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ZOOPLANKTON ABUNDANCE AND DIVERSITY IN DARDANELLE RESERVOIR, ARKANSAS, 1981-1990

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ABSTRACT

Zooplankton samples were collected quarterly from five stations representing the discharge bay and four "control" or "dispersing impact" stations. Rotifers dominated all samples numerically and by the number of taxa. All major groups (Rotifera, Cladocera, Copepoda, and Protozoa) exhibited greatest abundances during the summer. Quarterly variations in abundance and number of taxa were documented. Except for an increase in taxonomic analysis detail between 1981 and 1984 resulting in several more taxa added to the list, no long-term increases, declines or repeating cycles were apparent. Margalef's Richness Index reflected this change and showed a long-term increase with evidence of a 5- to 6-year repeating cycle. Shannon's Heterogeneity and Pielou's Evenness Indices showed no obvious trend or cycle. When these variables at Sta. 5 (discharge) were compared with other stations, no significant differences ($\alpha = 0.05$) were documented..

INTRODUCTION

Environmental studies on Dardanelle Reservoir have included plankton surveys (Palko 1970; Rickett and Watson 1983a, 1983b), surveys of radionuclides (Chittenden 1979, 1980) and general water chemistry (Rickett and Watson 1985). Several of these studies, including the present one, have been funded by Arkansas Power & Light Company (presently Entergy Corporation) to determine the environmental compatibility of the operation of Arkansas Nuclear One, a generating facility located on the north shore of the reservoir. Unit I of this facility began commercial production in 1975 and uses reservoir water pumped once through for condenser cooling. Rickett and Watson (1983a) described the general structure of the zooplankton community (taxa, abundances and temporal variations) between 1975 and 1983.

The principal objective of this project segment has been to document longer term impacts, if any, of plant operation on the composition and variations in the zooplankton community for the period 1981 through 1990. A secondary objective of this report was to review river discharge variations and relate such variations, if possible, to variations in the zooplankton community.

SITE DESCRIPTION

Dardanelle Reservoir was created on the main channel of the Arkansas River by the Kerr-McClellan Navigation System in the early 1960s and has been managed by the U.S. Army Corps of Engineers. Rickett and Watson (1985) reported morphometric data on the reservoir and a general description of watershed components. Since 1985 additional housing and urban development have occurred north and west of the city of Russellville, and limited development of agriculture and silviculture has occurred elsewhere in the watershed. There have also been minor development projects such as roads, small businesses and individual housing units in the watershed area.

Five stations were established to sample different general areas of the reservoir as well as to compare four "control" stations with the discharge station (Figure 1). The intake and upstream control stations (16 and 21, respectively) were distanced beyond the influence of the thermal discharge (5), whereas the mid-lake station (11) was expected to be within its influence. By the time discharge water reached the downstream station (15), no residual heat was expected to remain.

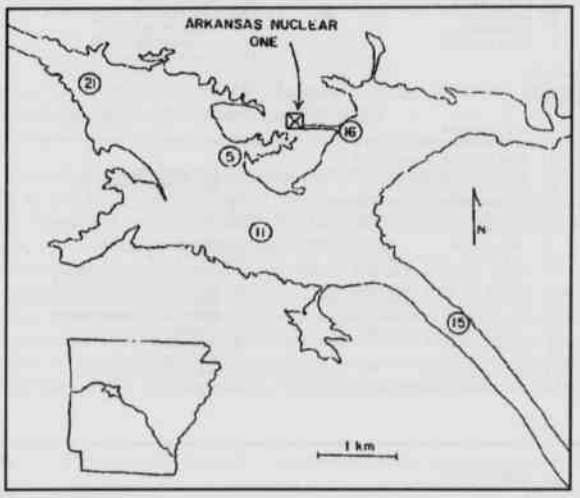

Figure 1. Dardanelle Reservoir in the vicinity of ANO with sampling sites noted.

METHODS

Depth-integrated zooplankton samples were collected quarterly at five stations on the reservoir during the years 1981-1990. Two hundred liters of water were pumped through a Wisconsin-style plankton net having 80-micron mesh size, and the filtrate was preserved with Meyer's fixative. Approximately two-thirds of the volume was taken from the surface to 0.3 m depth, whereas the remaining third was taken equally from 0.3 to 3.0 m, a depth generally representing the lower margin of the euphotic zone. In the lab, sample aliquots were placed in a Sedgwick-Rafter counting cell and viewed at 100x with a Nikon inverted microscope equipped with a mechanical stage. Organisms were identified to genus and tabulated as number per liter.

Community structure was described by evaluating zooplankton abundances, number of taxa, and three indices of diversity: Margalef's Richness, Shannon's Heterogeneity and Pielou's Evenness (see Appendix for formulae and notations). The Margalef formula compares the number

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of taxa in a sample and the total number of organisms comprising those taxa. The Shannon index evaluates how the individuals are distributed among the taxa, whereas the Pielou Evenness index is somewhat more sensitive than Shannon's in that it relates the distribution if the individuals back to the number of taxa in the sample. For all indices used, an increase in number of taxa without changing the number of individuals, or a decrease in the number of individuals or individuals per taxon without changing the number of taxa produces a larger calculated value, a feature which must be considered for interpretation.

RESULTS AND DISCUSSION

Forty-one genera representing the Protozoa, Rotifera, Copepoda and Cladocera were identified and enumerated (Table 1). Unspecified genera of Nematoda, Tardigrada and Ostracoda were also occasionally encountered and recorded. Rotifers dominated t.he samples during all seasons of the year, comprising 79 to 91.5 percent of individuals, (Figure 2) and demonstrating peaks of abundance in the summer. The other three major groups also exhibited their abundance peaks in the summer, but, combined, accounted for only 10-20 percent of the samples.

Table 1. List of zooplankton genera in Dardanelle Reservoir, 1981-1990.

Protozoa

1. *Difflugia*
2. *Suctoria*
3. *Trichodina*
4. *Verticella*

Nematoda

Rotifera

1. *Asplanchna*
2. *Brachionus angularis*
3. *Brachionus bidentata*
4. *Brachionus calyciflorus*
5. *Brachionus caudatus*
6. *Brachionus havannensis*
7. *Brachionus quadridentatus*
8. *Chromogaster*
9. *Conchilus*
10. *Filinia (=Tetramastyx)*
11. *Hexarthra*
12. *Kellicottia bostoniensis*
13. *Kellicottia longispina*
14. *Keratella cochlearis*
15. *Keratella quadrata*
16. *Monostyla*
17. *Notholca*
18. *Opercularia*
19. *Platyias patulus*
20. *Platyias quadricornis*
21. *Polyarthra*
22. *Polyphemus*
23. *Rotaria*
24. *Testudinella*
25. *Trichocera*
26. *Trochosphaera*

Tardigrada

Ostracoda

Copepoda

1. *Cyclops spp.*
2. *Diaptomus spp.*

Cladocera

1. *Alona*
2. *Alonella*
3. *Bosmina longirostris*
4. *Ceriodaphnia lacustris*
5. *Ceriodaphnia quadrangula*
6. *Chydorus sphaericus*
7. *Diaphanosoma*
8. *Daphnia*
9. *Holopedium*
10. *Moina*

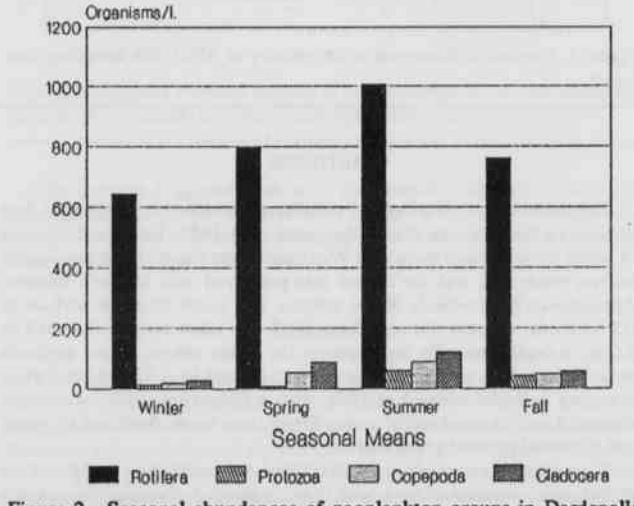

Figure 2. Seasonal abundances of zooplankton groups in Dardenelle Reservoir, 1981-1990.

For the mean number of organisms per station, the years 1981-1983 exhibited consistently low numbers (fewer than 1000 per liter), followed immediately (1984) by the highest peak of abundance of the project period. A second largest number was collected in 1987. In-between peaks occurred approximately once per year. Plotting annual means revealed a distinct bi-modal curve with modes at 1984 and 1987 and a steep decline from late 1987-1990 (Figure 3). However, the examination of abundance

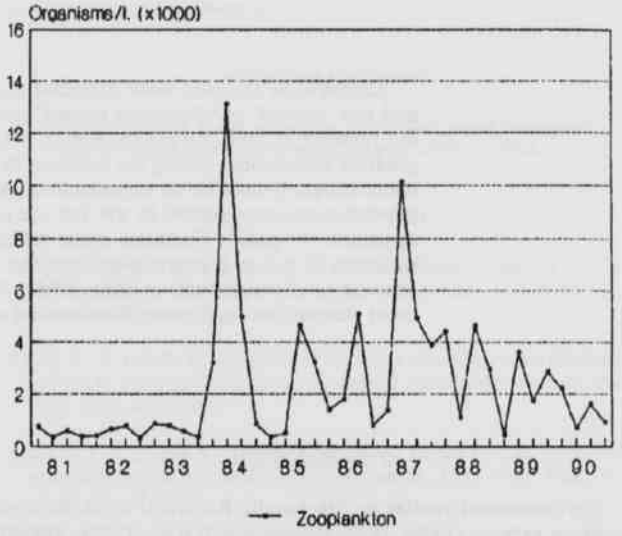

Figure 3. Mean number of zooplankton per station in Dardenelle Reservoir, 1981-1990.

curves for the individual stations showed two distinct patterns. Stations 11, 15 and 21, all in the main body of the reservoir, still exhibited bi-modal curves, but station 16 (intake) showed a curve with a single mode in 1987. Station 5 (discharge) had an intermediate abundance curve with a small mode in 1984, showing the mixing effect as the discharge water met the main body of the reservoir. Water taken into the plant was drawn from the Illinois Bayou arm of the reservoir and contained a number of different characteristics (Rickett and Watson 1985), reflected here by variations in zooplankton abundance.

When stations 11, 15, 16 and 21 were each paired with station 5 graphically, quarterly abundance peaks coincided in a]l pairs (Figure 4).

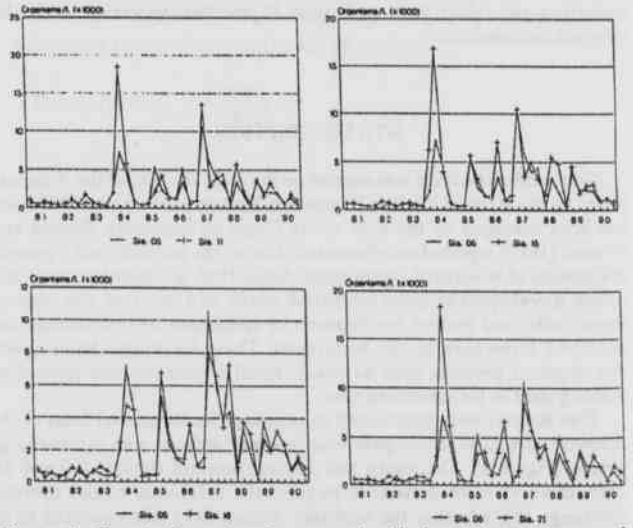

Figure 4. Zooplankton abundances at the discharge staton compared with each "control" station, Dardanelle Reservoir, 1981-1990.

Differences in peak height, particularly in 1984 and 1987 were present, but t-tests showed no significant difference ($\alpha = 0.05$) within any pair of abundance curves. The number of taxa identified rose sharply from a mean of seven (1981-1983) and ranged between 14 and 17.5 thereafter. This increase corresponded to an increase in the level of detail used in sample analysis (some taxon lumping had been done previously). The objective here, however, was to compare the number of taxa collected at station 5 with the other stations (Figure 5). No significant differences were observed when stations were paired, and no long-term trends were identified.

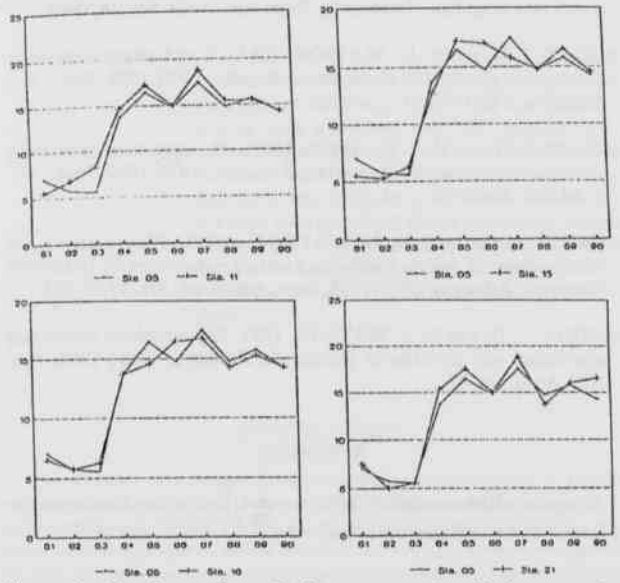

Figure 5. Numbers of zooplankton taxa at the discharge station compared with each "control" station, Dardenelle Reservoir, 1981-1990.

A composite of Margalef's Richness Index for all stations contained a peak which corresponded to the strongest abundance spike in 1985 (Figure 6). This peak was preceded by the lowest richness values for the study period, and a second peak of equal magnitude was in evidence in 1990. These curves corresponded generally to the number of taxa. When richness indices of Sta. 11, 15, 16 and 21 were compared with that of station 5, t-tests revealed no significant differences.

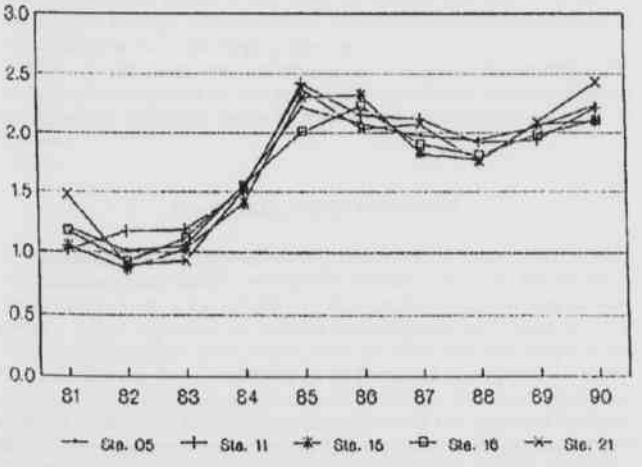

Figure 6. Annual means of Margalef's Richness index for zooplankton, Dardenelle Reservoir, 1981-1990.

Shannon's Heterogeneity Index increased gradually during the study period with minor dips in 1984 and 1988 (Figure 7). Greatest community heterogeneity was observed between 1985-1987 and 1989-1990. When stations were graphically and statistically compared in the pattern as before, no significant differences were noted.

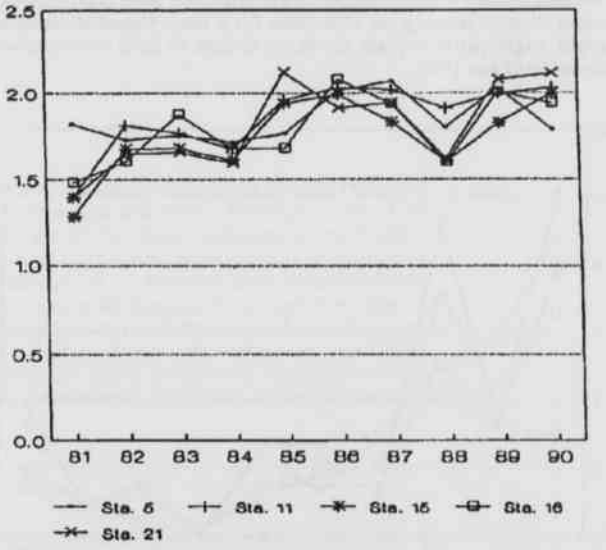

Figure 7. Annual means of Shannon's Heterogeneity index for zooplankton, Dardenelle Reservoir, 1981-1990.

Individual organisms were more evenly distributed among the taxa early in the study period (Figure 8), but after 1984 Pielou's Evenness Index remained fairly constant. When station 5 was compared with others, t-tests revealed no significant differences.

Numerical fluctuations of zooplankton did not always coincide with the same for phytoplankton (Rickett and Watson, 1992). If we were to assume a number of close predator-prey relationships between phytoplankton species and zooplankton species, we would expect a larger number of phytoplankton to support a given number of zooplankton. Calculation of P/Z (phytoplankton/zooplankton) ratios was a quick way

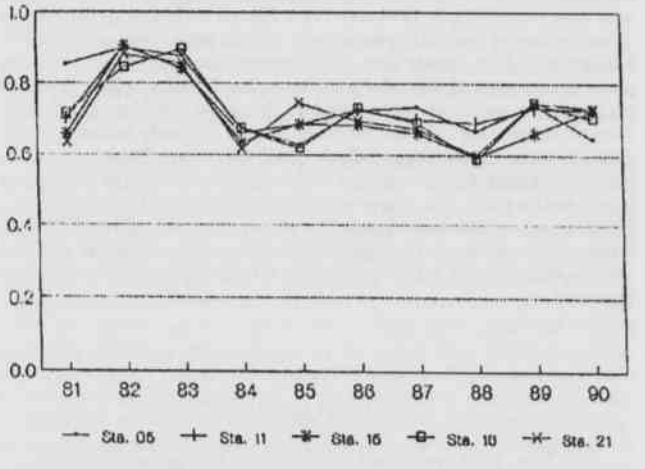

Figure 8. Annual means of Pielou's evenness index for zooplankton, Dardenelle Reservoir, 1981-1990.

to assess this relationship (Figure 9). During 70 percent of the study period, P/Z ratios were around or less than 2, too low to agree with the usual ecological pyramid. The lowest P/Z ratios corresponded to a strong zooplankton abundance peak and phytoplankton abundance dip in 1987. Perhaps a close feeding relationship does not exist continually, and some of the zooplankton were feeding on larger suspended particulates or small mauplii or were preying on each other for a time. Cannibalization of mauplii might partly explain the sharp decline in their own numbers between 1987 and 1990.

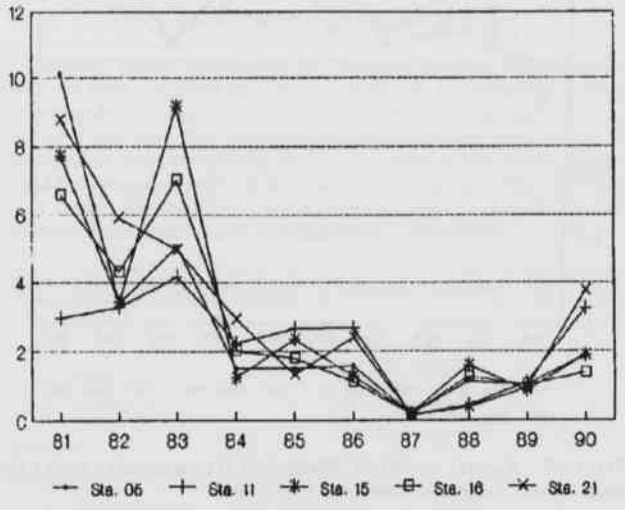

Figure 9. Phytoplankton/Zooplankton (P/Z) ratios based on numerical standing crop, Dardenelle Reservoir, 1981-1990.

SUMMARY

Rotifers constituted 79 to 91.5 percent of the numerical standing crop. All major groups of zooplankton exhibited greatest abundances during the summer. Considerable quarterly variations in abundance were present with peaks occurring in 1984 and 1987. Similar variations in the number of taxa collected were also present with a slight peak developing in 1987. Neither long-term trends nor cyclic patterns were apparent. With the possible exception of Margalef's Richness, the diversity indices exhibited no long-term trends or cyclic patterns. Margalef's Richness definitely showed an increase over the 10 years. Part of the early increase (1981-1985) was due to increasing analysis detail. Other than Pielou's Evenness index exhibiting a mirror image of Margalef's during 1981-1984, the other indices did not show corresponding variation. Shannon's Heterogeneity exhibited a gentle but steady increase, whereas Pielou's Evenness remained constant after 1984. When all variables at station 5 were compared with all other stations, no significant differences were observed.

ACKNOWLEDGMENT

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APPENDIX

Margalef's Richness Index (MRI) = $\frac{S - 1}{\log (N)}$, where S is the number of taxa; N is the total number of individuals.

Shannon's Heterogeneity Index (SHI) = $- \Sigma (p_i) \log (p_i)$, where p_i is the proportion the ith taxon comprises of the entire sample.

Pielou's Evenness Index (PEI) = $\frac{SHI}{\log (S)}$.