Journal of the Arkansas Academy of Science

Volume 37 Article 20

1983

Phytoplankton Community Structure in Dardanelle Reservoir, Arkansas, 1975-1982

John D. Rickett
University of Arkansas at Little Rock

Robert L. Watson
University of Arkansas at Little Rock

PHYTOPLANKTON COMMUNITY STRUCTURE IN DARDANELLE RESERVOIR, ARKANSAS, 1975-1982

JOHN D. RICKETT and ROBERT L. WATSON
Biology Department
University of Arkansas at Little Rock
Little Rock, Arkansas 72204

ABSTRACT

Phytoplankton data were collected with standard equipment and procedures over an eight-year period (1975-1982) in Dardanelle Reservoir, Arkansas. Community abundance and diversity at the genus level are described. Sixty-five genera representing 35 families and five divisions were identified. Total phytoplankton abundance and diversity were quite uniform among the stations but fluctuated considerably with time. These fluctuations did not correspond clearly with season. Dominant taxa were seasonal, though, with diatoms being usually dominant in January, April and October, and blue-greens dominant in July. The phytoplankton community structure has not been significantly altered by the operation of ANO Unit I.

INTRODUCTION

Information about phytoplankton community structure in Arkansas reservoirs is quite scarce. Some of the earlier papers (Meyer, 1969; Meyer *et al.*, 1970) dealt only with checklists, whereas others studied algae in relation to certain water quality parameters (Meyer, 1971; Rice and Meyer, 1977). Still other studies emphasized phytoplankton populations related to certain anthropogenic inputs, e.g., thermal discharge. Sinclair and Watson (1978) conducted such a survey in Dardanelle Reservoir for five years immediately prior to the operation of Arkansas Power and Light Company's Arkansas' Nuclear One (ANO) Unit I. Numerous papers have appeared concerning thermal disturbance in specific locations in other states (Gibbons and Sharitz, 1974; Esch and McFarlane, 1976). There is a definite lack in Arkansas of work describing phytoplankton community structure and dynamics and the impacts of thermal effluents. This report is a superficial analysis of data gathered in Dardanelle Reservoir over an eight-year post-operational period of ANO Unit I. The main points to be addressed in this paper are (1) seasonality or periodicity of community diversity and which taxa were dominant and when, (2) changes in abundance and diversity related to season and location with respect to thermal discharge, and (3) evidence of long-term trends or shifts in community structure.

METHODS AND MATERIALS

Phytoplankton samples were collected in January, April, July and October of the years 1975-1982 and strained through a standard No. 20 Wisconsin-style plankton net. The water column at each station and date was sampled by taking 2 l of water each from near the bottom, mid-depth and 0.6 m, and 4 l from the surface, constituting a 10 l sample. With rare exceptions, 10 stations were sampled quarterly (Figure 1) and the samples preserved in Meyer's Fixative (0.76% I_2, 0.38% KI, 3.8% glacial acetic acid, 19% concentrated formalin and 76% dH_2O, by weight).

In the lab the samples were diluted to 10 ml (if needed), and a 1 ml aliquot was removed and placed in a Sedgwick-Rafter counting cell. Quantitative evaluation was determined by counting randomly spaced strips across the counting cell to cover 38.9 percent of the area. Then a total quantitative cross-check was made by counting 10 randomly chosen fields. Colonial forms were counted as single cells, and organisms were identified to genus where possible and reported as number per liter.

Statistical procedures included calculation of the number of taxa, number of individuals, mean number of individuals per taxon and community diversity at the generic level. Diversity was calculated using the Shannon Index, $d = -\Sigma\left(\frac{n_i}{N}\right)\ln\left(\frac{n_i}{N}\right)$, where n_i is the number of organisms in each taxon in turn, and N is the total number of organisms per liter. Values are positive; the larger ones indicating greater community diversity.

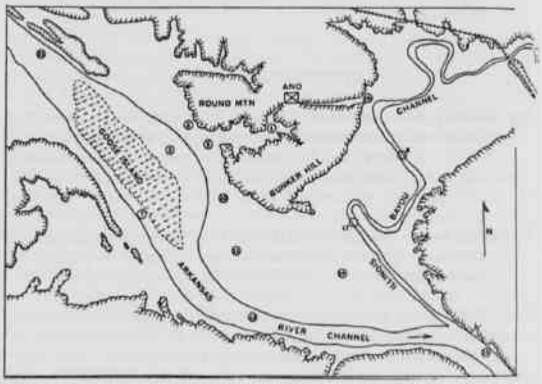

Figure 1. Plankton sampling stations on Dardanelle Reservoir, Arkansas, 1975-1982.

RESULTS AND DISCUSSION

Sixty-five genera representing 35 families in five divisions were identified (Table 1). Forty-six percent of the genera were in Chlorophyta, 31 were in Chrysophyta, 17 were in Cyanophyta, and Euglenophyta and Pyrrhophyta were represented by three percent each of the genera. Meyer (1969) reported 82 genera as occurring in Arkansas; 29 of which were present in this study. Meyer *et al.*, (1970) reported an additional 34 Arkansas genera, eight of which are reported in this study. Nelson and Harp (1972) reported four additional genera which were obtained in our study. This study presents 24 genera not reported by any of the three foregoing papers.

Table 2 is a summary by season (quarter) of individuals, number of taxa, individuals per taxon and diversity values listing stations close to and distant from the point of thermal discharge. Close stations (Nos. 1,2,3,5,10) were those generally influenced by thermal loading, whereas distant stations (Nos. 11,14,15,16,21) were those not apparently influencd (Rickett, 1981). A cursory examination of Table 2 reveals considerable fluctuation from quarter to quarter and from year to year. On the average, July samples contained the largest populations, numerically, the greatest number of taxa and the largest number per taxon, but the greatest community diversity indices were observed in October. Phytoplankton was very dense in July 1978, exhibited a serious decline in January 1981 and a rapid recovery between April and July 1981. The decline was probably a delayed response to the very hot and dry summer of 1980. Total phytoplankton peaked six times in July, four times in January and once in April. The peaks were spread by six to 12 months, so there was not a precise coincidence with season.

Table 1. Taxonomy of phytoplankton in Dardanelle Reservoir, Arkansas, 1975-82.

Division Chlorophyta
- Family Chlamydomonadaceae
  - 1. Chlamydomonas
- Family Volvocaceae
  - 2. Eudorina
  - 3. Gonium
  - 4. Pandorina
  - *5. Platydorina
  - 6. Volvox
- Family Gloeocystaceae
  - *7. Gloeococcus
- Family Chlorococcaceae
  - *8. Schroederia
- Family Palmellaceae
  - 9. Sphaerocystis
- Family Oocystaceae
  - 10. Ankistrodesmus
  - 11. Chlorella
  - *12. Chodatella
  - 13. Kirchneriella
- Family Micractiniaceae
  - 14. Micractinium
- Family Dictyosphaeriaceae
  - 15. Dictyosphaerium
  - *16. Dimorphococcus
- Family Scenedesmaceae
  - 17. Actinastrum
  - 18. Coelastrum
  - 19. Crucigenia
  - 20. Scenedesmus
- Family Hydrodictyaceae
  - 21. Pediastrum
- Family Ulotrichaceae
  - *22. Ulothrix
- Family Microsporaceae
  - 23. Microspora
- Family Chaetophoraceae
  - *24. Stigeoclonium
- Family Oedogoniaceae
  - 25. Oedogonium
- Family Cladophoraceae
  - *26. Cladophora
- Family Zygnemataceae
  - 27. Spriogyra
- Family Desmidiaceae
  - 28. Closterium
  - 29. Cosmarium
  - 30. Staurastrum

Division Chrysophyta
- Family Tribonemataceae
  - 31. Tribonema
- Family Chrysococcaceae
  - 32. Chrysococcus
- Family Dinobryaceae
  - 33. Dinobryon
- Family Synuraceae
  - 34. Synura
- Family Coscinodiscaceae
  - 35. Cyclotella
  - 36. Melosira
  - *37. Stephanodiscus
- Family Fragillariaceae
  - 38. Asterionella
  - 39. Fragillaria
  - *40. Meridion
  - 41. Synedra
  - 42. Tabellaria
- Family Naviculaceae
  - *43. Gyrosigma
  - *44. Navicula
  - *45. Neidium
  - *46. Stauroneis
- Family Gomphonemaceae
  - *47. Gomphonema
- Family Cymbellaceae
  - *48. Cymbella
- Family Nitzschiaceae
  - *49. Nitzschia
- Family Surirellaceae
  - 50. Surirella

Division Cyanophyta
- Family Chroococcaceae
  - 51. Chroococcus
  - *52. Gleocapsis
  - 53. Merimnopedium
  - *54. Microcystis (Anacystis)
- Family Oscillatoriaceae
  - *55. Arthrospira
  - *56. Lyngbya
  - 57. Oscillatoria
  - 58. Spirulina
- Family Nostocaceae
  - *59. Anabaena
  - *60. Anabaenopsis
- Family Scytonemataceae
  - *61. Scytonema

Division Euglenophyta
- Family Eugleraceae
  - 62. Euglena
  - 63. Phacus

Division Pyrrhophyta
- Family Peridiniaceae
  - 64. Peridinium
- Family Ceratiaceae
  - 65. Ceratium

*Not reported by Meyer (1969), Meyer et al. (1970), or Nelson and Harp (1972).

Table 2. Summary by season (quarter) of phytoplankton community structure, Dardanelle Reservoir, Arkansas, 1975-82.

JANUARY Year	Stations	Number of Organisms	Number of taxa	Number per taxon	Diversity Value
1975	Close	1309	12.7	104	1.796
	Distant	1214	11.5	104	1.638
1976	Close	5271	16.4	324	1.839
	Distant	5942	17.8	337	1.916
1977	Close	5061	16.4	309	1.997
	Distant	7064	20.0	353	1.895
1978	Close	3338	16.2	209	1.459
	Distant	2651	14.2	189	1.462
1979	Close	1336	14.8	90	2.086
	Distant	1206	12.3	98	1.956
1980	Close	4635	12.4	376	1.710
	Distant	4452	12.8	350	1.842
1981	Close	82	2.6	29	0.756
	Distant	92	2.8	32	0.582
1982	Close	4385	10.2	430	1.579
	Distant	3282	10.2	232	1.459
Mean	Close	3177	12.7	234	1.653
	Distant	3238	12.7	223	1.594
APRIL					
1975	Close	5012	17.0	300	1.869
	Distant	5467	16.6	338	1.755
1976	Close	2464	18.8	130	2.183
	Distant	2418	16.4	147	2.060
1977	Close	2851	17.0	164	2.128
	Distant	3803	16.0	247	2.045
1978	Close	5617	16.8	335	1.810
	Distant	5419	17.8	306	1.688
1979	Close	3087	14.4	214	1.797
	Distant	3313	15.6	211	1.863
1980	Close	842	8.6	99	1.715
	Distant	778	8.8	101	1.718
1981	Close	352	6.2	57	1.208
	Distant	322	4.0	70	0.963
1982	Close	3689	11.8	318	2.092
	Distant	3247	9.8	323	1.823
Mean	Close	2989	13.8	168	1.850
	Distant	3096	13.1	218	1.739

JULY Year	Stations	Number of Organisms	Number of taxa	Number per taxon	Diversity Value
1975	Close	3746	19.0	198	2.315
	Distant	4025	18.5	216	2.239
1976	Close	1759	15.8	147	2.041
	Distant	2507	17.4	142	2.121
1977	Close	4783	16.2	298	1.867
	Distant	4920	17.2	287	1.806
1978	Close	12524	21.6	588	1.289
	Distant	9129	23.0	381	1.542
1979	Close	3293	20.6	160	2.192
	Distant	4007	22.6	172	2.037
1980	Close	4293	12.8	332	1.599
	Distant	2463	11.8	221	1.759
1981	Close	11620	15.2	763	1.307
	Distant	12457	15.6	799	1.185
1982	Close	5168	12.6	414	1.834
	Distant	5887	10.8	555	1.847
Mean	Close	5898	16.7	362	1.806
	Distant	5674	17.1	347	1.817
OCTOBER					
1975	Close	2949	13.0	229	1.599
	Distant	2509	14.2	184	1.602
1976	Close	2015	14.8	138	2.102
	Distant	1558	14.6	110	2.126
1977	Close	3092	15.6	196	2.048
	Distant	3065	16.4	192	2.067
1978	Close	1832	14.8	126	2.123
	Distant	1737	14.6	120	1.877
1979	Close	2689	20.4	132	2.338
	Distant	2348	18.0	129	2.366
1980	Close	275	5.0	60	1.250
	Distant	232	5.0	53	1.133
1981	Close	1703	12.0	144	1.874
	Distant	2117	12.0	176	1.876
1982	Close	2539	10.2	261	1.848
	Distant	2622	11.6	228	1.927
Mean	Close	2137	13.2	161	1.898
	Distant	2024	13.3	149	1.872

Distant stations showed the same peaking sequence as close stations. Close stations had more total organisms 18 of 32 times with an average difference of 534 cells; however when distant stations had more cells, the average difference was 589. With respect to total phytoplankton, there was apparently little impact from thermal discharge.

At close stations six peaks in the average number of taxa occurred in July and two in April, whereas at distant stations seven peaks occurred in July and two in April, whereas at distant stations even peaks occurred in July, two in January and one in October. It seemed the heated water had some stabilizing influence on the number of taxa comprising the community. Distant stations exhibited a larger number of taxa 16.5 times of 32 (three ties), the average difference being 1.08 taxa. When close stations were greater, the difference was 1.28 taxa.

At close stations five peaks in the average number of organisms per taxon occurred in July, four in January and two in April, whereas at distant stations there was one less peak in January. Close stations had more individuals per taxon 16.5 times of 32 (one tie), the average difference being 39.1. When distant stations showed the greater number, the differencw was 22.8.

At close stations peak diversity occurred six times in October, five times in April and once in July, while at distant stations diversity peaked five times in October, twice each in April and July, and once in January.

The major community growth occurred in July with a minor growth period in January. Olsen and Sommerfield (1976) obtained similar periods of abundance and depression in Canyon Lake, Arizona. They also noted that the early spring peak was composed primarily of centric diatoms, whereas the mid- to late-summer peak was dominated by filamentous Cyanophyceae.

Between July and October there was a decline in both numbers of organisms and taxa, but the former apparently experienced a disproportionate decline which caused higher diversity values. This also happened somewhat between January and April. Both normal seasonal decline and zooplankton cropping may have been the cause.

Table 3 shows dominance timing and frequency of nine major genera during the study period considering each station each quarter. *Cyclotella* was the dominant (represented by the greatest number of cells) 86 times, far more than any other taxon, and its favored time was October (47.7% of total for *Cyclotella*). *Melosira* and *Oscillatoria* were dominant with about the same frequency (54 and 53 times, respectively) but favored different times — January for *Melosira* (38.9%) and July for *Oscillatoria* (77.4%). *Tribonema* was dominant 34 times (58.8% of the time in January), while *Asterionella* and *Navicula* were dominant 13 times each. *Asterionella* favored April (100%), whereas *Navicula* favored October (84.6%).

Table 3. Dominance timing and frequency of major phytoplankton taxa in Dardanelle Reservoir, Arkansas, 1975-1982.

	Number of times dominant per quarter:				
Dominant taxon	JAN	APR	JUL	OCT	Total
Cyclotella (Chrysophyta)	11	24	10	41	86
Melosira (Chrysophyta)	21	13	16	4	54
Oscillatoria (Cyanophyta)	1	6	41	5	53
Tribonema (Chrysophyta)	20	12	2	0	34
Asterionella (Chrysophyta)	0	13	0	0	13
Navicula (Chrysophyta)	1	1	0	11	13
Ankistrodesmus (Chlorophyta)	3	1	0	7	11
Anabaena (Cyanophyta)	0	1	1	9	11
Chlamydomonas (Chlorophyta)	0	0	3	0	3
Total	57	71	73	77	

In January *Melosira, Tribonema* and *Cyclotella* were dominant 36.8, 35.1 and 19.3 % of the time, respectively. In April *Cyclotella, Melosira, Asterionella* and *Tribonema* were dominant 33.8, 18.3, 18.3 and 16.9 %, respectively. In July *Oscillatoria, Melosira* and *Cyclotella* were dominant 56.2, 21.9 and 13.7 %, respectively, whereas in October *Cyclotella, Navicula* and *Anabaena* were dominant 53.2, 14.3 and 11.7 %, respectively. In January, April and October, Chrysophyta were strongly dominant, whereas Cyanophyta dominated in July. Evidence of the dominance shift back to Chrysophyta was seen in October. Data collected by Sinclair and Watson (1978) during pre-operational years (1970-74) showed the same dominance trends for the diatoms (Chrysophyta) versus the blue-greens (Cyanophyta). Chlorophyta was represented less strongly in spite of having the greatest number of genera.

A considerable number of researchers have attempted to assess and quantify the impacts of thermal discharges, mostly from generating stations into natural waters. Miller *et al.* (1976) worked with actual ΔT's between 8.5 and 15 °C and concluded that smaller ΔT's that did not push the ambient temperature above 25 °C were stimulatory, but 34 °C was definitely inhibitory. One of their major problems was separating the effects of thermal discharge and normal ambient variation. At ANO Unit I during periods of operation, the average ΔT's were 8.20, 7.44 and 5.99 °C for 1980, 1981 and 1982, respectively. Gurtz and Weiss (1974) studied experimental ΔT's of 5.6, 11.1 and 16.7 °C and observed continually increasing inhibition of phytoplankton productivity. Tilly (1974) obtained an average 20% increase in autotrophic respiration in ΔT's ranging up to 3.3 °C while there was no significant increase in photosynthesis. Patrick (1974) summarized by pointing out that small ΔT's stimulate while large ΔT's inhibit and cause changes in the species composition of the community to favor blue-green algae. Thermal shock usually had detrimental effects. Most of these studies have been conducted in eastern or northeastern United States, so these conclusions may not necessarily apply here. More geographic variation has been observed than was expected.

SUMMARY

It is always difficult to separate variables, especially when so many are present. In addition to daily temperature variations, wind velocity and direction, solar radiation and physico-chemical characteristics further confuse the understanding. Add to this the fact that Dardanelle Reservoir has two distinct areas, and water from one (Illinois Bayou) is pumped through the plant into the other (Arkansas River mainstream), thus mixing parameters. Include the somewhat sporadic operation of ANO Unit I, and the challenge of understanding becomes steeper.

These data suggest that phytoplankton diversity and abundance were fairly uniform at the various sampling stations, there was considerable fluctuation in abundance and numbers of taxa which did not conform closely to the seasons, dominant taxa were quite seasonal in their occurrence, the diatoms being usually dominant in January, April and October while the blue-green algae were dominant in July. Blue-green algae is apparently better adapted to warmer water since they may take over as dominants in area of thermal effluent. Power plant operation has not noticeably affected overall phytoplankton abundance and the number of taxa, but community diversity was slightly greater at the close stations but not statistically significant. Water temperature changes through the plant may be considered near the lower end of the expected range compared to similar results elsewhere.

ACKNOWLEDGEMENTS

The authors wish to thank the late Clarence B. Sinclair and William R. Bowen for analyzing the phytoplankton samples, and numerous staff and students for field assistance. Financial support was provided by Arkansas Power and Light Company.

LITERATURE CITED

ESCH, G. W., and R. W. MCFARLANE. 1976. Thermal Ecology, II. ERDA Symposium Series 40. 404 pp.

GIBBONS, J. W., and R. R. SHARITZ. 1974. Thermal Ecology, I. AEC Symposium Series. 670 pp.

GURTZ, M. E., and C. M. WEISS. 1974. Effect of thermal stress on phytoplankton productivity in condenser cooling water. *In:* Thermal Ecology, I, ed. by J. W. Gibbons and R. R. Sharitz, AEC Symposium Series, pp. 490-507.

MEYER, R. L. 1969. The freshwater algae of Arkansas. Proc. Ark. Acad. Sci. 23:145-155.

MEYER, R. L. 1971. A study of phytoplankton dynamics in Lake Fayetteville as a means of assessing water quality. Ark. Water Res. Res. Enter, Publ. No. 10. 59 pp.

MEYER, R. L., J. H. WHEELER, and J. R. BREWER. 1970. The freshwater algae of Arkansas, II. New Additions. Proc. Ark. Acad. Sci. 24:32-35.

MILLER, M. C., G. R. HATER, T. W. FEDERLE, and J. D. REED. 1976. Effects of power-plant operation on the biota of a thermal discharge channel. *In:* Thermal Ecology, II, ed. by G. W. Esch and R. W. McFarlane, ERDA Symposium Series 40, pp. 251-258.

NELSON, J. H., and G. L. HARP. 1972. Qualitative and quantitative variation of net plankton of Craighead Lake. Southw. Naturalist 17(3):239-248.

OLSEN, R. D., and M. R. SOMMERFIELD. 1976. Thermal ecology of phytoplankton in a desert reservoir. *In:* Thermal Ecology, II, ed. by G. W. Esch and R. W. McFarlane, ERDA Symposium Series 40, pp. 195-201.

PATRICK, R. 1974. Effects of abnormal temperatures on algal communities. *In:* Thermal Ecology, I, ed. by J. W. Gibbons and R. R. Shartiz, AEC Symposium Series, pp. 335-349.

RICE, R. G., and R. L. MEYER. 1977. Algal assemblage distribution as related to seasonal fluctuations of selected metal concentrations. Proc. Ark. Acad. Sci. 31:90-91.

RICKETT, J. D. 1981. Temperature and dissolved oxygen profiles in Dardanelle Reservoir, 1971-1980. Unpubl. paper presented at the Ark. Acad. Sci. meeting, Little Rock, AR, 17, 18 Apr 1981.

SINCLAIR, C. B., and R. L. WATSON. 1978. A primary ecological survey of Dardanelle Reservoir prior to nuclear facility effluent discharge. Ark. Water Res. Res. Center, Publ. No. 60.

TILLY, L. J. 1974. Respiration and net productivity of the plankton community in a reactor cooling reservoir. *In:* Thermal Ecology, I, ed. by J. W. Gibbons and R. R. sharitz, AEC Symposium Series, pp. 462-474.