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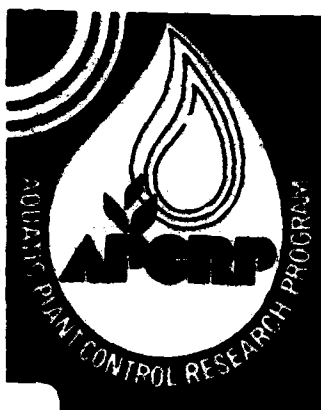
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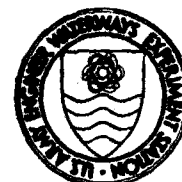


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LARGE-SCALE OPERATIONS MANAGEMENT TEST OF USE OF THE WHITE AMUR FOR CONTROL OF PROBLEM AQUATIC PLANTS

Report 2

FIRST YEAR POSTSTOCKING RESULTS

Volume III

The Plankton and Benthos of Lake Conway, Florida

By Thomas L. Crisman and Floor M. Kooijman

Department of Environmental Engineering Sciences
University of Florida
Gainesville, Fla. 32611

November 1981

Report 2 of a Series

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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**
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Report 2: First Year Poststocking Results

Report 3: Second Year Poststocking Results

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20. ABSTRACT (Continued).

data for the first 6 months of the first poststocking year were not collected. Data for the last 6 months were collected and the second poststocking year report will present and discuss the balance of the first year poststocking periphyton data, as well as the second year poststocking periphyton data.

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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 (UF), Gainesville, Fla. The work was sponsored by the U. S. Army Engineer District, Jacksonville, and by the Office, Chief of Engineers, U. S. Army, Washington, D. C.

This is the third of seven volumes that constitute Report 2 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, Fla. Report 1 of the series presents the results of the baseline studies of Lake Conway; Report 3 will present the second year poststocking results.

This volume was written by Dr. Thomas Crisman and Mr. Floor Kooijman, UF. The work was performed by the authors and the following UF graduate students: algal analysis, Messrs. Roger Conley, Charles Foorick, and Tom Hall, and Ms. Brenda Franey; zooplankton analysis, Mr. Don Blancher and Ms. Nancy Gourlie. Technical assistance was provided by Mr. John Allinson.

The work was monitored by the WES Environmental Laboratory (EL), Dr. John Harrison, Chief. The study was under the general supervision of Mr. B. O. Benn, Chief, Environmental Systems Division, EL, and the direct supervision of Mr. J. L. Decell, Manager, Aquatic Plant Control Research Program, EL. Principal investigators at WES for the study were: Messrs. R. F. Theriot, John Lunz, and Eugene Buglewicz, all of the ESD, EL.

Commanders and Directors of WES during the conduct of the study and preparation of the report were COL John L. Cannon, CE, and COL Nelson P. Conover, CE. Technical Director was Mr. F. R. Brown.

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

FIRST YEAR POSTSTOCKING RESULTS

The Plankton and Benthos of Lake Conway, Florida

PART I: INTRODUCTION

1. Lacustrine systems in areas with rapidly expanding human populations such as Florida often become more productive (eutrophication) as a direct result of the increased demands for recreational, residential, agricultural, or commercial purposes. Cultural eutrophication results from the increased release of essential nutrients, especially phosphorus and nitrogen, associated with human activities within the surrounding watershed; one manifestation of which is an increase in primary production, i.e. algae or macrophytes.

2. Eutrophic lakes tend to be dominated by either macrophytes or algae, but not both. Which of the two primary producers becomes dominant is a result of several interrelated factors including substrate, basin morphometry, and competition for nutrients and light (Wetzel 1975).

3. Several algal-dominated eutrophic lakes in Florida, including Lake Apopka and the four interconnected downstream lakes (Brezonik et al. 1977; Tuschall et al. 1979; Crisman, Fellows, and Brezonik 1979), have been studied in detail. Such systems are characterized by frequent fish kills, reduced light transmission, and high sustained biomass of blue-green algae throughout the year. With the exception of shoreline emergents, macrophytes are essentially absent, and the bottom sediments often become unstable and flocculent.

4. Eutrophic systems that are dominated by macrophytes are characterized by increased light transmission and, with the exception of the often extensive epiphytic algal biomass on the macrophytes themselves, have reduced algal populations (Wetzel 1975). The entire water column

in such lakes frequently is completely choked to the surface with macrophytes resulting in stunted fish populations and increased problems for recreational, navigational, and agricultural (irrigation) utilization.

5. In addition to a general biomass increase associated with cultural eutrophication, the macrophyte problem in Florida is further complicated by the establishment of several exotic plant species. These include waterhyacinth (Eichhornia crassipes), Florida elodea (Hydrilla verticillata), and Eurasian watermilfoil (Myriophyllum brasiliense).

6. Problem macrophytes may be controlled by either chemical, mechanical, or biological means. The purpose of the present research was both to evaluate the effectiveness of the white amur as a biological macrophyte control agent and to determine if any major ecosystem alterations occurred associated with the introduction of this exotic fish species into Florida lacustrine systems.

7. Lake Conway near Orlando, Fla., was chosen as the test site for white amur introduction by the U. S. Army Corps of Engineers and the Florida Game and Fresh Water Fish Commission. Chemical and biological monitoring of the system to establish baseline conditions prior to fish introduction began in January 1976 and continued on a monthly basis until September 1977. On 9 September 1977, white amur (7,600) averaging 450 g each were introduced into the Lake Conway system; this was the beginning of the poststocking period. The poststocking monitoring of the Lake Conway system was expected to continue until at least September 1980, with essentially the same parameters being monitored in both prestocking and poststocking periods. Specifically, macrophyte community composition and biomass were monitored by the Florida Department of Natural Resources, fish populations by the Florida Game and Fresh Water Fish Commission, reptiles and amphibians by the University of South Florida, chlorophyll and water chemistry by the Orange County Pollution Control Department, and primary productivity and development of an ecosystem response model by the School of Forest Resources and Conservation of the University of Florida. The Department of Environmental Engineering Sciences of the University of Florida was responsible for monitoring phytoplankton, zooplankton, and benthic invertebrates.

8. The present report is a summary of the biological monitoring conducted by the Department of Environmental Engineering Sciences of the University of Florida for the first year following white amur introduction in Lake Conway (September 1977-August 1978). In addition, detailed comparison with comparable data from the prestocking period has been included. Data summaries are available from either the senior author or the U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss.

PART II: MATERIALS AND METHODS

Study Site and Sampling Regime

9. Lake Conway, located southwest of Orlando, Fla., is a 740-hectare system of five interconnected pools. From north to south these pools include Lake Gatlin, the West and East Pools of Little Lake Conway, and the Middle and South Pools of Lake Conway proper. Morphometric features for each pool of the Lake Conway system are summarized in Table 1. Lake level for the system is maintained at approximately 26 m above mean sea level (msl) by a concrete and wooden dam at the southeast corner of the South Pool, the only outflow from the system. Greater than 70 percent of the watershed area of the Lake Conway system has been developed for residential purposes with the remainder of the watershed devoted principally to citrus agriculture (Blancher 1979).

10. The shoreline vegetation is dominated by cattail (Typha latifolia), maidencane (Panicum hemitomon), and torpedo grass (Panicum repens), but the overall areal extent of this community is rapidly diminishing due to residential shoreline development (Nall and Schardt 1979). The submersed macrophyte community is more highly developed and is dominated by Illinois pondweed (Potamogeton illinoensis), nitella (Nitella megacarpa), American eelgrass (Vallisneria americana), and Florida elodea (Hydrilla verticillata); the dominance of the latter species has been reduced following chemical treatment in 1975.

11. Benthic invertebrates have been sampled at 16 littoral and 5 limnetic stations in the Lake Conway system. Phytoplankton and zooplankton were originally sampled at these same 21 stations, but after April 1977 this was changed to 13 littoral and 13 limnetic stations (Figure 1). With the exception of benthic invertebrates, which have always been collected every other month, all sampling was conducted on a monthly basis.

Physical-Chemical Parameters

12. Secchi disk transparency, dissolved oxygen, and temperature

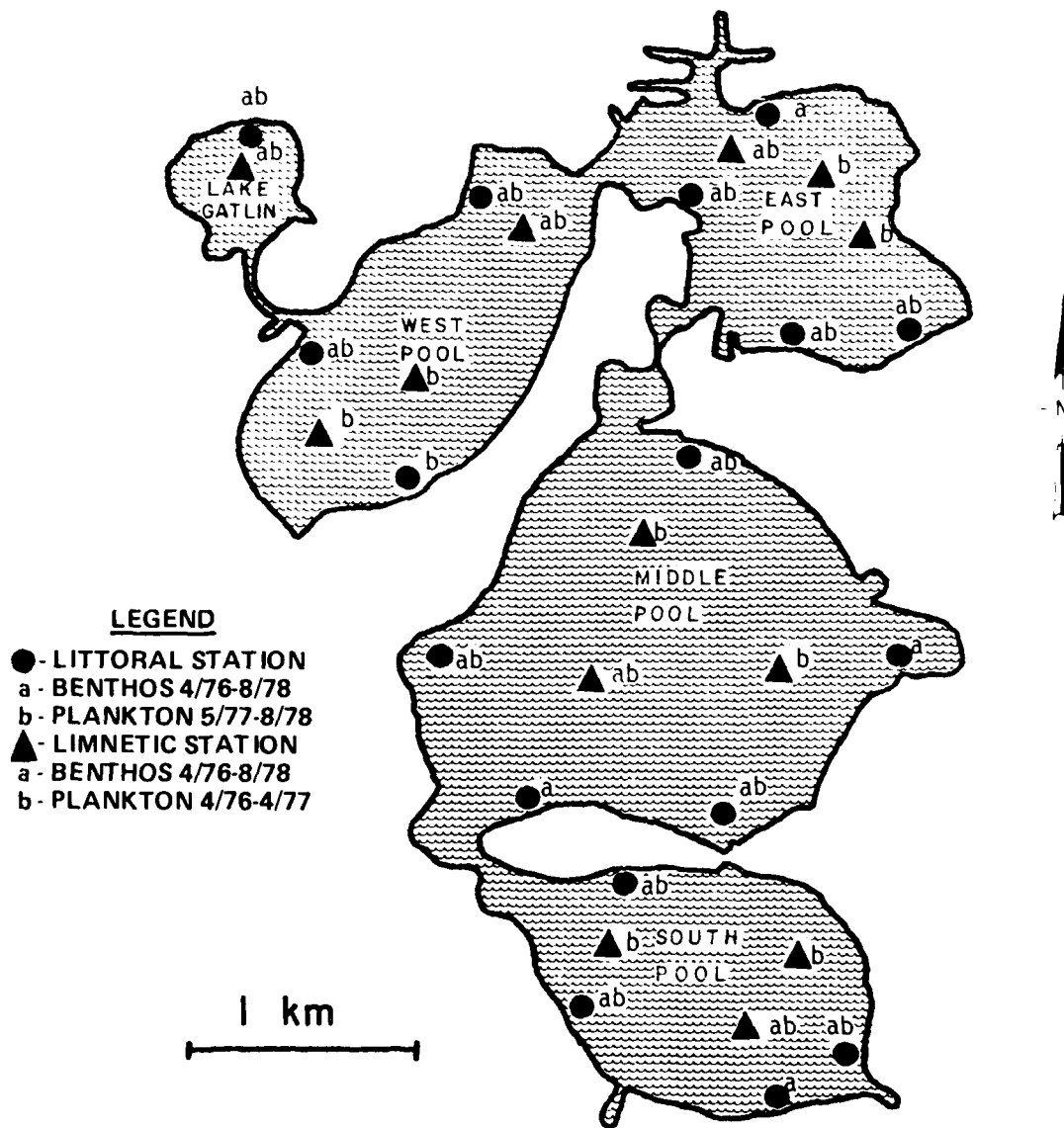


Figure 1. Location of sampling stations in the Lake Conway system

have been monitored since April 1976. From April 1976 until March 1977, temperature and dissolved oxygen were measured at 1-m intervals using an oxygen-thermistor probe (Yellow Springs Instruments). Since March 1977, temperature and dissolved oxygen have been measured in situ using a Hydrolab Surveyor (Hydrolab Inc.).

Plant Pigments

13. Water samples for pigments analysis were collected at a depth of 1 m for littoral stations (<3 m) by means of a Van Dorn or Kemmerer sample bottle. Limnetic stations (>3 m) were sampled at 1 m, middepth (usually 4 m), and 1 m above the bottom (approximately 7 m) by means of a 5-hp (3728.5-w) centrifugal pump equipped with a 10-m flexible hose (inside diameter 8 cm). The distal end of the hose was equipped with a device made of two horizontally oriented plates of stainless steel separated by three spacer bolts (10 cm) in order to ensure that the hose remained vertical during sampling and that sampling at any depth was predominantly along a horizontal plane.

14. Water samples were placed in opaque plastic bottles, stored on ice, and transported to the laboratory where all pigment analyses were completed within 48 hr. In the laboratory, sample water was filtered through a 0.45- μ Millipore filter; the amount filtered varied seasonally and ranged from 150 ml in the summer to 300 ml in the winter. To the final 5 ml of sample, 5 drops of aqueous saturated magnesium carbonate was added. The filters were subsequently dissolved in 10 ml of acetone and stored at -14°C for 24 hr, following which chlorophyll content was measured by the trichromatic method on a Beckman DBG spectrophotometer (American Public Health Association 1975). All pigment discussion in this report deals solely with functional chlorophyll a (denoted here simply as chlorophyll a), the active form of the pigment, i.e. total chlorophyll a corrected for phaeophytin (APHA 1975).

Phytoplankton

15. Phytoplankton samples from littoral stations (<3 m) were

collected at a depth of 1 m with either a Van Dorn or Kemmerer sample bottle; samples from limnetic stations (>3 m) were collected at 1 m, middepth (generally 4 m), and within 1 m of the bottom (approximately 7 m) by the previously described pump system. All phytoplankton samples were approximately 80 ml and were preserved in the field with 2 to 5 ml of tetraborate-buffered 5 percent formalin.

16. In the laboratory, subsamples were settled in Utermohl chambers, and approximately 200 to 400 algal cells were identified to the species level and quantified using a Unitron inverted microscope. Identifications were made using taxonomic keys in Prescott (1962), Patrick and Reimer (1966), Tiffany and Britton (1952), Forest (1954), and Whitford and Schumacher (1968).

Zooplankton

17. Zooplankton samples from each littoral and limnetic station represent a water column composite sample collected by means of a vertical haul with a U. S. Standard No. 10 (153- μ mesh) Wisconsin plankton net. Beginning in October 1976, additional samples for determination of nauplii and rotifers were collected with a U. S. Standard No. 20 net (64- μ mesh) at one limnetic station in each pool of the Conway system. Samples were rinsed into 80-ml sample bottles and preserved with either 70 percent alcohol (April-September 1976) or 5 percent formaline buffered with tetraborate (October 1976-August 1978).

18. In the laboratory, a 3- to 10-ml aliquot of the concentrated sample was subsampled so that 100 to 200 organisms would be counted. Samples were placed in a zooplankton counting wheel and counted under a dissecting microscope at a magnification of 250 \times . A compound microscope was used to make all identifications, and organisms were identified to species level wherever possible. Zooplankton identifications were based on taxonomic keys in Edmondson (1959), Pennak (1953), and Voigt (1956).

Benthic Invertebrates

19. Duplicate (April 1976-March 1978) and single (April 1978-

August 1978) macroinvertebrate samples were collected every other month at 21 stations throughout the Conway system by means of a petite Ponar grab (sampling area 0.023 m^2). Samples were sieved through a U. S. Standard No. 30 sieve (0.595-mm mesh) in the field and preserved with a mixture of 5 percent tetraborate-buffered formalin and rose bengal. The rose bengal acts as a vital stain and facilitates separation of benthic invertebrates from detritus in the laboratory.

20. Invertebrates were hand-picked from the detritus of each sample, transferred to 70 percent ethanol, and examined under a dissecting microscope at 7 to 25 \times . Chironomid identification was performed at 200 \times under a compound microscope. All organisms were identified to the species level where possible with the aid of taxonomic keys provided in Pennak (1953), Edmondson (1959), Mason (1968), Beck (1976), and Brinkhurst (1974).

21. Benthic invertebrate biomass can be expressed in terms of wet weight, dry weight, and ash-free dry weight. Once invertebrate samples were quantified, all organisms were combined, soaked in water for 24 hr to counteract alcohol dehydration, blotted to remove excess water, and weighed on a Mettler balance to determine the wet weight of the sample population. Dry weight was determined by weighing the sample after drying at 60°C for 24 hr. Finally, ash-free dry weight of the invertebrate sample was determined following incineration at 540°C for 2 hr.

Sediment Composition

22. The method for particle-size determination followed Nisson (1975): The sample was mixed thoroughly and a 300-g wet weight portion of sediment was placed in a 250-ml beaker; tap water was added and the sample was mixed to a homogeneous slurry. The sample was allowed to settle for 24 hr. The water was decanted and the sediment sieved through a 63- μ sieve with 1000 ml of water into a beaker. The contents of the sieve were then dried and weighed to obtain the sand fraction. The 1000 ml washed through the sieve was then placed in a 1000-ml graduated cylinder and bubbled. While bubbling, a 50-ml aliquot was

pipetted out, dried, and weighed to obtain the silt-clay fraction. The organic content of the sediment was derived by combusting a dried sample at 550°C for 2 hr.

PART III: RESULTS

23. The following section is intended as a summary of all routine monitoring conducted by the Department of Environmental Engineering Sciences in the Lake Conway system from September 1977 until August 1978, the first year following white amur introduction. All monthly and bi-monthly data reported for a given pool represent a mean of all stations in that pool for the appropriate time interval. The Middle Pool of Lake Conway was selected as representative of the system as a whole, and the following discussion of individual parameters emphasizes the data set of this pool. In addition, detailed discussion of the data from each pool as well as a comparison of poststocking with prestocking data will be made where appropriate. A detailed data printout for individual lake stations may be obtained from either the senior author or the WES.

Physical-Chemical Parameters

24. Although a complete discussion of temperature and dissolved oxygen changes falls outside the scope of this report, changes in these parameters can help explain biological changes; therefore, some representative data for the year 1978 are discussed herein. The basic changes in temperature and dissolved oxygen are very similar from year to year. Water transparency, discussed here as it relates to biological changes, is within the scope of this report.

Temperature

25. Seasonal changes in the temperature regime of the Middle Pool of Lake Conway are presented in Figure 2. The water column remained isothermal and thus well mixed from October through March. Stratification was established during April and became more pronounced during the summer (June to September). Destratification returned in October.

26. A similar pattern of approximately 6 months mixed and 6 months stratified was observed in the other four pools, thus adhering to the classical definition of a warm monomictic lake. It is important to note that stratification in any of the five pools will be observed only in

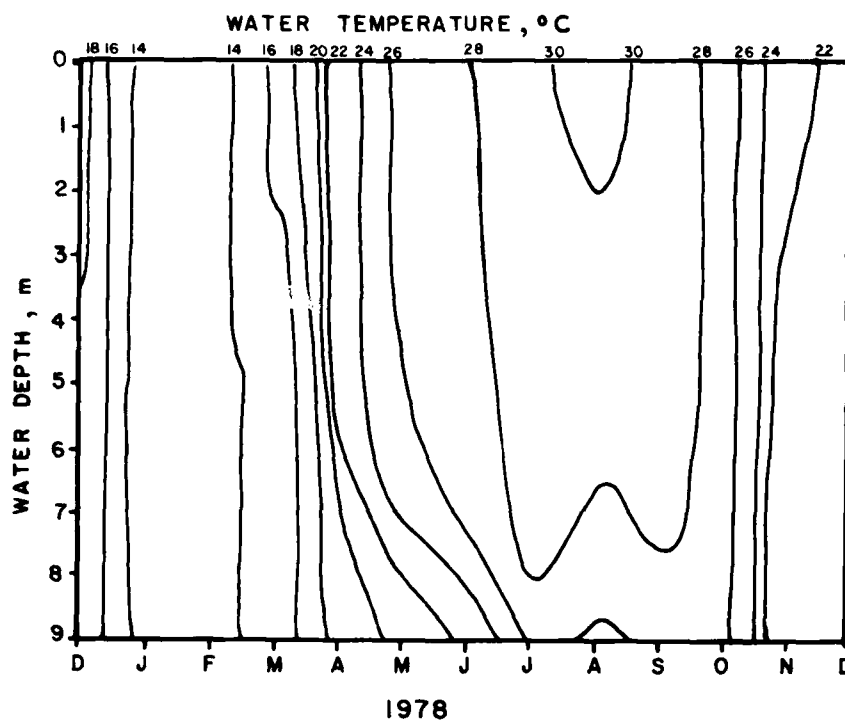


Figure 2. Seasonal trends in the temperature of the Middle Pool of Lake Conway from December 1977 to December 1978

those areas deeper than about 5 m and that shallower areas likely will be mixed completely to the bottom at any time of the year.

Dissolved oxygen

27. Figure 3 shows monthly variations in the dissolved oxygen concentrations for the Middle Pool of Lake Conway from December 1977 to December 1978. Oxygen levels remained essentially uniform throughout the water column during the period of destratification (October–March), but the period of stratification was marked by the development of a clinograde oxygen curve. Pronounced hypolimnetic oxygen depletion first appeared in May and continued through September, with bottom waters approaching anoxia during this period. Such conditions developed in areas deep enough to thermally stratify (>6 m) with shallower stations exhibiting essentially uniform oxygen levels throughout the water column.

28. The seasonal pattern of oxygen concentration presented for

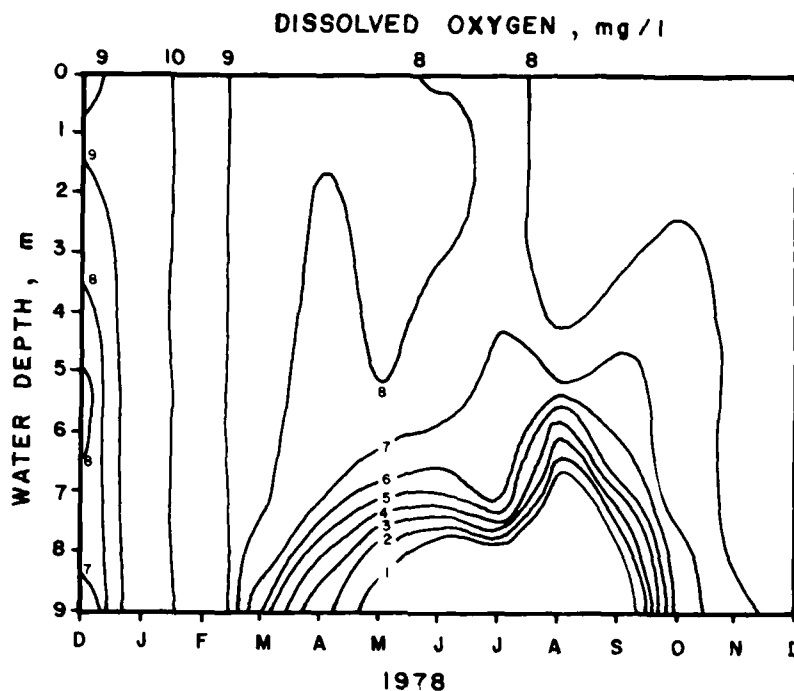


Figure 3. Seasonal trends in the dissolved oxygen concentration of the Middle Pool of Lake Conway from December 1977 to December 1978

the Middle Pool is considered representative of all areas in the Conway System deep enough to thermally stratify. Interbasin variations in the timing and severity of hypolimnetic deoxygenation are likely and are due in part to differences in epilimnetic productivity rates, basin morphology, and stability of stratification.

Water transparency

29. Average monthly Secchi disk transparency values for the Lake Conway system from April 1976 to August 1978 are presented in Figure 4. In general, transparency during the 29-month study was greatest from December through May. As will be demonstrated later, reduced water transparency during the warmer months is most likely due to greater biomass of suspended algae associated with higher productivity rates during this period.

30. Although seasonal trends were consistent between years, a

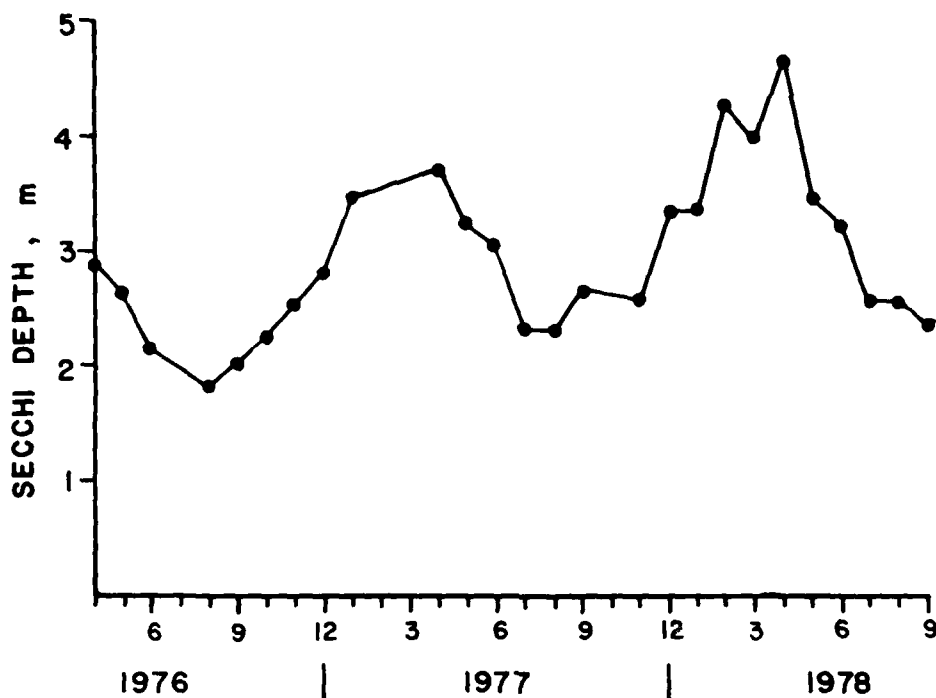


Figure 4. Mean monthly Secchi disk transparency for the Lake Conway system from April 1976 to August 1978. Each value represents a mean of Secchi disk readings from all sampling stations

change in mean annual Secchi disk values was noted. The mean annual Secchi disk value for the year prior to white amur introduction (September 1976 to August 1977) was 2.8 m, but the mean for the first post-stocking year (September 1977-August 1978) was 3.4 m. This 0.6-m increase in the mean annual Secchi disk value could be due to a reduced phytoplankton biomass following white amur introduction.

Plant Pigments, Functional Chlorophyll a

31. In the following discussion, chlorophyll a refers to the functional or active pigment, i.e., total chlorophyll a corrected for pigment oxidation products (phaeophytin). Seasonal trends for functional chlorophyll a in the Middle Pool of Lake Conway are presented in Figure 5. Chlorophyll concentrations during the study period (May 1976 to

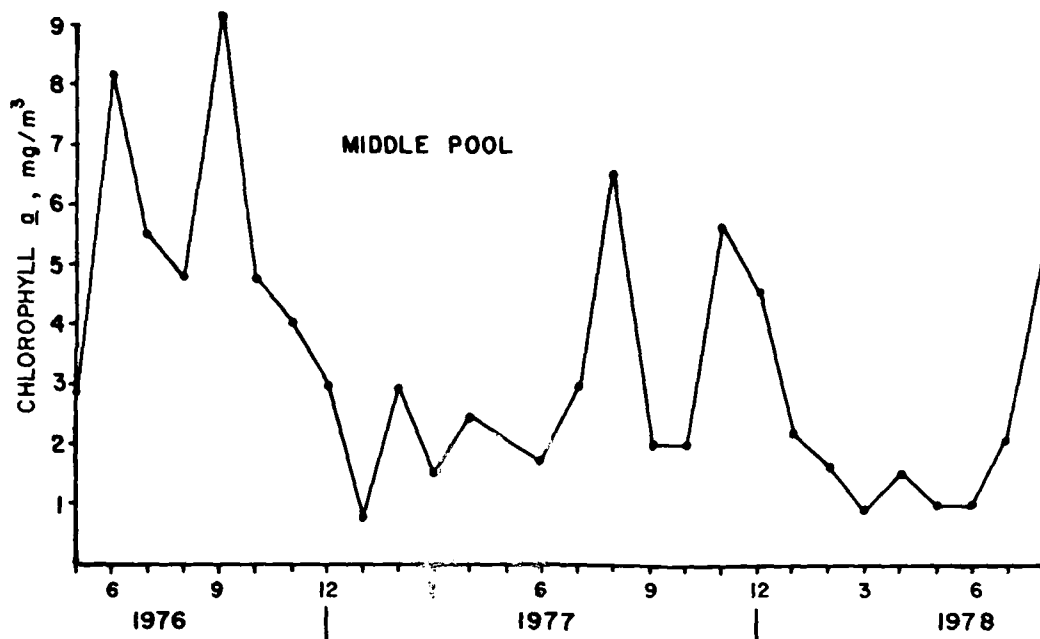


Figure 5. Variations in functional chlorophyll a for the Middle Pool of Lake Conway from May 1976 to August 1978

August 1978) showed a tendency to be higher during summer and fall and lower during winter and spring. The seasonal chlorophyll trends for the other four pools of the Conway system were comparable to those outlined for the Middle Pool during the same time interval (Figure 6). The principal difference between pools was in the magnitude of seasonal fluctuations in chlorophyll; Lake Gatlin consistently displayed the greatest seasonal fluctuation, and the West Pool displayed the least. Secchi disk transparency displayed a generally inverse relationship to chlorophyll concentrations, suggesting that seasonal fluctuations in the transparency of the water column are largely the result of variations in the biomass of suspended algae rather than suspended inorganic or detrital material.

32. Mean annual chlorophyll concentrations for individual pools of the Conway system for the 12-month period immediately prior to and following white amur introduction are presented in Table 2. Prior to white amur introduction (September 1976 to August 1977), Lake Gatlin

Further interpretation of chlorophyll results from such a limited data base for the poststocking period would be mere speculation.

34. The pools of the Conway system may be classified as mesotrophic lakes (Wetzel 1975): those systems with mean annual chlorophyll a concentrations between 2 and 15 mg/m³. A more quantitative estimate of trophic state is provided by the index of Carlson (1977). The Carlson Trophic State Index (TSI_{CHL}) based on chlorophyll a concentrations was evaluated for each pool of the Conway system by applying the calculated mean annual chlorophyll a concentrations (Table 2) to the following formula:

$$TSI_{CHL} = 10 \left(6 - \frac{2.04 - 0.68 \ln CHL}{\ln 2} \right) \quad (1)$$

The prestocking (September 1976 to August 1977) and poststocking (September 1977 to August 1978) TSI_{CHL} calculations for the Conway system are presented in Table 3. Lake Gatlin had the highest TSI for the prestocking period (55), with the remaining pools ranked in order of decreasing TSI as follows: West (46), East (44), Middle (44), and South (41). The highest TSI during the poststocking was also displayed by Lake Gatlin (51), but the remaining four pools all had TSI values of 37.

Phytoplankton

35. Average monthly phytoplankton density values for the Middle Pool and the remaining four pools of the Lake Conway system are presented in Figures 7 and 8, respectively. Algal abundance in the Middle Pool from 1976 to 1978 was consistently highest during summer (June to September) and lowest during winter and early spring (January to April), although the pattern was less pronounced in the littoral than in the limnetic zone. The algal reduction in the littoral zone may reflect a more intense interaction between algal and macrophyte communities in this area. A seasonal pattern similar to that described for the Middle Pool was also evident in the other four pools.

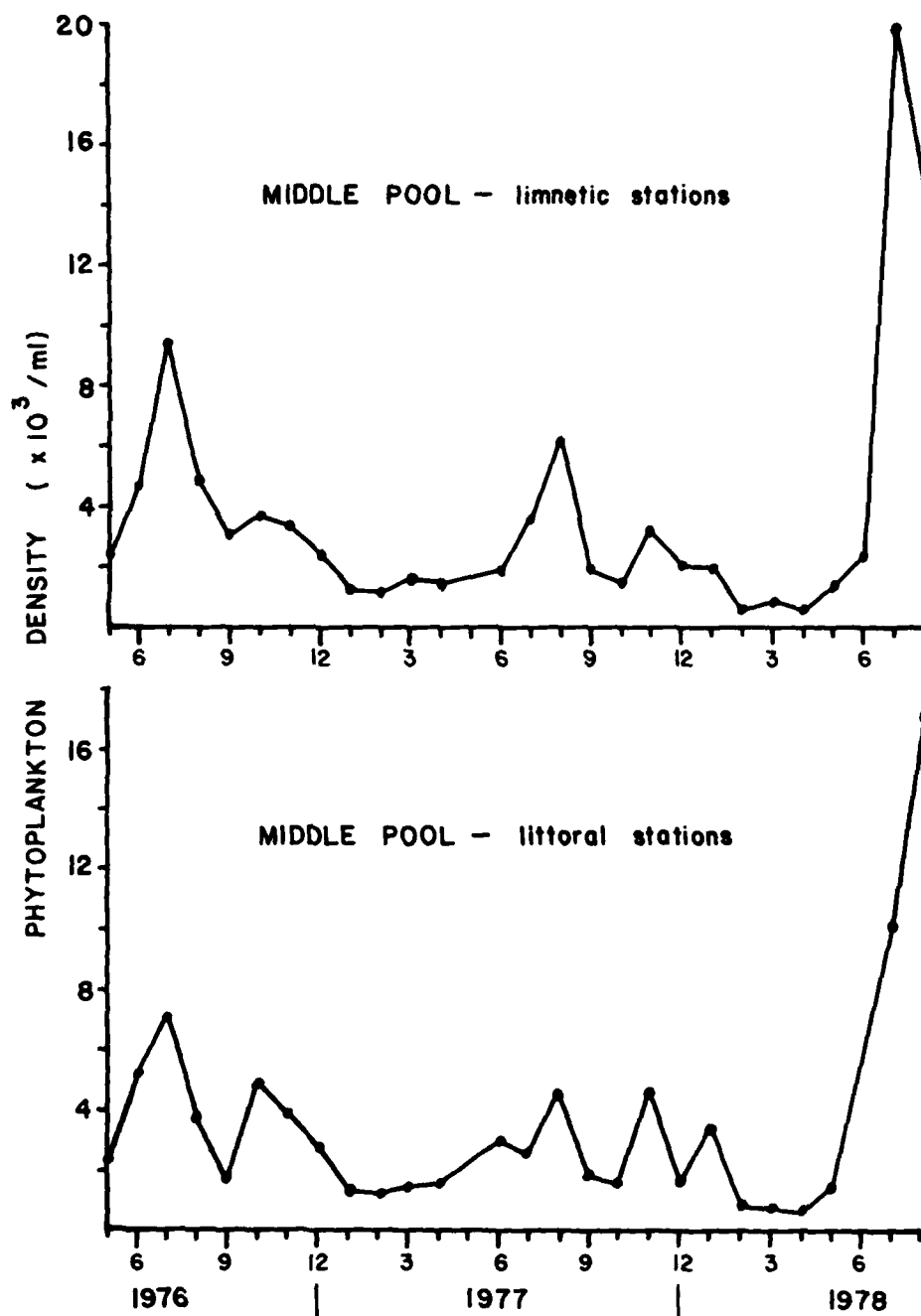


Figure 7. Mean monthly phytoplankton density for limnetic and littoral zones for the Middle Pool of Lake Conway from May 1976 to August 1978

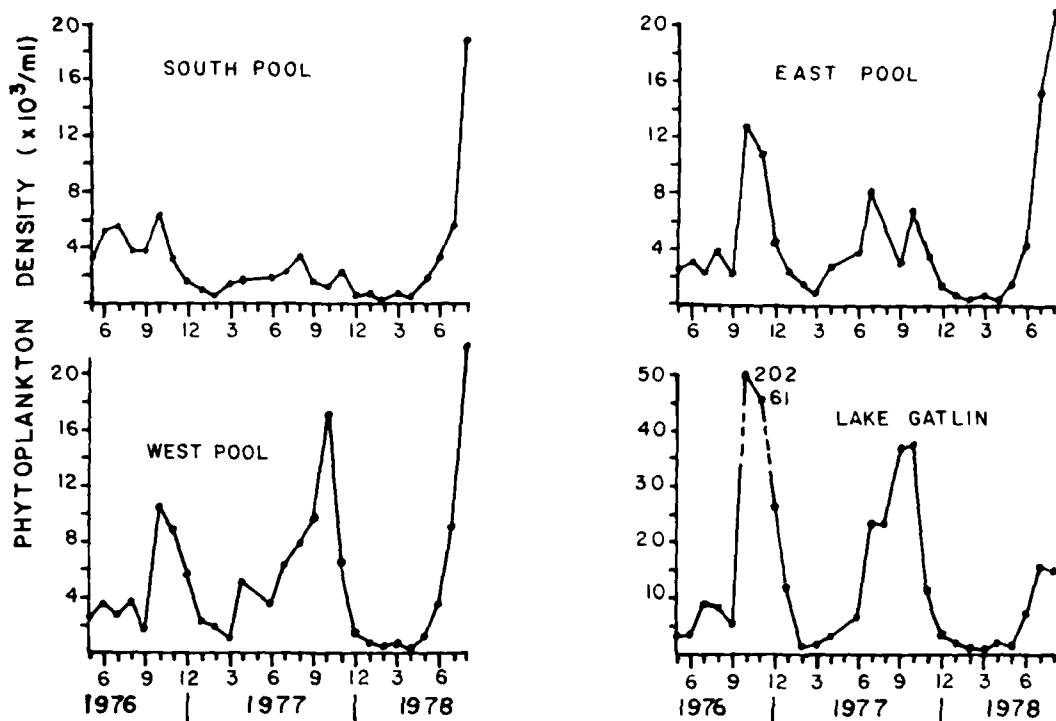


Figure 8. Mean monthly phytoplankton density for South Pool, East Pool, West Pool, and Lake Gatlin from May 1976 to August 1978

36. While the general seasonal pattern remained identifiable between successive years, the magnitude of the midsummer algal maximum differed between years. With the exception of the West Pool, the midsummer algal maximum in all pools was lower in 1977 than in 1976, ranging from a 50 percent reduction for the Middle Pool to a 500 percent reduction for Lake Gatlin. Such differences between successive years are likely due to short-term climatic fluctuations rather than a major irreversible alteration to the system, and demonstrate the need for an extended data base when assessing the impact of experimental manipulation on a lake system.

37. With the exception of Lake Gatlin, the midsummer algal maximum for the first poststocking year (1978) was higher than the combined average for the two prestocking years (1976 and 1977). The South Pool displayed the greatest increase in algal concentration (475 percent)

with the remaining pools ranked in order of decreasing response as follows: Middle Pool (266 percent), East Pool (240 percent), and West Pool (151 percent). Thus, the midsummer algal increase following white amur introduction was most pronounced in the least eutrophic pool (South Pool) and declined with increased trophic state, with the most eutrophic of the five pools (Gatlin) displaying a decrease, rather than an increase, in algal abundance of 800 percent.

38. On an annual basis, Lake Gatlin displayed the greatest seasonal population fluctuation (1 to 202×10^3 algae/ml), the largest recorded population (202×10^3 algae/ml), and the largest mean annual algal population (19.7×10^3 /ml) of any of the five pools of the Conway system. The remaining four pools were ranked in order of decreasing mean annual algal concentration as follows: West Pool (5.0×10^3 /ml), East Pool (4.5×10^3 /ml), Middle Pool (3.7×10^3 /ml), and South Pool (3.0×10^3 /ml). Thus, algal abundance clearly increases with increasing trophic state.

39. It would appear that the prestocking importance of macrophytes as a major component in total primary production decreases with increased trophic state concurrent with increasing algal concentrations. Thus, as observed, the reduction of macrophyte biomass through fish grazing would elicit a greater algal response in the more oligotrophic South Pool than in the highly productive Lake Gatlin, where the initial importance of macrophytes was greatly reduced.

40. While trends of algal density provide informative data, they do not indicate if algal species composition, cell size, or biomass also covaried. Monthly variations in the importance of the principal algal groups in the Middle Pool and the other four pools are presented in Figures 9 and 10, respectively. In general, the winter and spring phytoplankton assemblages (December-May) of all pools were dominated by green algae (Scenedesmus bijuga and Selenastrum minatum) and cryptophytes (Chroomonas minuta) with blue-green algae and diatoms as the principal subdominants. Beginning in June and continuing through September, filamentous blue-green algae (Oscillatoria limnetica, O. angustissima, Lyngbya limnetica, and Spirulina laxissima) dominated the phytoplankton

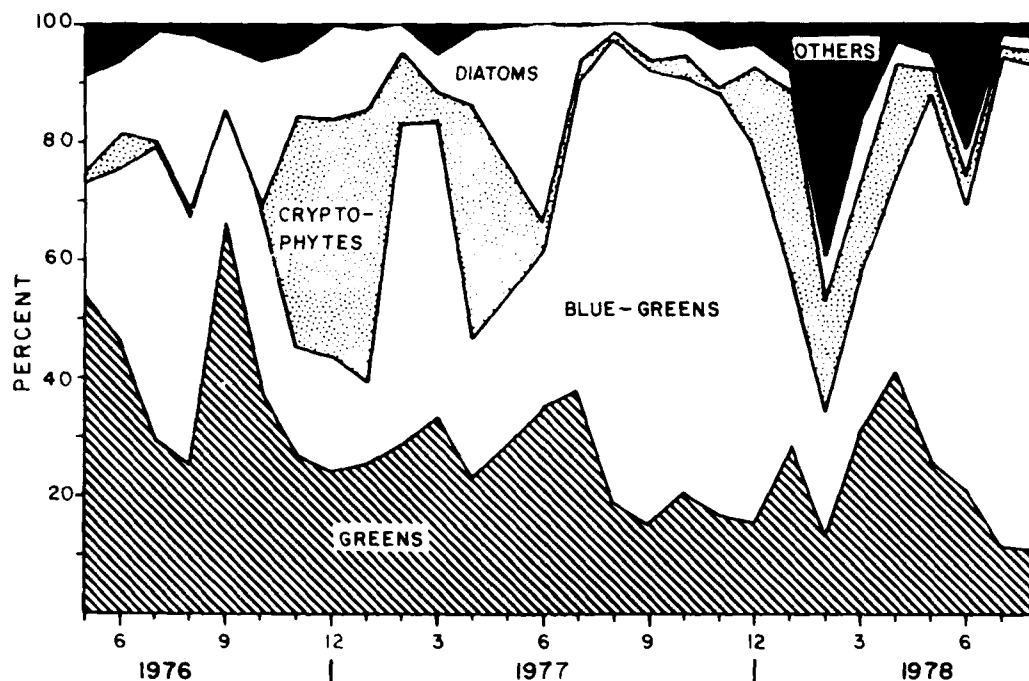


Figure 9. Partitioning of monthly algal assemblages for the Middle Pool of Lake Conaway into major taxonomic groups from May 1976 to August 1978

assemblages of all pools, largely at the expense of cryptophytes and diatoms and to a lesser extent green algae.

41. A number of differences were observed in the seasonal succession pattern of individual years. The midsummer importance of blue-green algae in 1977 and 1978 was far greater than in 1976, 80 versus 50 percent. Similarly, the importance of cryptophytes and diatoms in winter algal assemblages declined sharply between the winters of 1976-77 and 1977-78.

42. Monthly Shannon-Weiner diversity indices of the Middle Pool and all other pools are presented in Figures 11 and 12, respectively. Algal species diversity displayed great variation between pools and months but may have been slightly higher in 1976 than later years. No distinct seasonal patterns were evident for any pool of the Conway system.

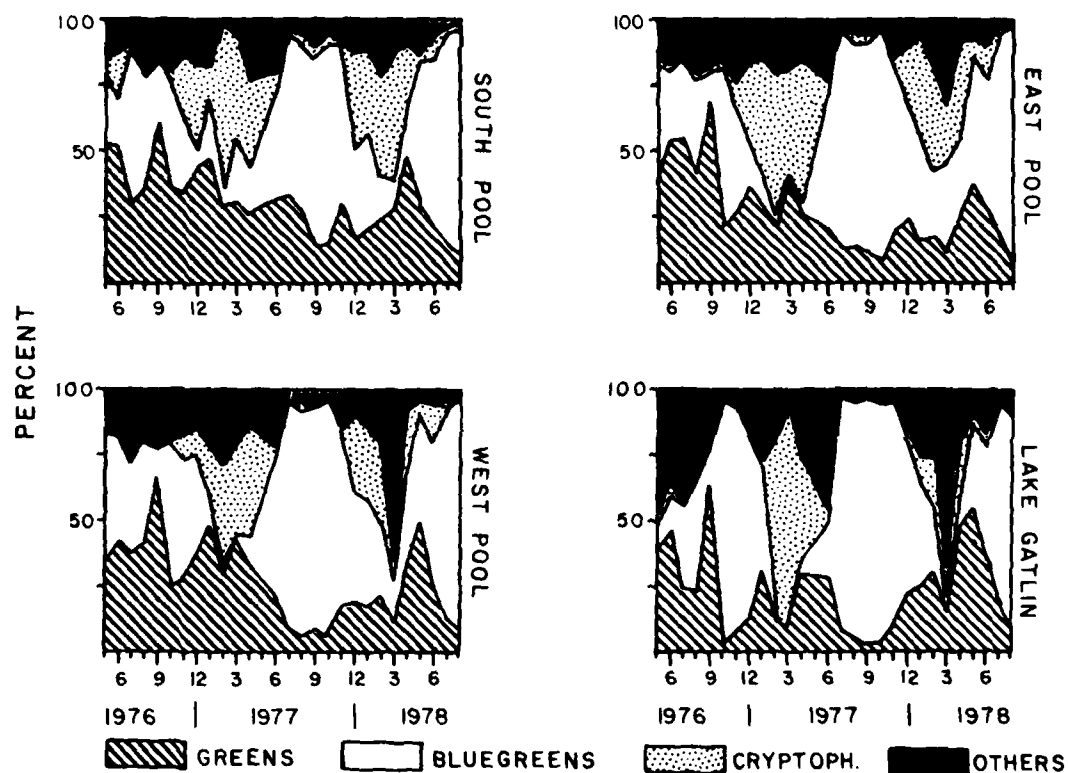


Figure 10. Partitioning of monthly algal assemblages for South Pool, East Pool, West Pool, and Lake Gatlin into major taxonomic groups for the period from May 1976 to August 1978

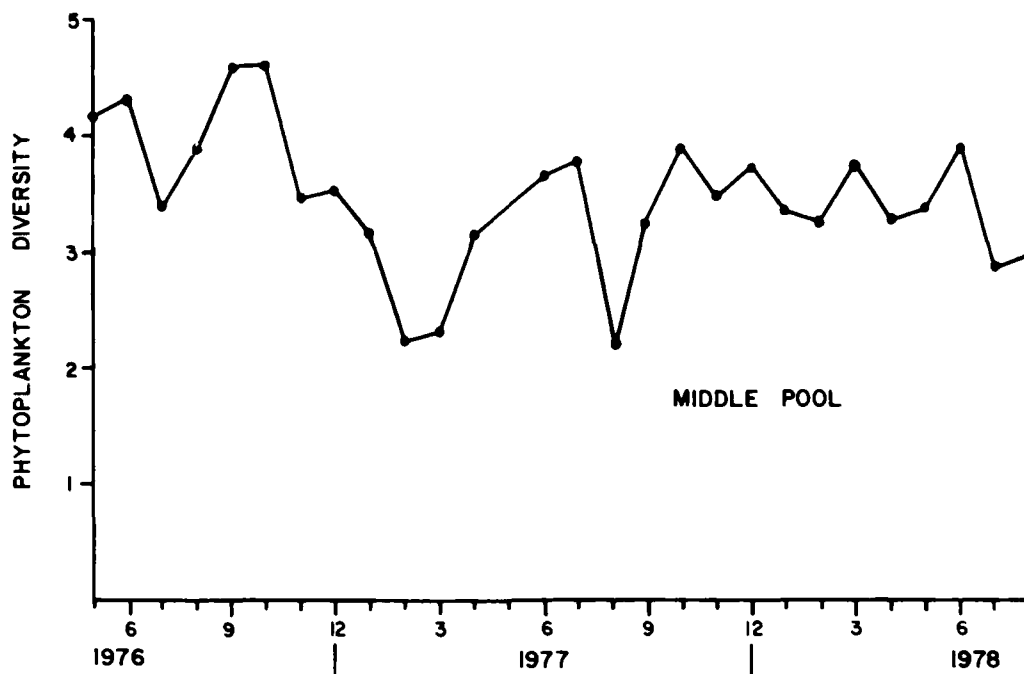


Figure 11. Monthly phytoplankton diversity for the Middle Pool of Lake Conway from May 1976 to August 1978

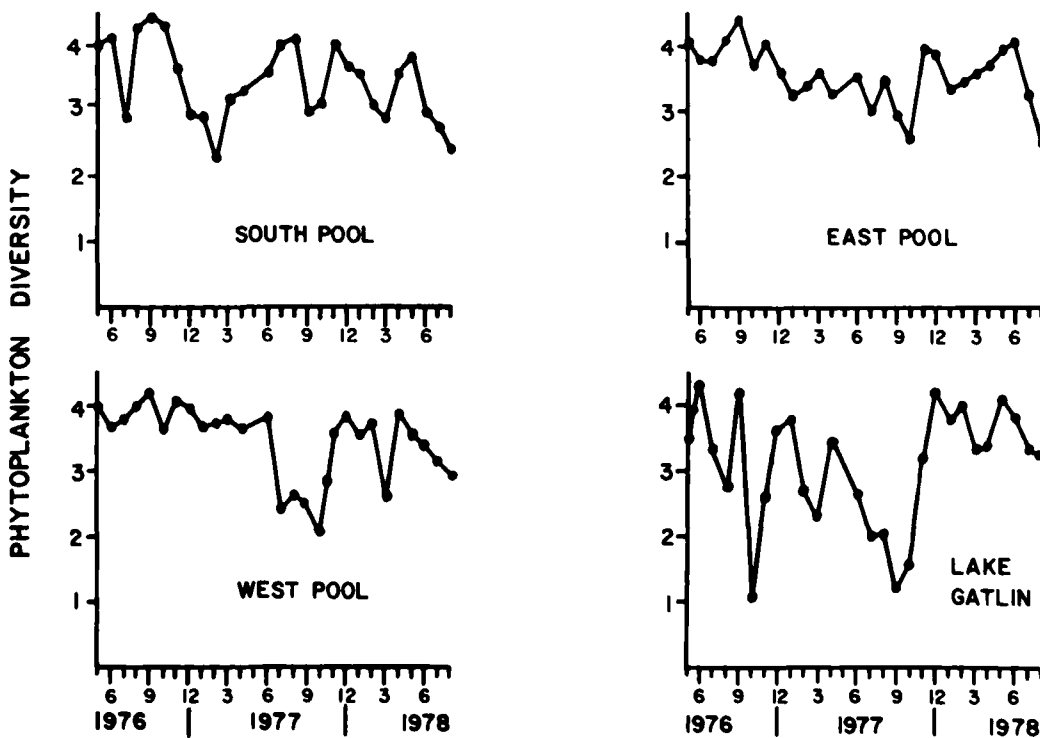


Figure 12. Monthly phytoplankton diversity for South Pool, East Pool, West Pool, and Lake Gatlin from May 1976 to August 1978

Zooplankton

43. Monthly zooplankton density, expressed as an average of all limnetic stations for the Middle Pool (Figure 13) and the four other

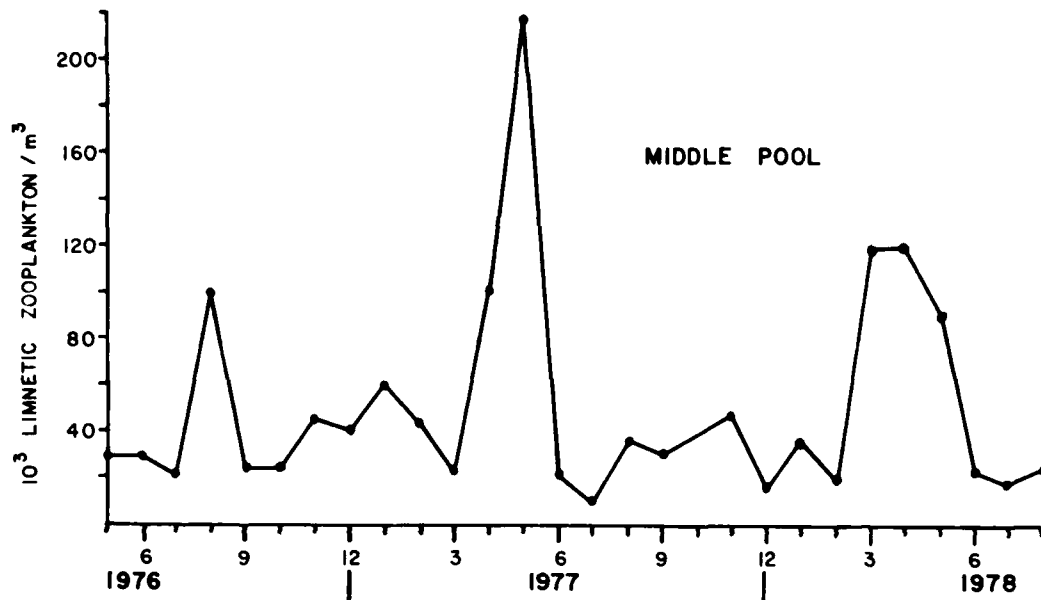


Figure 13. Monthly zooplankton density for the Middle Pool of Lake Conway expressed as an average of all limnetic stations from May 1976 to August 1978

pools of the Conway system (Figure 14), displayed a distinct seasonality. In all three years, zooplankton abundance was lowest from midsummer through winter (July to February), increased sharply in March, remained at maximum values throughout spring (April to May), and crashed in June.

44. The spring zooplankton maxima for all pools were higher during 1977 than 1976. The East Pool displayed the greatest percentage increase (150 percent) with the remaining pools ranked in order of diminishing response as Middle Pool (120 percent), Gatlin (54 percent), South Pool (28 percent), and West Pool (21 percent).

45. Similarly, with the exception of the Middle Pool, the 1978 spring maximum for each pool was greater than either of the two previous years, and midsummer zooplankton densities failed to decline to the

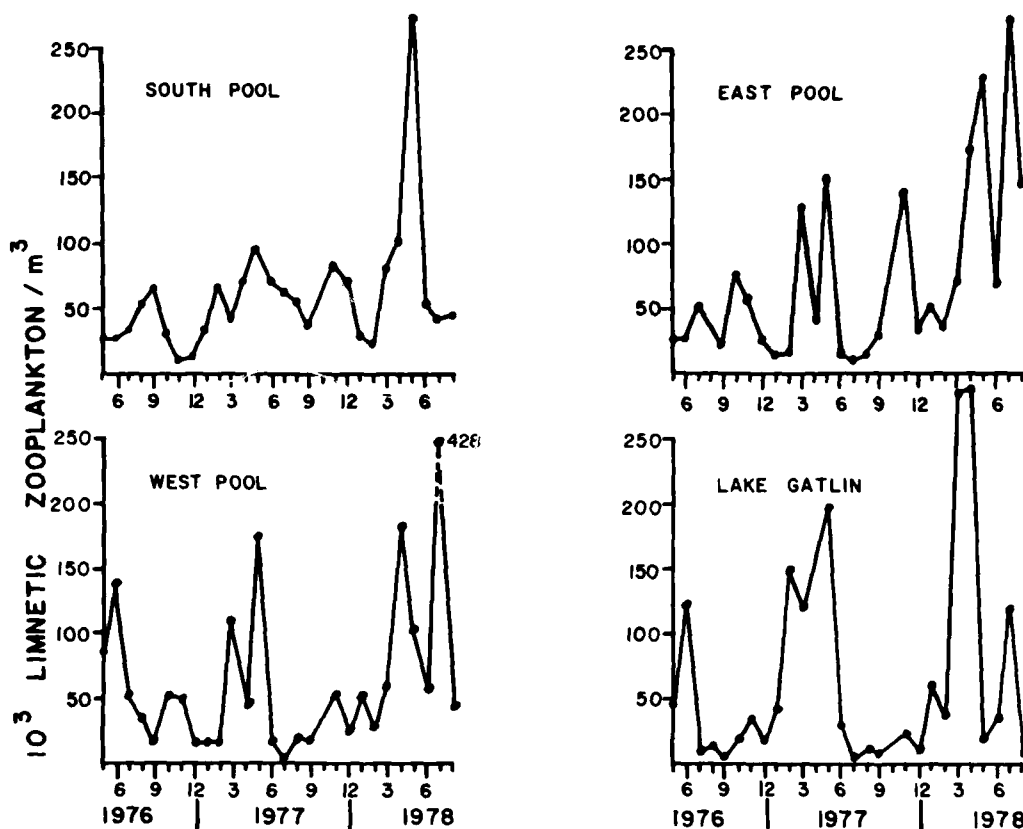


Figure 14. Monthly zooplankton density expressed as an average of all limnetic stations for South Pool, East Pool, West Pool, and Lake Gatlin from May 1976 to August 1978

levels recorded for a comparable period in 1976 and 1977. The midsummer zooplankton maxima of 1976 and 1977 were averaged and compared with the 1978 value as a means of defining the prestocking and poststocking response of zooplankton in each pool. With the exception of the Middle Pool, which displayed a 45 percent decrease, the midsummer zooplankton concentrations in all pools increased following the introduction of the white amur. South Pool displayed the greatest increase (240 percent) with the remaining pools ranked in order of decreasing response as: East Pool (148 percent), Gatlin (70 percent), and West Pool (61 percent). Such trends, while suggestive of a zooplankton response, are not considered definitive due to the range of normal year-to-year variations

(1976 to 1977) and the lack of an extensive poststocking data base.

46. Average monthly concentrations of free-swimming zooplankton in the littoral zones of the Middle Pool and the four other pools of the Conway system (Figures 15 and 16, respectively) displayed the same general seasonal pattern as described for the limnetic stations.

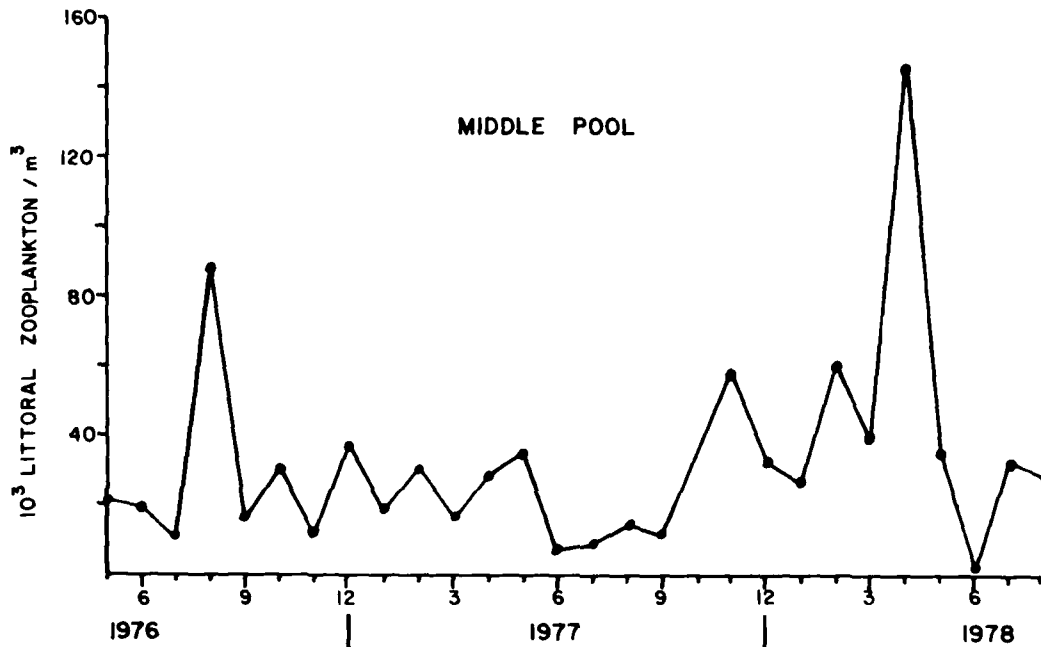


Figure 15. Monthly zooplankton density for the Middle Pool of Lake Conway expressed as an average of all littoral stations from May 1976 to August 1978

47. Partitioning of the monthly zooplankton abundance into the percent contribution of each of the major taxonomic groups for the Middle Pool (Figure 17) and the other four pools (Figure 18) demonstrates that seasonal fluctuations in zooplankton abundance are accompanied by major changes in the dominance of cladocerans, copepods, and rotifers. Fall and winter (October to February) populations are dominated by copepods and secondarily by cladocerans, with the latter group displaying maximum yearly abundance during this period. The spring population maximum (March-May) in each pool is accompanied by a replacement of the cladocerans and copepods by rotifers as the dominant zooplankters.

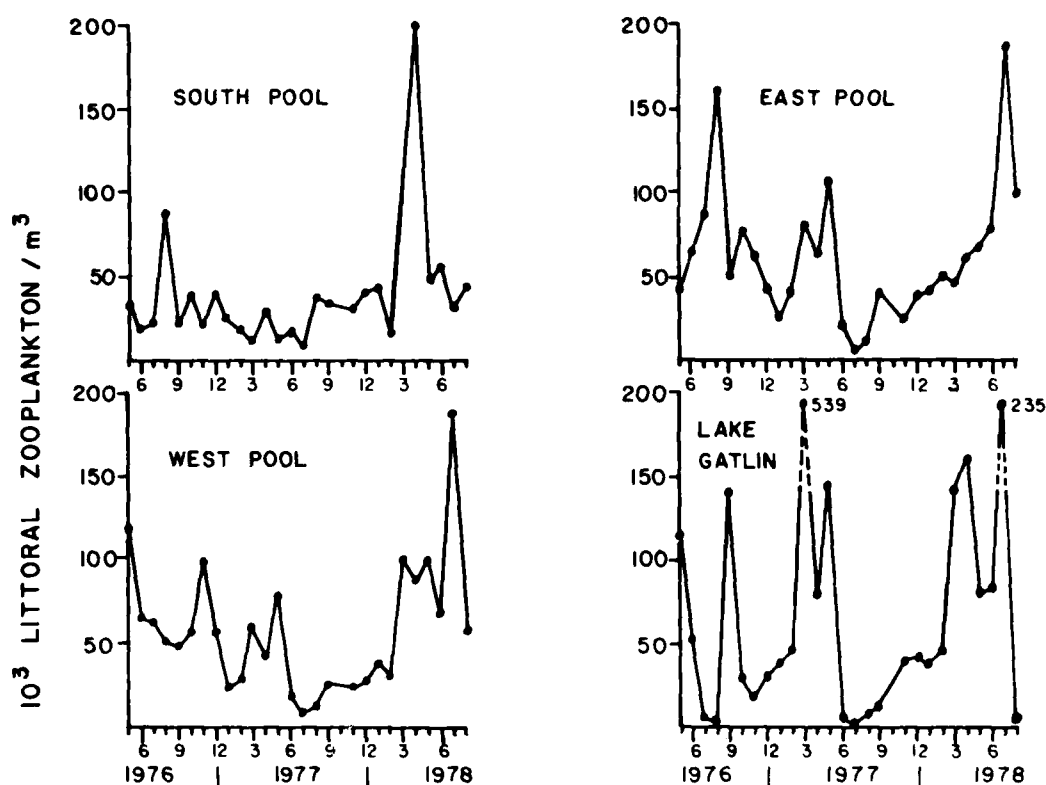


Figure 16. Monthly zooplankton density expressed as an average of all littoral stations for South Pool, East Pool, West Pool, and Lake Gatlin from May 1976 to August 1978

Cladoceran and especially copepod importance increases during June and remains high throughout the remainder of the year with the exception of a short period in either September or October when rotifers regain dominance. Such a seasonal replacement series was repeated in all pools for the 3-year period and no major variations occurred that could be attributed to the introduction of the white amur. Species dominance for copepods (Diaptomus floridanus, Cyclops vernalis, Mesocyclops edas, and Tropocyclops prasinus), cladocerans (Bosmina longirostris and Daphnia ambigua), and rotifers (Keratella cochlearis and Asplanchna sp.) remained intact throughout the investigation.

48. Monthly concentrations of copepods, cladocerans, and rotifers for each pool are given in Table 4. Lake Gatlin displayed the greatest

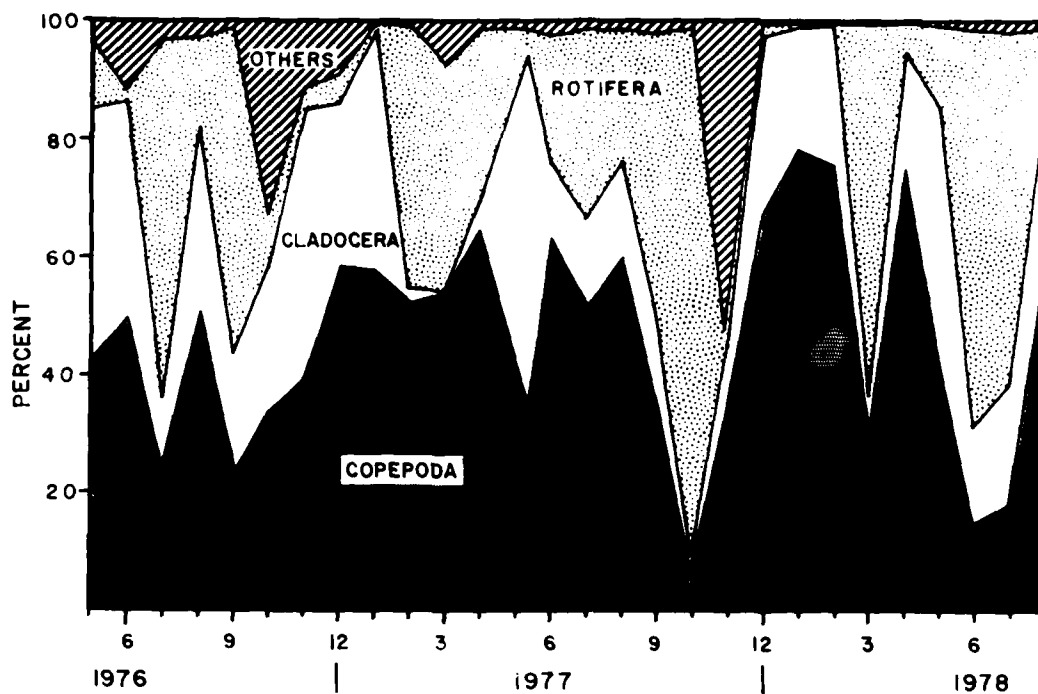


Figure 17. Percentage contribution of major taxonomic groups to the total zooplankton assemblage of the Middle Pool from May 1976 to August 1978

single monthly copepod peak ($8.5 \times 10^5/\text{m}^3$) with the remaining pools ranked in order of decreasing maxima as: West Pool ($5.9 \times 10^5/\text{m}^3$), Middle Pool ($4.7 \times 10^5/\text{m}^3$), South Pool ($3.9 \times 10^5/\text{m}^3$), and East Pool ($3.1 \times 10^5/\text{m}^3$). Similarly, the pools may be ranked both on the basis of declining cladoceran maxima as Gatlin ($7.4 \times 10^5/\text{m}^3$), West Pool ($4.2 \times 10^5/\text{m}^3$), South Pool ($3.7 \times 10^5/\text{m}^3$), Middle Pool ($3.2 \times 10^5/\text{m}^3$), and East Pool ($2.6 \times 10^5/\text{m}^3$); and on the basis of declining rotifer maxima as East Pool ($1.6 \times 10^6/\text{m}^3$), South Pool ($1.4 \times 10^6/\text{m}^3$), Gatlin ($1.4 \times 10^6/\text{m}^3$), West Pool ($1.0 \times 10^6/\text{m}^3$), and Middle Pool ($0.3 \times 10^6/\text{m}^3$). Thus, no clear trend can be associated with interbasin differences in trophic state.

49. Comparison of maxima for the Conway system with maxima for copepods ($2.6 \times 10^5/\text{m}^3$), cladocerans ($7.0 \times 10^5/\text{m}^3$), and rotifers ($2.0 \times 10^6/\text{m}^3$) in Lake Apopka, a eutrophic Florida lake, for a comparable

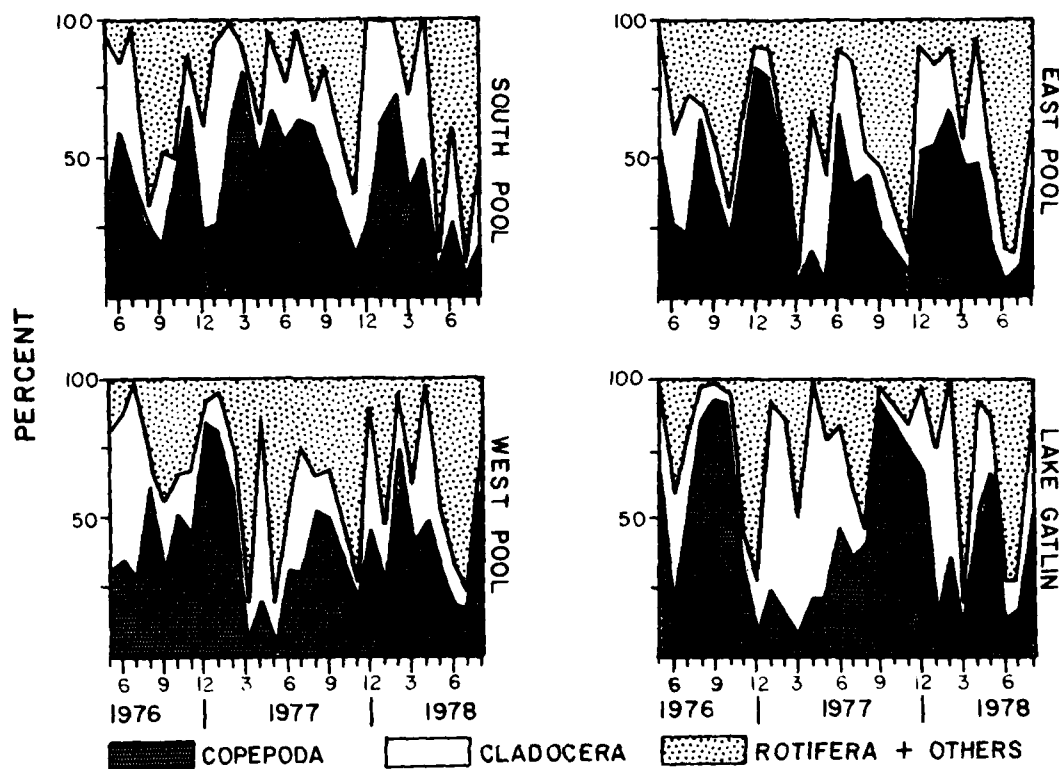


Figure 18. Percentage contribution of major taxonomic groups to the total zooplankton assemblage of South Pool, East Pool, West Pool, and Lake Gatlin from May 1976 to August 1978

period (Tuschall et al. 1979) reveals that the Conway system is characterized by lower cladoceran and rotifer densities and higher copepod densities than the latter eutrophic lake. These Florida data, when combined with the general observation of Allan (1976) that eutrophic lakes are characterized by more rotifers and cladocerans and fewer copepods than less productive systems, are further evidence for designating Lake Conway as a mesotrophic system.

50. Shannon-Weiner Diversity was calculated monthly for the zooplankton assemblages of the Middle Pool (Figure 19) and the other four pools of the Conway system (Figure 20). On an annual basis, zooplankton diversity in all pools was lowest during fall and winter when the assemblage was dominated by copepods and cladocerans, and was highest during

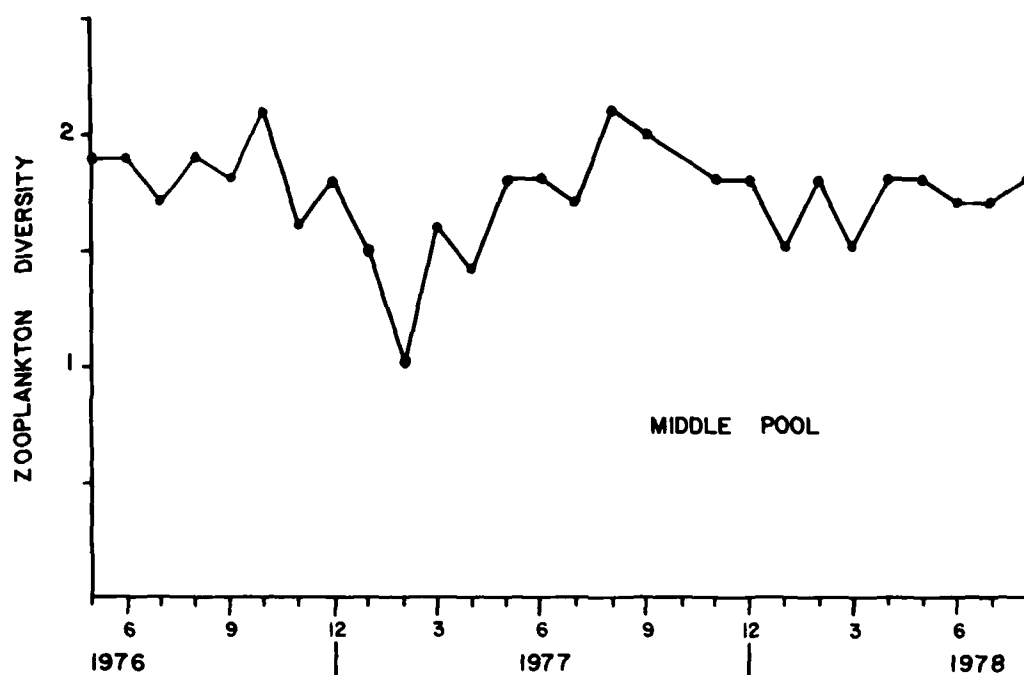


Figure 19. Shannon-Weiner Diversity calculated monthly for the zooplankton assemblage of the Middle Pool from May 1976 to August 1978

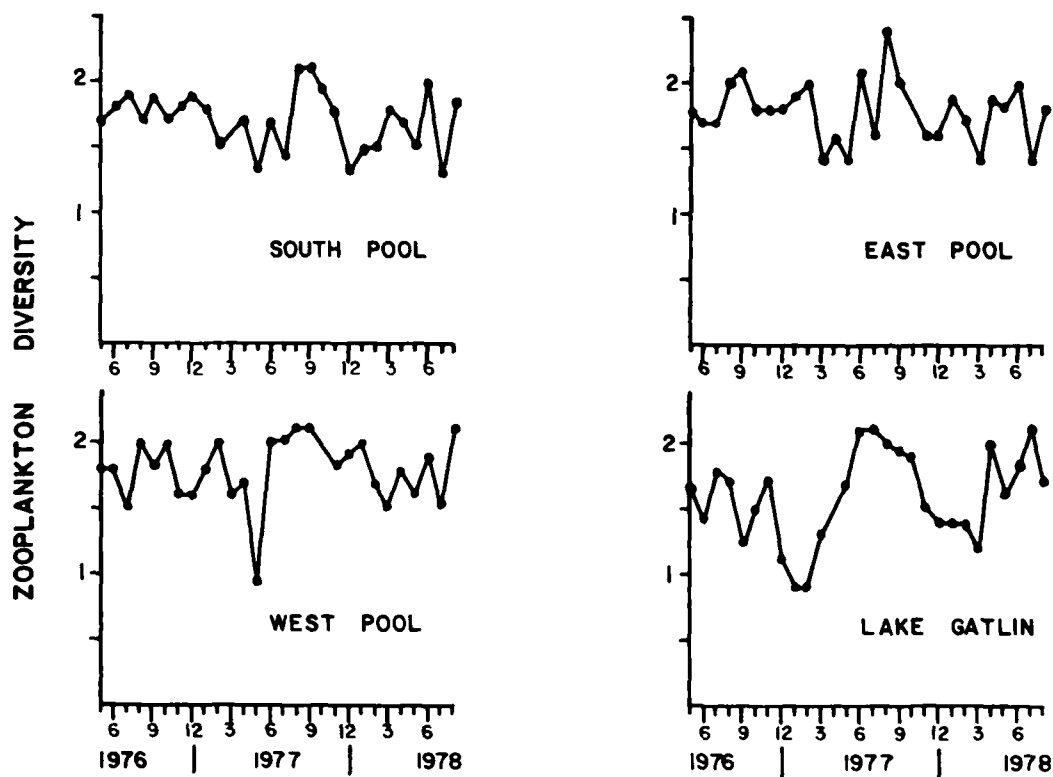


Figure 20. Shannon-Weiner Diversity calculated monthly for the zooplankton assemblage of the South Pool, East Pool, West Pool, and Lake Gatlin from May 1976 to August 1978

the period of maximal rotifer representation in the summer. The most productive pool (Gatlin) displayed a greater seasonal fluctuation in zooplankton diversity than the least productive pools (South and Middle), in addition to having the lowest diversity of any pool in the winter. Zooplankton diversity did not change appreciably in any pool following the introduction of the white amur.

Benthos

51. The species composition and distribution of benthic macroinvertebrates are controlled not only by the primary productivity of a system but also by additional factors including profundal oxygen

concentrations, basin morphometry, sediment composition, and macrophyte composition and distribution (Wetzel 1975). Thus, the benthic habitat is much more heterogeneous than the pelagic habitat occupied by phytoplankton and zooplankton, and interbasin comparisons regarding benthic macroinvertebrate assemblages are infeasible with only a limited number of sampling stations in each basin. In the present study, rather than stressing minor and often tenuous interbasin differences in macroinvertebrate assemblages, the authors considered the relationship of benthic invertebrates to their physical environment through: (a) data pooling of all littoral (<3 m) and all profundal (>3 m) stations in the Conway system, and (b) analysis of biological and physical data collected along a depth transect (0 to 8 m) in the Middle Pool.

52. Both the number of species and the total density of benthic invertebrates decreased with increasing depth along a transect in the Middle Pool of Lake Conway (Figure 21). Given the facts that all pools

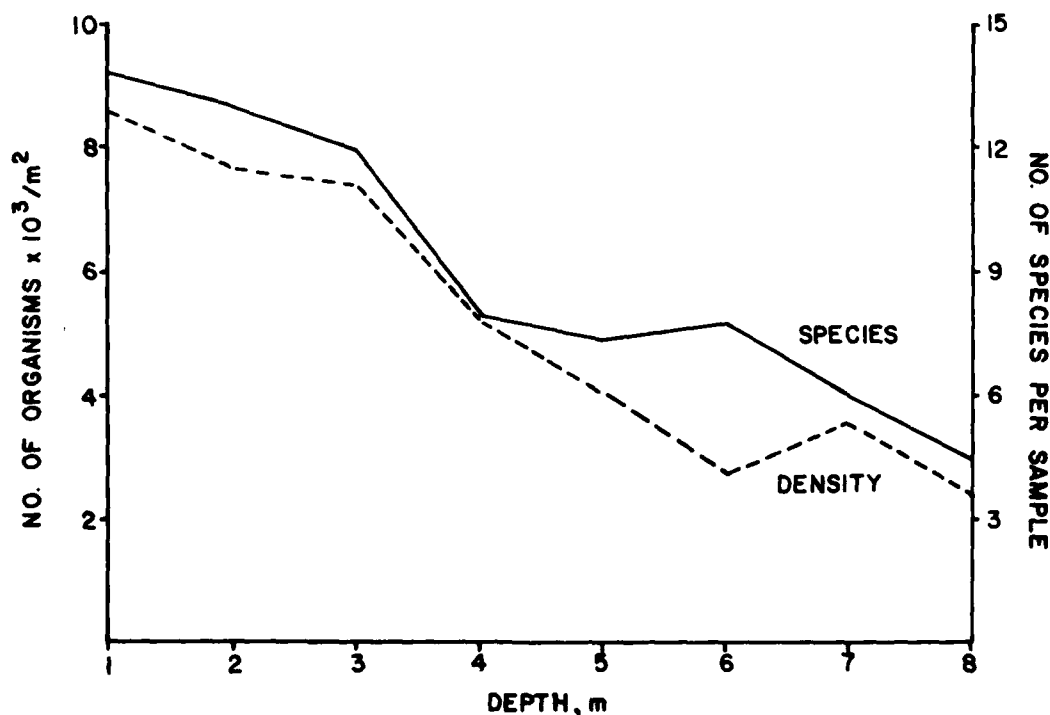


Figure 21. Species richness and the density of total benthic macroinvertebrates along a depth transect in the Middle Pool

characterized by severe oxygen depletion in profundal areas (>5 m) during summer stratification (Figure 3) and that benthic invertebrates display species specific oxygen requirements, the general reduction of the benthic assemblages with depth may be attributed in part to the general elimination of oxygen-sensitive species from deeper areas.

53. The distribution of burrowing macroinvertebrates (deposit feeders, filters feeders, and predators) is strongly influenced by the organic content and inorganic particle-size distribution of lacustrine sediments. Sediment composition is important for burrow construction, direct utilization (deposit feeders), and as a substrate for benthic algae. Sediment composition along the depth transect in the Middle Pool is strongly sand dominated (>80 percent by dry weight) at all depths, but organic content averaged approximately 3 percent at shallow stations and increased to 15 percent at stations deeper than 7 m (Figure 22).

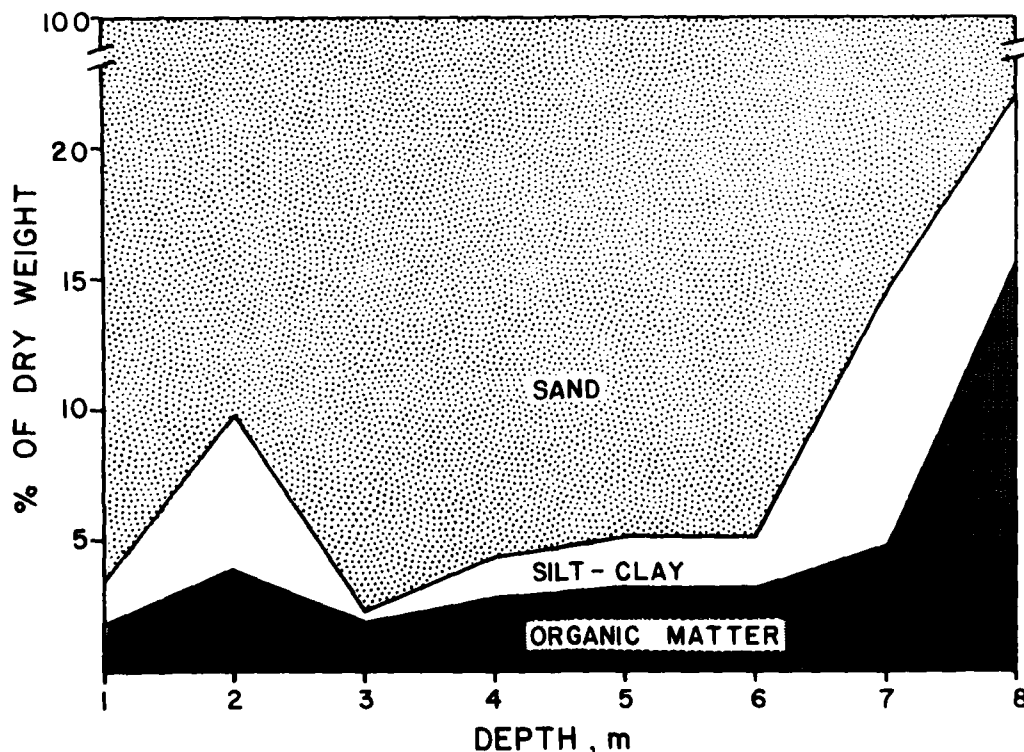


Figure 22. Sediment composition along a depth transect in the Middle Pool of Lake Conway

Finally, the silt-clay sediment fraction was greatest (>5 percent) at the shallowest (<3 m) and deepest (>6 m) stations and lowest at intermediate depths.

54. Both the species composition and overall abundance of aquatic macrophytes can strongly influence the distribution of benthic invertebrates, especially algal grazers, leaf miners, and predators. Many species are obligate plant dwellers upon which they depend for substrate, directly or indirectly (epiphytic algae) for food, or for protection from invertebrate and vertebrate predators. In the Lake Conway system in general, and along the depth transect of the Middle Pool in particular, Potamogeton is the dominant macrophyte from the shore to a depth of approximately 2 to 3 m. Below this depth and extending to 4 to 5 m, Nitella becomes the dominant macrophyte. Profundal areas greater than 5 m deep are essentially free of macrophytic growth.

55. On the basis of the preceding preliminary results from the depth transect of the Middle Pool, major differences may be expected between littoral and profundal stations in the Conway system with respect to sediment composition, and the abundance and community structure of both the macrophyte and benthic invertebrate communities. For purposes of the present discussion, the boundary between littoral (shallow) and profundal (deep) stations has been chosen as 3 m to correspond with phytoplankton and zooplankton sampling regimes. Of the 21 sampling stations for benthic invertebrates in the Conway system, 14 are classified as shallow stations and 7 as deep. The data have been pooled and averaged for the shallow and deep group separately, and the following discussion is based on these mean values.

56. The mean density of total benthic macroinvertebrates displayed a marked seasonality for both shallow and deep stations, but values for the former were consistently greater than those of the latter (Figure 23). Densities for both shallow and deep stations were greatest during fall and winter (September to January), but declined throughout late winter and spring to reach minimum values during midsummer. Similarly, both the number of species (Figure 24) and Shannon-Weiner Diversity (Figure 25) coincided with the trends established for

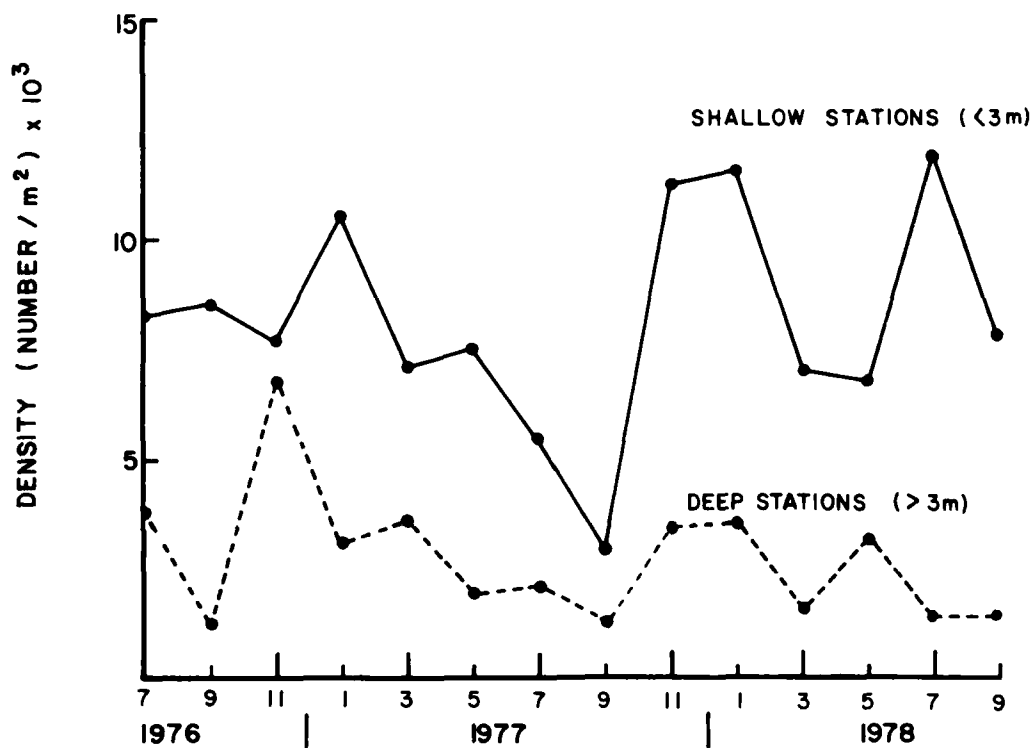


Figure 23. Mean density of total benthic macroinvertebrates averaged separately for all littoral (shallow) and profundal (deep) stations in the Conway system from July 1976 to September 1978

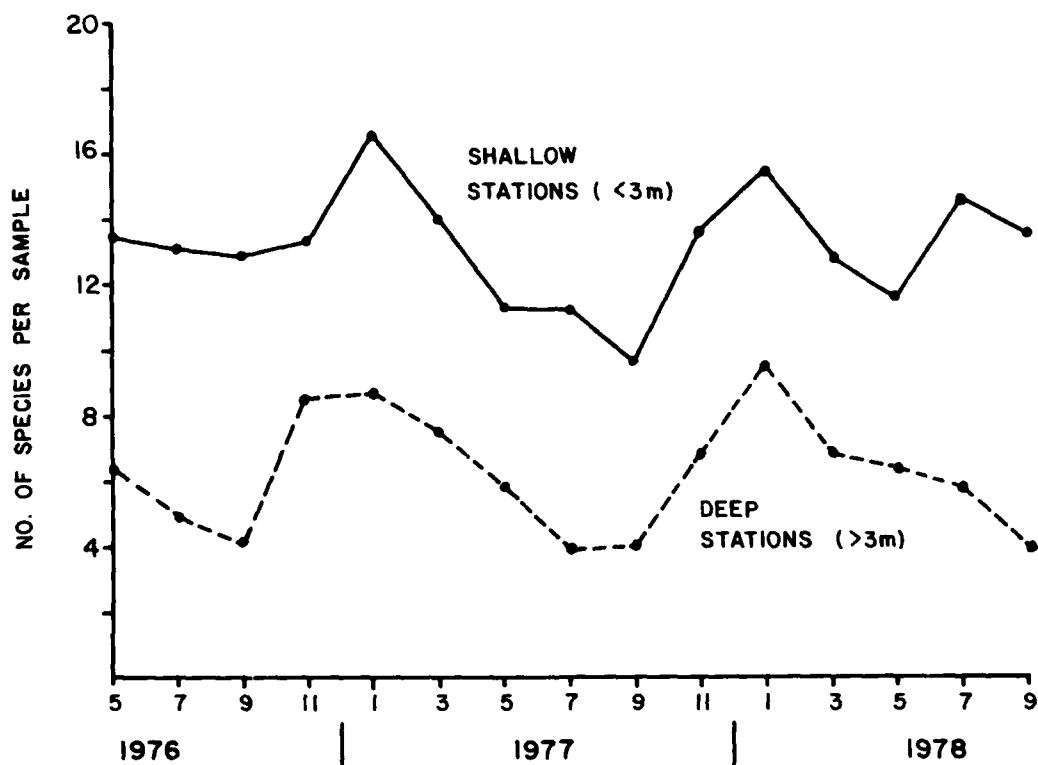


Figure 24. Mean number of species of benthic macroinvertebrates averaged separately for all littoral (shallow) and profundal (deep) stations in the Conway system from May 1976 to September 1978

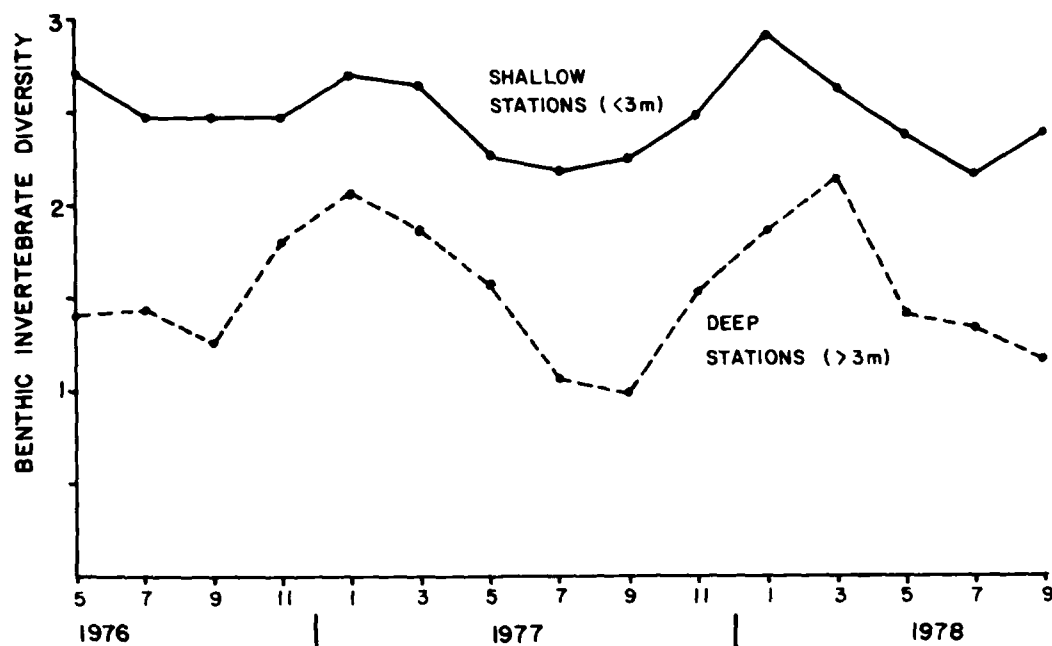


Figure 25. Mean diversity of the benthic macroinvertebrate assemblages averaged separately for all littoral (shallow) and profundal (deep) stations in the Conway system from May 1976 to September 1978

macroinvertebrate density in that both shallow and deep stations displayed maximum values during fall and winter (September to January), and minimum values during midsummer (July to August), with values for shallow stations being consistently higher than those recorded for deep stations.

57. The general reduction in the quality of the benthic community during midsummer is likely the result of seasonal changes in physical and biological factors including oxygen depletion, species life cycles, and predation intensity. Oxygen concentrations in the deepest part of the water column approach anoxia in all pools of the Conway system during midsummer thermal stratification (Figure 3). The high temperatures during this period would cause an increased microbial decomposition of the organic matter, with a concomitant oxygen demand because of bacterial respiration. As a result, the oxygen concentrations in the sediments and at the sediment-water interface can be expected to be even lower

than the oxygen concentrations in open water at the same depth. Therefore, during midsummer all but the most tolerant species will be eliminated from the deeper areas; species sensitive to depressed oxygen levels will also be reduced or eliminated even in shallower areas.

58. The length of the life cycle (egg-adult-egg) of benthic invertebrates is species specific with individual species producing from one to several generations per year. If one or several of the dominant species were univoltine and emerged as adults during late spring or early summer, then the midsummer invertebrate assemblage could appear impoverished if either:

- a. The adults remained as active terrestrial insects throughout summer and laid eggs only during late summer.
- b. The adults laid eggs shortly after emerging, and the eggs and/or early instars were not sampled by the field techniques.

59. Finally, the midsummer benthic assemblage may be responding to seasonal variations in predation intensity. Most of the centrarchid fish species that inhabit Lake Conway breed in late winter or early spring, and several of these species change their diet from predominantly zooplankton to predominantly benthic invertebrates as they mature. Thus, the predation impact of centrarchids on benthic invertebrates should change seasonally and may be more severe during midsummer as the year class matures. In addition, common invertebrate predators including midges and dragonflies are generally not predaceous until the final instars; therefore, the impact of invertebrate predation on other members of the benthic macroinvertebrate community will depend on the length and timing of the life cycle of individual predator species.

60. Both the abundance and diversity of the shallow water benthic invertebrate community are consistently higher throughout the year than recorded for the deep water areas. In part, this may be attributed to the generally higher oxygen values at shallow stations, but the importance of habitat heterogeneity cannot be overlooked. The presence of an abundant macrophyte community at shallow stations provides a suitable habitat for a wider variety of invertebrate taxa including leaf miners

and algal grazers, in addition to affording greater protection from invertebrate and vertebrate predators.

61. Neither the density nor the diversity of benthic macroinvertebrates at shallow stations in the Lake Conway system were similar to values recorded for the eutrophic Oklawaha lakes of central Florida: Lakes Apopka, Beauclair, Dora, Eustis, and Griffin (Tuschall et al. 1979). The mean density of invertebrates for shallow stations during the period of July 1976 to September 1978 ($8200/\text{m}^2$) was much greater than the 1977 or 1978 means calculated for the Oklawaha lakes (range 210 to $3677/\text{m}^2$), but the mean density for the deep stations of the Conway system ($2900/\text{m}^2$) was within the upper range recorded for the Oklawaha lakes.

62. Mean benthic diversity in Lake Conway averaged over 29 months for shallow (2.48) and deep (1.56) stations was higher than recorded for the Oklawaha lakes (range 0.7 to 1.2) during 1978. Diversity values for the deep stations of the Conway system were closer to eutrophic values than were values from shallow stations.

63. A pronounced difference exists in the taxonomic composition of shallow and deep stations in Lake Conway (Figure 26). Shallow stations are dominated (>60 percent) by oligochaetes and chironomid midges with other taxa including mollusks, dragonflies, amphipods, flatworms, and caddisflies comprising at least 20 percent of the fauna. These latter taxa decline in importance during midsummer and are largely replaced by oligochaetes, a fact not totally unexpected given their general sensitivity to low oxygen concentrations such as would occur during this period.

64. Chironomids and oligochaetes share the dominance of the deep water fauna with the phantom midge, Chaoborus punctipennis. This latter species is not an obligate benthic species but vertically migrates to feed on zooplankton in surface waters at night and returns to the benthic substrate during the day to avoid capture by such sight predators as fish. The maximum occurrence of Chaoborus during midsummer coincided with the minimum abundance of all other taxa and the lowest oxygen values of the year. The presence of Chaoborus, coupled with both the almost total elimination of extremely oxygen-sensitive forms including

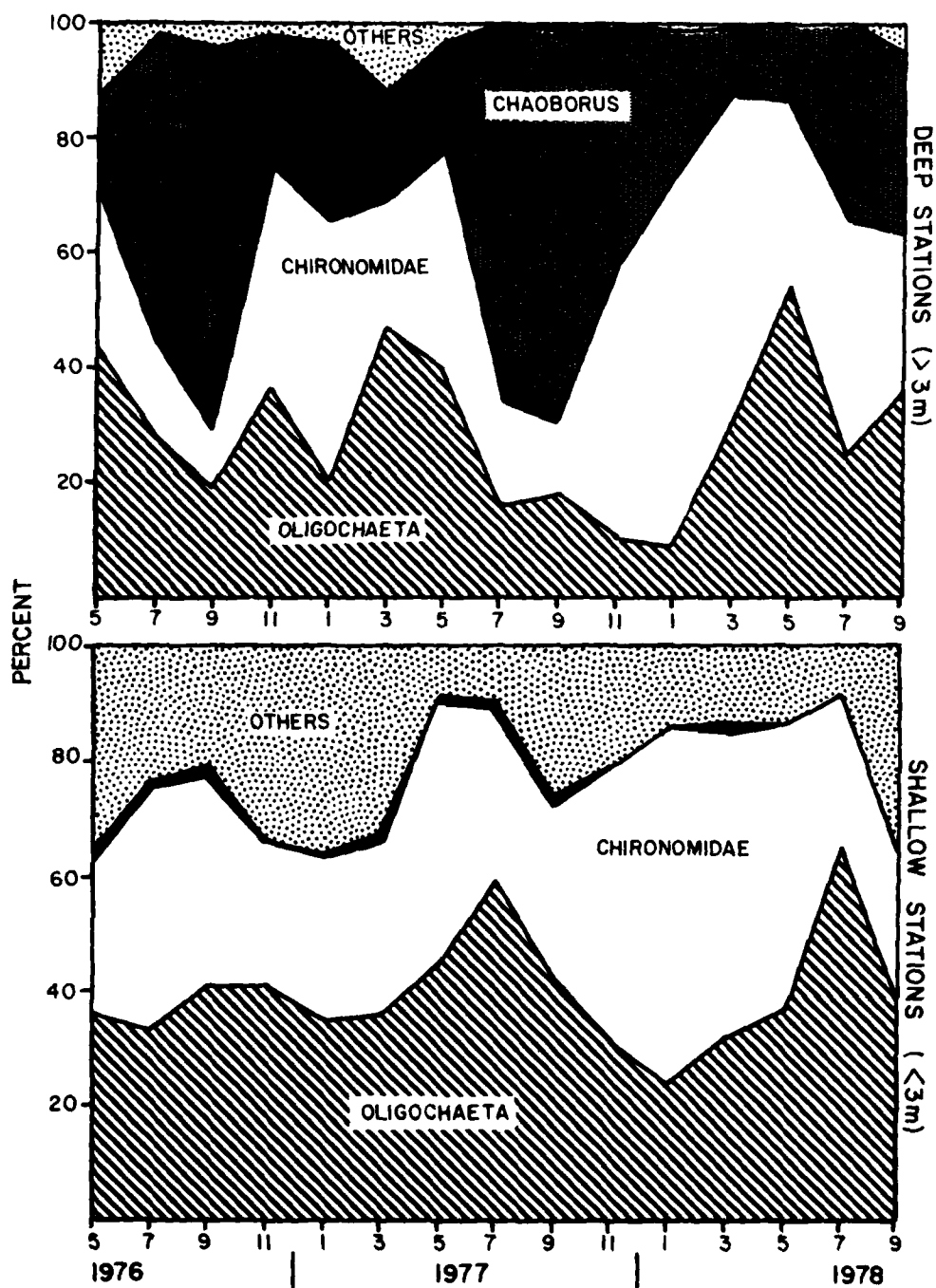


Figure 26. Contribution of major taxonomic groups to the benthic invertebrate assemblages at shallow and deep stations of the Conway system from May 1976 to September 1978

mollusks, dragonflies, amphipods, flatworms, and caddisflies and the pronounced midsummer reduction of taxa tolerant of reduced oxygen levels (chironomids and oligochaetes), suggest that the deep water assemblage is much more stressed than the shallow water assemblage. In addition, the composition of the deep water assemblage is more similar to the invertebrate assemblage of the eutrophic Oklawaha lakes than to that of the shallow water stations of the Conway system.

65. It was reported in the biological baseline report for Lake Conway (Conley et al. 1979) that benthic invertebrate biomass calculated as ash-free dry weight was approximately 10 percent of wet weight and that the biomass of deep stations was only 10 to 20 percent of that calculated for shallow stations. Reexamination of these calculations revealed that sporadic occurrence of large mollusks greatly biased the results. Mollusks generally are much larger than most other benthic invertebrates, tend to be restricted to shallow areas, and are not adequately sampled with a petite Ponar grab. One mollusk may account for 80 to 90 percent of the total biomass in any sample when they are present. The smaller invertebrate taxa may have lower combined biomass, but their biomass is much more available to predation and turnover than is the predominantly inorganic, slowly accreting biomass of mollusks. Since September 1977 the authors have calculated mollusk and nonmollusk biomass separately in order to construct more valid comparisons of shallow and deep stations.

66. Calculation of benthic invertebrate biomass exclusive of mollusks for the Conway system (Figure 27) demonstrates that, although the biomass at deep stations is consistently lower than that at shallow stations, the difference does not approach an order of magnitude as reported earlier (Conley et al. 1979). Invertebrate biomass at shallow stations increased continuously from September 1977 to March 1978, but declined slightly after March. Invertebrate density (Figure 23) displayed a similar trend except that the spring decline was both earlier and proportionally greater than recorded for biomass. Finally, invertebrate density increased during summer while biomass continued to

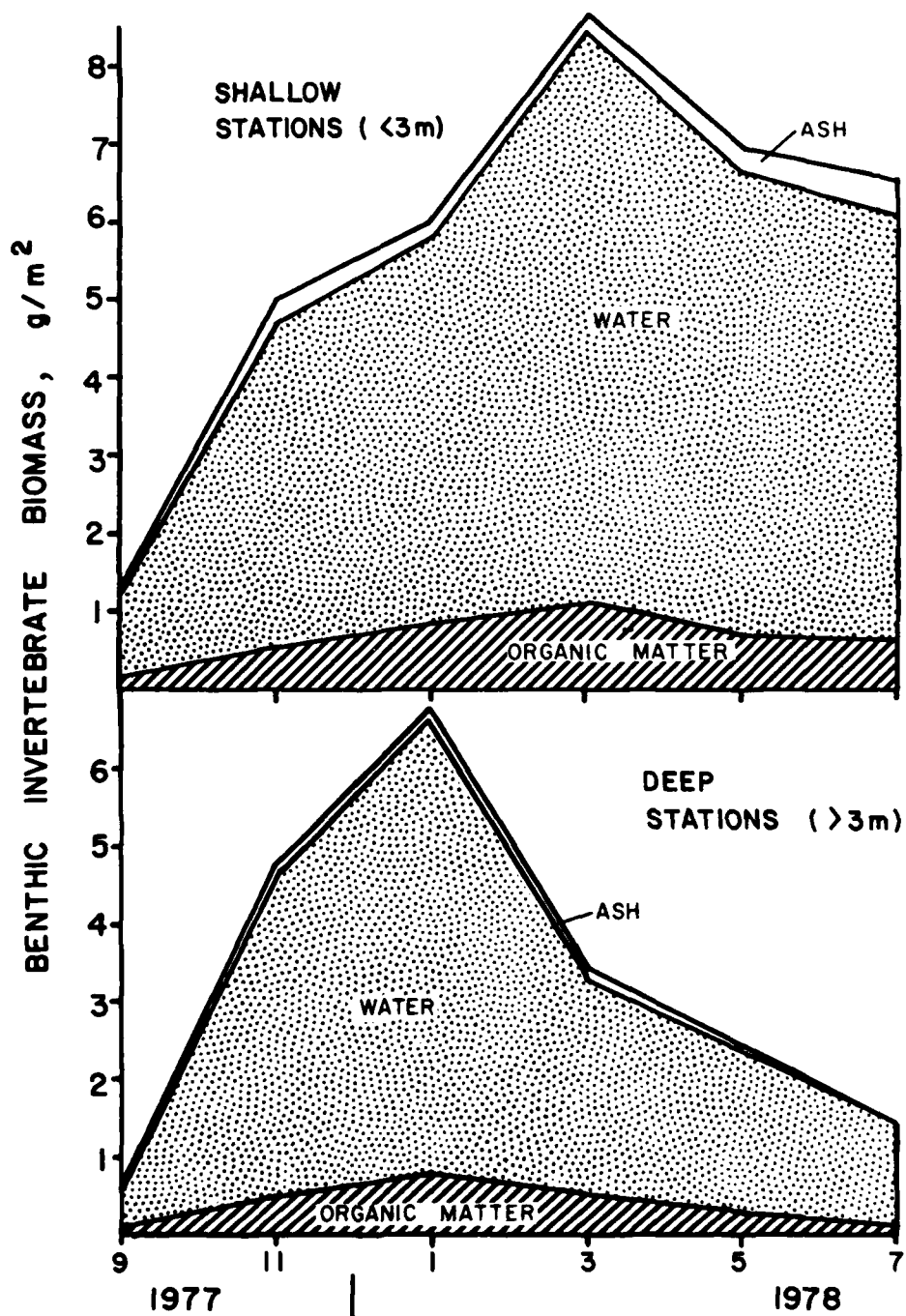


Figure 27. Benthic invertebrate biomass (exclusive of mollusks) pooled separately for all shallow and deep stations of the Conway system from September 1977 to July 1978

decrease suggesting the appearance of a new generation of invertebrates during this period.

67. Benthic invertebrate biomass also increased throughout fall and winter but peaked in January rather than February as observed for the shallow stations. The deep stations displayed the same trend of biomass reduction during spring and summer as the shallow stations, but the magnitude of the biomass loss was greater in the deep areas. Such a difference between shallow and deep stations could be accounted for by the presence of species in deep water whose life cycles or emergence times differ from similar species in shallow areas.

68. Mollusk biomass (Figure 28) has not been separated according

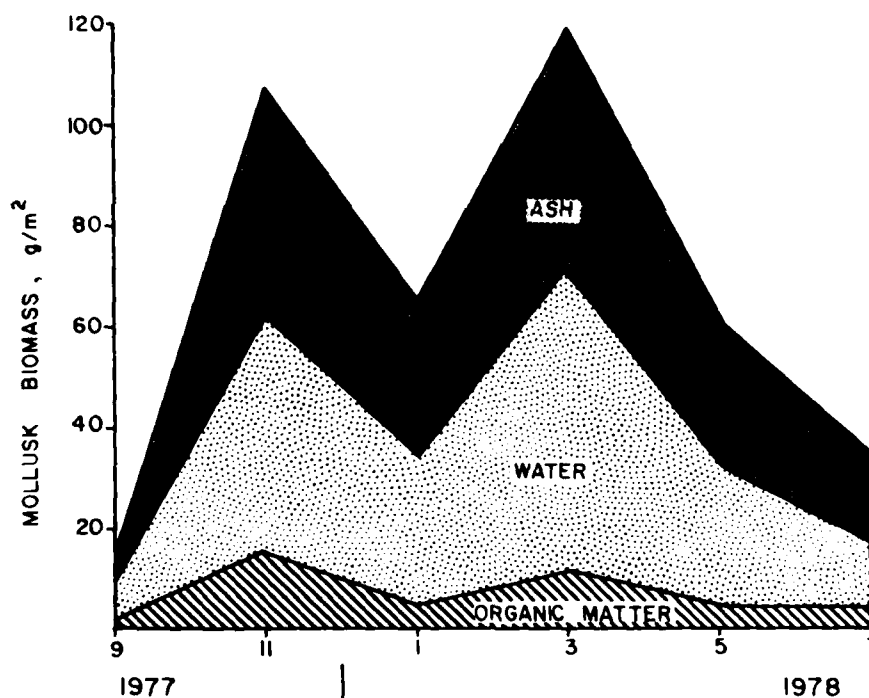


Figure 28. Mollusk biomass combined for all pools of the Conway system for the period from September 1977 to July 1978

to depth since mollusks occur almost exclusively in shallow areas of Lake Conway. Mollusk biomass was consistently at least an order of magnitude higher than nonmollusk biomass calculated at either shallow or

deep stations. Two peaks in mollusk biomass, November 1977 and March 1978, were recorded, but their significance is questionable. Mollusks cannot accrete biomass fast enough to explain the short-term biomass increase recorded prior to November 1977 and March 1978 nor would predation in the Conway system be severe enough to account for the biomass losses between November and January and following March. Thus, the fluctuation in mollusk biomass is likely due to inadequate sampling of this group by the methods employed in this investigation and the fact that mollusks are extremely mobile within the littoral zone.

69. The benthic invertebrate assemblages for the shallow stations of the Conway system are characterized by higher biomass, density, and species diversity than assemblages of deeper water. Although both assemblages are within the range expected for mesotrophic systems, the deep water assemblage in several respects is more similar to the invertebrate assemblages of the eutrophic Oklawaha lakes (Tuschall et al. 1979) than to the shallow water assemblage of the Conway system. Deep stations are dominated solely by sediment-dwelling species able to tolerate extremely low oxygen concentrations, while species usually associated with aquatic macrophytes and that are more sensitive to oxygen fluctuations are more important at shallow stations. Although no major changes in the benthic invertebrate assemblages of either shallow or deep stations were apparent at the end of the first year following introduction of the white amur, as compared with the prestocking period, the impact, if it occurs, may be most severe on the shallow water benthic assemblages.

PART IV: SUMMARY AND CONCLUSIONS

70. The Lake Conway system is comprised of five interconnected mesotrophic pools characterized by monomictic thermal regimes and mid-summer oxygen depletion of profundal areas. Mean Secchi disk transparency increased and mean chlorophyll a concentrations decreased in all five pools during the first year following introduction of the white amur (1978), suggestive of a general reduction in algal biomass compared to the preceding two prestocking years (1976 and 1977). Conversely, both midsummer algal abundance and the importance of blue-green algae were greater during the poststocking than during the prestocking period. Both of these latter two parameters displayed major yearly fluctuations between the two prestocking years, thus confounding comparison with the prestocking period.

71. Similarly, the spring maximum in zooplankton abundance was greatest during the first poststocking year (1978) than in either of the two prestocking years (1976 and 1977), but the 1977 peak was greater than that recorded for 1976. Neither species composition or seasonal dominance was altered during the study period.

72. Benthic invertebrate density and average number of species fluctuated in distinct annual cycles and were much lower in profundal areas than in shallow areas. These characteristics have not changed since the stocking date.

73. Major fluctuations in biological parameters between successive years, especially the two prestocking years, coupled with only 1 year of poststocking data, make separation of short-term climatic effects from the effects of white amur introduction nearly impossible. If productivity has increased in the Lake Conway system during the poststocking period, it probably does not exceed the normal range of between-year variations.

74. Further long-term investigation of the system is needed in order to separate climatic from fish-induced effects, note any lag-time response of selected biological elements, and provide the data base necessary to formulate a public policy governing the introduction of the white amur for macrophyte control.

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Table 1
Morphometric Features of the Lake Conway System*

<u>Pool</u>	<u>Area</u> <u>km²</u>	<u>Volume</u> <u>m³ × 10⁶</u>	<u>Mean Depth</u> <u>m</u>	<u>Maximum Depth</u> <u>m</u>
South Pool	1.37	8.24	6.01	9.0
Middle Pool	2.99	17.90	5.98	13.0
East Pool	1.27	5.76	4.54	8.2
West Pool	1.48	8.46	5.72	9.8
Lake Gatlin	0.28	1.18	4.18	8.0
	7.39	41.54	5.29	13.0

* Compiled from Blancher (1979).

Table 2

Mean Annual Values of Functional Chlorophyll a for the Last
Prestocking Year (September 1976 to August 1977) and the
First Poststocking Year (September 1977 to August 1978)

<u>Pool</u>	<u>Chlorophyll a, mg/m³</u>	
	<u>Prestocking</u>	<u>Poststocking</u>
South Pool	3	2
Middle Pool	4	2
East Pool	4	2
West Pool	5	2
Lake Gatlin	12	8

Table 3

Carlson Trophic State Index Calculated for the Last Prestocking
Year (September 1976 to August 1977) and the First
Poststocking Year (September 1977 to August 1978)

<u>Pool</u>	<u>Carlson Trophic State Index</u>	
	<u>Prestocking</u>	<u>Poststocking</u>
South Pool	41	37
Middle Pool	44	37
East Pool	44	37
West Pool	46	37
Lake Gatlin	55	51

Table 4
Monthly Pool Averages ($\#/m^3$) for Copepods (Co), Cladocerans (Cl), and
Rotifers (R) in the Conway System from May 1976 to August 1978

Date	South Pool			Middle Pool			East Pool			West Pool			Lake Gatlin		
	Co	Cl	R	Co	Cl	R	Co	Cl	R	Co	Cl	R	Co	Cl	R
1976															
M	48174	83793	5188	54687	52339	14138	91994	82020	8309	175048	292605	42150	198532	87714	21759
J	45762	81206	5177	54249	53762	13864	91008	79007	8651	217637	322305	81558	117746	277150	278943
J	90137	119009	2637	39522	20974	94497	84922	194707	3697	115883	287531	1201	23120	10840	3404
A	62722	16722	19004	324240	137932	64237	183947	22559	43945	167138	24402	30361	91312	2740	11578
S	49059	93251	128157	27907	22735	60919	66147	24681	64820	43814	41059	62908	25609	4520	10668
O	105328	9171	1156	37895	26698	10228	94296	35772	272835	143562	42559	12182	117982	5470	7216
N	49067	14318	2864	63403	76472	4984	173474	47514	118813	97240	55056	66496	80405	19572	31259
D	24507	32890	22974	89519	48412	8698	141742	14681	5010	94185	12649	6027	7105	18066	67920
1977															
J	34772	8444	1775	89233	70533	2762	69153	14632	6616	86293	16349	1525	75383	216255	25151
F	284508	182030	28	128756	8318	119539	52601	7055	41550	73778	16521	28325	161533	706281	158791
M	202577	21561	25425	49585	3068	37249	29030	50163	468473	24620	72958	266111	68693	370281	442815
A	224519	61406	172250	316118	26511	149220	37131	116584	24540	65530	217690	1815	180747	699074	0
M	398040	168681	30312	190287	326689	27354	32955	260995	332483	45024	187916	1001945	259384	741511	276187
J	253605	98423	96804	89052	16380	31203	60775	21991	6347	29153	26159	29263	85499	66845	23943
J	53374	28222	1649	32508	9913	21095	21082	22558	7407	4773	7247	3647	6194	4068	6762
A	156917	20641	76206	132553	35883	51778	23623	4466	23704	42029	10427	27669	24198	2137	32158
S	112029	92685	26843	67102	53768	69918	46598	46268	85410	46232	20608	30685	46848	2378	1135
O															
N	74983	111642	325604	113309	33661	449	71201	47563	590020	73394	24834	271318	113154	11468	473
D	126147	321730	0	79773	35920	960	116743	87971	4460	63810	60276	2890	40663	22459	1665
1978															
J	104454	67061	743	183172	50513	0	150762	77970	14481	93127	72738	156281	60681	270164	105220
F	102781	38616	676	187190	61854	96	221974	68227	2742	125446	34524	408	97011	147421	1401
M	182733	168454	137687	178379	57613	341433	184758	37248	184337	125183	71490	131655	174114	147476	1462216
A	369035	370568	2453	470137	141058	27598	249458	221918	37460	410149	426096	26531	855971	665154	136453
M	161740	91932	1475027	229262	221249	77498	214359	230250	523696	164363	106730	261752	75989	29245	15935
J	93445	115284	133221	24508	25234	109700	27313	52557	278134	59351	46757	216655	24811	24480	138965
J	18748	12385	254493	11498	13575	46630	159290	55697	1185674	136220	39820	631077	125418	83344	527765
A	49229	68900	132027	90003	46327	25162	318867	120041	349975	167044	42394	108143	18421	13269	6056

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