Using Probabilistic Monitoring Data to Recommend Stressor Risk Levels in Aquatic Life Use Total Maximum Daily Load Studies

Jason Hill, Mary Dail, and Larry Willis | 29 April 2014
Need for Stressor Thresholds

- More defensible stressor analysis process
- 563 “Biologically Impaired Reaches” in Virginia
  - 134 Category 4A (Benthic TMDL done and approved)
  - 265 Category 5A (Benthic TMDL needed)
  - 162 Category 5D (Benthic TMDL may be needed)
  - 2 Category 5F (Benthic TMDL may be needed)
Probabilistic data set: 474 sites with co-located benthic and water chemistry/habitat data
What makes a “healthy” benthic macroinvertebrate community?

- Diversity
- Presence of pollution intolerant invertebrates
  - Stonefly, Mayfly & Caddisfly larvae
- Habitat
- VSCI Score > 60
  - Integrated to reflect biological community characteristics and measure the overall response of the community to pollution or environmental stress
Statewide Virginia Stream Condition Index Scores by Basin
Statewide Virginia Stream Condition Index Scores by Tennessee River Sub-Basin
**GOAL**: Restore water quality and **DELIST** stream segment(s) based on follow-up Biomonitoring.

- **Impairment Listing**: Biomonitoring shows shift in benthic macroinvertebrate community.
- **TMDL Study**: • Stressor Analysis
  • Pollutant reductions
  • Public Participation
  • TMDL Report
- **TMDL IP**: • Address NPS & PS pollution
  • Develop Cleanup Plan
  • Identify & obtain funding

**Benthic Macroinvertebrate**

**TMDLs in Virginia**
2009 Biologist Self Assessment identified a need to improve stressor analyses for benthic TMDLs.

A workgroup was formed to develop *Benthic TMDLs: Data Collection and Stressor Thresholds* document:

- Foster greater collaboration between Biologists & TMDL staff
- Provide data collection guidelines
- Develop new tools for water quality data analyses
  - Screening values & statewide percentiles
- Data interpretation “how to”
- Establish a standing workgroup of technical experts for benthic TMDL advice.
Water Quality Stressors in Virginia

- VSCI/CPMI (Biomonitoring): 39.7% (+/-6.9%)
- Streambed Sedmentation: 39.0% (+/-7.5%)
- Total Phosphorus: 23.6% (+/-6.9%)
- Habitat Disturbance: 17.5% (+/-5.7%)
- pH (below 6): 9.3% (+/-5.0%)
- Total Nitrogen: 5.7% (+/-4.5%)
- Dissolved Oxygen: 3.5% (+/-3.0%)
- CCU Metals Index: 2.4% (+/-2.4%)
- Dissolved Nickel: 2.0% (+/-2.0%)
- Naphthalene in Sediment: 1.9% (+/-2.2%)
- Ionic Strength: 1.8% (+/-1.1%)
- DDE in Sediment: 1.1% (+/-1.0%)
- Nickel in Sediment: 1.0% (+/-2.0%)
- Total DDT in Sediment: 0.7% (+/-1.5%)
- DDD in Sediment: 0.7% (+/-1.5%)
- DDT in Sediment: 0.7% (+/-1.5%)
- Mercury in Sediment: 0.6% (+/-0.4%)
- Dissolved Cadmium: 0.4% (+/-0.4%)
- Dissolved Copper: 0.1% (+/-0.1%)

% Stream Miles
Sample Chapter: Total Nitrogen

- Chapter Content (Exit to Word)
  - Total Nitrogen
  - Total Nitrogen in VA
    - Box-and-whisker plots and percentiles by basin, ecoregion and stream order
  - Total Nitrogen (mg/L) Level Risk Recommendations for Aquatic Life
  - Relationship to other stressors

- Appendices contain in-depth statistical analyses
Provide Tools – Basin

Total Nitrogen (mg/L) By Basin

Virginia River Basin

Virginia, James, Roanoke, Pot-Shen, Rapp-York, Chowan, Tennessee, New
<table>
<thead>
<tr>
<th>Statistic</th>
<th>Virginia</th>
<th>James</th>
<th>Roanoke</th>
<th>Pot-Shen</th>
<th>Rapp-York</th>
<th>Chowan</th>
<th>Tennessee</th>
<th>New</th>
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<tr>
<td>1Pct</td>
<td>0.093</td>
<td>0.084</td>
<td>0.106</td>
<td>0.200</td>
<td>0.180</td>
<td>0.105</td>
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<td>0.109</td>
<td>0.172</td>
<td>0.247</td>
<td>0.262</td>
<td>0.130</td>
<td>0.180</td>
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<tr>
<td>25Pct</td>
<td>0.248</td>
<td>0.172</td>
<td>0.235</td>
<td>0.357</td>
<td>0.370</td>
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<td>0.246</td>
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<td>0.252</td>
<td>0.376</td>
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<td>0.503</td>
<td>0.470</td>
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<td>75Pct</td>
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<td>0.566</td>
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<td>0.864</td>
<td>1.210</td>
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<td>2.872</td>
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- Also would provide tables, graphics by stream order (size) and ecoregion to help determine stressor significance
Quantile Regression
Conditional Probability
### Interpretation

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Total Nitrogen (mg/L)</th>
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<tbody>
<tr>
<td>High Risk to Aquatic Life</td>
<td>&gt;2 (high stress)</td>
</tr>
<tr>
<td>Medium Risk to Aquatic Life</td>
<td>&gt;1, &lt;2 (medium stress)</td>
</tr>
<tr>
<td>Low Risk to Aquatic Life</td>
<td>&gt;0.5, &lt;1 (low stress)</td>
</tr>
<tr>
<td>No Risk to Aquatic Life</td>
<td>&lt;0.5 (non-stressor/background)</td>
</tr>
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</table>

**Stressor Parameter**

- **Optimal**
  - Total Nitrogen (mg/L): <1

- **Suboptimal**
  - Total Nitrogen (mg/L): >2

**VSCI Scores by Total Nitrogen (mg/L) Categories**

**Total Nitrogen Categories**
- TN < 0.5
- TN = 0.5 and TN < 1
- TN = 1 and TN < 2
- TN ≥ 2

**Histograms**

- Total Nitrogen
  - Range: 0.0% to 12.0%
  - Intervals: 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5

- Total Nitrogen
  - Range: 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5
Questions?
Statistics/Data Chapter Workgroup

Total Phosphorus (mg/L) By Basin

Virginia River Basin

Virginia, James, Roanoke, Pot-Shen, Rapp-York, Chowan, Tennessee, New
LRBS By Basin

Subpopulation
- James Basin
- Roanoke Basin
- Potomac-Shenandoah
- Rappahannock-York
- Chowan
- Tennessee
- New
Dissolved Metal CCU By Basin

Subpopulation
- James Basin
- Roanoke Basin
- Potomac-Shenandoah
- Rappahannock-York
- Chowan
- Tennessee
- New