DO in Lower South Bay

Habitats, mechanisms, and fluxes

May 19, 2017

Observations of DO

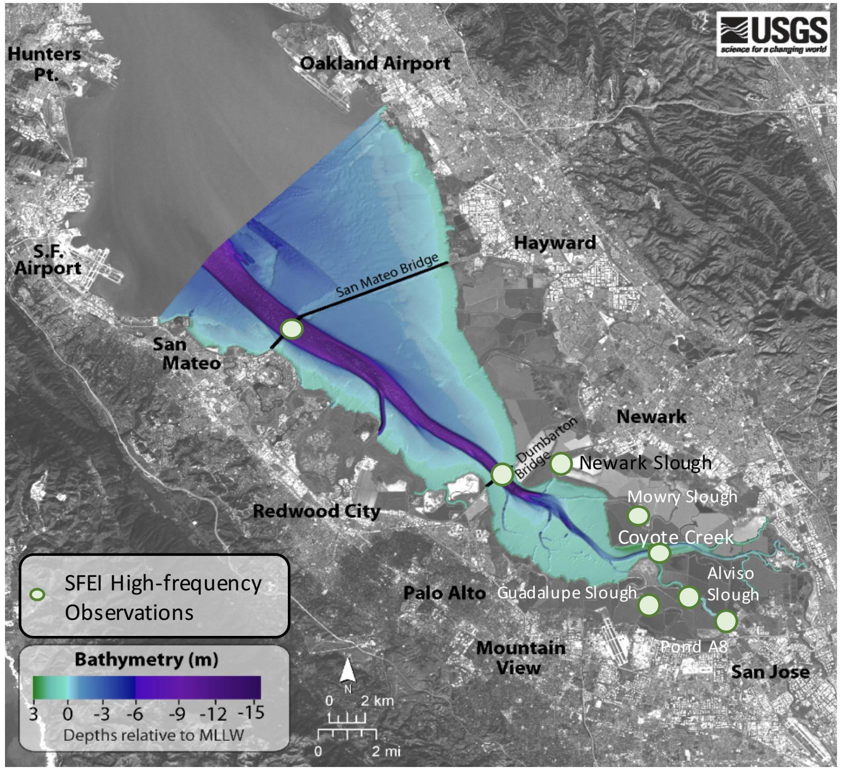
Understanding physical, biogeochemical drivers

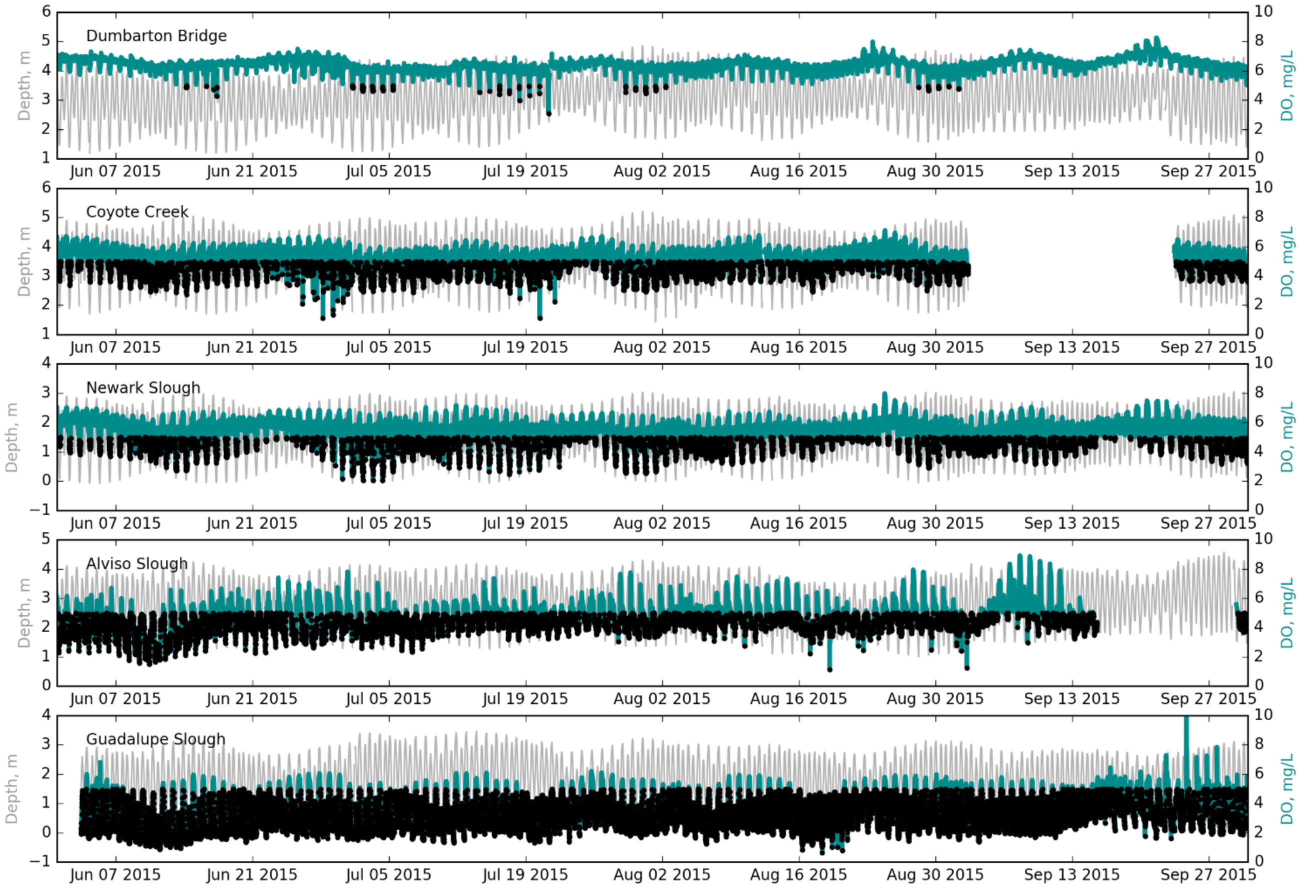
DO and habitat quality: workshop update

Mooring network: high resolution measurements in time and space

DO levels vary greatly between sensors and tidally/seasonally
DO in open Bay is less variable than DO in sloughs
Low DO at Dumbarton at low tide: possibly slough-sourced water

Summer 2015





Dumbarton Bridge
Coyote Creek
Newark Slough
Alviso Slough
Guadalupe Slough

Mooring network: high resolution measurements in time and space

Now that we know something about DO in LSB:

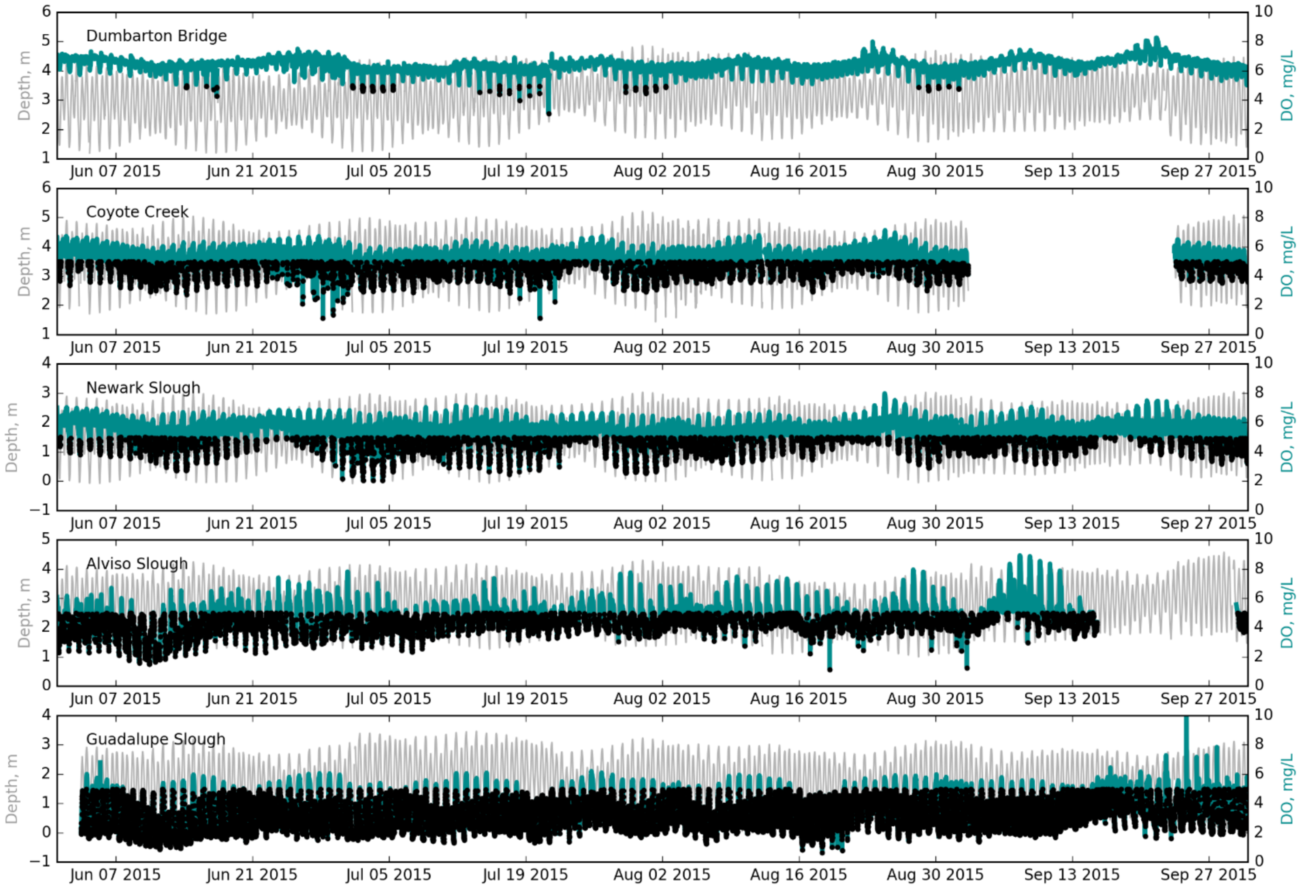
Is low DO causing problems *ecologically*?

What are the dominant *mechanisms*?

Are low-DO episodes different than those that occur *naturally*?

Do *nutrients* play a role?

Summer 2015



Dumbarton Bridge

Coyote Creek

Newark Slough

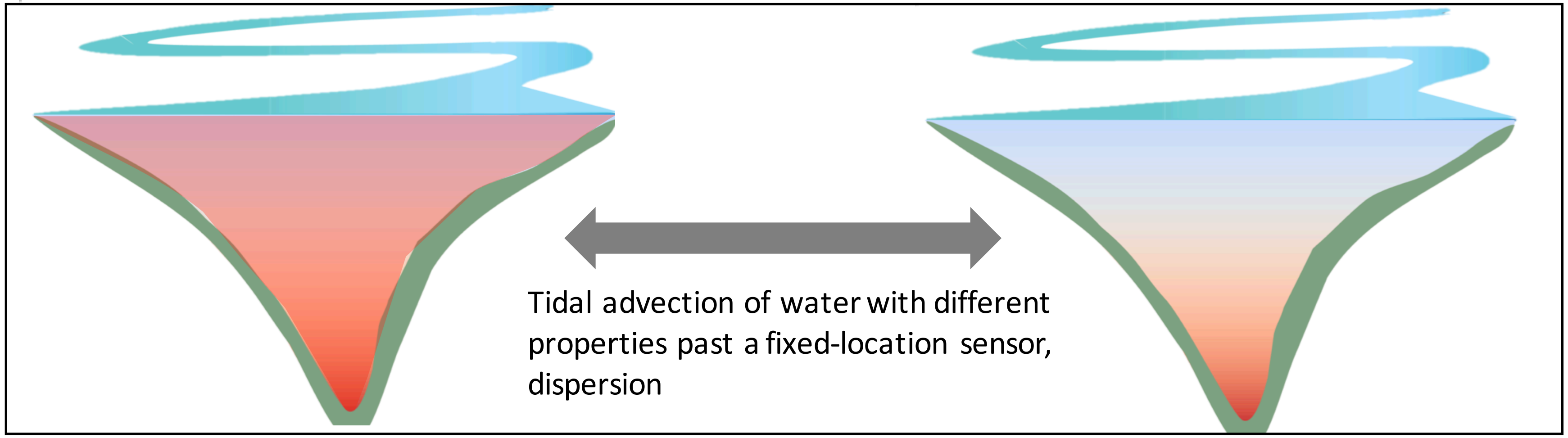
Alviso Slough

Guadalupe Slough

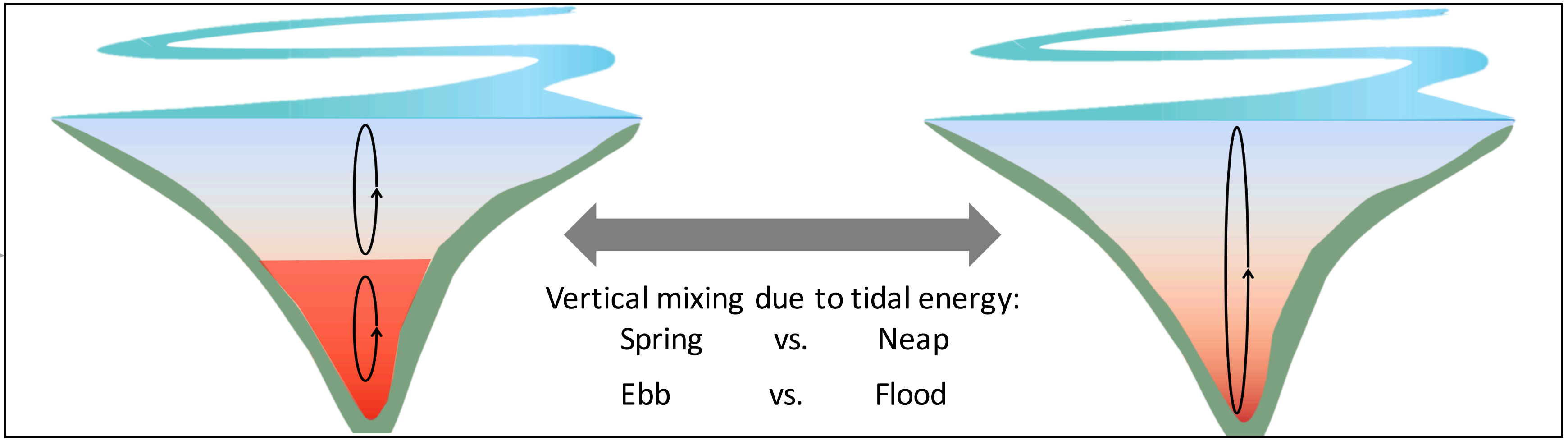
Possible mechanisms controlling DO

Physical: transport of water masses

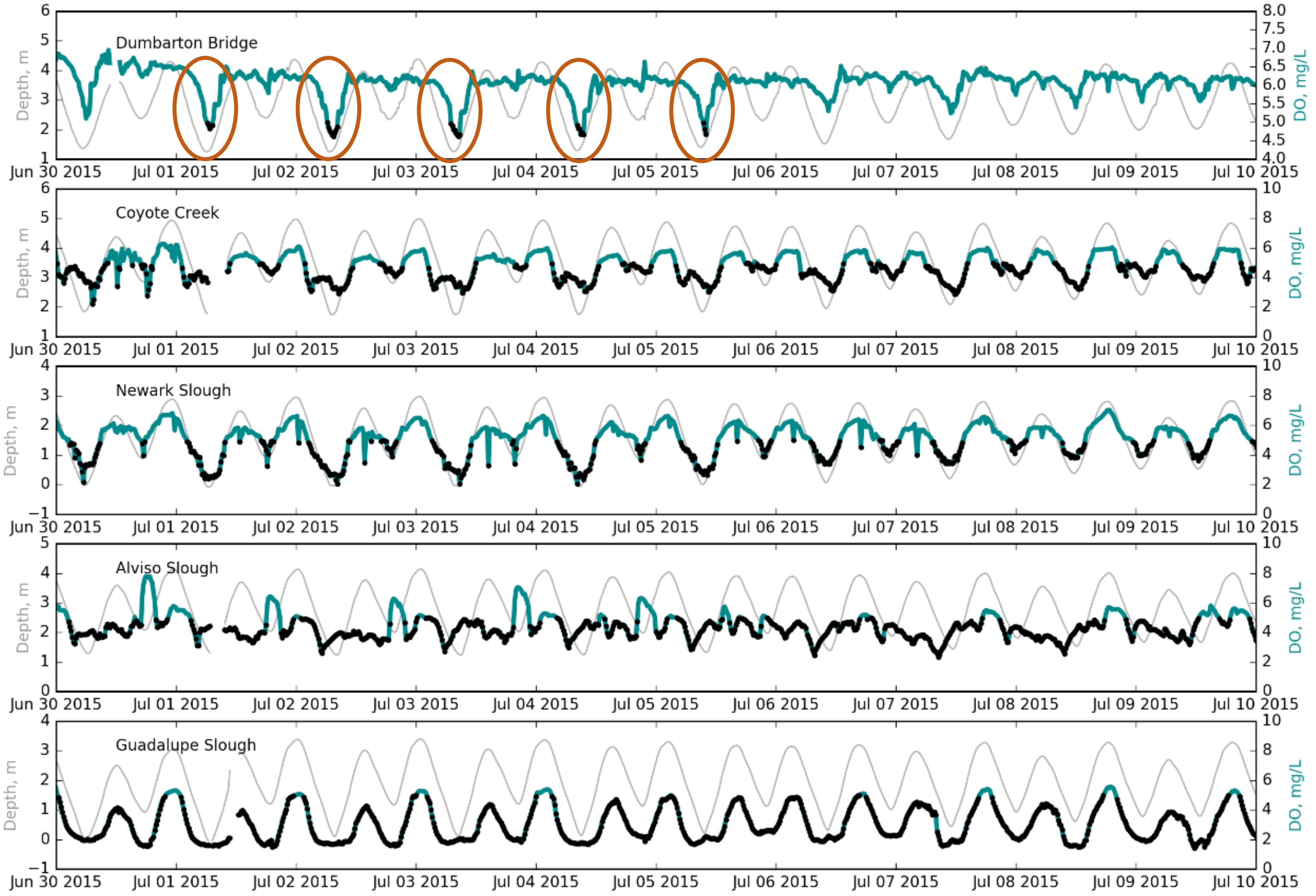
Biogeochemical: in-situ transformations (production, benthic/pelagic respiration)



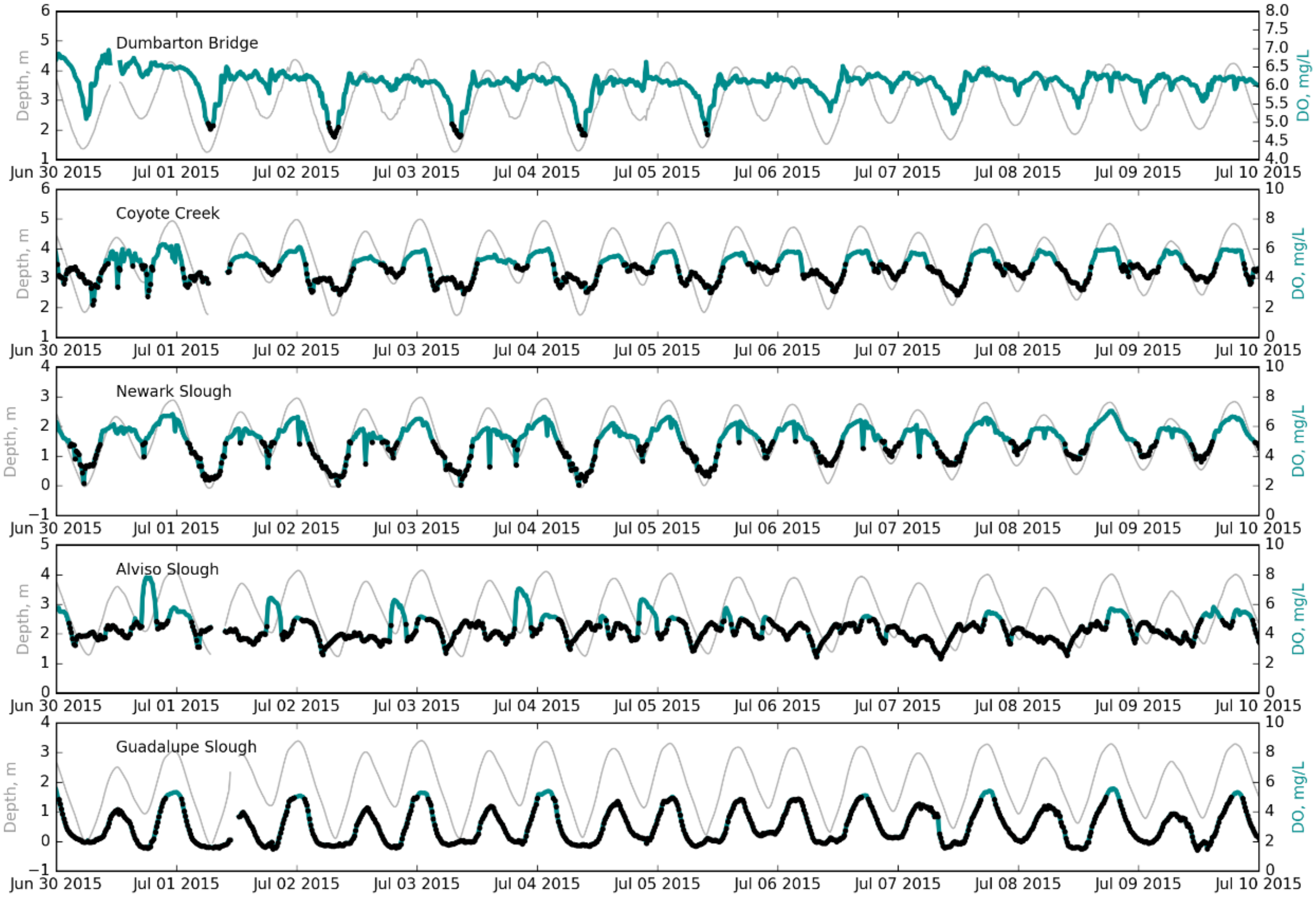
Physical-biogeochemical interaction: stratification-enhanced respiration, mixing of oxygen down from the surface, sediment resuspension



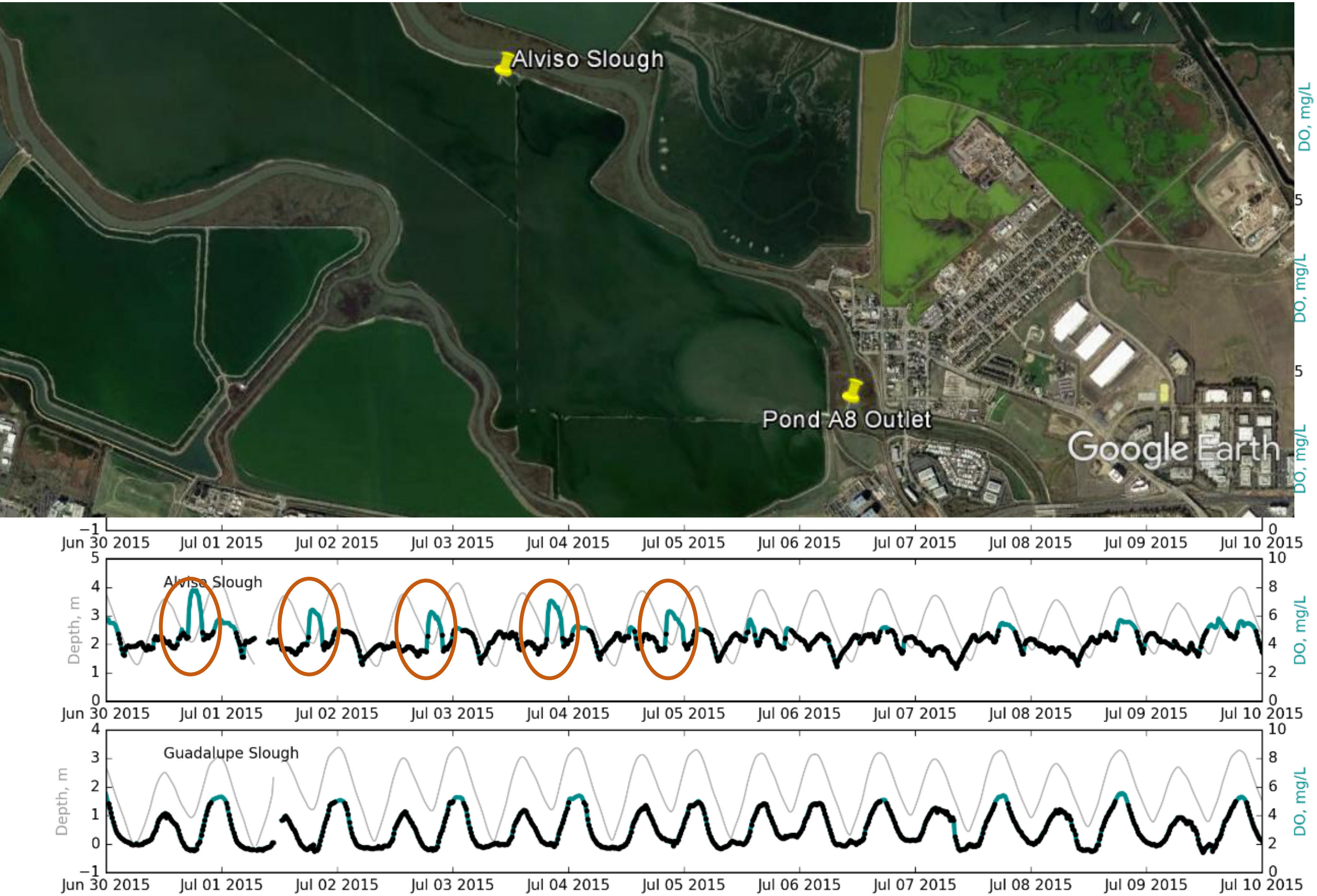
Connect observations to mechanisms



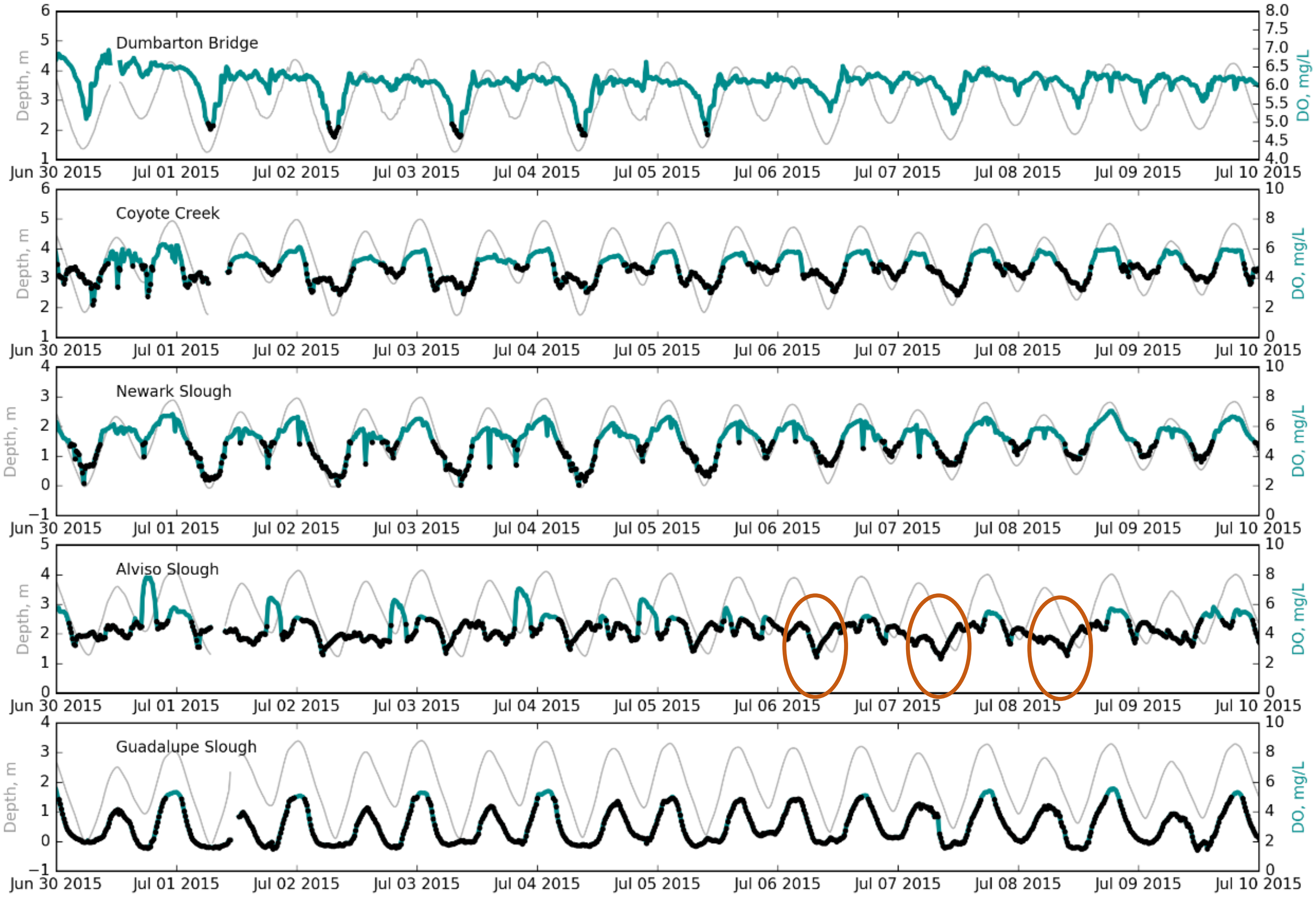
In open Bay, low DO occurs at lowest (spring) tides → **Advection of *slough-sourced water mass***



In some sloughs, there is evidence of tidal advection of a gradient, but no obvious water masses

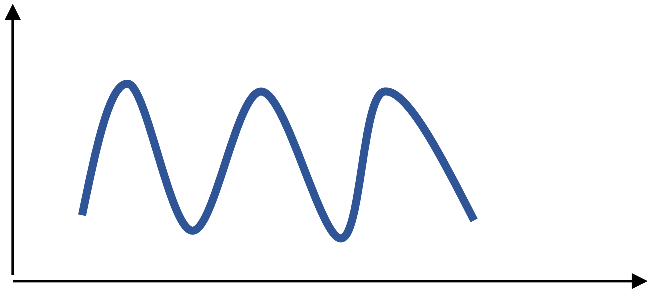


End of ebb:
Pond A8 effluent
(**Advection**)



Mid-ebb: O_2 drawdown in Alviso Slough (**Physical-BGC interaction?**)

Open Bay: transport



Sloughs, shoals, margins, far reaches of channels:

Complex interactions between physical and biogeochemical processes control DO in the environments connecting the extremes.

Ponds: BGC reactions

Parsing mechanisms in the sloughs

- Goal: estimate DO fluxes, where:
  - DO concentration = f(**production + pelagic respiration + benthic respiration + air-sea exchange** + transport)
- Challenge: tidal advection is strong!

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Factors Controlling Net Ecosystem Metabolism in U.S. Estuaries

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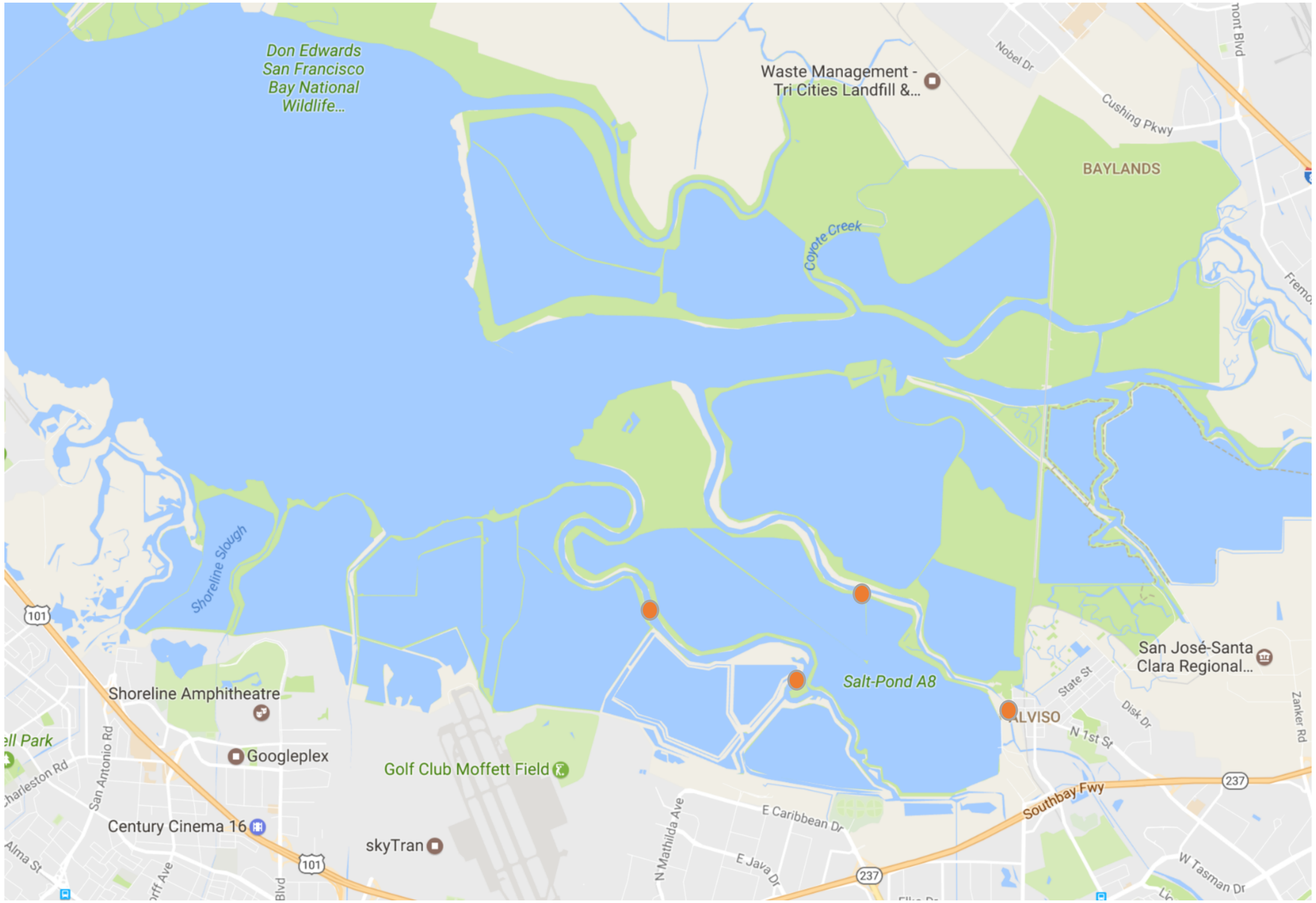
Methods

This study used half-hourly records of dissolved oxygen collected by the NERR System Wide Monitoring Program, January 1995–December 2000. Dissolved oxygen, temperature, salinity, pH, and turbidity were measured with YSI data sondes. Data were collected from two sites at each of 22 Reserves (Fig. 1 and Table 1). Two sites were excluded from this analysis based on a previous study, which suggested that physical factors overwhelmed biological activity at these locations (Caffrey 2003). At these two sites, dissolved oxygen concentrations varied depending on water flow and rarely showed the characteristic diurnal pattern that was observed at all other sites. Sites were categorized based on the dominant habitat adjacent to the deployment site. Detailed descriptions of each site are available in Wenner et al. (2001). Water surface area (Table 1) was calculated based on individual descriptions of sites (Wenner et al. 2001) and generally represent subsystems (i.e., tidal creek or embayment) within the estuary as a whole.

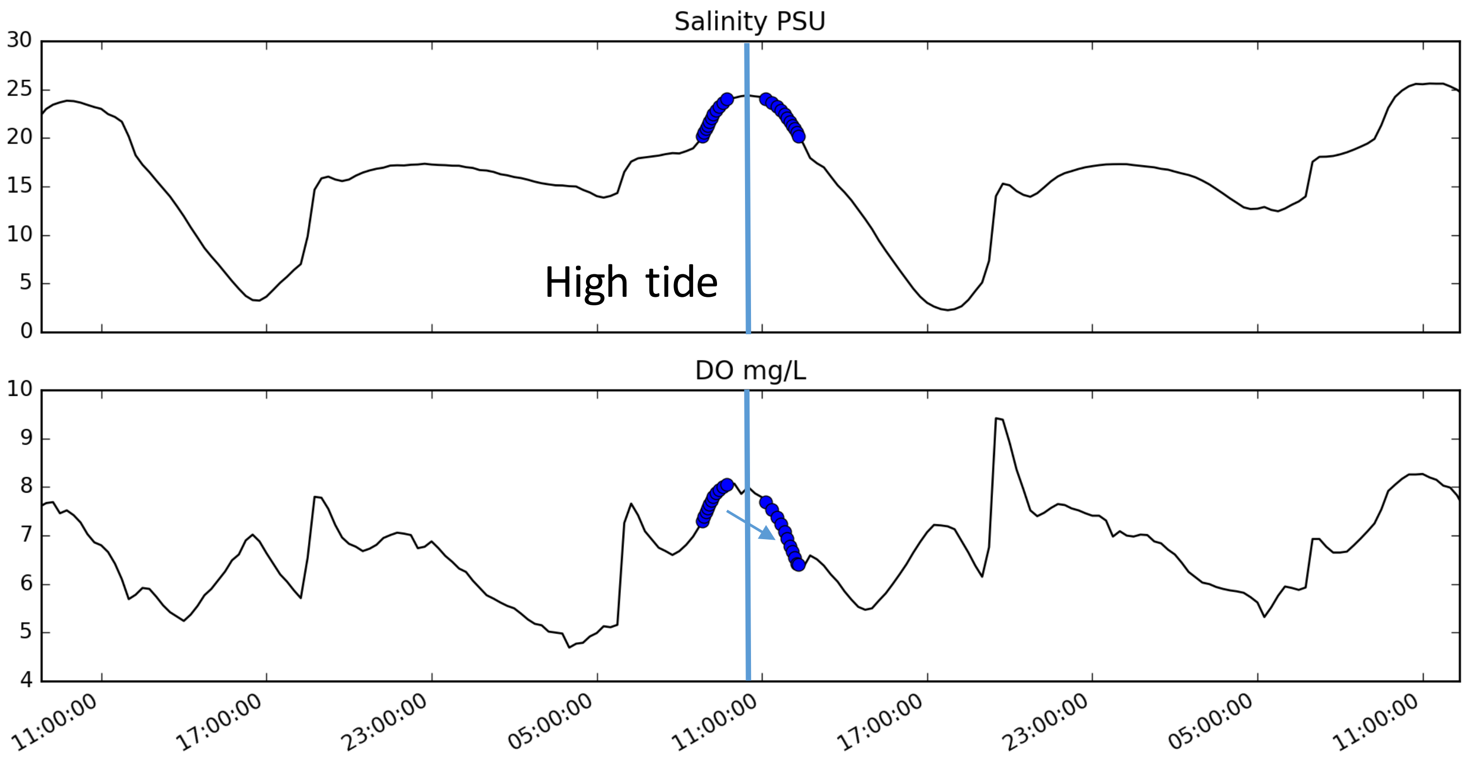
All data has undergone extensive quality control and quality assurance to remove data collected when data sondes were malfunctioning (Wenner et al. 2001).

Methods for calculating BGC DO flux



- Control volume analysis:
  - Intensive field study: summer 2016
    - Characterize DO flux into and out of control volumes on Alviso, Guadalupe
    - ADCPs, CTDs, vertical arrays of MiniDOTs
    - Profiling & transecting
- Develop a new method that can be applied to each moored sensor

A new, simple method for estimating DO flux



Data from Alviso Slough

Can be used at every mooring for broad spatial coverage of DO flux estimates

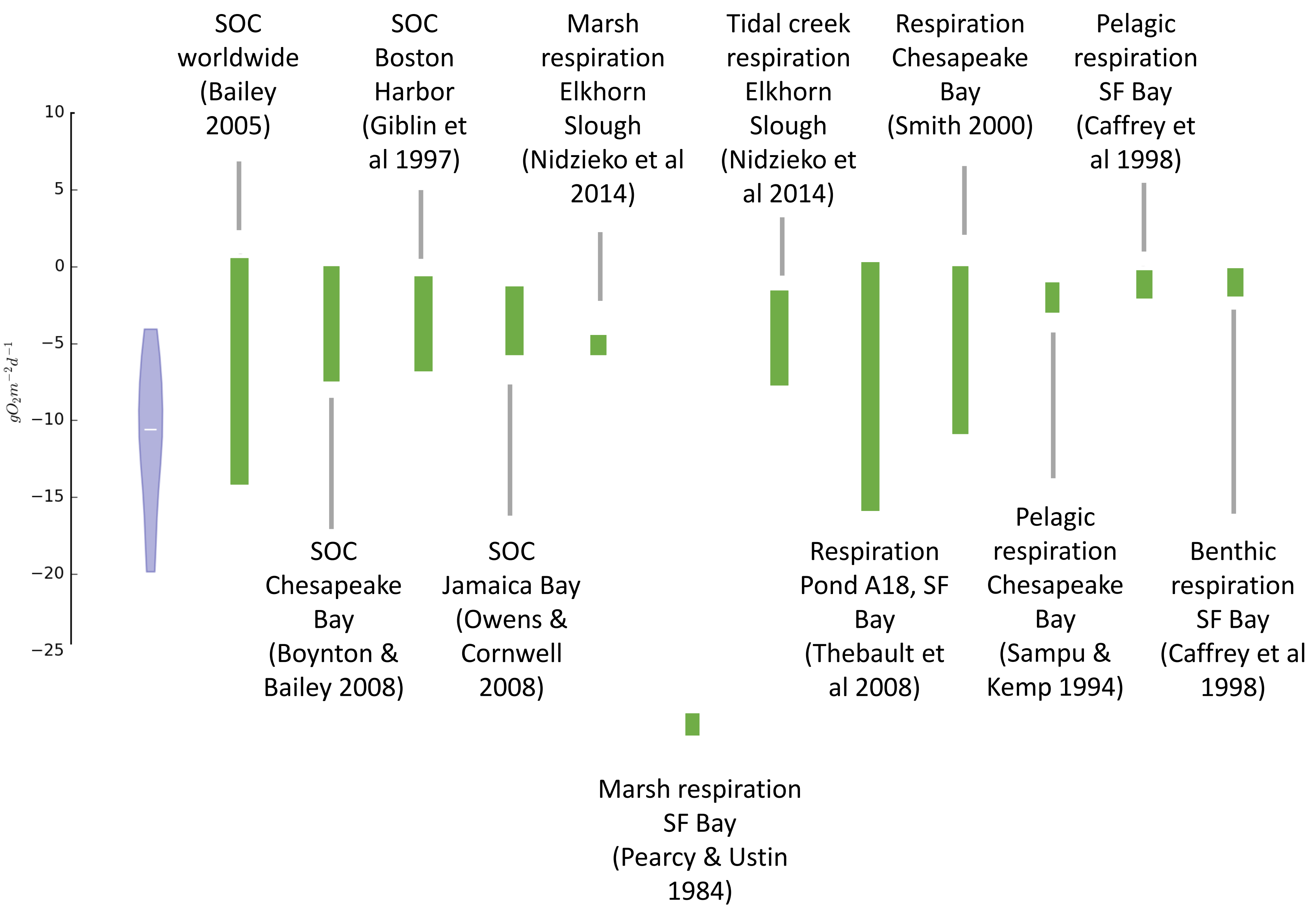
- Control for advection
- Identify times when the *same water mass* passes by our sensor twice (on flood, then on ebb)
- Determine how much DO was lost between those times

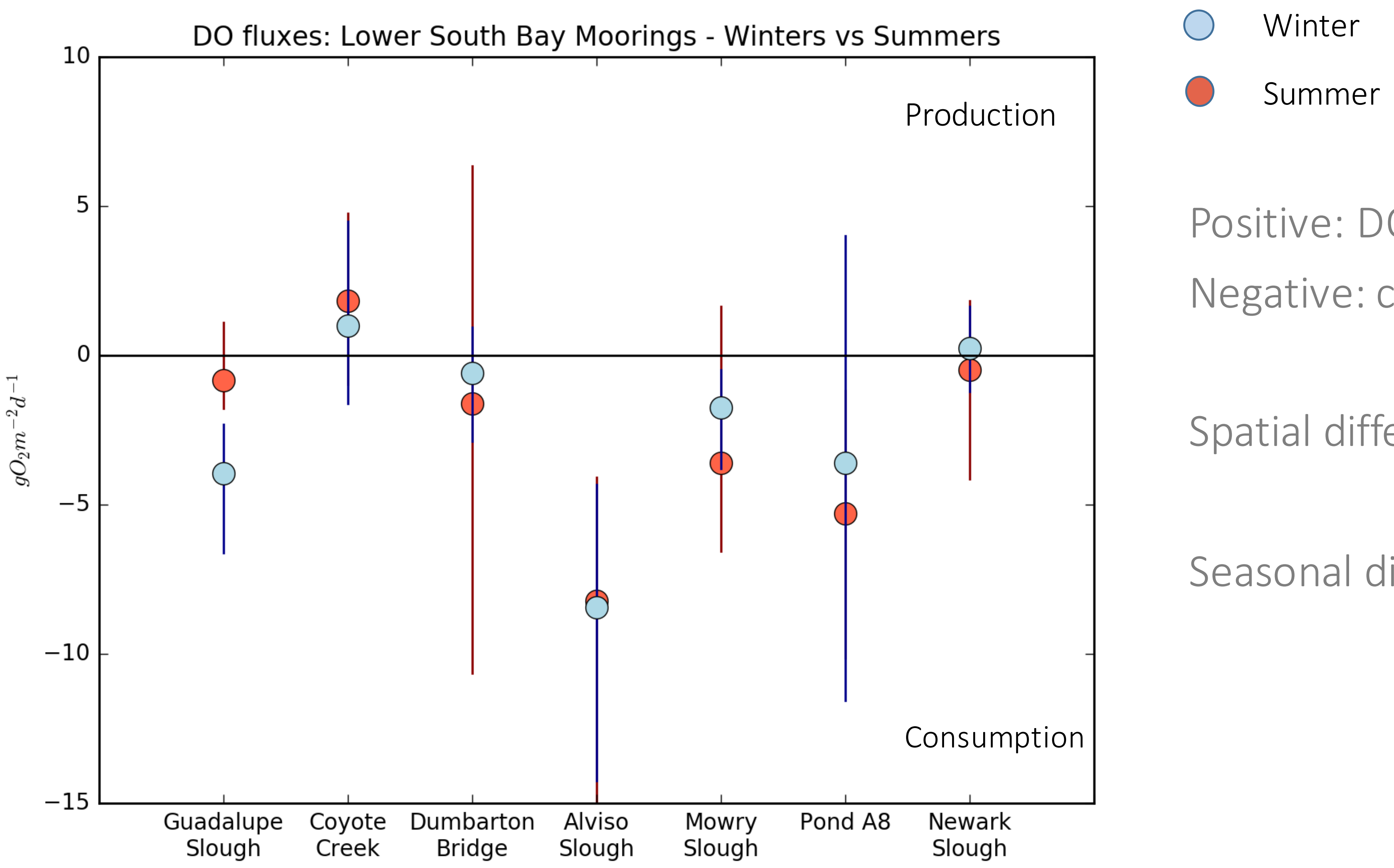
$$DOflux = \frac{\Delta DO}{\Delta t} H_{avg} \quad \left[\frac{\text{g O2}}{\text{m}^2\ \text{day}}\right]$$

- This net value includes all production & respiration

DO fluxes: preliminary results

- Alviso Slough net O_2 flux is negative (dominated by respiration)
- Magnitude is on the high end of published values
- Respiration is even greater (in magnitude) since net flux includes air-sea exchange and production



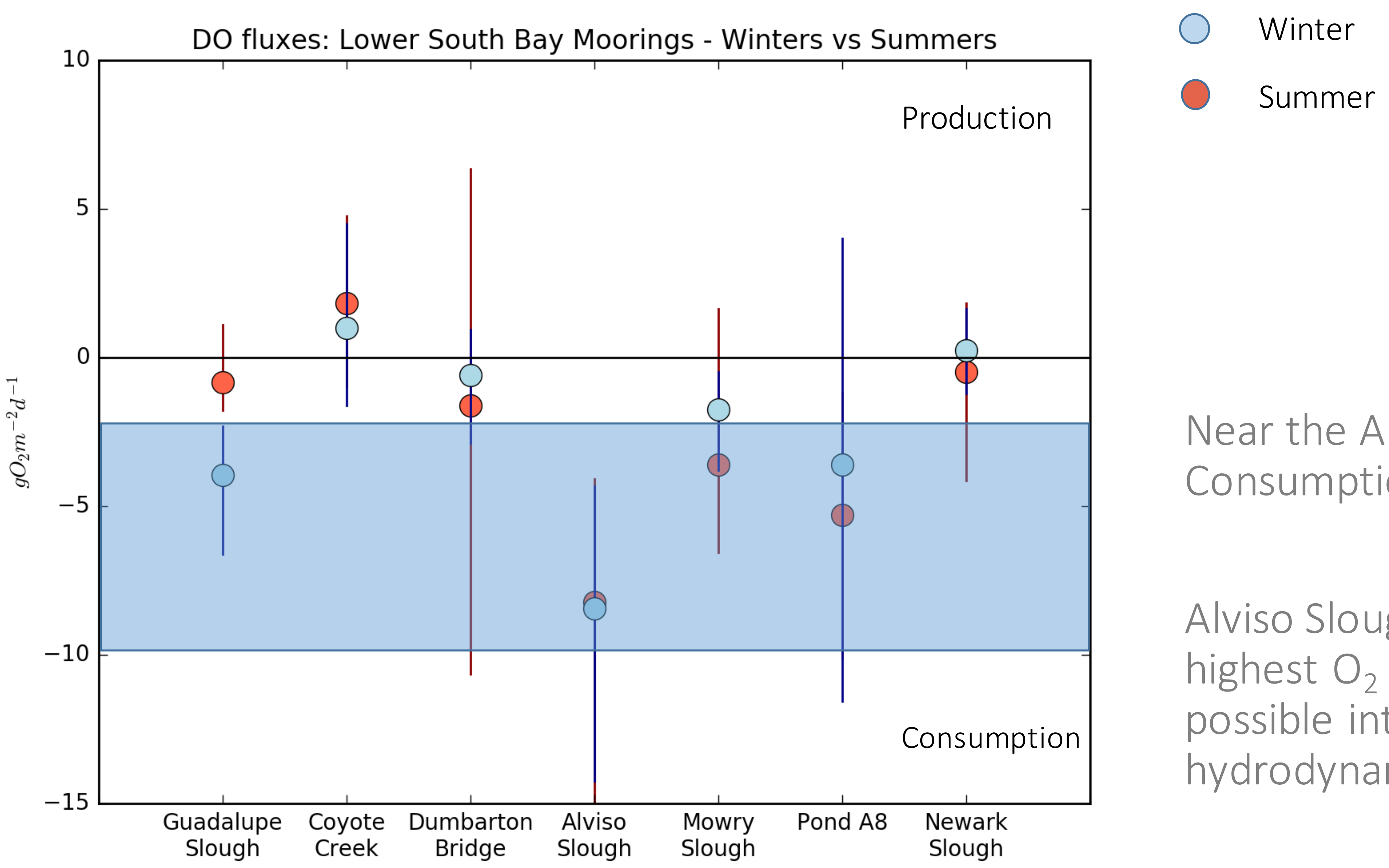


Positive: DO production

Negative: consumption

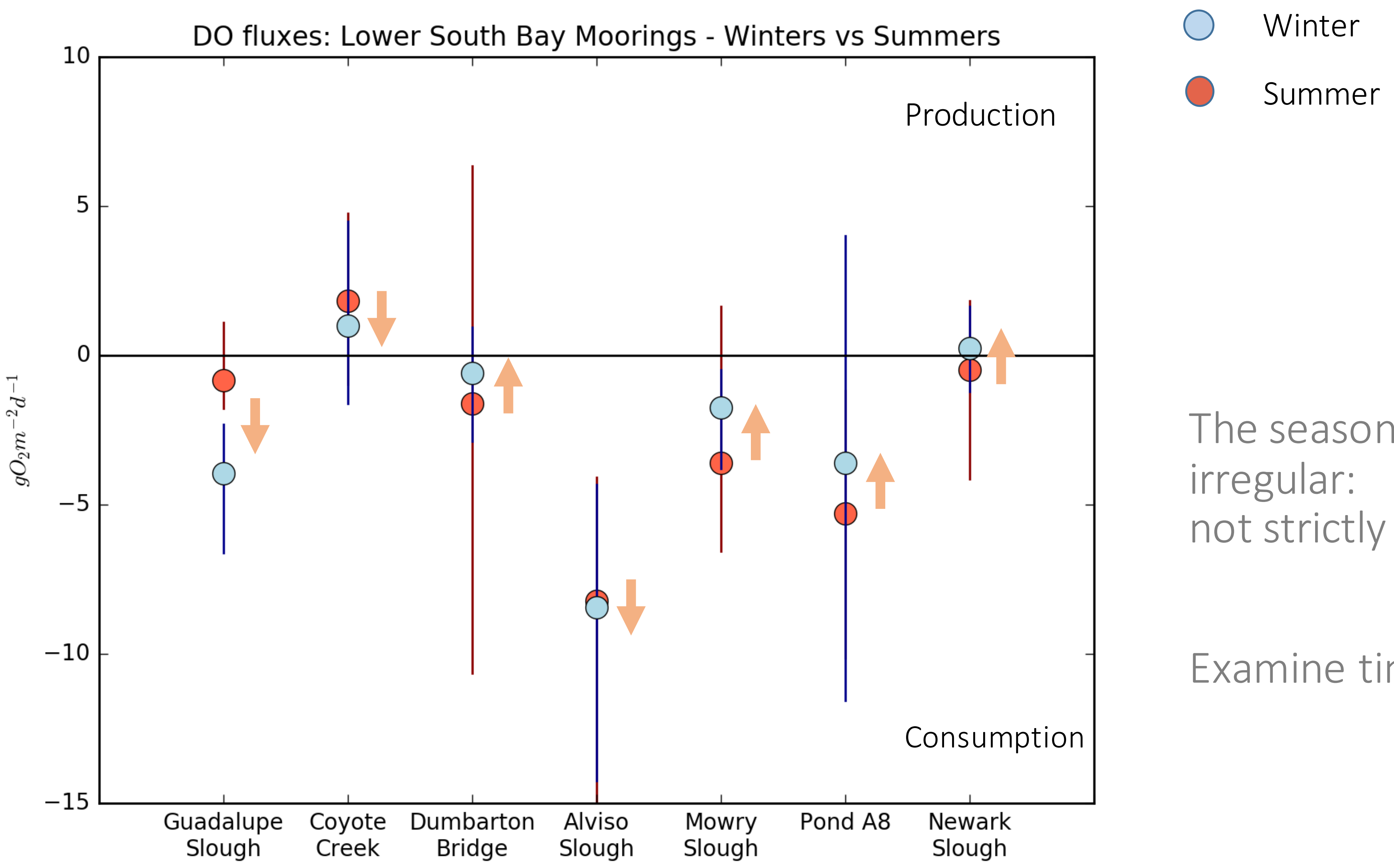
Spatial differences

Seasonal differences



Near the Alviso complex: Consumption rates are high

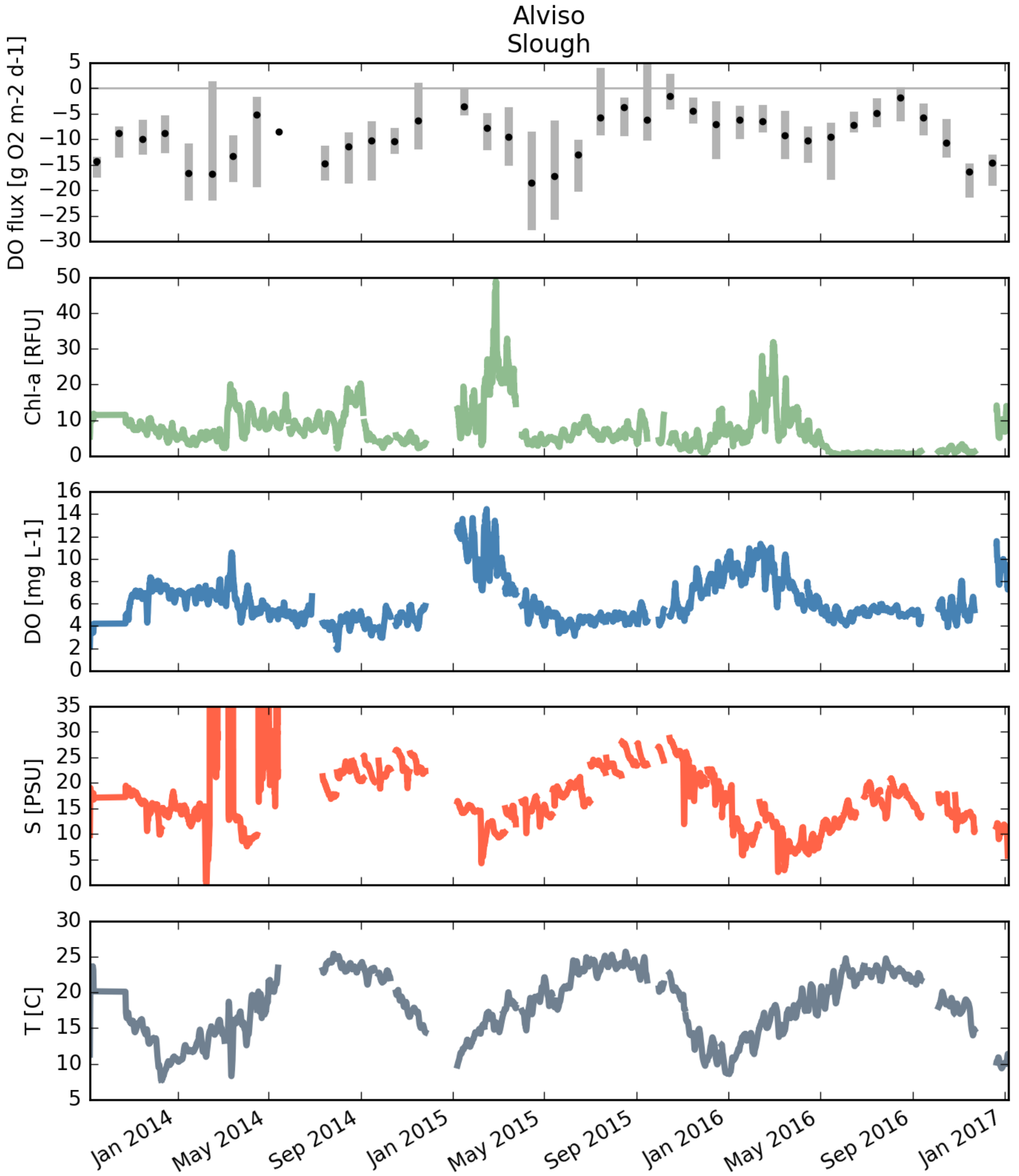
Alviso Slough has the highest O_2 consumption – possible interactions with hydrodynamics



The seasonal difference is irregular:
not strictly seasonally-driven

Examine time-series…

DO flux time-series

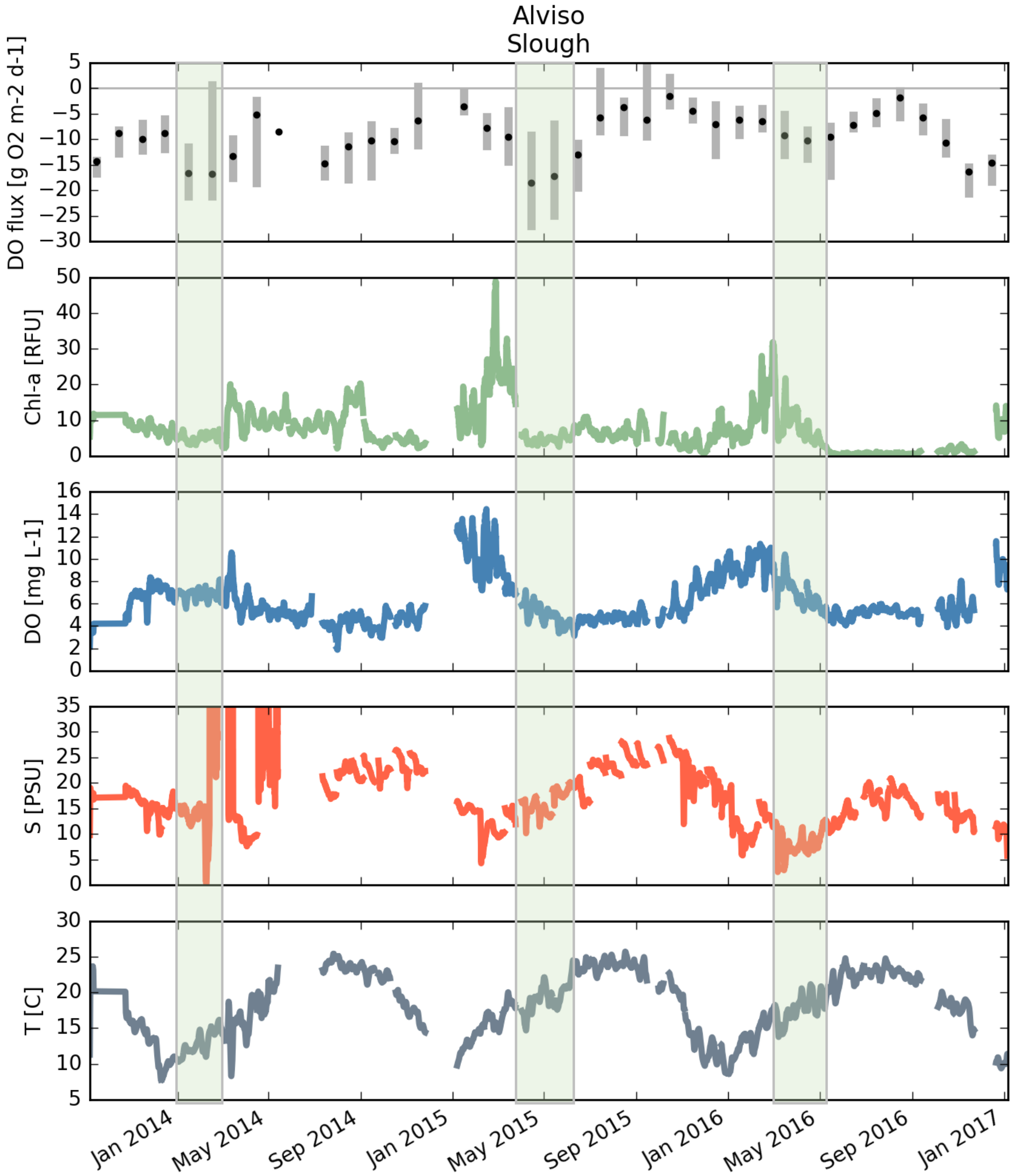


Daily averages

75th percentile

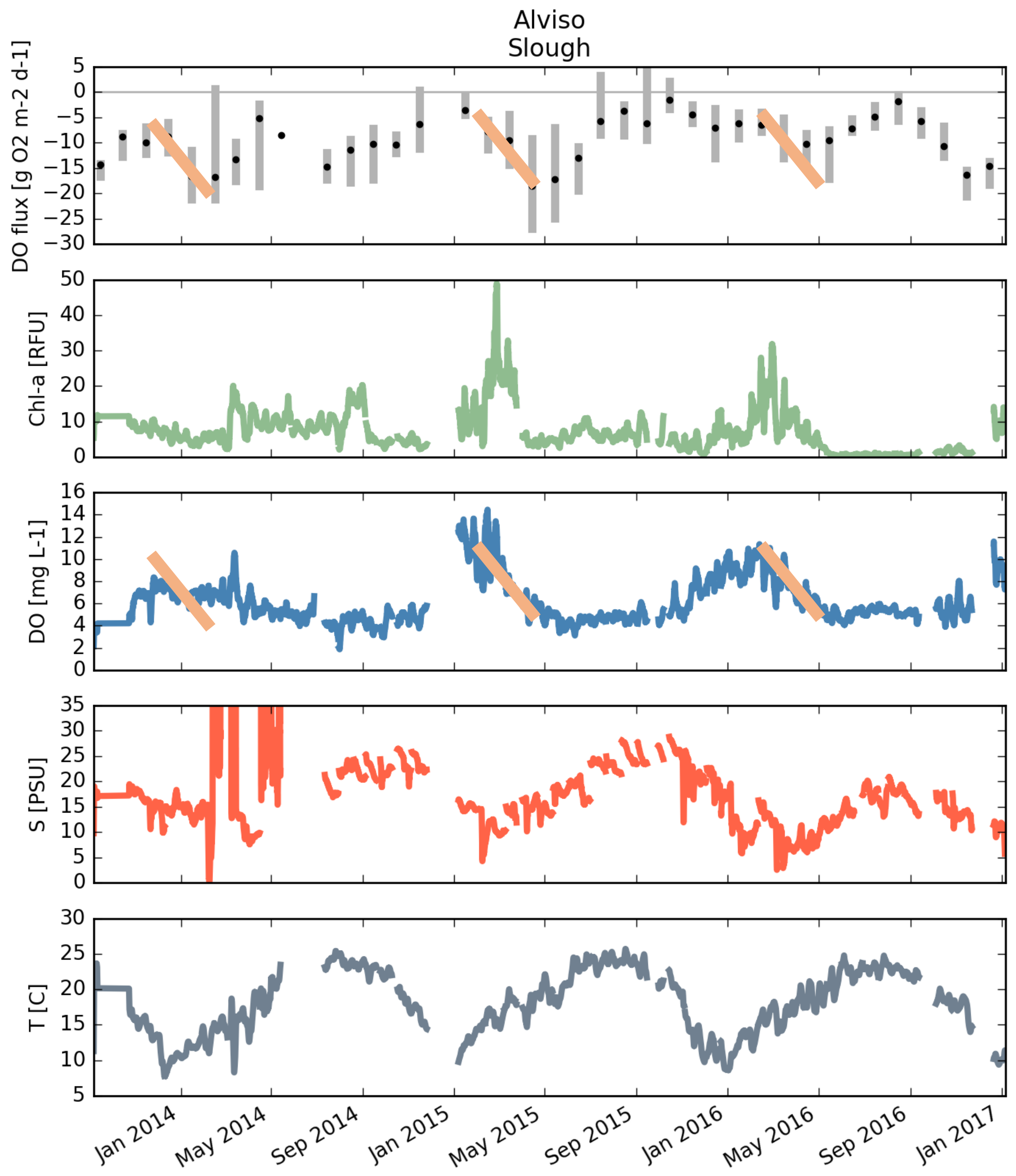
Monthly median value

25th percentile



DO flux time-series

- Highest DO consumption is related to Chl-a bloom events
- 2015, 2016 events were linked to annual cycle
- 2014 “consumption event” did not follow a sizeable bloom – other mechanism?
- *Hard to interpret winter vs summer DO flux*



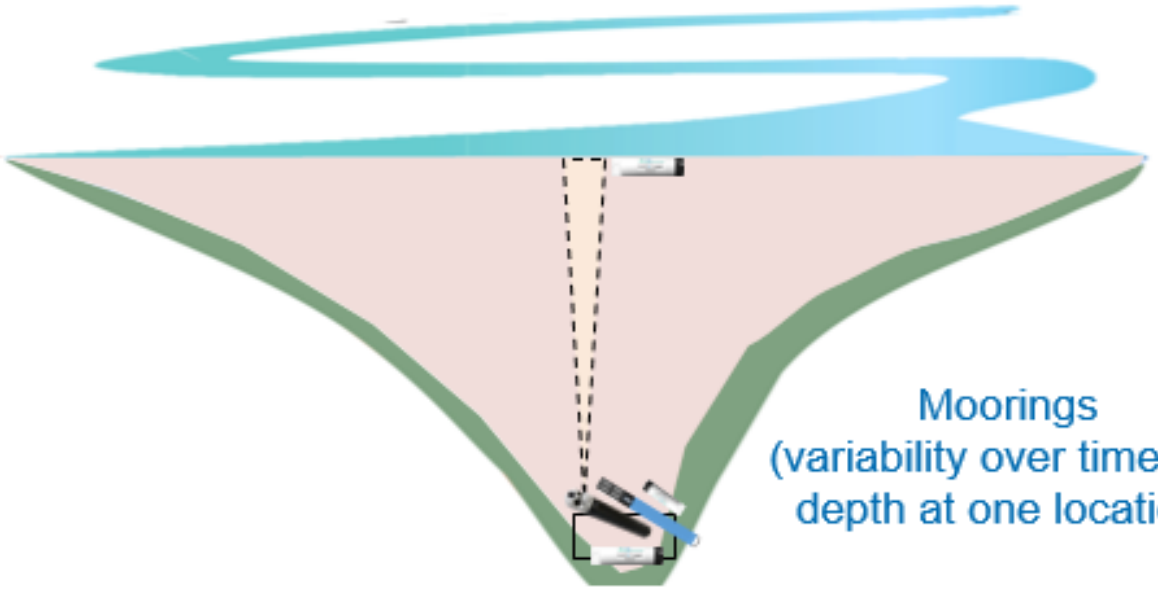
DO flux time-series

- Decline in daily-averaged DO concentration reflects increased consumption rates
- DO consumption is calculated using measurements 10 to 60 minutes apart
- *It appears that the DO consumption flux is real, across time-scales*

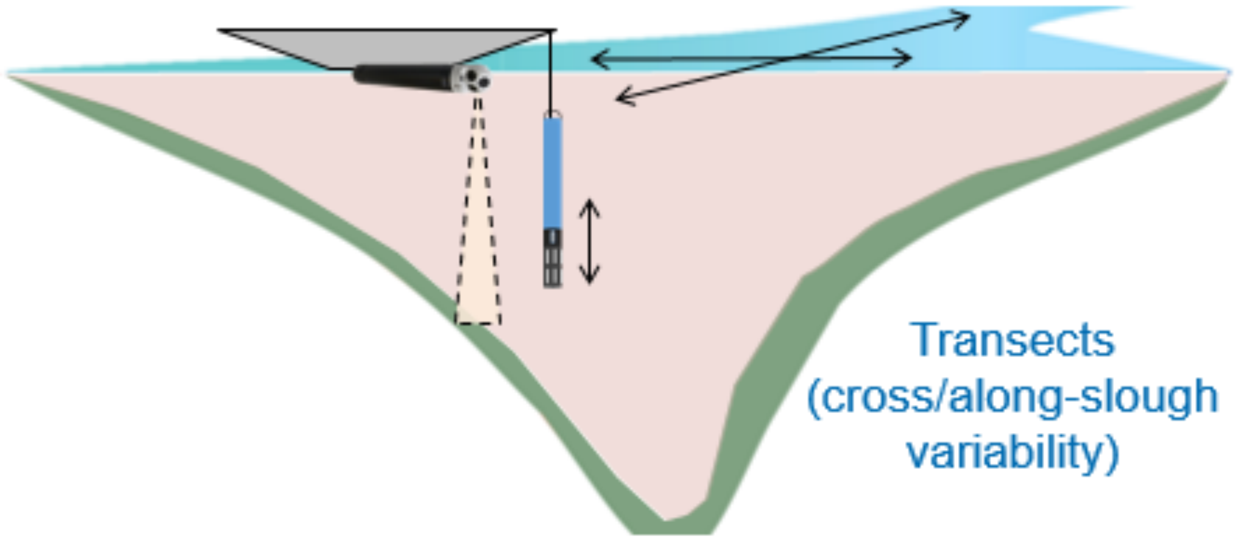
Next steps:
(1) validate BGC DO flux estimates with additional data

Control volume analysis for BGC DO flux

- 2016 special deployment
- Guadalupe, Alviso sloughs
- 2 weeks of continuous data
- Profiles + transects



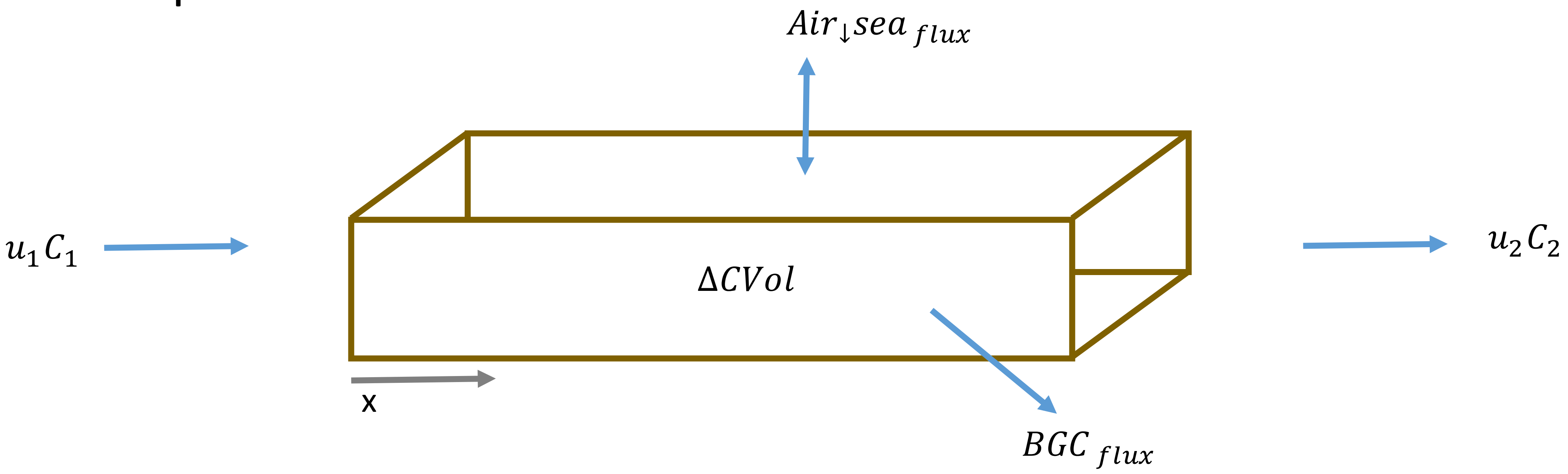
Moorings
(variability over time and
depth at one location)



Transects
(cross/along-slough
variability)

Control volume analysis for BGC DO flux

- If dispersion << advection:



$$-\frac{\Delta C}{\Delta t} - \frac{\Delta u C}{\Delta x} + \frac{Air_{\downarrow}sea_{\ flux}}{H} = \frac{BGC_{\ flux}}{H}$$

This analysis is underway…

- Control volume estimates
  - Estimate $u(z,t)$ from profiler data
  - Get total water flux through the cross-section using surveyed bathymetry
  - Get total mass flux of O_2
  - → Get $d(uC)/dx$
  - Assume mass of O_2 in control volume is average of DO at either end
  - → Get dC/dt
  - $BGC_{flux} = (d(uC)/dx - dC/dt)H$ in g O_2 per m^2 per day
  - Preliminary results are noisy! Needs refining. Stay tuned!

Next steps:
(2) use targeted studies to investigate **physical-BGC interactions**

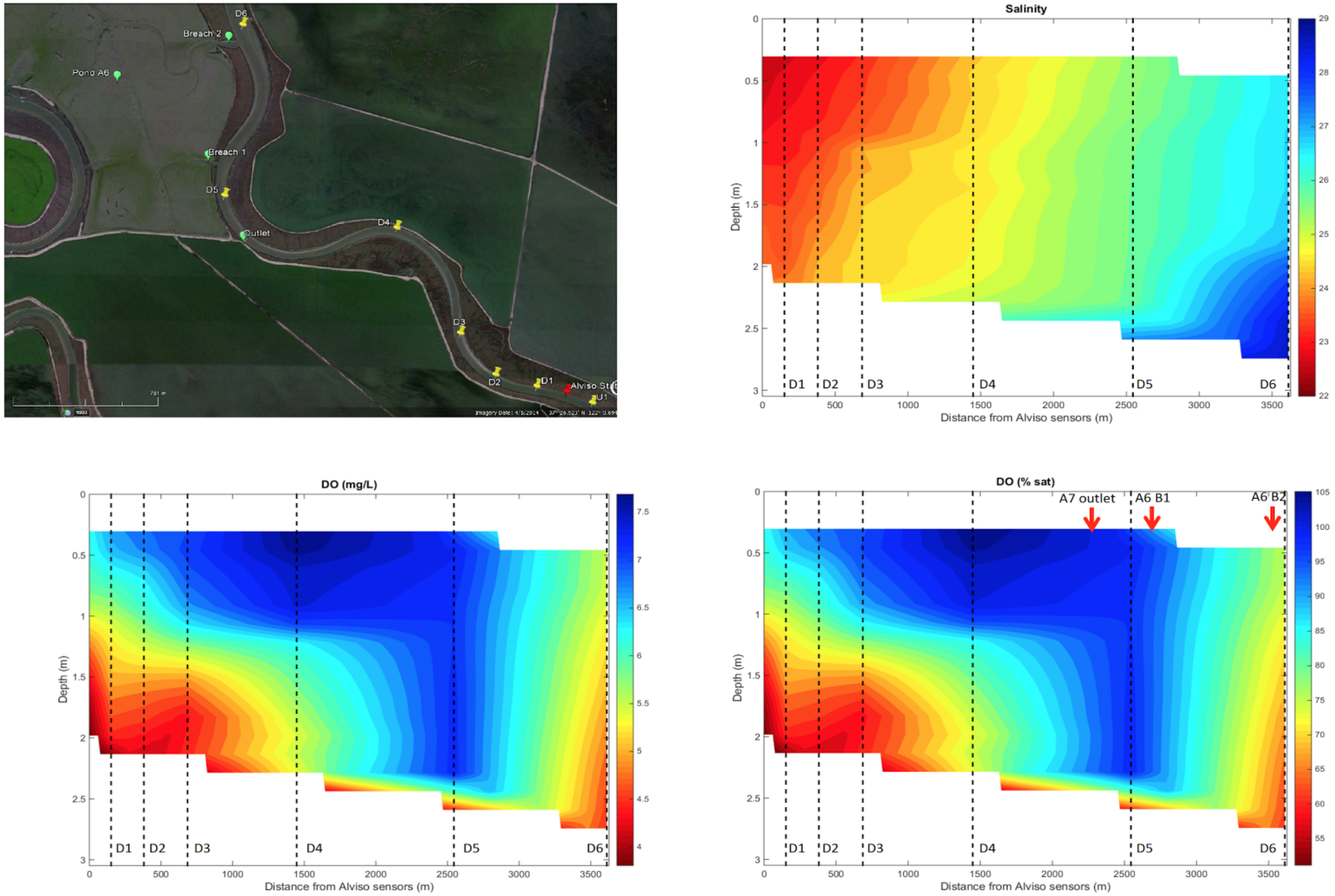


Figure 6.15 Salinity, DO (mg/L) and DO%sat measuread along a transect in Alviso Panel. Red marker in the upper left panel indicates the location of the Alviso moored station., and yellow markers indicate vertical profile stations. Measurements were made around slack low tide on the weaker of the two daily low tides.

Next steps:
(3) relate DO in the environment to biota to **characterize habitat quality**: direction from workshop in April 2017:

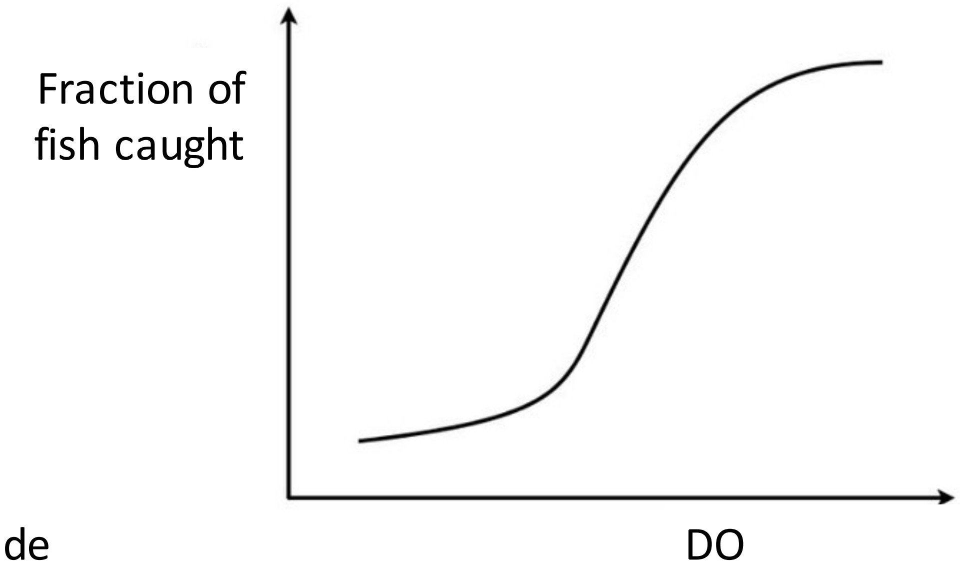
Lower South Bay DO-related Habitat Quality

General work-plan

- Evaluate all surveyed LSB animals:
    - determine **DO preferences from data** using catch curves
    - determine **DO preferences from literature** using family or genus, as needed, to link LSB species to existing studies (a la VPA)
    - Use available information to limit the animals considered; no need to select key species at this stage
- Associate animals with a useful **functional group**, such as life stage or trophic level. DO preferences within functional groups can be used as illustrative bands. Importantly, **LSB is nursery habitat** for many species, so at a minimum, an early life-stage functional group will be used.
- Use **data analyses** and mass-conservation models to understand DO(x,y,z,t)
- From DO(x,y,z,t), identify volumes of the estuary that fall below specified DO values, or within DO bands
- Account for multiple stressors (temperature, salinity) using similar analyses
- From these, **habitat quality by functional group can be characterized**

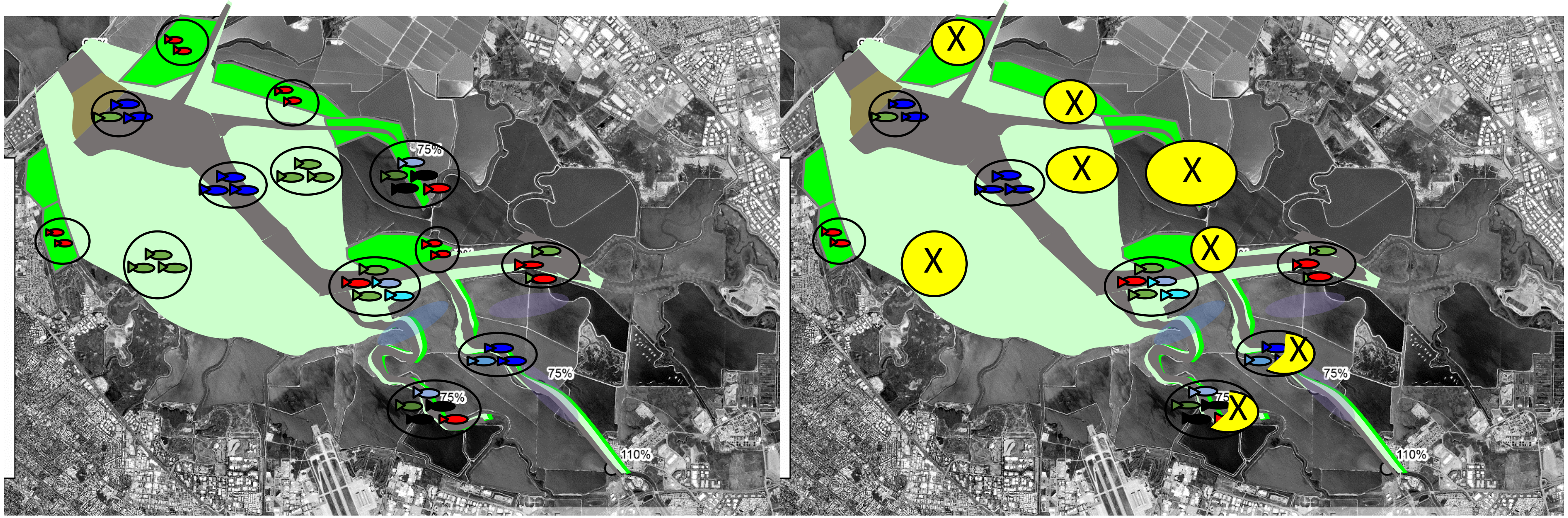
Use fish, benthic surveys to illustrate biological preferences (DO, T, S)

Merge biological surveys with moored sensors



High tide

Low tide



DO(x,y,z,t)

Use environmental DO to determine what volume of the estuary is not suitable habitat (for each species)

Generate index in volume-days: how much under DO threshold, for how long?

New studies and analyses to narrow uncertainties

- (*Observational*) **Surveys of fish and benthos at low tide, which is coincident with low DO**
- *(Analysis)* **Link DO measurements from moored sensors to survey locations**
- (*Laboratory*) Laboratory studies on hypoxia of LSB species (not essential)
- (*Analysis*) Generate DO(x,y,z,t) such that estuary volume-days can be calculated: a metric of the volume and duration of the estuary below a specific DO level (2-3 mg/L is typical)
- (*Observational*) Measure exchange with managed ponds, such as A8. The flow into and out of these ponds, and its phasing, are not yet known.
- (*Observational*) Continue moored sensor studies for water quality following this exceptionally wet winter.


Questions?
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