Is there a Nutrient Flux from the Sediments in Clear Lake?

Blue Ribbon Committee – Technical Subcommittee Meeting #10
July 23rd, 2020
Processes Affecting the Lake Water Quality

Understanding the dominant processes in the lake watershed and in the lake itself that are negatively impacting lake water quality and ecosystem health.
Internal Loading and Anoxia

Under **anoxic** conditions .... $PO_4^{-3}$ is released from the lake sediments

Under **oxic** conditions ... Fe$_3$PO$_4$ prevails insoluble in the lake sediments

**Internal Loading**
Quantifying Internal Loading in Clear Lake

• UCD – TERC
  ➢ Collected Lake Sediment Cores in Clear Lake
  ➢ Conducted Lab Nutrient Release Experiments

• First Measurements of Internal Phosphorous-Release from the Lake Sediments in Clear Lake

(Nick Framsted, MS Student)
Is there a Phosphorus Flux from the Sediments?

<table>
<thead>
<tr>
<th>P-Loading Source</th>
<th>P-Species</th>
<th>Annual Load (MT yr⁻¹)</th>
<th>% Annual SRP load</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td>SRP</td>
<td>37.1 - 51.4¹</td>
<td>59-67%</td>
</tr>
<tr>
<td>Internal</td>
<td>SRP</td>
<td>25.6</td>
<td>33-41%</td>
</tr>
</tbody>
</table>

Red represents anoxia during the stratified period in 2019

(Nick Framsted, MS Student)
Magnitude of Phosphorous Flux from the Sediments Under Different Ambient Conditions

Laboratory Experiments @ 15°C

Temperature correction @ 24°C

### Annual Internal Load

<table>
<thead>
<tr>
<th>P-Loading Source</th>
<th>P-Species</th>
<th>Annual Load (MT yr⁻¹)</th>
<th>% Annual SRP load</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td>SRP</td>
<td>37.1 - 51.4¹</td>
<td>39-67%</td>
</tr>
<tr>
<td>Internal</td>
<td>SRP</td>
<td>25.6</td>
<td>53-41%</td>
</tr>
</tbody>
</table>

(Nick Framsted, MS Student)
Happening this Summer!

• Second **Lab Nutrient Release Experiment** under Warm (summer) Conditions

• **Goal:** *Validate* our theoretical estimates of corrected P-release rates from the sediments
Thank you Alicia and TERC/ UC Davis team!

Now...Long-term data can confirm importance of potential sediment flux combined with climate for Clear Lake Management
Turning up the heat:
Effects of Wildfire and Climate Warming on Water Quality of a Hypereutrophic California Lake

Angela De Palma-Dow
Lake County Water Resources
Ian McCullough
Michigan State University
Jennifer A. Brentrup
University of Vermont

Submitted to:
Journal of Lake and Reservoir Management, in review
Presented to:
-2020, June CA Water Data Symposium
-2020, July Ecological Society of America
Project Motivation
A need for post-fire lake studies: Temperate Lakes

“Despite over 30 years of increasing fire exposure, fire effects on fresh waters have not been well studied...and most of the limited lake-fire research has been conducted in boreal landscapes”
Q: What is predicting WQ conditions in Clear Lake?


Lake WQ $\rightarrow$ Total Phosphorus (TP), Total Suspended Solids (TSS), Chlorophyll-A (Chl-a)

**Why?**

A) Sound & effective management decisions
B) Utilize Long Term Data Sets
C) Info sharing with other lake managers with wildfire & climate complications, eutrophic & temperate lakes
Long-Term, Public Data We Used

- CDWR Water Data Library (TP 1968-2020, TSS 2004-2020)
- Clear Lake Nutrient TMDL program (Chl A 2004-2020)
- PRISM Climate Data (Precip, Air Temp 1968–2020)
- CalFIRE FRAP data (Fire, 1923-2018)
- LAGOS (spatial data)

  - https://github.com/cont-limno/ClearLakeCA
Clear Lake Drainage Area

30 m DEM (1309-4810 ft)  

2016 National Land Cover Database
Wildfire History around Clear Lake
No Association TP x Burned Watershed Area

$r = 0.14 - 0.17$

$p = 0.24 - 0.34$

No Recent Association

TSS vs. Burned Area
Mendocino Complex Wildfire and WQ:
15-year Pre & 1.25-year Post x TSS, TP, Chl A

Rule out fire impacts on WQ – for now
- Still monitor for 3-5 years (USGS 2016)
- Drinking water system complications with carbon/organics up to 15 years (Hohner et al. 2019)
• So if not wildfire, and not rain...
• What is influencing TP over time?

Precipitation (inputs): Precip x TP
Correl negative, all seasons, all arms pooled (r range = -0.09 through -0.26)
Long Term Annual TP – Monthly medians (MESSY!)
Extract periods of interest

HABs Blooms Season: June - October
Long-term surface TP (July-Oct)
Increasing over time? Yes!
Thiel-Sen slope annual rate of increase

Upper: 0.005 mg/L (Kendall's p = 0.03)

Lower: 0.003 mg/L (Kendall's p = 0.05)

Oaks: 0.004 mg/L (Kendall's p = 0.05)
3) Climate correlations (long term TP)

*Max air temp is stronger predictor*

---

**Table 3b:** Pearson correlations between seasonal climate and median July-October total phosphorus (TP) in Clear Lake, CA (1968-2018)

<table>
<thead>
<tr>
<th></th>
<th>Upper</th>
<th>Lower</th>
<th>Oaks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nov-Mar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tmin</td>
<td>-0.04</td>
<td>-0.03</td>
<td>0</td>
</tr>
<tr>
<td>Tmax</td>
<td>0.35</td>
<td>0.33</td>
<td>0.38</td>
</tr>
<tr>
<td>Precip</td>
<td>-0.27</td>
<td>-0.26</td>
<td>-0.24</td>
</tr>
<tr>
<td>Apr-Jun</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tmin</td>
<td>0.21</td>
<td>0.31</td>
<td>0.24</td>
</tr>
<tr>
<td>Tmax</td>
<td>0.17</td>
<td>0.2</td>
<td>0.21</td>
</tr>
<tr>
<td>Precip</td>
<td>-0.13</td>
<td>-0.09</td>
<td>-0.12</td>
</tr>
<tr>
<td>Jul-Oct</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tmin</td>
<td>-0.03</td>
<td>0.03</td>
<td>-0.01</td>
</tr>
<tr>
<td>Tmax</td>
<td>0.24</td>
<td>0.23</td>
<td>0.29</td>
</tr>
<tr>
<td>Precip</td>
<td>-0.22</td>
<td>-0.16</td>
<td>-0.23</td>
</tr>
</tbody>
</table>

**bold:** p < 0.05, **italics:** p < 0.1

- Don’t have enough TSS & Chl A long term to confidently connect to climate at this time, drives the importance of continued monitoring!
4) Climate correlations
Does Drought predict TP?

TP not associated with Wildfire, Precip, but winter max air temp, negative with precip = DROUGHT conditions
Future Considerations

- Internal loading analysis / sediment contribution underway

- MONITORING NEEDS
  - VIP pre/post-fire
  - Monitoring Future Uncertainty
    - Long Term State Funding withdrawals
    - Chl A & Nutrients

- Data & Info Sharing
  - Partners
  - Policy Makers
  - Public!!
    - Future efforts to get TERC / County work out there

Blue Ribbon Committee for the Rehabilitation of Clear Lake

UC Davis Tahoe Environmental Research Center

Lake County Water Resources
Department @lakecountywater

Spring time is here time! You too can help track those awesome, endemic... a year ago 140 views

Measuring water clarity with Angela & Marina a year ago 37 views

Too lovely was the liewn der of a holy lake " -Edgar Allan Poe a year ago 146 views

Learn about lake sediment sampling with Water Resources and Californ... a year ago 270 views

Learn about monitoring stream water quality with us at Water Resources!! a year ago 190 views

*One touch of nature makes the whole world kin" - William Shakespeare a year ago 99 views
Thank You! Stay Safe and Healthy!

Questions / Comments?
Angela.DePalma-Dow@lakecountyca.gov
(707)-263-2344 watershed.co.lake.ca.us
Long-term surface and bottom median dissolved oxygen (DO) profile data for July-October (1968-2020)
### Have hypoxia events changed?

<table>
<thead>
<tr>
<th># Days / month</th>
<th>Upper Arm</th>
<th>Lower Arm</th>
<th>Oaks Arm</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>July</td>
<td>12</td>
<td>15</td>
<td>11</td>
</tr>
<tr>
<td>Aug</td>
<td>17</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>Sep</td>
<td>3</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Oct</td>
<td>5</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

| 1964-1991      | 26        | 32        | 25       |
| Percentage     | 4%        | 5%        | 4%       |
| Deep samples   | 271, 9.6% | 300, 10.7%| 309,8%   |

| 1998-2019      | 16        | 18        | 11       |
| Percentage     | 5%        | 5.60%     | 3.40%    |
| Deep Samples   | 152, 10.5%| 157,11.5%| 157,7%   |
Clear Lake Surface Temps SUMMER (July, August, Sept) 1968 - 2017

- MAX: $y = 0.0174x - 8.3011$
- AVERAGE: $y = 0.0479x - 70.618$
- MIN: $y = 0.0801x - 136.9$

Temp Celsius vs YEAR from 1960 to 2020.