Controls of Declining Epilimnion Thickness in Acadia National Park and Implications for Phytoplankton

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Outline

1. Intro & background to research
2. Identification of 2 main parts of research and corresponding key questions
3. Part I: Trends in epilimnion thickness, and identification of factors that control these trends
4. Part II: Biological implications of these trends, for phytoplankton specifically
5. Conclusions & broader significance
Jordan Pond, Acadia National Park

Lakes as **sentinels** of change
Sentinel Response: transparency
Global and local importance
Recent trends in clarity
Drivers of Lake Clarity

Chlorophyll (algae)

Dissolved organic carbon (DOC/DOM)
Drivers of Lake Clarity in Acadia

Strock et al. 2013
Drivers of increased DOC concentration
Patterns of Wet Sulfate Deposition

Sulfate ion wet deposition, 1994

Sulfate ion wet deposition, 2000

Sulfate ion wet deposition, 2009
Drivers of increased DOC concentration

Precipitation Patterns

number of events with >2” rain in 24 hours

↑ Rainfall ↑ DOC

Fernandez et al. 2015
Epilimnion Thickness

↑DOC ↓ light ↓ epilimnion thickness

..Other factors that drive ET..
3 main questions

Part I

(1) What are the trends in epilimnion thickness in Jordan Pond and other Acadia Lakes?
(2) What controls these changes?

Part II

(3) What do these changes mean for phytoplankton in Acadia lakes?
Part I: Study Sites
Question 1: Trends of Epilimnion Thickness

Approach: Historical Data

Strock et al. 2016 in review
Question 2: Controls on epilimnion thickness

Approach: Modern High-Frequency Data

www.jpbuoy.com
Question 2: Controls on epilimnion thickness

**Approach: Modern High-Frequency Data**

**What the buoy measures**
- Water temperature
- pH
- Conductivity
- fDOM (organic matter)
- Dissolved oxygen
- Chlorophyll
- Light attenuation
- Water temperature profile (to 16 m depth)

**What the weather station measures**
- Air temperature
- Wind speed, direction
- Rain fall
- Barometric pressure
- Light conditions
Question 2: Controls on epilimnion thickness

Approach: Modern High-Frequency Data

fDOM explained the most variability in epilimnion thickness
\( (R^2=0.759, \ p<0.001) \)

Strock et al. 2016 in review
Question 2: Controls on epilimnion thickness

*Approach: Modern High-Frequency Data*

Proximate cause of seasonal change

↓ DOC  
↑ Epilimnion thickness

↓ Rainfall

Buoy captures increased magnitude of rain events
Conclusions Pt. I

DOC controls epilimnion thickness across short and long temporal scales.
Question 3: What do changes in epilimnion thickness mean for phytoplankton in Acadia lakes?

*Background*

- DOC important ecosystem regulator, less known about the implications for ecosystems
- Numerous effects of ↑DOC on phytoplankton (nutrient subsidy, trophic changes, *light changes*)
- Experiment focuses on the effect of changes in light phyto will experience in altered epilimnion thickness
Part II: Study Sites

<table>
<thead>
<tr>
<th>Lake</th>
<th>Area (ha)</th>
<th>Max Depth (m)</th>
<th>DOC (mg L⁻¹)</th>
<th>Secchi</th>
<th>Epilimnion Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jordan</td>
<td>75</td>
<td>46</td>
<td>1.9</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Seal Cove</td>
<td>103</td>
<td>13</td>
<td>4.7</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>
Question 3: What do changes in epilimnion thickness mean for phytoplankton in Acadia lakes?

**Approach: Experimental Manipulation**

<table>
<thead>
<tr>
<th></th>
<th>Jordan Pond</th>
<th>Seal Cove</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light Manipulation</td>
<td>Simulated Epi Depth (m)</td>
<td>Simulated Epi Depth (m)</td>
</tr>
<tr>
<td>Thinner Epilimnion</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Average Epilimnion</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Thicker epilimnion</td>
<td>10</td>
<td>9</td>
</tr>
</tbody>
</table>

- Response variables
- Predictions
Question 3: What do changes in epilimnion thickness mean for phytoplankton in Acadia lakes?

**Approach: Experimental Manipulation**
Question 3: What do changes in epilimnion thickness mean for phytoplankton in Acadia lakes?

**Approach: Experimental Manipulation**

**Jordan Pond**

**Algal Biomass**

- Chlorophyll (µg/L)
  - Low light
  - Med light
  - High light

**Algal Biovolume**

- Total Biovolume (µm³/mL)
  - Low light
  - Med light
  - High light

Thick epi  →  Thin epi
Question 3: What do changes in epilimnion thickness mean for phytoplankton in Acadia lakes?

*Approach: Experimental Manipulation*

**Seal Cove**

<table>
<thead>
<tr>
<th></th>
<th>Low light</th>
<th>Med light</th>
<th>High light</th>
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</thead>
<tbody>
<tr>
<td>Chlorophyll (µg/L)</td>
<td>[Graph]</td>
<td>[Graph]</td>
<td>[Graph]</td>
</tr>
<tr>
<td>Algal Biomass</td>
<td></td>
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<tr>
<td>Algal Biovolume</td>
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<tr>
<td>Total Biovolume / mL</td>
<td>[Graph]</td>
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Thick epi  →  Thin epi
Conclusions Pt. II

• Biological implications of changing trends in DOC relatively understudied

• Altered chlorophyll production in low light conditions, in high DOC system
Conclusions & Broader Implications

• Lakes are declining in clarity and epi thickness
• DOC playing key role
• Looking at data across temporal scales is key
• Key to focus on biological implications of changes in DOC
• Revisiting lakes as sentinels
Stay tuned for FS 2016...
Public Education & Outreach

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