Par Pond Phytoplankton in Association With Refilling of the Pond: Final Report for Sampling From February 1995 - September 1996(U)

by

E. W. Wilde

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

M. A. Johnson

W. C. Cody

MASTER

DOE Contract No. **DE-AC09-89SR18035**

DISCLAIMER

WSRC-TR-96-0318

PAR POND PHYTOPLANKTON IN ASSOCIATION WITH REFILLING OF THE POND: FINAL REPORT FOR SAMPLING FROM FEBRUARY 1995 - SEPTEMBER 1996

E. W. Wilde M.A. Johnson and W.C Cody

Prepared for the U.S. Department of Energy under contract No. DE-AC09-89SR18035

Approved by: T.C. Hazen
Environmental Biotechnology Section
Savannah River Technology Center

Table of Contents

List of Tables and Figures

1.0 Executive Summary

This report describes the results of phytoplankton analyses from Par Pond samples collected between February 1995 and September 1996. The principal objective of the study was to determine the effect of refilling of Par Pond following repair of the dam on the phytoplankton community. Algal blooms are often responsible for fish kills and other detrimental effects in ponds and lakes, and it was postulated that decaying vegetation from formerly exposed sediments might trigger algal blooms that could result in fish kills in Par Pond following the refill. Sporadic algal blooms involving blue-green algae were detected, especially during the summer of 1996. However, the data derived from the study demonstrates that overall, the refilling effort caused no significant negative impact to the pond attributable to phytoplankton dynamics.

2.0 Introduction

Par Pond is a reactor cooling impoundment at the Savannah River Site. It was created in 1958 by construction of an earthen dam across the headwaters of Lower Three Runs Creek and used as a cooling pond, primarily for P-Reactor until 1989 when the reactor was shut down. In the spring of 1991, a depression was discovered on the downstream side of the dam and the pond water level was lowered approximately 19 ft. to facilitate dam repair and ensure safety of downstream residents in case of dam failure. Refilling of the pond was initiated in the winter of 1995. Sampling for phytoplankton from the winter of 1995 through the summer of 1996 was included in the monitoring effort to determine the effect of the refill on water quality and aquatic communities. For example, it was postulated that decaying vegetation from formerly exposed sediments might trigger algal blooms that could result in oxygen depletion and fish kills.

3.0 Methods

Samples were collected bi-monthly from February 1995 through July 1995 and monthly from August 1995 through September 1996. Whole water samples were collected on each date by filling 250ml (or larger) polyethylene bottles dipped into the pond near the surface, The following four locations were sampled:

P-1 or Par 1T - near the "bubble up" or former "hot" Dam
P-2 or Par 2T - near the primary "cold" dam
P-3 or Par 3T - in the former intake arm near the Par Pond pumphouse
P-4 or Par 4T - located near the distal end of the North Arm

Samples were kept refrigerated and in the dark prior to processing at the Par Pond Laboratory. One 50ml aliquot of each sample was preserved with modified Lugol's solution (Lund, et al., 1958, Vollenweider, 1969) and subsequently quantitatively analyzed using an inverted microscope. Another aliquot was qualitatively analyzed using fluorescence microscopy (Wilde and Fliermans 1979). Analysis of unpreserved sample material with the fluorescence microscopy technique facilitated the differentiation of phototrophic algal cells from non-phototrophic algal and non-algal particles of similar size and shape.

Non-pigmented organisms (as determined by fluorescence microscopical examinations of non-preserved and gluteraldehyde-preserved samples) including flagellates and other small rod-shaped or coccoid-shaped cells that are sometimes considered to be heterotrophic algae and cyanobacteria were considered in this study to be protozoa or bacteria. Quantitative results are presented both with and without the phototrophic picoplankton (cells <2um) to demonstrate the differences these tiny blue-green algal cells can make in terms of total phytoplankton density estimates and community composition analyses. Cell numbers were counted for all unicellular and colonial algae. Filamentous blue-green algae were counted in units with each unit comprising a 25um length of filament.

4.0 Results and Discussion

A total of 107 individual phytoplankton samples were analyzed during the study period. One hundred seventy-three (173) taxa were identified (Table 1). Seven major taxonomic groups were represented including: Chlorophyta (green algae) (83 spp.), Bacillariophyta (diatoms) (39 spp.), Cyanophyta (blue-green algae) (21 spp) Chrysophyta (yellow-green algae) (12 spp), Pyrrophyta (dinoflagellates) (9 spp), Euglenophyta (euglenoids) (7 spp) and Cryptophyta (cryptophytes) (2 spp).

Total phytoplankton abundance (excluding picoplankton) ranged from 160 organisms/ml at Location P-2 on 3/8/95 to 88,318 organisms/ml at Location P-1 on 8/7/96 and averaged 8,828 for all samples at all locations for the study period. The densities showed considerable spatial and temporal variation (Figure 1) as was typically the case in past studies of the Par Pond phytoplankton (Wilde 1983; Chimney et.al. 1985). None of the four locations were consistently more or less populated with phytoplankton than the others. Large peaks were observed in February, June, and August of 1996. These peaks were almost exclusively caused by pulses of two species of blue-green algae, *Lyngbya limnetica,* and *Anabaenopsis seriata* (Figure 2).

The Average overall phytoplankton density in Par Pond during this study (8,828) was higher than values {(i.e. 3,779 (Wilde, 1983), and 4,771, (Chimney et al. 1985)} reported in previous studies of Par Pond phytoplankton. However, the differences were once again primarily caused by the June,1996 and August, 1996 pulses of *Lyngbya limnetica* and *Anabaenopsis seriata* (Figure 3). *Lyngbya limnetica* was abundant during summer in the previous phytoplankton studies of Par Pond (Wilde 1983; Chimney et.al. 1985). However, *A. seriata* was not previously reported from Par Pond on any occasion before or after August 1996. *Anabaenopsis seriata* is an uncommon species that was first identified in 1954 (Prescott and Andrews, 1954) in a small Kansas lake where it blomed for two days and then disintegrated. Its one time appearance in Par Pond, while noteworthy, is probably of little ecological significance.

Table 2 shows phytoplankton densities at specific locations sampled in this study and in a 1984/85 study by Chimney et al. (1985). Diatoms and cryptophyta were much less abundant in the recent study while green algae and blue-green algae were much more abundant. This indicates likely eutrophication probably emanating from the decaying vegetation that was established during the drawdown and subsequently killed by the refill.

Overall, in terms of numerical abundance, the phytoplankton community was primarily comprised of Cyanophyta, Chlorophyta, Chrysophyta and Bacillariophyta (Table 3). Figures 4-7 show the temporal and spatial distribution

patterns for these four major groups of Par Pond phytoplankton during the study period.

Figures 8-10 demonstrate the differences in community characterization at one of the locations based on algal cell counts with and without the picoplankton which can only be detected with high quality microscopes equipped with fluorescence and high magnification (1000X or higher) capabilities. Although the picoplankton are relatively unimportant in Par Pond with regard to total algal biovolume, they greatly influence numerical abundance data.

In conclusion, despite a few pulses of blue-green algae, which were not correlated to oxygen depletion, the refilling of Par Pond had no adverse impact on the phytoplankton community.

5.0 Literature Cited

Chimney, M.J., W.R. Cody and W.M. Starkel. 1985. Final Report on the Water Quality, Phytoplankton, and Zooplankton of Par Pond and Pond B: January 1984-June 1985. DPST-85-789-I,II,III. Prepared by Environmental Sciences Inc. for E.I. du Pont de Nemours and Company, Savannah River Laboratory, Aiken SC.

Lund, J.W.G., C. Kipling and E.D. Le Cren. 1958. The inverted microscope method of estimating algal numbers and statistical basis of estimations by counting. *Hydrobiologia* 11:143-170.

Prescott, G.W. and T. F. Andrews. 1954. A new species of Anabaenopsis in a KansasLake with notes on Limnology. *Hydrobiologia* 7:60-63

Vollenweider, R.A., ed. 1969. Manual on Methods for Measuring Primary Production in Aquatic Environments. Int. Biol. Program Handbook 12. Oxford, Blackwell Scientific Publications. 213pp.

Wilde, E.W. & C.B. Fliermans, 1979. Fluorescence microscopy for algal studies. *Trans. Am. Microsc. Soc.*, 98: 96-102.

Wilde, E.W. 1983. Phytoplankton distribution in three thermally distinct reactor cooling reservoirs. *Trans. Am. Microsc. Soc.*, 102: 145-164.

Table 1. Phytoplankton taxa collected from Par Pond locations P-1, P-2, P-3, and P-4. February 22, 1995-September 25, 1996

		P1	P2	P3	P4
Cyanophyta					
	Anabaena wisconsinense	*	*	*	*
	Anabaenopsis seriata	*	*	*	*
	Aphanizomneon flosaquae			*	
	Chroococcus dispersus				*
	Chroococcus minimus	*	*	*	*
	Coccoid cyanophyta 2.1-5.0um	*		*	*
	Coccoid cyanophyta 5.1-10.0um	*	*	*	*
	Coelosphaerium naegelianum	*	*	*	*
	Cyanobacteria 0.7-1.2um	*	*	*	*
	Lyngbya aerugineo-caerulea		*		
	Lyngbya limnetica	*	*	*	*
	Lyngbya sp1	*	*	*	*
	Merismopedia tenuissima	*	*	*	*
	Microcystis aeruginosa	*	*	*	*
	Oscillatoria amphibia		*		
	Oscillatoria angusta	*	*		*
	Oscillatoria geminata			*	*
	Oscillatoria limnetica	*	*	*	*
	Oscillatoria minnesotensis		*		
	Oscillatoria sp.	*			*
	Phormidium tenue				*
Chlorophyta					
	Ankistrodesmus convolutus			*	
	Ankistrodesmus falcatus	*	*	*	*
	Ankistrodesmus spiralis	*	*	*	*
	Arthrodesmus validus		*		
	Carteria sp.				*
	Characium spp.		*	*	*
	Chlamydomonas spp.	*			*
	Chlorobiflagellate <5um	*	*	*	*
	Chlorobiflagellate 5-10um		*	*	
	Closteriopsis longissima			*	*
	Closterium aciculare	*			*
	Closterium acutum	*	*	*	*
	Closterium gracile			*	
	Closterium pseudodianae				*
	Coccoid chlorophyta 2-5um	*	*	*	*

Coccoid chlorophyta 5-10um	*	*	*	*

Table 1. Cont.

	P1	P2	P3	P4
Coelastrum microporum	*	*	*	*
Cosmarium depressum		*	*	
Cosmarium tenue	*	*		*
Cosmarium vegnellii		*		
Crucigenia apiculata	*		*	
Crucigenia quadrata	*	*		
Crucigenia tetrapedia	*	*	*	*
Dictyosphaerium pulchellum			*	
Elakatothrix viridis	*	*	*	*
Euastrum binale		*		
Euastrum denticulatum			*	*
Eudorina elegans	*		*	*
Franceia ovalis	*		*	*
Gloeocystis planctonica	*			
Gonatozygon brebissonii	*	*	*	*
Kirchneriella lunaris irregularis	*	*	*	*
Lagerheimia subsalsa	*	*	*	*
Micractinium pusillum	*	*	*	*
Monoraphidium circinale	*	*	*	*
Monoraphidium curvata		*		
Mougeotia spp.	*	*	*	*
Nephrocytium agardhianum				*
Nephrocytium limneticum	*	*	*	*
Oedogonium spp				*
Oocystis parva	*	*	*	*
Oocystis sp.			*	
Oocystis submarina	*			
Palmella miniata		*		
Pandorina charkowiensis		*		
Pandorina morum			*	
Pediastrum tetras	*	*	*	*
Phacotus lenticularis	*			
Quadrigula chodatii				*
Scenedesmus bicaudatus	*	*	*	*
Scenedesmus bijuga	*	*	*	*
Scenedesmus denticulatus			*	
Scenedesmus dispar	*	*		*

Table 1. Cont.

		P1	P2	P3	P4
	Scenedesmus excavatum minimum			*	*
	Scenedesmus insignis	*			
	Scenedesmus longiseta	*			
	Scenedesmus longispina		*	*	*
	Scenedesmus opoliensis				*
	Scenedesmus quadricauda	*			*
	Scenedesmus serratus	*	*	*	*
	Scenedesmus smithii				*
	Scenedesmus sp.	*			
	Scenedesmus spinosus			*	
	Scenedesmus tetracerum				*
	Schroderia setigera				*
	Selenastrum gracile	*			
	Selenastrum minutum	*	*	*	*
	Sorastrum spinulosum			*	
	Sphaerocystis schroeteri	*	*	*	*
	Spondylosium planum			*	
	Staurastrum cingulum	*	*	*	*
	Staurastrum excavatum minimum	*	*	*	*
	Staurastrum megacanthum	*	*	*	*
	Staurastrum muticum				*
	Staurastrum octoverrucosum			*	
	Staurastrum pseudopelagicum	*		*	*
	Staurastrum tetracerum	*	*	*	*
	Tetraedron caudatum	*		*	
	Tetraedron gracile	*			*
	Tetraedron minimum	*	*	*	*
	Tetraedron nastatum	*			*
	Tetraedron tigonum	*			
	Treubaria setigerum	*	*	*	*
Cryptophyta					
	Cryptomonas erosa	*	*	*	*
	Rhodomonas minuta	*	*	*	*
Euglenophyta					
	Euglena minuta	*	*	*	*
	Euglena spp.	*	*		

Table 1 Cont.

		P1	P2	P3	P4
	Phacus acuminatus			*	
	Trachelomonas hispida	*	*		
	Trachelomonas oblonga	*	*		*
	Trachelomonas spp.		*		
	Trachelomonas volvocina	*	*	*	*
Pyrrhophyta					
	Glenodinium quadridens		*		
	Gymnodinium ordinatum	*	*	*	*
	Gymnodinium sp1	*	*		
	Gymnodinium spp.	*	*	*	
	Peridinium inconspicuum	*	*	*	*
	Peridinium spl.			*	
	Peridinium spp	*		*	*
	Peridinium volzii			*	
	Peridinum wisconsinense	*	*	*	
Chrysophyta					
	Bitrichia longspina	*	*	*	*
	Bitrichia spl.			*	
	Chrysidalis sp1	*	*	*	*
	Chrysobiflagellate 5-10um	*	*	*	*
	Chrysococcus spl.	*	*	*	
	Coccoid chrysophyta 5-10um	*		*	*
	Dinobryon bavaricum	*	*	*	*
	Dinobryon cyst	*		*	*
	Dinobryon divergens				*
	Mallomonas caudata		*	*	
	Mallomonas spp.	*	*		*
	Ophiocytium capitatum	*	*	*	*
Bacillariophyta					
	Achnanthes minutissima	*	*	*	*
	Asterionella formosa	*	*	*	*
	Asterionella formssall				*
	Attheya zachariasi	*	*	*	*
	Cyclotella pseudostelligera	*	*	*	*
	Cyclotella spp.		*		

Table 1. Cont.

	P1	P2	P3	P4
Cyclotella stelligera	*	*	*	*
Cymbella lunata				*
Cymbella microcephala				*
Eunotia curvata	*		*	*
Eunotia flexuosa				*
Eunotia pectinalis	*		*	
Eunotia tenella	*			
Eunotia zazumensis	*	*	*	*
Fragilaria capucina	*	*	*	*
Fragilaria crotonensis	*	*	*	*
Fragilaria spp.			*	
Fragilaria vaucheriae		*	*	*
Frustulia vulgaris				*
Gomphonema parvulum	*			*
Gomphonema sp.				*
Melosira ambigua	*	*	*	*
Melosira distans		*		
Melosira distans v. tenera	*	*	*	*
Navicula gregaria	*			
Navicula spp	*			
Nitzschia frustulum				*
Nitzschia gracilis				*
Nitzschia spp.			*	*
Pinnularia abaujensis			*	
Pinnularia spp.				*
Rhizosolenia eriensis	*	*	*	*
Synedra acus				*
Synedra delicatissima	*	*	*	*
Synedra planktonica	*	*	*	*
Synedra rumpens		*	*	*
Synedra tenera	*	*	*	*
Synedra ulna	*	*	*	*
Tabellaria fenestrata	*	*	*	*

Table 2. Mean Phytoplankton densities (organisms/ml of Par Pond and Pond B phytoplankton in two studies.

	P-1		P-2		P-3		P-4		Pond B
	1995-96	1984-85	1995-96	1984-85	1995-96	1984-85	1995-96	1984-85	1984-85
Taxa									
Bacillariophtya	492	1358	461	2061	447	2312	469	1126	8
Chlorophyta	2874	457	1811	432	2203	459	2220	507	1528
Chrysophyta	756	675	1249	444	520	601	1288	667	675
Cryptophyta	71	421	101	505	60	420	111	332	60
Cyanophyta	4890	536	4337	239	5618	340	4939	316	421
Euglenophyta	13	27	30	20	29	16	14	18	26
Pyrrophyta	57	54	88	35	86	48	79	944	94
phytoflagellates	----	627	---	682	---	910	---	36	247
Total mean density	9398	4482	8325	4418	9386	5106	9398	3946	3058

Table 3. Overall Percent composition of Phytoplankton at four locations in Par Pond. February 22, 1995-September 25, 1996

	Location			
	P1	**P-2**	**P-3**	**P4**
Chrysophyta	8.26	15.46	5.80	14.12
Chlorophyta	31.39	22.43	24.58	24.34
Cyanophyta	53.43	53.71	62.69	54.15
Bacillariophyta	5.38	5.71	4.99	5.14
Cryptophyta	0.77	1.25	0.66	1.22
Pyrrhophyta	0.63	1.09	0.96	0.86
Euglenophyta	0.14	0.37	0.32	0.16

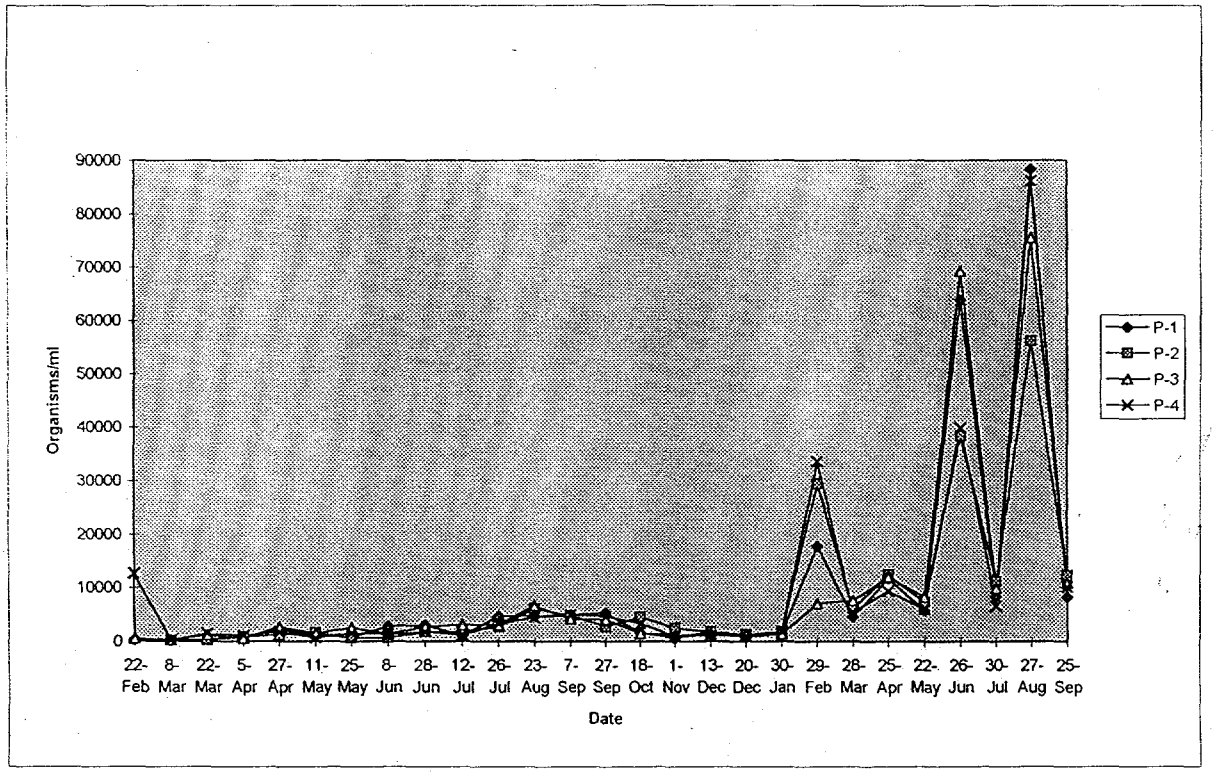


Figure 1. Total phytoplankton abundance (excluding picoplankton) at Locations P-1, P-2, P-3, and P-4, February 22, 1995 to September 25, 1996

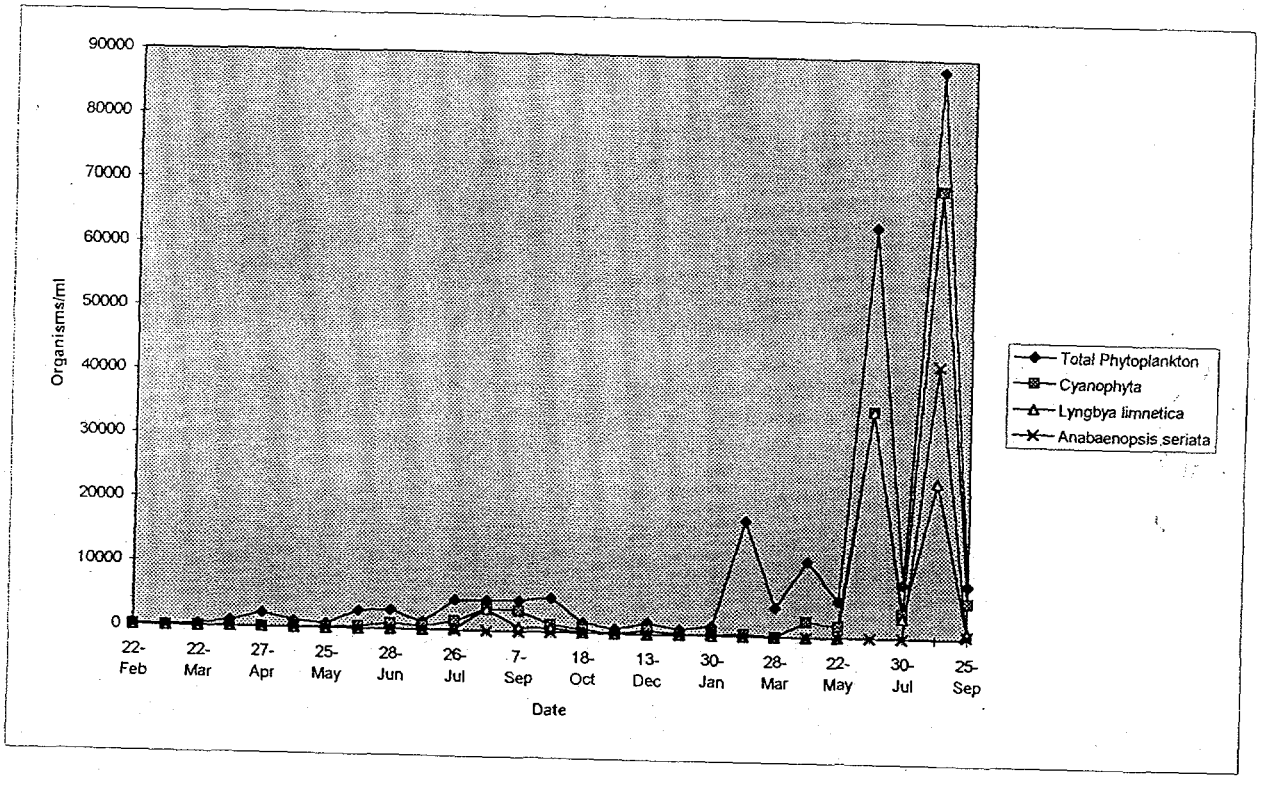
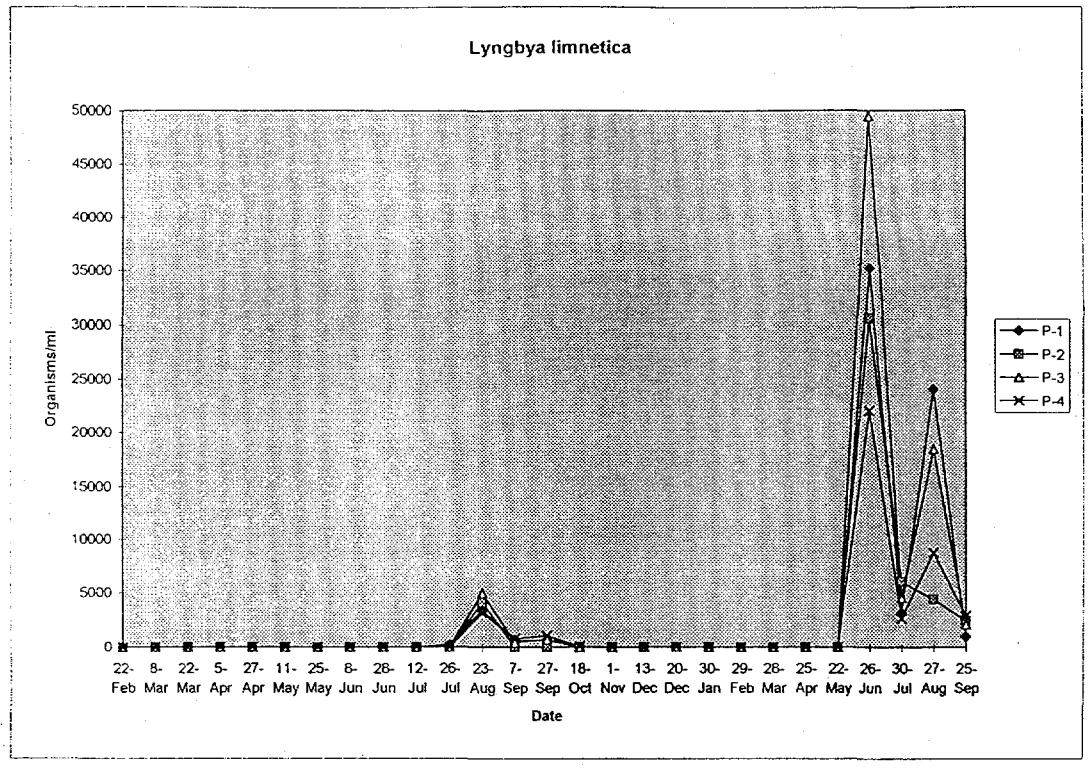


Figure 2. Phytoplankton distribution (excluding picoplankton) at Location P-1, February 22, 1995-September 25, 1996



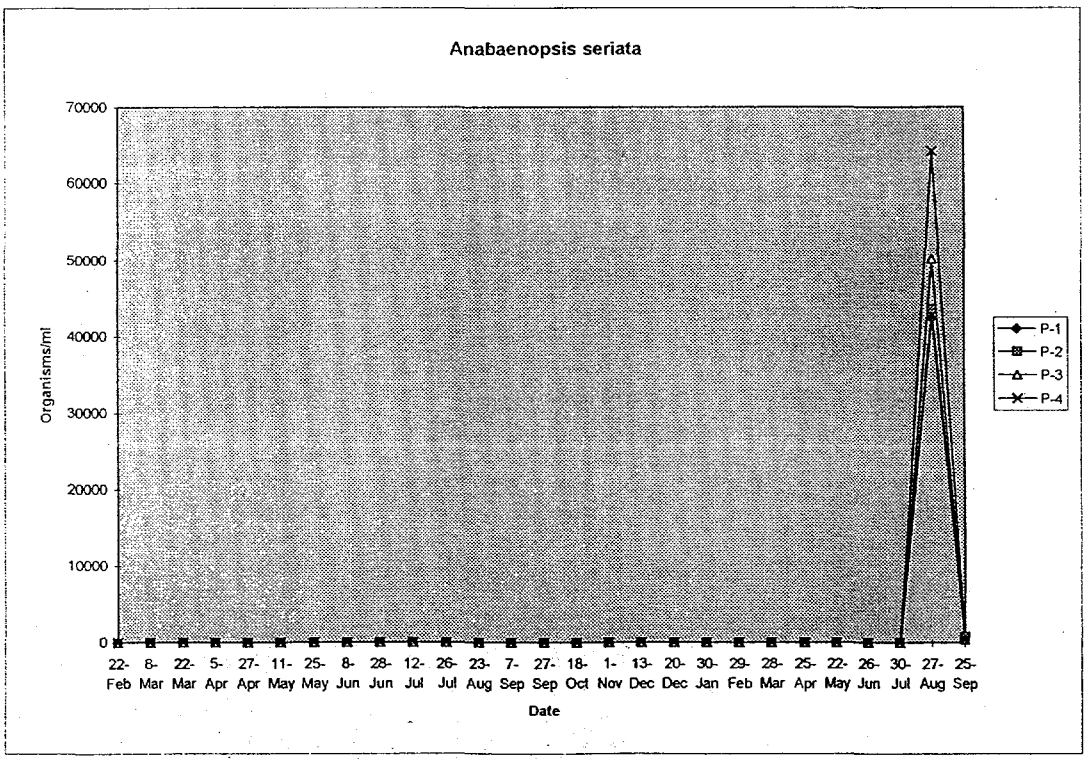


Figure 3. *Lyngbya limnetica* and *Anabaenopsis seriata* abundance in Par pond, February 22, 1995 to September 25, 1996

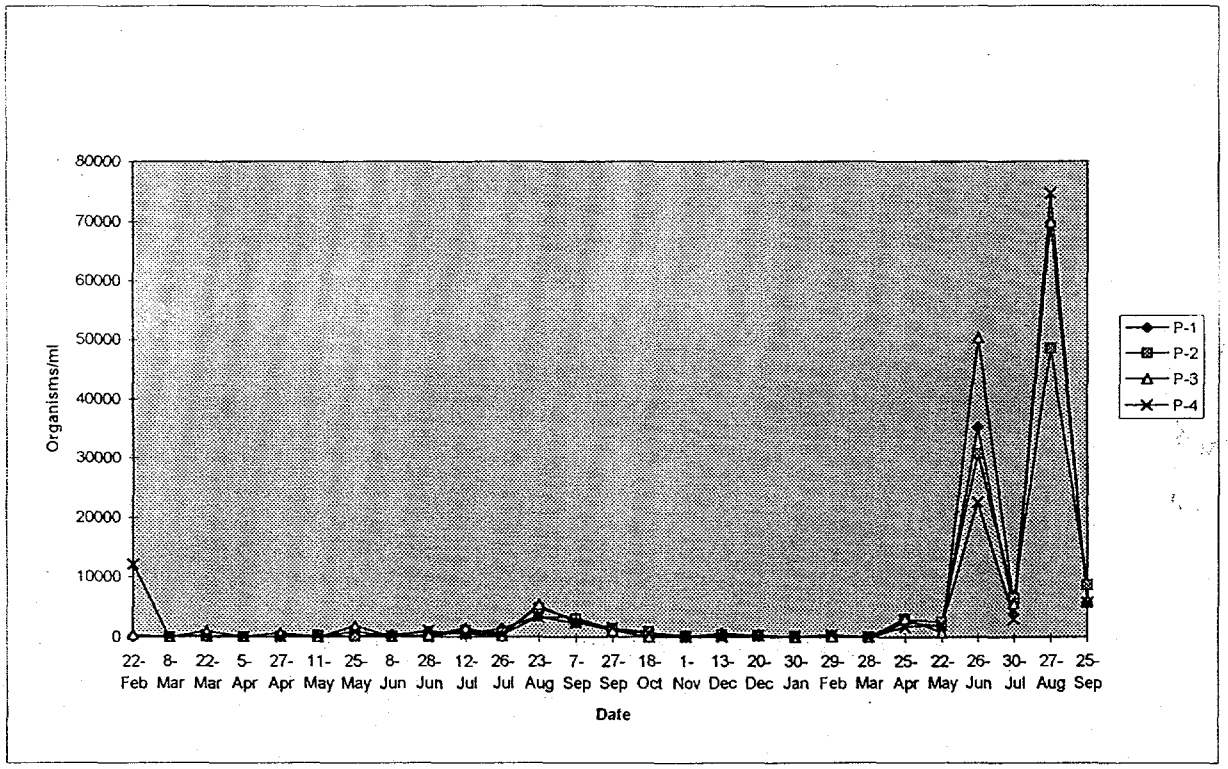


Figure 4. Cyanophyta abundance (excluding picoplankton) at Locations P-1, P-2, P-3, and P-4, February 22, 1995 to September 25, 1996

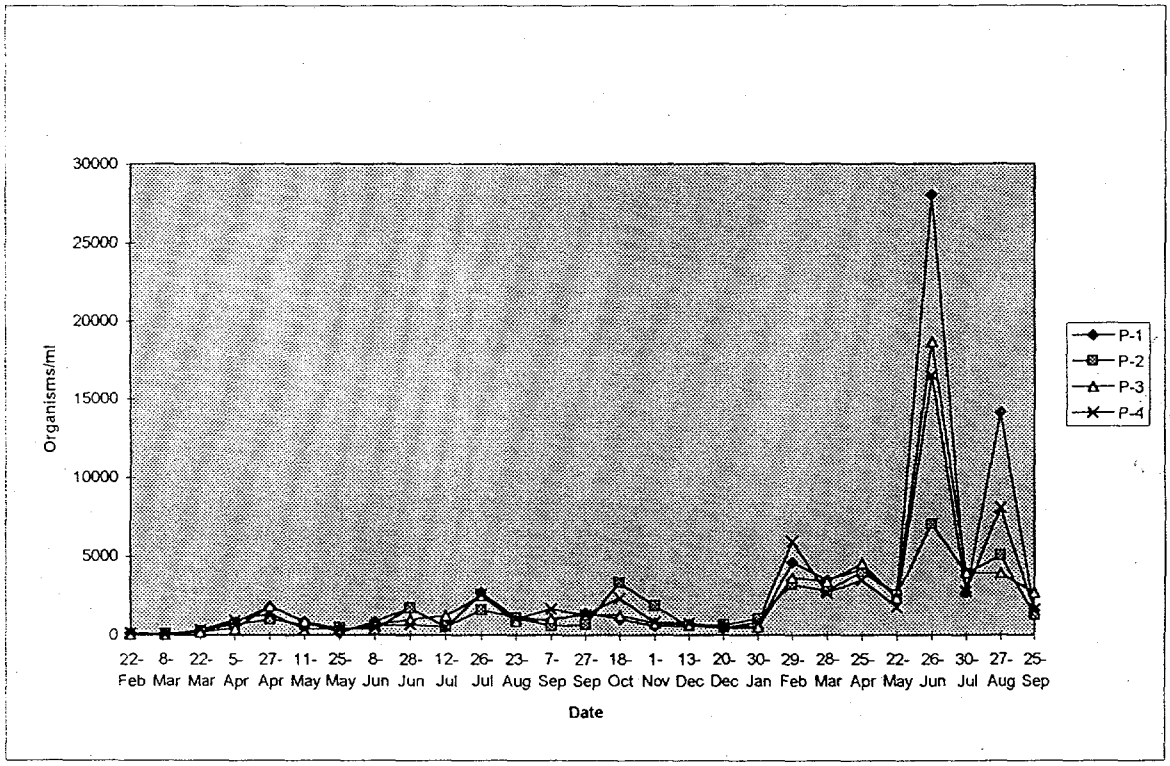


Figure 5. Chlorophyta abundance (excluding picoplankton) at Locations P-1, P-2, P-3, and P-4, February 22, 1995 to September 25, 1996

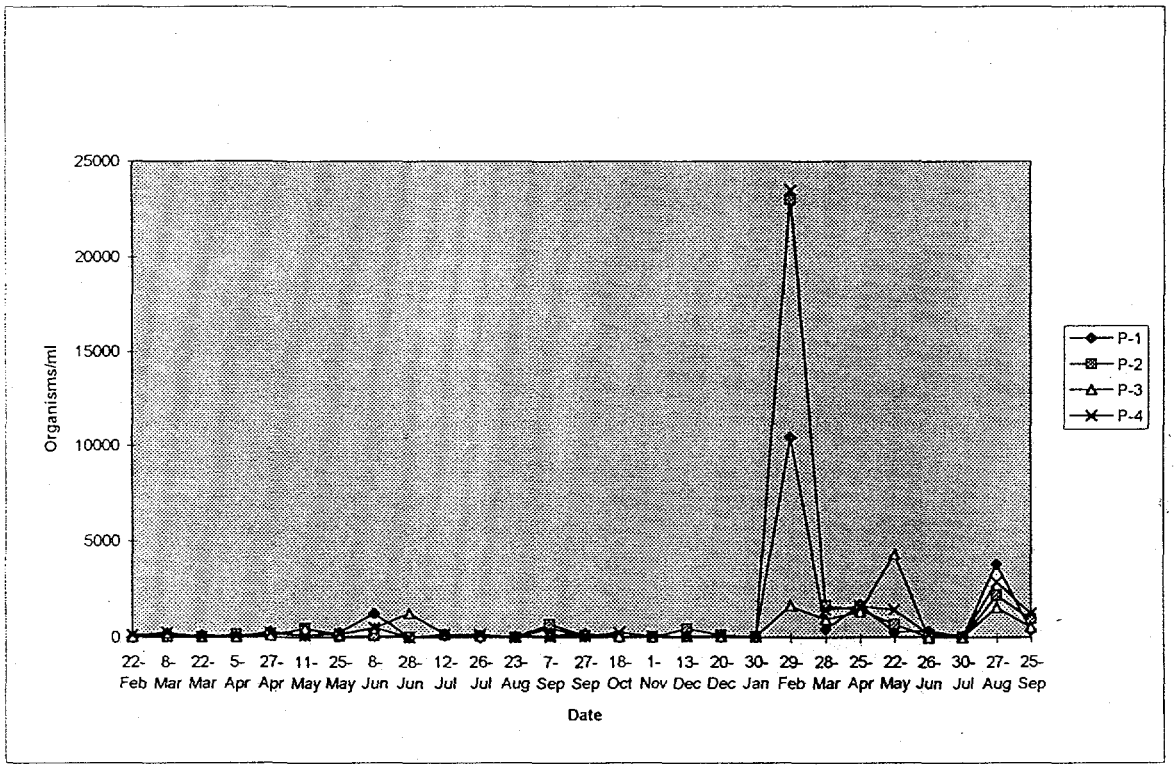


Figure 6. Chrysophyta abundance (excluding picoplankton) at Locations P-1, P-2, P-3, and P-4, February 22, 1995 to September 25, 1996

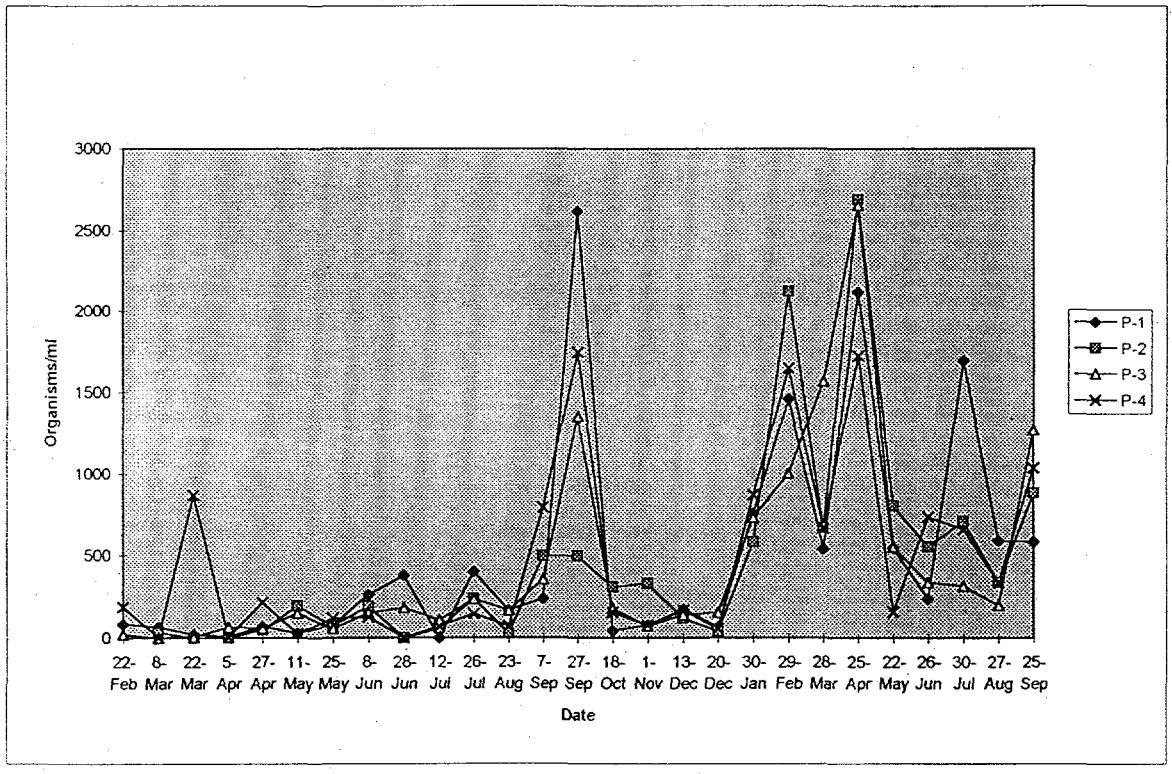
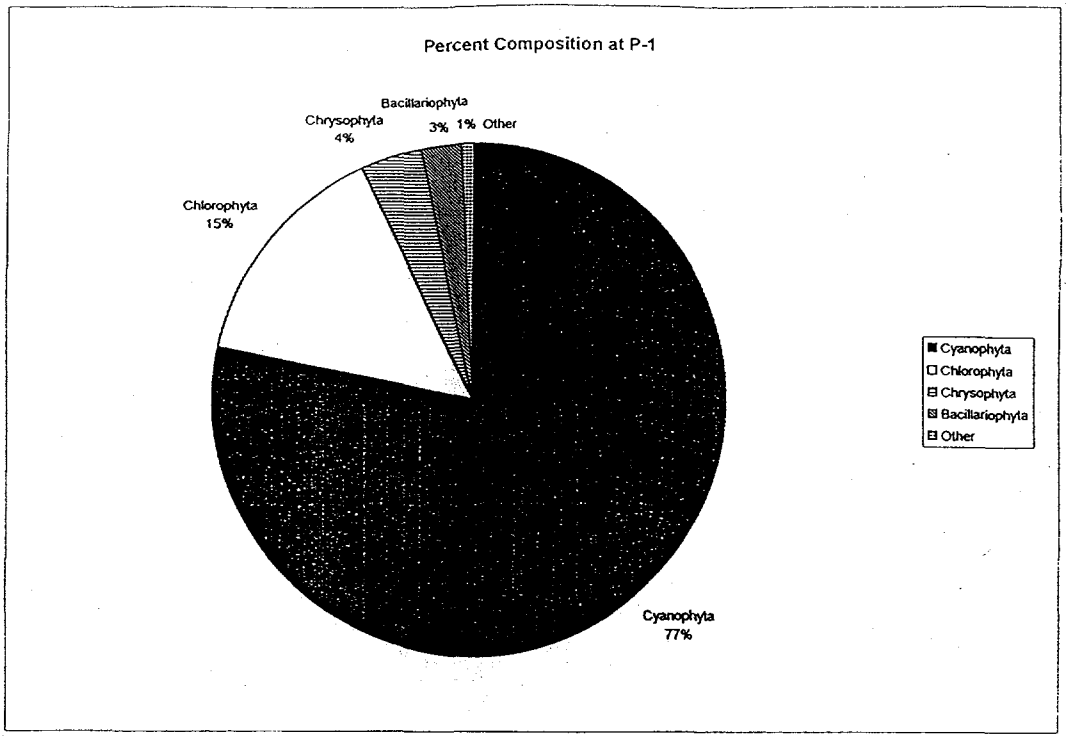


Figure 7. Bacillariophyta abundance (excluding picoplankton) at Locations P-1, P-2, P-3, and P-4, February 22, 1995 to September 25, 1996



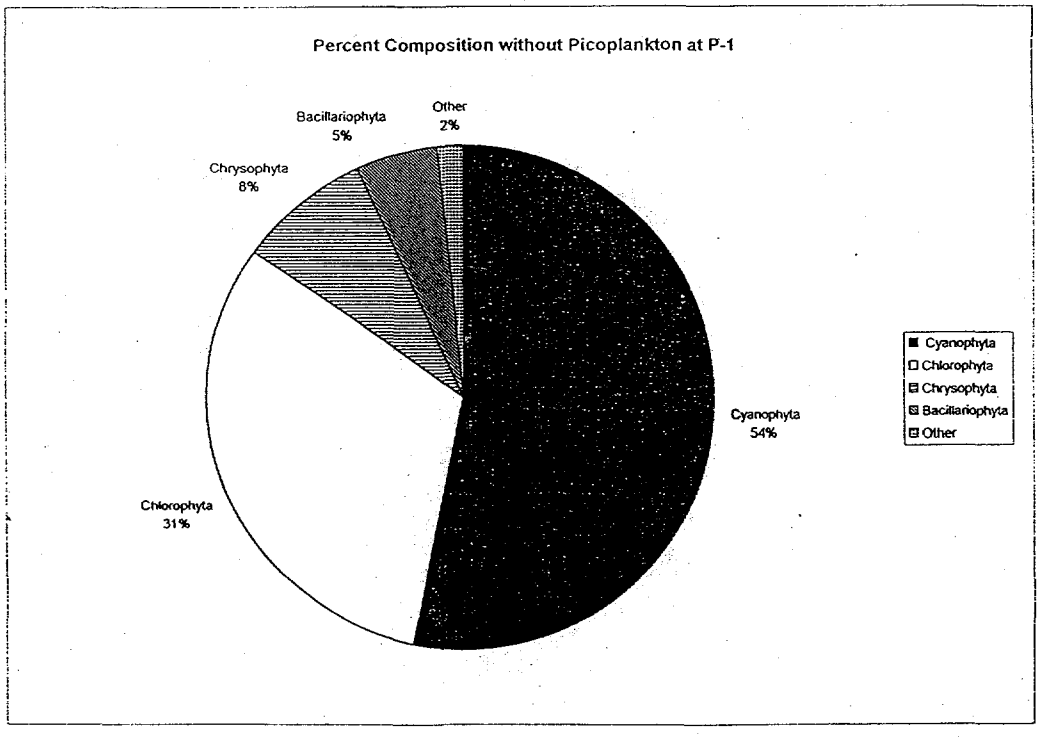


Figure 8. Percent Composition of the phytoplankton at Location P-1 based on the presence or exclusion of picoplankton

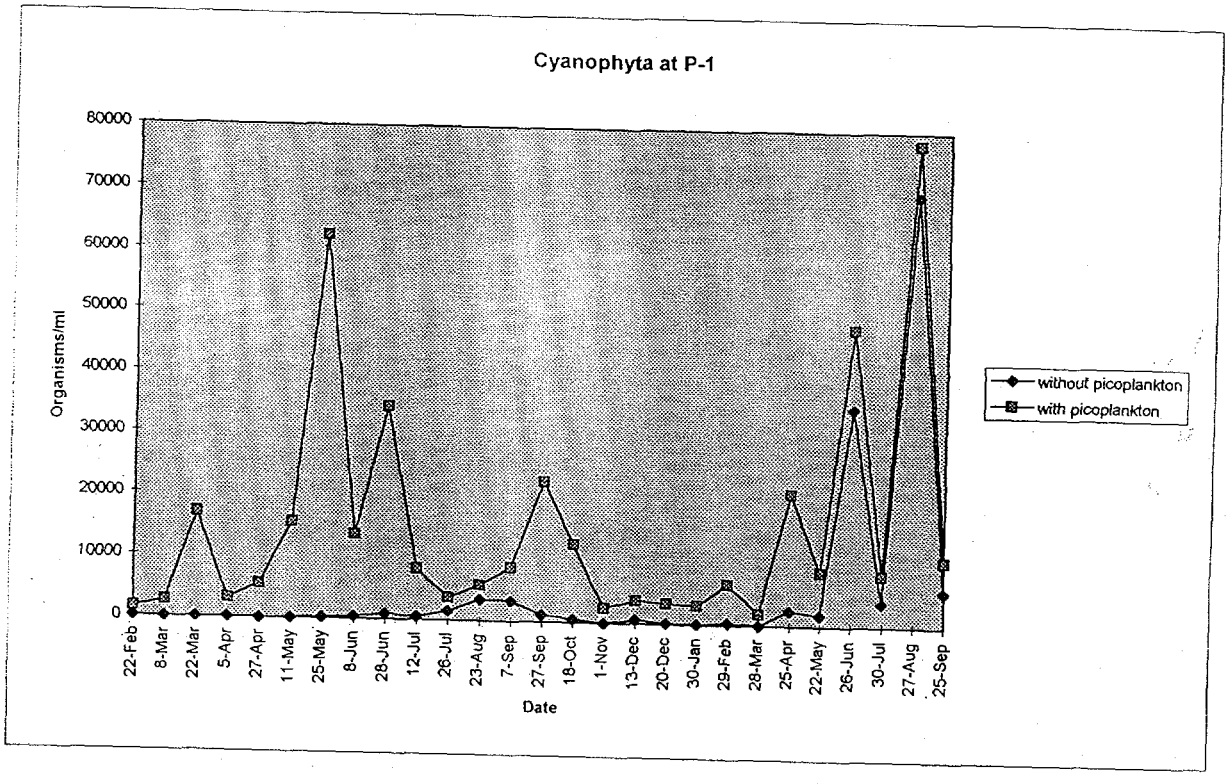
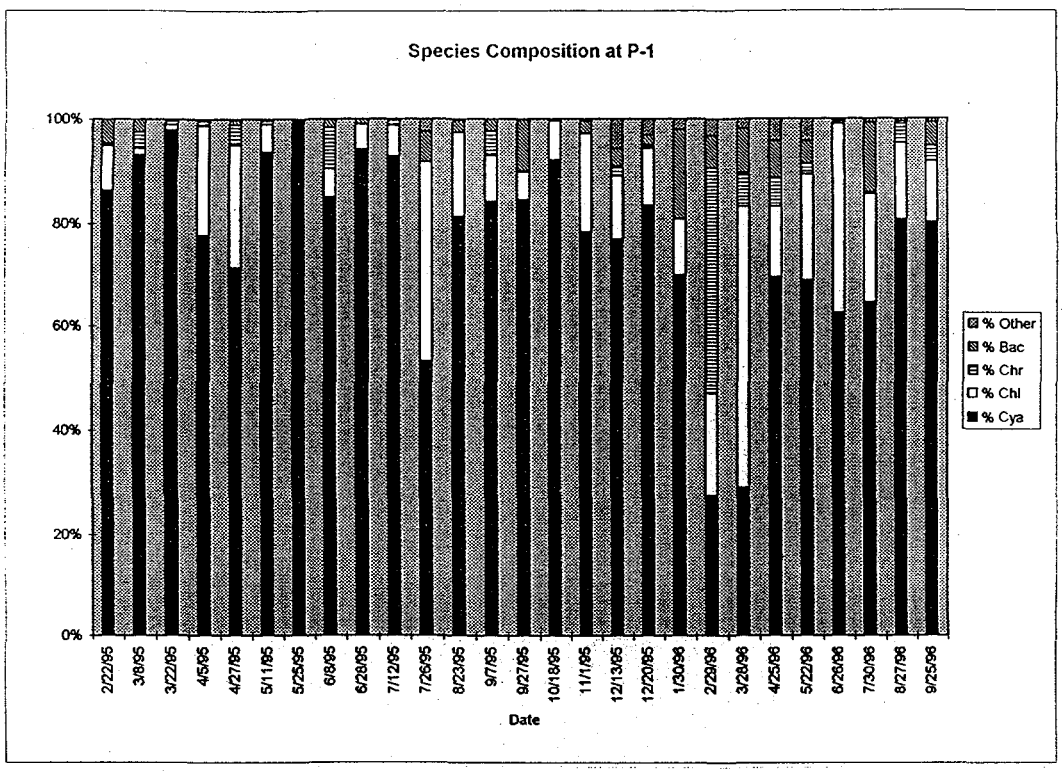


Figure 9. Cyanophyta abundance with and without picoplankton at Location P-1, February 22, 1995- September 25, 1996



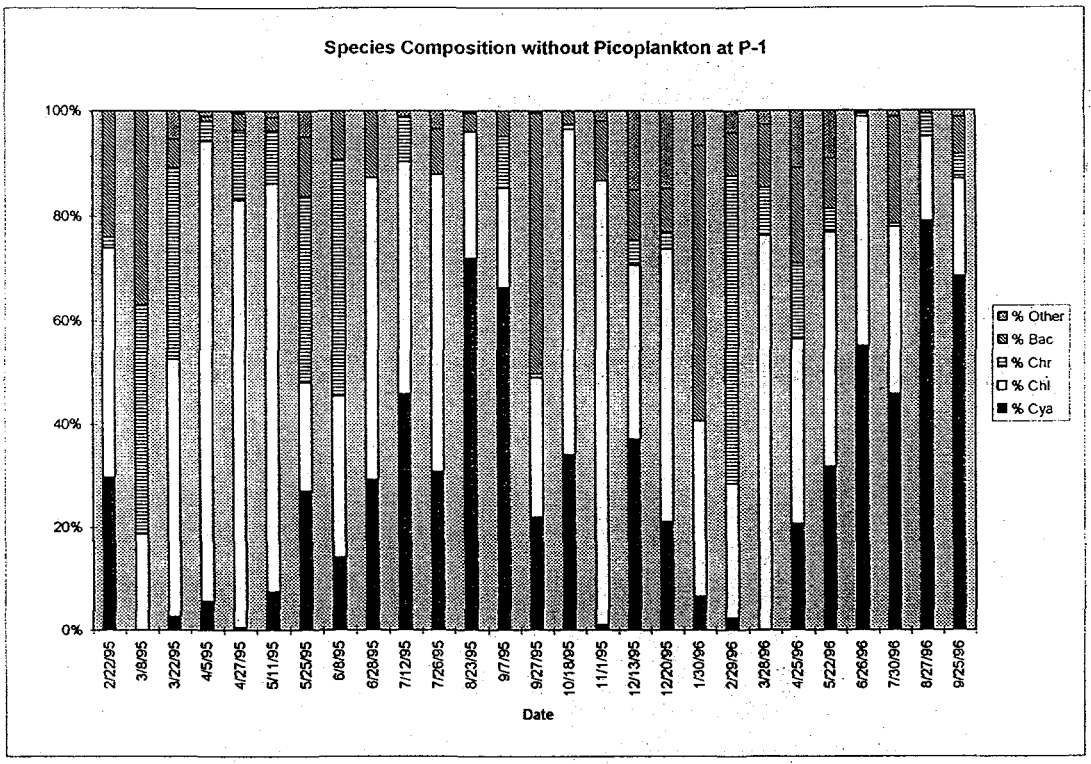


Figure 10. Temporal variation in relative abundance of major phytoplankton groups at location P-1 with and without picoplankton