

A STUDY OF THE DIATOM FLORA OF
BOISE RIVER, IDAHO
SPRING 2007

Prepared by

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Introduction

Biological water quality is reflected by diatom floras in aquatic ecosystems. Diatom species are often sensitive indicators of biotic and/or abiotic factors in aquatic environments. Information about diatom assemblages can be valuable in assessing extant biological water quality and in establishing baselines for ecosystems that are in flux or in danger of perturbation. A sizable literature has developed surrounding diatoms as effective water quality indicators.

Laboratory methods

Samples were delivered to our laboratory where diatom subsamples were divided from the original sample and prepared via protoplast oxidation methods (below) to facilitate accurate identification of diatoms to the lowest taxonomic category possible. Identifications were made based on the structure of the cell wall, symmetry, valve structure, and other physical characteristics (Patrick and Reimer 1966). A careful analysis of diatom cell structures demands frustules be cleared of organic matter. We conducted a nitric acid digestion procedure for each sample to clear internal and external organic matter in order to clearly view the silica cell walls of all diatoms present.

Following the digestion process, the solution was centrifuged and the supernatant decanted. The diatom pellet was then washed and centrifuged in distilled water multiple times in order to remove all acid residue. Approximately 1 ml of a final diatom suspension was dispersed on a glass cover slip and air dried.

The cover slip was then mounted on a slide using Naphrax diatom mountant. The Naphrax was diluted with toluene; a drop placed on a glass slide and brought to boil on a hot plate. The cover slip coated with the diatom frustules was placed on the hot Naphrax and pressed firmly against the slide until all air bubbles were forced out. The slide was then allowed to cool and excess mountant was scraped away with a razor blade. At this point, the slides were ready for examination.

The slides were carefully examined and diatom species identified using a Zeiss RA research microscope equipped with Nomarski DIC. Permanent slides for each sample were archived in our laboratory. Replicate slides will be placed in the California Academy of Sciences public diatom herbarium for future reference. The number of species per sample was tallied and recorded. A percent relative density for each taxon was calculated using the biovolume for that taxon in the sample. The rank of each taxon in that sample was also calculated based upon its biovolume per sample.

Numerical Analysis

EPL

A Shannon-Wiener diversity index for each stand was calculated using the relative biomass of each taxon in the count (Margalef 1958, Patten 1962, Shannon and Wiener 1963).

A species richness factor was calculated after Atlas and Bartha (1981). This factor is similar to many other diversity factors and is considered to be a second measure of diversity by many biologists.

An Important Species Index (ISI) value was calculated for each taxon in the count. ISI values were calculated by multiplying the percent frequency of the taxon by its average relative density according to biomass (Kaczmarska and Rushforth 1983).

Values for each of these indices as calculated for species encountered in each count can be found in the Appendix of this report.

Table 1. Species found in diatom samples collected from Boise River, spring 2007.

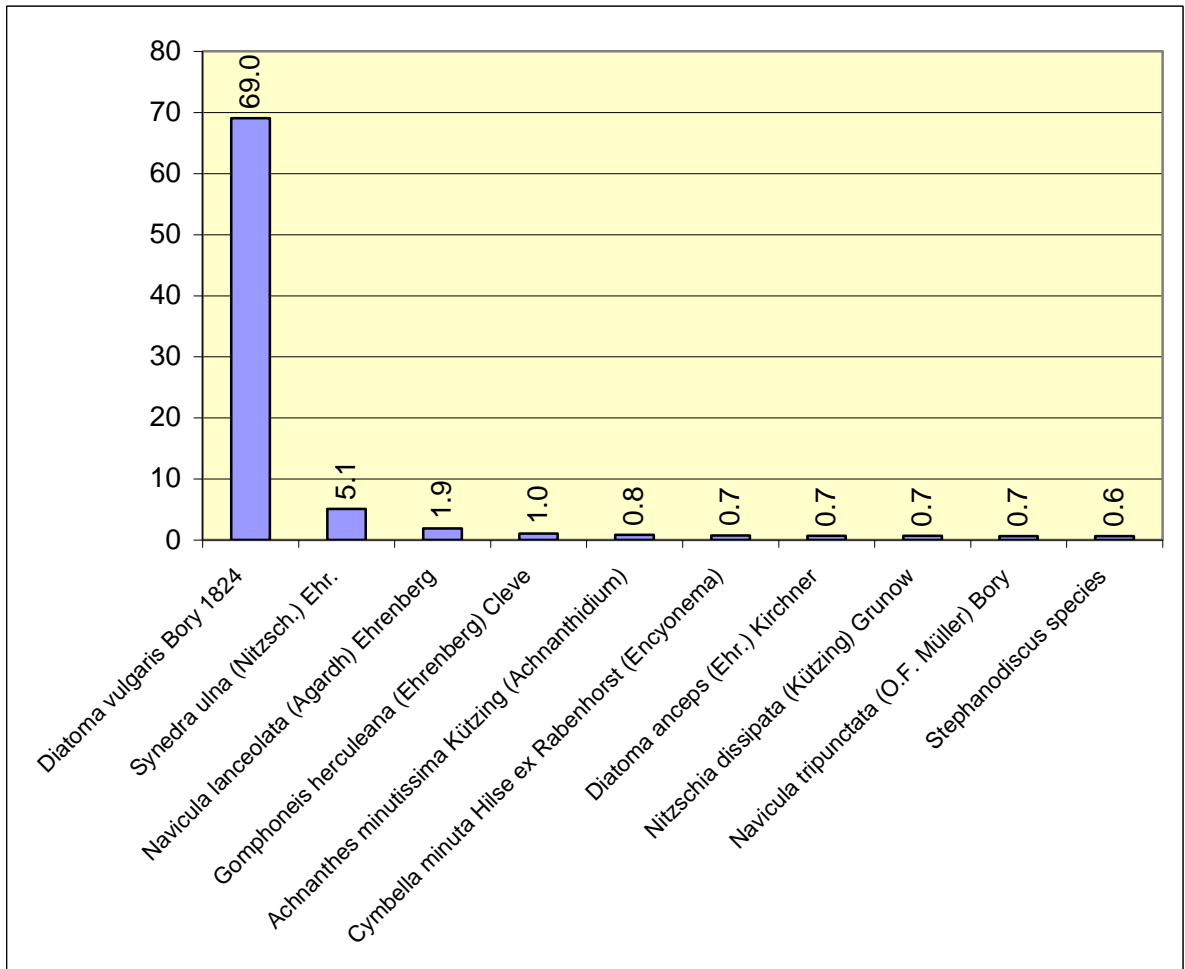
Achnanthes lanceolata (Breb.) Grunow
Achnanthes lanceolata (Breb.) Grunow ssp. *dubia* (Grunow) Lange-Bertalot
Achnanthes linearis (W. Sm.) Grunow
Achnanthes minutissima Kützing (Achnanthidium)
Amphora perpusilla Grunow
Asterionella formosa Hassall
Cocconeis pediculus Ehrenberg
Cocconeis placentula Ehrenberg
Cocconeis placentula Ehrenberg var. *euglypta* (Her.) Grunow
Cocconeis placentula Ehrenberg var. *lineata* (Ehr.) Van Heurck
Cyclotella meneghiniana Kützing
Cymbella affinis Kützing
Cymbella mexicana (Ehr.) Cleve
Cymbella minuta Hilse ex Rabenhorst (Encyonema)
Cymbella sinuata Gregory
Diatoma anceps (Ehr.) Kirchner
Diatoma vulgare Bory
Fragilaria capucina Desmazieres
Fragilaria construens f. *binodis* (Ehr.) Hustedt
Fragilaria crotonensis Kitton
Fragilaria leptostauron (Ehr.) Hustedt var. *dubia* (Grunow) Hustedt
Fragilaria vaucheriae (Kützing) Petersen
Gomphonema herculeana (Ehrenberg) Cleve
Gomphonema clevei Fricke
Gomphonema olivaceum (Hornemann) Brébisson
Gomphonema parvulum Kützing
Melosira granulata (Ehr.) Ralfs
Melosira varians Agardh
Navicula cryptocephala Kützing
Navicula cryptocephala Kützing var. *veneta* (Kütz.) Rabenhorst
Navicula lanceolata (Agardh) Ehrenberg
Navicula mutica Kützing
Navicula radiosa Kützing
Navicula secreta Pantocsek. var. *apiculata* Patrick
Navicula tripunctata (O.F. Müller) Bory
Navicula tripunctata var. *schizomenoides* (Van Heurck) Patrick
Nitzschia amphibia Grunow f. *amphibian*
Nitzschia dissipata (Kützing) Grunow
Nitzschia frustulum (Kützing) Grunow
Nitzschia inconspicua Grunow
Nitzschia intermedia Hantzsch ex Cleve & Grunow
Nitzschia palea (Kützing) W. Smith
Nitzschia paleacea (Grunow) Grunow in van Heurck
Nitzschia sinuata (Thwaites) Grunow

Pinnularia brebissonii (Kütz.) Rabenhors
Rhoicosphenia curvata (Kützing) Grunow
Stephanodiscus niagarae Ehr.
Stephanodiscus species
Surirella angusta Kützing
Surirella ovalis Brebisson
Synedra rumpens Kützing
Synedra ulna (Nitzsch.) Ehr.

Table 2. Species in diatom samples collected from Boiser River, spring 2007, with an IS value of 0.5 or greater

<i>Diatoma vulgare</i> Bory	69.0
<i>Synedra ulna</i> (Nitzsch.) Ehr.	5.2
<i>Navicula lanceolata</i> (Agardh) Ehrenberg	1.9
<i>Gomphoneis herculeana</i> (Ehrenberg) Cleve	1.0
<i>Achnanthes minutissima</i> Kützing (Achnantheidium)	0.8
<i>Cymbella minuta</i> Hilse ex Rabenhorst (Encyonema)	0.7
<i>Diatoma anceps</i> (Ehr.) Kirchner	0.7
<i>Nitzschia dissipata</i> (Kützing) Grunow	0.7
<i>Navicula tripunctata</i> (O.F. Müller) Bory	0.7
<i>Stephanodiscus</i> species	0.6

Figure 1. Species in diatom samples collected from Boiser River, spring 2007, with IS value of 0.5 or greater



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Appendix: Specific Data from Diatom Samples
Collected from Boise River, spring 2007

Algal taxa present in a scrape sample collected from **Caldwell** on **3/15/2007**. The percent relative density based on cell volume, species rank in the sample, number of organisms counted, and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	Rank	Relative Density	Number Per Milliliter	Cell Volume (μ^3/ml)
Bacillariophyta				
<i>Achnanthes lanceolata</i> (Breb.) Grunow	23	0.2	6.0	828.0
<i>Achnanthes lanceolata</i> (Breb.) Grunow ssp. dubia (Grunow) Lange-Bertalot	28	0.1	2.0	276.0
<i>Achnanthes minutissima</i> Kützing (Achnanthidium)	16	0.8	52.0	4056.0
<i>Cocconeis placentula</i> Ehrenberg var. lineata (Ehr.) Van Heurck	11	1.3	6.0	6258.0
<i>Cyclotella meneghiniana</i> Kützing	17	0.6	4.0	2872.0
<i>Cymbella minuta</i> Hilse ex Rabenhorst (Encyonema)	18	0.4	16.0	1920.0
<i>Cymbella sinuata</i> Gregory	30	0.0	2.0	212.0
<i>Diatoma anceps</i> (Ehr.) Kirchner	3	9.5	16.0	45232.0
<i>Diatoma vulgare</i> Bory 1824	1	42.8	54.0	204444.0
<i>Fragilaria crotonensis</i> Kitton	14	0.9	2.0	4336.0
<i>Fragilaria vaucheriae</i> (Kützing) Petersen	26	0.1	2.0	432.0
<i>Gomphonema clevei</i> Fricke	22	0.2	4.0	872.0
<i>Gomphonema olivaceum</i> (Hornemann) Brébisson	24	0.2	2.0	780.0
<i>Melosira granulata</i> (Ehr.) Ralfs	6	4.1	2.0	19600.0
<i>Navicula cryptocephala</i> Kützing var. veneta (Kütz.) Rabenhorst	20	0.3	4.0	1360.0
<i>Navicula lanceolata</i> (Agardh) Ehrenberg	5	7.9	30.0	37800.0
<i>Navicula tripunctata</i> (O.F. Müller) Bory	8	2.3	12.0	11100.0
<i>Navicula tripunctata</i> var. schizomenoides (Van Heurck) Patrick	12	1.2	4.0	5608.0
<i>Nitzschia amphibia</i> Grunow f. amphibia	27	0.1	2.0	376.0
<i>Nitzschia dissipata</i> (Kützing) Grunow	7	3.0	56.0	14392.0
<i>Nitzschia frustulum</i> (Kützing) Grunow var. frustulum	9	1.6	146.0	7446.0
<i>Nitzschia inconspicua</i> Grunow	10	1.3	136.0	6392.0
<i>Nitzschia intermedia</i> Hantzsch ex Cleve & Grunow	19	0.4	2.0	1768.0
<i>Nitzschia palea</i> (Kützing) W. Smith	25	0.1	2.0	562.0
<i>Nitzschia paleacea</i> (Grunow) Grunow in van Heurck	15	0.9	14.0	4088.0
<i>Nitzschia sinuata</i> (Thwaites) Grunow	21	0.2	2.0	1160.0
<i>Rhoicosphenia curvata</i> (Kützing) Grunow	13	1.1	10.0	5090.0
<i>Surirella ovalis</i> Brébisson	4	8.2	2.0	39072.0
<i>Synedra rumpens</i> Kützing	29	0.0	2.0	236.0

Synedra ulna (Nitzsch.) Ehr.	2	10.4	8.0	49560.0
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Total Bacillariophyta		100.0	602.0	478128.0
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TOTAL FOR ALL GROUPS		100.0	602.0	478128.0
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Shannon-Wiener Index	=2.41
Species Evenness	=0.71
Species Richness	=4.53
Number of Species	=30

Algal taxa present in a scrape sample collected from **Veterans** on **3/14/2007**. The percent relative density based on cell volume, species rank in the sample, number of organisms counted, and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	Rank	Relative Density	Number Per Milliliter	Cell Volume (μ^3/ml)
Bacillariophyta				
Achnanthes linearis (W. Sm.) Grunow	7	0.1	14.0	2212.0
Achnanthes minutissima Kützing (Achnantheidium)	8	0.1	28.0	2184.0
Cymbella affinis Kützing	6	0.2	8.0	4128.0
Cymbella minuta Hilse ex Rabenhorst (Encyonema)	4	0.3	48.0	5760.0
Diatoma vulgare Bory 1824	1	91.8	444.0	1680984.0
Fragilaria vaucheriae (Kützing) Petersen	5	0.2	20.0	4320.0
Gomphoneis herculeana (Ehrenberg) Cleve	3	0.7	2.0	13006.0
Gomphonema clevei Fricke	10	0.1	8.0	1744.0
Gomphonema olivaceum (Hornemann) Brébisson	12	0.0	2.0	780.0
Navicula tripunctata (O.F. Müller) Bory	9	0.1	2.0	1850.0
Nitzschia dissipata (Kützing) Grunow	13	0.0	2.0	514.0
Nitzschia frustulum (Kützing) Grunow	14	0.0	8.0	408.0
Nitzschia inconspicua Grunow	15	0.0	2.0	94.0
Nitzschia paleacea (Grunow) Grunow in van Heurck	11	0.1	4.0	1168.0
Synedra ulna (Nitzsch.) Ehr.	2	6.1	18.0	111510.0
Total Bacillariophyta		100.0	610.0	1830662.0
TOTAL FOR ALL GROUPS		100.0	610.0	1830662.0
Shannon-Wiener Index	=1.17			
Species Evenness	=0.43			
Species Richness	=2.18			
Number of Species	=15			

Algal taxa present in a scrape sample collected from **Barber/Eckert** on **3/14/2007**. The percent relative density based on cell volume, species rank in the sample, number of organisms counted, and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	Rank	Relative Density	Number Per Milliliter	Cell Volume (μ^3/ml)
Bacillariophyta				
<i>Achnanthes lanceolata</i> (Breb.) Grunow	15	0.3	26.0	3588.0
<i>Achnanthes lanceolata</i> (Breb.) Grunow ssp. dubia (Grunow) Lange-Bertalot	17	0.2	18.0	2484.0
<i>Achnanthes minutissima</i> Kützing (Achnanthidium)	7	0.6	92.0	7176.0
<i>Amphora perpusilla</i> Grunow	24	0.1	42.0	1176.0
<i>Asterionella formosa</i> Hassall	14	0.4	8.0	3968.0
<i>Cocconeis pediculus</i> Ehrenberg	10	0.6	2.0	6228.0
<i>Cocconeis placentula</i> Ehrenberg var. lineata (Ehr.) Van Heurck	6	1.1	12.0	12516.0
<i>Cyclotella meneghiniana</i> Kützing	21	0.1	2.0	1436.0
<i>Cymbella affinis</i> Kützing	26	0.1	2.0	1032.0
<i>Cymbella minuta</i> Hilse ex Rabenhorst (Encyonema)	8	0.6	54.0	6480.0
<i>Cymbella sinuata</i> Gregory	28	0.1	6.0	636.0
<i>Diatoma anceps</i> (Ehr.) Kirchner	5	3.0	12.0	33924.0
<i>Diatoma vulgare</i> Bory 1824	1	52.7	156.0	590616.0
<i>Fragilaria capucina</i> Desmazieres	30	0.0	2.0	196.0
<i>Fragilaria construens</i> f. binodis (Ehr.) Hustedt	29	0.1	2.0	600.0
<i>Fragilaria crotonensis</i> Kitton	13	0.4	2.0	4336.0
<i>Gomphonema olivaceum</i> (Hornemann) Brébisson	27	0.1	2.0	780.0
<i>Navicula cryptocephala</i> Kützing	19	0.2	6.0	2034.0
<i>Navicula cryptocephala</i> Kützing var. veneta (Kütz.) Rabenhorst	23	0.1	4.0	1360.0
<i>Navicula mutica</i> Kützing	25	0.1	2.0	1046.0
<i>Navicula tripunctata</i> (O.F. Müller) Bory	11	0.5	6.0	5550.0
<i>Nitzschia dissipata</i> (Kützing) Grunow	20	0.1	6.0	1542.0
<i>Nitzschia frustulum</i> (Kützing) Grunow var. frustulum	18	0.2	46.0	2346.0
<i>Nitzschia inconspicua</i> Grunow	16	0.2	56.0	2632.0
<i>Nitzschia paleacea</i> (Grunow) Grunow in van Heurck	12	0.5	18.0	5256.0
<i>Stephanodiscus niagarae</i> Ehr.	3	11.4	4.0	127304.0
<i>Stephanodiscus</i> species	2	22.3	10.0	250000.0
<i>Surirella angusta</i> Kützing	9	0.6	2.0	6292.0

Synedra rumpens Kützing	22	0.1	12.0	1416.0
Synedra ulna (Nitzsch.) Ehr.	4	3.3	6.0	37170.0
Total Bacillariophyta		100.0	618.0	1121120.0

TOTAL FOR ALL GROUPS **100.0** **618.0** **1121120.0**

Shannon-Wiener Index =2.59
Species Evenness =0.76
Species Richness =4.51
Number of Species =30

Algal taxa present in a scrape sample collected from **Parma** on **3/16/2006**. The percent relative density based on cell volume, species rank in the sample, number of organisms counted, and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	Rank	Relative Density	Number Per Milliliter	Cell Volume (μ^3/ml)
Bacillariophyta				
<i>Achnanthes lanceolata</i> (Breb.) Grunow	17	0.1	7.2	993.6
<i>Achnanthes linearis</i> (W. Sm.) Grunow	9	0.7	31.2	4929.6
<i>Achnanthes minutissima</i> Kützing (<i>Achnantheidium</i>)	5	3.2	278.4	21715.2
<i>Amphora perpusilla</i> Grunow	23	0.0	4.8	134.4
<i>Cocconeis placentula</i> Ehrenberg var. <i>euglypta</i> (Ehr.) Grunow	15	0.2	2.4	1408.8
<i>Cyclotella meneghiniana</i> Kützing	13	0.3	2.4	1723.2
<i>Cymbella minuta</i> Hilse ex Rabenhorst (<i>Encyonema</i>)	14	0.2	12.0	1440.0
<i>Diatoma vulgare</i> Bory 1824	1	68.6	124.8	472492.8
<i>Fragilaria vaucheriae</i> (Kützing) Petersen	20	0.1	2.4	518.4
<i>Gomphonema parvulum</i> Kützing	19	0.1	2.4	520.8
<i>Navicula cryptocephala</i> Kützing	18	0.1	2.4	813.6
<i>Navicula cryptocephala</i> Kützing var. <i>veneta</i> (Kutz.) Rabenhorst	6	1.2	24.0	8160.0
<i>Navicula lanceolata</i> (Agardh) Ehrenberg	2	13.2	72.0	90720.0
<i>Navicula secreta</i> Pantocsek. var. <i>apiculata</i> Patrick	10	0.6	4.8	4334.4
<i>Navicula tripunctata</i> (O.F. Müller) Bory	8	1.0	7.2	6660.0
<i>Nitzschia amphibia</i> Grunow f. <i>amphibia</i>	21	0.1	2.4	451.2
<i>Nitzschia dissipata</i> (Kützing) Grunow	7	1.0	26.4	6784.8
<i>Nitzschia frustulum</i> (Kützing) Grunow	22	0.1	7.2	367.2
<i>Nitzschia inconspicua</i> Grunow	12	0.3	40.8	1917.6
<i>Nitzschia paleacea</i> (Grunow) Grunow in van Heurck	11	0.6	14.4	4204.8
<i>Nitzschia sinuata</i> (Thwaites) Grunow	16	0.2	2.4	1392.0
<i>Rhoicosphenia curvata</i> (Kützing) Grunow	4	3.9	52.8	26875.2
<i>Synedra ulna</i> (Nitzsch.) Ehr.	3	4.3	4.8	29736.0
Total Bacillariophyta		100.0	729.6	688293.6
TOTAL FOR ALL GROUPS		100.0	729.6	688293.6

Shannon-Wiener Index

=2.13

Species Evenness	=0.68
Species Richness	=3.43
Number of Species	=23

Algal taxa present in a scrape sample collected from **Middleton** on **3/15/2007**. The percent relative density based on cell volume, species rank in the sample, number of organisms counted, and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	Rank	Relative Density	Number Per Milliliter	Cell Volume (μ^3/ml)
Bacillariophyta				
<i>Achnanthes linearis</i> (W. Sm.) Grunow	23	0.0	2.0	316.0
<i>Achnanthes minutissima</i> Kützing (Achnanthidium)	15	0.2	34.0	2652.0
<i>Cocconeis pediculus</i> Ehrenberg	9	0.5	2.0	6228.0
<i>Cocconeis placentula</i> Ehrenberg	19	0.1	2.0	1514.0
<i>Cymbella minuta</i> Hilse ex Rabenhorst (Encyonema)	13	0.3	26.0	3120.0
<i>Diatoma vulgare</i> Bory 1824	1	84.3	254.0	961644.0
<i>Fragilaria crotonensis</i> Kitton	10	0.4	2.0	4336.0
<i>Fragilaria vaucheriae</i> (Kützing) Petersen	22	0.0	2.0	432.0
<i>Gomphoneis herculeana</i> (Ehrenberg) Cleve	2	4.6	8.0	52024.0
<i>Navicula cryptocephala</i> Kützing var. <i>veneta</i> (Kütz.) Rabenhorst	20	0.1	2.0	680.0
<i>Navicula lanceolata</i> (Agardh) Ehrenberg	5	1.8	16.0	20160.0
<i>Navicula radiosa</i> Kützing	16	0.2	2.0	2220.0
<i>Navicula secreta</i> Pantocsek. var. <i>apiculata</i> Patrick	12	0.3	4.0	3612.0
<i>Navicula tripunctata</i> (O.F. Müller) Bory	6	0.8	10.0	9250.0
<i>Nitzschia amphibia</i> Grunow f. <i>amphibia</i>	14	0.3	16.0	3008.0
<i>Nitzschia dissipata</i> (Kützing) Grunow	7	0.7	32.0	8224.0
<i>Nitzschia frustulum</i> (Kützing) Grunow	8	0.7	148.0	7548.0
<i>Nitzschia inconspicua</i> Grunow	18	0.1	36.0	1692.0
<i>Nitzschia intermedia</i> Hantzsch ex Cleve & Grunow	17	0.2	2.0	1768.0
<i>Nitzschia paleacea</i> (Grunow) Grunow in van Heurck	21	0.1	2.0	584.0
<i>Pinnularia brebissonii</i> (Kütz.) Rabenhors	4	1.8	2.0	20734.0
<i>Rhoicosphenia curvata</i> (Kützing) Grunow	11	0.4	8.0	4072.0
<i>Synedra ulna</i> (Nitzsch.) Ehr.	3	2.2	4.0	24780.0
Total Bacillariophyta		100.0	616.0	1140598.0
TOTAL FOR ALL GROUPS		100.0	616.0	1140598.0

Shannon-Wiener Index

=1.94

Species Evenness	=0.62
Species Richness	=3.43
Number of Species	=23

Algal taxa present in a scrape sample collected from **Glenwood** on **3/14/2007**. The percent relative density based on cell volume, species rank in the sample, number of organisms counted, and cell volume per milliliter are also provided. Descriptive statistics are given at the end of the list of taxa.

Taxon	Rank	Relative Density	Number Per Milliliter	Cell Volume (μ^3/ml)
Bacillariophyta				
<i>Achnanthes lanceolata</i> (Breb.) Grunow	21	0.0	2.0	276.0
<i>Achnanthes linearis</i> (W. Sm.) Grunow	16	0.1	4.0	632.0
<i>Achnanthes minutissima</i> Kützing (<i>Achnanthidium</i>)	20	0.0	4.0	312.0
<i>Cocconeis pediculus</i> Ehrenberg	9	0.7	2.0	6228.0
<i>Cocconeis placentula</i> Ehrenberg var. <i>lineata</i> (Ehr.) Van Heurck	10	0.2	2.0	2086.0
<i>Cyclotella meneghiniana</i> Kützing	11	0.2	2.0	1436.0
<i>Cymbella affinis</i> Kützing	14	0.1	2.0	1032.0
<i>Cymbella mexicana</i> (Ehr.) Cleve	5	3.6	6.0	32028.0
<i>Cymbella minuta</i> Hilse ex Rabenhorst (<i>Encyonema</i>)	6	2.6	192.0	23040.0
<i>Cymbella sinuata</i> Gregory	13	0.1	10.0	1060.0
<i>Diatoma vulgare</i> Bory 1824	1	74.0	176.0	666336.0
<i>Fragilaria crotonensis</i> Kitton	8	1.0	4.0	8672.0
<i>Fragilaria leptostauron</i> (Ehr.) Hustedt var. <i>dubia</i> (Grunow) Hustedt	12	0.2	2.0	1422.0
<i>Fragilaria vaucheriae</i> (Kützing) Petersen	19	0.0	2.0	432.0
<i>Gomphoneis herculeana</i> (Ehrenberg) Cleve	2	7.2	10.0	65030.0
<i>Gomphonema clevei</i> Fricke	18	0.0	2.0	436.0
<i>Melosira varians</i> Agardh	3	4.6	8.0	41656.0
<i>Navicula cryptocephala</i> Kützing	15	0.1	2.0	678.0
<i>Nitzschia frustulum</i> (Kützing) Grunow	7	1.1	186.0	9486.0
<i>Nitzschia paleacea</i> (Grunow) Grunow in van Heurck	17	0.1	2.0	584.0
<i>Synedra ulna</i> (Nitzsch.) Ehr.	4	4.1	6.0	37170.0
Total Bacillariophyta		100.0	626.0	900032.0
TOTAL FOR ALL GROUPS		100.0	626.0	900032.0
Shannon-Wiener Index	=1.64			
Species Evenness	=0.54			
Species Richness	=3.11			
Number of Species	=21			

Shannon-Wiener = $-\sum(P_i \log P_i)$

Where: P_i is the proportion of the total number of individuals in the i^{th} species

Species Evenness = Shannon-Wiener / $\log S$

Where: S is the number of species

Species Richness = $S - 1 / \log N$

Where: S is the number of species and N is the number of individuals