

Biological Assessment of the Susquehanna River Using Phytoplankton and Periphyton

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Abstract

Five sites were monitored between Sunbury and Selinsgrove on the Susquehanna River for periphyton and seven sites for phytoplankton (metaphyton). The purpose of the study was to examine the metaphyton and periphyton populations of the river during the summer in order to determine the stability of the algal ecosystem and assess the quality of the river. A total 87 species of algae were identified in the phytoplankton communities, which were sampled weekly. Artificial substrates for periphyton were placed in the river for a total of 3 weeks and 26 diatom taxa were found. Metrics such as the Pollution Tolerance Index (PTI), Shannon Weaver index and Bray Curtis were used to determine species distribution and site similarities from June 4 through July 19. Shannon Weaver values for phytoplankton ranged from 1.53 to 2.90 and 0.31 to 1.91 for periphyton. Pollution tolerance index (PTI) values were calculated for each site based on the observed periphyton collected from the periphytometers. Those PTI values ranged from 2.7 through 2.99 where site 4 had the lowest PTI value and 5 had the highest PTI Value.

Introduction

- Diatoms, a dominant group of algae and major component of the river biofilm communities, are used to evaluate water quality (Werner 1977).
- Diatoms are hypersensitive towards their environments (Pan et al. 1996), and, therefore are good biological indicators (Stevenson et al. 2008).
- Phytoplankton communities occur in large rivers and can reflect short-term environmental conditions (Prescott 1951).
- The purpose of this study is to use diatom periphyton and phytoplankton (metaphyton) in the continuing assessment of water quality at the Byers Island Transect on the upper main stem of the Susquehanna River.

Site Description

The Byers Island Transect (Figure 1) straddles Byers Island 7km south of the confluence of the West and North branches of the Susquehanna River. Sites 1-4 are below the low head dams at the Sunbury Generation plant. Site 5 is above the low head dam on the west side of the river. Periphyton was sampled at sites 1-5 (each labeled with a star). Metaphyton was sampled at sites 1-4 and between them at 100m intervals (1.3, 1.6, and 3.5, each labeled with a blue dot).

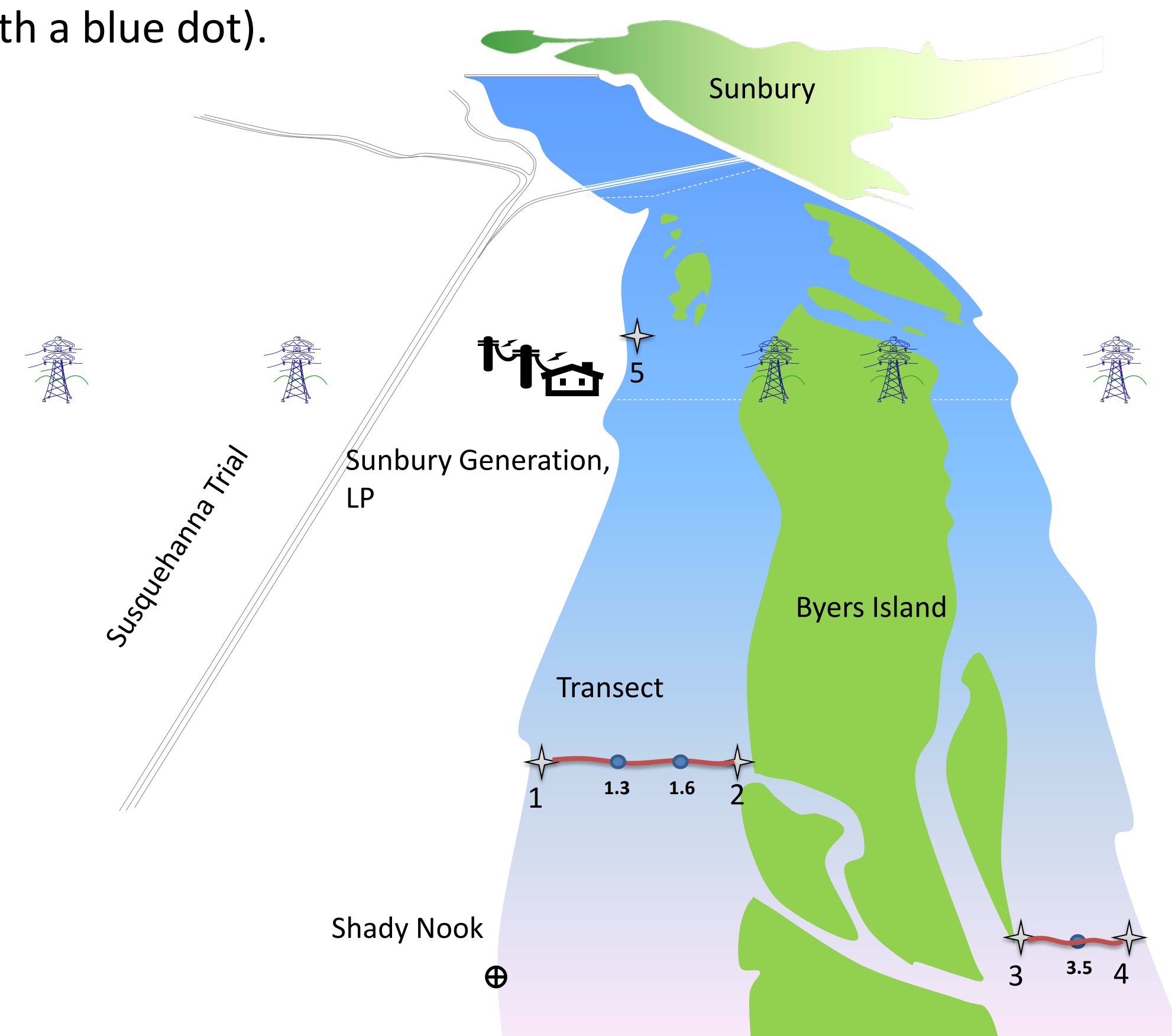


Figure 1: Map of the study sites. Those sites marked with a star were sampled for phytoplankton and periphyton. The sites marked with blue dots were sampled for phytoplankton only.

Methods

- The methods were those of Barbour et al. (1999) as modified by Wargo and Holt (1998).
- Deployed diatometers (prepared Carolina blue boxes), each with 5 slides at sites 1, 2, 3, 4, 5. Diatometers were allowed to incubate *in situ* for 3 weeks (Richardson et al. 1996).
- Slides from the diatometers were fixed with Carosafe and mounted with Karo. Minimum of 300 individual periphyton and were counted from each slide (1500 cells per site).
- Diatom ID confirmed by JEOL 5970LV SEM.
- Pollution Tolerance Index (PTI) calculated according to Stephenson et al. (2008).
- Bray-Curtis Proportional Similarity according to Bloom (1981).
- 7 whole water samples were taken weekly from June 4 through July 19 from sites identified on Figure 1. Samples were preserved with Lugols iodine.
- Phytoplankton taxa were identified and counted (300 cell minimum) using a Nikon eclipse E200 light microscope using a Palmer-Maloney slide.

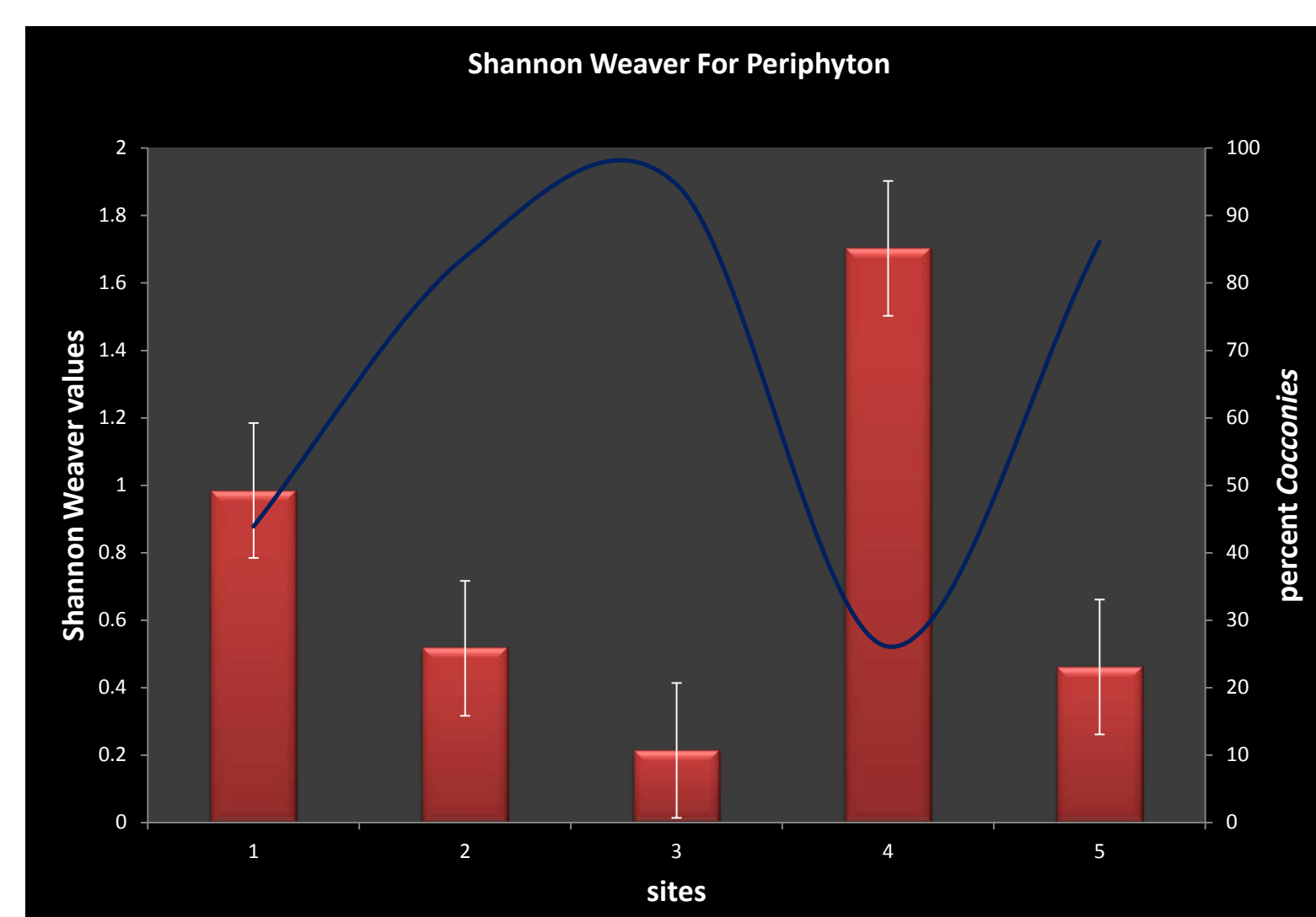


Figure 2: Shannon Weaver values obtained from diatom counts. The Shannon Weaver values are relatively low, even with the exception of site 4. Notably the Shannon diversity index for Diatoms is driven by the relative percent *Cocconeis* available at each site.

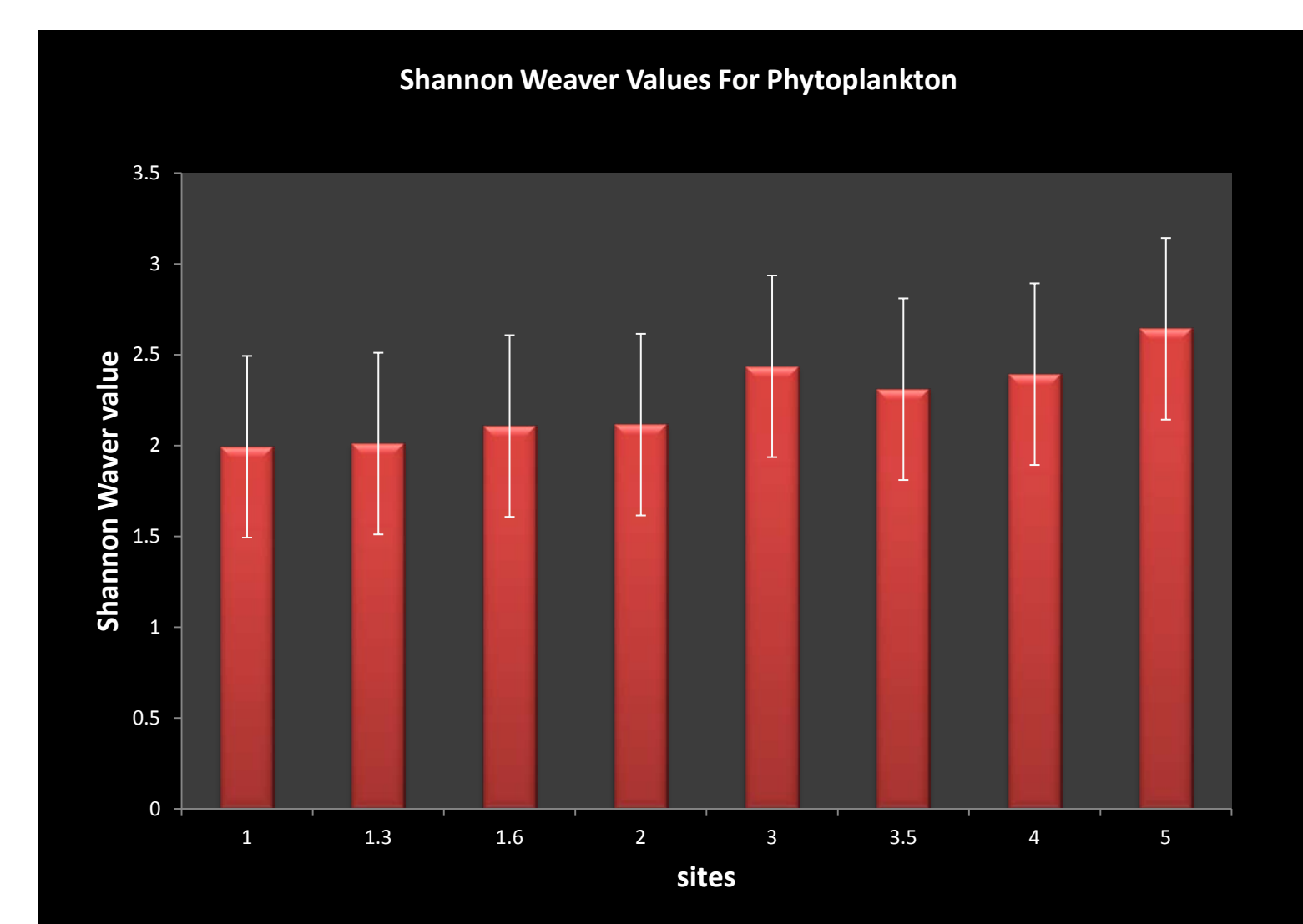


Figure 4: The mean Shannon Weaver (log e) values for phytoplankton at each site on the Byers Island transect. Each site maintained fairly consistent values from June 4 through July 19.

Tables 1A and 1B: Table A1 shows the frequency of Diatoms observed from the periphytometers where the majority of the observed taxa is *Cocconeis placentula*. Table A2 shows the frequency of phytoplankton observed from whole water samples taken from June 4th through July 19th. Taxa shaded in orange are true plankters.

DIATOM TAXA	1A FREQUENCY	1B FREQUENCY
<i>COCCONEIS PLACENTULA</i>	0.640	>10%
<i>ACHNANTHIDIUM MINUTISSIMUM</i>	0.190	
<i>MELOSIRA VARIANS</i>	0.057	1-10%
<i>FRAGILARIA CAPUCINA</i>	0.047	
<i>SYNEDRA ULNA</i>	0.046	
<i>ACHNANTHES COARCTATA</i>	0.005	<1%
<i>EUNOTIA MINOR</i>	0.002	
<i>NAVICULA LANCEOLATA</i>	0.002	
<i>CYCLOTELLA</i>	0.002	
<i>AMPHORA OVATA</i>	0.002	
<i>DIATOMA MESODON</i>	0.001	
<i>CYMBELLA CISTULA</i>	0.001	
<i>NAVICULA CRYPTOCEPHALA</i>	0.001	
<i>COCCONEIS PEDICULUS</i>	0.001	
<i>GOMPHONEIS HERCULEANA</i>	0.001	
<i>RHOICOSPHEHIA CURVATA</i>	0.001	
<i>AMPHORA PEDICULUS</i>	0.001	
<i>GYROSIGMA EXILIS</i>	0.001	
<i>NAVICULA MINUSCULUS</i>	0.001	
<i>CYMBELLA TUMIDA</i>	0.001	
<i>DIATOMA VULGARE</i>	0.001	
<i>MERIDION CIRCULARE</i>	0.001	
<i>NAVICULA ATOMUS</i>	0.001	
<i>CYMBELLA MINUTA SILESIA</i>	0.001	
<i>CYMBELLA PROSTRATA</i>	0.001	
<i>NAVICULA RHYNCHOCEPHALA</i>	0.001	
CERCOZOA		
<i>CERCOMONAS EUGLYPHA</i>		0.001
CHAROPHYTA		
<i>COSMARIUM MONOMAZUM</i>		0.002
CHLOROPHYTA		
<i>ACTINASTRUM HANTZSCHII</i>		0.026
<i>ANKISTRODESIMUS FALCATUS</i>		0.043
<i>CARTERIA sp.</i>		0.001
<i>COELASTRUM MICROPORUM</i>		0.002
<i>CHLAMYDOMONAS GLOBOSA</i>		0.050
<i>ECHINOSPHERELLA LIMNETICA</i>		0.001
<i>GOLENKENIA sp.</i>		0.027
<i>KIRCHNERIELLA OBESA</i>		0.018
<i>LAGERHEIMIA QUADRISETA</i>		0.001
<i>MICRACTINIUM PUSILLUM</i>		0.003
<i>TETRASTRUM ELEGANS</i>		0.001
<i>TETRADESIMUS HETERACANTHUM</i>		0.002
<i>SCENEDESMUS ABUNDANS</i>		0.002
<i>SCENEDESMUS ACUMINATUS</i>		0.008
<i>SCENEDESMUS ARMATUS</i>		0.006
<i>SCENEDESMUS BILUGA</i>		0.006
<i>SCENEDESMUS DIMORPHUS</i>		0.001
<i>SCENEDESMUS OPOLIENSIS</i>		0.009
<i>SCENEDESMUS QUADRICAUDA</i>		0.021
<i>DEDOGONIUM LONGATIUM</i>		0.008
<i>OOCYSTIS BURGEI</i>		0.004
<i>OOCYSTIS ELLIPTICA</i>		0.004
<i>OOCYSTIS SOLITERIA</i>		0.001
<i>PEDIASTRUM BORYANUM</i>		0.002
<i>PEDIASTRUM TETRAS</i>		0.002
<i>PYRAMIMONAS TETRAHYNCHUS</i>		0.014
CRYPTOPHYTA		
<i>CRYPTOMONAS EROSA</i>		0.150
<i>CRYPTOMONAS OVATA</i>		0.015
<i>CRYPTOMONAS PUSILLUM</i>		0.006
CYANOBACTERIA		
<i>CHROOCOCCUS DISPERSUS</i>		0.134
<i>CHROOCOCCUS VARIUS</i>		0.007
<i>GLOEOTHECE RUPESTRIS</i>		0.001
<i>SPIRULINA sp.</i>		0.003
EUGLENOPHYTA		
<i>EUGLENA sp.</i>		0.002
<i>TRACHELONONAS VOLVOCINA</i>		0.004
HAPTOPHYTA		
<i>CHRYSOCHROMULINA PARVA</i>		0.002
BACILLARIOPHYTA		
<i>ACHNANTHIDIUM LANCEOLATA</i>		0.002
<i>ACHNANTHIDIUM MINUTISSIMUM</i>		0.037
<i>AMPHORA sp.</i>		0.016
<i>COCCONEIS PLACENTULA</i>		0.042
<i>CYCLOTELLA MENEHGINIANA</i>		0.015
<i>CYMATOPLEURA ELLIPTICA</i>		0.001
<i>CYMBELLA AFFINIS</i>		0.002
<i>CYMBELLA CISTULA</i>		0.010
<i>CYMBELLA GRACILIS</i>		0.001
<i>CYMBELLA SILESIA</i>		0.001
<i>CYMBELLA MINUTA</i>		0.004
<i>CYMBELLA HELVETICA</i>		0.001
<i>DIATOMA VULGARE</i>		0.007
<i>EUNOTIA BILUNARIS</i>		0.002
<i>FRUSTALIA RHOMBOIDES</i>		0.005
<i>FRAGILARIA CAPUCINA</i>		0.106
<i>FRAGILARIA CROTONENSIS</i>		0.013
<i>GOMPHONEIS HERCULEANA</i>		0.001
<i>GYROSIGMA EXILIS</i>		0.001
<i>GYROSIGMA ACUMINATUM</i>		0.001
<i>MELOSIRA AMBIGUA</i>		0.022
<i>MELOSIRA VARIANS</i>		0.038
<i>NAVICULA CAPITATA</i>		0.001
<i>NAVICULA CRYPTOCEPHALA</i>		0.014
<i>NAVICULA LANCEOLATA</i>		0.009
<i>NAVICULA MENISCUS</i>		0.006
<i>NAVICULA PUSILLA</i>		0.001
<i>NAVICULA RHYNCHOCEPHALA</i>		0.002
<i>NAVICULA VERIDULA</i>		0.001
<i>NITZSCHIA ANGUSTATA</i>		0.002
<i>NITZSCHIA LANCEOLATA</i>		0.001
<i>NITZSCHIA MINUTA</i>		0.001
<i>NITZSCHIA PALEA</i>		0.001
<i>RHOICOSPHEHIA CURVATA</i>		0.007
<i>STEPHANODISCUS HANTZSCHII</i>		0.010
<i>SURIRELLA MINUTA</i>		0.003
<i>SYNEDRA ULNA</i>		0.019
CHRYSOPHYTA		
<i>DINOBRYON SOCIALE</i>		0.001
<i>NEPHROCHLORIS sp.</i>		0.002

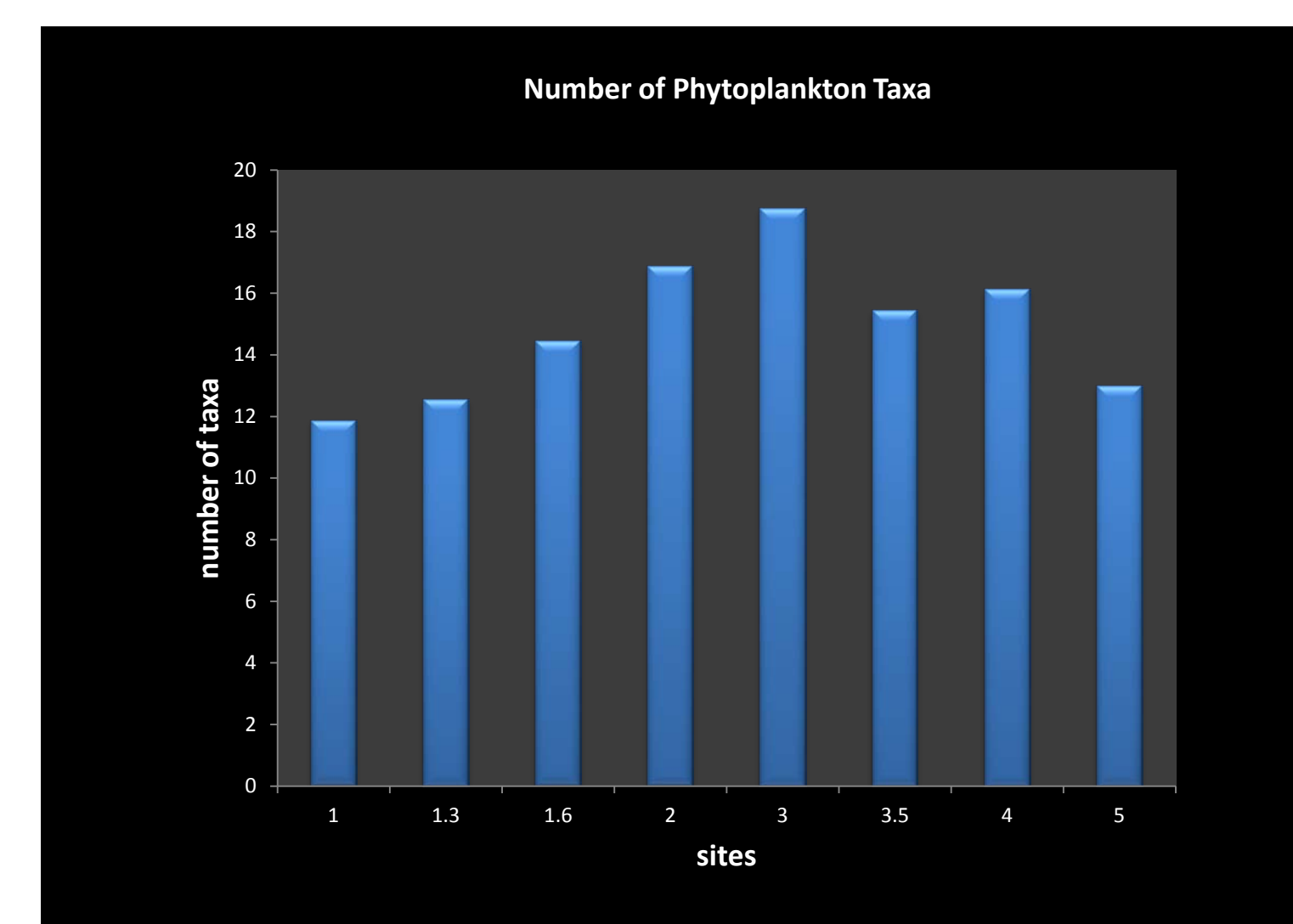


Figure 3: The mean number of free-floating organisms in the Susquehanna River at each site from June 4 through July 19, where site 3 has the highest number of observed taxa.

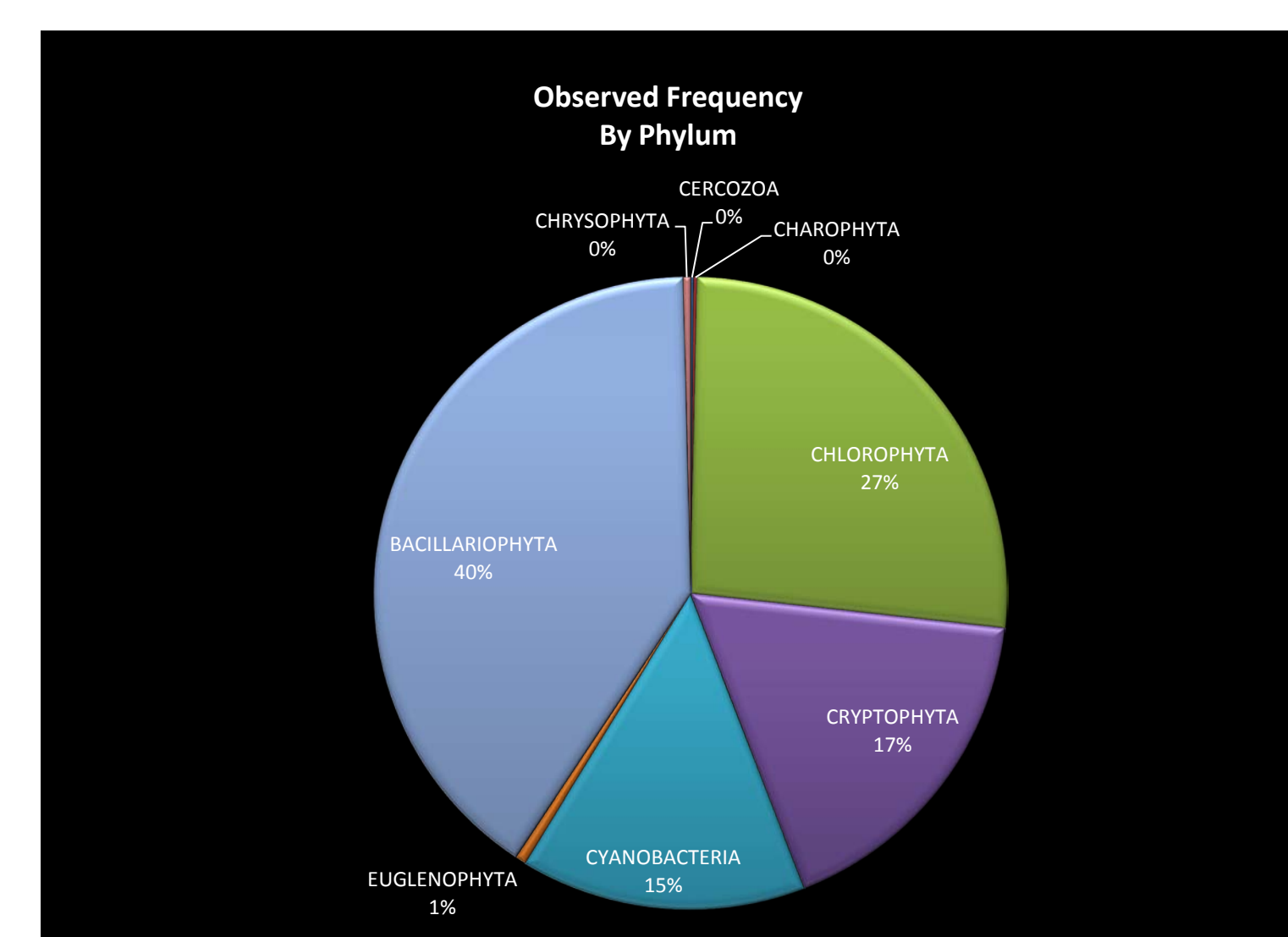


Figure 5: Chart indicating the relative contribution by taxa in the phytoplankton by phylum. The dominant phyla were Bacillariophyta (diatoms) and Chlorophyta (green algae).

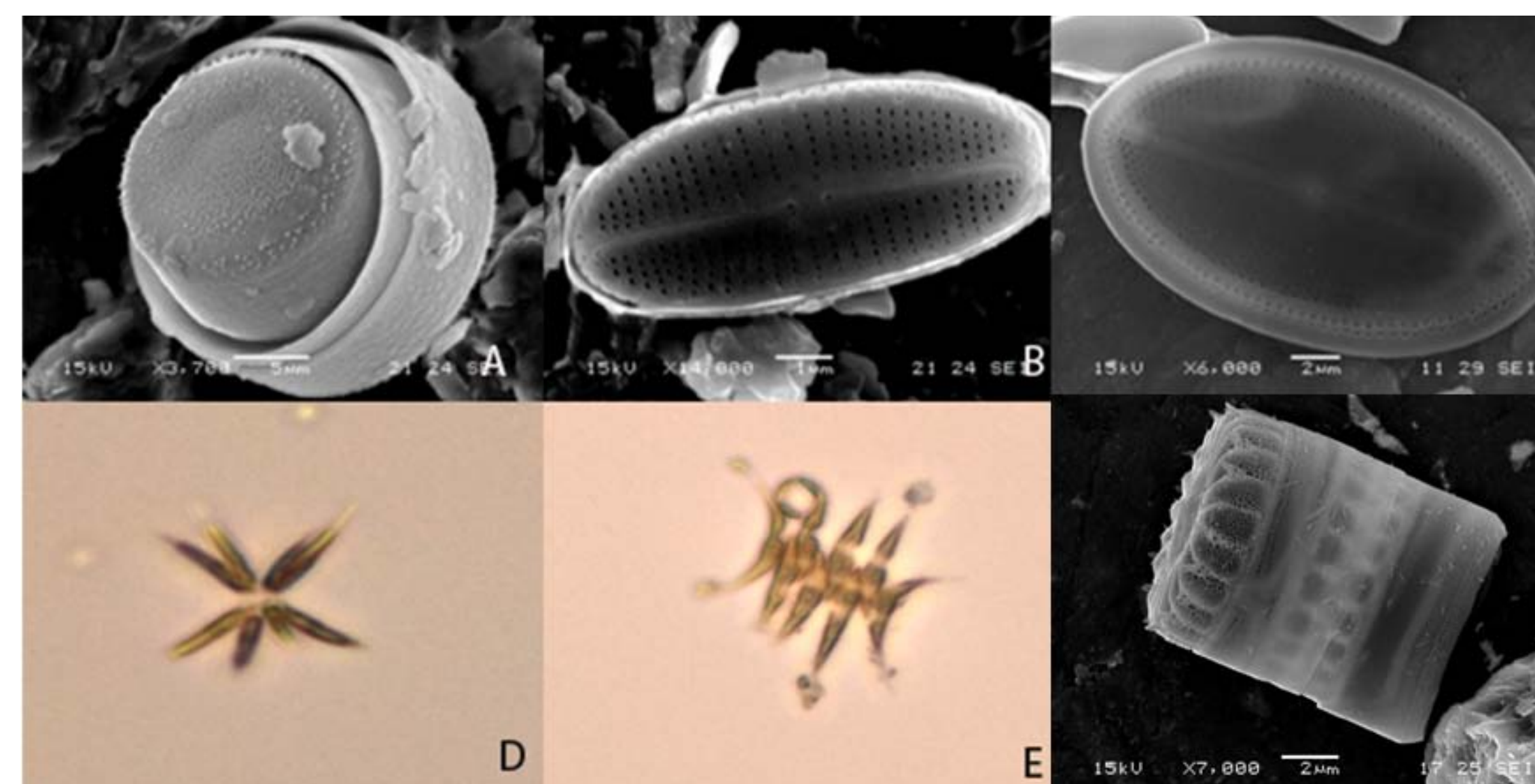
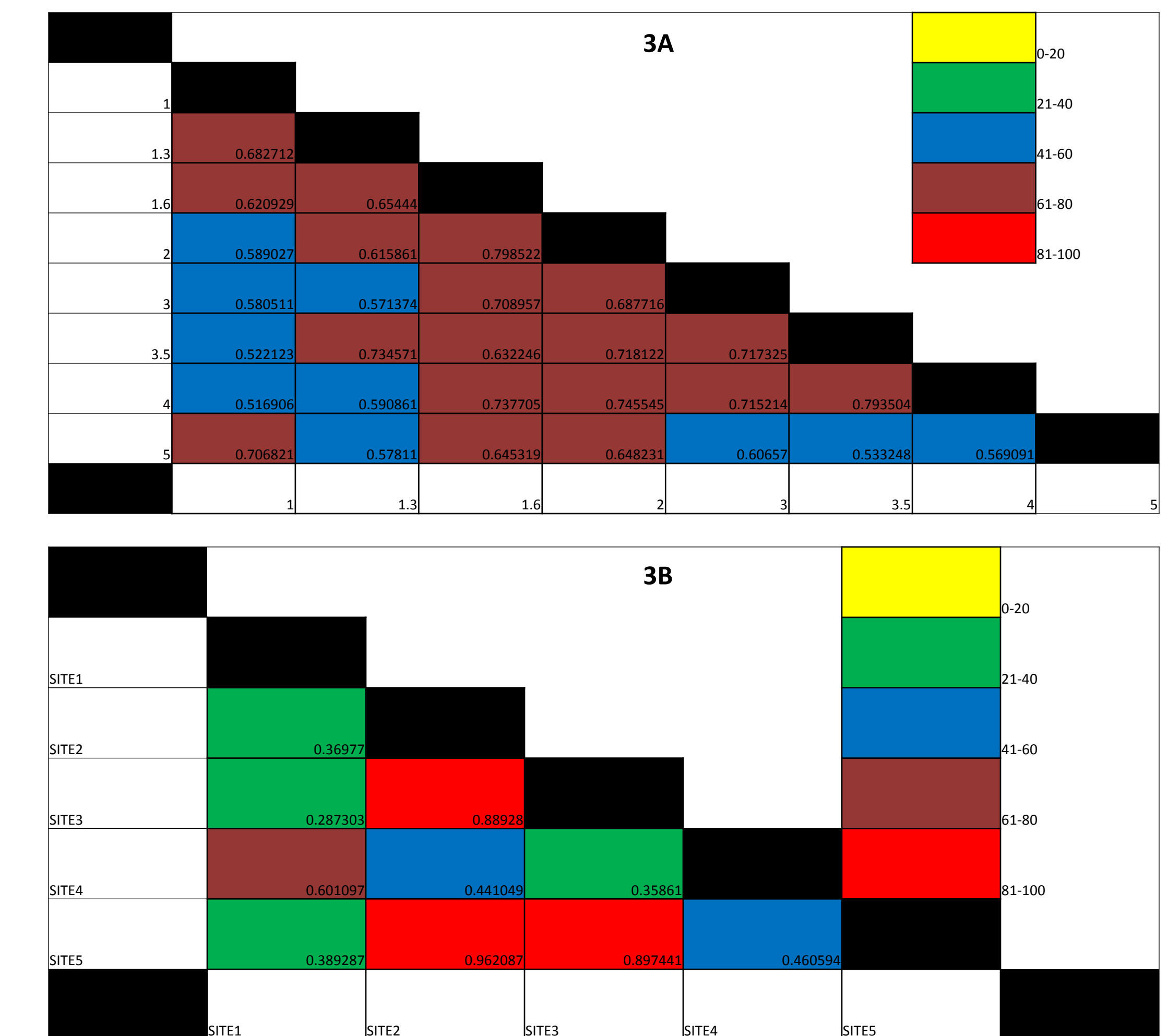


Figure 6 (right): Images A-C are periphyton taxa. A. *Melosira varians*, B. *Achnantheidium minutissimum*, C. *Cocconeis placentula*. Images D-E are phytoplankton taxa. D. *Actinastrum hantzschii*, E. *Scenedesmus acuminatus*, F. *Stephanodiscus hantzschii*.

Tables 3A and 3B: B1 and B2 are Bray-Curtis Indices, which show site similarities. B1 is the Bray Curtis index for collected phytoplankton for the examined 8 sites. The index shows that each site remains fairly similar with regard to observed taxa. B2 depicts the Bray-Curtis or similarity using just the diatom communities from the periphytometers where similarities between each site are driven by *Cocconeis placentula*.



Discussion

- Shannon Weaver values for periphyton are driven by the presence of *Cocconeis placentula* (Figure 2). When *Cocconeis* dominates (greater than 50%) Shannon Weaver index diversity values are greatly depressed (Table 1A).
- The number of taxa at each site varied as seen in Figure 3, however the Shannon Weaver values are for phytoplankton are fairly stable through the sample period as seen in Figure 4.
- Bacillariophyta (diatoms) and Chlorophyta (green algae) make up the majority of the free floating algae in the Susquehanna River (Figure 5). However most diatoms are from biofilms that became suspended and the green algae mostly are true plankters (Table 1B). Diatom taxa of the suspended assemblage, though they have their origin in the biofilm, do not show the same relative proportions.
- PTI values from the diatom counts were mid ranged. This is in part due to the relative number of *Cocconeis placentula*, which has a PTI value of 3 (Table 2).
- Bray Curtis proportional similarities indicate that phytoplankton taxa are very evenly distributed throughout the sites (Table 3A). The periphyton communities, however, are much more heterogeneous (Table 3B). Because *Cocconeis placentula* is dominant within the periphyton communities, sites which contain *Cocconeis* are very similar and sites that do not have *Cocconeis* are very dissimilar.
- Given the overwhelming dominance of *Cocconeis placentula* in the periphyton and its impact on important metrics (e.g. PTI) in the upper main stem, metaphyton may provide more detailed information for the assessment of the Susquehanna River.
- Current work on periphyton communities involve DNA analysis to compare observed taxa with molecular markers.

Table 2: Pollution tolerance values for sites along the Susquehanna River.

Sites	PTI
1	2.75
2	2.88
3	2.99
4	2.70
5	2.96

References available upon request.