Long-Term Water Quality Trends in Wisconsin Lakes

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Wisconsin Department of Natural Resources
14,300 lakes > 1 hectare
Is lake water quality getting better, worse, or staying the same?

Melvin McCartney, Lake Monona
Long-Term Water Quality Monitoring

Spring and 3 X’s in summer:
- Secchi depth
- Temperature/D.O. profile
- Total Phosphorus
- Chlorophyll $a$
- Conductivity (optional)
- pH (optional)

1 X in summer:
- Color
- Total Kjeldahl Nitrogen
- NO$_2$+NO$_3$
- Alkalinity

5 year cycle:
- Ca
- Mg
Trends in Total Phosphorus Over Time

8 lakes decreasing TP
46 lakes no change in TP
6 lakes increasing TP

Average + stdev

Latitude

decrease steady increase

42 43 44 45 46 47
Trends in Total Phosphorus Over Time

**Decrease**
- Browns

**Steady**
- Pelican

**Increase**
- Lac Courte Oreilles
- Crystal
- Pewaukee
- Ripley
Trends in Total Phosphorus Over Time

**Decrease**

- Browns
- TP Criteria

**Steady**

- Pelican

**Increase**

- Lac Courte Oreilles

- Pewaukee

- Recreation Criteria

- Ripley

- Crystal
Expand analysis to all WDNR data

WDNR Data Download:
- 218,300 records
- 1501 lakes
- Data from 1968 - 2015
- Up to 34 years of data on a single lake
Exclude hypereutrophic lakes (≥ 0.1 mg/L) from Total Phosphorus analysis

153 hypereutrophic lakes
Simple linear regressions

- June 15 – September 15
- Annual Average
- Natural logarithm of concentration
Limit trend analysis to lakes with at least 3-5 years of data.

Graphs showing the trend analysis for different water chemistry parameters:
- **Total Phosphorus**
- **Total Kjeldahl Nitrogen**
- **NO2+NO3**
- **Alkalinity**
- **Calcium**
- **Magnesium**

The graphs illustrate the change in concentration over time, with arrows indicating a significant change or trend.
Limit trend analysis to lakes with at least 3-5 years of data
Trend Slopes Near 0 on Most Lakes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Median Slope</th>
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<tbody>
<tr>
<td>TP</td>
<td>0.003</td>
</tr>
<tr>
<td>TKN</td>
<td>0.25</td>
</tr>
<tr>
<td>NO2+NO3</td>
<td>0.000</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>0.13</td>
</tr>
<tr>
<td>Ca</td>
<td>-0.68</td>
</tr>
<tr>
<td>Mg</td>
<td>-0.94</td>
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<tr>
<td>Color</td>
<td>0.72</td>
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3%-27% of lakes had a significant trend

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Total N</th>
<th>Increasing</th>
<th>Decreasing</th>
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<tbody>
<tr>
<td>TP</td>
<td>502</td>
<td>92</td>
<td>140</td>
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<tr>
<td>TKN</td>
<td>82</td>
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<td>29</td>
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<td>NO2+NO3</td>
<td>140</td>
<td>59</td>
<td>19</td>
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<tr>
<td>Alk</td>
<td>29</td>
<td>19</td>
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</tr>
<tr>
<td>Ca</td>
<td>19</td>
<td></td>
<td></td>
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<tr>
<td>Mg</td>
<td>59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Color</td>
<td>59</td>
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<td></td>
</tr>
</tbody>
</table>

**Total N:** 502
No Spatial Pattern in Temporal Trends
No Spatial Pattern in Temporal Trends
No Spatial Pattern in Temporal Trends

Calcium

Magnesium
No Spatial Pattern in Temporal Trends
Are lakes getting better or worse?

Minimum TP (mg/L) vs. Maximum TP (mg/L) diagram:
- TP Stays Low
- TP Stays High
- Decreasing
- Increasing
- Recreation Criterion
- No change
National Aquatic Resource Surveys: Minimally Disturbed Lakes and Streams are Getting Worse

Survey Comparison
- Lakes (2007-2012)
- Streams (2000/04-2008/09)
- Streams (2008/09-2013/-14)

Annual Change in TP (µg/L)
- < 0
- 0 - 2
- 2 - 4
- > 4

from Stoddard et al. 2016 Env Sci & Tech
National vs. Wisconsin Trends

Median annual TP increase: 1.6 ug/L/year

from Stoddard et al. 2016 Env Sci & Tech
Trends in Total Phosphorus from 2007-2012 vs. Full Record

Full Record

- Years of Data: 4 - 31
- Start Year: 1973 - 2007
- End Year: 2012 - 2015

Paired T-Test (p<0.02)
Summary of Trends

• Most lakes have not changed over time spans of 3 – 43 years, but a small percent of lakes have significantly increasing or decreasing trends.
• Lack of spatial pattern suggests local watershed processes are important drivers.
• Median slope
  – Calcium, Magnesium
  0 NO2+NO3
  + TP, TKN, Alkalinity, Color
Thanks to Department of Natural Resources lake biologists, summer staff, and citizen volunteers!