Sloughs and Salt Ponds: Investigating Water Quality in a Complex Ecosystem

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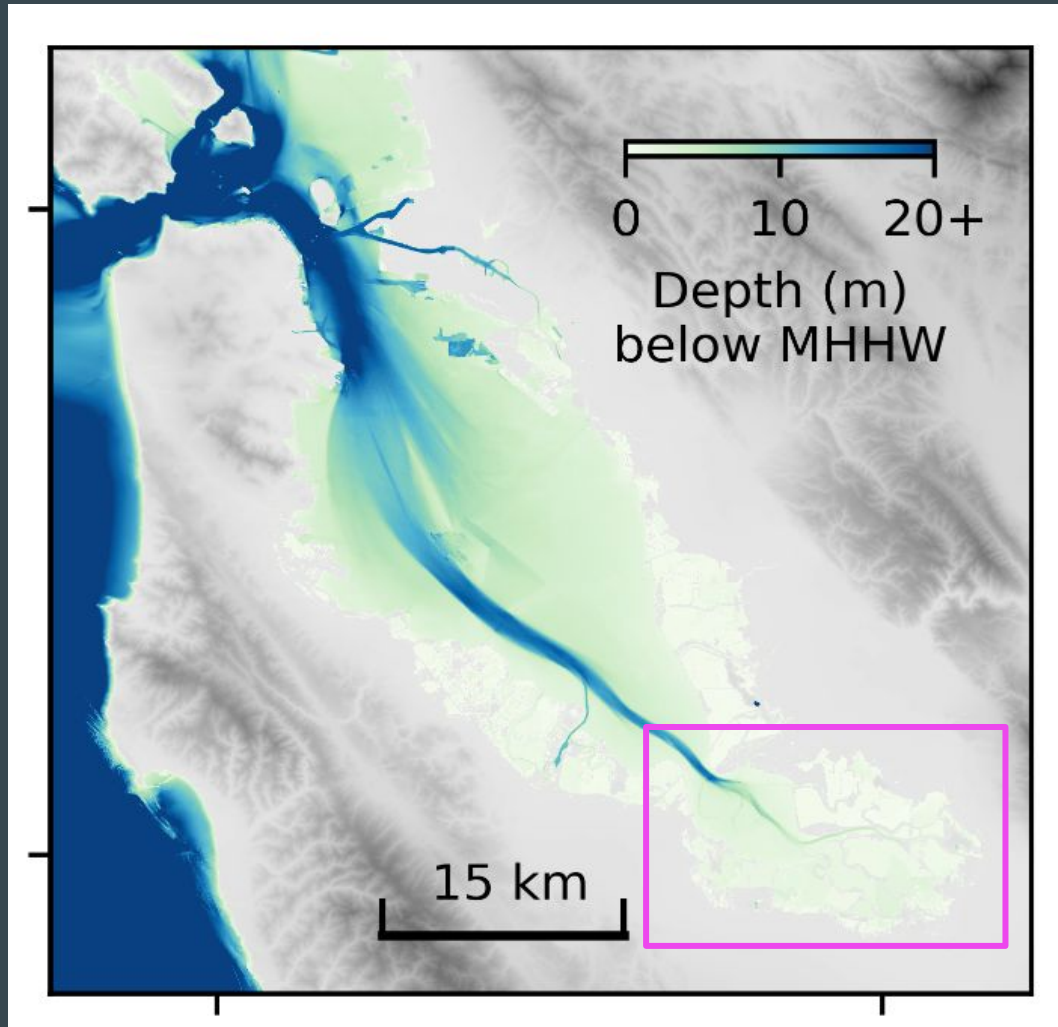USGS WSC

Stillwater Sciences

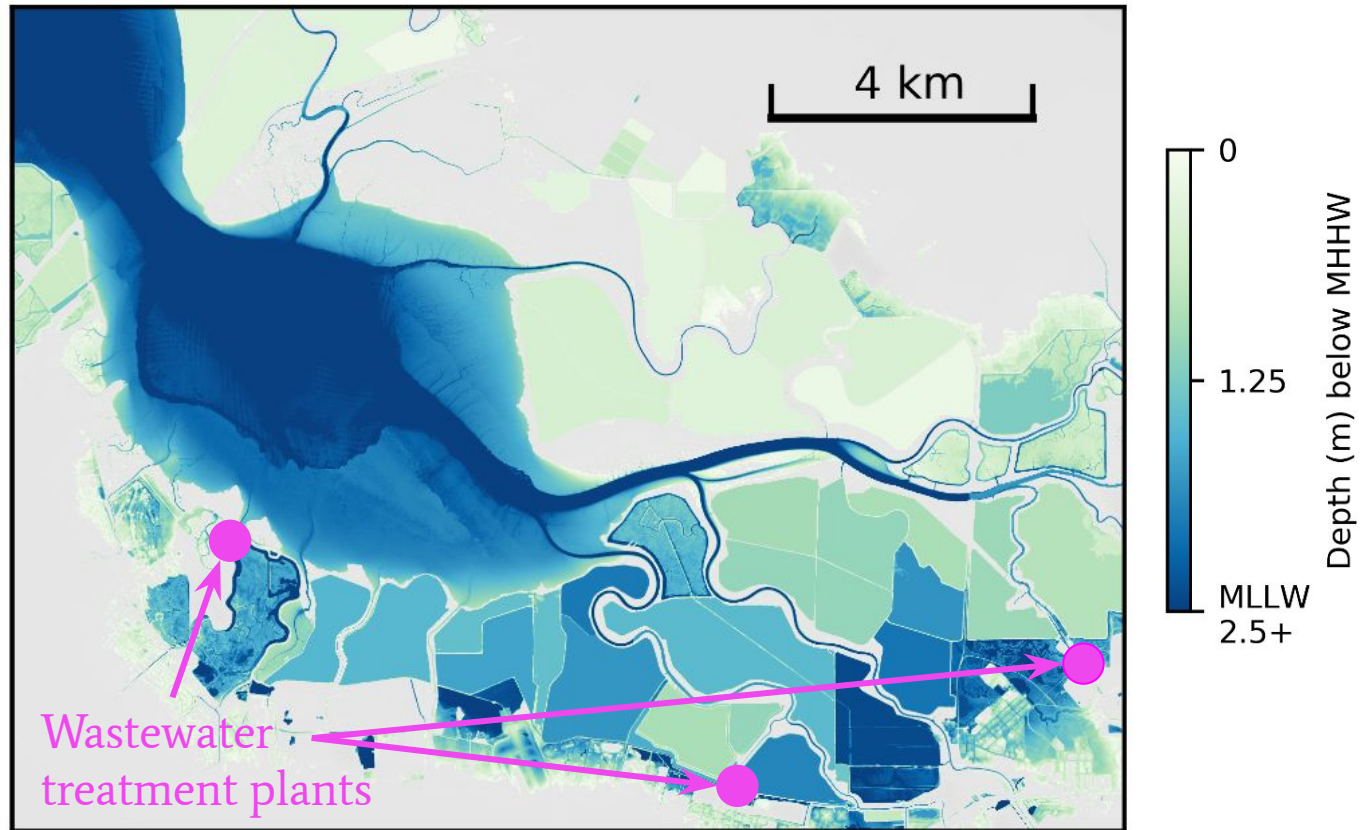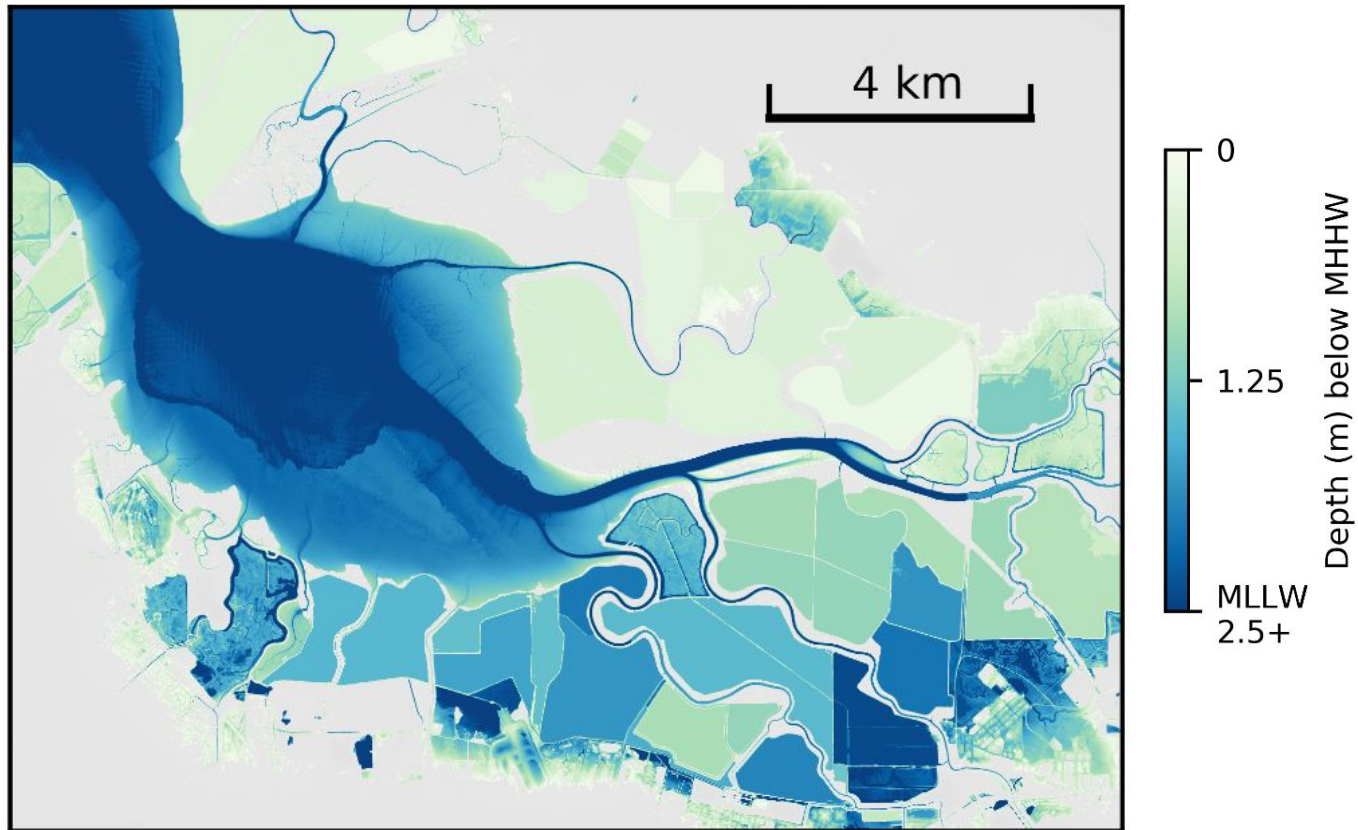Watershed Stewardship Program

Funding sources
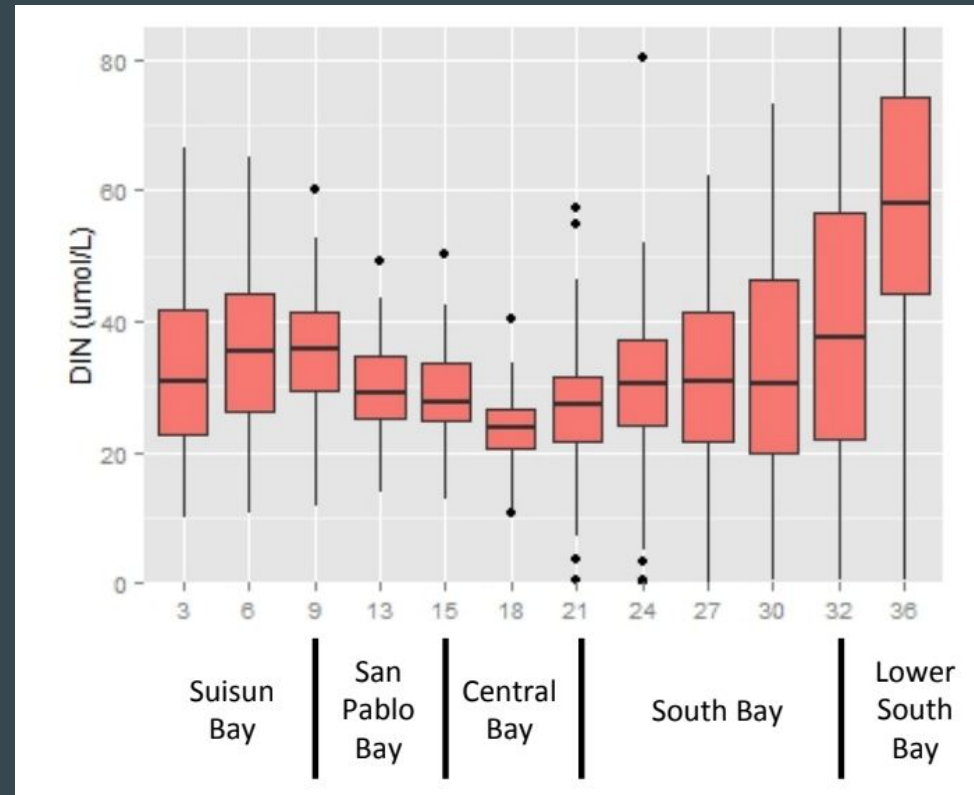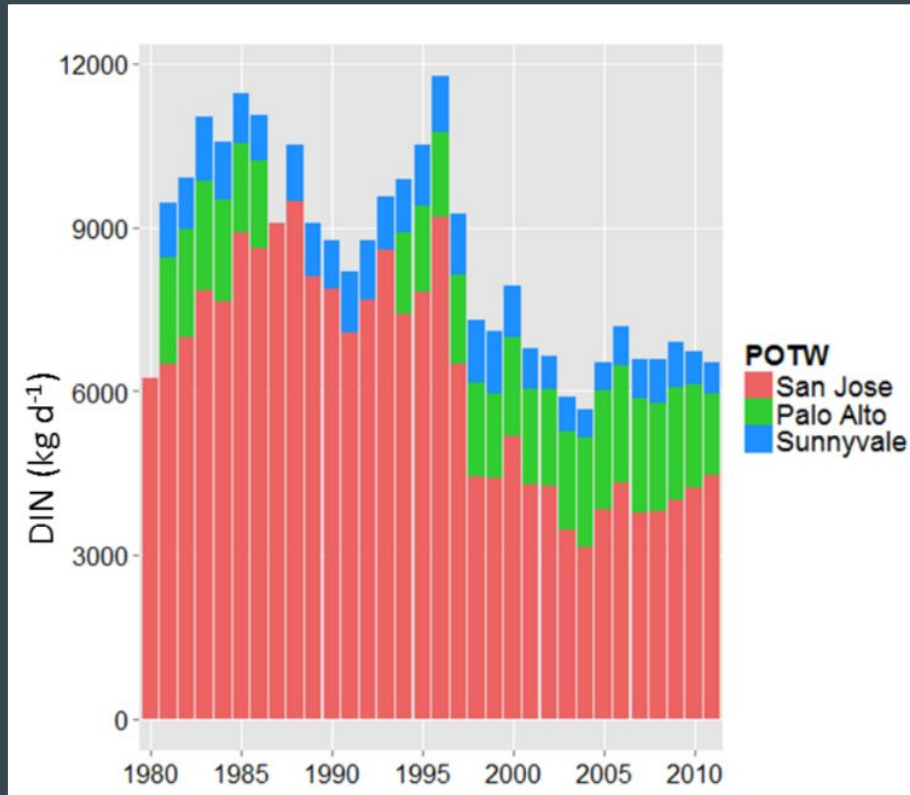
Lower South San Francisco Bay

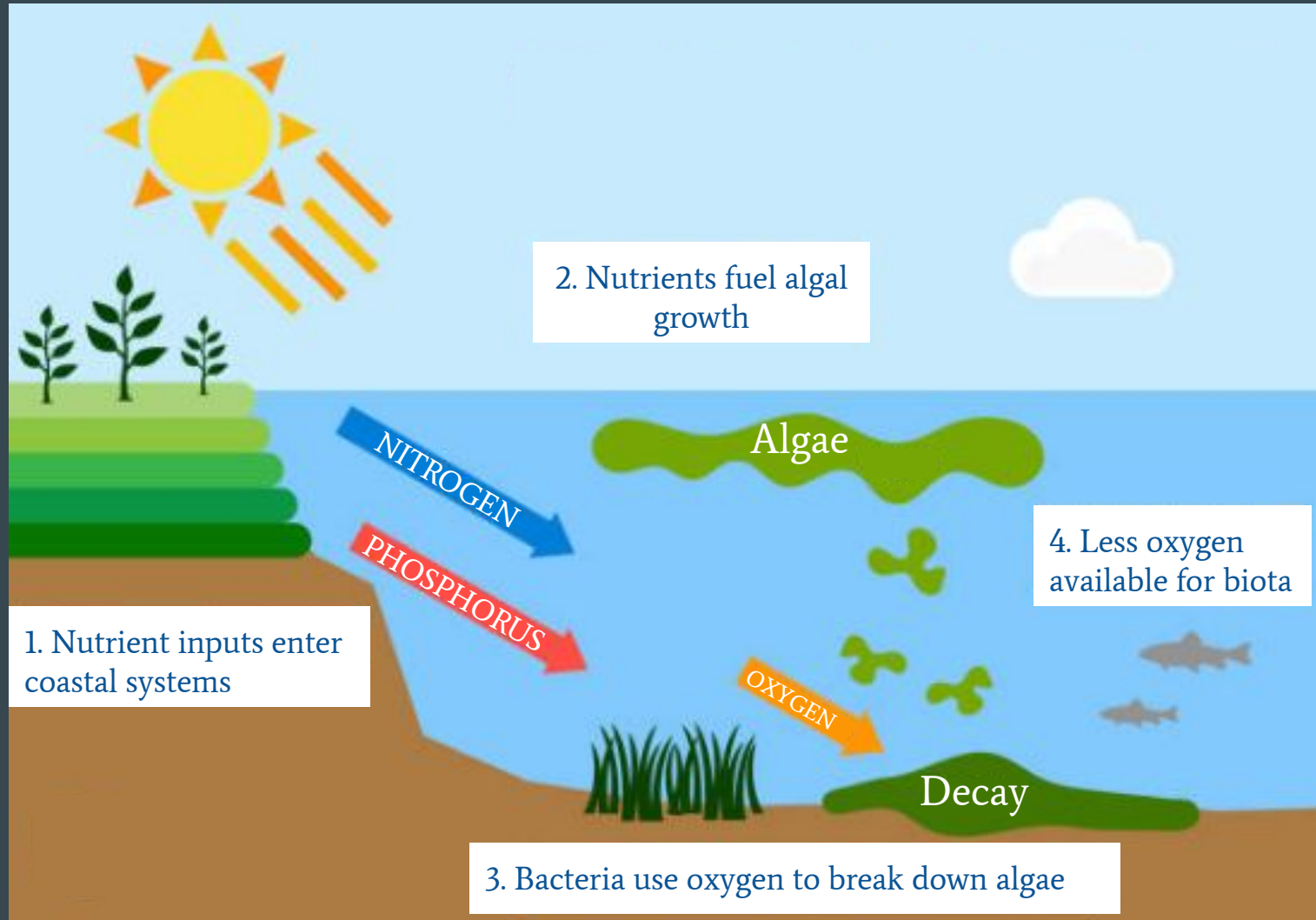# Complex system of managed former salt ponds and sloughs

Complex system of managed former salt ponds and sloughs, with nutrient inputs from wastewater treatment plants
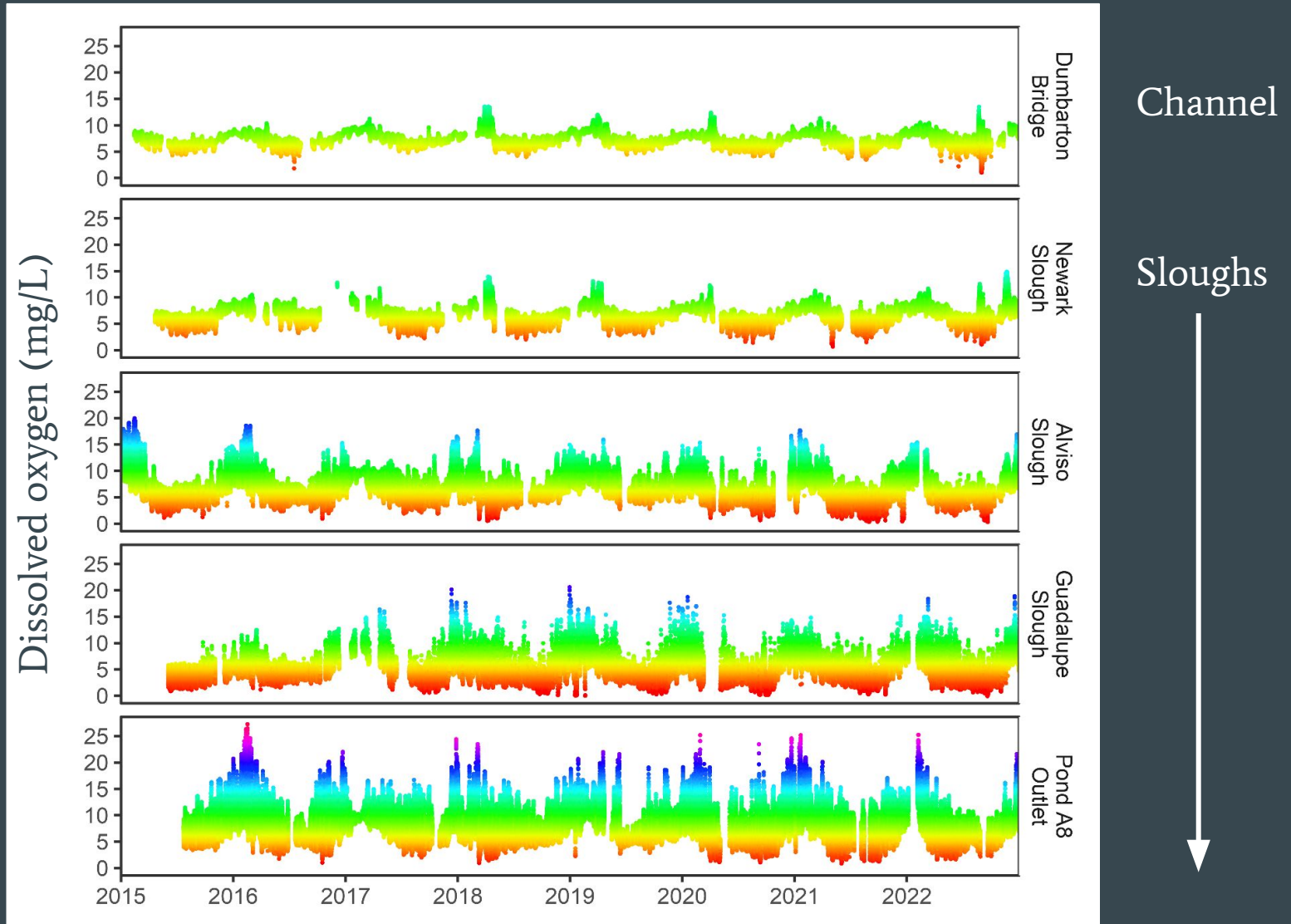
Water quality dynamics: high nutrients

SFEI 2016

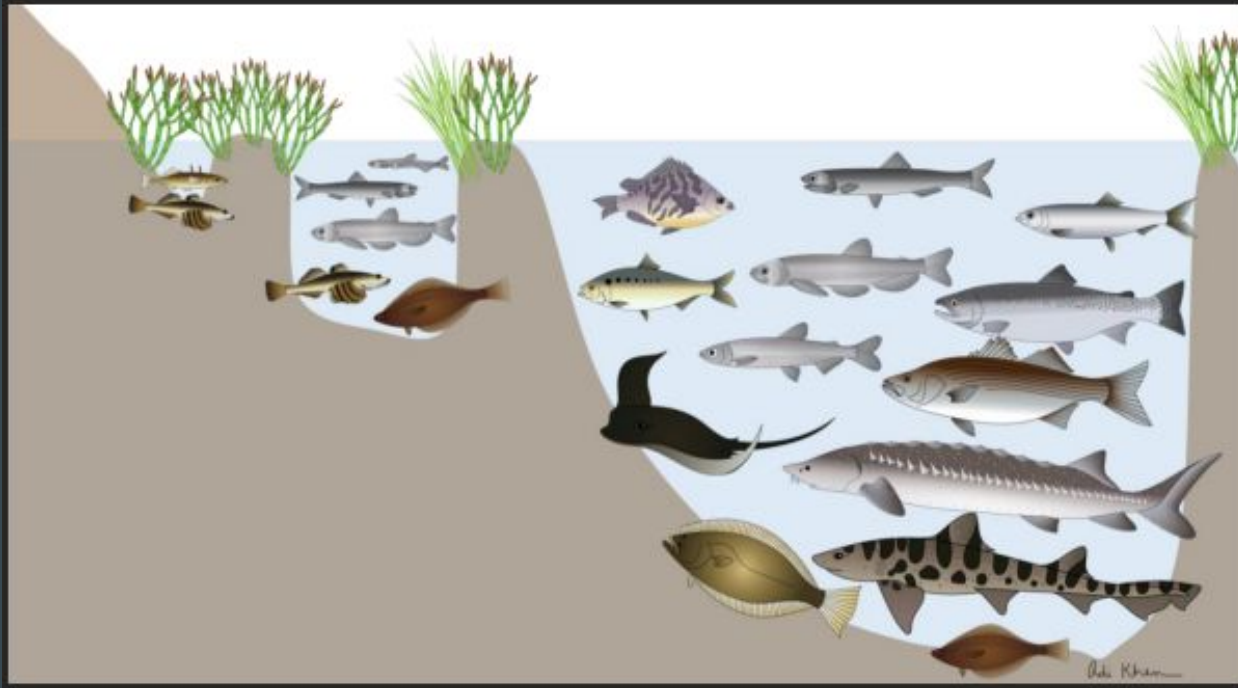# Water quality dynamics: high nutrients → low oxygen
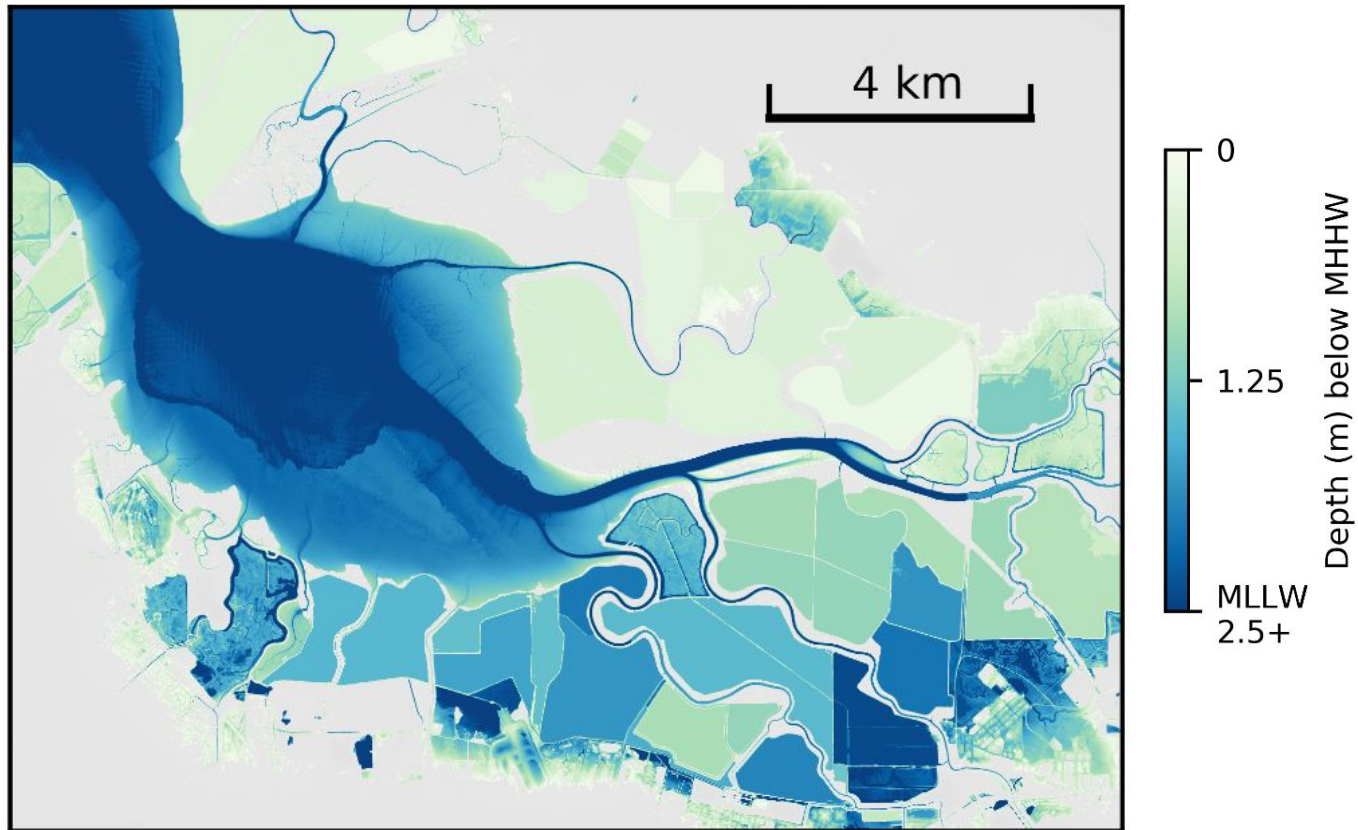
Water quality dynamics: low oxygen

Who cares?   Fish!

Fish Communities and Dissolved Oxygen in Wetlands of the San Francisco Estuary

Levi Lewis 2024
Artwork by Adi Khen

# Complex system of managed former salt ponds and sloughs

Research Questions

1. How does the interaction between high nutrients and the former salt ponds impact water quality in LSB sloughs?

2. How will water quality be affected by planned restoration activities?

3. Can restored ponds help buffer nutrient inputs from nearby wastewater treatment plants?

Hypothesis

Nutrients are advected into ponds, algae grows, then transported back into sloughs where it causes drawdown of oxygen

Slough

Nutrients

Algae/ Organic Carbon

Salt
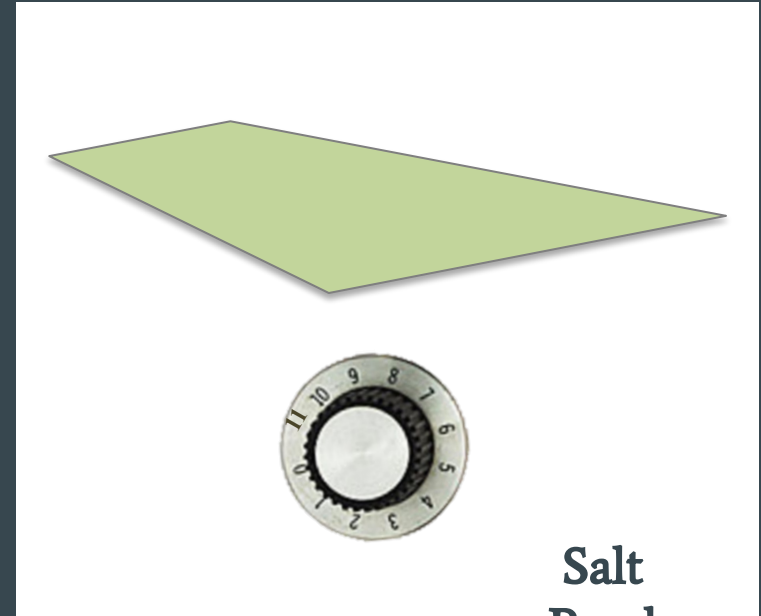
Hypothesis
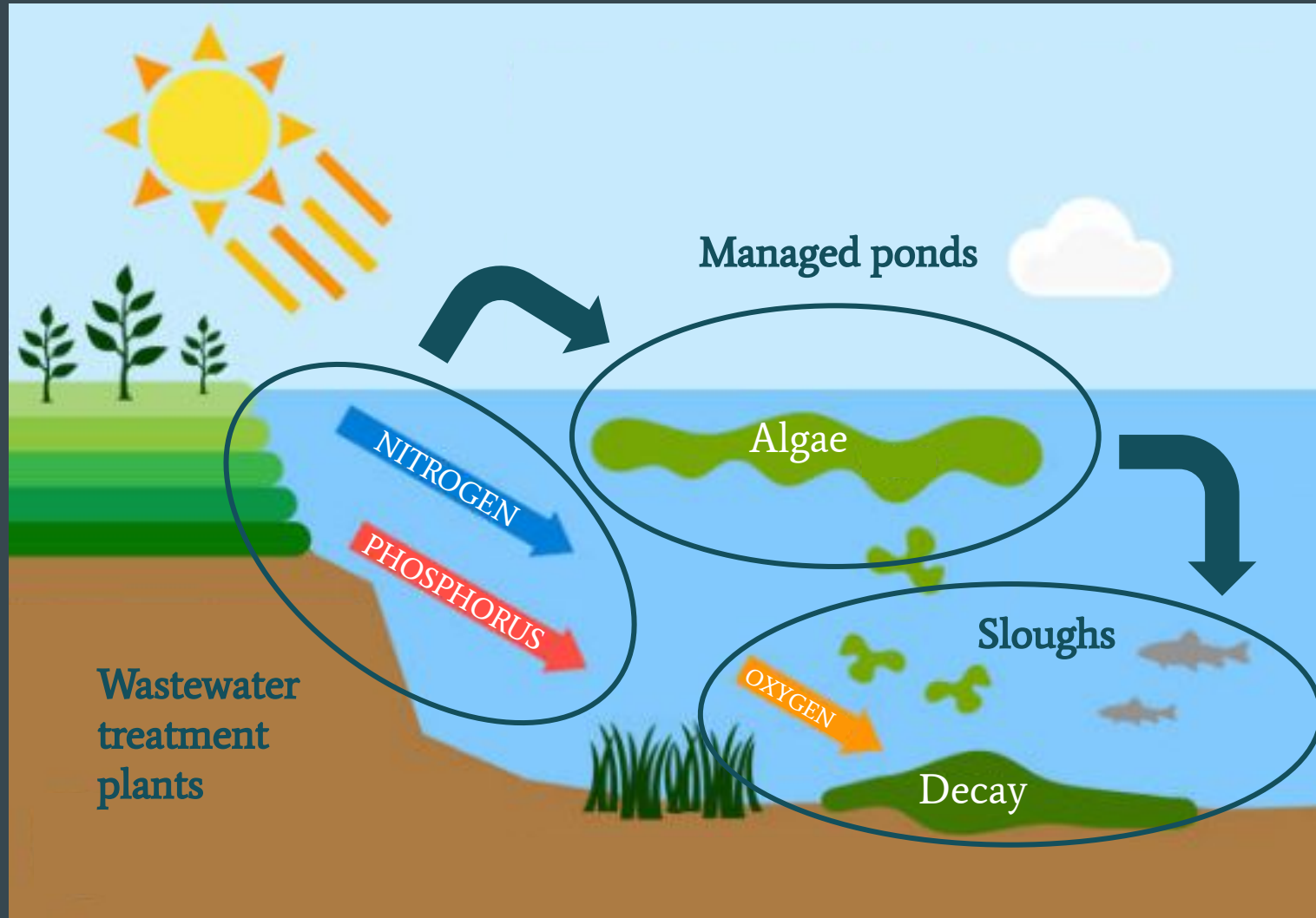
Lower South Bay monitoring stations
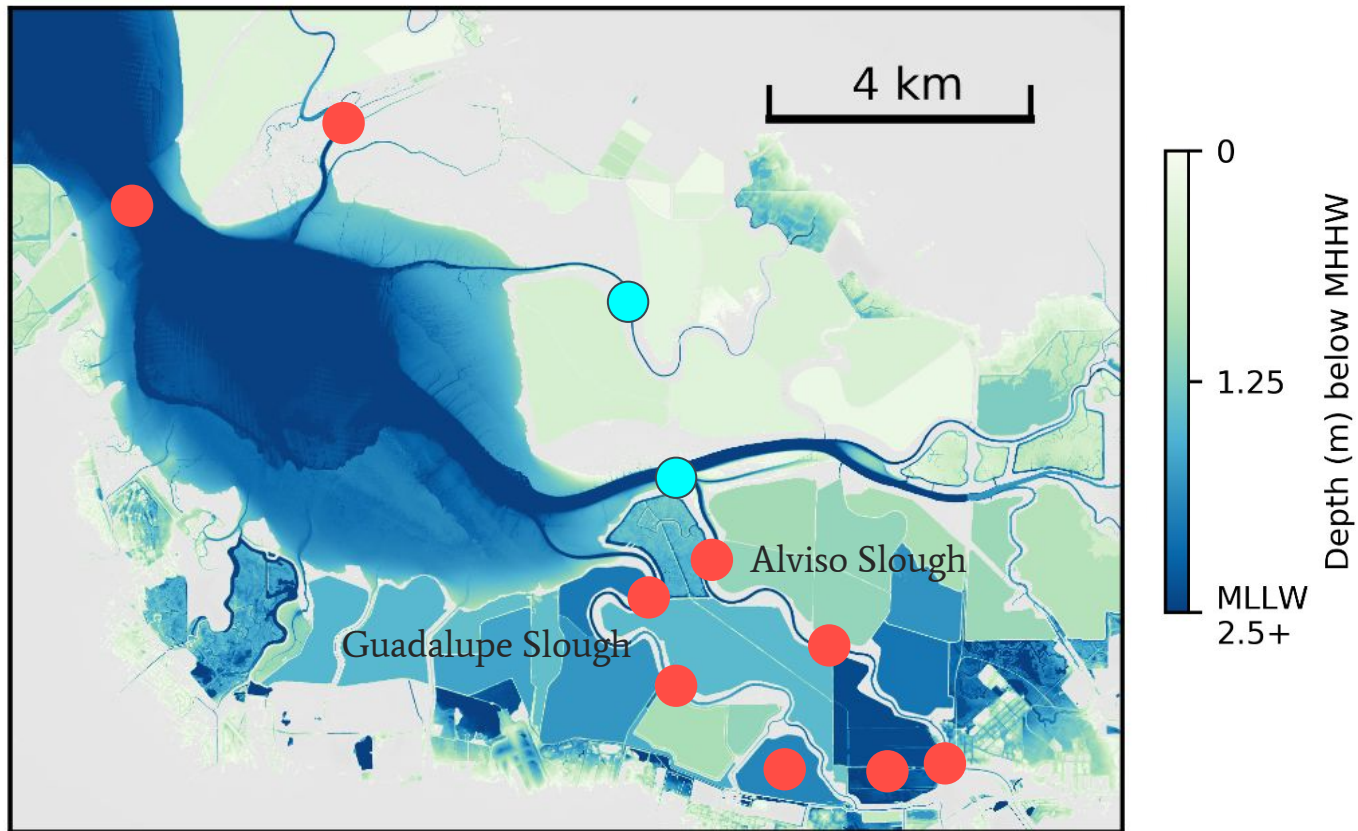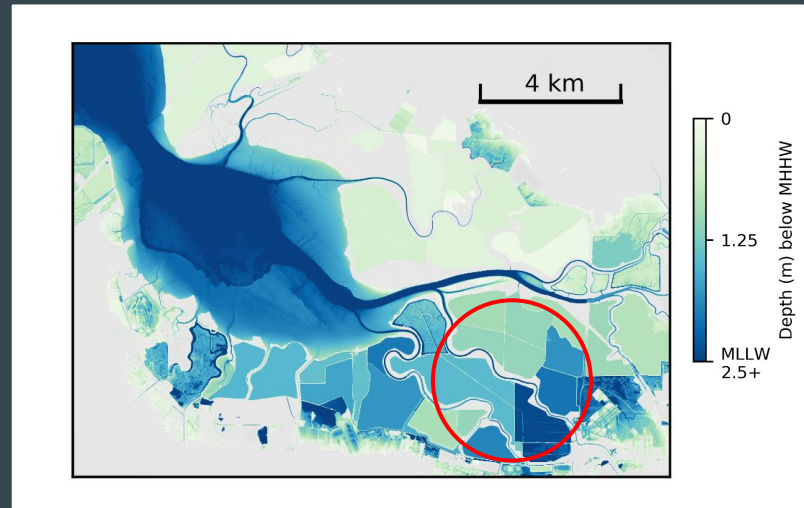
Stations collect water quality data at 15-minute intervals, including temp, dissolved oxygen, salinity, and chlorophyll

Preliminary evidence…

Chlorophyll-a (RFU)

Close A8

Open A8

Nov 2013

Mar 2013

11. Nov   25. Nov   9. Dec   23. Dec   6. Jan   20. Jan   3. Feb   17. Feb   3. Mar   17. Mar   31. Mar

Preliminary evidence...

Chlorophyll-a (RFU) - 2015

Open A3W

Preliminary evidence...

Flood tide   July 15-16 2015   Ebb tide

DO

Chl-a

NO_3^-

DO (mg/L)

Chl-a fl (RFU)

NO_3 (μM)

Downing et al., in prep
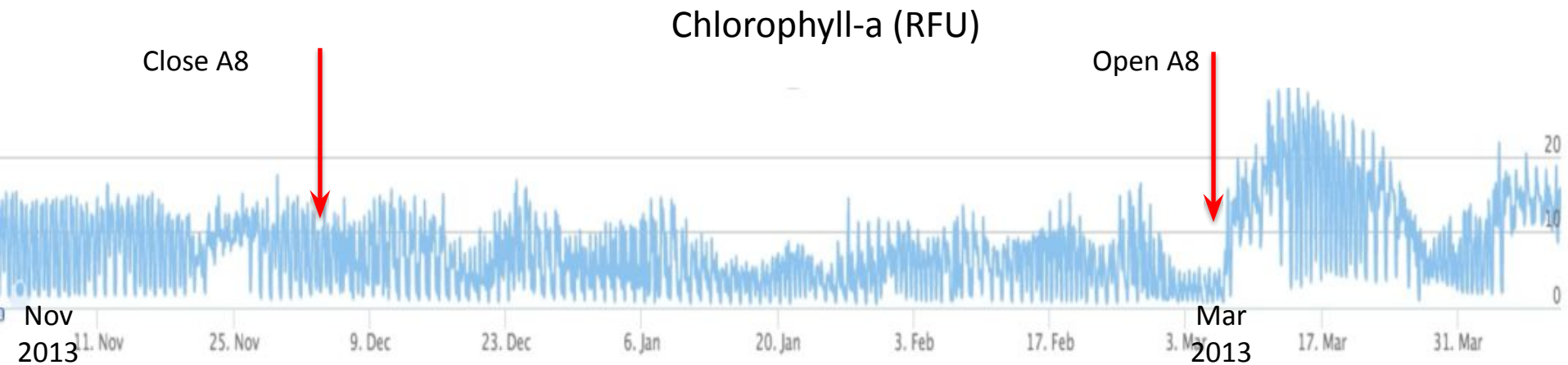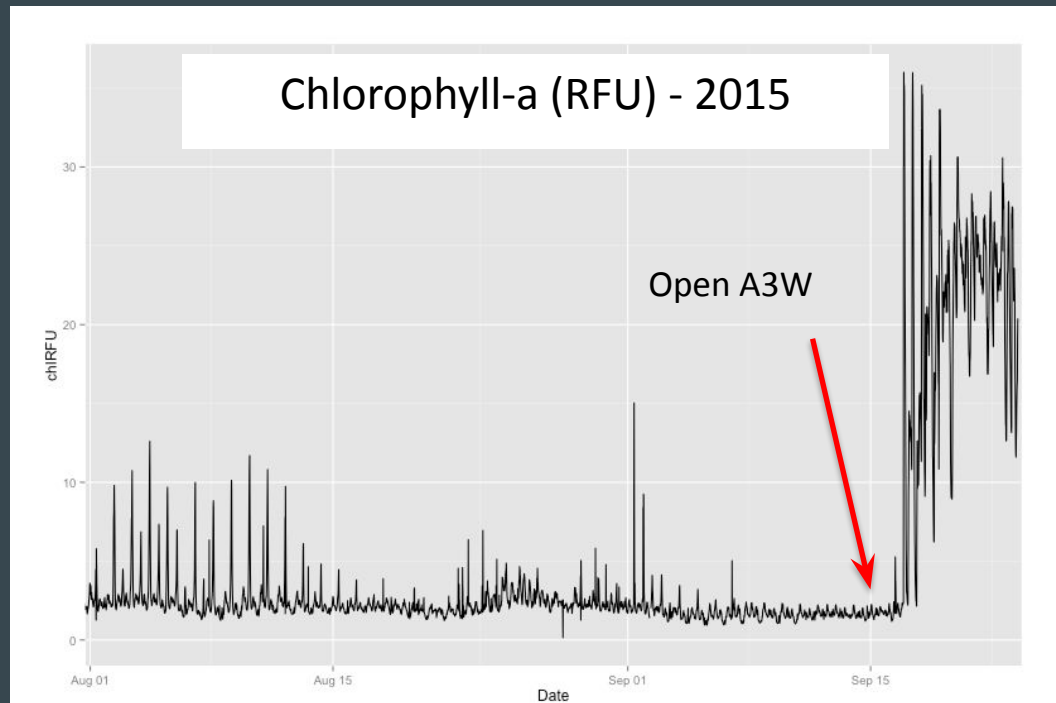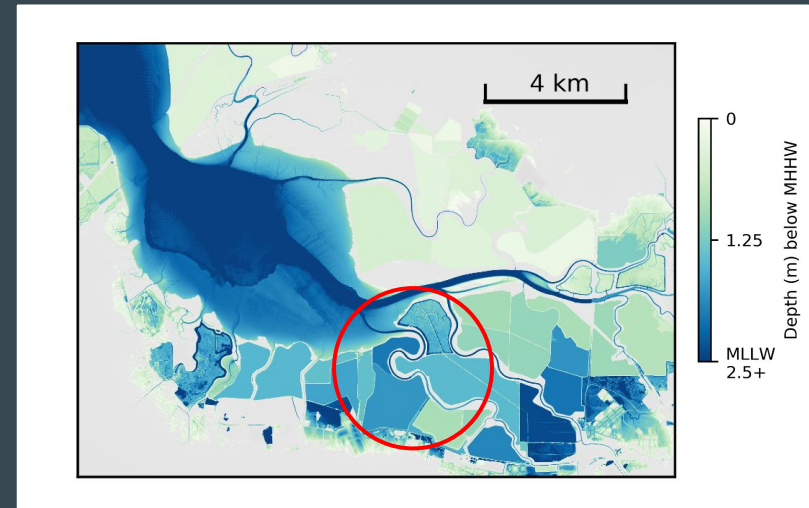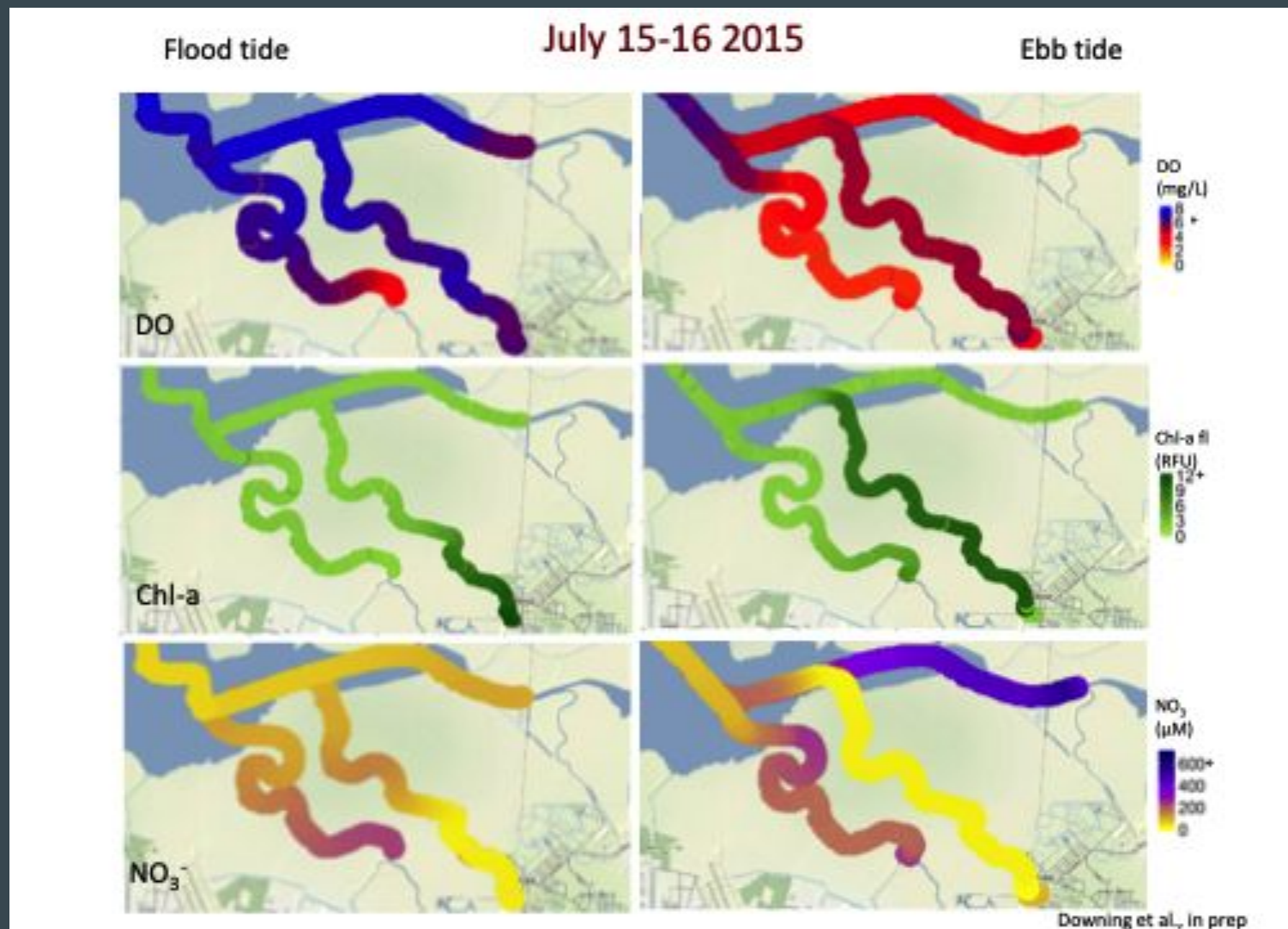
Data collected in collaboration with the USGS

Preliminary evidence...

Pond A8 chlorophyll data - Sept to Nov 2024

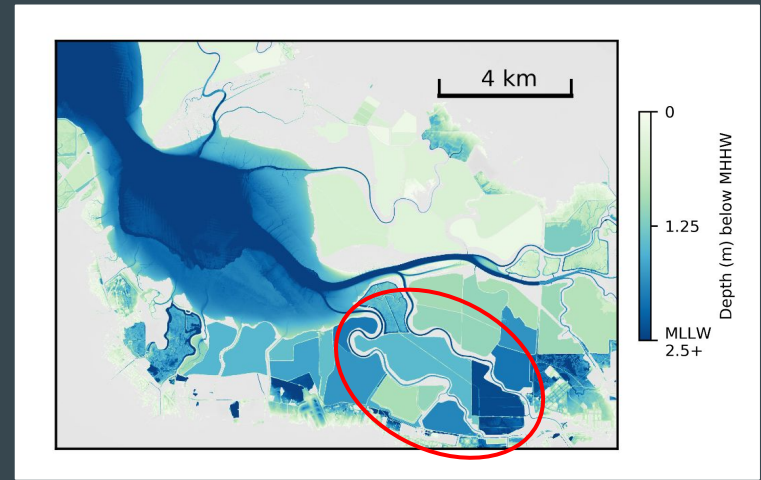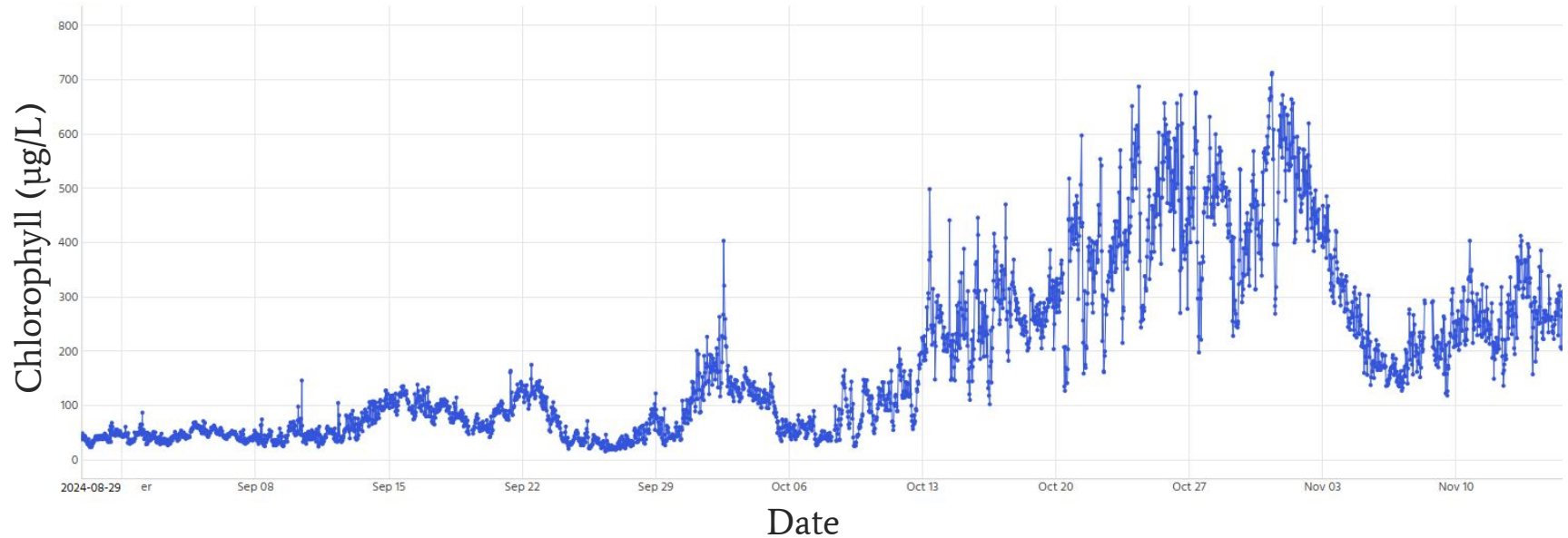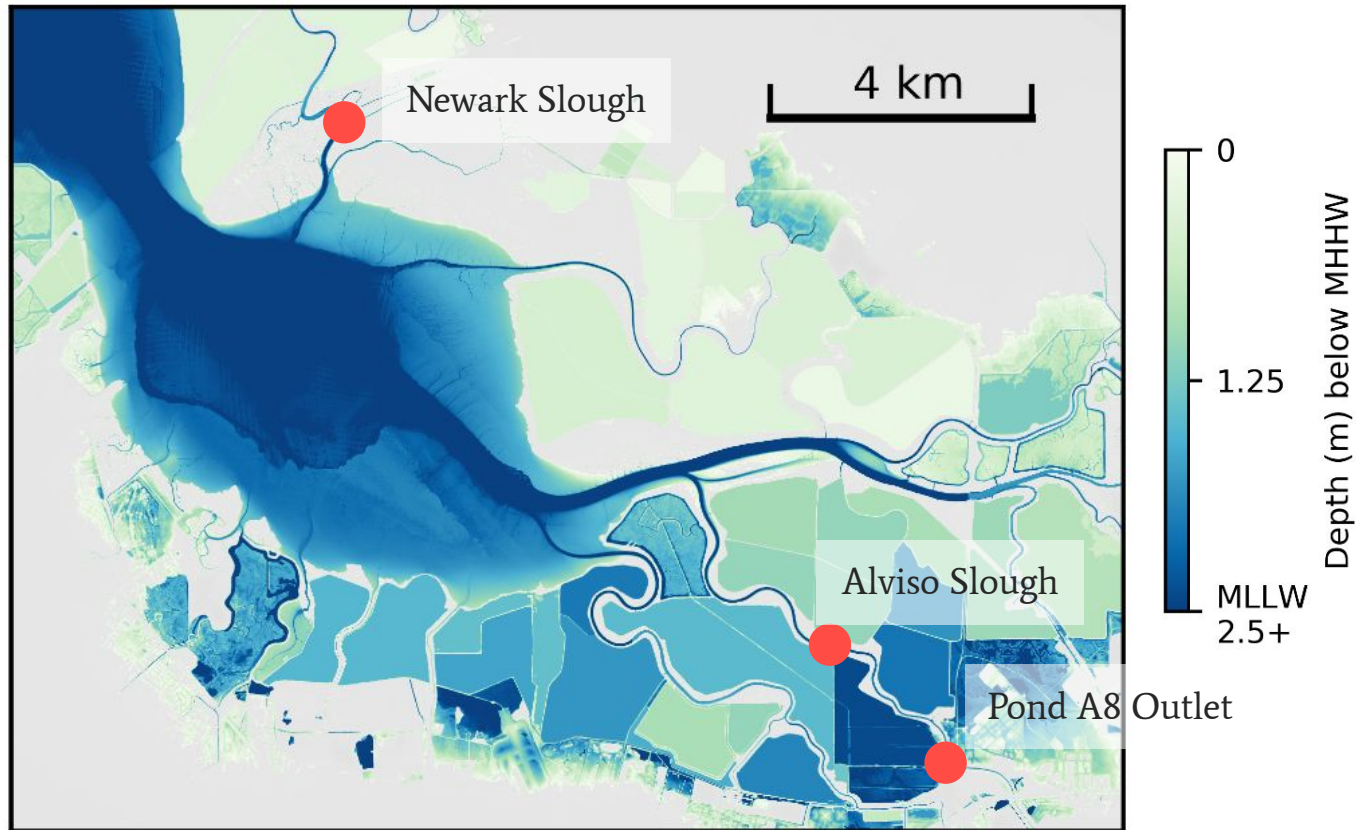Data collected in collaboration with Valley Water and Stillwater Sciences

Oxygen uptake estimates in sloughs

Oxygen uptake in sloughs
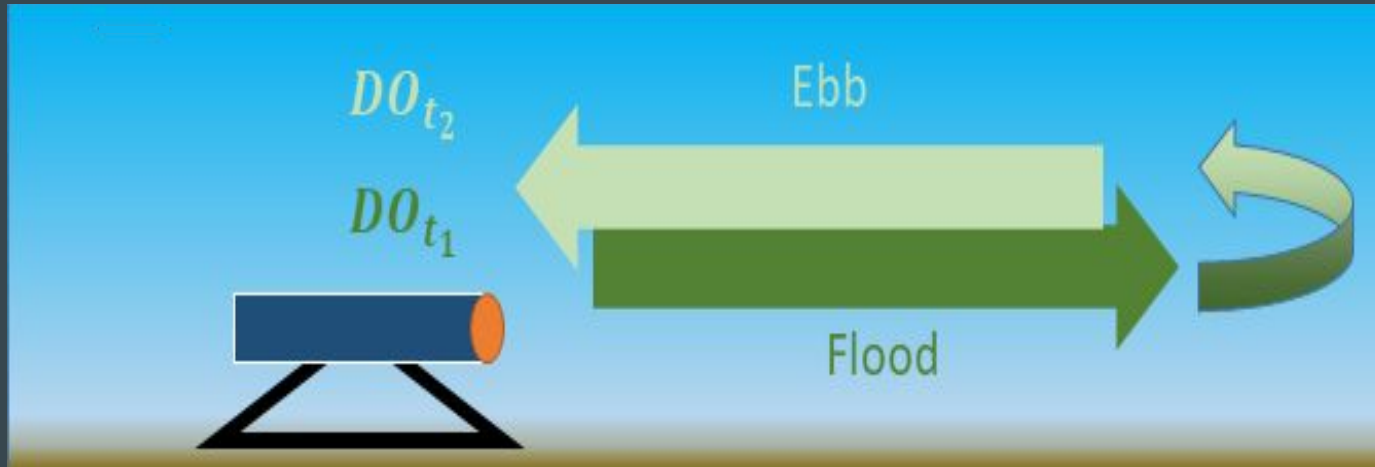
- Rate estimates calculated from one sensor station
- Change in DO from flood to ebb tide
- Five years of data (2015-2019), ~1000 tidal cycles per site

Oxygen uptake in sloughs
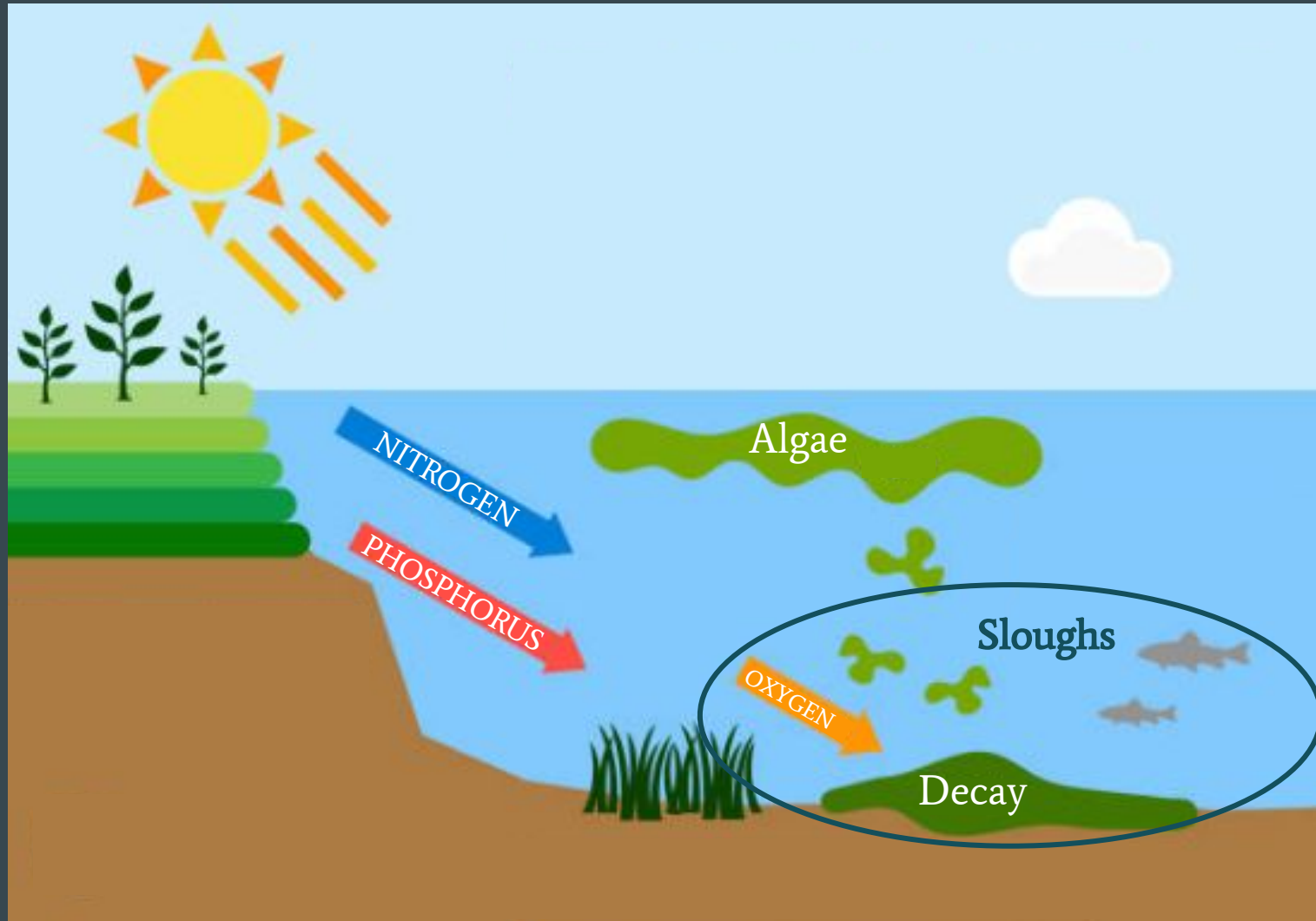
Dissolved oxygen concentrations

- Dissolved oxygen (DO) levels generally peak in winter and early spring

- DO minima occurred in spring or summer

- Chlorophyll-a peaks at Alviso Slough coincide with DO maxima
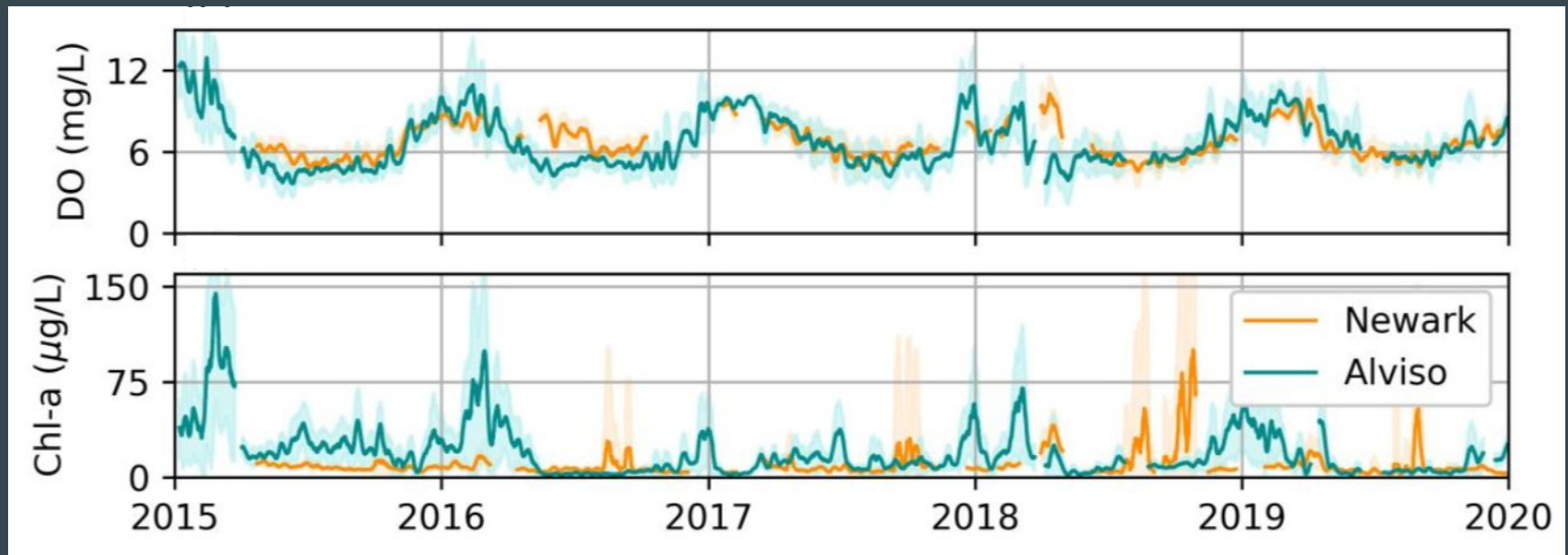
Oxygen uptake/respiration

- Remarkably different seasonal patterns between sites

- Newark Slough showed strongly seasonal rates, with highest respiration in summer

- Alviso Slough dynamics are more complicated...

Oxygen uptake/respiration

- High respiration rates in the winter and spring

- Respiration rapidly decreased into summer

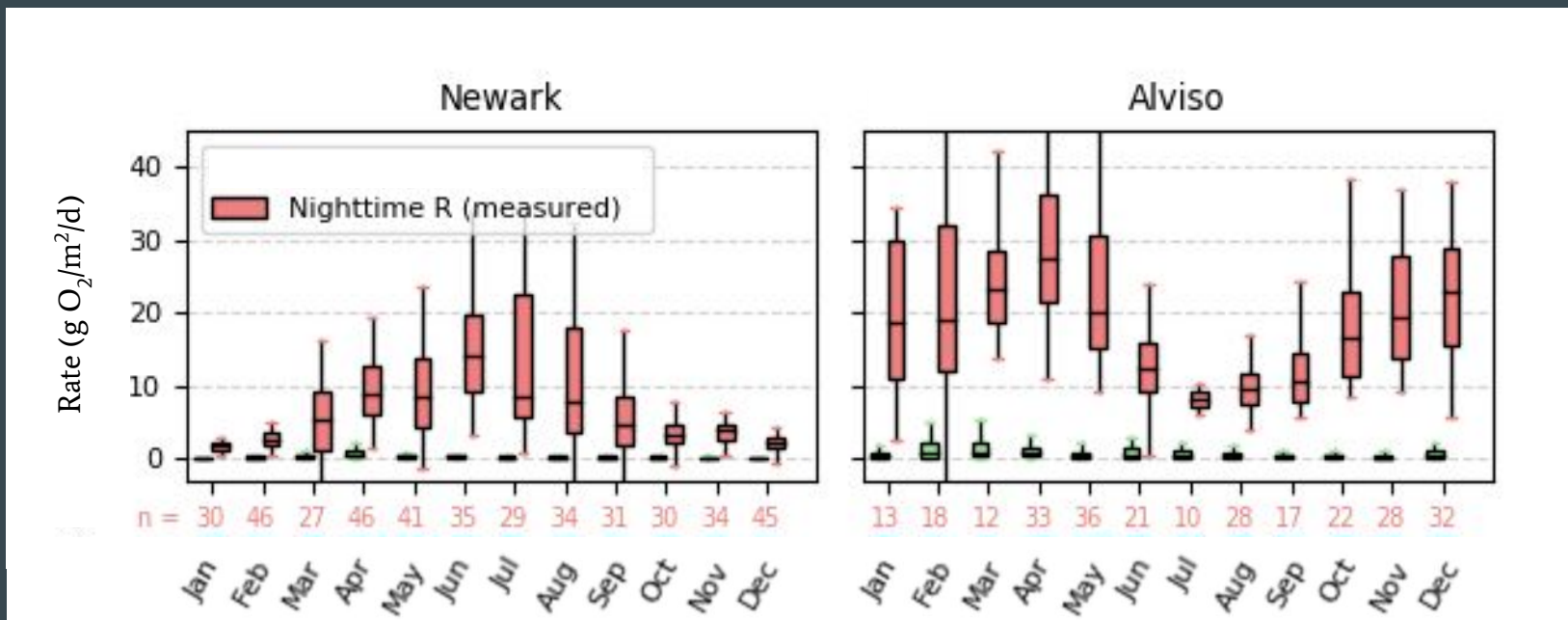- Peak in respiration not consistent with periods of lowest DO

- May be explained by the complex pond-slough exchange dynamics during bloom events
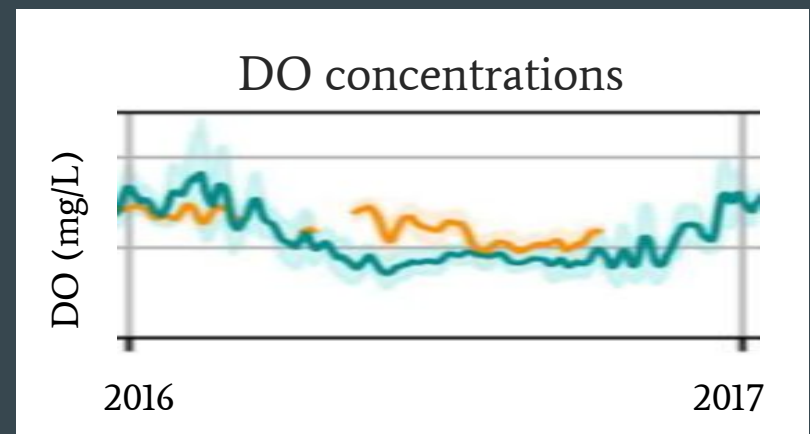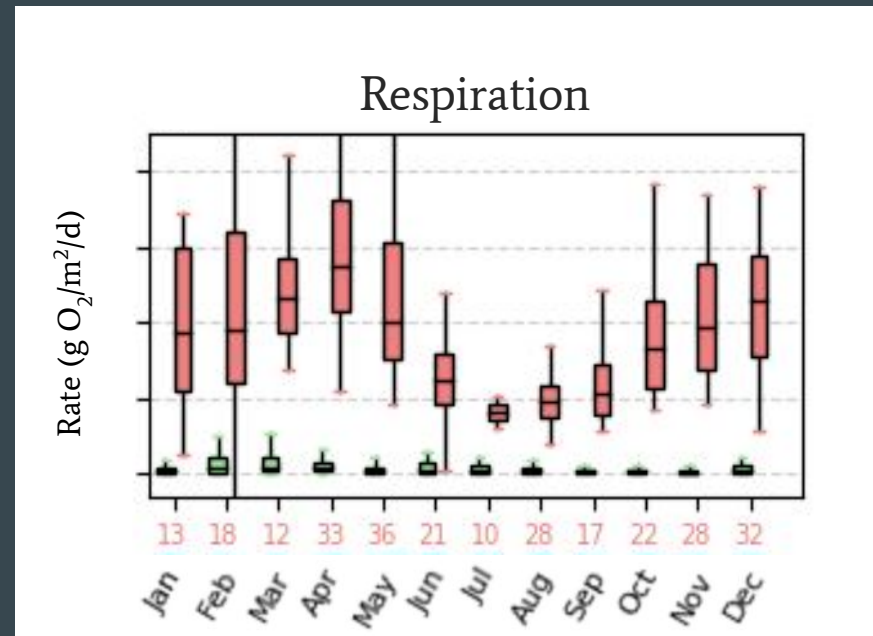
Respiration

Rate (g O_2/m^2/d)

13 18 12 33 36 21 10 28 17 22 28 32

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

DO concentrations

DO (mg/L)

2016   2017

Roberts et al., 2022, Estuaries and Coasts

Link between slough and pond

- Lagged and muted DO and chlorophyll-a signals at Alviso relative to Pond A8 Outlet with peaks during ebb tide

- Suggest elevated chlorophyll-a concentrations in Alviso Slough driven by biomass export from Pond A8
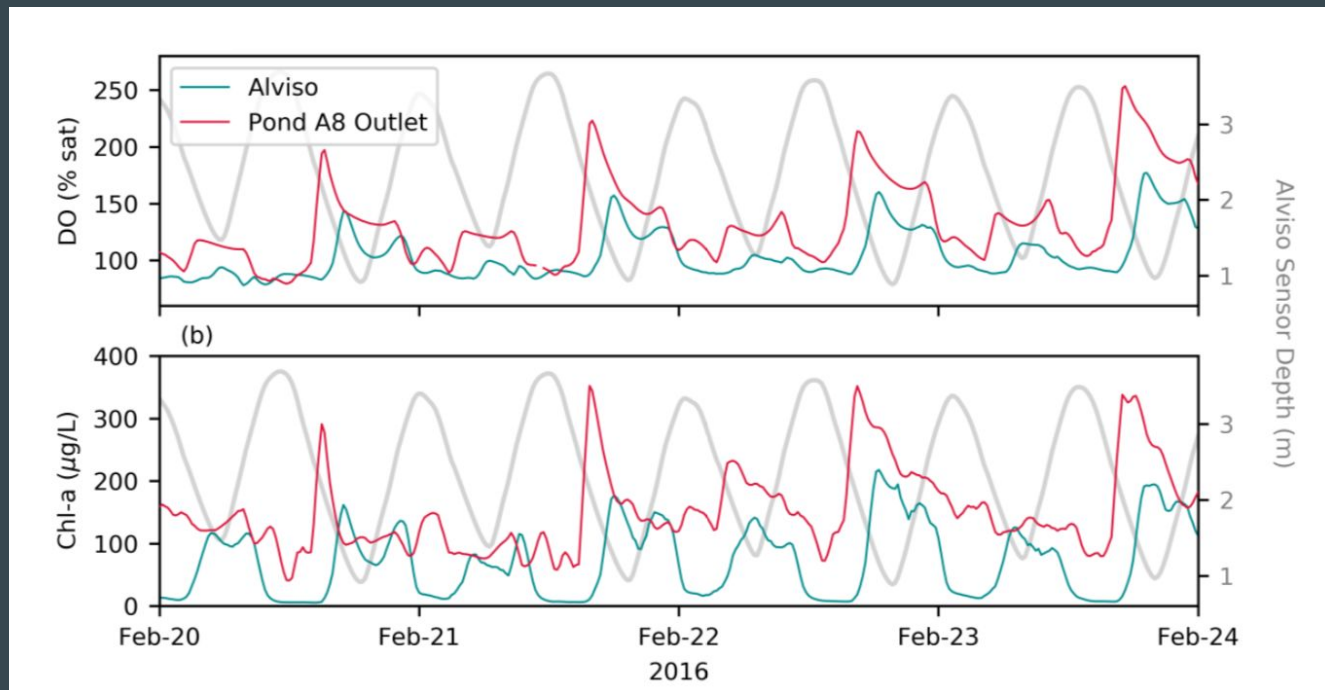
Oxygen uptake estimates in sloughs

Link between slough and pond

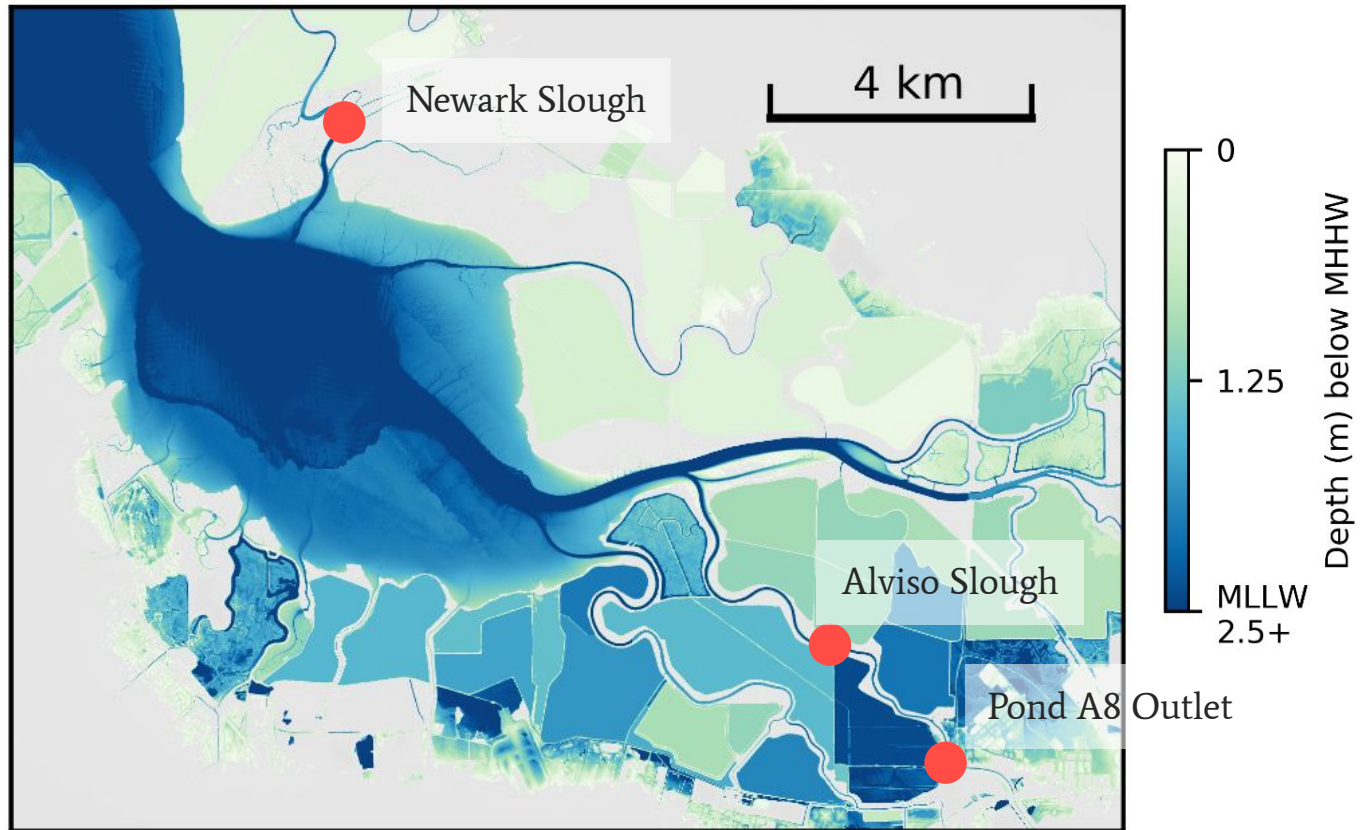- Lagged and muted DO and chlorophyll-a signals at Alviso relative to Pond A8 Outlet with peaks during ebb tide

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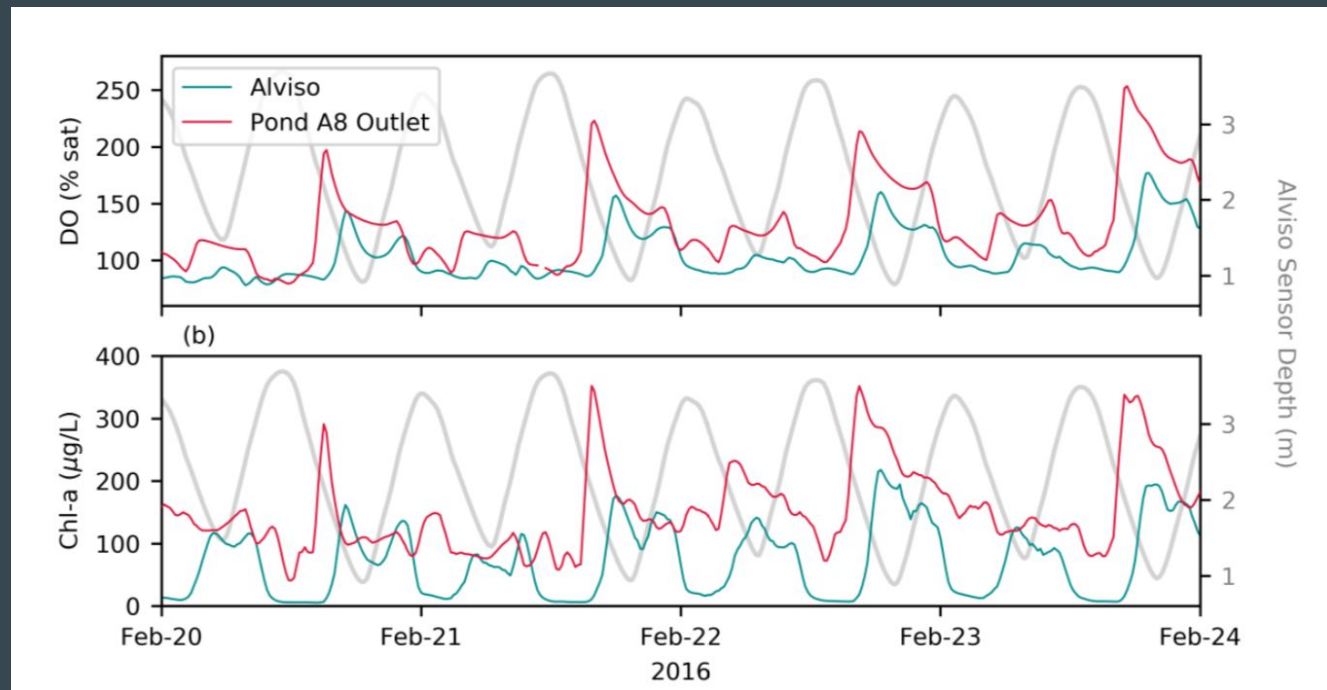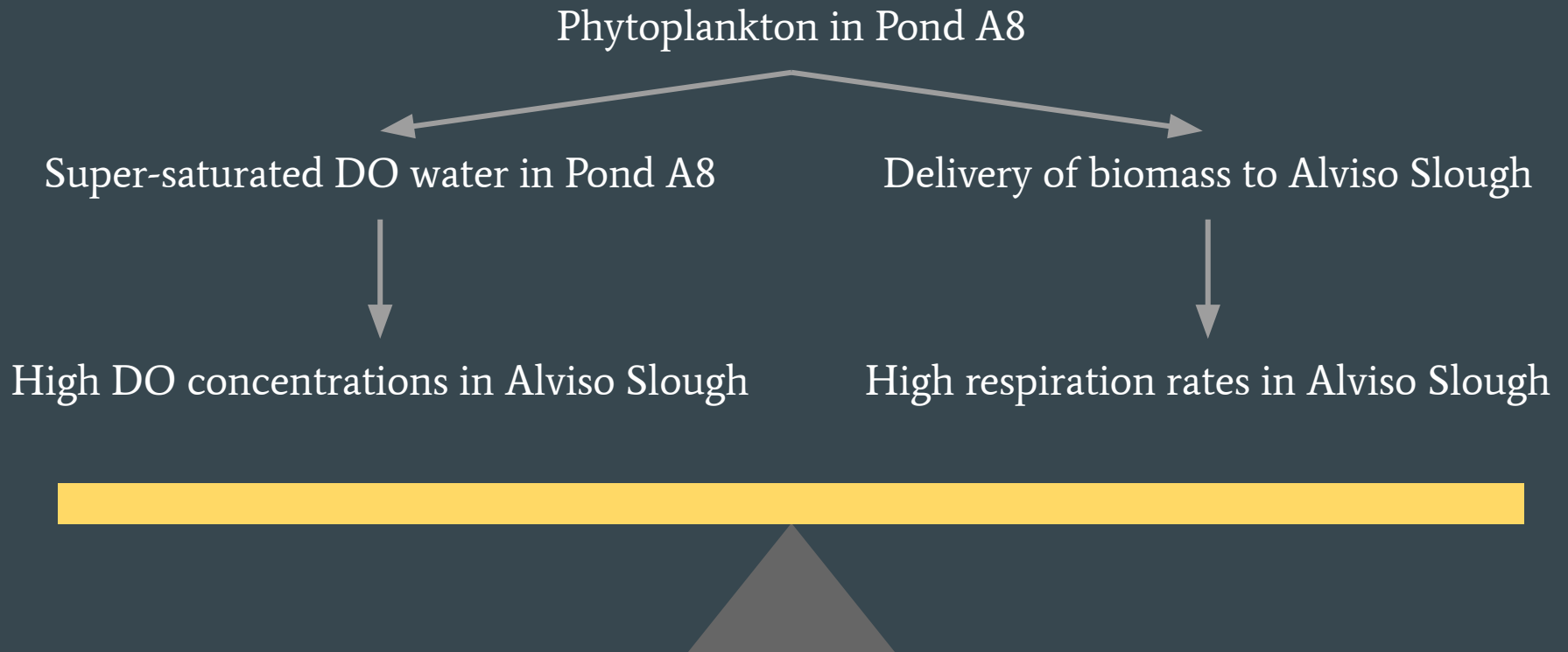
Link to salt pond production

Phytoplankton in Pond A8

Super-saturated DO water in Pond A8

Delivery of biomass to Alviso Slough

High DO concentrations in Alviso Slough

High respiration rates in Alviso Slough

Link to salt pond production
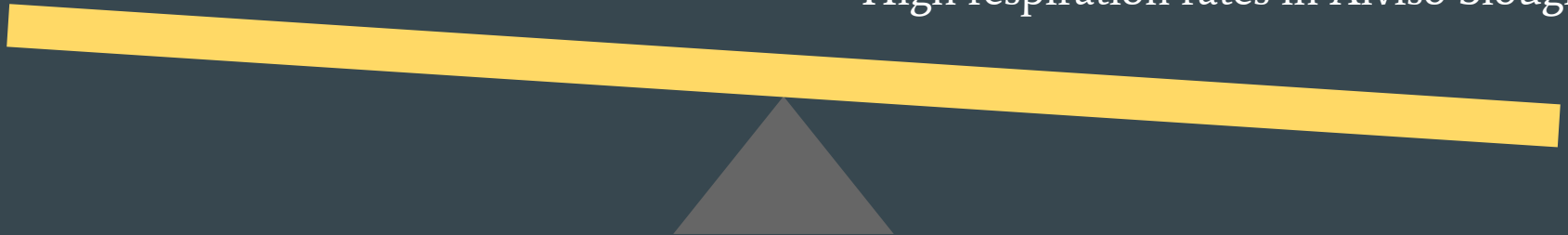
Bloom period

Super-saturated DO water in Pond A8

High DO concentrations in Alviso Slough

Delivery of biomass to Alviso Slough

High respiration rates in Alviso Slough
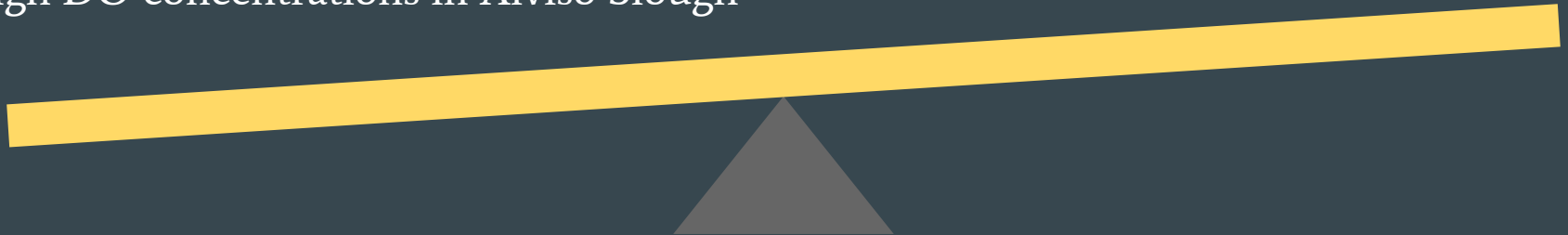
Link to salt pond production

Non-bloom period

Delivery of biomass to Alviso Slough
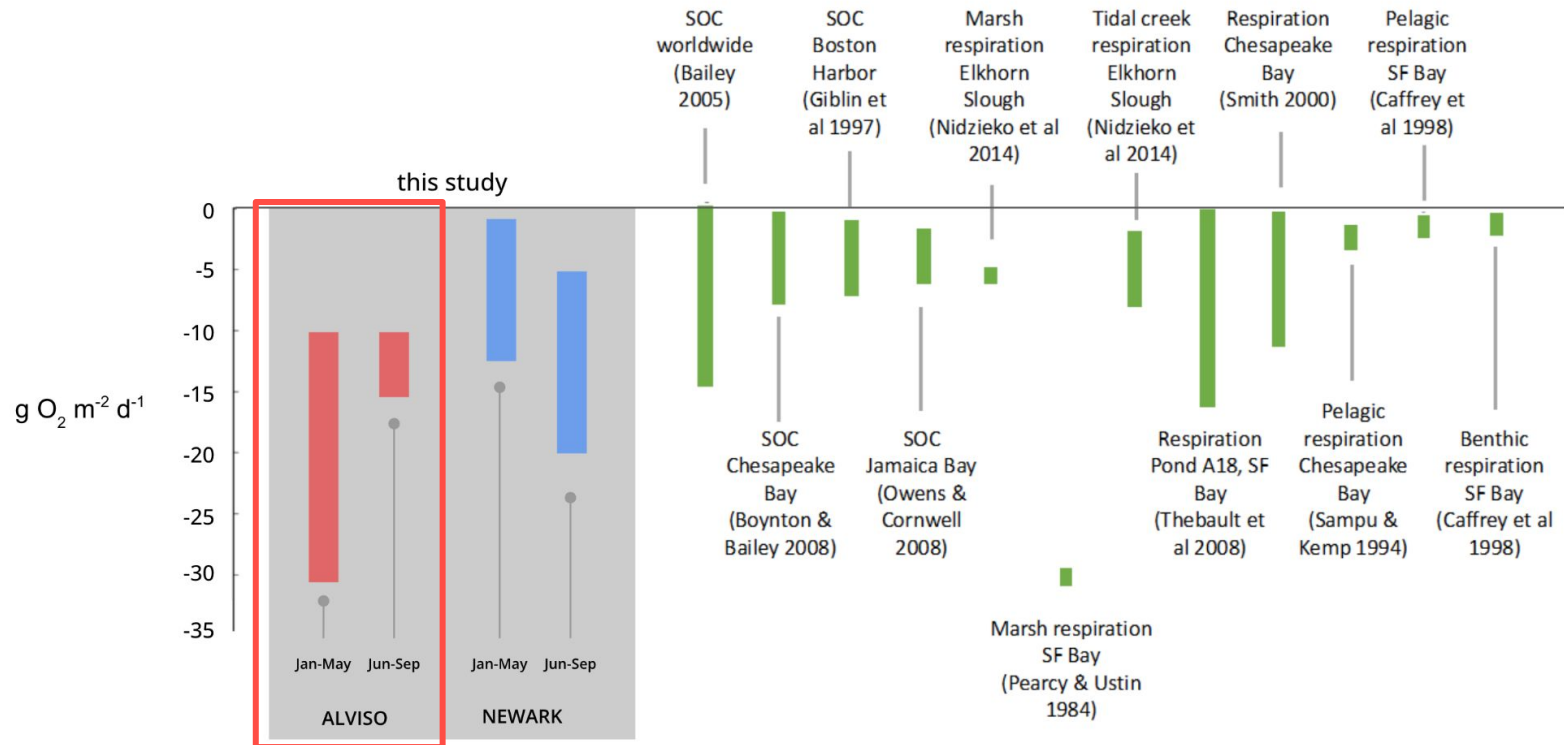
Super-saturated DO water in Pond A8

High respiration rates in Alviso Slough

High DO concentrations in Alviso Slough

High rates compared to other estuarine systems

Roberts et al., 2022, Estuaries and Coasts

Modeling results - Pond A8 and Alviso Slough

Additional Tracer Sources
Palo Alto 5.1 km
San Mateo 21.7 km

ALV

San Jose

Sunnyvale

▲ Tracer sources
⋀⋁ Pond tracer source region
— Mooring and flux cross section
Mesh bathymetry
Bed elevation, m NAVD88
3

-10

Volaric et al, in prep
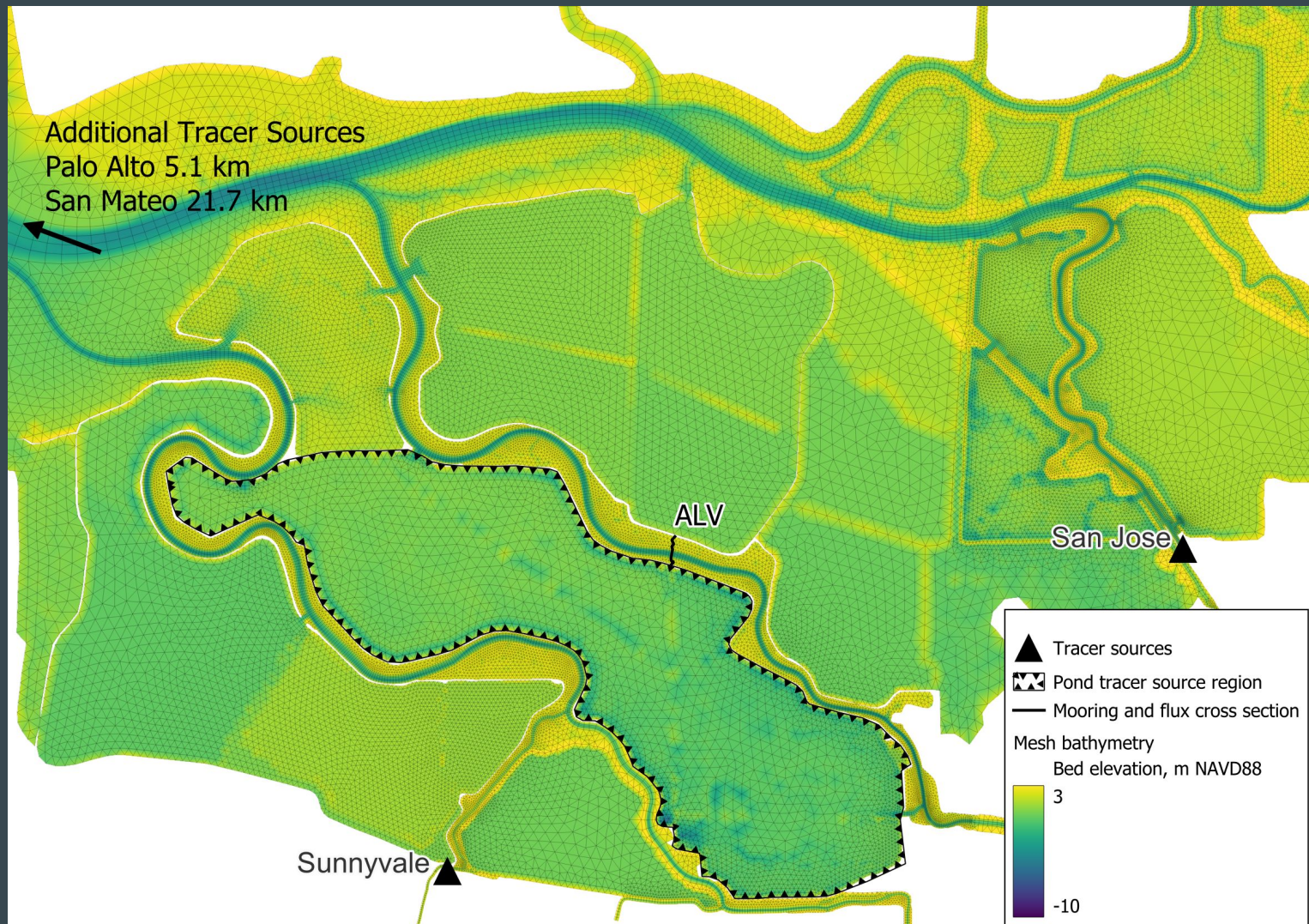
Modeling results - Pond A8 and Alviso Slough
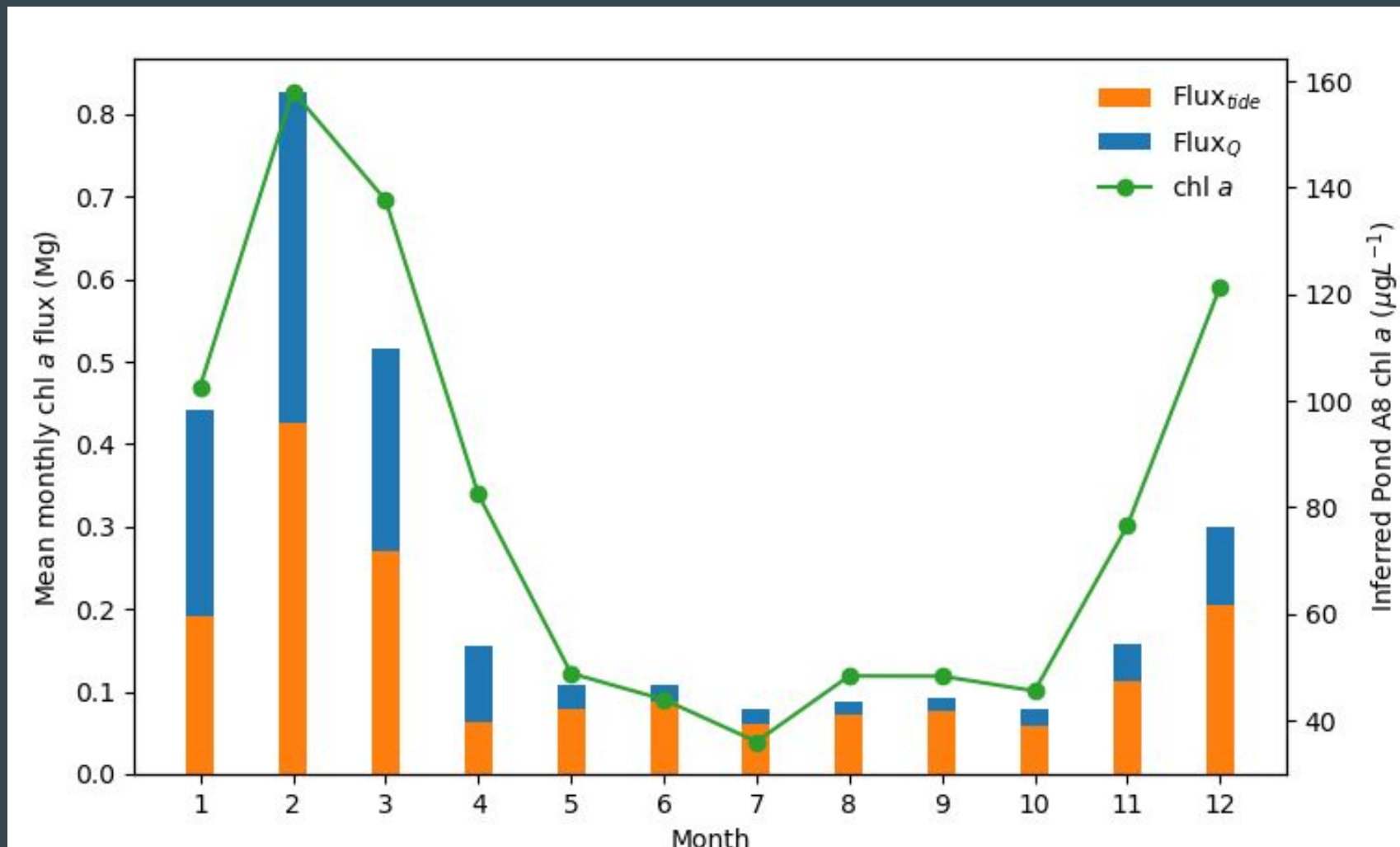
Modeling results - Pond A8 and Alviso Slough

- Modeling confirms net transport of phytoplankton out of Pond A8 into Alviso Slough

- Transport is driven by a combination of flow from the Guadalupe River (which becomes Alviso Slough) and tidal pumping

- Nearly all phytoplankton that leaves Pond A8 is respired within Alviso Slough before reaching open Bay

Takeaways - Results support hypothesized mechanism
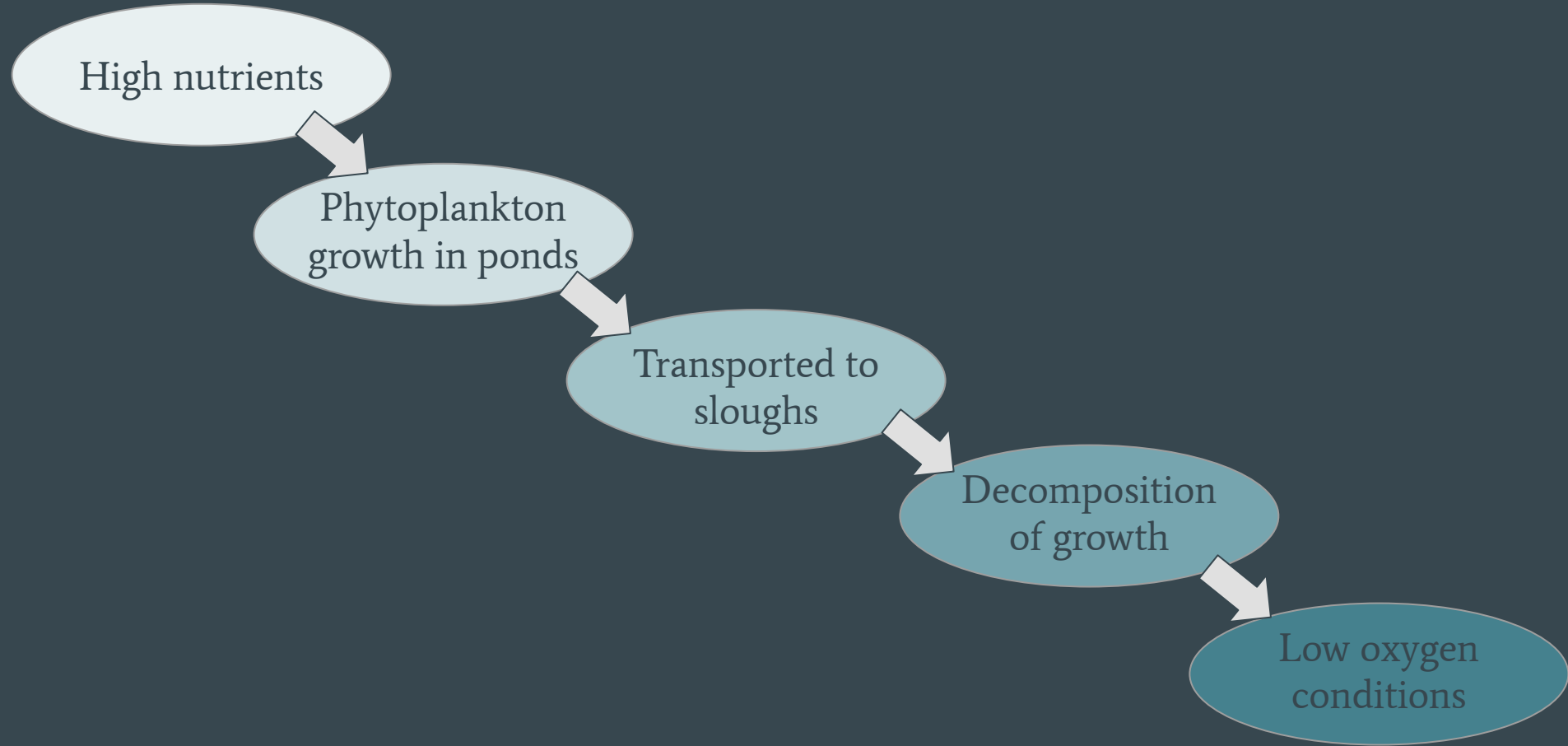
High nutrients

Phytoplankton growth in ponds

Transported to sloughs

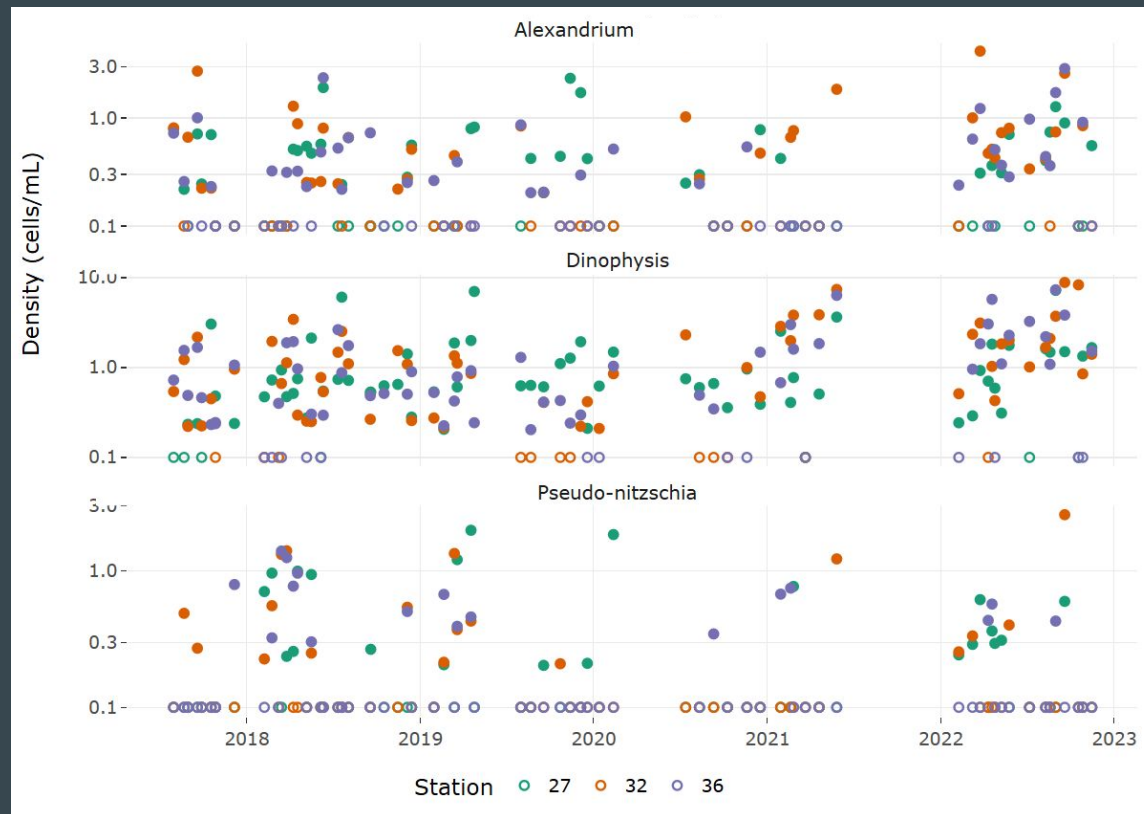Decomposition of growth

Low oxygen conditions

Takeaways

- Interaction between high nutrients and managed ponds have the potential to impact water quality in LSB sloughs

- Delicate balance creates potential for low DO conditions

- Restoring connections between managed ponds and sloughs may alter this balance → potential effects should be considered during the restoration process

Key uncertainties and future work

- Impact of changing wastewater nutrient loads on pond phytoplankton growth

- Effect of pond restoration process on water quality in sloughs

- Ability of restored ponds to buffer nutrient inputs

- Continue synthesis and modeling of existing data from LSB sloughs/ponds

- Field data collection in managed ponds as restoration process proceeds

HABs in former salt ponds

- Presence of up to six potentially toxic HAB taxa: Alexandrium, Aureococcus, Chatonella, Karenia, Anabaenopsis and Anabaena

Link

Questions?