Benthic Macroinvertebrates and MS4
Outline

1. Aquatic life use: Why monitor benthic macroinvertebrates?
2. Overview of benthic macroinvertebrates
3. Assessments with benthic macroinvertebrates
4. Identification of stressors with benthic macroinvertebrates
Designated Uses

“All state waters...are designated for the following uses: recreational uses, e.g., swimming and boating; propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and shellfish.”
Common “Aquatic Life Use” Parameters

- Temperature (less than 32° C)
- pH (pH between 6.0 and 9.0)
- Dissolved Oxygen (greater than 4.0 mg/L)
- Nutrients
- Suspended solids
Weaknesses of Common Aquatic Life Use Parameters

• Surrogates (indirect)
• Criteria are broad
• Measurements are typically “snapshots”
Biomonitoring (Direct assessment of aquatic community)

Algae  Fish

Benthic Macroinvertebrates (aka Fish Food)
Benthic Macroinvertebrates

• Benthic - associated with the bottom of a water body (includes banks and other stable substrate associated with the bottom such as woody debris and macrophytes

• Macroinvertebrates – Animals without backbones that can be seen with the naked eye (insects, crayfish, snails, etc.)
Advantages of benthic macroinvertebrates

- Easy to collect
- Relatively easy to identify (family)
- Information about stream health over time (videotape vs. snapshot)
- Accurate assessments of aquatic life use
  a. Differences in pollution sensitivity
  b. Diversity
Pollution Intolerant Invertebrates

- Mayfly
- Stonefly
- Caddisfly
- Water Penny
- Riffle Beetle
Moderately Pollution Tolerant Invertebrates

- Crayfish
- Dragonfly
- Netspinning Caddisfly
- Aquatic Sowbug
- Cranefly
Highly Pollution Tolerant Invertebrates

- Midge Larvae
- Pouch Snail
- Segmented Worm
- Leech
- Flatworm
Benthic Macroinvertebrate Diversity

I. Feeding Groups

A. Shredders

Giant Stonefly

Giant Case Maker Caddisfly
I. Feeding Groups

B. Collector-Gatherers

Midge

Riffle Beetle Adult
I. Feeding Groups

C. Collector-Filterers

Black Fly Larva

Net-Spinning Caddisfly
I. Feeding Groups

D. Scrapers

Lunged Snail

Flat-headed Mayfly
I. Feeding Groups

E. Predators

Common Stonelfly

Dragonfly
II. Movement/Habit

A. Clingers

Water Pennies

Free-living Caddisfly
II. Movement/Habit

B. Climbers

Micro-Caddisfly
II. Movement/Habit

C. Sprawlers

Small Square-gill Mayfly
II. Movement/Habit

D. Burrowers

Common Burrower Mayfly
II. Movement/Habit

E. Swimmer/Divers

Small Minnow Mayfly

Water Scavenger Beetle
Assessments with Benthic Macroinvertebrates
Basic Steps in DEQ Biological Monitoring

1. Collection
   - Single habitat method (Riffles only)
   - Multihabitat method (20 proportional jabs in best available habitat)

2. Pick random sample of 100 organisms (or 200) from preserved material.

3. Identify organisms to family (genus)
Identification

- DEQ identifies each organism to the taxonomic level of **Family** (moving to Genus in future)

  **Kingdom** (Animalia)

  **Phylum** (Arthropoda)

  **Class** (Hexapoda)

  **Subclass** (Insecta)

  **Order** (mayflies, stoneflies, beetles, etc.)

  **Family** (Flatheaded mayflies, giant stoneflies, riffle beetles, etc.)

  **Genus**

  **Species**
The Key Question

How does one know whether a benthic macroinvertebrate community is “good enough” – meets the aquatic life use designation???
Virginia SCI uses 8 metrics to evaluate the health of a macroinvertebrate community:

1. Total Taxa (Total number of different families)
2. EPT Taxa (Number of different mayfly, stonefly, and caddisfly families)
3. % Ephemeroptera (% mayflies)
4. % PT-H (% stoneflies and caddisflies minus the hydropsychid caddisflies)
SCI Metrics (Continued)

5. % Scrapers
6. % Chironomidae (% of midge larvae)
7. % 2 Dominant (% of subsample made up of the two most frequent families)
8. MFBI (Family Biotic Index – measure of average tolerance value)
Virginia SCI Validation

SCI (Continued)

• SCI = 60 is the cut-off score
  (Based on comparison of many streams that are deemed to be minimally impacted by human activities versus streams that have been clearly stressed by human activities.)
• Scores above 60 – meet designated use for aquatic life
• Scores below 60 – listed as impaired for aquatic life use
### Examples from Piedmont Streams

<table>
<thead>
<tr>
<th>Metric</th>
<th>Flat Creek</th>
<th>Stony Run</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Taxa</td>
<td>20 (91)</td>
<td>8 (36)</td>
</tr>
<tr>
<td>EPT Taxa</td>
<td>9 (82)</td>
<td>1 (9)</td>
</tr>
<tr>
<td>% Ephem.</td>
<td>16 (26)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>% PT - H</td>
<td>18 (51)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>% Scraper</td>
<td>28 (54)</td>
<td>21 (40)</td>
</tr>
<tr>
<td>% Chiro.</td>
<td>34 (66)</td>
<td>59 (41)</td>
</tr>
<tr>
<td>% 2 Dom.</td>
<td>50 (73)</td>
<td>72 (40)</td>
</tr>
<tr>
<td>MFBI</td>
<td>4.5 (80)</td>
<td>5.7 (63)</td>
</tr>
<tr>
<td>SCI Score</td>
<td>65.3</td>
<td>28.8</td>
</tr>
</tbody>
</table>
Flat Creek – meets aquatic life use

Stony Run - impaired
Probabilistic Monitoring

Sample Sites 2003-2008
Report on 100% of Streams
Water Quality Stressors

Attributable Risk = Estimates the % of streams that would not have a poor VSCI/CPMI score if that stressor could be eliminated.
Excess Nutrients
Total Phosphorus and VSCI Scores
Effects of sedimentation

Lots of space between rocks for aquatic insects and small fish.

Little space under rocks. Rocks are “embedded” by sediment. Terrible habitat quality.
Statewide Relative Risk

\[
RR = \frac{Pr(\text{Poor VSCI/CPMI, given poor sediment condition})}{Pr(\text{Poor VSCI/CPMI, given good sediment condition})}
\]

Sedimentation is one of the most prevalent impacts to benthic communities. Excess sediment fills interstitial spaces in between stream substrates used by aquatic organisms for habitat. Until recently, tools for rapidly quantifying sedimentation impacts in streams have been inadequate. Methods existed for describing dominant particle size, but it was difficult to differentiate between natural conditions and anthropogenic problems. Virginia has a variety of stream types; many are naturally sand/silt bed streams, so simply measuring the size of the sediment particles cannot differentiate natural and human-influenced sediment load.

In a healthy stream, spaces between rocks provide habitat for benthos ...

As fine sediment begins to accumulate, this habitat is reduced ...

Interstitial spaces are beginning to fill in ...

Benthic habitat completely fills in as fine sediment settles out.
Relative Bed Stability (RBS)

Avg. Particle Size

\[
LRBS = \frac{\text{Avg. Particle Size}}{\text{Stream Power}}
\]

Avg. particles size comes from actual field measures.

Stream power is what avg particle size should be carried in the stream based on slope and bankfull stream geometry.
Innovative Monitoring

- Sediment endpoint in many biological studies
- Relative bed stability = quantitative habitat data
Index of Biological Integrity vs. Impervious Cover
Uses of Benthic Macroinvertebrate Data

1. Accurate assessment of streams
   - Effective use of limited resources, setting priorities, land use decisions, etc.

2. Baseline information to monitor effectiveness of BMPs or negative impacts of land use over time

3. Stressor identification

4. Education/Outreach
DEQ Links of Interest

- Water quality standards - [http://www.deq.state.va.us/wqs/](http://www.deq.state.va.us/wqs/)
- Biological monitoring
  - [http://www.deq.state.va.us/watermonitoring/bio.html](http://www.deq.state.va.us/watermonitoring/bio.html)
  - [http://www.deq.state.va.us/probmon/homepage.html](http://www.deq.state.va.us/probmon/homepage.html) (Probabilistic Monitoring)
- Citizen Monitoring - [http://www.deq.state.va.us/cmonitor/](http://www.deq.state.va.us/cmonitor/)
- TMDL/Impaired waters
  - [http://www.deq.state.va.us/tmdl/](http://www.deq.state.va.us/tmdl/) (Main TMDL page)
  - [http://gisweb.deq.state.va.us/303d/srch303d.cfm](http://gisweb.deq.state.va.us/303d/srch303d.cfm) (Fact sheet search)
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