Harmful Algal Blooms

Sarah Rushforth
Rushforth Phycology
Phycological Research Consortium
sarah@rushforthphycology.com
801 376 3516
What are HABs?

HABs occur when algal colonies increase to the point of causing visible mats that result in harmful effects on aquatic life, people and other mammals or birds.

Why now

• Cyanobacteria have been around for approximately 400 million years. They’re not a new phenomena.
• Why only now seeing cyanobacteria blooms?
• Increases in human impact. Higher Nitrogen release from fertilizer, burning fossil fuels. Increase in P from sewage, detergents, etc.
• Increase in frequency/intensity/distribution
• Increase in available nutrients (runoff, wastewater, etc.).
• Global warming: Harmful algae thrive in warm water. Advantage over non-harmful algae

Potential human/animal health impacts

• Response to toxin production:
  • liver /kidney function
  • Neurological symptoms
  • GI symptoms

Potential ecological impacts

• Anoxic condition
• Light limitation

Assessing bloom composition

• Taxonomy
• Toxicity testing

Many unanswered questions about ecology of HABs

What are HABs?

HABs occur when algal colonies increase to the point of causing visible mats that result in harmful effects on aquatic life, people and other mammals or birds.

Why now

• Cyanobacteria have been around for approximately 400 million years. They’re not a new phenomena.
• Why only now seeing cyanobacteria blooms?
• Increases in human impact. Higher Nitrogen release from fertilizer, burning fossil fuels. Increase in P from sewage, detergents, etc.
• Increase in frequency/intensity/distribution
• Increase in available nutrients (runoff, wastewater, etc.).
• Global warming: Harmful algae thrive in warm water. Advantage over non-harmful algae

Potential human/animal health impacts

• Response to toxin production:
  • liver /kidney function
  • Neurological symptoms
  • GI symptoms

Potential ecological impacts

• Anoxic condition
• Light limitation

Assessing bloom composition

• Taxonomy
• Toxicity testing

Many unanswered questions about ecology of HABs
Why Now?

increase in frequency and intensity is calling attention to algal blooms.

Not a new phenomena.

Population Growth

- Urbanization
- Global warming
- Increased recreational use
- Increased agricultural production
- Increased burning of fossil fuel
Ecological Traits of HABs: Unanswered Questions Critical for Management

- How might the definition of a bloom vary according to differences in space e.g., near shore mat vs. expansive surface film?
- How do we adjust sampling protocols to account for the volume of a bloom throughout the water column vs. a surface bloom?
- What drivers determine the longevity of a bloom? Is the composition of a bloom maintained throughout or does dominance shift? What drives changes in composition?
- What are the drivers of diversity within a blooms? We often think of blooms as monospecific, but more frequently, they are not.
- What factors determine the abundance of different taxa that can co-exist under “bloom conditions?”
- How often does bloom dominance change between groups?
- What conditions determine composition similarity in blooms across time?
- Does diversity within a bloom fluctuate between cyanobacteria dominance vs. diatom vs. dinoflagellate vs. green algae blooms?
- Do toxins have inhibitive or facilitative interactions?
Identifying HABs:
Things to keep in mind:

1. *Not all algal blooms are cyanobacteria*

2. *Cyanobacteria blooms are not always harmful*

3. *Initial sampling is a screening*
**Algal Masses**

*Spyrogyra* sp.

*Didymosphenia* stalk

*Euglena* sp.

Images: USGS, Sarah Rushforth, Sarah Spaulding
Identifying Harmful Algal Blooms (HABs)

Utah Lake, October 8, 2014

Dolichospermum spiroides
Aphanizomenon flos-aquae

Cyanobacteria (Blue-Green) Bloom

Utah Lake, August 25, 2015

Oocystis species
Diatom assemblage
Euglena sp

Chlorophyta (Green Algae)
Very little cyanobacteria present
Not HAB
Cyanobacteria

Identification and Enumeration:
1. Taxonomic analysis of a possible HAB starts with presence/absence of cyanobacteria

2. HAB confirmation

3. If bloom is an HAB, extent and level of taxonomy needed is determined case by case

4. Early observation of high cell density of a potentially toxic taxa may result in an immediate recommendation for toxicity testing

5. Taxonomic identification and enumeration continues and narrows as needed
The Taxonomy of HABs

1. Confirmation of cyanobacteria (presence/absence)

2. Qualitative (relative abundance)
   1. to category
   2. to genus
   3. to species

3. Quantitative (enumeration)
   1. of categories
   2. of genera
   3. of species

Along with guidelines for toxicity levels, cells per mL can help determine the course of action taken in response to a bloom event.

WHO’s HAB guidelines include c/mL and states are developing guidelines that follow that criteria.

May save time and money without loss of data if enumeration is conducted to natural counting units p/mL.
Taxonomy of the Cyanobacteria:

**Anabaena**
- Pictured here: 4 species

**Cylindrospermum**
- Pictured here: 7 species

**Dolichospermum**
- Pictured here: 4 species
Resistant cyanobacteria from hot spring approximately 105 degrees. At least 12 genera in this image.
Common Cyanobacteria Taxa Found in HABs

**Pseudanabaena**

<table>
<thead>
<tr>
<th>Subgenus</th>
<th><em>Pseudanabaena</em></th>
<th><em>Skujanema</em></th>
<th><em>Nyonema</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell form</td>
<td>± cylindrical</td>
<td>± cylindrical</td>
<td>± cylindrical</td>
</tr>
<tr>
<td>Terminal aerotopes</td>
<td>— or (+)</td>
<td>— or (+)</td>
<td>+</td>
</tr>
<tr>
<td>Width of trichomes</td>
<td>0.8–2.5 µm</td>
<td>2 µm</td>
<td>3 µm</td>
</tr>
<tr>
<td>Apical cell</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
</tbody>
</table>

**Type species**

- *P. catenata* **Lauterbr.** 1915
- *P. arcuata* (Skuja) c. n.
- *P. biceps* **Bocher** 1946

**Species**

- *P. articulata* **Skuja** 1948
- *P. accicularis* (Nygl.) c. n.
- *P. batrachospernum* (Skuja) c. n.

- *P. limnetica* (Lemm.) **KOM.** 1974
- *P. franquetti* (Boehr.) Boehr. 1970
- *P. galeata* **Bocher** 1949

- *P. tenus* **Koppe** 1924
- *P. mucicola* (Naum. et Huc-Pest.) Boehr. 1970
- *P. lonchoides* **Anagn.** 1961

- *P. nematodes* (Skuja) c. n.
- *P. papillaterminata* (Kisiel.) **Kork** 1959

- *P. raphidioides* (Geitl.) c. n.
- *P. skujae* **Claus** 1962

Planktolyngbya

- Solitary trichomes (planktic)
- Max. width 2.8 um
- Presents of obligatory sheaths
oscillatorialean characters:
1. Filamentous.
2. Absence of heterocytes and akinetes.

Images: Sarah Rushforth, Mindy Morales, and Kalina Monolov
Nostocaceae (filamentous, with heterocyte and akinete)

*Anabaena*–coiled or straight trichome, usually solitary, with aero topes
*Cylindrospermum*–cylindrical trichomes in benthic mats, epiphytic, akinetes always adjacent to terminal heterocytes
*Cylindrospermopsis*–trichomes planktonic or solitary, akinetes near or next to the heterocytes, attenuated in both ends
*Aphanizomenon*–trichomes asymmetric, narrowed terminal cells, akinetes intercalary, some form fascicles
*Nostoc*–trichomes within distinct colonies
*Nodularia*–cells shorter than wide, planktonic with aerotopes, benthic in mats
*Anabaenopsis*–planktonic, heterocytes appear terminal
Dolichospermum circinale

Dolichospermum crassum

Heterocytous characteristics
Gloeotrichia

Fig. 2.53. Cyanobacteria. *Gloeotrichia echinulata*. Portion of a sterile colony.
Chroococcales

Colonial

Fig. 2.39. cyanobacteria *Microcystis*. A colony containing hundreds of cells.

Family-Oscillatoriaceae