Turning up the heat:
Long-term climate warming masks wildfire effects on water quality of a large,hypereutrophic California lake

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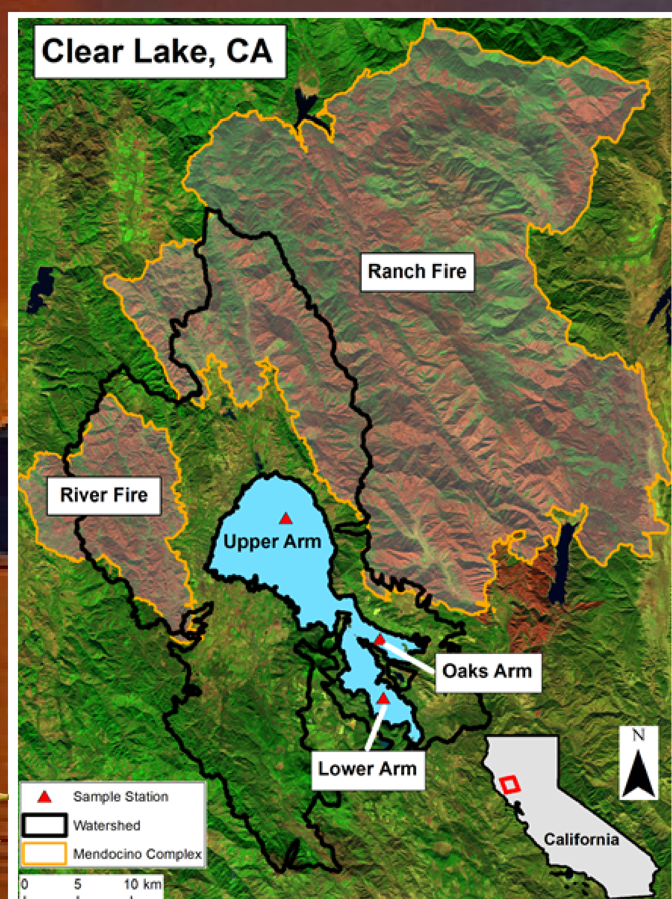


INTRODUCTION

In fall 2018, the Mendocino Complex, the largest wildfire in California's post-settlement history(1) burned around Clear Lake. This was of significance because:

- 459,123 acres including 40% of the Clear Lake Watershed (*Fig 1*) were burned in this fire;
- Clear Lake is the largest natural freshwater lake located entirely within California and provides vital irrigation to Central Valley CA;
- Clear Lake is hypereutrophic and primarily used locally for drinking water, tribal use, and supports a significant local fishing economy.

It is unknown how this large wildfire, and other climate variables, have impacted this valuable water resource and is a main concern for managers and water users.

Fig 1. The River Fire, part of the Mendocino Complex, burns over Clear Lake. Photo Credit: R. Keas

DATA USED & METHODS

We used long-term State and County monthly Clear Lake monitoring data to identify the:

1) Historic watershed burn size impact on dependent lake WQ variables like Total Phosphorus (TP).
2) TP trends over time. Nutrients like TP are strongly associated with dependent WQ variables like pigment Chlorophyll A (Chl-*a*), a biological indicator of lake health representing algae/ phytoplankton growth.
3) Chl-*a* conc. pre and post Mendocino Fire occurrence.
4) How climate variables (like temp and precipitation) explain WQ patterns not explained by wildfire.

Data Used in this Research included:

- CA DWR Water Data Library (TP 1968-2020) **(2)**
- Clear Lake Nutrient TMDL program (Chl-*a* 2004-20) **(3)**
- PRISM Climate Data (Precip, Air Temp 1968–2020) **(4)**
- CalFIRE FRAP data (Fire, 1923-2018) **(1,5)**
- LAGOS spatial data (lagoslakes.org)
- Data Accessible online: github.com/cont-limno/ClearLakeCA

Fig 2. Clear Lake location, sample sites, Mendocino Complex fire and watershed boundary.

RESULTS

Figure 3. Historically, burned watershed area, is not associated with July-Oct surface TP over time across all three arms. (r= 0.14 - 0.17, p= 0.24 - 0.34)

Fig 3. Watershed burn area vs. TP

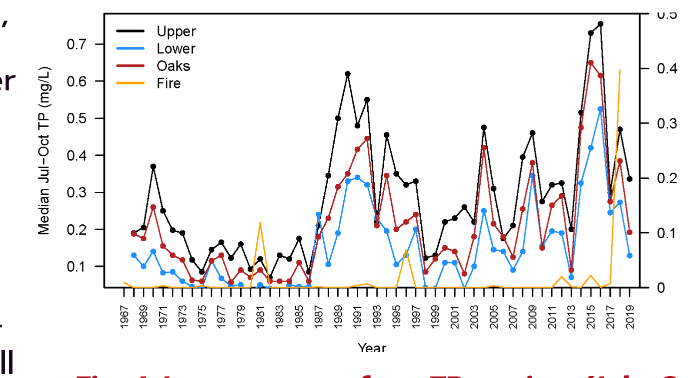


Figure 4. Long-term median monthly (July - Oct) surface TP in Clear Lake has increased in all three arms based on Thiel-Sen slope rate of 3-5 µg/L between 1968 - 2020. (p = 0.03-0.05)

Fig. 4. Long-term surface TP vs time (July-Oct)

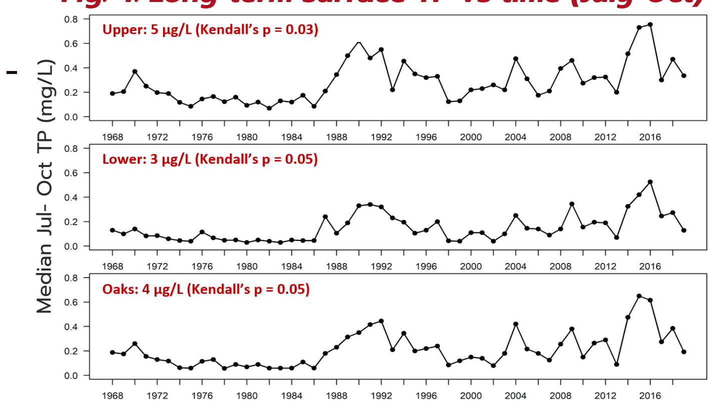
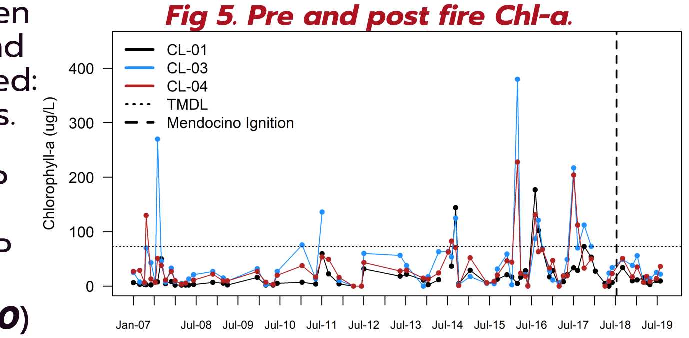


Figure 5. TP is strongly associated with Chl-*a*. but comparing pre and post Mendocino Fire conditions, Chl-*a* did not show an increase.

Fig 5. Pre and post fire Chl-a.



Correlations between climate variables and TP (all arms) revealed:
1) Nov-March MaxTemp vs. TP **(r= 0.33 -0.38, p<0.05)**
2) Nov-March Pricip vs. TP **(r= *-0.4 to -0.27, p< 0.10*)**
3) Jul-Oct MaxTemp vs. TP in Upper and Oaks arm. **(r= *0.24-0.29, p=0.05 - 0.10*)**

CONCLUSION

1) Historically, fire is not associated with TP increases in Clear Lake and Chl-*a* did not increase post Mendocino Complex Fire compared to pre fire conditions.
2) Long-term TP data revealed that TP concentrations have significantly increased in all 3 arms at approximately 3-5 µg/L.
3) Climate variables, particularly low precipitation and warmer winter/spring air temps were more closely associated with increased TP than wildfire indicators

SUMMARY: Eutrophication conditions in Clear Lake are mostly predicted by climate variables and not predominately wildfire. There could be impacts from wildfire, however these effects are probably being masked by climate influences. Future work will include a closer look at impacts of dissolved oxygen, hypoxia occurrence and the role of nutrient rich sediments in determining WQ in Clear Lake.

SOURCES: (1) [CalFire] California Department of Forestry and Fire Protection. 2019. Top 20 Largest California Wildfires. CalFire Statistics and Events [accessed April 28, 2020] https://www.fire.ca.gov/media/5510/top20_acres.pdf (2) [CDWR] California Department of Water Resources. 2002. Bryte Chemical Laboratory Quality Assurance Manual. 2002. Quality Assurance Technical Document 8. Department of Water Resources Publications, Sacramento, California. 48 pp. (3) Lake County Water Resources Department. 2018. Quality Assurance Project Plan for Lake Chlorophyll a and Sediment Nutrient Sampling in Clear Lake, CA. (4) PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu Created 4 Feb 2004. (5) [NFIC] National Interagency Fire Center 2018 National Large Incident Year-To-Date Report; [Cited January 2020] Available at: https://gacc.nifc.gov/sacc/predictive/intelligence/NationalLargeIncidentYTDReport.pdf