Utah Lake: HABs and potential drivers of algal growth

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2014 Harmful Algae Blooms

Microcystins:
>4 ug/L: 3 samples
0-4 ug/L: 9 samples
2016 Harmful Algae Blooms

Exceedances of 100K cell/mL benchmark:

- July 13 – Aug 31
- Open water, marinas/beaches, and Jordan River at outlet
- Surface scum & integrated samples
- 34 of 108 samples

14 samples exceeded 1M cells/mL.
2016 Harmful Algae Blooms

![Graph showing average total cyanobacteria (cells/mL) from July 15 to October 1. The graph compares Marinas & beaches, Open water, and JR at outlet.](image-url)
2016 Harmful Algae Blooms

Open water

Marinas and beaches
2016 Harmful Algae Blooms

Lincoln Harbor/Beach

Microcystins: 3.6 - 600+ ug/L
Aphanizomenon: 2 M - 43.5 M
Dolichospermum: 2 K – 225 K

Marinas and beaches

Microcystins: 63 ug/L
Aphanizomenon: 20 M
Dolichospermum: 0
Potential drivers of algal growth

1. Lake elevation
2. Water temperature
3. Nutrients
4. Mineral turbidity & light
DWQ’s Utah Lake dataset

25+ years of data
1. Water temperature
2. Chlorophyll a
3. Water clarity
4. Nutrients

Lake elevation data from CUWCD

Chlorophyll a as a proxy for HAB likelihood

Buoy network for specific HAB event predictions
DWQ’s Utah Lake dataset

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Buoy network for specific HAB event predictions
Chlorophyll $a$ and lake elevation

All months

Aug-Oct

Lake elevation (ft)
Chlorophyll $a$ and temperature

\[ \text{Chl} \ a \ (\text{ug/L}) \]

Water temperature ($^\circ$C)

\[ r^2=0.01 \]
\[ p=0.04 \]

\[ r^2=0.03 \]
\[ p=0.04 \]
Trophic State Indices

Tool for estimating primary productivity in lakes

1. Chlorophyll $a$
2. Nutrients (total phosphorus)
3. Water clarity (Secchi disk depth)

Effectively re-scales trophic indicators into consistent units.

Differences or similarities in TSI values among types can be used to make inferences regarding limiting factors or lake processes.

(Carlson and Simpson 1996, Carlson and Havens 2005)
Table 1. Suggested interpretations of TSI relationships (adapted from Carlson and Havens 2005).

<table>
<thead>
<tr>
<th>TSI Relationship</th>
<th>Suggested interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSI (Chl-a) = TSI (SD)</td>
<td>Algae dominate light attenuation.</td>
</tr>
<tr>
<td>TSI (SD) = TSI (Chl-a) ≥ TSI (TP)</td>
<td>Phosphorus limits algal biomass, and algae dominate light attenuation.</td>
</tr>
<tr>
<td>TSI (TP) &gt; TSI (Chl-a) = TSI (SD)</td>
<td>Some factor other than phosphorus (zooplankton grazing, nitrogen, etc.) limits algal biomass.</td>
</tr>
<tr>
<td>TSI (Chl-a) &lt; TSI (SD)</td>
<td>Small particles, not necessarily related to algae, dominate light attenuation</td>
</tr>
<tr>
<td>TSI (TP) = TSI (SD) &gt; TSI (Chl-a)</td>
<td>Non algal particulate matter dominates light attenuation. Particles contain phosphorus, but do not contain chlorophyll.</td>
</tr>
<tr>
<td>TSI (SD) &gt; TSI (Chl-a) = TSI (TP)</td>
<td>Dissolved color affects transparency but not chlorophyll or total phosphorus concentrations.</td>
</tr>
<tr>
<td>TSI (TP) &gt; TSI (SD) &gt; TSI (Chl-a)</td>
<td>Zooplankton grazing Has reduced the number of smaller particles, leaving larger particles. Biomass has been reduced below levels predicted from total phosphorus.</td>
</tr>
<tr>
<td>TSI (Chl-a) &gt; TSI (SD)</td>
<td>Large phosphorus-containing particulates dominate.</td>
</tr>
<tr>
<td>TSI (Chl-a) = TSI (TP) &gt;&gt; TSI (SD)</td>
<td>Large chlorophyll-containing particulates, such as Aphanizomenon flakes, dominate.</td>
</tr>
</tbody>
</table>
TSI: Long term trends
TSI differences in Utah Lake

All months

August - October
TSI Interpretations (Carlson and Havens 2005)

**TSI Chl-a < TSI SD**
Small particles, not necessarily related to algae, dominate light attenuation

**TSI Chl-a ≥ TSI TP**
Phosphorus limits algal biomass.

**TSI SD > TSI Chl-a = TSI TP**
Dissolved color affects transparency but not chlorophyll or total phosphorus concentrations.
Total phosphorus (ug/L) vs Chlorophyll a (ug/L)

$r^2 = 0.2$

$P < 0.001$

National context for Utah Lake
National context for Utah Lake

Total phosphorus (ug/L)

Chlorophyll a (ug/L)

NLA

$r^2=0.43$

$P<<0.001$
National context for Utah Lake

Chlorophyll $\alpha$ (ug/L) vs. Total phosphorus (ug/L)

- $NLA$
- $r^2=0.43$
- $P<<0.001$

Other limiting factors
National context for Utah Lake

NLA 2012 Data

Chlorophyll $a$ (ug/L) vs. Total phosphorus (ug/L)

- Triangles: TN/TP $\geq$ 7.2
- Squares: TN/TP < 7.2
National context for Utah Lake

NLA 2012 Data

Chlorophyll a (ug/L) vs Total phosphorus (ug/L)

- Green circles: Utah Lake
- Orange triangles: TN/TP>=7.2
- Purple squares: TN/TP<7.2
Questions
Citations


IR 2016 Methods

Beneficial Use Supported
The beneficial use is supported if cyanobacteria cell counts are < 20,000 cells/ml.

Beneficial Use Not Supported
The beneficial use is not supported if the cyanobacteria cell count exceeds 100,000 cells/ml for more than one sampling event or other narrative indicators (e.g., phycocyanin, chlorophyll a, harmful algal bloom–related beach closures) suggest recreational uses are not being attained.

Insufficient Data and Information
The waterbody will be categorized 3A if there is one exceedance of 20,000 cells/mL. These waterbodies will be prioritized for further evaluation with respective public health managing partners such as the Utah Department of Health and state parks departments.
Seasonal patterns
Annual lake elevation
ChlA and Turbidity Measures

- ChlA vs. TSS (mg/L): $r^2 = 0.22$, $p < 0.001$
- ChlA vs. TFS (mg/L): $r^2 = 0.07$, $p < 0.001$
- ChlA vs. TVS (mg/L): $r^2 = 0.12$, $p < 0.001$
- ChlA vs. Turbidity (NTU): $r^2 = 0.14$, $p < 0.001$
NLA TSIs
Utah Lake TSI difference plot

- **TSI ChlA - TSI TP**
- **TSI ChlA < TSI TP**
- **TSI ChlA > TSI TP**
- **P surplus**
- **P limitation**

- **TSI Secchi > TSI TP**
- **TSI Secchi = TSI TP**
- **TSI Secchi < TSI TP**

**TSI ChlA < TSI Secchi**

**TSI ChlA > TSI Secchi**

Blue = Provo Bay
Utah Lake and NLA Trophic Relationships