Sean Buczek, Environmental Specialist I, NCDEQ

In his role as an Environmental Specialist for the Intensive Surveys Branch of the Water Sciences Section, Sean’s primary focus is the collection and monitoring of surface water, sediment and biota samples as they pertain to water quality studies. He is also leading the ISB’s effort toward characterizing the distribution of select contaminants of emerging concern in surface waters throughout the state. Sean received his M.S. in Fisheries, Wildlife, and Conservation Biology from North Carolina State University. His primary research was environmental toxicology and studying the role of Unionid mussels in reservoir nutrient cycling.
Effects of Turbidity and Sediment on Aquatic Organisms

Overview

- Defining Terms
  - Turbidity, suspended sediment, & sedimentation
- The Problem
- Direct & Indirect Effects
- The Role of Toxicology
- Effects on Aquatic Organisms
- Regulations
- Future Needs
Effects of Turbidity and Sediment on Aquatic Organisms

Suspended Sediment & Turbidity

- Turbidity
  - Measure of refracted light (NTU)
  - Surrogate measure of suspended sediment
- Suspended Sediment
  - SSC or TSS (mg/L)
- Sources
  - Natural
  - Legacy sediments
  - Intensive agriculture/grazing
  - Changes in land cover
  - Construction activities
• The Problem…
  • Primary pollutant (US EPA 1991)
    • Impair 45% of US river miles
    • 37% impaired by nutrients
  • Ubiquitous, natural, and not novel (Ellis, 1936)
  • Highly imperiled aquatic fauna (Williams et al., 1993)
    • Mollusks ~70%
    • Crayfish ~65%
    • Fish ~37%
    • Amphibians ~35%
  • Cascading effects (Henley et al., 2000)
• A closer look…
Effects of Turbidity and Sediment on Aquatic Organisms

Direct vs. Indirect Effects of Suspended Sediment & Turbidity

- **Direct Effects**
  - Exposure resulting in a direct effect to species fitness (±)
    - Abrasion
    - Clogging
    - Drift
    - Burial

- **Indirect Effects**
  - Result in a change to species fitness through a mediator (±)
    - Oxygen concentration
Effects of Turbidity and Sediment on Aquatic Organisms
The Role of Environmental Toxicology

- Toxicology
  - “The study of the detection, occurrence, properties, effects and regulation of toxic substances”

- Role
  - Protect human health & environment

**Effects of Turbidity and Sediment on Aquatic Organisms**

Exposure Concentration, Duration, & Regulation

- **Exposure Concentration**
  - Amount of toxicant (mg/L or ppm) NTU

- **Exposure Duration**
  - Length of exposure (time)

- **Dose Response Curve**
  - Median lethal concentration (LC50)

- **Concentration*Duration=Response**
  - Typical toxicity tests have set assessment time-points
  - Don’t highlight concentration/duration interaction

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Ambient Lakes Monitoring Program

- Acute Exposure
  - Short exposure duration/higher concentration
    - Burial
    - Scouring/Dislodgment
    - Mortality

- Chronic Exposure
  - Long-term exposure/lower concentration
    - Low DO
    - Loss of habitat
    - Sub-lethal effects
    - Stress leading to mortality

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Chronic vs Acute Exposure

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Effects of Turbidity and Sediment on Aquatic Organisms
Aquatic Ecosystems and the Influence of Suspended Sediment

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Primary Producers

- **Bacteria**
  - Increased bacteria & nitrification (xia et al., 2009)
- **Phytoplankton**
  - Increased biomass (Schallenberg & Burns, 2004)
  - Decreased blue-green biomass (Smith, 1990)
  - Recovery mechanisms—P uptake, colony fragmentation, & temporary cysts (Burkholder, 1992)
- **Periphyton**
  - Impacted by scouring (Francoeur & Biggs, 2006)
- **Macrophytes**
  - Reduced photosynthesis (Bilotta & Brazier, 2008)
Primary Consumers
- Zooplankton
  - *D. magna* LC50 5–74 mg/L (Capper, 2006)
- Benthic invertebrates
  - Decreased densities & increased drift (Quinn et al., 1992)
  - Sensitive species tolerant of 24h at 20,000 NTU (Suren et al., 2005)
- Mollusks
  - Reduced display behavior (Corey et al., 2006)
  - Reduced reproduction (Landis et al., 2013)
  - Periodic exposure (10-100 NTU) increased closure response (Bucci et al., 2011)
  - Reduced attachment and metamorphosis (Beussink, 2007)
## Effects of Turbidity and Sediment on Aquatic Organisms

Influence of Suspended Sediment — Primary Consumers

### Frequency of Explanation for Unionacean Declines Postulated by Authors of 45 Published Articles (From Strayer and co-workers, 2004)

<table>
<thead>
<tr>
<th>Cause</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollution, water quality degradation</td>
<td>47</td>
</tr>
<tr>
<td>Habitat destruction, alteration</td>
<td>47</td>
</tr>
<tr>
<td>Damming and impoundment</td>
<td>33</td>
</tr>
<tr>
<td>Introduction of exotic species</td>
<td>29</td>
</tr>
<tr>
<td>Hydrologic change</td>
<td>20</td>
</tr>
<tr>
<td>Exploitation and harvesting</td>
<td>18</td>
</tr>
<tr>
<td>Recruitment failure, lack of fish hosts</td>
<td>13</td>
</tr>
<tr>
<td>Watershed alterations</td>
<td>13</td>
</tr>
<tr>
<td>Riparian alterations</td>
<td>07</td>
</tr>
<tr>
<td>Predation</td>
<td>07</td>
</tr>
</tbody>
</table>
Effects of Turbidity, Sediment, and Polyacrylamide on Native Freshwater Mussels

- Settled Sediment
- Suspended Sediment
- Flocculated Sediment
Acute (96 h) Effects of Turbidity, Sediment, and Polyacrylamide on Native Freshwater Mussels

- **Suspended**
  - Protein: Sig >
  - ATP: Sig >
  - Oxidation: Sig >

- **Flocculated**
  - Protein: Sig >
  - ATP: Sig >
  - Oxidation: Sig >

- **Settled**
  - Protein: Sig >
  - ATP: Sig >
  - Oxidation: Sig >
Chronic (20 d) Effects of Turbidity, Sediment, and Polyacrylamide on Native Freshwater Mussels

- **Protein**
  - Suspended
  - Flocculated
  - Settled

- **ATP**
  - Suspended
  - Flocculated
  - Settled

Legend:
- **Sig >**
- **Sig <**
- **G>Sig>R**
- **NS**

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Secondary Consumers

- Cool water species
  - Secondary infection (Redding et al., 1984)
  - Gill damage (Herbert & Merkens, 1961)
  - Increased mortality (Lake & Hitch, 1999)

- Warm water species
  - Decrease in feeding rate (Gardner, 1981)

- Imperiled fishes
  - Decreased schooling behavior (Gray et al., 2014)
Effects of Turbidity and Sediment on Aquatic Organisms

Influence of Suspended Sediment — Secondary Consumers

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• How to inform regulation with generated data
  • Simplistic dose response model (Newcombe & McDonald, 1991)
  • Improved Model (Newcombe & McDonald, 1993)
    • Thresholds, behavioral, sublethal, & lethal effects
  • More improvements (Newcombe & Jensen, 1996)
    • Duration
  • Expanding the model (Kjelland et al., 2015)
    • Transgenerational implications

(Kjelland et al., 2015)
Effects of Turbidity and Sediment on Aquatic Organisms

EPA 2001 Survey of Sediment Regulations

- **Numeric Criteria**: 32
- **Narrative Criteria Only**: 13
- **No Sediment Criteria**: 8

EPA 2001 Survey of Turbidity Regulations

- **No Numeric**: 32
- **Background**: 15
- **Absolute Value**: 12
- **Combination**: 2


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• Future Needs
  • Additional research data for model development
    • Environmental data
  • Data on adsorbed constituents
  • Statewide or national standard unlikely
    • Inform local decisions and policy

Effects of Turbidity and Sediment on Aquatic Organisms
Sediment & Turbidity Regulation

(Gordon and Palmer, 2015)
Questions?

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