THE INFLUENCE OF TURBIDITY ON PLANKTONIC AND BENTHIC ORGANISMS

by

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INTRODUCTION

Descriptions of water quality are very often expressed in nebulous and broad terms. Essentially, the terms reflect the nature of the water as it affects the human responses of sight, smell, and taste; three factors which may have little correlation to actual biological condition of the system. Normally the description for visual response is turbidity. Smell and taste of the water may be indicative of degradation of the environment from organic pollutants and man's activities in general. Turbidity, on the contrary, is more often associated with expected natural errosion and usually occurs to some degree regardless of the intervention of man. Increases in levels of turbidity beyond long-term levels, however, are very often encountered in systems in which man has intervened.

Precise definition of what constitutes turbidity is often encountered in the literature. The U. S. National Oceanographic Instrumentation Turbidity Workshop (1) point to it as a qualitative description of other factors associated with the phenomenon. McCluney (2) suggests the term be retained as a qualitative descriptor in visual estimates of water clarity but at the same time to other fundamental qualities such as extinction coefficient. Duchrow and Everhart (3) related turbidity with bottom types and termed it a questionable parameter for establishing water quality standards. Turbidity, for purposes of this study, is a measured amount of SiO_2 in parts per million reflecting suspended materials washed in from the north central hill strata geological formations in northern Mississippi.

Planktonic and benthic organisms from Grenada Lake, Mississippi, were gathered and the resulting data compared to the concentration of SiO_2, a commonly used descriptor of turbidity. A quantitative evaluation of samples taken monthly during 1973 and 1974 and weekly samples in 1975 and 1976 was made. The data from 1975 and 1976 were entered in a stepwise linear regression equation using the BMDO2R computer program developed by the Health Sciences Computer Facility of U. C. L. A. (4). Bottom organisms taken in samples from 1973 to 1975 were also analysed. Evaluations of benthos were made based on qualitative and quantitative observations taken from a variety of locations with widely varying water velocity and sediment deposition rates.

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MATERIALS AND METHODS

Three stations for plankton analysis were established within the conservation pool and represented water samples from both the Skuna and Yalobusha Rivers. Station location is indicated by the numbers 1, 3, and 7 on Figure 1. Temperature was recorded at one meter intervals from the surface to the bottom at each station. Free carbon dioxide, dissolved oxygen, and pH were analyzed at the surface and each five meter depth to the bottom according to methods outlined in Standard Methods for Examination of Water and Wastewater (5). Turbidity was measured with a Hellige Turbidimeter and recorded in ppm SiO_2. Three Vitro bottles of unaerated water from each location were returned to the laboratory for subsequent analysis for iron, ammonium nitrogen, nitrates, nitrites, orthophosphates, metaphosphates, silica, alkalinity, and specific conductance. Illuminance in foot candles was recorded at the surface and each 0.5 meter to extinction using an Interocean Marine Illuminance meter Model 510 with a Tiffen ND 1.0 filter. Plankton samples were taken at the surface and each five meters to the bottom with a 2 liter Kemmerer sampler. The sample consisted of 100 l of lake water filtered through a number 20 nylon Wisconsin net and the wash concentrated to 100 ml. Formalin was added as a preservative.

Three longitudinal strip counts of the preserved plankton were made using procedures outlined by Lind (6), and the organisms encountered identified to genus. Calculations of number of plankton per liter of unfiltered lake water were made and that figure entered in standard FORTRAN IV language into the BMDO2R program.

Benthic organisms were obtained from samples of bottom deposits collected by Ekman dredge and strained through a U. S. Standard No. 30 sieve. Samples were taken from transects represented by letters on Figure 1. Organisms were separated to family in the laboratory and 3,500 were cleared and mounted for subsequent identification to species. Representative samples were measured volumetrically to obtain quantitative productivity of benthos.

EXPERIMENTAL RESULTS

The data obtained from samples taken at station three on the Skuna-Turkey arm of the reservoir may be considered fairly typical of those found at the other two stations and is presented here. Substances which are measured as turbidity in the Skuna drainage may be expected to represent materials eroded from Eocene and Paleocene formations shown below:

Formation	Components
Eocene	
Tallahata	- sand containing clay
Wilcox	- irregularly bedded fine to coarse sand with lignitic clay and lignite
Palcocene	
Naheola	- fine to coarse micaceous sand, kaolin, and bauxitic clay
Porter's Creek	- dark gray clay with sand lenses

Agriculture in the drainage consists mainly of cotton and soybean mixed with some pastureland, estimated at less than 50% of the area. The remaining area is mixed hardwood and pine forest.

The regression summary for the BMDO2R program indicated the multiple R with respect to turbidity ranged from a low of 0.875 for iron to 0.956 for orthophosphate. Intermediate values for metaphosphate, ammonium nitrogen, nitrates, nitrites, and silica were computed. Maximum concentrations of the substances occurred during high turbidity periods from December through March, declining to no detectable amounts of orthophosphate, metaphosphate, ammonium nitrogen, nitrates, and nitrites during August and September of 1975.

The predominant organism of the limnetic zone was the diatom Melosira sp., which reached a peak of 337,000 organisms per liter in December, 1975. Levels of more than 300,000 per liter were maintained through March, 1976. Melosira was observed to decline to less than 100 per liter during August and September. A comparison of Melosira counts and turbidity is seen in Figure 2. The rapid increase in numbers followed a temperature decline to below $20^{o}C$ and an initial increase in turbidity.

Two other phytoplankters Anabaena sp. and Asterionella sp. exceeded 1,000 organisms per liter with a peak for both occurring in late May. The rotifer Keratella sp. (Figure 3) was the predominant zooplankter with a peak of 620 per liter on April 3, 1975. The species was represented throughout the year in Grenada reservoir but usually declined significantly to less than 5 per liter from July through September. The shelled amoeba Difflugia sp. (Figure 4) was a common zooplankter observed, the concentrations increasing as the temperature and turbidity increased. The largest of the zooplankters represented in the samples was Cyclops sp. and copepod nauplii (Figures 5 and 6). Correlation between these organisms and the level of turbidity and Melosira is evident. Numbers of organisms in deeper strata are also correlated indicating other than merely negative phototaxis during high insolation periods.

Five phyla of benthic invertebrates were collected. The Arthropoda were represented by 21 identifiable species. The Mollusca followed with 14 genera and 16 species. Three genera of Annelida were found each represented by a single species. Small numbers of Nematoda and statoblasts from 2 species of Bryozoa were recorded. The Arthropoda composed over 99 per cent of all individuals collected from the 39 genera and 41 species identified. The Diptera were predominant during the entire study although members of the Ephemeroptera represented the majority of benthic faunal mass during part of the study.

DISCUSSION

The appearance of phytoplankton during periods of high turbidity is significant. Counts of more than 300,000 Melosira per liter when sustained turbidity readings of more than 52 ppm SiO_2 were observed. Comparison of samples taken at 0, 5, and 10 meters showed little difference indicating thorough mixing and turnover through the photic zone. Chemical analysis indicates the concentration of many nutrients and other biologically assimilated materials may be expected to rise significantly during the periods of increased turbidity. Turbidity reached a maximum of 76 ppm during the most productive period for the phytoplankter Melosira and sustained levels above 50 ppm did not appear to be detrimental, as long as vertical mixing occurred. Melosira may be expected to be a major contributor to organic bottom deposits. Zooplankters which ultimately depend on the diatoms for sustenance may be expected to show parallel fluctuations in numbers encountered.

The number of all representative plankters has shown a steady increase since 1973 continuing into 1976. Peak counts of 12,000 per liter of Melosira occurred during the flood period of 1973 to an increase of thirty-fold at the conclusion of the study in 1976.

No obvious detrimental effects on the benthos by silting from turbidity in the profundal zones of the reservoir could be ascertained. To the contrary, mud-muck substrate provided by low levels of deposition provided the most suitable habitation for macrobenthos when compared to other reservoir habitats sampled. Detrimental effects of deposited materials was observed, however, in several areas studied. During periods of heavy rainfall and increased flow, a scouring and grinding action destroyed all benthos in the streams except for shelled Molluska. Turbidity in the stream environments occasionally exceeded 1,000 ppm and always proved destructive to benthos. Deltas where streams entered the reservoir typically had fewer species than the profundal zone due to the shifting and layering of the sand and clay substrates. Areas of large concentrations of solids in flowing waters or in delta regions generally had little diversity of benthic species and poor habitats prevailed.

Evidence exists that under certain conditions turbidity may actually stimulate growth of plankton and benthos in Grenada reservoir. The materials transported into the reservoir during periods when runoff occurs may possibly supply nutrients to a degree overshadowing the detrimental effects of light attenuation so long as turbidity readings remain somewhat below 70 ppm SiO_2. Sustained readings above this level may be expected to degrade the environment.

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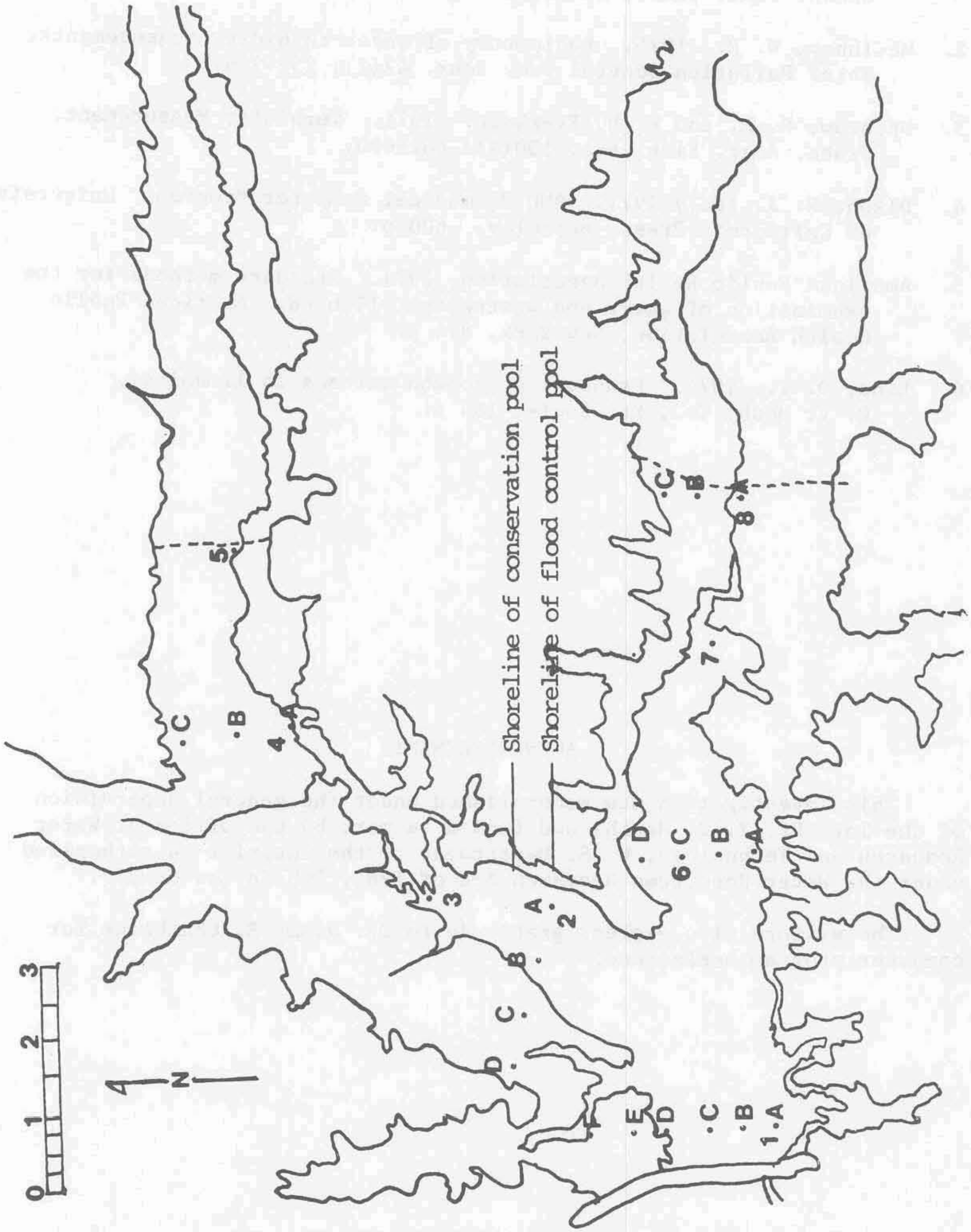

Fig. 1. Grenada Reservoir conservation and flood control pools, showing stations and transects.

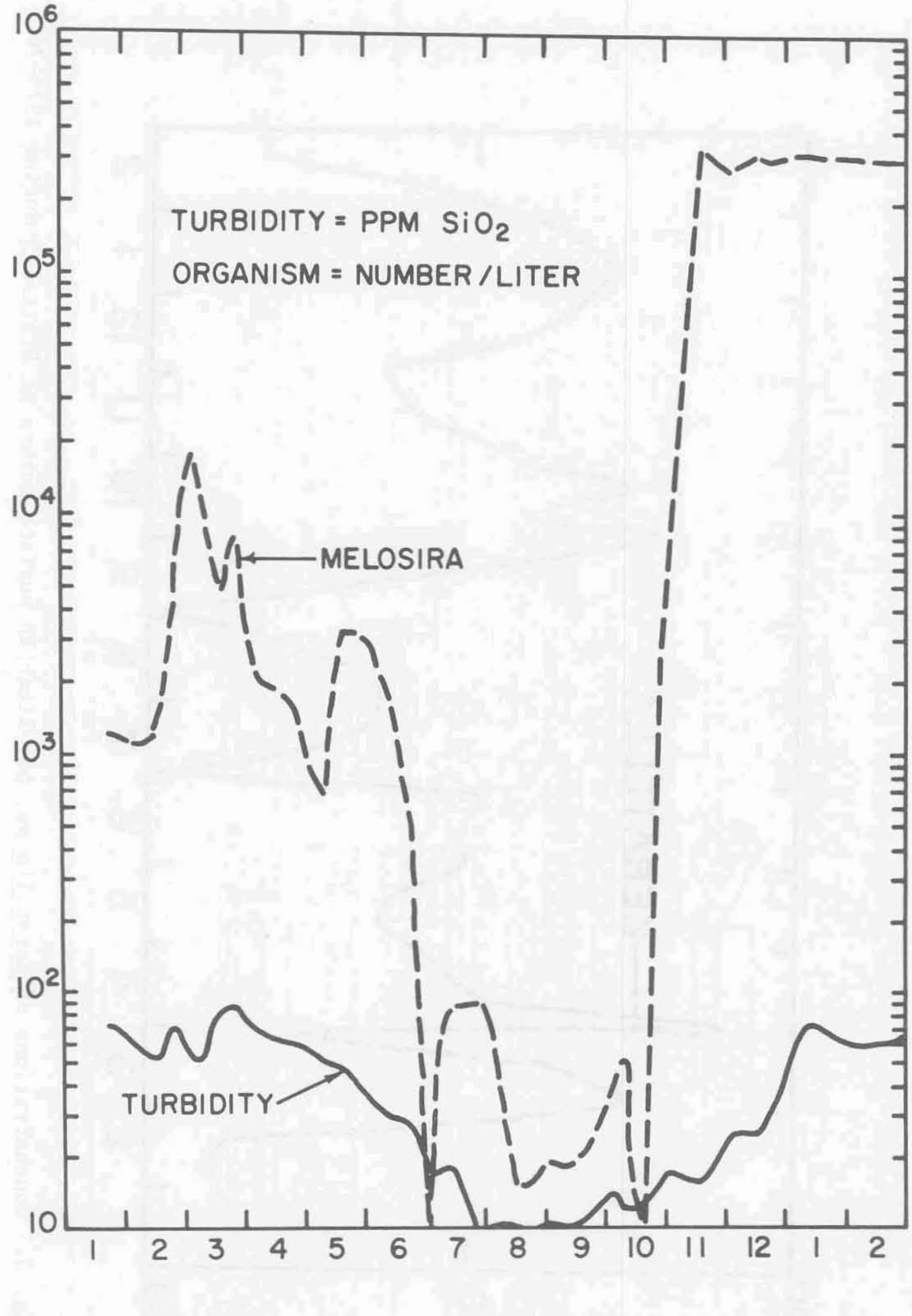

Fig. 2. Comparison of Melosira sp. per liter and turbidity in Station 3 surface waters during 1975-76.

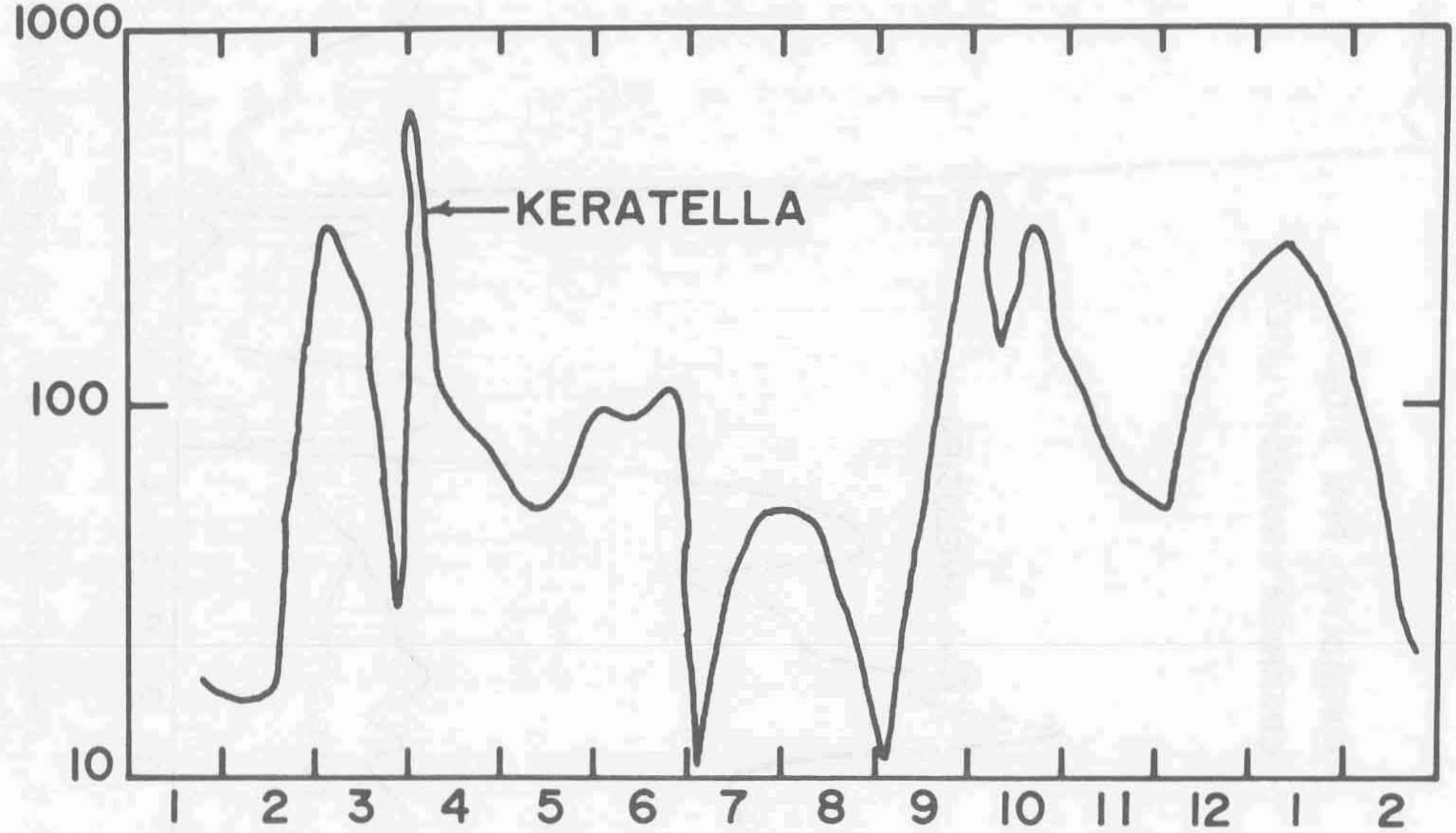

Fig. 3. Concentrations of Keratella sp. per liter in surface waters at Station 3 during 1975-76.

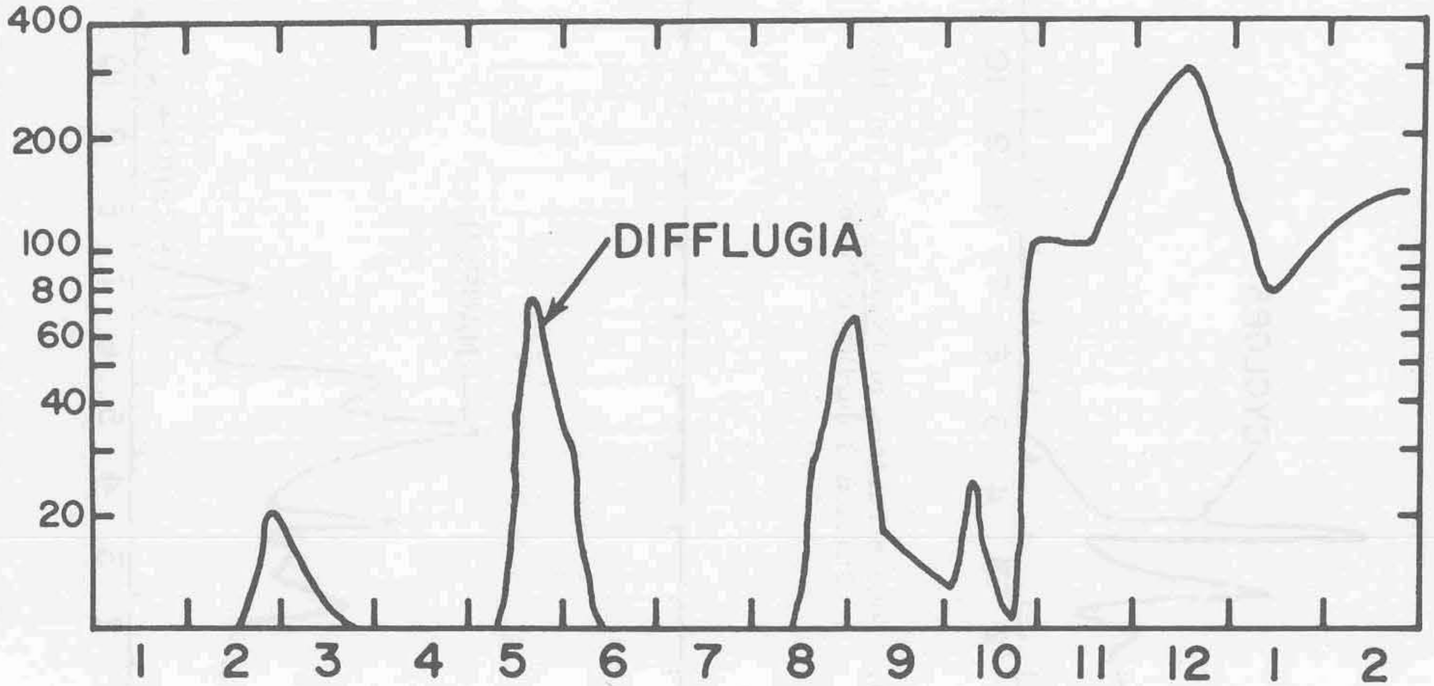

Fig. 4. Concentrations of Difflugia sp. per liter in surface waters at Station 3 during 1975-76.

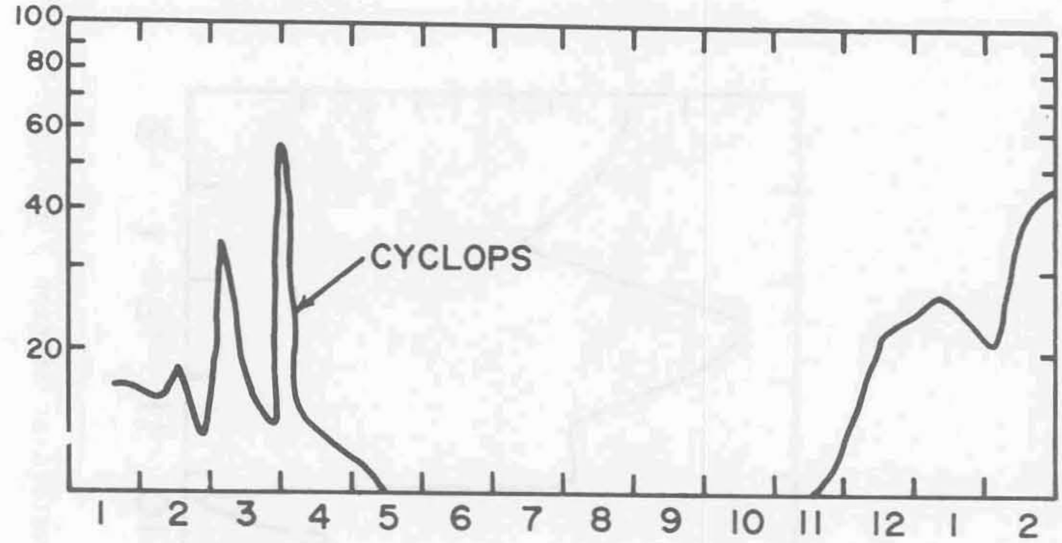

Fig. 5. Concentrations of Cyclops sp. per liter in surface waters at Station 3 during 1975-76.

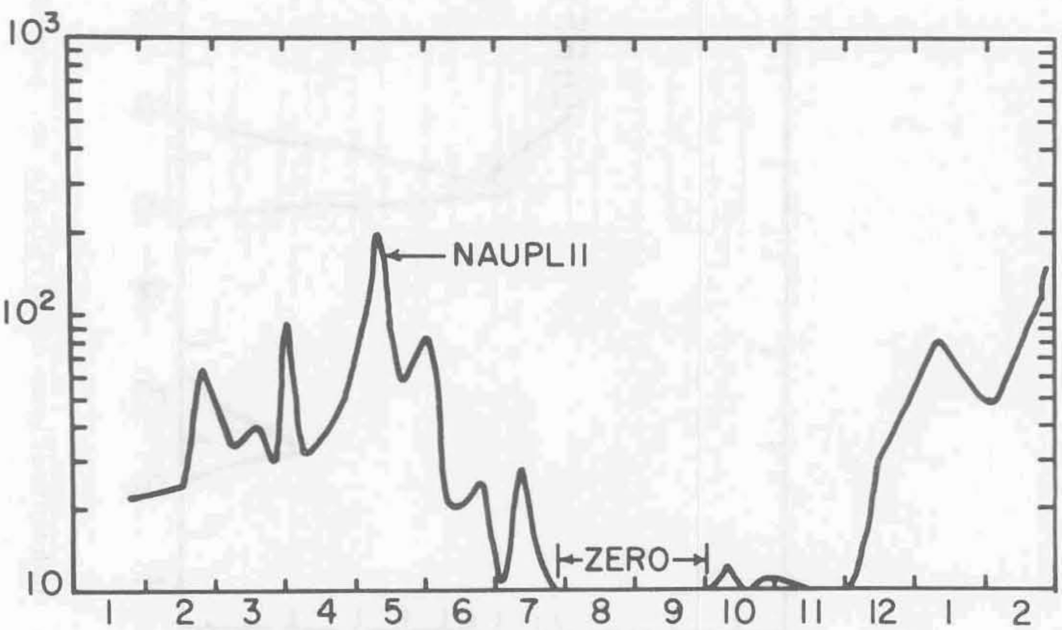

Fig. 6. Concentrations of nauplii per liter in surface waters at Station 3 during 1975-76.