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Using Ecological Models to Inform Aquatic Ecosystems Management

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Tools to Evaluate and Ensure Water Quality Standards

Statistical Models

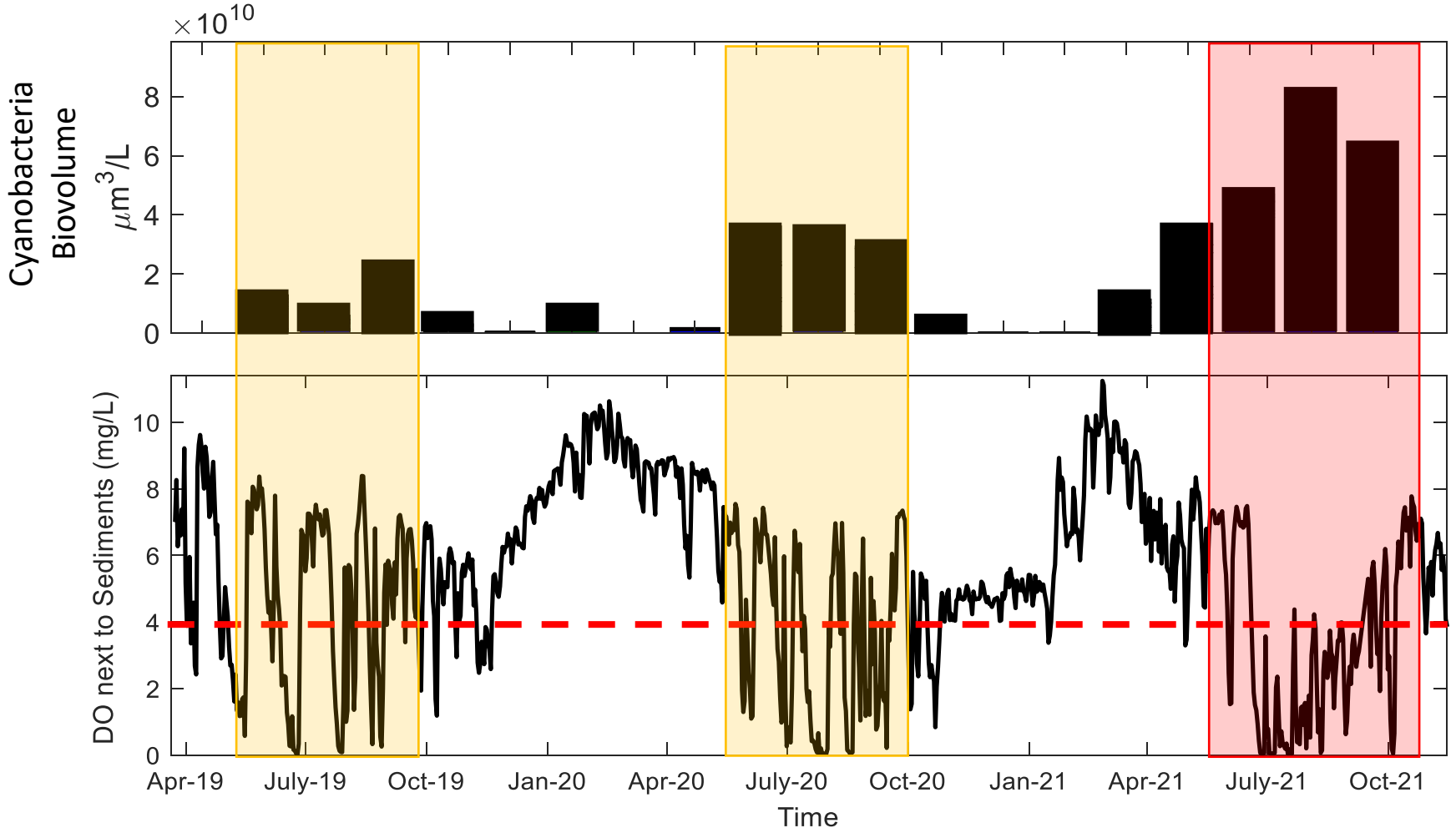
Machine Learning

1D Numerical Models

3D Numerical Models

They allow determining the ecological status using key variables:
Temperature, Nutrients, **Dissolved oxygen**

Consequences of Hypoxia: Cyanobacterial Blooms



Low Benthic Dissolved Oxygen (DO)

↓

Internal Loading

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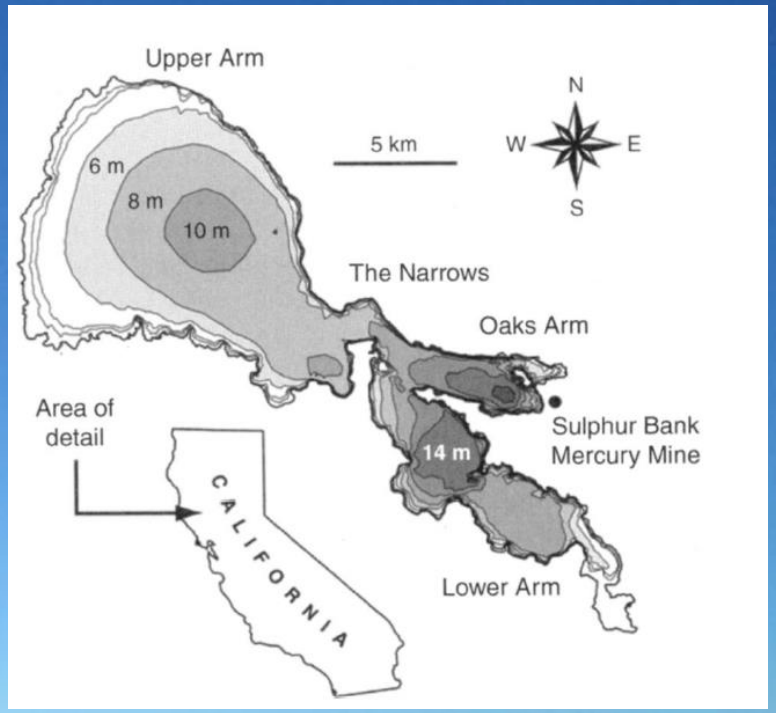
More Intense Cyanobacterial Blooms

Main Goal

Predicting the drawdown of DO in lakes and reservoirs
BUT
Using a 1-D model that requires
only a few input variables



Clear Lake, California

The **largest** natural lake in California (SA = 151 km^2, z_{max} = 15 m)

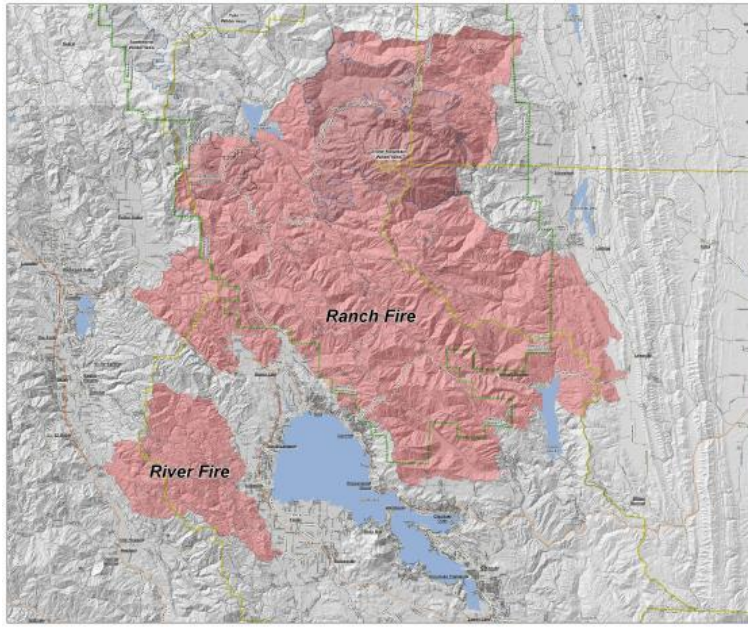
The **oldest** lake in North California (2.5 million years)

Top contributor to the local **Lake County economy** (boating, bass fishing)

Essential for cultural activities and economies of **Native American Tribes**

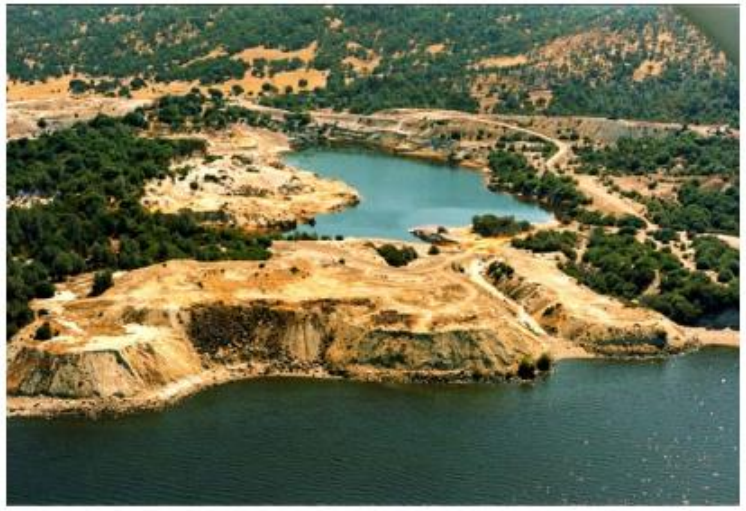
Clear Lake Environmental Challenges

- Eutrophication
- Cyanobacterial blooms
- Extreme wildfires
- Mercury contamination
- Fish kills
- Drinking water quality



Impact of 2018 Mendocino Complex Fire

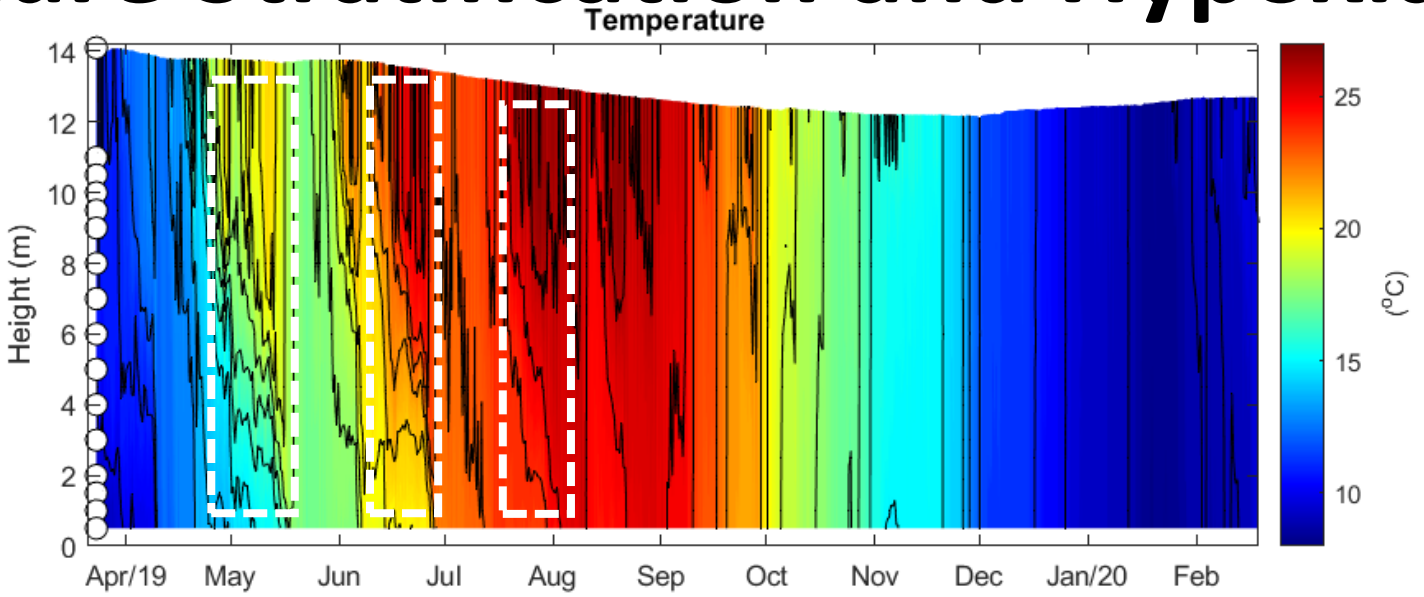
Cyanobacterial bloom, July 2016

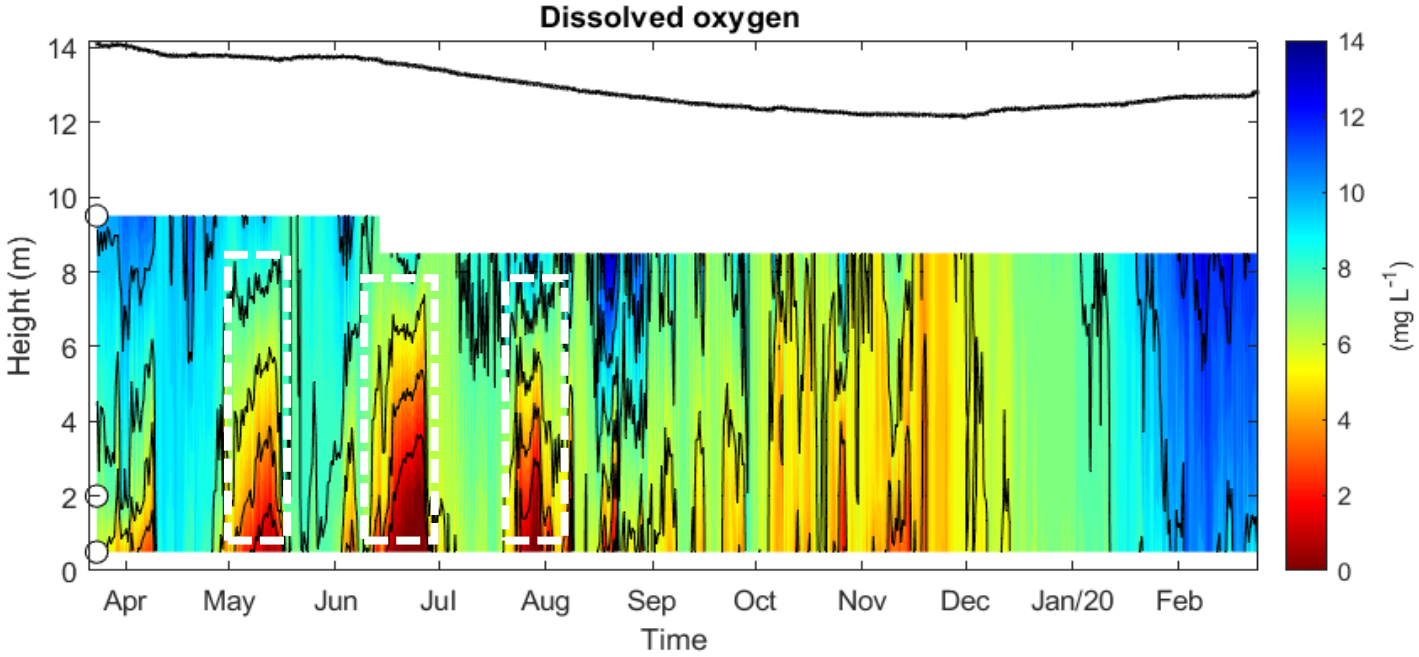


Aerial view of the Sulphur Bank Mercury Mine

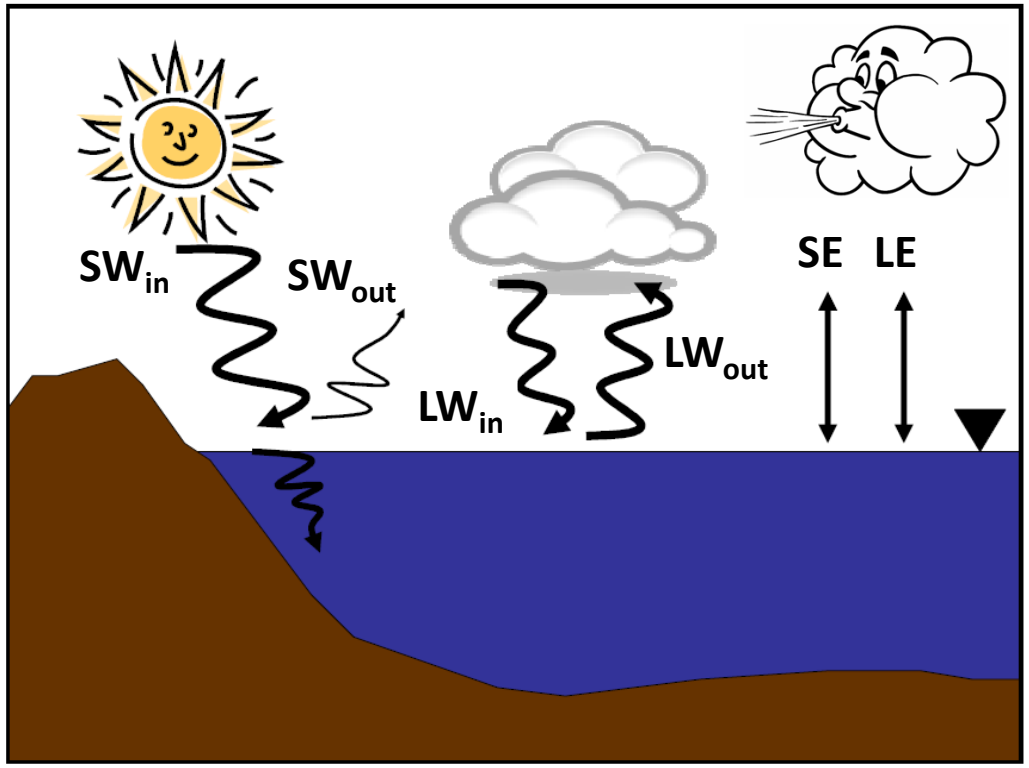
Lake Temperature Stratification and Hypoxia

How can we link Lake Temperature Stratification and Hypoxia?





Meteorological Forcing: Net Surface Heat Fluxes (NSHF)



SW_{net} = Net short-wave radiation ($SW_{in} - SW_{out}$)
LW_{net} = Net long-wave radiation ($LW_{in} - LW_{out}$)
SE = Sensible heat flux (convection)
LE = Latent heat flux (evaporation)

$NSHF = SW_{net} + LW_{net} + SE + LE$

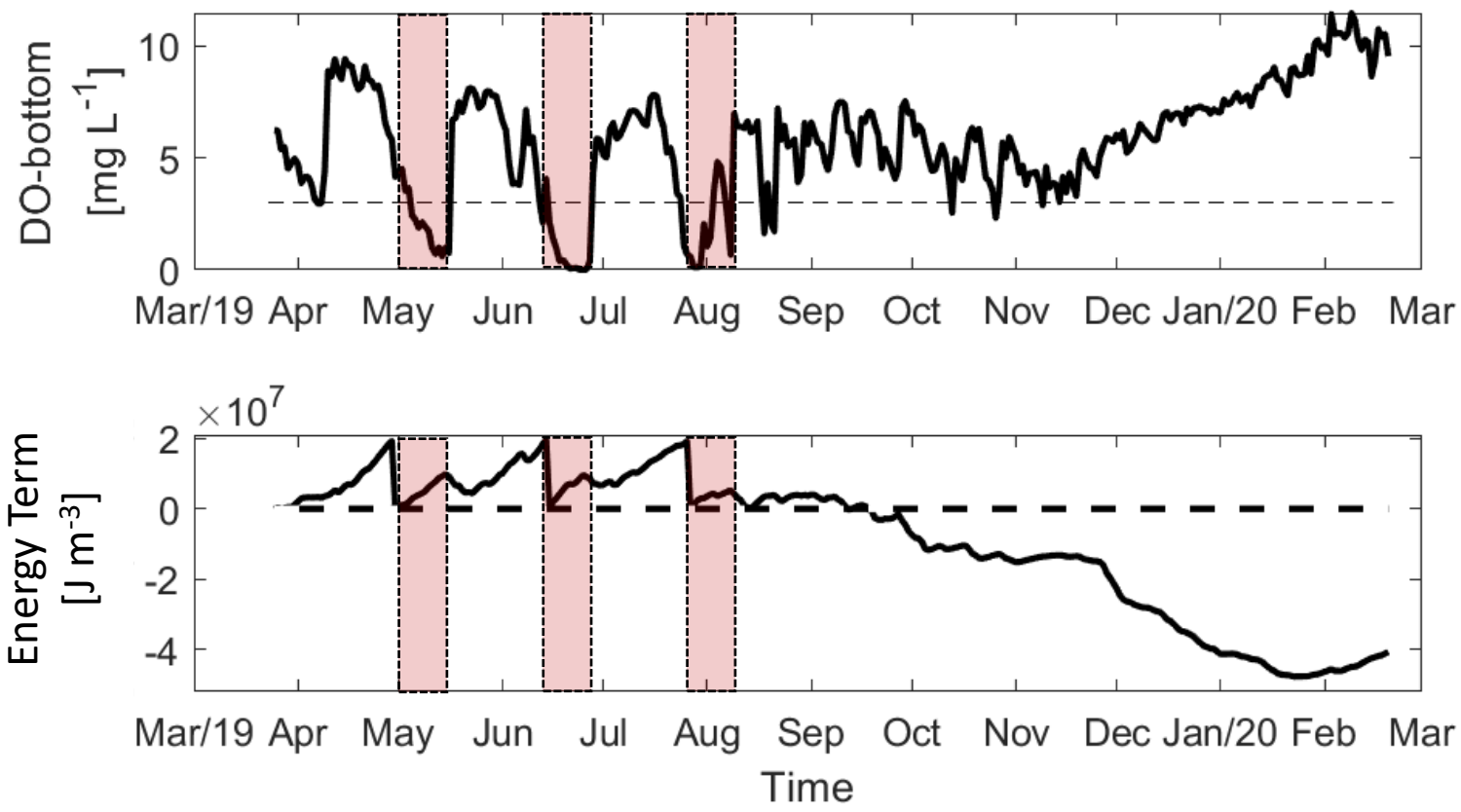
- Incoming Shortwave Radiation
- Air Temperature
- Relative Humidity
- Wind Speed
- Lake Surface Temperature

Predictive Tool of Hypoxic Events based on How Much the Lake Heats and Cools

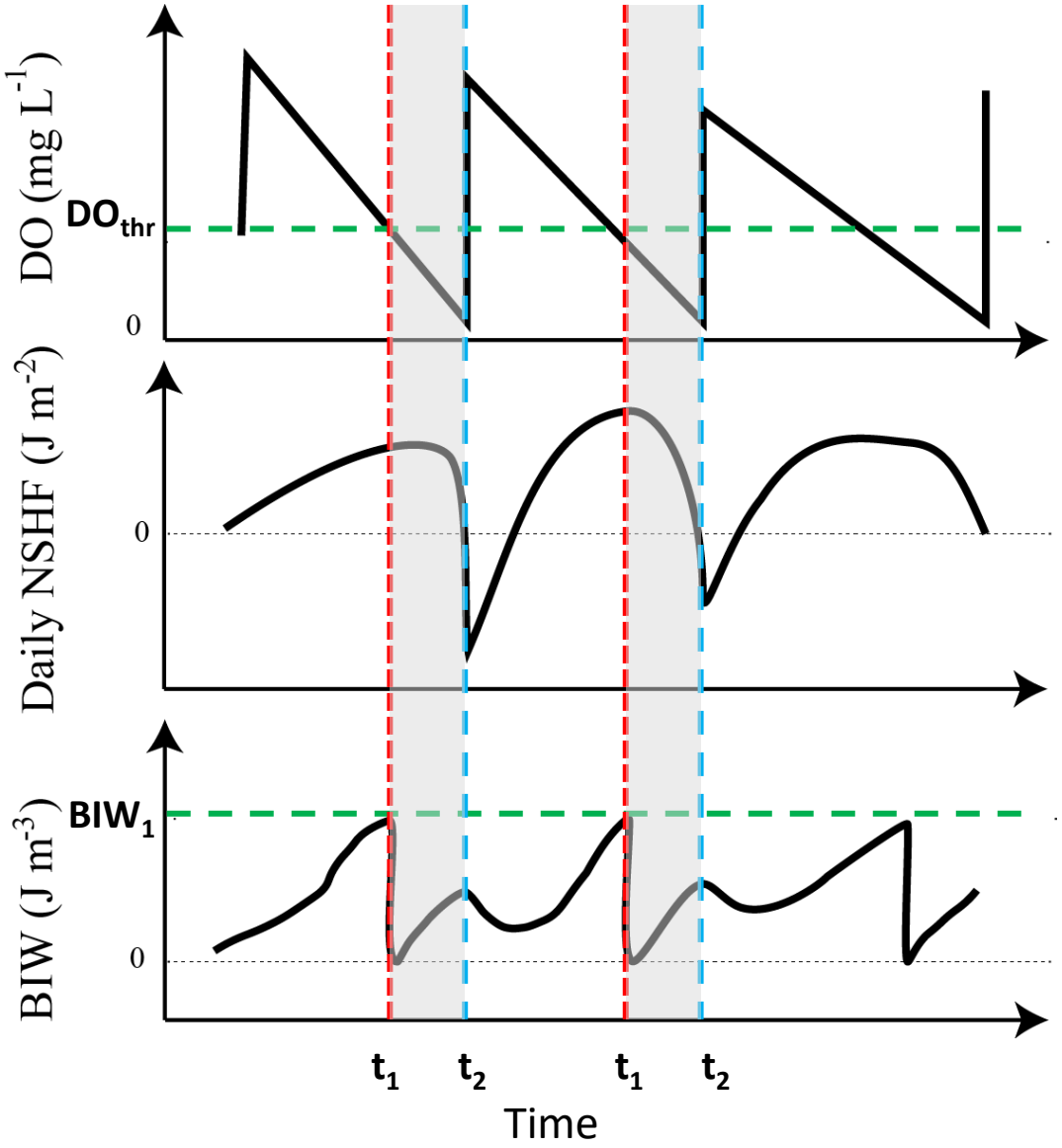
Prediction of Hypoxia from Meteorological Forcing

Lake Data

Prediction of Hypoxia
- **When does it start?**
- **How long does it last?**



Birge-Winkler Method to Predict Hypoxia



NSHF = *Net Surface Heat Flux* = Amount of heat that the lake gains or losses (met forcing)

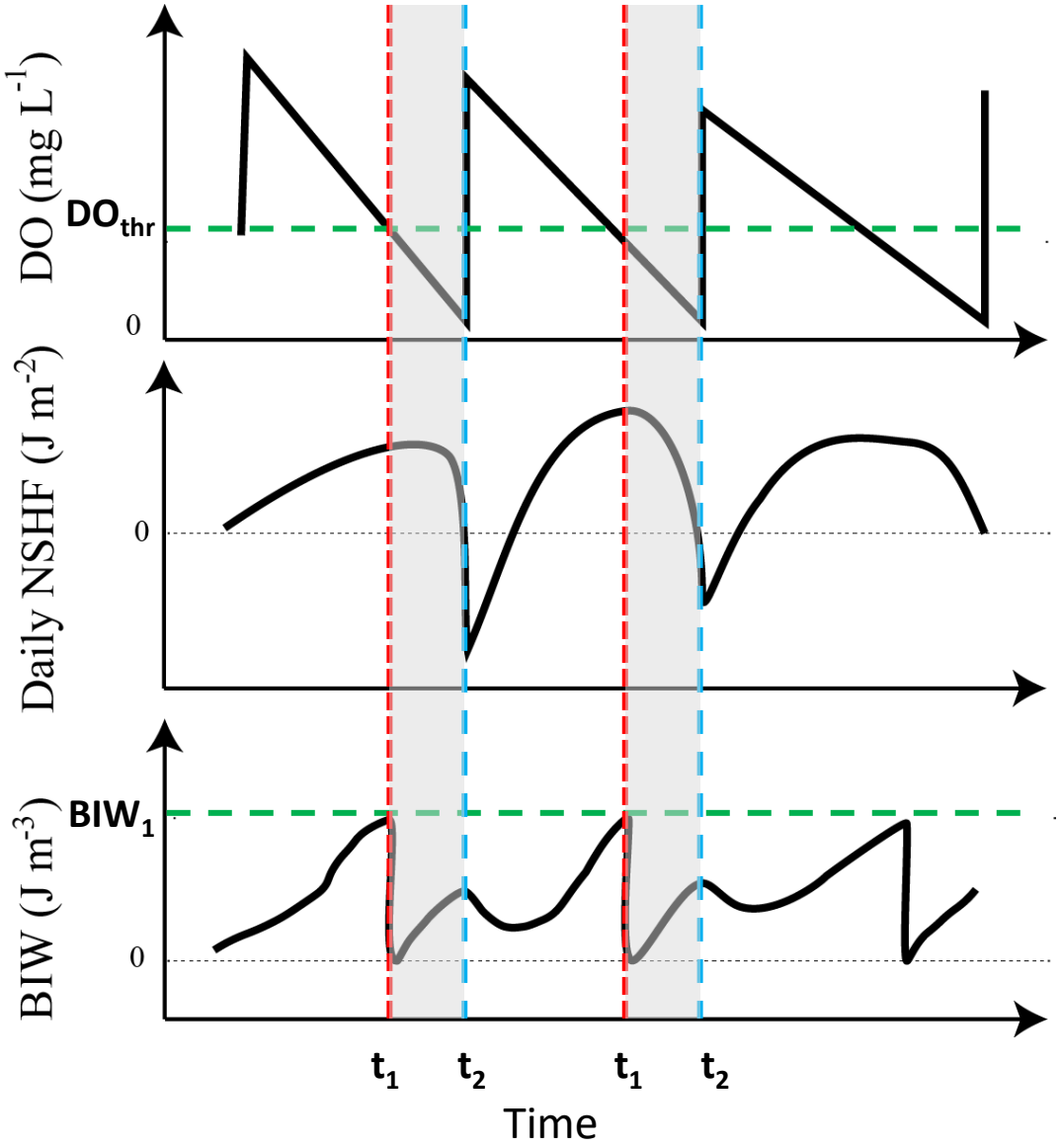
BIW = *Birge-Winkler Energy Term* = Cumulative NSHF between two consecutive hypoxic events

Model Calibration

1. Define a DO threshold of hypoxia ($\mathbf{DO_{thr}}$) and the first day of a hypoxic event ($\mathbf{t_1}$)
2. Compute the cumulative NSHF (BIW) and identify its value at the beginning of the hypoxic event ($\mathbf{BIW_1}$)
3. Identify the day when BIW experiences a sudden drop as the end of the hypoxic event ($\mathbf{t_2}$).
4. The length of the hypoxic event is:

$$t_{hypo} = t_2 - t_1$$

Birge-Winkler Method to Predict Hypoxia



NSHF = *Net Surface Heat Flux* = Amount of heat that the lake gains a losses (met forcing)
BIW = *Birge-Winkler Energy Term* = Cumulative NSHF between two consecutive hypoxic events

Once we identify the BIW value at the beginning of the hypoxic event (**BIW_1**) for a specific water body *we do not need time series of DO next to sediments*, and we can predict:

- When hypoxic events start
- How long hypoxic events last

Warning Tool for Water Purveyors, Cyanobacterial Sampling, Oxygenation Systems

https://terc-clearlake.wixsite.com/cldashboard

Research Team

Name	Position
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Steve Sadro	Co-PI
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Steven Sesma	Research Associate (Chemistry)
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Katie Senft	Research Associate (scuba & field)
Brandon Berry	Research Associate (scuba & field)
Samantha Sharp	Graduate Student
Micah Swann	Graduate Student
Ruth Thirkill	Graduate Student
Kanarat (Job) Pinkanjananavee	Graduate Student
Carmen Woods	Project administration
Lindsay Vaughan	Undergraduate

Thank you!
Questions?

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