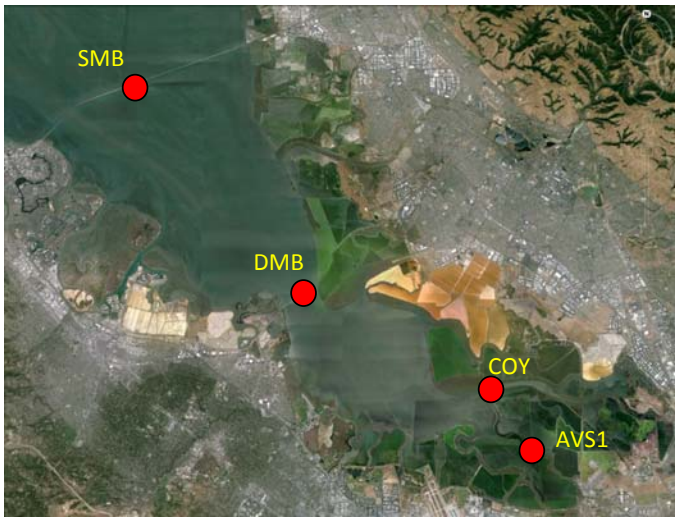
Special Study: Nutrients Strategy

Program

Since 2012, San Francisco Bay regulators and stakeholders have been working collaboratively to implement the San Francisco Bay Nutrient Management Strategy (NMS). In 2014, the NMS Steering Committee was formed to oversee NMS implementation. The Regional Monitoring Program was an early and important funder of NMS efforts. In FY2015, RMP special study funds were combined with ~$880,000 from a Bay-wide Nutrient Watershed Permit, to conduct nutrient-related science and monitoring. In FY2016, RMP special studies will again be combined with Watershed Permit funds. At its June 12 2015 meeting, the NMS Steering Committee approved a slate of recommended projects and budget for FY2016. The two projects below, which are among the highest priority projects for FY2016 based on science advisor and Nutrient Technical Workgroup input, are being proposed for RMP 2016 funding.

Proposal 1A: Moored Sensor Monitoring

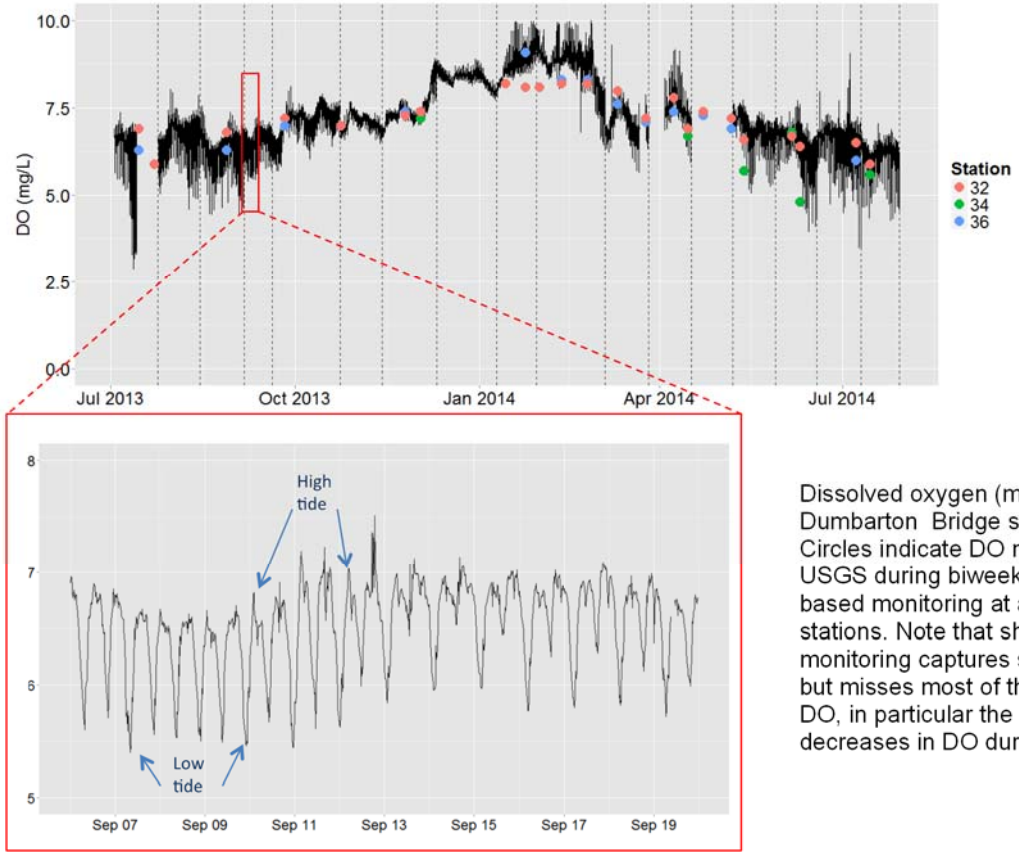
While scientific studies and monitoring by the USGS, DWR-EMP, and RMP have provided several decades of water quality data in the Bay, most of the data have been collected at weekly-monthly time intervals. Phytoplankton biomass and related parameters such as nutrients, dissolved oxygen, and light levels vary strongly over much shorter time scales (hours) due to diel cycles, mixing, biogeochemical processes, and tides. To better assess the Bay's condition, and to collect high-frequency data to calibrate water quality models, the RMP launched a moored sensor network in 2013. We propose this work be continued in 2016, with an increased emphasis on data interpretation to better understand the factors that regulate the budgets and concentrations of DO, phytoplankton biomass, and nutrients.



Over the past 2+ years, a network of 4 stations has been installed south of the San Mateo Bridge as part of the core Nutrient Management Strategy (NMS) moored sensor program (left). At each station, an instrument has been deployed that houses sensors for specific conductance (or salinity), temperature, depth, dissolved oxygen, turbidity, chlorophyll-a, fDOM, and phycocyanin. During 2016, each sensor sites will be visited every ~3 weeks for servicing, calibration, and downloading data. The sensors record a measurement every 15 minutes.

The high-frequency data from these moored sensors are already offering new insights into the processes that regulate observed phytoplankton abundance and dissolved oxygen in the open Bay

(SFEI 2014). Exchange with the shallow margin habitats, like sloughs and creeks, appears to have a strong influence on water quality in open-bay areas of Lower South Bay (see DO and chl-a graphics below). The substantial changes in some parameters over periods of just a few hours demonstrate that such high frequency data are going to be essential for accurately calibrating the biogeochemical models needed to predict ecosystem condition and evaluate the effectiveness of potential management actions.

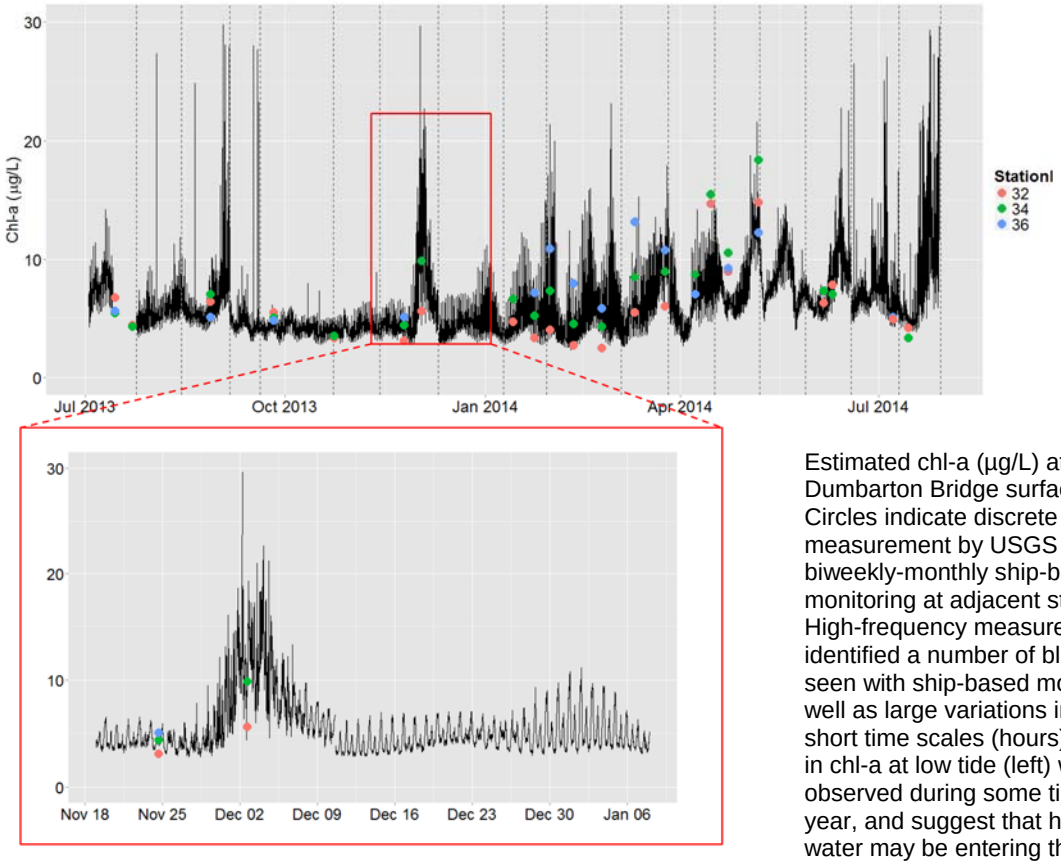


Dissolved oxygen (mg/L) at the NMS Dumbarton Bridge surface sensor. Circles indicate DO measurement by USGS during biweekly-monthly ship-based monitoring at adjacent stations. Note that ship-based monitoring captures seasonal trend but misses most of the variability in DO, in particular the substantial decreases in DO during ebb tides.

In 2016, moored sensor activities will include:

- Sensor maintenance and calibration. Periodic maintenance will occur every ~3 weeks, requiring 2-3 boat days per maintenance cycle.
- Data management, including QA/QC, and applying semi-automated routines to correct for noise and sensor drift
- Sensor calibration through discrete sample collection, as well as data analysis and possible field experiments, if possible, to improve accuracy and precision of predictions.
- Install SUNA nitrate sensors at 1-2 sites and assess the importance of this data (one sensor already purchased).
- Continued development of the web-based platform (www.enviz.org) for visualizing and downloading historic and real-time continuous data, where stakeholders and scientists can visualize and download data.
- Data analysis and interpretation to inform understanding about factors that influence DO, phytoplankton biomass, and nutrient cycling.

Over the past 2 years, the moored sensor effort has been understaffed in terms of time available to more fully interpret the large volume of data that is being amassed. A new full-time scientist will begin at SFEI in August 2015 whose time will be split between moored sensor and DO in margin work (discussed below). This will greatly increase our capacity for interpreting the moored sensor data, and identifying future directions for this program. No new stations are planned for 2016.



Estimated chl-a (µg/L) at the NMS Dumbarton Bridge surface sensor. Circles indicate discrete chl measurement by USGS during biweekly-monthly ship-based monitoring at adjacent stations. High-frequency measurements identified a number of blooms not seen with ship-based monitoring, as well as large variations in chl-a over short time scales (hours). Increases in chl-a at low tide (left) were observed during some times of the year, and suggest that high-chl-a water may be entering the open bay from sloughs and creeks.

Deliverables

- Technical report (draft, Q2 of 2016) that analyzes and interprets data from 2013-2015, and uses that data to quantitatively explore carbon, oxygen, and nutrient budgets. The report will also offer recommendations for continued moored sensor program work.
- Enhance the web-based data visualization platform to include new stations added in 2015, and add important features (e.g., real-time data, data-download) or enhancements.

Estimated cost: Option 1-$200,000; Option 2-$150,000
Oversight Team: Nutrients Strategy Team
Proposed By: David Senn and Emily Novick

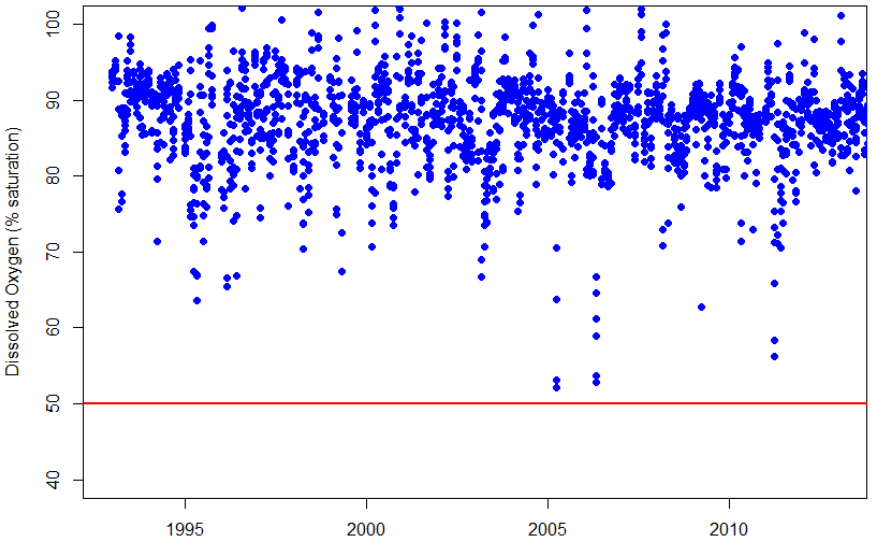
Budget Justification

Of the proposed $200,000, $150,000 will be used to support personnel working on maintenance, data interpretation, etc. $40,000 will be directed to USGS-Sacramento for field logistic support and scientific support (e.g., time series analysis). Small equipment, consumables, and discrete sample analysis will cost $10,000.

Proposal 1B: Monitoring Dissolved Oxygen in Shallow Margin Habitats

This proposed project will continue work begun in 2015 to install, maintain, and interpret results from a several-station network of continuous monitoring stations for low dissolved oxygen (DO) and other parameters in shallow margin habitats (creeks, sloughs) in Lower South Bay. The overall goals of the project include collecting monitoring data to assess condition with respect to DO in sloughs, and to inform our understanding of the major factors regulating DO in sloughs and creeks

Low DO is a common symptom of excessive nutrient loads to estuaries and other water bodies, and results from oxygen consumption during microbial degradation of organic matter (e.g., phytoplankton). Because of its well-established mechanistic link to nutrients, dissolved



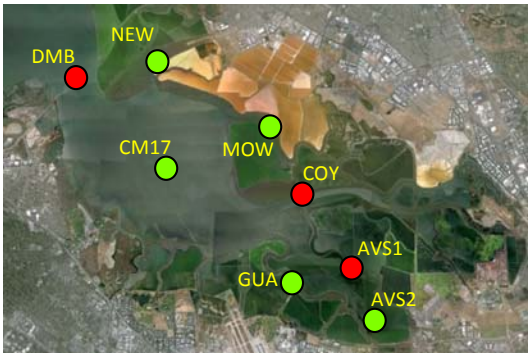
DO %saturation in bottom waters in deep subtidal areas at all USGS stations south of the Bay Bridge, 1993-2013. 100% saturation corresponds to 8.5±1.5 mg/L depending on temperature and salinity.

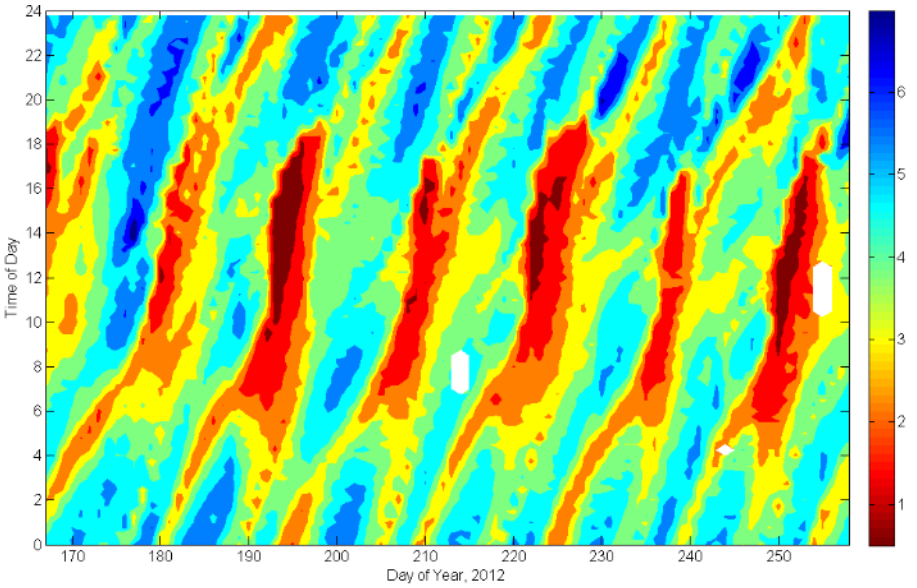
oxygen concentration is among the likely indicators of nutrient-related ecosystem health in San Francisco Bay. Most data on dissolved oxygen concentrations over the past ~20+ years have been collected in deep subtidal habitats, and DO concentrations, in general, have met or exceeded the Basin Plan criterion of 5 mg/L or 80% saturation (above).

Considerably less data is available for shallow margin habitats in San Francisco Bay, including sloughs, creeks, tidal wetlands, and former salt ponds undergoing restoration. Although these areas represent important habitats for aquatic organisms at certain life stages, there is no coordinated, systematic monitoring across a representative set of sites. A recent survey of existing continuous DO data collected over a 12 year period by assorted programs in South Bay and Lower South Bay margin habitats showed that DO was frequently below 5 mg/L (40% and 55% of the time, averaged across sites, in slough and former salt ponds, respectively; SFEI, 2015). Low DO occurs naturally in margin habitats like wetlands and sloughs. However there is currently insufficient information to characterize the frequency, duration, and severity (how low) of events, or to explore the underlying causes (importance of natural vs. anthropogenic factors). One excellent data set, collected in Alviso Slough demonstrates that low DO exhibits strong periodicity and persists at levels <2-3 mg/L for 12 hours or more over several

days (below). This station is 4 km upslough from the confluence with Coyote Creek, and the spatial extent of low DO there, and how representative this condition is of other sites, are unknown.

Funding was allocated in 2015 and work moved forward on study design, field reconnaissance, equipment purchasing, and sensor deployment. Moored sensor locations for this project include 4 slough sites sloughs (green circles, plus AVS1) and 1 open Bay site (CM17). NEW, MOW, GUA have been installed; AVS2 and CM17 will be installed in June 2015. Stations AVS2 and CM17 will be operated and maintained by collaborators (UC Berkeley and USGS-Sac, respectively), and NMS sensors will be deployed alongside other packages to cost-effectively maximize data collection. Although sensor deployment commenced in 2015, the new staff person who will work ~50% on this project (other 50% on moored sensors) will not begin until August 2015 and unspent personnel funds were returned to NMS reserves.





DO (contours; mg/L) as a function of date and time of day, Jun 15 –Sep 14 2012. Sensor was ~2 ft above the bottom. Low DO occurred during strongly periodic windows that coincided with weak neap tides. During these windows, DO was lowest during daylight hours when oxygen production would otherwise be expected, and DO increased during highest tide of the day, which occurred during the late evening. One hypothesis that can explain the daily pattern is that stratification developed due to low tidal mixing energy during these weak neap tides, and oxygen was rapidly consumed in the bottom layer due to sediment oxygen demand. An alternate hypothesis is that the entire water column had low DO concentrations, and the low DO water mass was pushed further upstream during high tide. Data: M Downing-Kunz; SFEI 2014.

Funding is being requested for 2016 to continue this project, which will determine the frequency, duration, and spatial extent of low DO in representative margin habits (sloughs, creeks) using moored sensors complemented by field sampling/calibration. This project's major goals, include:

1. Characterize temporal (tides, diel) and spatial patterns in DO and related parameters across a sites having a representative range of physical/biological characteristics;
2. Determine the frequency and duration of events with DO < 5 mg/L (and other relevant thresholds);
3. Through additional field measurements (vertical profiles during longitudinal transects), characterize the spatial extent of noteworthy events or common conditions,
4. Through the use of basic modeling and field data, semi-quantitatively test hypotheses for why low DO occurs

Instruments will require maintenance and data download approximately every 3 weeks, depending on the time of year and rate of biofouling. During regular maintenance trips and some special field trips (to coincide with events), DO will be measured in vertical profiles at stations along longitudinal transects in creeks and sloughs to spatially-characterize conditions.

Deliverables

- A Year 1 progress report will be prepared in Q2 of 2016 summarizing major observations from year 1 of DO in margin monitoring work, and describing interpretations that can be made at that point. Since deployments began in May/June 2015, the report will be limited in its depth of interpretation, based simply on the amount of data available. To the extent possible, we will also use DO-related results from stations funded by project 1A, since that will be a longer record. Progress updates (powerpoint) will also be given at NTW meetings, at RMP TRC and SC meetings.
- A final technical report will be produced at the project's completion.

Estimated cost: Option 1-$200,000; Option 2-$150,000
Oversight Team: Nutrients Strategy Team
Proposed By: David Senn and Emily Novick

Budget Justification

During 2016, funds will be directed toward staff time for field work and data interpretation ($150,000), field support and science support from USGS-Sacramento ($40,000), and small equipment, consumables, and discrete sample analysis ($10,000). No new major equipment will be purchased in 2016, since all necessary equipment and instrumentation for the current deployment was purchased with 2015 funds; however, additional sites or equipment may be needed in 2017.

Total Proposal Request

Task Description	**Task Budget Option 1**	**Task Budget Option 2**
Moored sensor monitoring	$200,000	$150,000
Dissolved oxygen monitoring	$200,000	$150,000
TOTAL	$400,000	$300,000