A Chesapeake Bay Basin-wide Benthic Index of Biotic Integrity

Katie Foreman¹, Claire Buchanan², Andrea Nagel², Caroline Wicks³, Bill Dennison⁴
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¹University of Maryland Center for Environmental Science-Chesapeake Bay Program Office
²Interstate Commission on the Potomac River Basin
³Ecocheck/NOAA UMCES partnership
⁴University of Maryland Center for Environmental Science
Introduction
Benthic macroinvertebrates are a good indicators of stream health
Introduction
There is a need for a standardized index

- 64,000 square mile watershed – 6 states, District of Colombia
- Many different methodologies for monitoring and assessment (benthic, fish, habitat, water quality)
- There is a need to evaluate stream health in a uniform manner and in the context of the entire Chesapeake Bay watershed.
Methodology

Family Level Regional B-IBI

- Developed in 2008 by Chesapeake Bay Program’s Nontidal Water Quality Workgroup (Federal, State, County, River Basin Commissions scientists)


  - Assumption: A standardized regional B-IBI can be developed from multi-jurisdictional data if family level benthic data collection and RBP protocols are employed by each organization. Differences in sampling size, gear used, etc. are not significant at the family level of assessment.
Methodology

Data Sources and station locations

<table>
<thead>
<tr>
<th>Collecting Agency</th>
<th>Collection Dates Start</th>
<th>Collection Dates End</th>
<th>Number of samples Benthic</th>
<th>Number of samples Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>DE DNREC*</td>
<td>10/16/2001</td>
<td>11/14/2005</td>
<td>36</td>
<td>36</td>
</tr>
<tr>
<td>FC SPS</td>
<td>7/31/2001</td>
<td>12/31/2001</td>
<td>41</td>
<td>33</td>
</tr>
<tr>
<td>PA DEP*</td>
<td>4/6/2000</td>
<td>1/14/2008</td>
<td>500</td>
<td>301</td>
</tr>
<tr>
<td>SRBC*</td>
<td>4/14/1986</td>
<td>8/15/2008</td>
<td>947</td>
<td>710</td>
</tr>
<tr>
<td>VA DEQ*</td>
<td>3/7/2000</td>
<td>12/11/2007</td>
<td>1,486</td>
<td>1,280</td>
</tr>
<tr>
<td>WV DEP*</td>
<td>3/28/2000</td>
<td>1/16/2008</td>
<td>503</td>
<td>512</td>
</tr>
</tbody>
</table>

The asterisked data sets (*) were used to develop the B-IBI. All of the data sets were used in portraying 2000-2006 status.
Methodology

Eight steps to calculate the B-IBI

1. **Sampling**
   Scientists sampled 3,291 different stream sections during different times of the year from 2000–2006.

2. **Collecting**
   Numerous bottom-dwellers are collected from a variety of stream habitats over one stream section.

3. **Sorting**
   Scientists sort the samples and count how many and what kind of bottom-dwellers are in each sample.

Example of threshold values for each metric

<table>
<thead>
<tr>
<th>Metric</th>
<th>Thresholds for Piedmont</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>% Clinger Taxa</td>
<td>Best: 76.8</td>
<td>Worst: 42.4</td>
<td></td>
</tr>
<tr>
<td>% Collector Taxa</td>
<td>Best: 77.3</td>
<td>Worst: 53.5</td>
<td></td>
</tr>
<tr>
<td>% Dominant Taxa</td>
<td>Best: 47.0</td>
<td>Worst: 27.9</td>
<td></td>
</tr>
<tr>
<td>% may-, stone-, &amp; caddisfly taxa</td>
<td>Best: 79.1</td>
<td>Worst: 49.8</td>
<td></td>
</tr>
<tr>
<td>Family-level Hilsenhoff Biotic Index (unitless)</td>
<td>Best: 4.39</td>
<td>Worst: 3.16</td>
<td></td>
</tr>
<tr>
<td># of may-, stone-, &amp; caddisfly taxa (count)</td>
<td>Best: 7</td>
<td>Worst: 5</td>
<td></td>
</tr>
</tbody>
</table>

4. **Classifying**
   Samples are classified into one of five eco-regions:
   - Northern Appalachians
   - Highlands
   - Valleys
   - Piedmont
   - Coastal Plain

5. **Setting Thresholds**
   Within each eco-region, threshold values are determined for key metrics based on a comparison to “best sites.” Best and worst quality sites were identified from water quality and habitat quality information.

6. **Scoring**
   The basin-wide Benthic Index of Biotic Integrity scores various abundance, diversity, pollution tolerance, and feeding and habitat characteristics of each sample with eco-region-specific thresholds, and provides an overall numeric score for each site. For a list of all scored metrics see References.

7. **Ranking**
   Results are grouped into five qualitative categories based on their comparison to thresholds of the best and worst sites on one of two unitless scales.

<table>
<thead>
<tr>
<th></th>
<th>N. Appalachians, Highlands, Valleys, Piedmont</th>
<th>Coastal Plain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>≥27</td>
<td>≥3.86</td>
</tr>
<tr>
<td>Good</td>
<td>23–26.9</td>
<td>3.29–3.85</td>
</tr>
<tr>
<td>Fair</td>
<td>19–22.9</td>
<td>2.71–3.28</td>
</tr>
<tr>
<td>Poor</td>
<td>14–18.9</td>
<td>2.00–2.70</td>
</tr>
<tr>
<td>Very poor</td>
<td>&lt;14</td>
<td>≤2.00</td>
</tr>
</tbody>
</table>

8. **Mapping**
   Bottom-dweller community health at each location indicates the general health of the stream.
Results

Most of the stream health is characterized as very poor to fair.
Results

There is a link between stream health and land-based activities

Potomac River Watershed Example

Lower Potomac River Watershed: Predominately urban

Upper Potomac River Watershed: Predominately forested
Water quality in Chesapeake Bay is linked to the health of the 64,000 square miles of land and associated streams and rivers that comprise its watershed. Land-based activities (e.g., development, agriculture) can add pollution, such as nutrients and sediment, to local streams and rivers, which ultimately flow into Chesapeake Bay. The new stream health indicator (Benthic Index of Biotic Integrity (BIBI)) illustrates this link between stream health and land-based activities. For example, stream health conditions tend to be very poor to fair in areas that have extreme land disturbance, such as new construction, which results in high levels of pollution, altered water flow, and poor quantity and quality of streamside vegetation. Such unhealthy streams tend to be clustered around large urban areas such as metropolitan Washington, D.C. in the lower Potomac River watershed, and in areas that have land-uses dominated by agriculture (e.g., Eastern Shore of Maryland) and mining (e.g., parts of Pennsylvania and West Virginia). In contrast, stream health conditions tend to be good to excellent in areas with little land disturbance that offer low levels of pollution and natural in-stream and streamside habitat. Such healthy areas tend to be clustered around forested and prairie areas, such as the upper Potomac River watershed. The health of streams is variable throughout the Bay watershed and can vary even within a smaller subwatershed (e.g., the Potomac River watershed). Exceptions to these generalizations linking land-based activities to stream health are expected and are due to complexities within the ecosystem. Overall, 1,632 of the sites had very poor or poor health conditions and 1,056 sites had good or excellent conditions, out of a total of 3,291 sampling sites. Developing this indicator provides an important tool for managers and watershed groups who are focusing efforts to restore degraded streams and protect the quality of the healthiest ones.

http://www.eco-check.org/reportcard/chesapeake/2008/streamhealth/
Discussion

Advantages of a basin-wide B-IBI

- Larger data sets increase rigor of metric testing and reference site selection
- Broader geographic distribution
  - Less unintentional bias in results
- Consistent scoring across jurisdictional boundaries
  - Inequalities due to different state assessment methods are minimized allowing for regional water quality assessments
  - Tool can be used to help managers target areas for stream restoration and protection

Courtesy of ICPRB, 2007
Discussion
Steps to Improve the BIBI

- **2009:** Duplicate 2008 B-IBI development with new data
  - More county level data and some volunteer data

- **2010:** Address issues of concern in methodology
  - Assess the effects of differences in gear types, area sampled, subsample size, seasonality, limestone on BIBI results
  - Revisit classification scheme, scoring approach and biometrics included
  - Determine the influence of targeted vs. random sampling design

- **Future:** Additional analyzes
  - Relate results to a healthy “goal”, be able to talk about the overall health of watersheds vs. just sites
  - Assess effect of local landuse of BIBI score
  - Develop a Habitat Quality Index to accompany BIBI
  - Incorporate into management decision support tools (e.g. COAST)
  - Link nontidal B-IBI scores to tidal BIBI scores
Acknowledgements


Foreman, K., Buchanan C., Nagel, A. 2008. *Development of ecosystem health indexes for nontidal wadeable streams and rivers in the Chesapeake Bay basin.* Report to the Chesapeake Bay Program Non-Tidal Water Quality Workgroup. 12/5/08.