DO in Lower South Bay

Habitats, mechanisms, and fluxes

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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
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?
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

- 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

\[
DO_{\text{flux}} = \frac{\Delta DO}{\Delta t} H_{\text{avg}} \quad [\text{g O}_2 \text{ m}^{-2} \text{ day}^{-1}]
\]

- This net value includes all production & respiration

Can be used at every mooring for broad spatial coverage of DO flux estimates
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 O₂ consumption – possible interactions with hydrodynamics
The seasonal difference is irregular: not strictly seasonally-driven.

Examine time-series...
DO flux time-series

Alviso Slough

Monthly median value

75th percentile

Daily averages

25th percentile

Daily averages

- DO flux [g O2 m-2 d-1]
- CHa [RFU]
- DO [mg L-1]
- S [PSU]
- T(°C)

January 2014 to January 2017
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:

$$\Delta CVol = -\frac{\Delta C}{\Delta t} - \frac{\Delta uC}{\Delta x} + \frac{Air_{\downarrow} sea_{flux}}{H} = \frac{BGC_{flux}}{H}$$
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 $O_2$
  - $\Rightarrow$ Get $d(uC)/dx$
  - Assume mass of $O_2$ in control volume is average of DO at either end
  - $\Rightarrow$ 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 measured along a transect in Alviso Panel. Red markers 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
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?