Special Study Proposal: Suspended sediment and light attenuation in San Francisco Bay

Summary: Recent NMS modeling work indicates that space-time variations in water column light extinction are among the most important data gaps with regard to predicting both phytoplankton production and nutrient cycling. In general, the main control on light extinction in SFB is suspended sediment concentration (SSC). This project will build capacity to predict, or hindcast, suspended sediment concentrations (SSC) through supporting improvements to sediment transport models and by data collection and data analysis to improve model calibration. Initial work is already underway through a related project, working with Anchor-QEA to generate wy2013 and wy2017 output. A portion of the funding from this proposed project would be used to cover some remaining costs related to this work. Remaining funds would be used for simulating additional time periods. The specific approach taken for that next step in sediment modeling work will take into account the potential to build capacity that allows for efficiently and cost-effectively generating new results.

Estimated Cost: $125k-$150k
Oversight Group: Nutrient Management Strategy
Proposed by: Dave Senn (Nutrients Management Strategy)
Time Sensitive: Yes, critical data gap that will inform nutrient cycling and phytoplankton production and builds on current work being done by collaborators.
Links to other workgroups: Sediment Workgroup (Continuous suspended sediment proposal)

Proposed Deliverables and Timeline

Deliverable	**Due Date**
Task 1: Model output of near-surface suspended sediment concentrations	June 2021
Task 2: Technical memo evaluating the potential utility of remote-sensed products for estimating surface turbidity and light attenuation.	December 2021

Background

Recent NMS modeling work (in particular recent sensitivity analyses) indicates that space-time variations in water column light extinction are among the most important data gaps with regard to predicting both phytoplankton production and nutrient cycling. In general, the main control on light extinction in SFB is suspended sediment concentration (SSC; light extinction proportional to 1/SSC). Accurate and spatio-temporally resolved light attenuation information is crucial to biogeochemical model calibration and application. The current best available estimates for baywide light attenuation conditions over space and time are based on sensor and cruise data from channel locations, extrapolated laterally to shoals, and therefore have major limitations. To address this limitation, the NMS has made some investments in sediment transport modeling (see below), and plans to invest further in that direction through this project. To calibrate those models, additional data collection is also needed, to improve evaluation of and refinements to the existing and/or future sediment transport models, or may provide alternative options for representing light conditions in the model. Modeling sediment dynamics in the Bay is also one of the priorities outlined in the Sediment Monitoring and Modeling Strategy.

Approach

This project will build capacity to predict, or hindcast, suspended sediment concentrations (SSC) through supporting improvements to sediment transport models and by data collection and data analysis to improve model calibration. As one part of the work, we will collaborate with SFB modelers simulating sediment transport modeling and acquire best-available hindcast SSC data (to compute time-space varying k_att). Initial work is already underway through a related project, partially supported (in FY2020) by other NMS funds, working with Anchor-QEA to generate wy2013 and wy2017 output. A portion of the funding from this proposed project would be used to cover some remaining costs related to refining and simulating the full wy2013 and wy2017 and post-processing to generate the surface sediment model output dataset. Remaining funds would be used for simulating additional time periods that are part of the next round of modeling priorities. The specific approach taken for that next step in sediment modeling work will take into account the potential to build capacity that allows for efficiently and cost-effectively generating new results.

A potential add-on study would evaluate the utility of using remote-sensed products for quantifying near-surface SSC, and the potential to use that data to either assist with numerical model calibration/validation and/or to develop empirical predictions. While this analysis will not immediately address the need for more SSC data, it has the potential to greatly enhance our ability to calibrate subsequent sediment transport model runs, and may allow for improved model predictions in one to two years.

Budget

Task	Estimated cost
Task 1: Model output	$125,000
Task 2: Technical memo for remote sensing pilot	$25,000
Total	**$150,000**

Budget Justification

Task 1 costs will be used to support Anchor QEA's work to continue to develop the suspended sediment transport model for SFB. Task 2 represents costs for SFEI staff to develop a technical memo on the utility of remote sensing for model calibration and validation.

Special Study Proposal: Moored sensor high-frequency observation network

Summary: Bay-wide cruises have been critical to our understanding of the system. The Bay is spatially and temporally heterogeneous, however, and monthly measurements miss changes in water quality that are driven by short time scale processes, including tidal forcing, wind, and biological cycles. The eight sensors in the moored, high-frequency observation network in South Bay collect water quality data every 15 minutes and contribute to our understanding of Bay processes that affect nutrient and chlorophyll dynamics.

Estimated Cost: $180k
Oversight Group: Nutrient Management Strategy (NMS)
Proposed by: Dave Senn (NMS)
Time Sensitive: Yes, long-term dataset.

Proposed Deliverables and Timeline

Deliverable	Due Date
Sensors deployed, downloaded, maintained, and calibrated	January 2022

Background

San Francisco Bay is a dynamic and heterogeneous system. Data collected during USGS cruises over the past 40 years have played critically-important roles in shaping both our current understanding of the major factors regulating water quality in San Francisco Bay (SFB), and in documenting water quality changes over that time. We also know, from other research in SFB, including along South Bay's broad shoals, that important water quality indicators - e.g., salinity, temperature, chlorophyll-a, nutrients, dissolved oxygen, suspended sediment - have strong spatial gradients (Cloern et al., 1985), and can change substantially over fairly short time scales (e.g., hours to days), shaped by tidal forcings, wind, day-night variations in biological cycles, and other factors.

Therefore, over the past several years, the NMS has prioritized developing a moored sensor network for high-frequency in-situ measurements, focused in South Bay and Lower South Bay (Figure 1). Analysis of limited existing data for sloughs and creeks, along with early mooring network data,highlighted the complex spatial and temporal variations in key water quality parameters (Figure 2). Two key aims for the mooring network were to allow for more comprehensive condition assessment, and to foster data collection that will allow us to better characterize and quantify ecosystem response to SFB's high nutrient loads, including by aiding the calibration of numerical models (SFEI 2014).

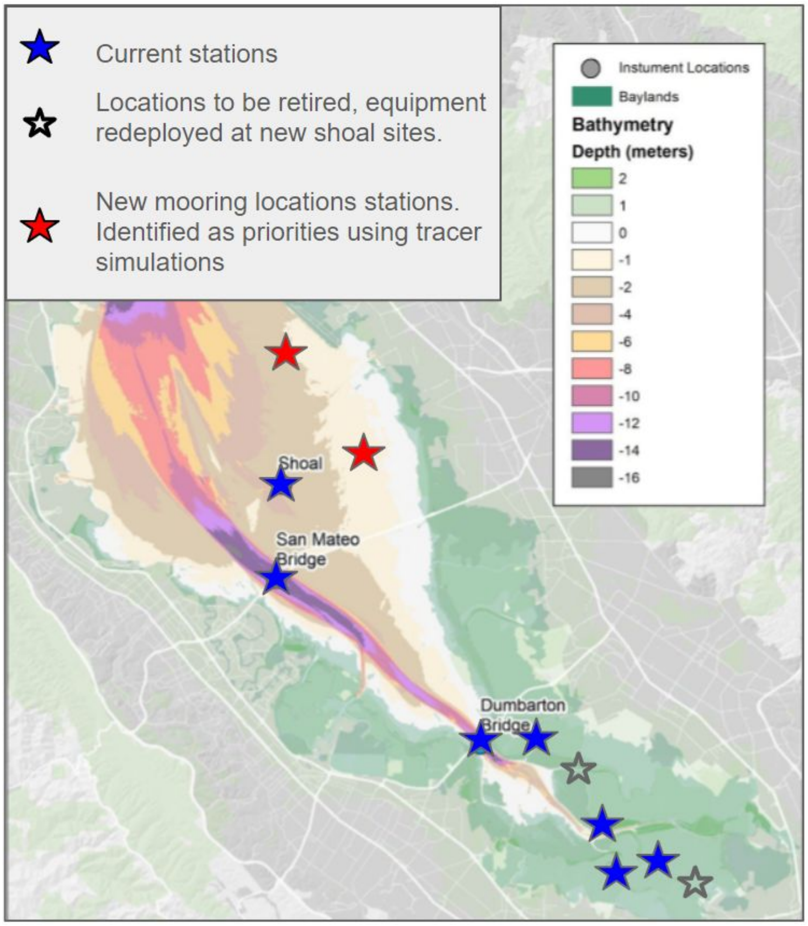

Figure 1. NMS moored sensor program site locations (as of May, 2019)

Approach

The eight sensors in South and Lower South Bay are maintained at three week intervals in collaboration with the USGS (12-15 maintenance trips per year). Two sensors from the current array will be moved to South Bay eastern shoal stations in 2021 to better capture phytoplankton bloom dynamics. Data are reviewed and cleaned using established QA/QC protocols; in FY2021, one planned task is to modify, streamline, and better document data QA/QC processing scripts. A summary of major observations are contained in a 2019 moored sensor program update (SFEI 2019), with data applied in model calibration and in synthesis reports, with those costs covered under other NMS tasks.

Budget

Task	Estimated cost
Equipment and supplies	$30,000
USGS field support	$150,000

RMP Total	$180,000
Matching funds from NMS: SFEI field support	$190,000
RMP + NMS Project total	**$370,000**

Budget Justification

USGS field support (including boat, fuel, mooring maintenance, and field technicians) supports the three-weekly maintenance of the sensors. Equipment and supply costs include batteries, sensor maintenance, sensor calibration, and hardware. Staff time, data interpretation, and annual reporting is covered by the NMS. SFEI staff time for fieldwork and program management will be covered by the NMS ($190k).

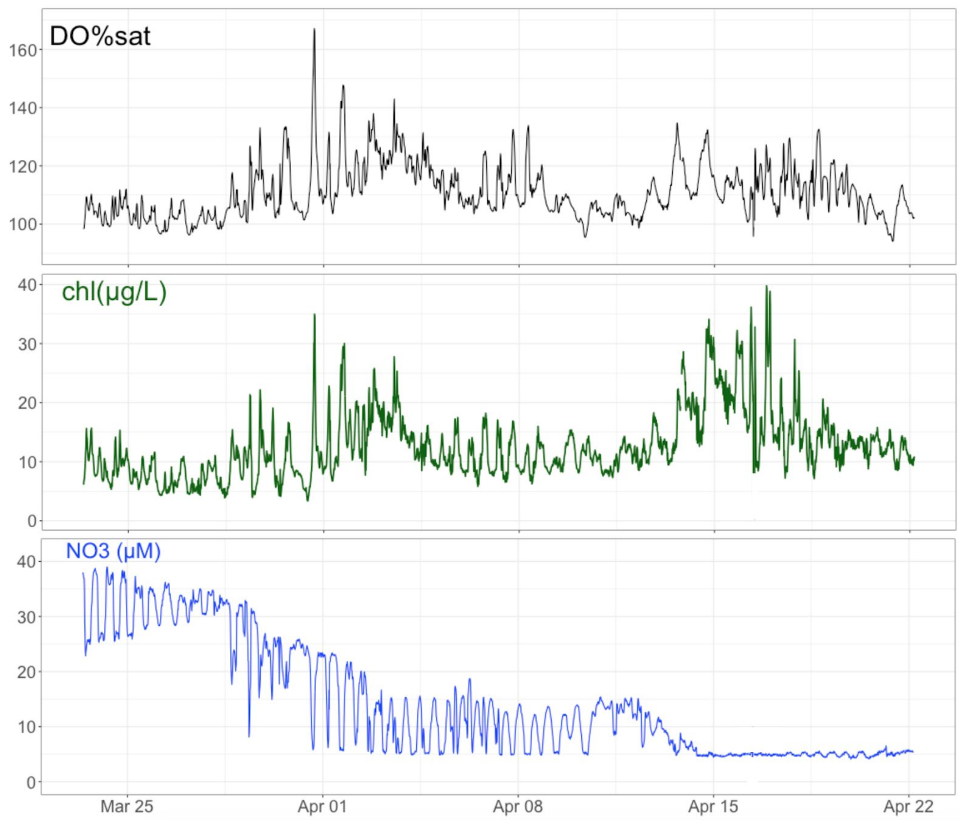

Figure 2 Dissolved oxygen (%saturation), chlorophyll-a, and nitrate levels estimated from in situ sensors the South Bay Shoal mooring site, Mar 23-Apr 29 2019. Supersaturated dissolved oxygen (>100%) coincided with chl-a peaks, consistent with primary production by phytoplankton. Nitrate concentration minima coincided with DO and chl-a peaks, suggesting that nitrate was being drawn down via uptake by phytoplankton. Because the detection limit for the nitrate sensor is in the range of 5-8 µM, the true concentrations during minima after April 1 and during the flat-line period between April 15-22 may have been less than 5 µM.

References

Cloern, J.E., Cole, B.E., Wong, R.L. and Alpine, A.E., 1985. Temporal dynamics of estuarine phytoplankton: a case study of San Francisco Bay. In *Temporal Dynamics of an Estuary: San Francisco Bay* (pp. 153-176). Springer, Dordrecht.

SFEI (2014). San Francisco Bay Nutrient Management Strategy: Detailed Modeling Workplan for FY15-FY21. San Francisco Estuary Institute, Richmond. CA. Contribution # 733.

SFEI (2019). Nutrient Moored Sensor Program: program update. San Francisco Bay Nutrient Management Strategy. San Francisco Estuary Institute, Richmond. CA.