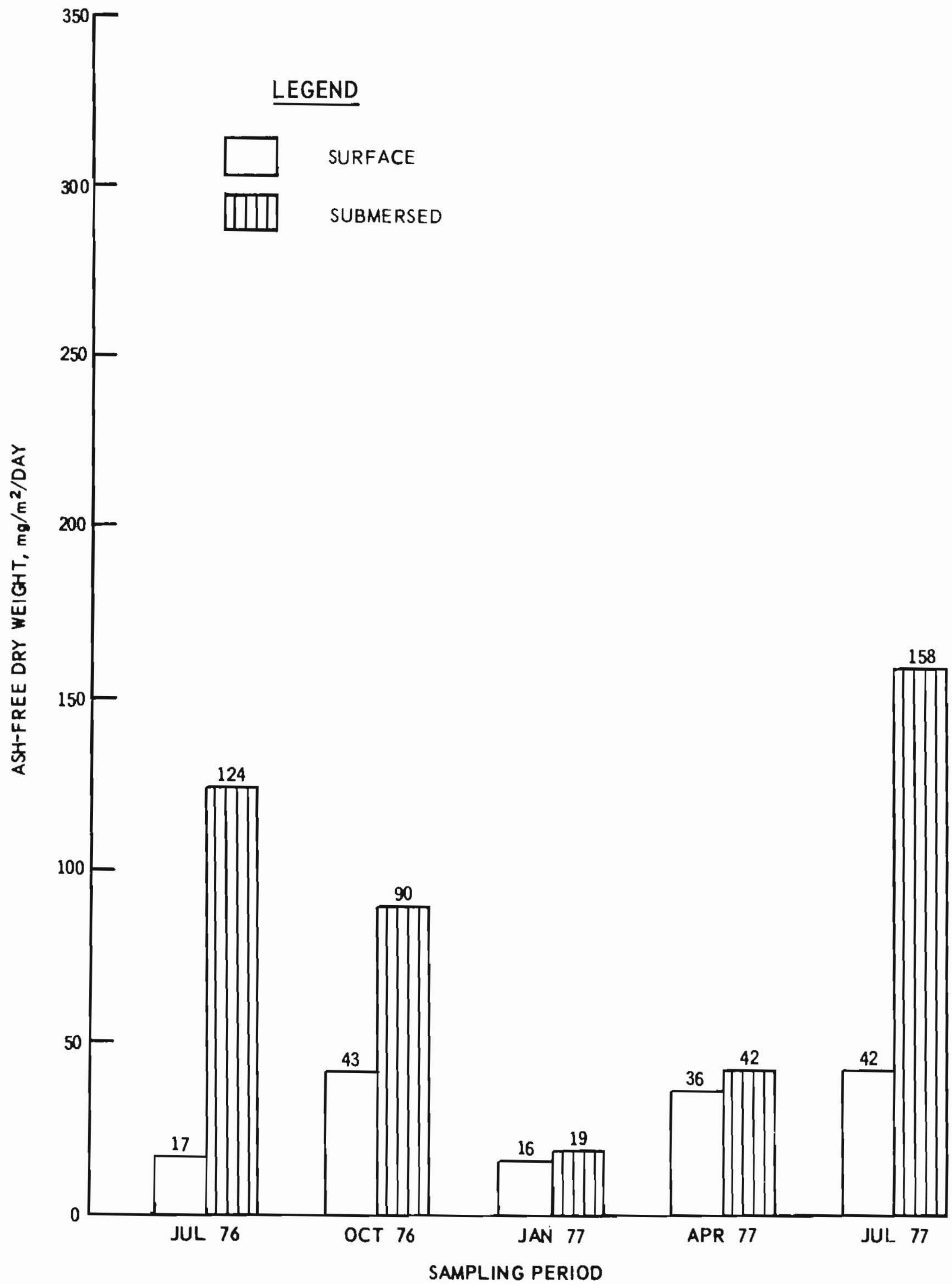

Figure 7. Ash-free dry weight production (average for the six stations) on 6-cm and 1-m slides

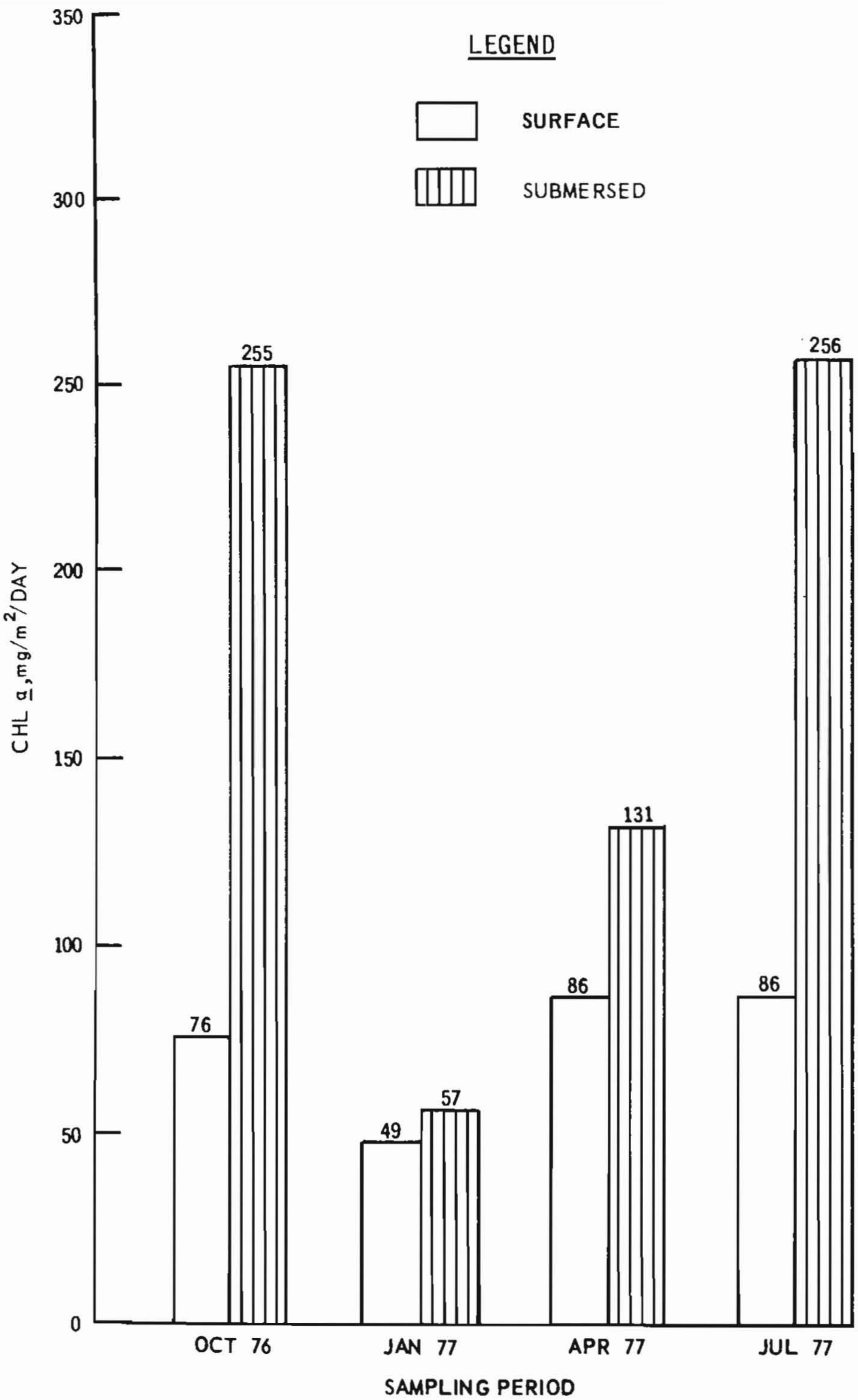

Figure 8. Chlorophyll a production (average for the six stations) on 6-cm and 1-m slides

dividing the parameter of biomass by the incubation time in days. Production was highest during the summer months and was greater throughout the year on the 1-m slides, presumably due to photoinhibition at 6 cm. The lowest production occurred during the winter.

34. The high summer production values were caused by high populations of blue-green algae, of which the most abundant in July 1976 were Lyngbya limnetica, Lyngbya epiphytica, Oscillatoria limnetica, and Schizothrix calcicola (see Table 4). The fall and winter periphyton, especially at 6 cm, were dominated by diatoms, which included Achnanthes minutissima, Synedra rumpens, Cyclotella stelligera, and species of Navicula. Even during the fall and winter, however, the blue-greens composed 37 and 9 percent, respectively, of the total periphyton population. The blue-greens increased in abundance and percent composition during the spring and again comprised the predominant group in the summer 1977 periphyton. Oscillatoria limnetica and Oscillatoria geminata were the most abundant species in July 1977.

35. Periphyton species diversity at 1 m was higher that at 6 cm. However, diversity at both depths exhibited similar seasonal trends. Diversity decreased from July 1976 to January 1977 and failed to return to its July 1976 level by the following summer.

36. Average periphyton abundance on macrophytes is shown in Figure 9. Maximum numbers occurred during the fall (7171 per square millimetre). Blue-green algae (Cyanophyceae) were dominant on macrophytes throughout the year (Table 5). Diatoms reached their highest numbers during the fall and winter, but never reached the proportion of the total that they did on the glass slides. Also unlike the slide growth, the proportion of green algae exceeded the proportion of diatoms in the fall of 1977.

37. The fall peak of epiphytic algae observed may be a response to nutrients released by dying or dead macrophytes. During the spring and summer, when the macrophytes are growing rapidly, periphyton populations are lower. At that time, however, phytoplankton populations are high. Thus, nutrient limitation and shading are additional factors which act to keep periphyton levels low in the spring and summer.

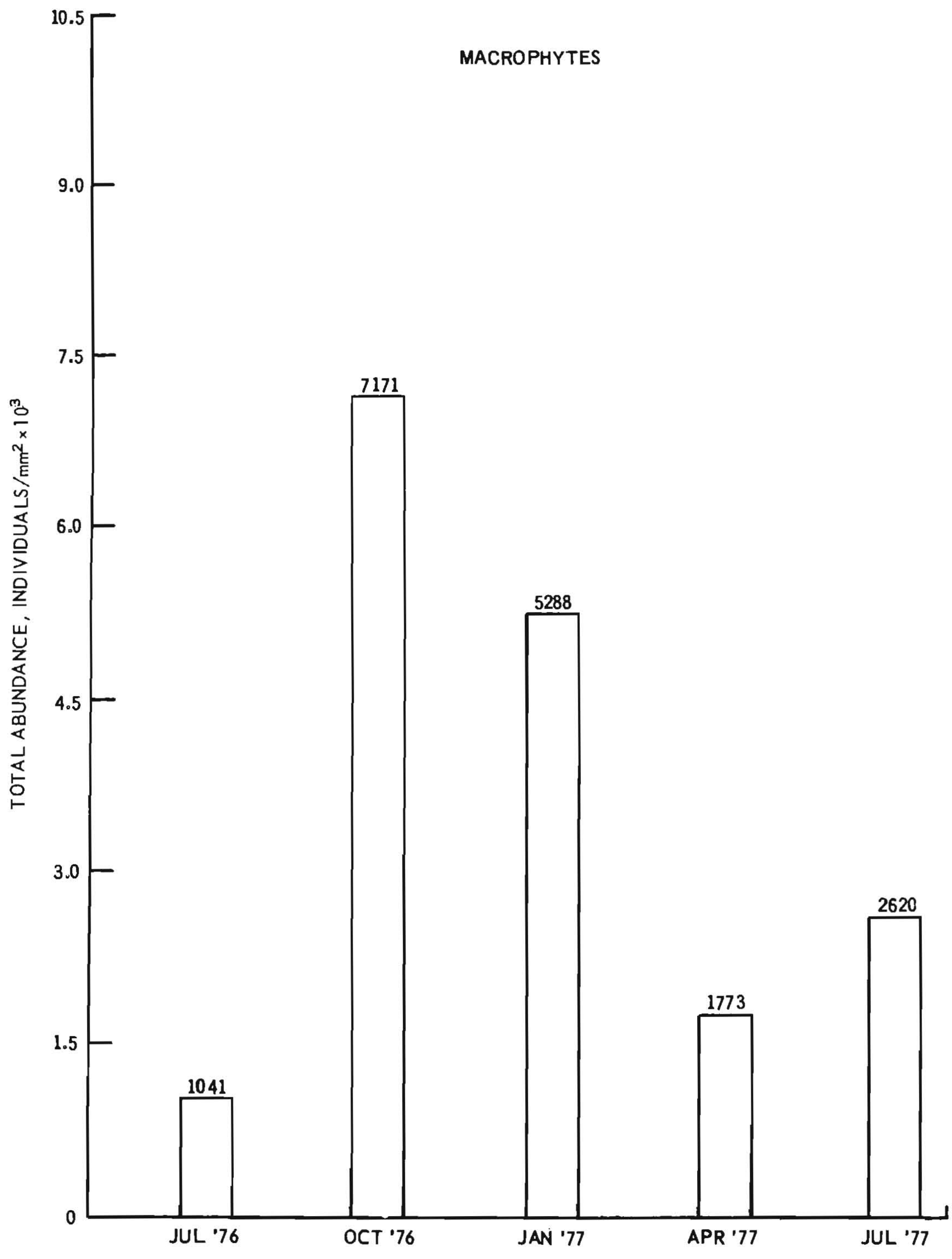

Figure 9. Total abundance (average for the six stations) on macrophytes

38. Species diversity of the macrophytic periphyton was usually greater than 4.0 throughout the year, about a unit higher than the diversity found on glass slides (Table 6). This higher diversity is a reflection of the greater age of the epiphyton and the resulting ecological stability. Colonizing ecosystems, such as those on glass slides, generally have lower diversity that do mature systems.

39. It is apparent that periphyton growth on glass slides does not adequately reflect natural periphyton populations. Although most of the species found on the macrophytes also occurred on the slides, large differences in abundance and dominance occurred at most sampling stations throughout the year.

40. The growth on the 1-m slides more nearly approximated natural growth than the periphyton on the 6-cm slides. With the exception of *Oscillatoria splendida*, most of the observed species were able to attach to slides at both depths. However, physical extremes at the water surface (high temperature, high light intensity, wave action) clearly affected growth there. No consistent differences were observed between the epiphyte communities associated with the three species of macrophytes.

Benthic Macroinvertebrates

41. A total of 75 taxa of benthic macroinvertebrates have been identified from Lake Conway. The most commonly encountered taxa are listed in Table 7. The organisms are distributed over a wide variety of groups, including groups that are commonly associated with unstressed environmental conditions, such as bryozoans (moss animalcules), trichopterans (caddis flies) and zygopterans (damsel flies). Other groups, such as the tubificids (sludgeworms) and many species of chironomids (midges) have a much greater tolerance for environmental stress and often occur in highly eutrophic waters (EPA 1973). But the trophic conditions of a body of water are usually judged by the presence or absence of environmentally sensitive species rather than by the occurrence of species that will tolerate a wide range of habitats.

42. Because great faunal differences exist between deep and shallow areas of the lake, results have been graphed separately for the 14 shallow stations (less than 3 m deep) and the 7 deep stations (more than 3 m deep). Plant growth is generally absent from deep stations, sediments are highly organic, and bottom dissolved oxygen values are usually much lower than at shallow stations. All of these factors greatly influence the invertebrate fauna.

43. Figure 10 shows the average monthly densities of macroinvertebrates for all pools combined. Densities at shallow stations are generally about twice as high as at deep stations, and major seasonal fluctuations are evident. Densities at both shallow and deep stations reach a maximum during late fall or winter, while minimum values occur in late summer. A similar trend was present for the average number of species per sample (Figure 11) and species diversity (Figure 12). On the average, twice as many species are present in samples from shallow

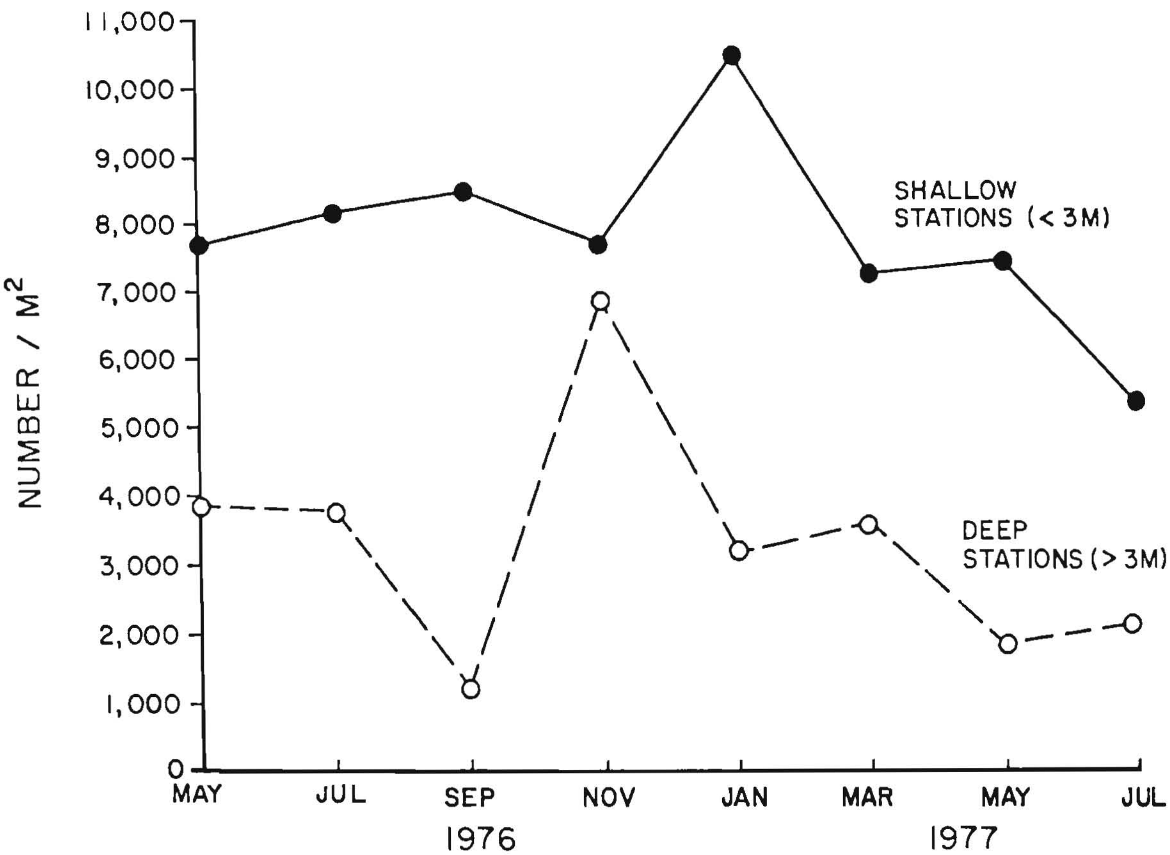

Figure 10. Average number of macroinvertebrates per square metre

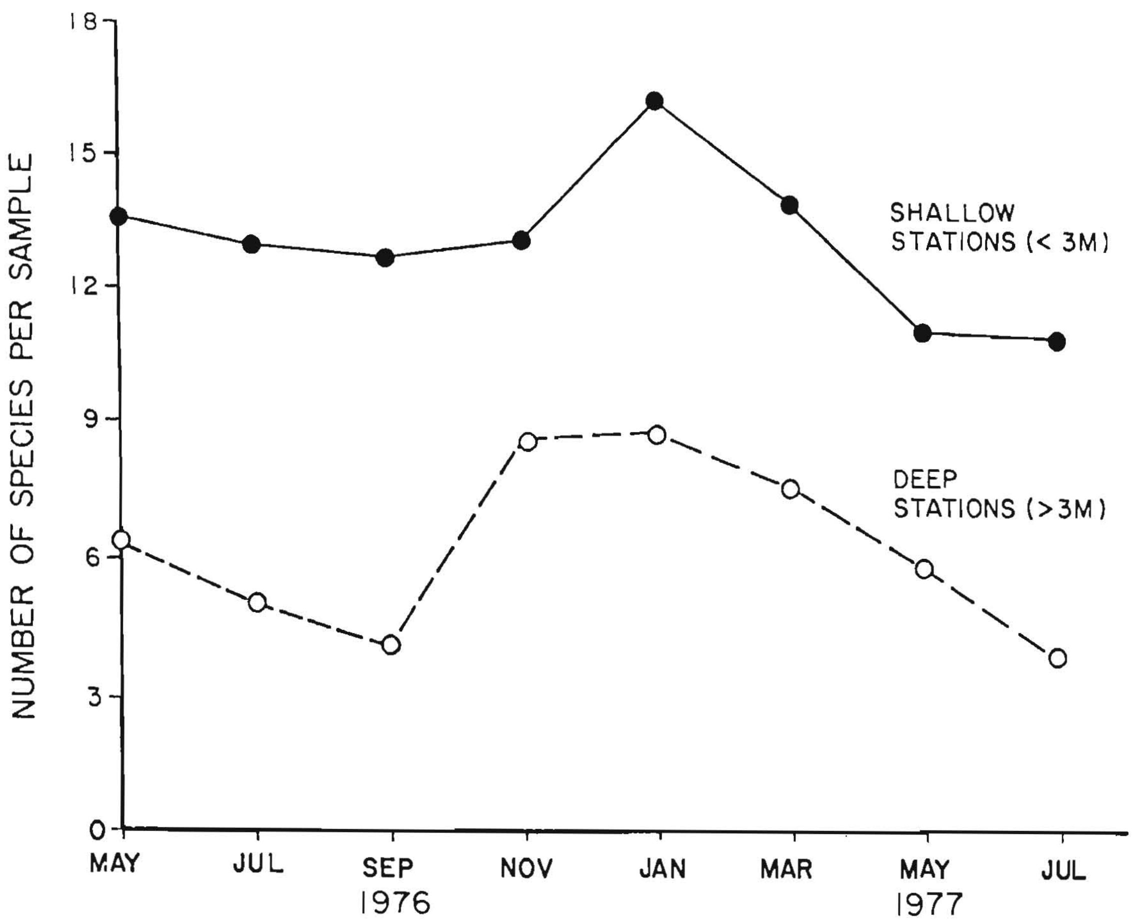

Figure 11. Average number of benthic macroinvertebrate species per sample

stations as deep stations. Also, the number of species reaches a maximum in winter and a minimum in late summer. High water temperatures in summer accelerated microbial decomposition of organic detritus resulting in low dissolved oxygen values near the sediment. These depressed oxygen levels limit the abundance and species of benthic invertebrates capable of surviving under those environmental conditions. In addition, several insect species are absent from summer samples because they emerge in spring and exist as flying adults during the summer period. Differences between shallow and deep stations may also be explained in part by environmental conditions. The higher sediment organic content at deep stations, coupled with lake stratification during summer favors a reduction in dissolved oxygen. Finally, greater

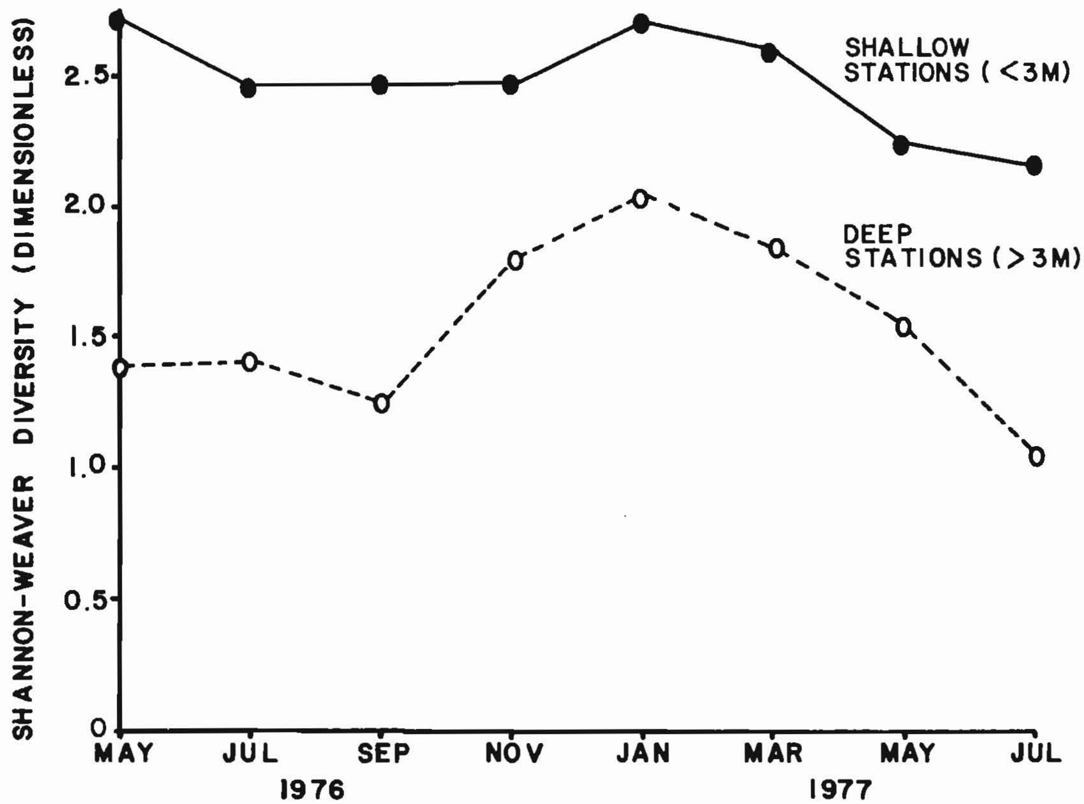

Figure 12. Benthic macroinvertebrate species diversity

abundance, species numbers, and diversity of invertebrates in shallow areas may also be attributed to the preference of individual species for the habitats there (sandy sediments, aquatic macrophytes, etc.).

44. Biomass is graphed in Figure 13 for shallow areas and in Figure 14 for deep areas. About 75 percent of the wet weight and 60 percent of the ash-free dry weight is accounted for by gastropods and bivalves, which are much larger and heavier than the other taxa of benthic macroinvertebrates. These mollusks are limited to the shallow areas and are not usually found in samples from deep areas. The Ponar grab is not designed to sample these larger organisms accurately. Therefore, many of the large fluctuations in both graphs are due to whether or not mollusks were present in a particular series of samples. Generally, average biomass per square metre is approximately 10 times higher in shallow areas than in deep areas. Ash (mainly shells of mollusks) accounts for up to about one half and ash-free dry weight

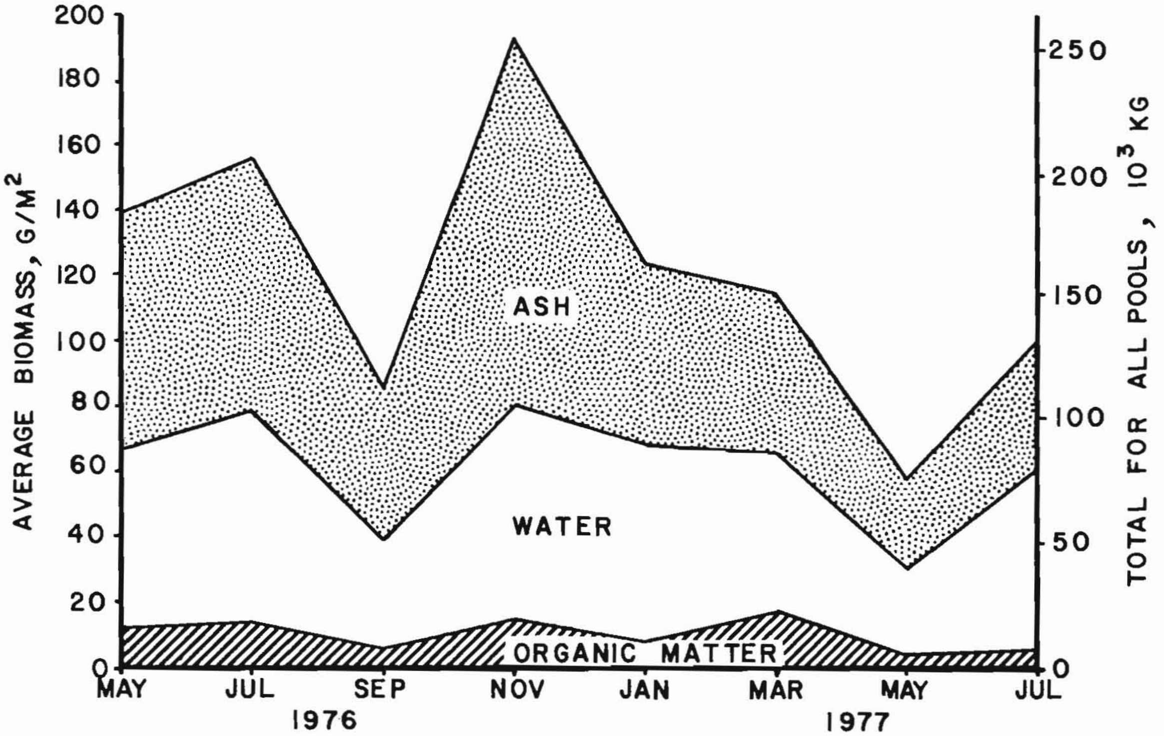

Figure 13. Biomass of benthic macroinvertebrates in shallow areas (<3 m)

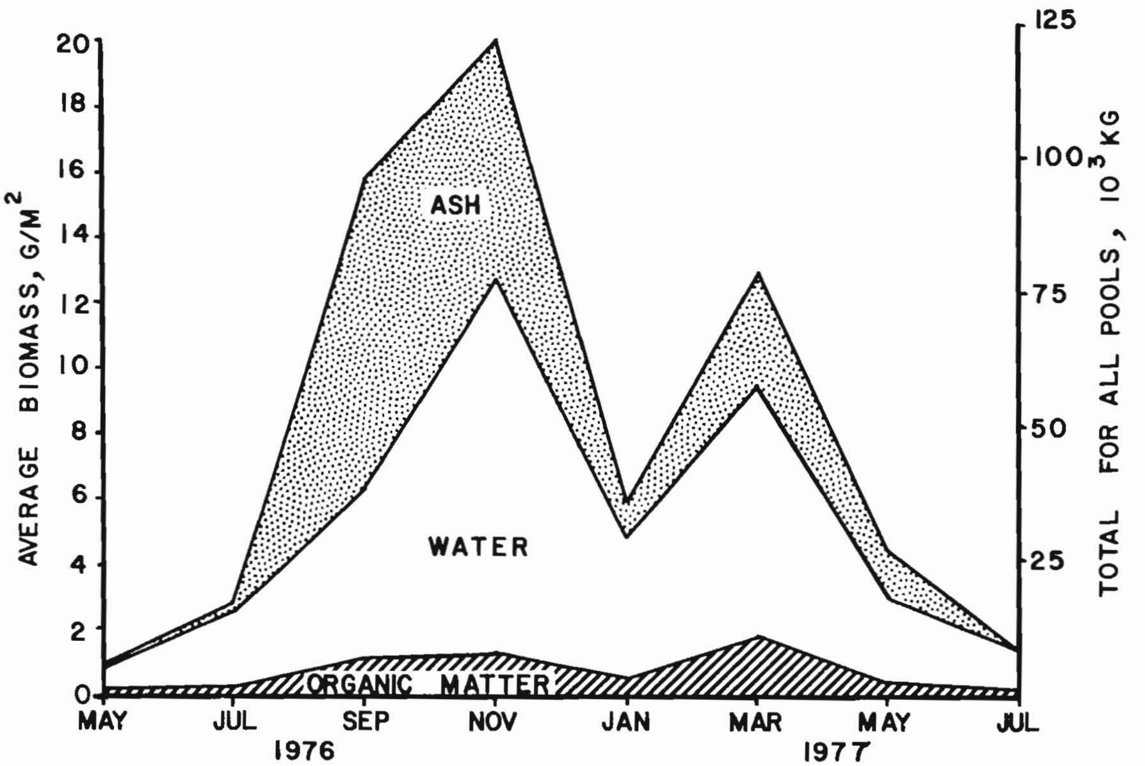

Figure 14. Biomass of benthic macroinvertebrates in deep areas (>3 m)

(organic matter) for about one tenth of the total weight. As for the other parameters that were studied, the biomass peaks during fall and winter and reaches a low during spring or summer, but the large variations in the number of mollusks caught make it hard to determine exactly when the minima and maxima occur.

45. The composition of the benthic invertebrate fauna at shallow stations is shown in Figure 15. The fauna may be divided into three major groups: oligochaetes (sludgeworms); chironomids (midge larvae); and a group of all the other species (other insect larvae, crustaceans, and flatworms). During the cooler part of the year, each of these groups comprises about one third of the total fauna, but from late spring to early fall, chironomids and oligochaetes account for up to 90 percent of the total. Species from these two groups are known to be more tolerant of the adverse environmental conditions of summer.

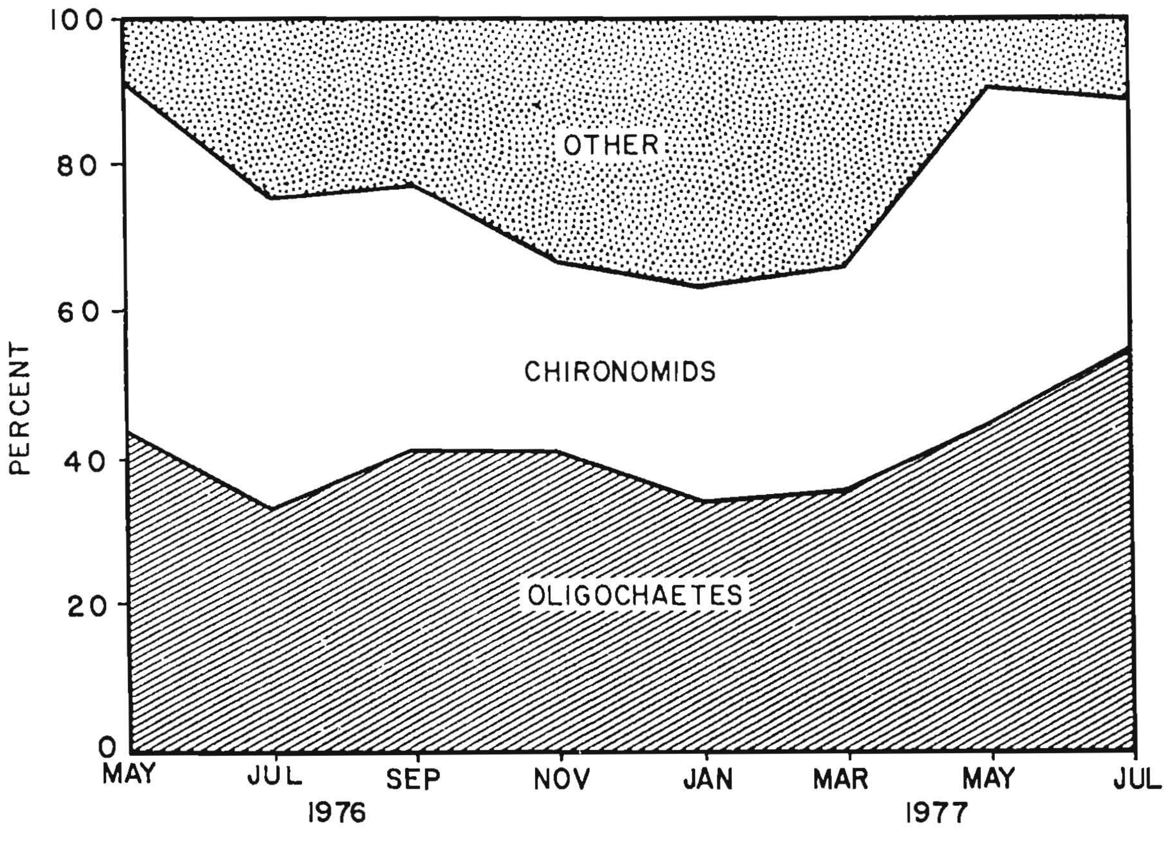

Figure 15. Composition of benthic macroinvertebrate fauna at shallow stations (<3 m)

Therefore, as the more sensitive organisms disappear during the warm season, oligochaetes and chironomids achieve a greater relative dominance (although their absolute numbers decline). At deep stations (Figure 16) the trend is somewhat different. Here the group of "Others" is composed mainly of one species, Chaoborus albipes (phantom midge), a species occurring only in deep areas. This organism migrates vertically in the water column at night to feed on zooplankton and is therefore not completely dependent on dissolved oxygen near the bottom sediments. Thus, it is able to survive very stressful conditions at deep stations even better than oligochaetes and chironomids. This explains why its relative abundance increases during summer when compared to the other two groups.

46. The life histories of individual species are very diverse and are often radically different from the trends of the total community.

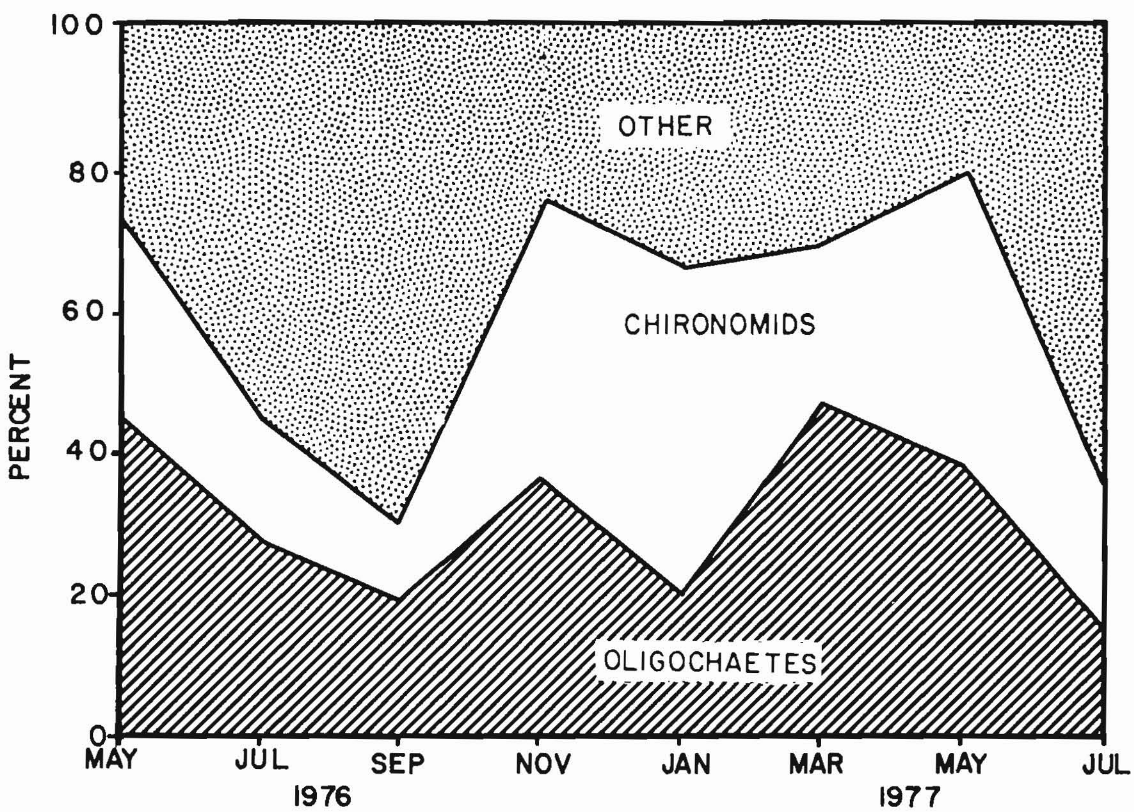

Figure 16. Composition of benthic macroinvertebrate fauna at deep stations (>3 m)

In general it can be said that Lake Conway supports a varied fauna during most of the year (including many environmentally sensitive species), while only during the summer months are conditions stressful enough to impose limitations on the numbers and species composition of benthic invertebrates.

PART IV: SUMMARY AND CONCLUSIONS

47. In general, the plankton and benthos are typical of mesotrophic Florida lakes. Phytoplankton communities are diverse with average densities approaching 5000 to 6000 cells per millilitre during summer. Blue-green blooms were observed in fall 1976, but the species involved are not as aesthetically unpleasant as in eutrophic lakes that are dominated by Aphanizomenon, Anabaena, or Microcystis, because those genera often form a foul-smelling scum on the water surface. Periphyton communities show much the same patterns as phytoplankton in terms of maximum diversity in summer and peak abundance in fall. In addition, many of the species are common to both communities although the relative abundances are often quite different. Zooplankton abundance (averaging about 50 per litre) and species composition are similar to other Florida lakes and are characteristic of the mean range of trophic state. Zooplankton diversity is 1.5 to 1.8 as an overall average. Benthic macroinvertebrates have both tolerant and intolerant indicator species present and are fairly diverse. The benthic fauna displays effects of summer hypolimnetic anoxia, but the littoral assemblage remains fairly diverse. For all of these communities there is a broad data base to allow evaluation of the effects of the white amur on Lake Conway.

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Table 1

Major Algal Species from Lake Conway

Chlorophyta (greens)	
	Ankistrodesmus falcatus
	Chlorella sp.
	Cosmarium lapponicum
	Gloeocystis vesiculosa
	Scenedesmus bijuga
	Selenastrum minutum
	Tetraedron minimum
Bacillariophyceae (diatoms)	
	Achnanthes minutissima
	Cyclotella stelligera
	Synedra rumpens
Cryptophyta (cryptophytes)	
	Chroomonas minuta
	2 unidentified spp.
Cyanophyta (blue-greens)	
	Agmenellum punctata
	Aphanocapsa delicatissima
	Aphanothece nidulans
	Chroococcus dispersus
	Chroococcus limneticus
	Coelosphaerium
	Lyngbya epiphytica
	Lyngbya limnetica
	Microcystis aeruginosa
	Oscillatoria angustissima
	Oscillatoria geminata
	Oscillatoria limnetica
	Schizothrix calcicola

Table 2

Zooplankton Collected from the Lake Conway System

April 1976-August 1977

Rotifera

cf. *Ascomorpha* sp.
**Asplanchna* sp.
Brachionus havanaensis
B. quadridentata
B. sp.
Conochiloides cf. *dossvarius*
**Conochilus unicornis*
Enteroploa lacustris
Epiphanes sp.
Euchlanis
Filinia longiseta
Hexarthra sp.
Kellicotia sp.
**Keratella cochlearis*
Lepadella sp.
Lecane sp.
Monostyla sp.
**Platyias patulus*
Polyarthra cf. *vulgaris*
Sinantherina sp.
**Trichocerca longiseta*
T. multicrinis
Trochosphaera solstitialis

Copepoda

Calanoida
**Diaptomus floridanus*

Cyclopoida
Cyclops bicuspidatus
**C. vernalis*
Ergasilus sp.
**Mesocyclops edax*
**Tropocyclops prasinus*

Branchiopoda

Cladocera
Alona rectangula
Alona sp.
**Bosmina longirostris*
Camptocercus vectirostris
**Ceriodaphnia* sp.
**Chydorus sphaericus*
Chydorus sp.
**Daphnia ambigua*
**Diaphanosoma brachyurum*
Ilyocryptus sordidus
Latonopsis occidentalis
Macrothrix hirsutocornis
Pleurexus sp.
Simocephalus sp.

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* Species frequently encountered.

Table 3

Average Areal Abundances and Percentages of Major Zooplankton Taxa in the Lake Conway System

	Copepoda		Cladocera		Rotifera		
	No./m^2	%	No./m^2	%	No./m^2	%	Total
South Pool	107,938	50.3	69,735	32.4	36,975	17.2	214,648
Middle Pool	101,844	50.6	56,299	27.96	43,208	21.5	201,351
East Pool	78,367	34.4	62,182	27.3	87,485	38.4	228,034
West Pool	89,075	31.6	102,089	36.2	90,809	32.2	281,973
Lake Gatlin	90,870	23.9	201,800	53.2	86,316	22.7	378,986

Table 4

Percent of Total Periphyton Represented by Cyanophyceae, Chlorophyceae, and Bacillariophyceae Collected from Surface and Submerged Glass Slides

Station	Percentage Total Periphyton*																													
	Surface Glass Slides															Submerged Glass Slides														
	7/76			10/76			1/77			4/77			7/77			7/76			10/76			1/77			4/77			7/77		
South Pool	67	21	12	15	8	77	9	4	87	33	2	65	80	9	11															
Middle Pool 1	52	45	3	22	4	74	22	4	74	50	17	33	75	15	10				35	6	59	35	6	59	60	23	17	82	12	6
Middle Pool 2	72	16	12	33	33	34	27	7	66	59	28	13	83	7	10	63	19	18	56	15	29	38	32	30	72	10	18	78	14	8
East Pool	78	10	12	65	15	20	15	8	77	81	14	5	79	14	7				62	13	25	27	7	66	91	6	3	69	25	6
West Pool	45	31	24	52	11	37	29	12	59	68	5	27	77	16	7	60	19	21				71	7	22	75	11	14	77	13	10
Lake Gatlin	80	7	13	64	6	30	1	2	97	9	4	87	79	15	6	56	7	37				9	3	88	8	8	84	79	14	7
Average	76	13	11	37	11	52	9	3	88	35	6	59	79	13	8	60	19	21	46	13	41	52	8	40	52	11	37	79	12	9

* Cyanophyceae (first column), Chlorophyceae (second column), and Bacillariophyceae (third column) under each date.

Table 5

Percent of Total Periphyton Represented by Cyanophyceae, Chlorophyceae, and Bacillariophyceae Collected from Select Macrophytes

Station	Macrophyte	Percentage Total Periphyton*														
		7/76			10/76			1/77			4/77			7/77		
South Pool	Potamogeton	65	14	21	62	24	14	66	13	21	73	16	11	70	24	6
Middle Pool 1	Potamogeton				59	18	23	57	14	29	80	13	7	80	13	7
Middle Pool 2	Potamogeton													77	14	9
	Hydrilla	68	18	14												
East Pool	Potamogeton				64	19	17	55	28	17	39	43	18	80	13	7
	Vallisneria	82	11	7	45	31	24	47	37	16	40	45	15	70	20	10
	Nitella				60	15	25	55	10	35	47	38	15	69	26	5
West Pool	Potamogeton				58	23	19	59	9	32	54	33	13	74	17	9
	Vallisneria				59	18	23									
	Nitella				51	20	29	53	16	31	43	45	12			
Average		68	15	17	58	19	23	62	14	24	47	38	15	71	20	9

* Cyanophyceae (first column), Chlorophyceae (second column), and Bacillariophyceae (third column) under each date.

Table 6

Shannon-Weaver Species Diversity Index for Periphyton

Collected from Select Macrophytes

Station	Macrophyte	Species Diversity				
		7/76	10/76	1/77	4/77	7/77
South Pool	*Potamogeton*	4.56	4.30	3.43	4.34	3.88
Middle Pool 1	*Potamogeton*		3.80	3.83	3.80	3.74
Middle Pool 2	*Potamogeton*					4.24
	Hydrilla	4.71				
East Pool	*Potamogeton*		4.30	4.20	4.25	3.63
	Vallisneria	4.00	4.20	4.33	3.95	4.28
	Nitella		4.55	4.16	3.77	4.04
West Pool	*Potamogeton*		3.96	3.38	4.22	3.79
	Vallisneria		3.90			
	Nitella		4.32	4.27	4.36	
Median		4.56	4.25	4.16	4.22	3.88

Table 7

Most Common Taxa of Benthic Macroinvertebrates in Lake Conway

Turbellaria:	*Dugesia tigrina*
Bryozoa:	*Plumatella repens*
Gastropoda:	*Gyraulus* sp.
	Pomacea sp.
	Goniobasis sp.
Pelecypoda:	Unionidae
Oligochaeta:	Tubificidae
	Pristina breviseta
Amphipoda:	*Hyalella azteca*
Decapoda:	*Palaeomonetes paludosus*
Odonata:	*Enallagma signatum*
	Epicordulia regina
	Somatochlora filosa
Trichoptera:	*Leptocella* sp.
Diptera:	*Chaoborus punctipennis*
	Procladius sp.
	Tanypus sp.
	Ablabesmyia peleensis
	Chironomus attenuatus
	Cryptochironomus fulvus
	Polypedilum halterale
	Glyptotendipes senilis
	Cladotanytarsus sp.

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Conley, Roger
Large-scale operations management test of use of the white amur for control of problem aquatic plants; Report 1: Baseline studies; Volume III: The plankton and benthos of Lake Conway, Florida / by Roger Conley ... [et al.], Department of Environmental Engineering Sciences, University of Florida, Gainesville, Fla. Vicksburg, Miss. : U. S. Waterways Experiment Station ; Springfield, Va. : available from National Technical Information Service, 1979.
33, [7] p. : ill. ; 27 cm. (Technical report - U. S. Army Engineer Waterways Experiment Station ; A-78-2, Report 1, v.3)
Prepared for U. S. Army Engineer District, Jacksonville, Jacksonville, Fla., and Office, Chief of Engineers, U. S. Army, Washington, D. C., under Contract No. DACW39-76-C-0076.
References: p. 32-33.

1. Aquatic plant control. 2. Benthos. 3. Biological control. 4. Lake Conway. 5. Plankton. 6. White amur. I. Florida. University. Gainesville. Dept. of Environmental Engineering

(Continued on next card)

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