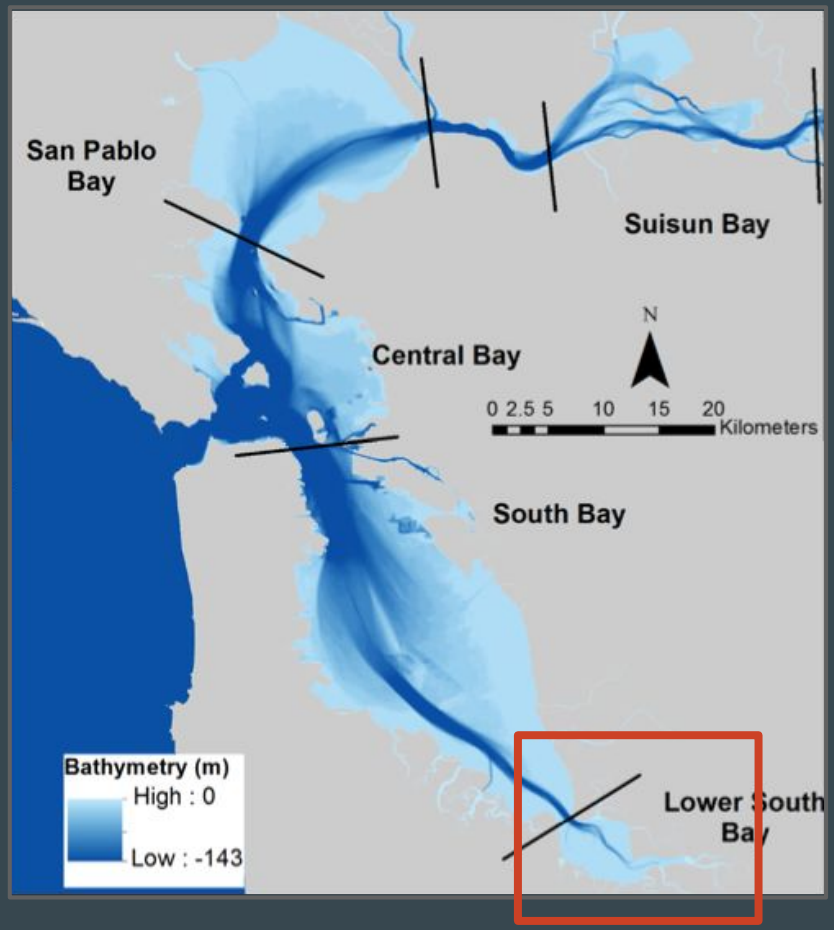
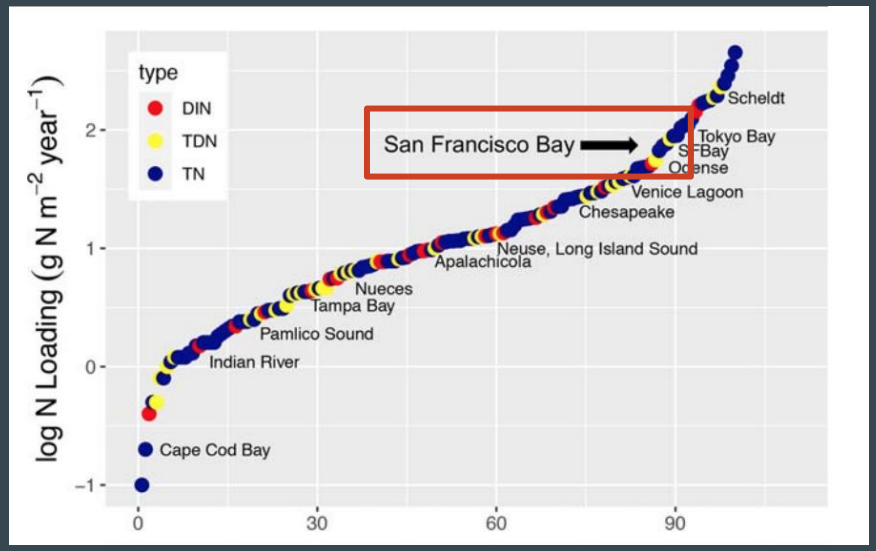
# The link between nutrient dynamics and water quality in the Lower South Bay

**Ariella Chelsky**, Derek Roberts, Kristin Art, Lilia Mourier, David Senn

SFEI | AQUATIC SCIENCE CENTER
SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER

# Nutrients in SF Bay



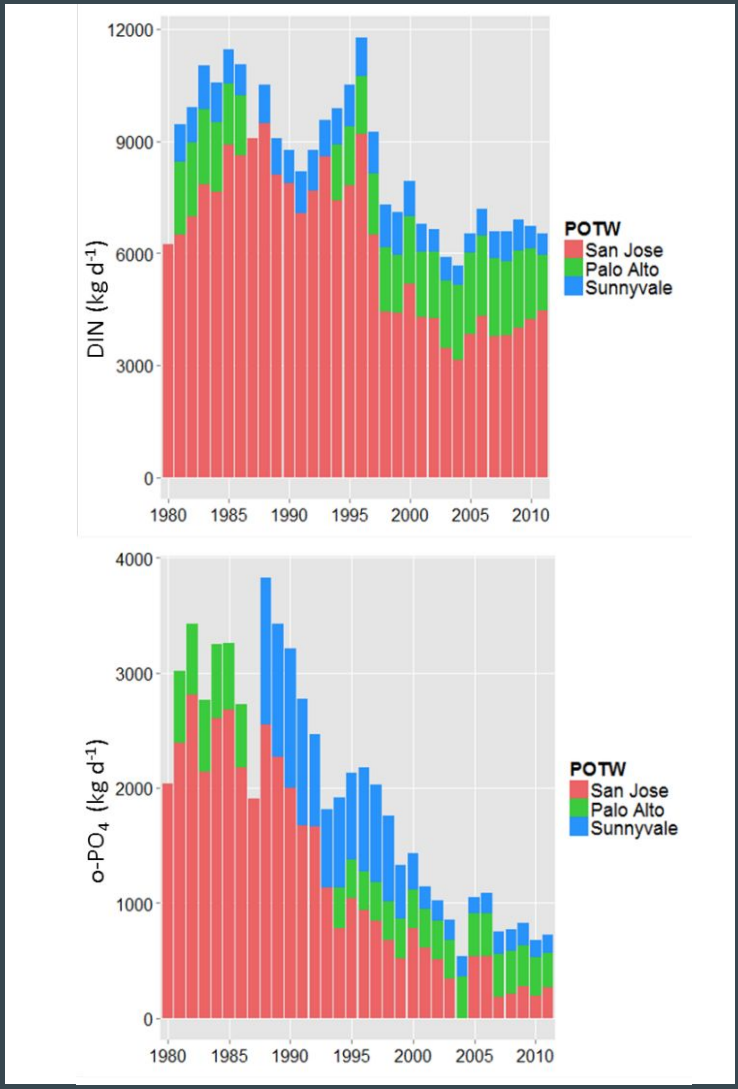



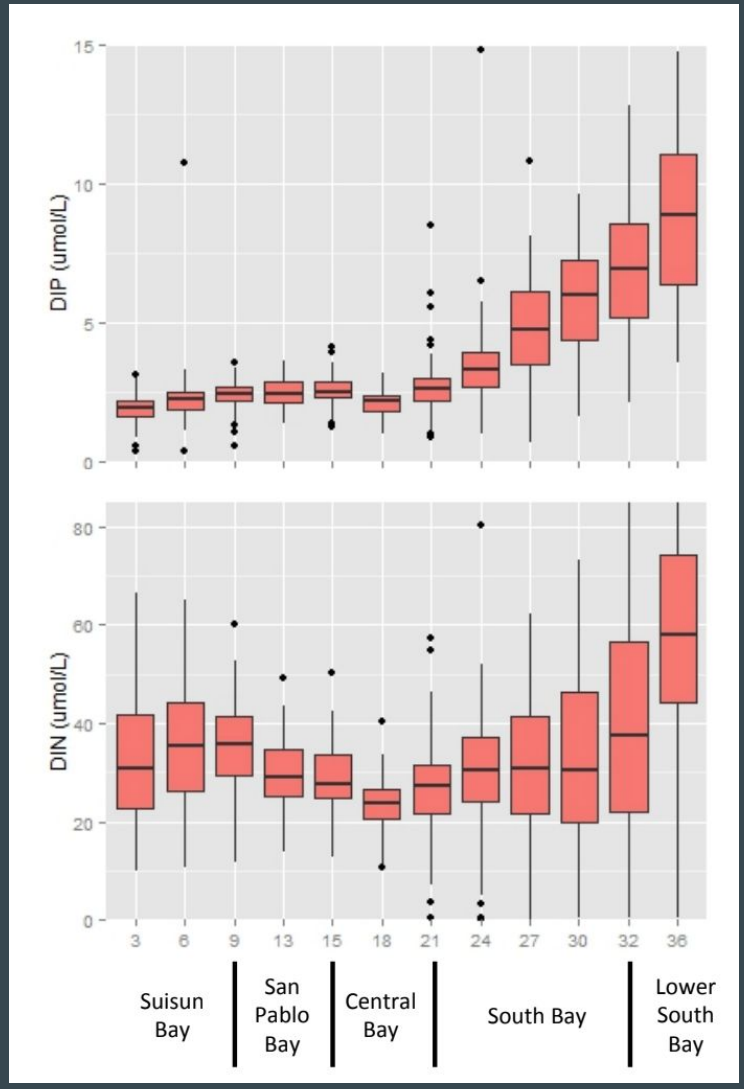

Cloern et al. 2020, Estuaries and Coasts

| Bay-wide Loads | |
|---|---|
| N: | 50,000 kg d$^{-1}$ |
| P: | 5,000kg d$^{-1}$ |

| | |
|---|---|
| 65% | Wastewater |
| 20% | Agriculture |
| 15% | Stormwater |

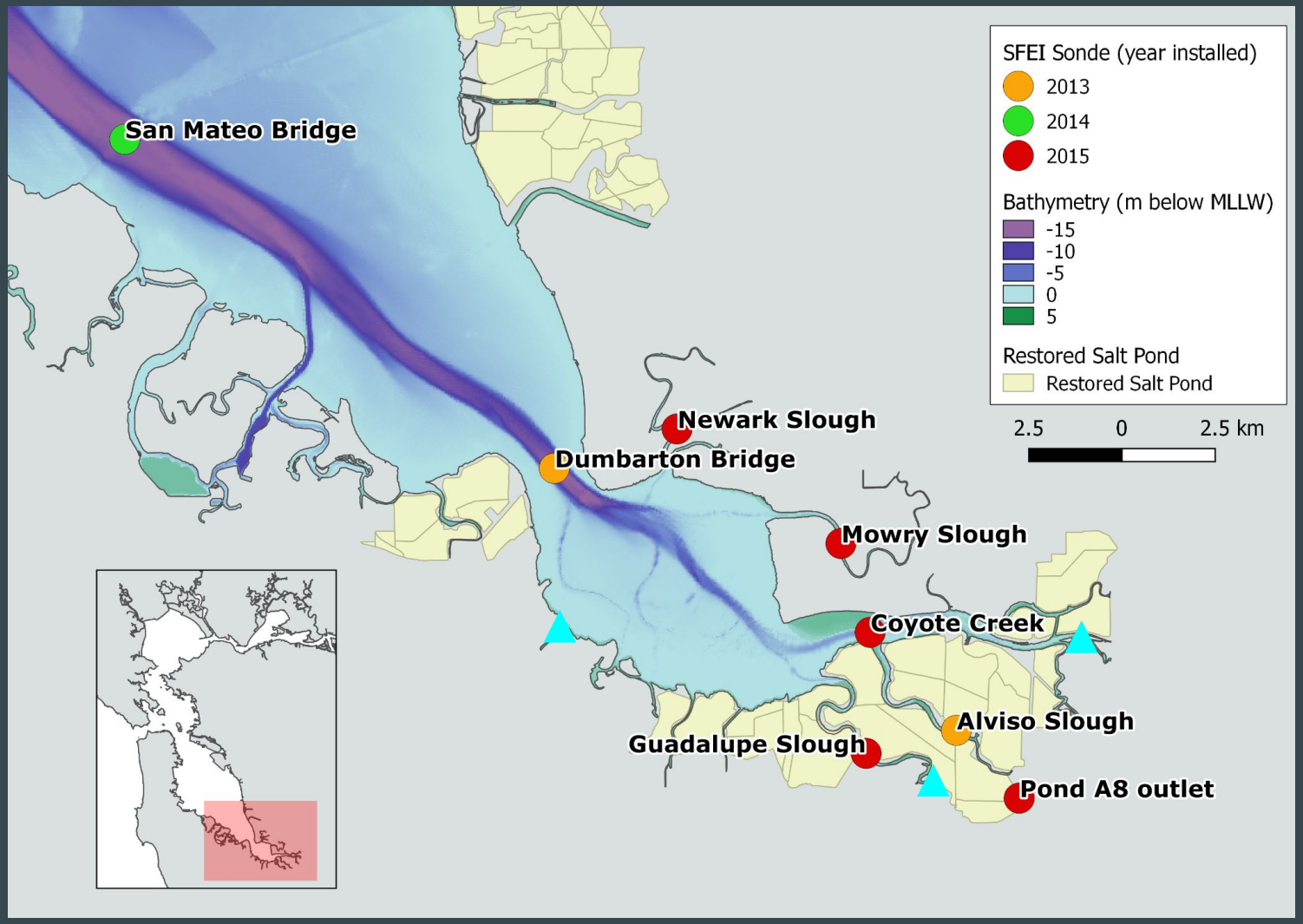
# Nutrient Dynamics in LSB



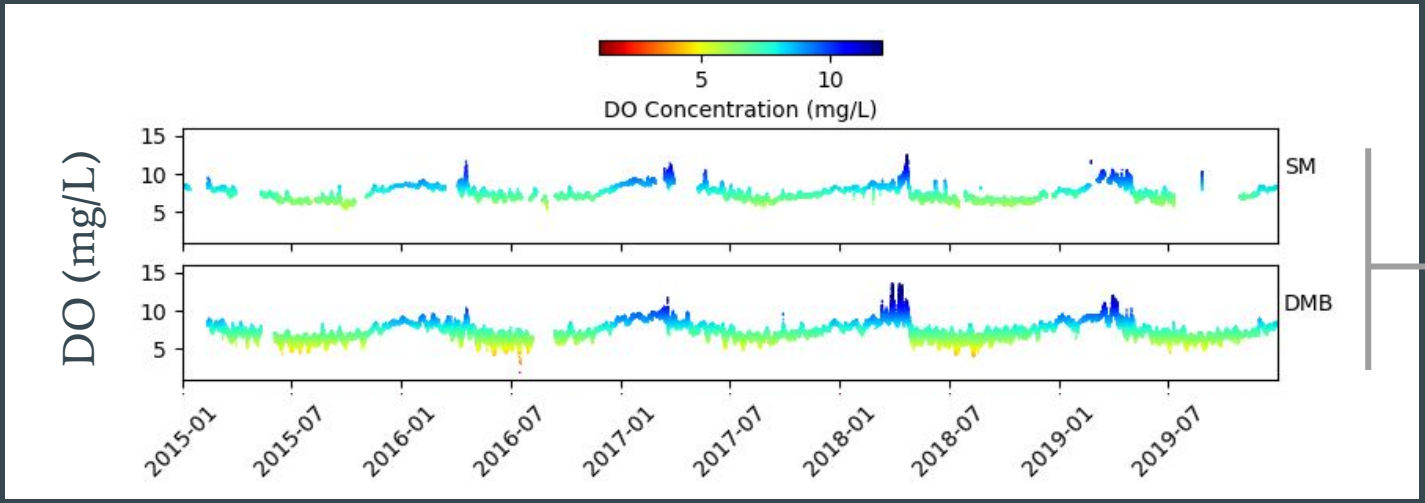




Crauder et al. 2016, SFEI

# Lower South Bay Margin Habitats



# Low DO in Margin Habitats



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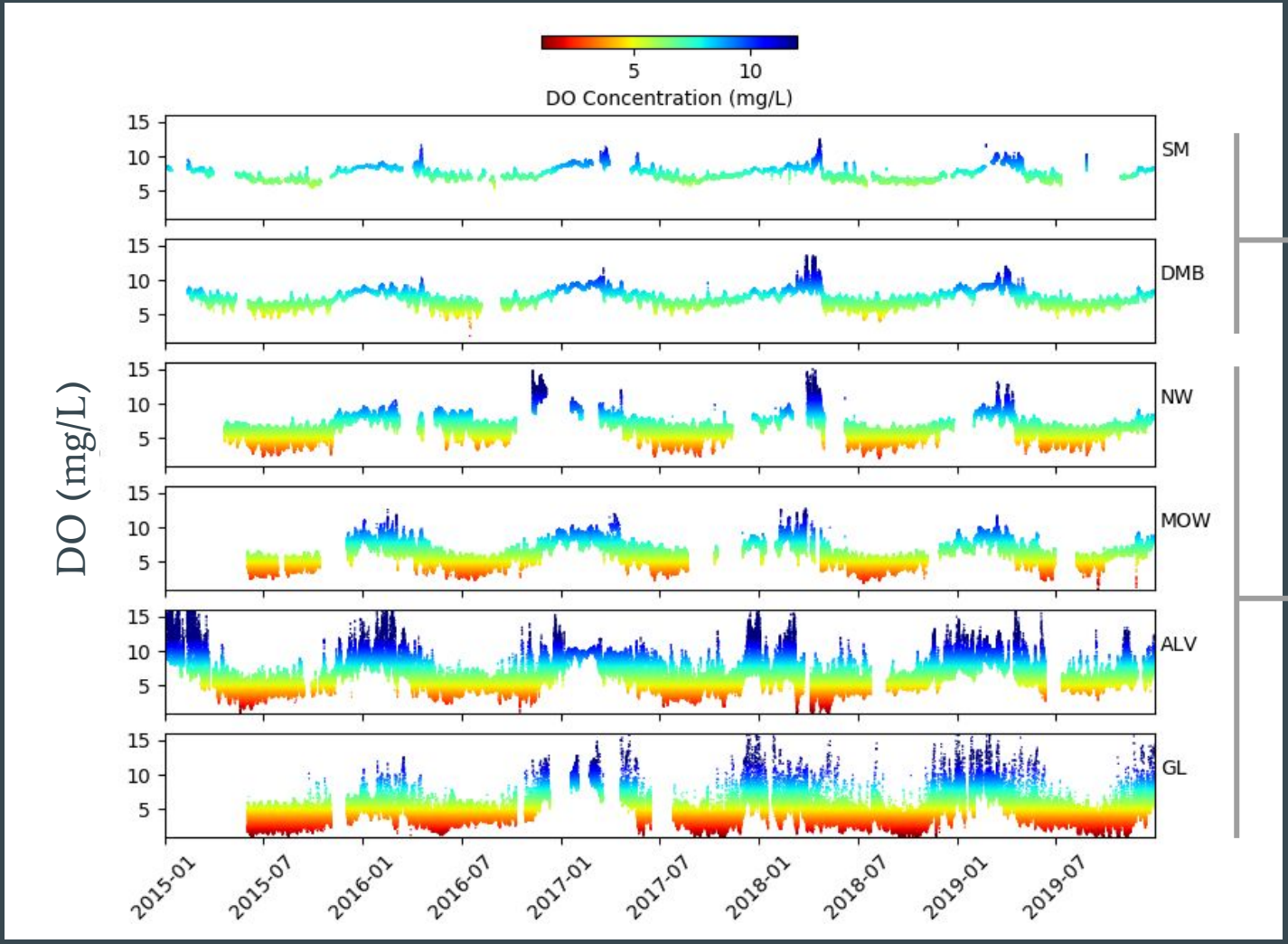

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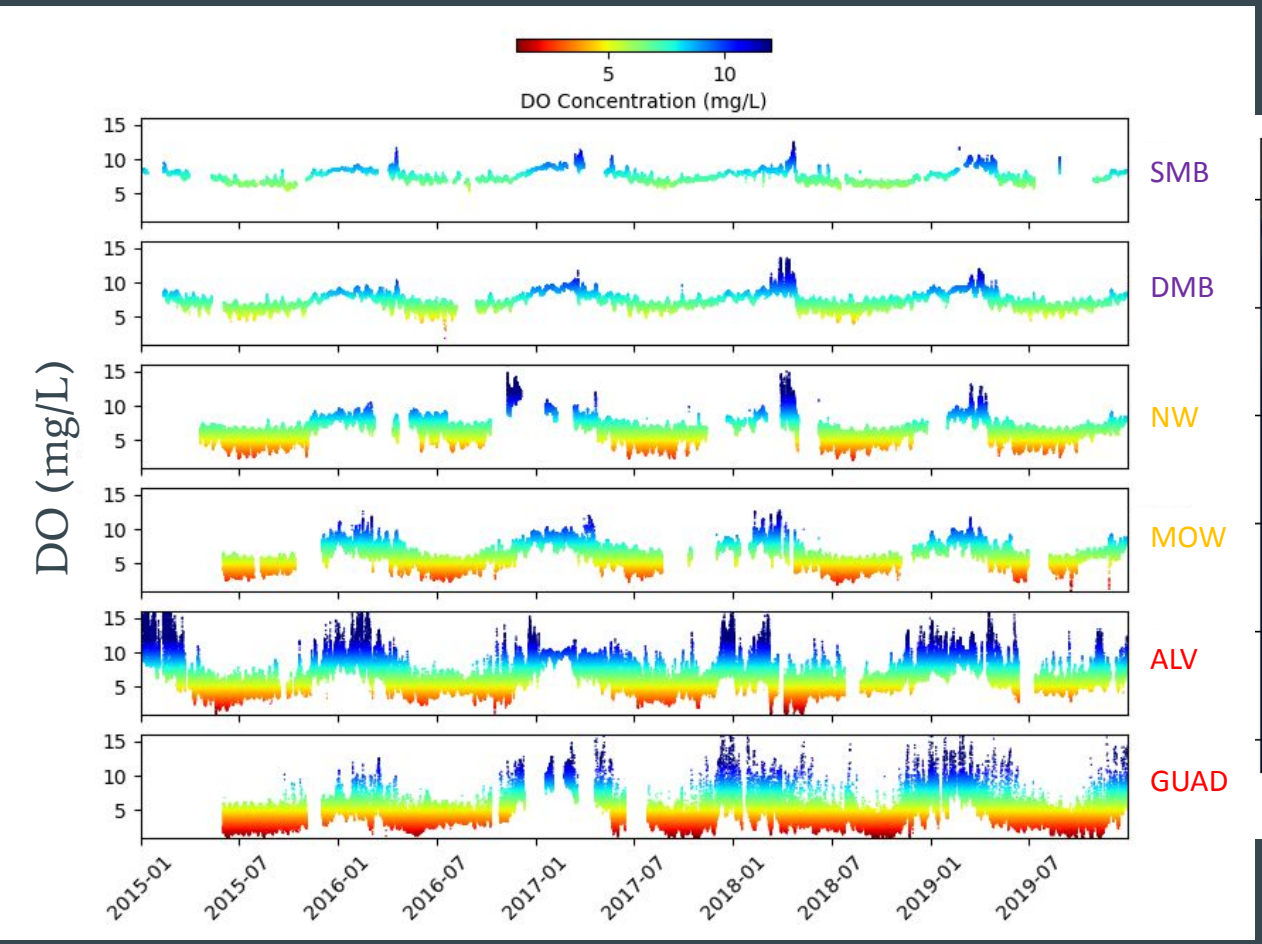
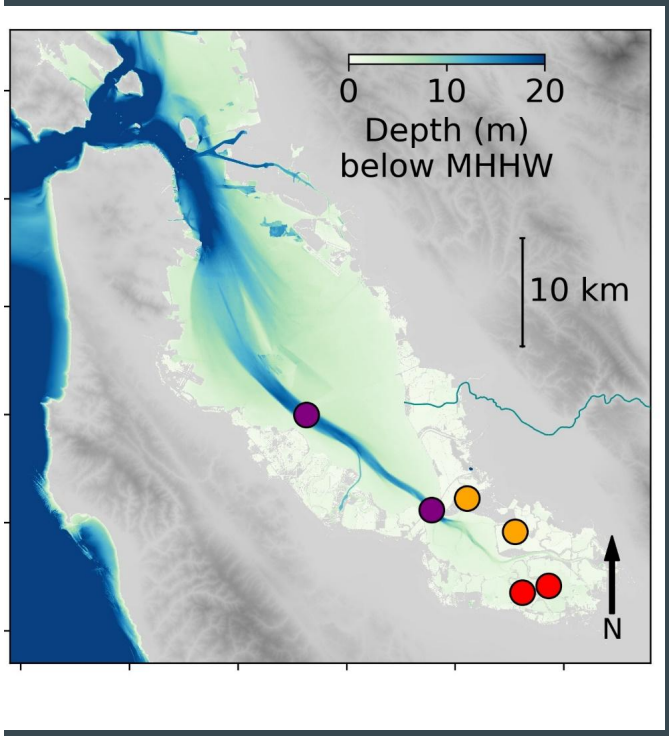
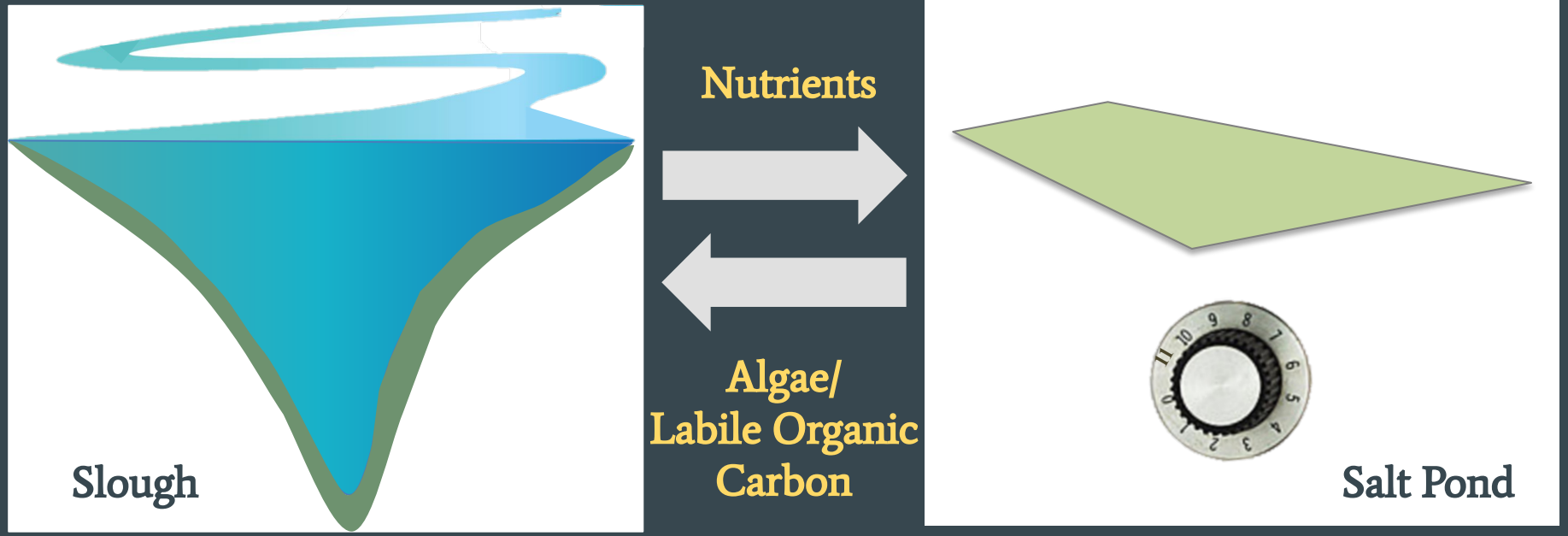
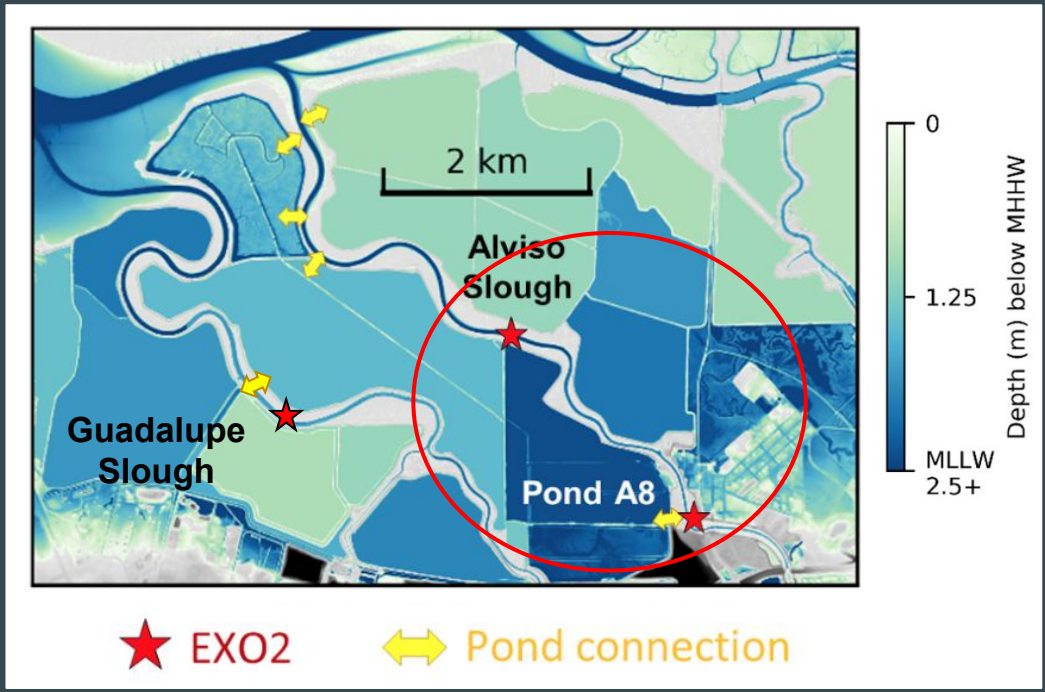


# What is driving low DO in the sloughs?

Nutrients? Salt ponds? Both?

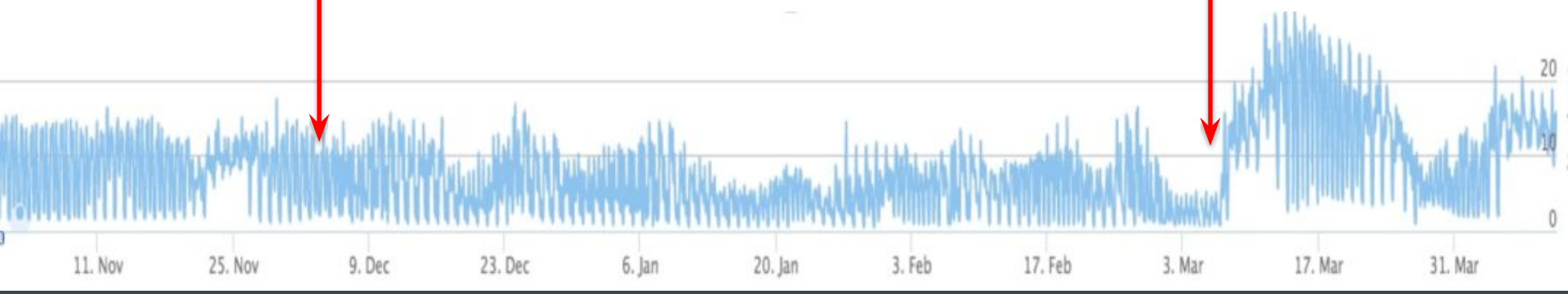


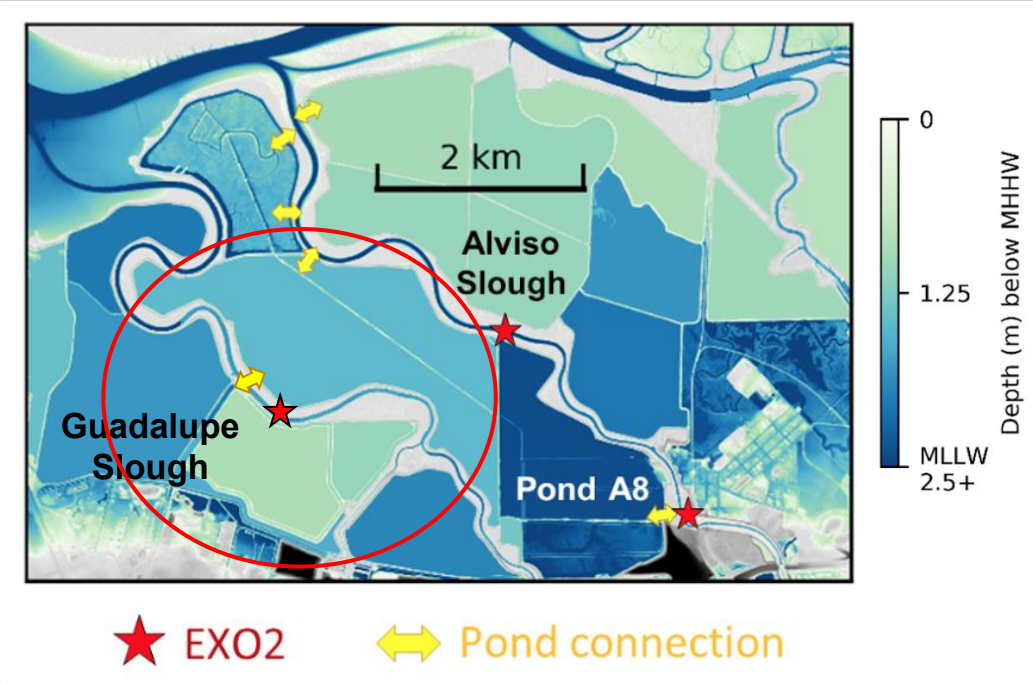


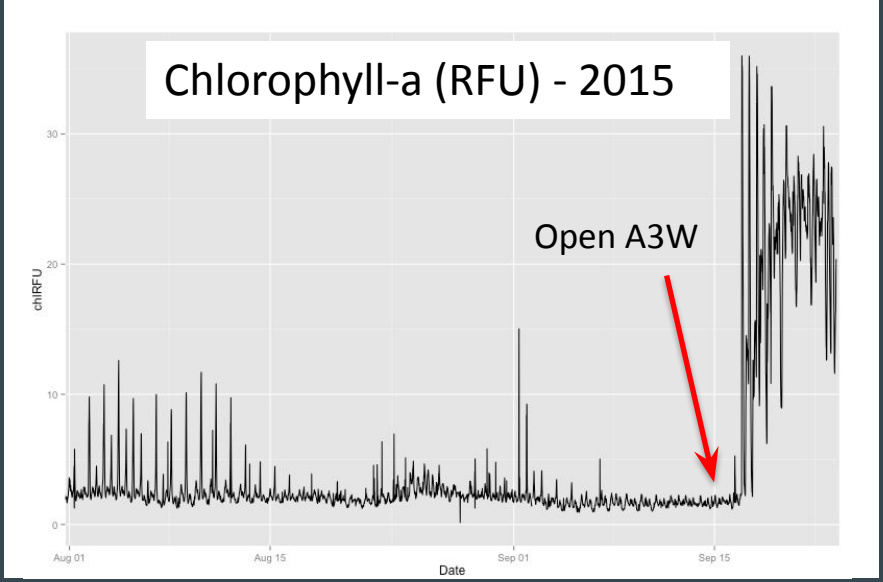

Chlorophyll-a (RFU) - 2013

Close A8

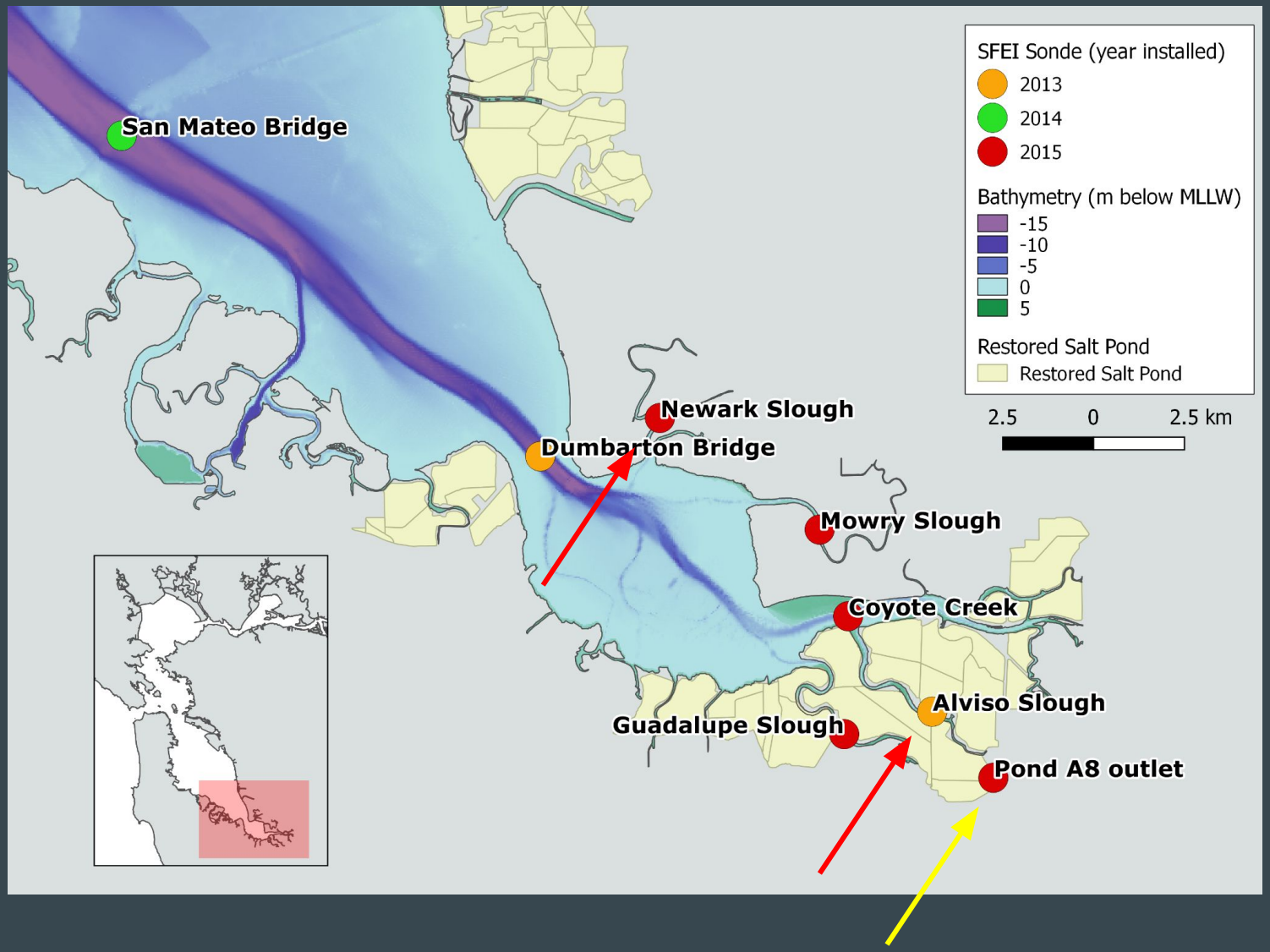
Open A8




2 km
Alviso Slough
Guadalupe Slough
Pond A8
0
1.25
MLLW
2.5+
Depth (m) below MHHW
EXO2
Pond connection


Chlorophyll-a (RFU) - 2015
Open A3W
chlRFU
30
20
10
0
Aug 01
Aug 15
Sep 01
Sep 15
Date

# Metabolism estimates in sloughs



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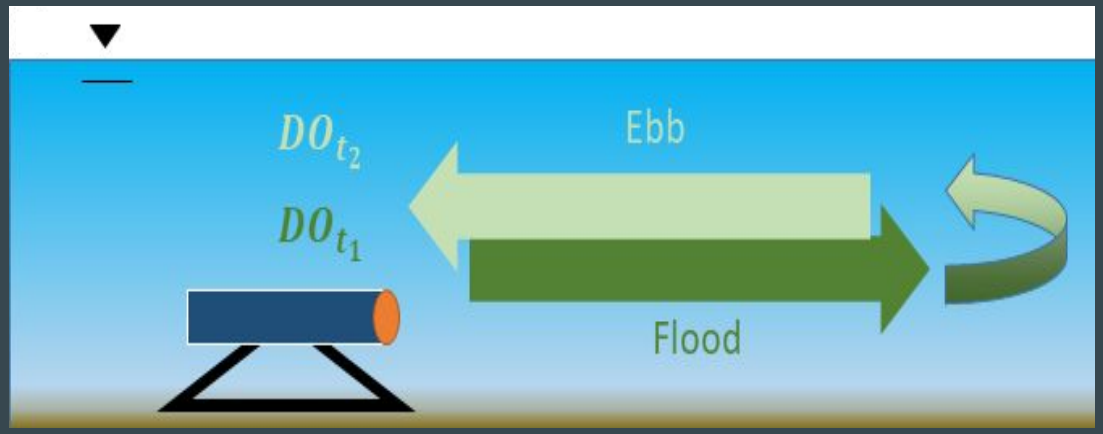
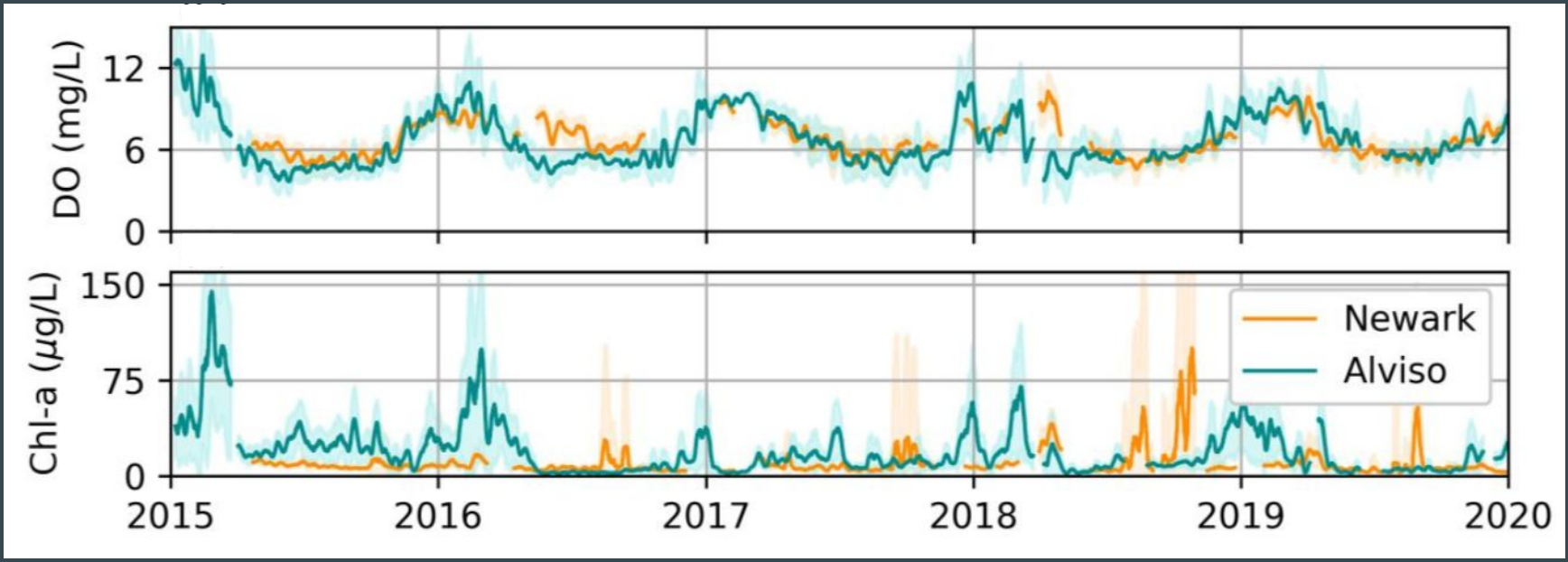



- Rate estimates are based on one sensor station
- Change in DO from flood to ebb
- Five years of data (2015-2019)
  - ~1000 tidal cycles per site
- Calculate tidal-cycle average net ecosystem production (*NEP*) rate -> GPP minus R
- Nighttime *NEP* values represent respiration (*R)*

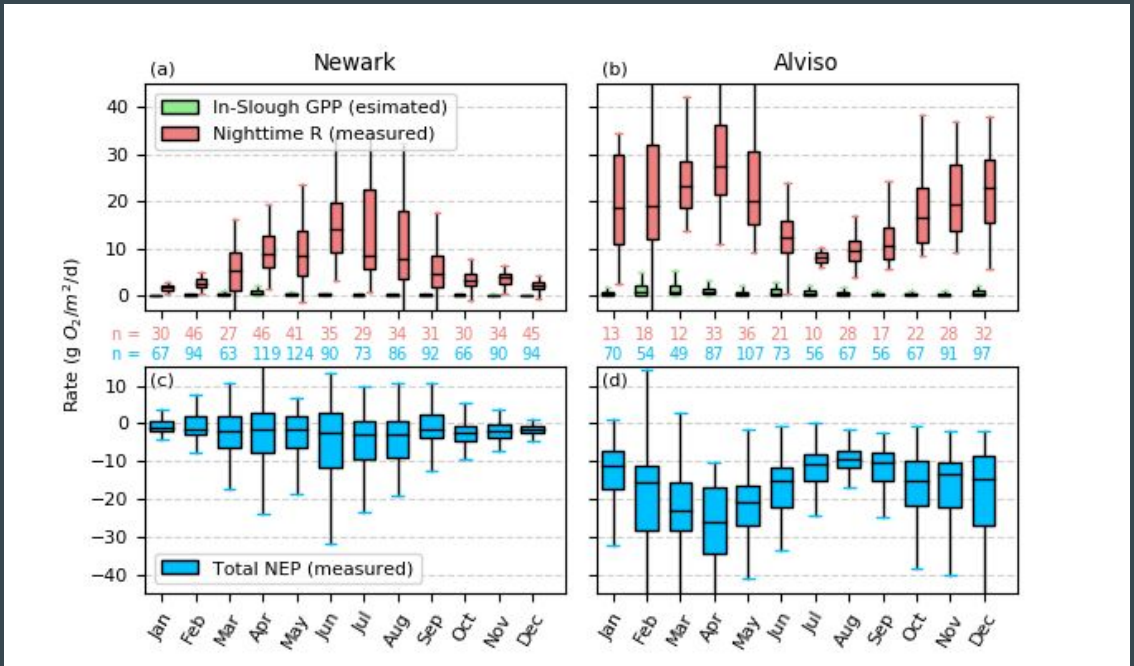
# Seasonality in dissolved oxygen

- Dissolved oxygen (DO) levels generally peak in winter and early spring at both sites
- DO minima occurred in spring or summer
- Chlorophyll-a peaks at Alviso Slough coincide with DO maxima
- Newark Slough chlorophyll-a levels were only rarely elevated



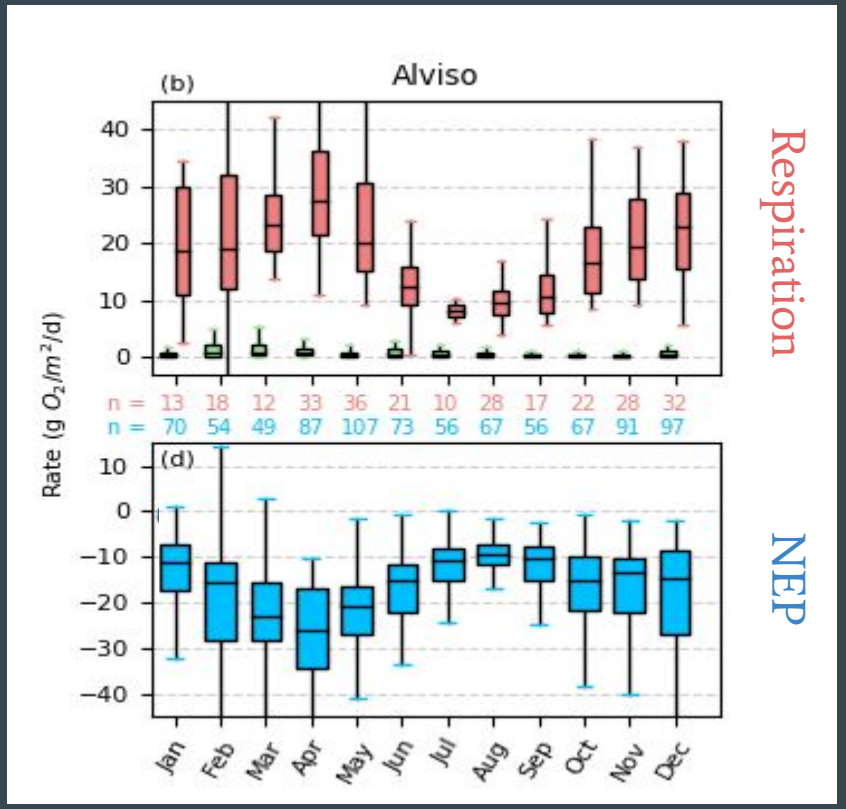
# Seasonality in respiration and NEP

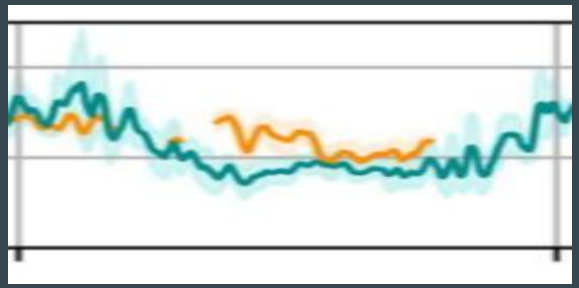
- Remarkably different seasonal patterns between sites
- Newark Slough showed strongly seasonal metabolic rates, with highest net heterotrophy in summer
- Alviso Slough dynamics are more complicated...



# Seasonality in respiration and NEP

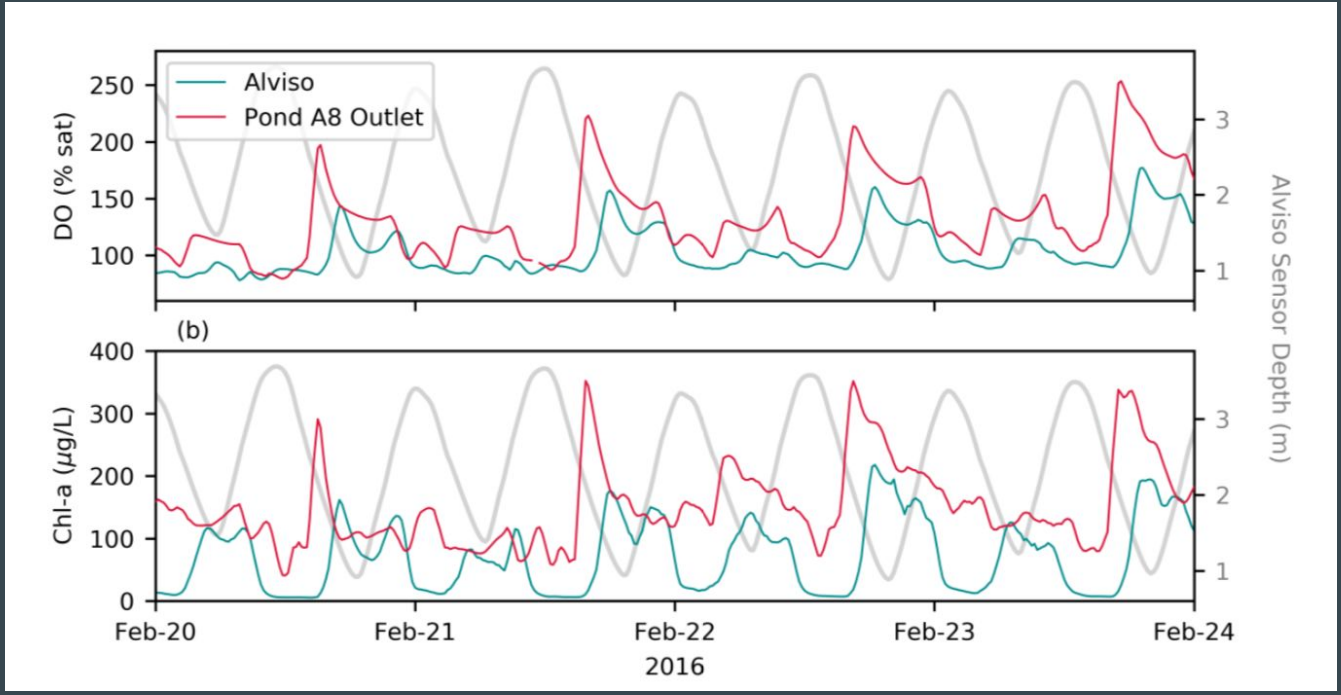
- High respiration rates in the winter and spring, with very negative NEP
- Respiration rapidly decreased into summer, NEP still consistently negative
- Peak in respiration not consistent with periods of lowest DO
- May be explained by the complex pond-slough exchange dynamics during bloom events



# Link to salt pond production

- Lagged and muted DO and chlorophyll-a signals at Alviso relative to Pond A8 with ebb-centered timing of peaks
- Suggest elevated chlorophyll-a concentrations in Alviso Slough driven by biomass export from Pond A8



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- Lagged and muted DO and chlorophyll-a signals at Alviso relative to Pond A8 with ebb-centered timing of peaks
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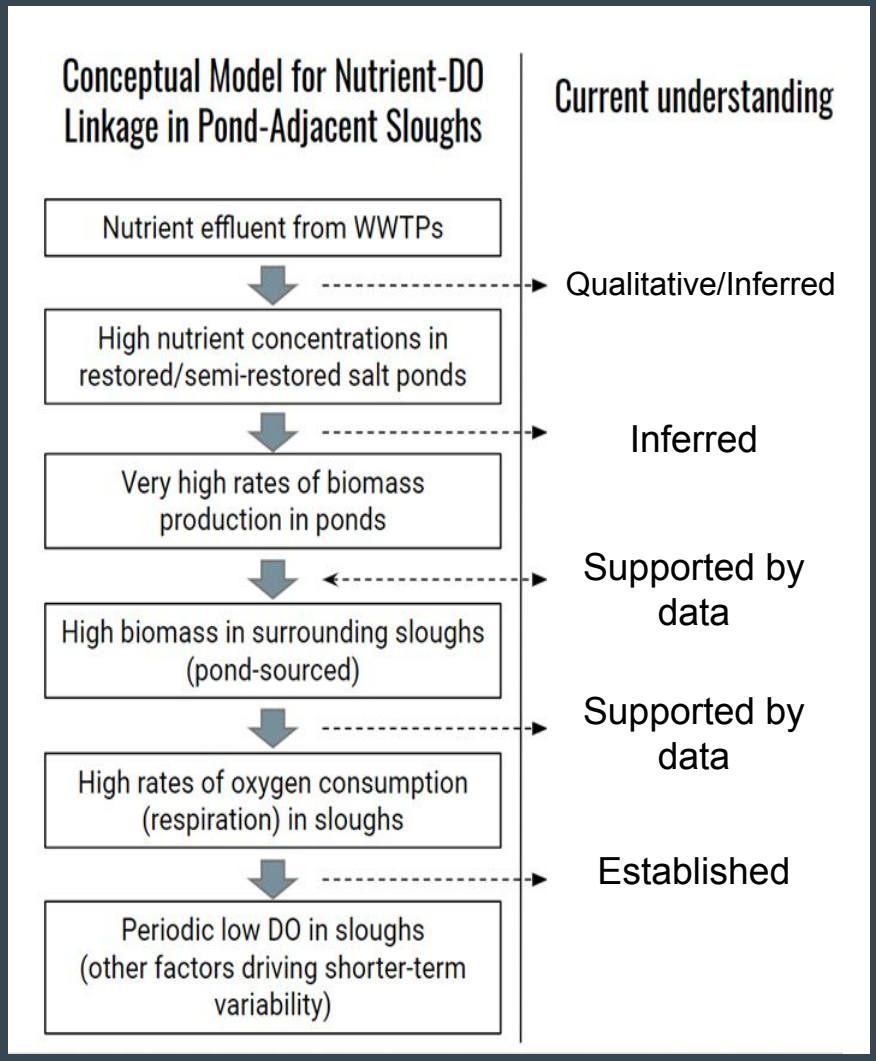
- High frequency data indicatepeak respiration rates/heterotrophy in Alviso associated with spring bloom period when large biomass outflow from highly productive pond
- Highly elevated rates of oxygen demand offset by super-saturated DO concentrations in RSP effluent during the bloom periods
- DO minima in summer, when RSP effluent lower in DO, and in-slough respiration rates were at an annual minimum but were still high

# Takeaways

- Respiration rates in Alviso Slough are very high, comparable to tropical, warm-water estuaries
- Creates high potential for low DO conditions
- Seasonal R and chl-a patterns match, and are totally different from what we observe at a not-pond-connected site
- Metabolic signal strongly tied to pond dynamics
- Peak R associated with input of pond organics to slough, offset by elevated DO from ponds during winter/spring bloom
- Minimum DO in summer when baseline R remains high and rates are no longer offset by oxygen-saturated pond effluent
- Consistently negative NEP associated with slough sediments

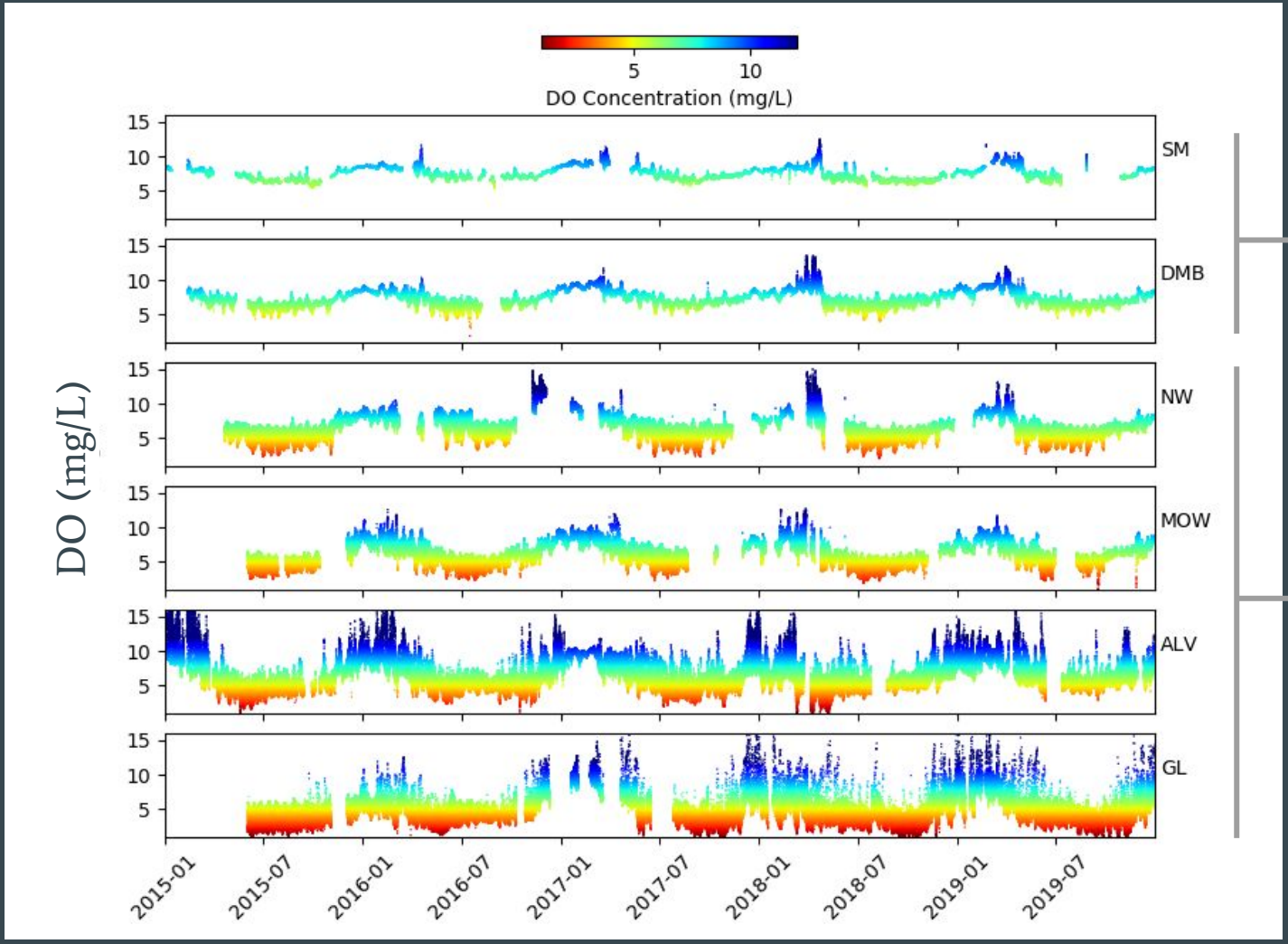
# Key uncertainties and future work

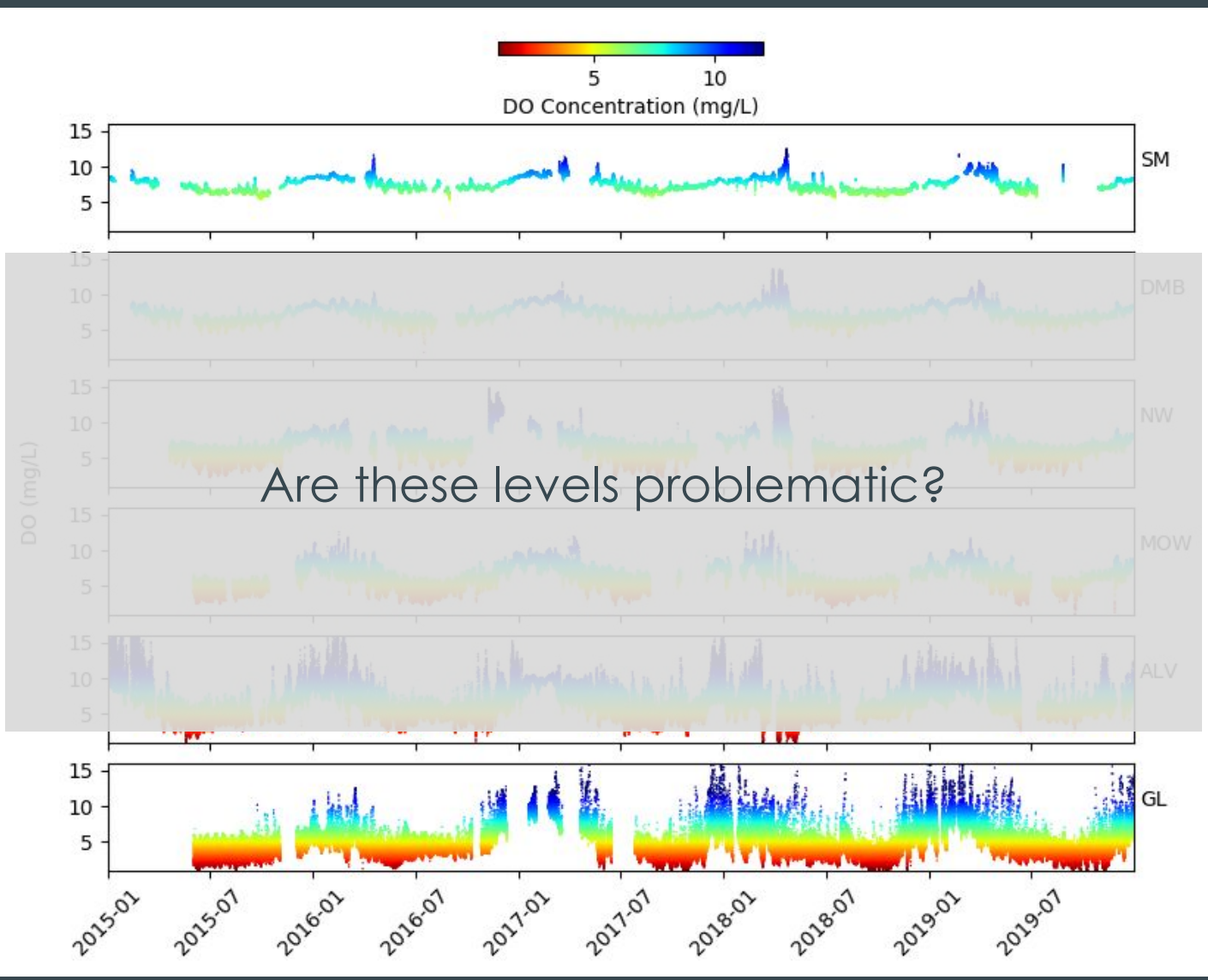



- The extent to which WWTP nutrient loads contribute to production in ponds
- Degree of nutrient limitation in ponds
- Impact of increased POTW nutrient loads on pond biomass production
- Effect of pond restoration process on water quality in sloughs

- Continue synthesis and modeling of existing data from LSB sloughs/ponds
- Field data collection in ponds at different stages of restoration

# Identifying protective DO levels



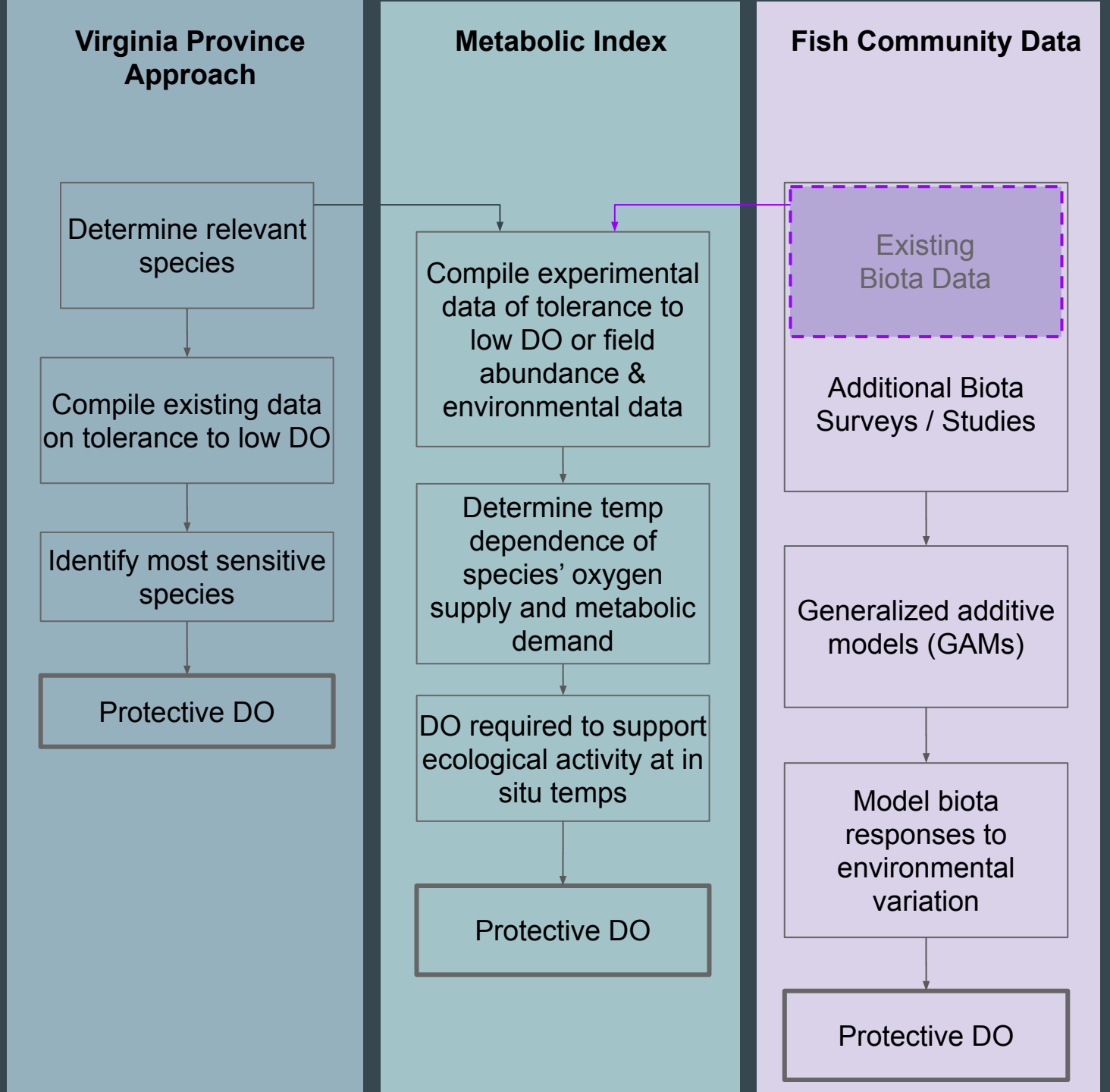



Are these levels problematic?

# Assessment Framework Goals

Establish ecologically relevant thresholds for protective DO conditions in LSB margin habitats.

Assess protective dissolved oxygen thresholds under future conditions.


Virginia Province Approach
Metabolic Index
Fish Community Data
Determine relevant species
Compile existing data on tolerance to low DO
Identify most sensitive species
Protective DO
Compile experimental data of tolerance to low DO or field abundance & environmental data
Determine temp dependence of species' oxygen supply and metabolic demand
DO required to support ecological activity at in situ temps
Protective DO
Existing Biota Data
Additional Biota Surveys / Studies
Generalized additive models (GAMs)
Model biota responses to environmental variation
Protective DO

# Thanks to our collaborators

Lissa MacVean

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Perry de Valpine

Martha Sutula

Evan Howard

Jeremy Diamond

Alexis Walls

Sujoy Roy

USGS MarFac

USGS WSC