Diatoms as Water Quality Indicators: New Jersey Rivers and Streams

Don Charles

Patrick Center for Environmental Research
Academy of Natural Sciences
Philadelphia, PA
Questions / Outline

• What are diatoms? Why are they good indicators?

• How do you do the work? - field, lab, development and application of indicators

• New Jersey diatom research
  – Nutrient indicators
  – Impairment indicators (BCG)
Diatoms on *Cladophora*
Advantages of Diatoms as Ecological Indicators

- Important ecosystem components
- Widely distributed in many habitats
- Siliceous remains preserve well
- Identifiable to lowest taxonomic level
- Many taxa / Large number of individuals
- Strong correlations with environmental characteristics / Sensitive to stress
- Rapid response to change / Diagnostic
- Efficient storage of representative assemblages
Northern NJ
Sample substrate : rocks

Karin Ponader
Southern New Jersey
Sampling Substrate:
Diatometer and
Sand / silt
Diatoms
“Tabulator” program for entering diatom counts and documentation information.
North American Diatom Ecological Database - NADED  
Phycology Section, Patrick Center For Environmental Research - ANSP  
Diatom Count Report

<table>
<thead>
<tr>
<th>Water Body: Assumpink Creek</th>
<th>Site Location ID: NJAN0118</th>
<th>Sample Label: NJ_118_1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample ID: NJ000009</td>
<td>Client Sample ID: AN0118</td>
<td></td>
</tr>
<tr>
<td>Date Sample Collected: 10/3/00</td>
<td>Count Finished: 3/6/01</td>
<td></td>
</tr>
<tr>
<td>Subsample ID: DT1</td>
<td>Slide Replicate ID: 1</td>
<td></td>
</tr>
<tr>
<td>Counted by: Karin C Ponader (KCP)</td>
<td>Sample Type:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Master NADED Number</th>
<th>Taxon Name</th>
<th>Percent</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>Achnanthes lanceolata (Bréb. in Kütz.) Grun.</td>
<td>0.83</td>
<td>5</td>
</tr>
<tr>
<td>2224</td>
<td>Achnanthes lanceolata subsp. frequentissima Lange-Bert.</td>
<td>1.67</td>
<td>10</td>
</tr>
<tr>
<td>2026</td>
<td>Achnanthes pusilla (Grun.) DeT.</td>
<td>0.67</td>
<td>4</td>
</tr>
<tr>
<td>2132</td>
<td>Achnanthes subhudsonis var. kraeuselii Choln.</td>
<td>3.33</td>
<td>20</td>
</tr>
<tr>
<td>12001</td>
<td>Caloneis bacillum (Grun.) Cl.</td>
<td>1.17</td>
<td>7</td>
</tr>
<tr>
<td>20012</td>
<td>Cyclotella pseudostelligera Hust.</td>
<td>0.33</td>
<td>2</td>
</tr>
<tr>
<td>37197</td>
<td>Gomphonema kobayasii Kociolek &amp; Kingston</td>
<td>29.50</td>
<td>177</td>
</tr>
<tr>
<td>37010</td>
<td>Gomphonema parvulum (Kütz.) Kütz.</td>
<td>1.00</td>
<td>6</td>
</tr>
<tr>
<td>130001</td>
<td>Luticola goeppertiana (Bleisch in Rabh.) Mann</td>
<td>7.50</td>
<td>45</td>
</tr>
<tr>
<td>44073</td>
<td>Melosira varians Ag.</td>
<td>0.17</td>
<td>1</td>
</tr>
<tr>
<td>46421</td>
<td>Navicula agrestis Hust.</td>
<td>0.17</td>
<td>1</td>
</tr>
<tr>
<td>46003</td>
<td>Navicula arvensis Hust.</td>
<td>0.33</td>
<td>2</td>
</tr>
<tr>
<td>46661</td>
<td>Navicula capitatoradiata Germain</td>
<td>0.17</td>
<td>1</td>
</tr>
<tr>
<td>46023</td>
<td>Navicula gregaria Donk.</td>
<td>8.00</td>
<td>48</td>
</tr>
<tr>
<td>46039</td>
<td>Navicula minima Grun.</td>
<td>19.00</td>
<td>114</td>
</tr>
<tr>
<td>46649</td>
<td>Navicula recens Lange-Bert.</td>
<td>0.33</td>
<td>2</td>
</tr>
<tr>
<td>46562</td>
<td>Navicula subminuscula Mang.</td>
<td>0.67</td>
<td>4</td>
</tr>
<tr>
<td>46400</td>
<td>Navicula symmetrica Patr.</td>
<td>0.33</td>
<td>2</td>
</tr>
<tr>
<td>48347</td>
<td>Nitzschia acidoclinata Lange-Bert.</td>
<td>0.50</td>
<td>3</td>
</tr>
<tr>
<td>48004</td>
<td>Nitzschia amphibia Grun.</td>
<td>3.83</td>
<td>23</td>
</tr>
<tr>
<td>48025</td>
<td>Nitzschia palea (Kütz.) W. Sm.</td>
<td>2.50</td>
<td>15</td>
</tr>
<tr>
<td>186008</td>
<td>Psammothidium subatomoides Hüst.) Bukht. et Round</td>
<td>1.17</td>
<td>7</td>
</tr>
<tr>
<td>57001</td>
<td>Rhoicosphenia curvata (Kütz.) Grun. ex Rabh.</td>
<td>0.67</td>
<td>4</td>
</tr>
<tr>
<td>170014</td>
<td>Sellaphora seminulum (Grun.) Mann</td>
<td>14.17</td>
<td>85</td>
</tr>
<tr>
<td>66053</td>
<td>Synedra delicatissima var. angustissima Grun.</td>
<td>0.67</td>
<td>4</td>
</tr>
<tr>
<td>66018</td>
<td>Synedra rumpens var. familiaris (Kütz.) Hust.</td>
<td>1.33</td>
<td>8</td>
</tr>
</tbody>
</table>

Report Date: 4/9/01  
Total Number of Taxa: 26  
Total Number Counted: 600
Periphyton Metrics

- Taxa richness / Diversity
- Percent Similarity wrt reference conditions
- Indicator taxa
- Percent sensitive species
- Pollution Index / Pollution Tolerance Index
- Siltation Index (motile diatoms)
- Multivariate approaches (e.g., CCA)
- Autecological indices (e.g., prefer high nutrients)
- Inference models (Weighted Averaging)
Diatoms as indicators of environmental conditions: What is a species indicator value?

Gaussian response curve:

- \( c \) - maximal abundance of the species,
- \( \mu \) - position of the mode = species optimum, or indicator value
- \( t \) - standard deviation of the curve, or species tolerance

Species Abundance

Environmental Variable
Abundance of taxa

Total P conc. gradient – Study streams
Diatom Sample Sites – ANSP Database

Projects

USGS National Water Quality Assessment (NAWQA)
States: DE, ID, ME, MD, MT, NM, NY, NJ, VA
ANSP River studies (R. Patrick)

Not shown
EPA
National Lake Assessment
National River and Stream Assessment
ANSP Diatom Study Sites in and near the Chesapeake Watershed

April 2009
Development of an Algae Indicator Monitoring Program for New Jersey Streams

Nutrient indicators
Problem: Excess algal biomass and community change

Cause: Nutrient (P and N) from sewage treatment plants, industries, agriculture, fertilizer, urban runoff

Solution: Nutrient standards to limit inputs
Algal indicators of nutrient conditions
New Jersey needs:

- Monitoring and regulatory tools
- Accurately characterize nutrient enrichment and biological response
  - determine impairment
  - diagnose cause of impairment
- Consistent with State nutrient criteria
Study sites
2000 – 2004

Piedmont        28
Ridge & Val.     5
Highlands       12
Coastal Plain  34

Total: 79 streams,
13 resampled
Field sampling

- Width, depth, velocity range
- Substrate, canopy cover
- Nutrients – several forms of N and P
- Composite algal sample for chl a, AFDM, and filamentous algae taxa
- Composite sample for diatom analysis
- Visual estimate of algal abundance along transects
Relationship between total phosphorus and diatom taxa composition is stronger than with chlorophyll a
New Jersey Diatom TALU

Using the Biological Condition Gradient Approach

Patrick Center for Environmental Research, Academy of Natural Sciences of Philadelphia

New Jersey Department of Environmental Protection
Trenton, NJ
The Biological Condition Gradient – Concept

Natural structure & function of biotic community maintained

Increasing Effect of Human Activity

1. Natural structure & function of biotic community maintained

2. Minimal changes in structure & function

3. Evident changes in structure and minimal changes in function

4. Moderate changes in structure & minimal changes in function

5. Major changes in structure & moderate changes in function

6. Severe changes in structure & function
Diatom TALU Approach

• Examine variation in natural characteristics; basis for classification?
• Define stressor gradients
• Develop autecological data; assign taxa to Biological Condition Gradient (BCG) attributes
• Workshop of diatom experts to assign sites to BCG categories and review taxa attributes
• Develop rules for using % taxa in BCG’s to assign sites; BCG cat’s, and nutrient criteria
Study sites 2000 – 2004

Piedmont    28
Ridge & Val.  5
Highlands   12
Coastal Plain  34

Total: 79 streams,
13 resampled
PCA AMNET 7 NatChars data not trans 27June09

Classification of sites
Natural characteristics
Biological Condition

1. Native or natural condition
2. Minimal loss of species; some density changes may occur
3. Some replacement of sensitive-rare species; functions fully maintained
4. Some sensitive species maintained but notable replacement by more tolerant taxa; altered distributions; functions largely maintained
5. Tolerant species show increasing dominance; sensitive species are rare; functions altered
6. Severe alteration of structure and function

Natural Degraded

Stressor Gradient

Low High
Placoneis conspicua

Tolerant

NJ TALU taxa vs stressors - 140 diatom samples

PCA Stressor Score

PCA Str

PLconspi
New Jersey Diatom TALU Workshop – Aug 2009

Diatom Experts
Rex Lowe
Kalina Manoylov
Jan Stevenson
Jerry Sgro
Hunter Carrick
Dean DeNicola
Marina Potapova

Facilitator
Jeroen Gerritsen
Contributors

ANSP

- Karin Ponader
- Diane Winter
- Marina Potapova
- David Velinsky
- Andrew Tuccillo

NJ DEP and others

- Tom Belton
- Tom Varnum
- Kevin Berry
- John Kennon
- Bob Limbeck
Acknowledgements:

Research funded by the NJ Department of Environmental Protection (NJ DEP)

Many thanks to Tom Belton and other NJ DEP staff and PCER staff Josh Collins, Dan Mellott, Erin Hagan, Mike Hoffmann, Eduardo Morales, Marina Potapova, Kathleen Sprouffske and Diane Winter, Andrew Tuccillo, and many others.
End