Extensive Biogeochemical Sampling of the Sediment and Water Column in the Tidal Freshwater Delaware River, 2012-2014 (ongoing)

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Dissolved Oxygen has improved tremendously from the 60’s.
However, as a result of productivity, organic matter loading and hydrodynamics of the tidal river; there still is a DO sag.
Three objectives of the model are:

A) Represent tidal system around Philadelphia in its current state prior to large scale reductions in CSO loads

B) Capture water quality features in tidal river (e.g., DO sag, nutrient levels, etc.)

C) Represent the major loadings into the system from all relevant categories (WWTPs, tributaries, CSOs, runoff)

D) Understand oxygen dynamics under changing flow and loadings scenarios
Questions

• How much oxygen consumption is occurring at the sediment-water interface?
  - seasonal
  - spatial

• Are there sediment quality parameters that can be used to predict sediment oxygen demand?

• Which is more dominant: sediment or water column demand?
Elements of the Study (2012 – Present)

- **Surface Sediment Survey**
  - CNP, chlor a, Grain Size
- **Sediment Oxygen Demand**
  - Multiple surveys, seasonal
- **Sediment Porewater**
  - NH$_4$, NO$_3$, PO$_4$
- **Nutrient Flux Measurement**
  - N$_2$, NH$_4$, NO$_3$, PO$_4$
- **Water Column Nitrification**
  - Selected sites
- **Water Quality**
  - Ammonium, phosphate
- **Biochemical Oxygen Demand**
  - 5-, 20- and 90-day (NBOD, CBOD)
Water Temperature in the Philadelphia Region (Woods Hole Group Buoy B) at RM93.7 from June 2012 to November 2014
Sediment Surrogate Study 2012 and 2013

- Sampling at 88 sites from Trenton to Delaware City (RM130 to RM60)
- Surface sediments were taken from top ~3-4 cm
- Locations based on previous datasets and on-water best professional judgment Sommerfield and Madsen (2003), US EPA, PDE (DEBI)
- Sampling sites were chosen mainly based on grain size distribution (limited OC data)
- Samples were taken and analyzed for organic C, total N, organic matter, grain size (% >> 63 um) and solid phase Chlor a

Results were used to help guide further SOD sampling.
Sediment Quality Data (mean ± se) for the Five Sampling Periods

Note: The mid-spring survey locations are new stations not sampled in the previous sampling surveys.
Sediment Oxygen Demand and Sediment Quality Parameters

Note scale change
Regression Analysis Between SOD and Sediment Quality Parameters

<table>
<thead>
<tr>
<th>SOD vs...</th>
<th>Transformation</th>
<th>All Data Combined</th>
<th>R²</th>
<th>P Value</th>
</tr>
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<tbody>
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<td>Chlorophyll a</td>
<td>Log Chlor a</td>
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<td>Percent OM</td>
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<tr>
<td>Percent GS</td>
<td>Arc Sine Sq RT %GS</td>
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<td>0.005</td>
<td>0.472</td>
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</tbody>
</table>

2-Data were corrected to 20°C. P values in bold and italic are significant.

Note: There were significant relationships between some variables with SOD, but not enough of the differences were explained by SOD alone.
Sediment Oxygen Demand and Nutrient Fluxes

Cruises:
- August 2012 (55 cores: N₂, O₂; 23 N, P)
- November 2012 (36 cores: N₂, O₂, N, P)
- May 2013 (36 cores: N₂, O₂, N, P)
- August 2013 (36 cores: N₂, O₂, N, P)

Methods:
- Core incubations in stirred microcosms
- Flux rates corrected for changes in water column blank
- Time course sampling of dissolved gases and nutrients
- Direct measurements of N₂ production using Membrane Inlet Mass Spectrometry
Surface Water Temperature in the Philadelphia Region (Woods Hole Group Buoy B) at RM93.7 from June 2012 to November 2014
Our SOD values are substantially lower than Albert (1988) but similar to previous Delaware and Potomac River studies’ rates.
Seasonal SOD for Zones 2-5 in the Tidal Delaware River

- Rates were corrected to 20°C for comparison of data
- Rates were higher in the upper reach (Zone 2)
- Follows a trend for sediment grain size and organic C
Nitrogen fluxes and SO for Zones 2-5 in the Tidal Delaware River

- Large rates of denitrification
- Seasonal changes in nitrate fluxes
- Ammonium flux generally out of sediment
- \(O_2\) consumption by sediments
Data suggest that N₂ production (i.e., denitrification) is controlled by nitrate flux into sediments.
Summary

• Low variance in SOD across the sampling domain overall average 0.88 ± 0.52 g m⁻² d⁻¹
• High rates of denitrification
• Sediment quality parameters did not explain a substantial portion of the SOD variation
• Sediment metabolism and water column nitrate are strong controls on denitrification
• Appears that water column respiration larger than sediment oxygen demand
• Denitrification removes approx. 1.65M kg N annually or ~22% of the point source loading
Questions?

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