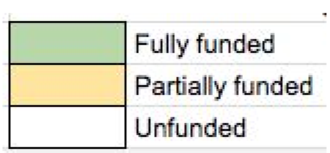
Item 5 Requested Actions

1. Approve $1,439,000 in NMS funding from new revenue and reserves to implement items C.1-C.5 and P.1-P.4, P.7, P.8, and P.11 in the FY18 Program Plan.
    a. Assumes $100,000 shortfall from RMP (i.e., RMP funding = $400k)
    b. Leaves ~$10,000 in reserves

2. Approve items P.4 and P.6 to proceed at their current partial funding levels.
    a. P.4 is 95% funded
    b. For P.6, the scoped work for the existing funds (30k) is a no-cost continuation of already-approved and funded FY17 work.

3. Approve full implementation of items P.4-P.6, P.9, and P.10 in the FY18 Program Plan, contingent upon necessary funding being secured.

The colors bar below indicates the level of funding allocated to Core Program and Projects at current funding levels



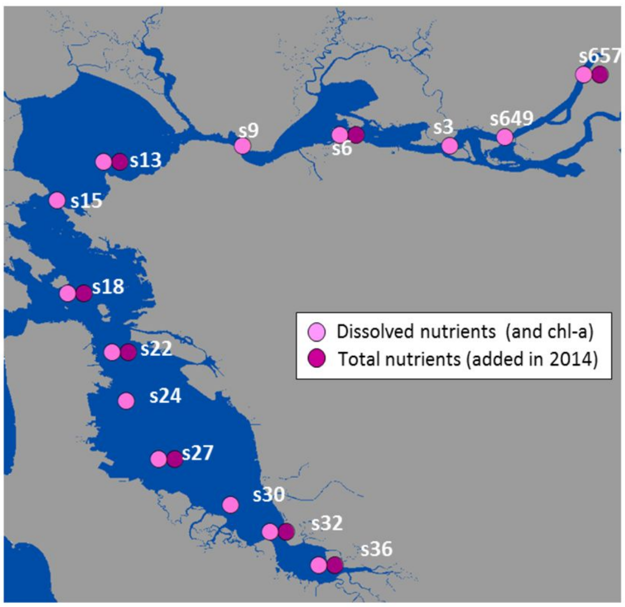
FY2018 NMS Budget		6/9/2017				
Revenue						
	Source					
R.1	Nutrient Permit FY2018	880,000				
R.2	RMP CY2018	400,000				
R.3	SEP	100,000				
	Total Revenue	**1,380,000**				
Expenses						
1	**Program**	**Project Total**	**Existing Funds***	**New Funds**	**Balance**	**% Funded**
	Monitoring					
C.1	Ship-based sampling and sampling analysis	171,000	7,000	164,000	0	*100%*
C.2	Open-Bay and slough moored sensors: data analysis, interpretation, and maintenance	311,000	40,000	271,000	0	*100%*
	Modeling					
C.3	Biogeochemical model development and application	255,000	0	255,000	0	*100%*
	Program coordination					
C.4	Science Program Coordination	281,000	0	281,000	0	*100%*
C.5	Program management	56,000	0	56,000	0	*100%*
	Program subtotal	1,074,000	47,000	1,027,000		
2	**Projects**					
P.1	Monitoring pilot: Algal toxin monitoring in bivalves from Central, South, and Lower South Bay	153,000	0	153,000	0	*100%*
P.2	Monitoring pilot: Imaging flow cytobot, data interpretation	80,000	0	80,000	0	*100%*
P.3	Monitoring pilot: Regional integration of moored sensor programs	30,000	15,000	15,000	0	*100%*
P.4	Data analysis and synthesis	176,000	70,000	97,000	(9,000)	*95%*
P.5	Monitoring pilot: South Bay eastern shoal mooring	90,000	0	0	(90,000)	*0%*
P.6	DO related habitat quality, including biological indicators	80,000	30,000	0	(50,000)	*38%*
P.7	Expanded program coordination	60,000	20,000	40,000	0	*100%*
P.8	Management Alternative Evaluation	20,000	18,000	2,000	0	*100%*
P.9	Monitoring Pilot: South Bay eastern shoal HF mapping	72,000	0	0	(72,000)	*0%*
P.10	Mechanistic Harmful algae bloom investigations	75,000	0	0	(75,000)	*0%*
P.11	External Advising/Review: Modeling Advisory Group	25,000	0	25,000	0	*100%*
P.12	Coastal export	100,000	0	0	(100,000)	*0%*
P.13	Additional monitoring pilot projects	75,000	0	0	(75,000)	*0%*
P.14	Data management	40,000	0	0	(40,000)	*0%*
P.15	Biogeochem field studies	200,000	0	0	(200,000)	*0%*
	Project subtotal		153,000	412,000		
	Total			**1,439,000**		
	Surplus/(Deficit)			(59,000)		
	Starting Reserves			69,000		
	Transfer from/to Reserves			(59,000)		
	Ending Reserves			10,000		

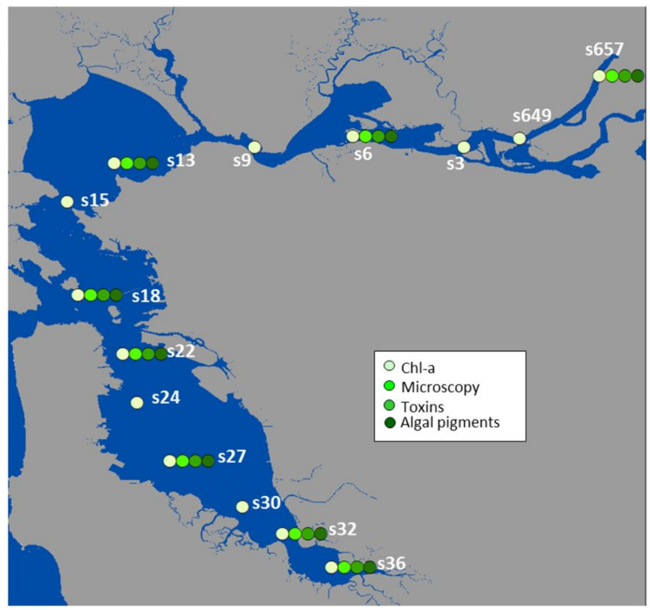
*Estimated funds remaining from FY17 or proposed reallocation. Numbers will be updated after the end of FY17.

(green)	Fully funded
(yellow)	Partially funded
(blank)	Unfunded

C.1 Ship-based sampling and sample analysis
FY18 Estimated NMS Cost = $171,000
Collaborators: USGS, UCSC, SFEI

Ship-based samples will be collected and analyzed for a range of nutrient-related parameters. This data is essential for basic condition assessment, model calibration, and improved understanding of nutrient behavior and nutrient-related effects in the Bay. Ship-based discrete samples will be collected by USGS aboard the R/V Peterson on ~12 full-bay cruises and an additional ~12 South Bay cruises.





Costs covered by NMS

- Nutrient analyses (USGS national lab)
- Analysis of integrated toxin samples (SPATT), discrete toxin samples, and algal pigments (at UCSC)
- Basic data QA/QC and basic reporting
- Additional staff support on cruises to support the collection of NMS-related samples: inorganic nutrients, total nutrients, microscopy, algal pigments, and particulate algal toxins; spatially integrated toxin samples (SPATT)

Costs covered by USGS as part of their core program

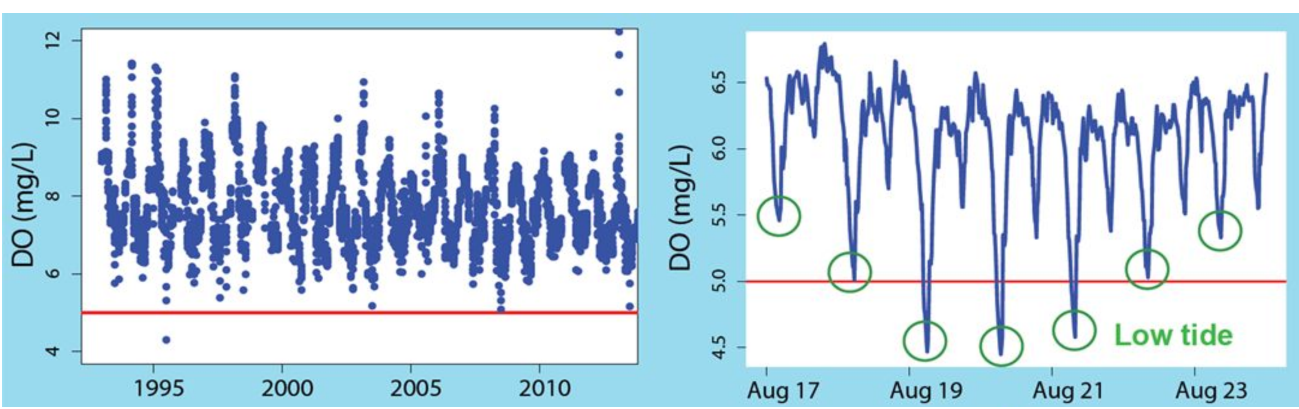
- Collection of samples for chlorophyll and ancillary data (e.g., suspended particulate matter, dissolved oxygen, salinity)
- Vertical profiles for multiple parameters
- Underway flowthrough data collection (salinity, T, chl-a fluorescence, turbidity/optical backscatter)
- Program management, scientific oversight
- Data management for USGS parameters plus inorganic nutrients
- Ship maintenance, fuel, crew, etc.

Deliverables
Nutrient and chl-a data will be made publicly available through USGS's website. Datasets for toxins, phytoplankton microscopy, and pigments will also be made available through the NMS. Results will also be summarized in the NMS Annual Report. Data will be used for many aspects of the NMS (model calibration, condition assessment, assessment framework development).

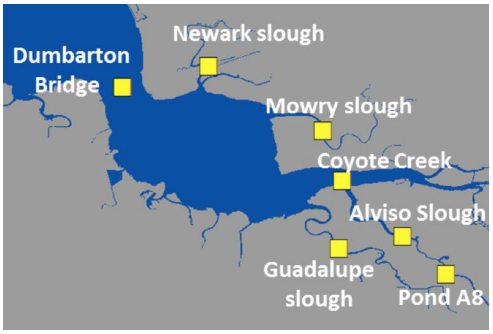
Budget Justification
Nutrient analyses for 300 station-date samples ($40,000; ammonium, nitrate + nitrite, reactive phosphorous, dissolved silicate; total N and total P will be measured at 75% of the sites); Taxonomy on ~200 samples for phytoplankton community composition and biovolume ($45k); toxin and algal pigment measurements ($50k); additional staff support for field work, basic reporting, and managing overall coordination to support NMS activities ($42k).

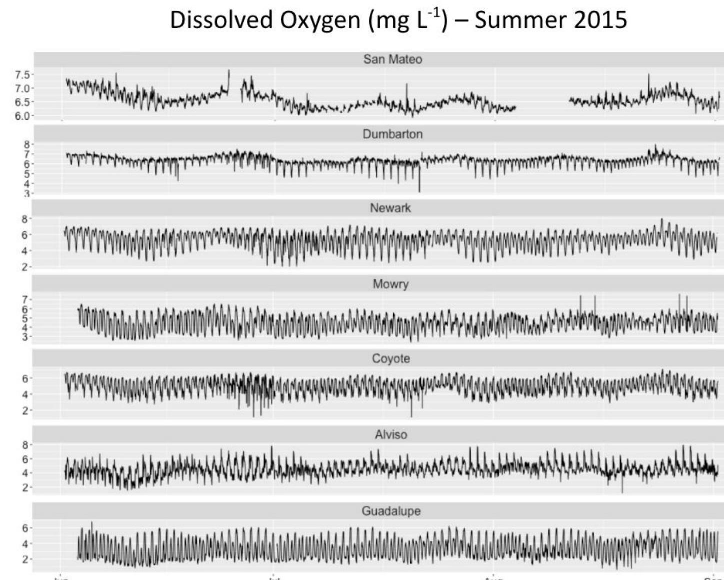
C.2 Open-Bay and slough moored sensors: data analysis, interpretation, and maintenance
FY18 Estimated NMS Cost = $311,000
Collaborators: SFEI

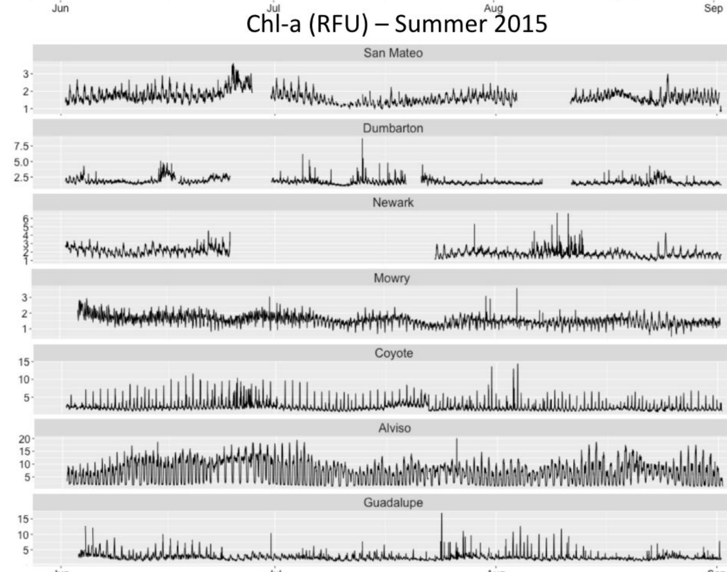
While San Francisco Bay is generally not known to be either eutrophic (organic carbon supply > 300 g C m^{-2} y^{-1}) or hypoxic (dissolved oxygen < 2 mg L^{-1}), a substantial portion of our knowledge of SFB biogeochemistry comes from a long-term dataset collected in the Bay's main channel. Over the past ~2 decades, dissolved oxygen rarely dipped below 5 mg L^{-1} during biweekly to monthly surveys at stations in South and Lower South Bay (below left). More recently, though, high-frequency moored *in situ* sensors at the Dumbarton Bridge have shown that dissolved oxygen concentrations frequently drop to levels not typically observed in the long time series. For example, dissolved oxygen repeatedly dipped near or below 5 mg L^{-1} in August 2013 during the lower low tide several days in a row (below, right). The DO signal was strongly coupled to the tides at multiple frequencies (semidiurnal: two highs and two lows per day; fortnightly: two spring tides and two neap tides per lunar month), with lowest DO observed around the spring tide on August 20, 2013. Since dissolved oxygen decreases on ebbing tides, we hypothesized that lower dissolved oxygen waters were being advected from margin habitats, including the extensive network of sloughs and creeks in Lower South Bay (SFEI 2015a).



We began testing this hypothesis in Spring/Summer 2015 by installing a network of moored sensors in margin areas of Lower South Bay, measuring dissolved oxygen and a range of other parameters (e.g., salinity, T, turbidity, chl-a fluorescence). Observations over Summer 2015 and 2016 confirmed that DO frequently fell below 5 mg L^{-1} at multiple sites. The data also indicated that condition varied substantially among the sites, and that DO concentration was strongly influenced by the tides. High levels of phytoplankton biomass (as chl-a) were also evident in sloughs and other regions influenced by exchange with restored salt ponds.







Dissolved oxygen and chl-a concentrations at a subset high-frequency moored sensors sites in Lower South Bay.

FY18 work will focus on the following:

- Complete Year 4 of open bay stations (San Mateo, Dumbarton Bridges) and Alviso Slough.
- Continue slough creek deployments into Year 3 of slough/creek deployments, including spring-summer-fall of the extremely wet WY2017 which came on the heels of several drought years.
- Data analysis, with a major focus on quantitative mechanistic interpretation to identify factors contributing to observed DO conditions, possibly including the use of simplified reactive-transport models.
- Sensor network maintenance.
- At some sites, migrate to a different sensor package that is expected to improve data quality and decrease maintenance frequency
- Data management and QA/QC.

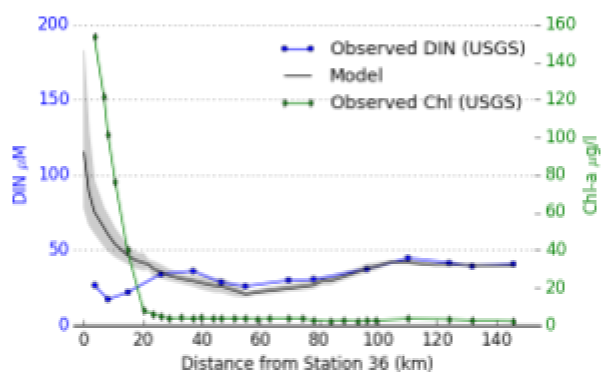
Deliverables:

- Summary of major observations in the NMS FY18 Annual Report (e.g., [NMS FY16 Annual Report]())
- One or more technical appendices to that report characterizing, e.g.,
    - Mechanistic interpretations of factors contributing to periodically low DO at slough sites and physical and biogeochemical factors. The goal is to submit this report as a manuscript to a peer-reviewed journal.
    - Multi-year overview: Inter-year comparison of key parameters, what new has been learned relative to ship-based monitoring alone (e.g., variance in DO, turbidity, and chl-a),
    - Spatial/temporal variability in LSB/SouthBay open-Bay and slough water quality (DO, chl, etc.) to inform evaluation of DO-related condition.

Budget Justification: Partial support for 3 staff for field work, data management, data analysis and interpretation, and report preparation (0.5 FTE and 0.25 junior staff, 0.5 FTE senior staff; \$197,000); field support (including boat, fuel, field technicians; \$40,000); equipment/supplies (\$70k, replacement sensors, instrument replacement and/or upgrades, reagents and maintenance supplies); and analysis of discrete samples for instrument calibration (\$5,000)

C.3 Biogeochemical model development and application
FY18 Estimated NMS Cost = \$255,000
Collaborators: SFEI, Deltares, USGS, UC Berkeley

Biogeochemical modeling work for San Francisco Bay continues to progress towards a suite of mechanistic, calibrated models for water quality throughout the Bay/Delta. With major hurdles in hydrodynamics largely behind us, year two of the modeling effort has begun to tackle the many dimensions of biogeochemical modeling in the Bay. Substantial strides have been made with models of nitrogen cycling and sub-embayment scale budgets for dissolved inorganic nitrogen. Early simulations that include phytoplankton are showing promise but also belie the marked increase in complexity beyond the nitrogen cycling model.

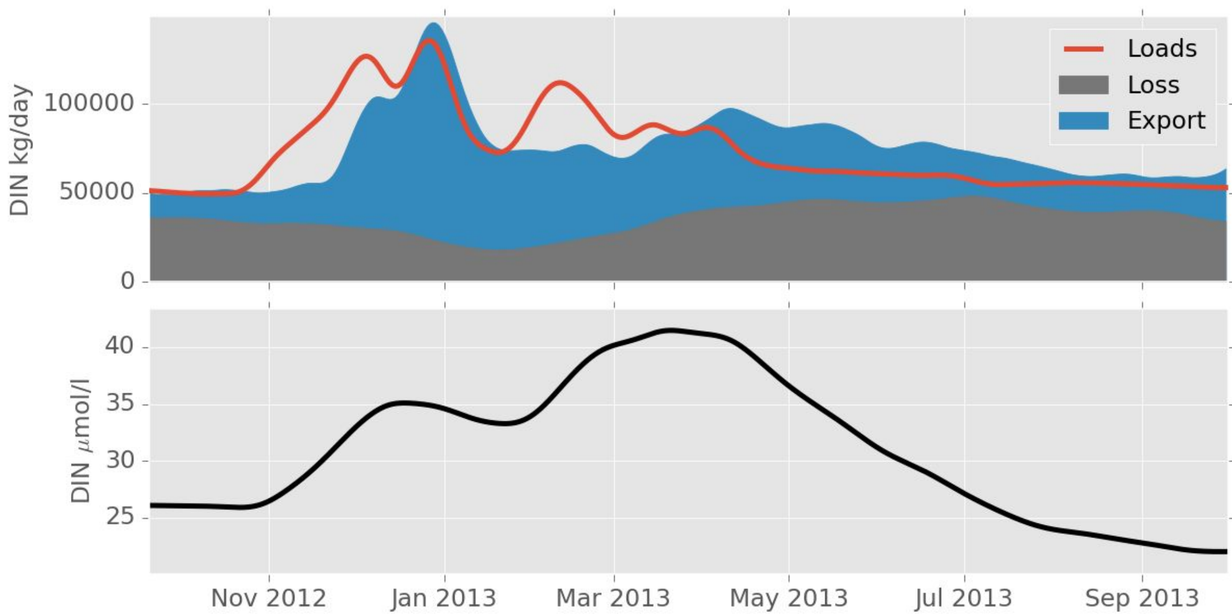


Model-observation comparison of DIN, from LSB to Suisun on 2013-02-26, demonstrating good agreement except for LSB phytoplankton drawdown.

Hydrodynamic data taken from the SF Bay SUNTANS model has continued to be the work-horse of water quality modeling. However, with the publication of a key manuscript from the CASCaDE project and significant efforts at SFEI to further improve and validate that model, the stage is set for the transition from SUNTANS to D-Flow FM. This transition will bring improved interoperability with other modeling teams and projects, and greater fidelity in Suisun Bay and the Delta. Long-term modeling needs within the

NMS and across the Bay-modeling community point to the use of Deltares tools for hydrodynamics, and the status of D-Flow FM in San Francisco Bay has reached a usable stage. This recent progress has come out of efforts from the USGS CASCaDE project, the NMS, and collaborators at Deltares, TU-Delft and RMA.

The majority of the water quality simulations to date have utilized a minimal set of reaction terms: nitrification, denitrification, an imposed sediment oxygen demand, and reaeration. Year 3 will focus on phytoplankton parameterizations and the associated questions of light availability, benthic nutrient cycling, and grazing of phytoplankton biomass. Simplified multi-box models previously developed will be central to taming the multitude of tunable parameters. With the modeling efforts expanding to include a wider variety of biogeochemical processes, we will be convening a Modeling Advisory Group to provide expert input on the relative importance and feasibility of modeling biogeochemical processes in the Bay.



Dissolved inorganic nitrogen budgets for the full Bay in water year 2013. This budget is based on load data gathered by HDR, transport from the SUNTANS hydrodynamic model, and parameterizations of nitrification and denitrification. Reaction rates were optimized to minimize error in ambient NO_3 and NH_4 levels relative to observations on USGS water quality cruises. (upper panel) Flux terms in the budget, with loads generally balanced by a combination of export to the coastal ocean and in-Bay denitrification (loss). (lower panel) The storage term in the nitrogen budget, as an average Bay-wide DIN concentration.

Focus in FY18

- Refinement of parameterizations for phytoplankton growth and grazing to the full-Bay model. Model evaluation in simplified-domain and fully-resolved model runs, and on-going tests of the model's ability to reproduce major features in the observational data record, e.g.: seasonal nutrient and chl-a trends; tidal variation at high-frequency moorings; large blooms observed during some years; trend of increasing fall chl-a.
- Refinement of Delft Flexible Mesh hydrodynamics, including additional simulation years. Integration with hydrologic model for freshwater flows.

- Evaluation and integration of suspended sediments / turbidity model output to shape light field in water quality model.
- Identifying key parameters with high sensitivity and/or uncertainty, and using these to prioritize among data collection needs.
- Convene Modeling Advisory Group to solicit input on modeling plans.

Deliverables:

- Overview of modeling progress presented in the FY18 Annual Progress report
- Technical appendix to Progress Report, with expanded description of FY18 results including
    - Summary of nutrient and phytoplankton model skill;
    - Inter-model comparison between version of hydrodynamic models (SUNTANS, CASCaDE, updated CASCaDE)
- Summary of priority data gaps arising from model evaluation and sensitivity studies;
- Summary of input from Modeling Advisory Group.

Budget Justification: 0.6 FTE senior modeler + 0.5 FTE junior modeler ($205,000); Deltares, technical assistance and model development ($25,000); regional collaborators or technical advisors ($25,000). Cost for convening Modeling Advisory Group is included under P.12

C.4 and C.5 Science Program Coordination and Program Management
FY18 Estimated NMS Cost = $281,000 + $56,000
Collaborators: SFEI

Science Program Coordination accounts for lead scientists effort across all scientific activities of the NMS and for overall Program coordination. The distribution of work is estimated to be 60% hands-on science and/or managing directing projects and 40% program coordination (fundraising, stakeholder engagement, NMS and PS process). Program Management includes project and financial management ($51k) and travel ($5k).

PROJECTS

P.1 Algal toxin monitoring in bivalves
FY18 Estimated NMS Cost = $153,000
Collaborators: SFEI, UCSC

Goals:

- Quantify toxin concentrations entering biota in Central, South, and Lower South Bay through measurements in naturally occurring mussels.
- Collect samples with sufficient frequency that concentrations in mussels can serve as semi-quantitative bioindicators of ambient toxin concentrations in the water column as a function of space and time, to address monitoring goals and inform mechanistic understanding of where and under what conditions toxins are being produced.

In September 2015 the NMS launched a pilot study to measure toxin concentrations in naturally-occurring mussels. Mussels can serve as valuable time-integrating measures of toxin levels that are entering aquatic biota, and as semi-quantitative bioindicators of ambient toxin concentrations. However, toxin concentrations in mussel tissue can respond quickly to changes in ambient toxins concentrations, because mussels excrete some toxins at fast rates (e.g., excretion half-life is on the order of days for domoic acid). Thus, mussels need to be sampled at high enough frequency in order for them to serve as informative indicators of time-varying toxin concentrations.

Over the past ~2 years, the biweekly sampling of naturally-occurring mussels from floating docks around the Bay has proven to be an efficient and cost-effective approach to monitoring ambient condition with respect to toxins over approximately 60% of San Francisco Bay. In the 1 year of samples measured thus far, both domoic acid and microcystins were detected throughout Central and South Bays with seasonally-varying concentrations (see right and below). Saxitoxin was also consistently detected in mussels (not shown).

Collecting samples from the 10+ stations can be accomplished by just one person, traveling by car and accessing docks from land, with just 1-2 days of effort. However, mussels have only been consistently found in Central and South Bays, likely due to their limited tolerance of low salinity waters.

FY18 activities will include:

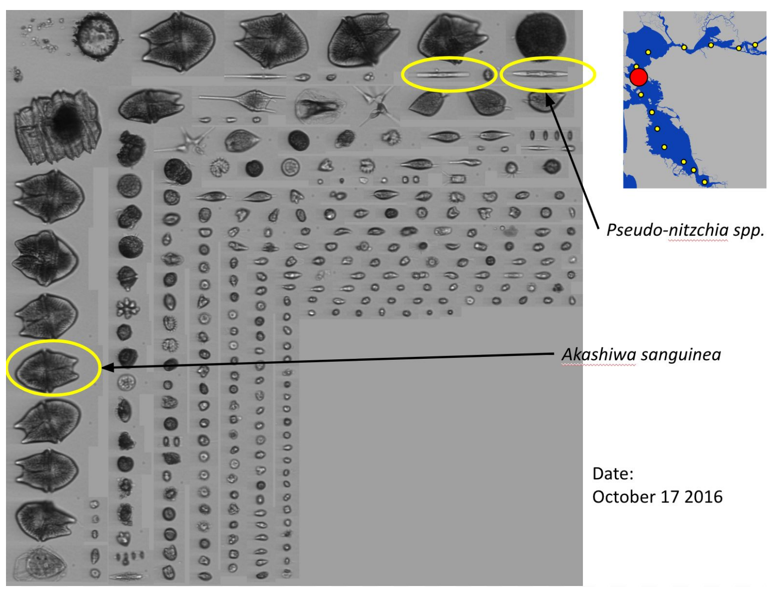
- Continue collecting naturally occurring mussels from ~10 stations on a biweekly basis. In FY18 increasing attention will be paid toward establishing a sampling schedule relative to tides (e.g., spring neap), to the extent feasible.
- Collect and analyze basic water quality data at sampling sites.
- Analyze mussels for multiple toxins: domoic acid, microcystin, saxitoxin, and potentially other toxins.
- Time and budget permitting, pilot the deployment of “standard” mussel-watch mussel species and passive samplers alongside native mussels, and also at sites near the Bay channel, for comparison between techniques. This will also allow us to assess toxin levels in locations where mussels have thus far been absent.
- Analysis and interpretation of FY15-FY17 data will be carried out as part of P.4 Data Analysis and Synthesis

Deliverables: Data will be incorporated into the FY18 annual report. A more detailed technical report will also be prepared under **P.4,** reporting on 2-3 years of data, which will be included as a technical appendix to the FY18 annual report, and will developed with the goal of submitting it as a peer-reviewed journal manuscript

Budget Justification: Staff time (50% junior staff, 10% senior staff; $86k); sample preparation and sample analysis ($30k); sampling/travel ($2500); additional costs of deployed mussels in SFB ($10k); technical support from collaborator ($20k); discrete water quality data ($5000);

P.2 Integrating new technology for characterizing phytoplankton assemblage into NMS observation program
FY18 Estimated NMS Cost = $80,000
Collaborators: SFEI, UCSC, USGS

Two years ago, UC Santa Cruz researchers (PI: R Kudela) submitted a successful collaborative proposal (with SFEI and USGS as co-PIs) to NOAA and secured two Imaging Flow CytoBots (IFCBs) that allow for real-time detection of phytoplankton taxa down to the genus level through image recognition. The intent of the grant is for both IFCBs to be eventually integrated into a SFB nutrient and phytoplankton monitoring program. One of the IFCBs has been regularly deployed on USGS cruises since September 2016, analyzing water at a rate of 10-15 samples per hour while the ship is underway (see sample images from a Central Bay station, October 17 2016). Although results to date are promising and suggest that the technique holds considerable promise for supporting NMS-related objectives, there is currently no NMS-supported staff focused on evaluating the IFCB performance, and optimizing its use for achieving NMS-related goals.



Funding will support a scientist to work with IFCB data and optimize the sampling program for achieving NMS goals relative to trade-offs such as spatial resolution, reliable count statistics, field vs. lab measurements, and calibration/validation with microscopy.

Deliverable: A phytoplankton community technical report based on IFCB results, including sections on HAB genera and cyanobacteria, to the extent possible.

Budget Justification**:** Postdoc researcher (0.5 FTE; $50,000), operating and analytical costs (e.g., additional microscopy or molecular techniques, travel; $15,000); support for regional collaborators ($15,000).

P.3 Regional integration of moored sensor programs
FY18 Estimated NMS Cost = $15,000 (+ $15,000 match from Delta RMP)
Collaborators: SFEI, Delta RMP, USGS, DWR, IEP

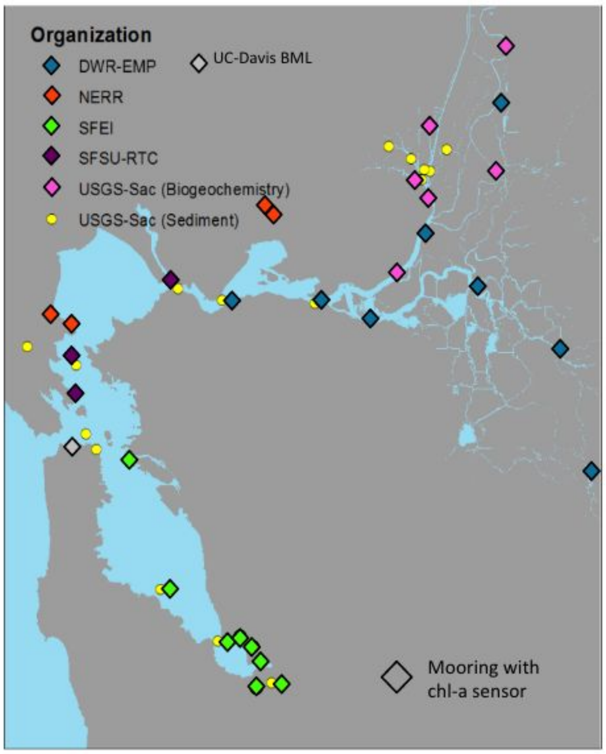
Across the Bay-Delta there are >30 water quality stations hosting chl-a sensors maintained by multiple programs or agencies (Figure A). The high frequency measurements made possible with in situ chl-a sensors can yield valuable data for model calibration, improved understanding of mechanisms regulating productivity, and real-time information on condition in the estuary. Moreover, the efficiencies gained through data sharing among programs could result in major cost savings. However, chl-a sensors are subject to large interferences that can influence readings and substantially affect the accuracy and precision of measurements. In order ensure that data are reliable, standardized methods and rigorous in situ calibration are needed, along with careful data management and data analysis. Currently there is little coordination among the programs maintaining chl-a sensors, severely limiting the ability to confidently share and use data. There is reason to be optimistic that data can be reliably shared across programs: Initial work on side-by-side deployments in SFB found that sensors respond similarly and predictably, even with different sensor designs/manufacturers (Fig B); and chl-a concentrations (discrete samples) can be accurately predicted across a wide range of conditions at some well-studied sites (Fig C). However, there is also evidence that sensor response can be strongly influenced by factors such as suspended sediment concentration, indicating that adjusting for interferences may be important (Fig D).

This project, jointly funded by the Bay NMS and the Delta RMP, will bring together scientists and program managers from multiple programs to begin assessing data quality and inter-comparability. In Phase 1 (FY18), work will include convening one or more technical working group meetings; gathering metadata related to each program's calibration protocols; analyzing calibration data, quantifying the importance of potential interferences, and testing approaches to quantitatively adjust for interferences; and provisionally assessing the feasibility of inter-program data-sharing. If initial data analysis shows that data from different programs can be related, this project will be continued in a second year, with additional data analysis; potentially some field experiments to further test and improve the accuracy and precision of sensor-derived estimates (e.g., side-by-side deployments, quantifying the effects of photo-quenching and suspended sediment interference); and working toward establishing common calibration protocols.

Work Products/Deliverables:
Deliverables related to the combined funding will include:
- One or more technical working group meetings and meeting summaries
- Combined electronic datasets, and field method descriptions from each cooperating program
- Technical report describing the findings from the data analysis

Budget Justification: The combined funding will support for 0.15 FTE of a mid-level scientist ($25k) for planning multi-institution meetings, management and analysis of data from multiple program, and final technical report preparation; and support for collaborators or convening meetings ($5k).

A



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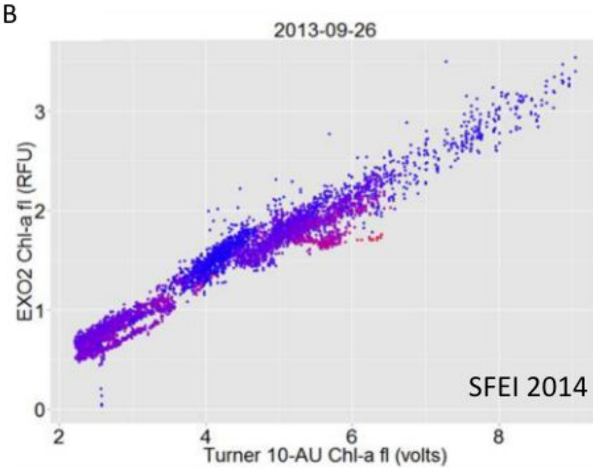

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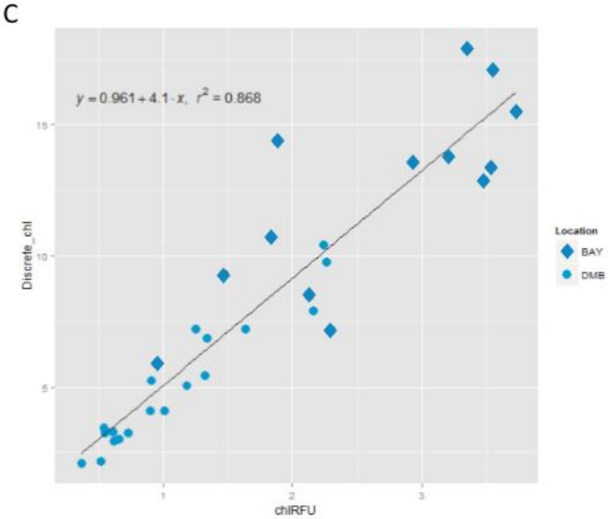

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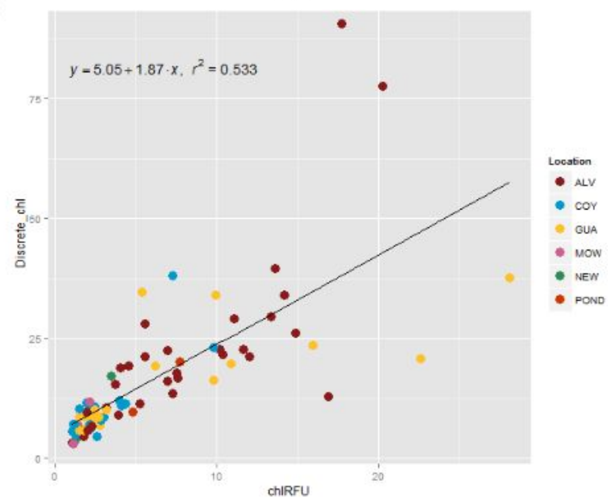


A: Locations of moorings with chl-a sensors. B. Raw instrument response during codeployment of two chl-a sensors aboard the R/V Polaris during full-Bay cruises. During 10+ deployments in 2013-2014, R^2 was typically in the range of 0.85-0.9 (SFEI 2014). C. Discrete chl-a vs. in situ sensor raw reading (relative fluorescence units) at Dumbarton Bridge and at open-Bay locations in Lower South Bay. D. Discrete chl-a vs. in situ sensor raw reading Lower South Bay sloughs, where suspended sediment concentrations were elevated. These values have not yet been corrected or adjusted for suspended sediments.

P.4 Data analysis and Synthesis
FY18 Estimated NMS Cost = $176,000
Collaborators: SFEI and collaborators

The NMS has numerous projects that are generating large amounts of data that need on-going analysis and interpretation, and need to be presented to technical and non-technical audiences in the form of technical documents, progress reports, and graphics for presentations.

This Data Analysis and Synthesis task is expected to be an on-going program need. Activities fall into two broad categories, with priorities, specific deliverables, and feasible timelines still needing to be identified through discussions with the NMS SC and collaborators:

1. Basic reporting on NMS results and progress to stakeholders and regulators. This includes producing the NMS annual report (i.e., FY17 report during Q1 of FY18), as well as materials for presentations, media requests, etc.
2. Analysis and interpretation of long-term water quality datasets and newly available data being generated through NMS projects to advance our understanding of how SFB responds to nutrients, assess condition, and work toward identifying protective nutrient loads. In FY18 work will pursue one or more of the following topics, and will be presented in one or more technical report(s) completed in FY18:
    a. *Characterizing phycotoxin and harmful algae occurrences in SFB:* Analysis of phycotoxin data and occurrences of harmful algae in SFB, including the recently completed 3+ year particulate toxin record, multi-year SPATT toxin data, and multiple toxins measured in bivalve sampling over the past 3 years (i.e., generated through P.1). One focus of data analysis during FY18 will be on characterizing how SFB's toxin levels compare with those observed in other estuaries and with established thresholds (e.g., regulatory for human consumption, or chronic toxicity to marine biota).
    b. *Mechanisms regulating phytoplankton community, harmful algae occurrences, and phycotoxins in SFB:* Analyzing long-term and newly-available water quality datasets for SFB with the aim of identifying mechanistic relationships between physical, chemical, and biological factors and phytoplankton community response (including HABs) and toxin levels in water and biota.
    c. Analysis of both long-term and newly-available water quality datasets to 'test-drive' and refine approaches for assessing nutrient-related condition in SFB, or develop new approaches for areas or parameters not covered by other recent work.
        i. In deep subtidal habitats, the analysis would build upon recent work by Sutula et al (submitted), which explored linkages between chl-a levels and dissolved oxygen, HABs, and phycotoxins in deep SFB's subtidal habitats.

ii. New phycotoxin datasets (discussed above) also need to be incorporated into a framework for assessing condition; and

iii. Finally, dissolved oxygen levels (and high productivity) in shallow margin habitats, and co-located fish and benthos data also need be incorporated into a framework for assessing condition (see P.6 below).

Deliverables:
- NMS Annual Report
- One or more technical reports and technical appendices that accompany the Annual Report
- Data analysis and data visualization for the above reports, and to support public presentations to the NMS SC, NTW, and stakeholders, and at regional conferences

Budget Justification: The funding level is equivalent to ~1 FTE of a mid-level scientist ($146k), with additional funding for scientific collaborators ($30k).

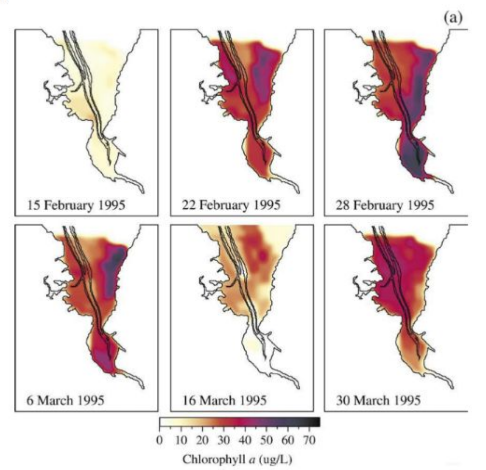
P.5 Pilot Monitoring Study: South Bay eastern shoal mooring
FY18 Estimated NMS Cost = $89,000
Collaborators: SFEI, USGS biogeochemistry group (Sacramento)

Past studies have shown that South Bay's broad shoals are areas where phytoplankton biomass commonly reaches much greater levels than in the adjacent deep channel, due in part to the shallower water column and relatively higher light levels (Figures A and B). However, measurements along the shoals are not part of routine monitoring, limiting our ability to accurately assess condition, estimate gross primary production, and calibrate models. Projects P.5 and P.9 are pilot projects aimed at addressing these data gaps by developing the NMS approach for shoal sampling to address.

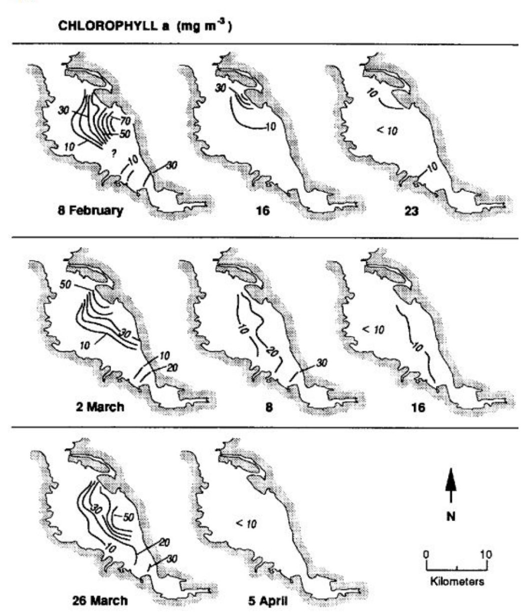
In Mar-Apr 2017 we conducted a pilot study to evaluate two complementary measurement approaches along the shoals: a mooring with multiple sensors (Figure C), and high-resolution biogeochemical mapping, using similar instrumentation to the mooring, plumbed to flow-through system sensors aboard a fast-moving boat (Fig D). Mooring data showed the evolution of a pronounced shoal bloom, and its apparent influence on nitrate concentrations (as chl-a increased nitrate decreased) and increased DO %saturation. The strong variations in chl-a and nitrate signals over hourly time-scales are evidence of sharp spatial concentration gradients, measurable at a fixed location because of the tides moving water masses with different chemical signatures past the sensor. Mapping work confirms that sharp gradients were present, with elevated chl-a concentrations co-occurring with decreased NO_3^- concentrations, consistent with NO_3^- drawdown during phytoplankton growth (Figure D). Turbidity (Figure E, bottom panel), which was at its lowest during neap tides (beginning, middle, end of record) and exhibited large daily peaks during spring tides, provides an approximate measure of light attenuation (photic depth ~3.4 m and ~1.2 m when turbidity are 10 FTU and 50 FTU, respectively).

For P.5, a water quality mooring (chl-a, NO3, salinity, T, turbidity) will be installed along South Bay's eastern shoal at a similar location as in Mar-Apr 2017 (see location in Figure D), in collaboration with researchers from

A



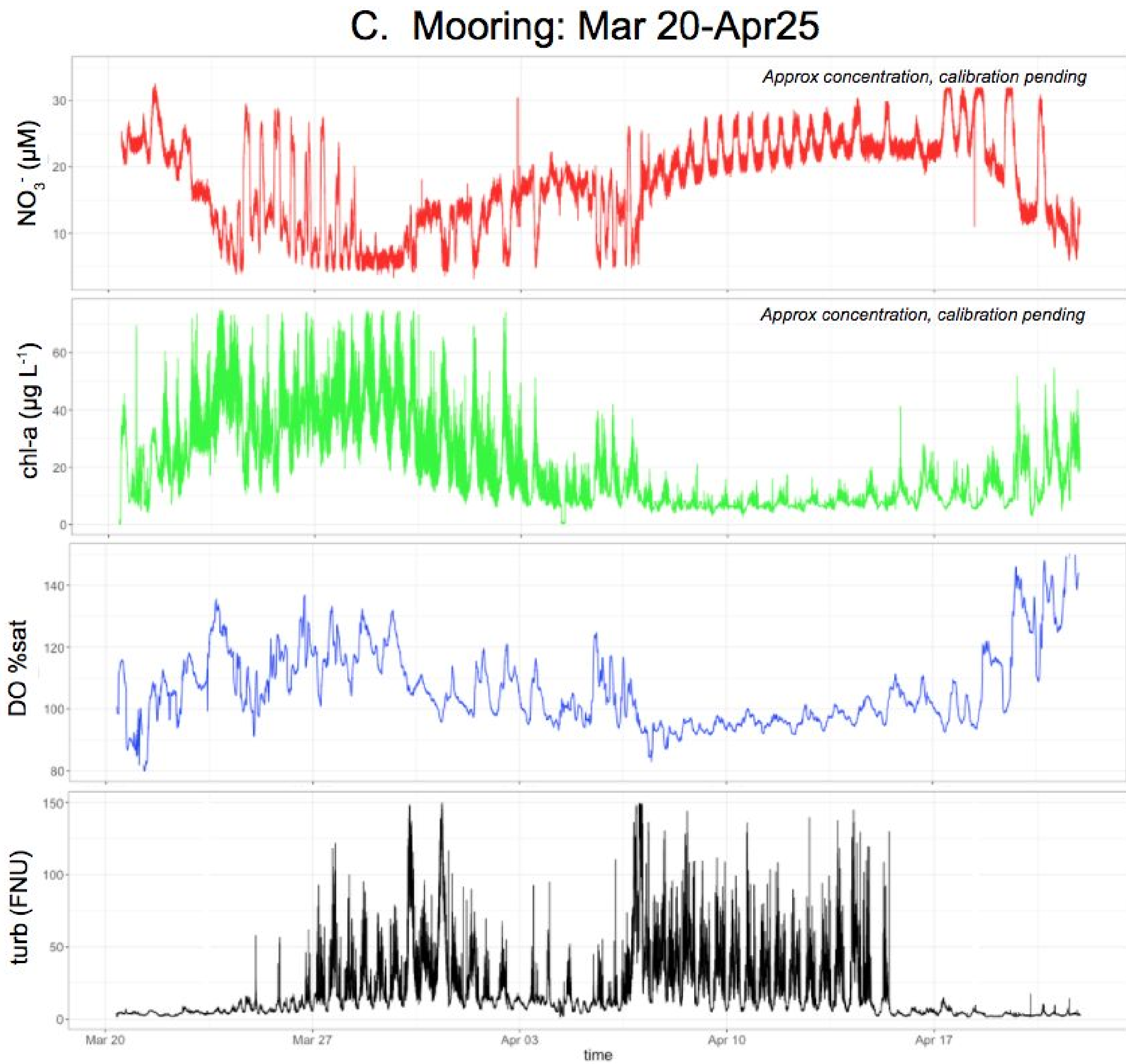
B



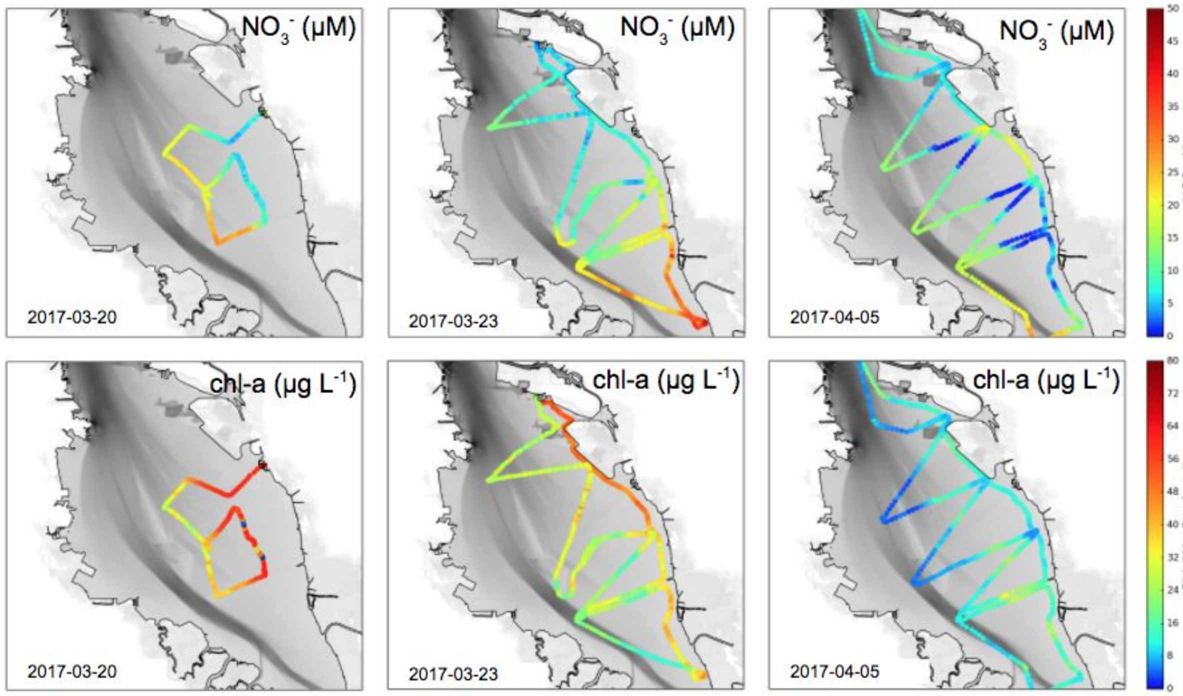
A. From Thompson et al 2008, showing blooms developing along and sometimes propagating to the channel, with highest chl-a levels observed on the shoals. B. Huzzey et al 1990. Large lateral chl-a gradients during winter-spring 1982, with high chl-a concentraiton evidet along the shoal while channel concentrations remained low

USGS-Sac (Bergamaschi et al.). The mooring will be deployed for two 4-month windows (Jan-Apr 2018; Jul-Oct 2018) with maintenance trips scheduled every 3-4 weeks. To minimize cost, we will, as much as possible, use instrumentation and deployment equipment already owned by the two groups.

For P.9 (separate funding, see below), high-res biogeochemical mapping will be conducted along South Bay shoals in FY18. Work will include 7-15 survey days, timed to coincide with key periods of interest during mooring deployments.



D. High Resolution Biogeochemical Mapping



Deliverables:

- QA'd dataset
- Summary of results in FY18 annual report.
- Application and interpretation of results within model development and calibration (C.3), and within moored sensors (C.2).

Budget Justification: Mooring set-up and deployment, field support, and collaboration on data interpretation (USGS, $35,000); data management, data interpretation (SFEI staff, 0.2 FTE, $29k); equipment/instrumentation ($25k).

P.6 DO related habitat quality, including biological indicators
FY18 Estimated NMS Cost = $30,000-$100,000-$180,000
Collaborators: SFEI, UC-Davis (Hobbs), other external experts

Over the past 3 years, SFEI has been monitoring DO and other parameters throughout LSB. As noted in project description for **C.2,** low dissolved oxygen levels commonly occur in LSB sloughs for short periods of time (~hours). Although tidal transport plays an important role in moving around water masses with very different dissolved oxygen levels, the actual causes of the low DO excursions in LSB sloughs are currently poorly understand. Extensive fish survey data is also available for areas of Lower South Bay, collected by UC Davis researchers over the past 3+ years, funded initially by the South Bay Salt Pond Restoration Program and more recently by the San Jose-Santa Clara Regional Wastewater Facility. These two datasets, although collected as part of unrelated studies, nonetheless provide complementary information about DO levels and fish populations in Lower South Bay.

In April 2017 SFEI held an expert workshop to launch an effort to develop the scientific foundation to evaluate DO-related habitat quality in Lower South Bay (LSB), and in particular in its sloughs and creeks. During the lead-up to and during the workshop, the SFEI and UC Davis datasets served as the basis for developing conceptual models for spatial and temporal variability of dissolved oxygen concentrations and fish abundance and assemblage. The workshop yielded valuable input that is guiding the current round of work.

P.6 is a continuation of the FY17 workshop project, and the low-end cost estimate for P.6 is simply a no-cost extension of FY17 project's remaining scope (remainder = $30k), including coordinating with UC Davis researchers. The FY17 project is also supporting UC Davis researchers to analyze their dataset through the lens of DO dynamics.

The intermediate funding level ($100k) would support additional DO and fish related data analysis by UC Davis and SFEI, and also support reconvening a subset of the the external experts in Fall 2017 to comment on and finalize the technical report. The high cost project ($180k) would include the expanded interpretation and follow-up technical team meeting, and also allow for a modest level of additional data collection, either targeted additional fish/benthos sampling, or collection of additional DO data to maximize the alignment between DO data spatial/temporal coverage and fish survey data.

Deliverables: Analysis of this data will be incorporated into the technical report described in C.2, and data will be summarized in the FY18 annual report.

P.7 Expanded Program coordination
FY18 Estimated NMS Cost = $75,000
Collaborators: SFEI, Ian Wren

FY17 Program activities included a program coordination task supported from a voluntary $100k contribution from BACWA. Activities conducted pursuant to this task included meeting management, stakeholder engagement, fundraising and alternatives analysis. Outcomes from this pilot effort are summarized here, with recommendations for FY18 program activities.

Task 1: Meeting Management/Stakeholder Engagement
Program coordination activities in FY17 enhanced overall program effectiveness and achieved cost reductions associated with eliminating external facilitation needs. In FY18 meeting and stakeholder coordination will continue to ensure successful meeting management and timely response to stakeholder needs.

Program coordination outcomes for FY18 shall include:

1. Effective meeting management and responsive stakeholder engagement;
2. Additional implementation of the "one tent" approach for SF Bay nutrient science and management;
3. Provide public-oriented information for general audiences and media, where possible (e.g. contributions to the RMP Pulse of the Bay and eUpdates).

Task 2: Fundraising
The 2017 Fundraising and Outreach Strategy established guiding principles and goals for program coordination efforts, with a three-year strategy for fulfilling the following objectives:

1. Attract public funds for SF Bay nutrient research, to a level on par with comparable estuaries.
2. Coordinate and influence existing monitoring programs to achieve economies of scale, collect necessary data with limited funds, and enhance regional collaboration.
3. Secure new funding from stakeholders currently unaffiliated with the NMS.
4. Work with existing stakeholders to identify special projects of high priority to both the NMS and individual agencies.

Additional partnerships and potential opportunities were developed in FY17 to enhance cooperation and funding with in-Delta monitoring programs, consistent with objective #2. Further coordination with regional monitoring programs (i.e. Interagency Ecological Program (IEP) and USGS) is considered a high priority objective for FY18 and is reflected as Task 3. New funding sources were also explored to secure funding for management action planning and integration of nutrient management efforts within other multi-benefit efforts (i.e. wetland management and recycled water).

In FY17, over $1 million was secured from existing and new partners to support modeling and science activities:

Source	Amount	Activity
Central Contra Costa Sanitary District	$200,000	Suisun Bay modeling
Delta Science Program	$100,000	Delta/Suisun Bay modeling
Sacramento Regional Sanitary District	$100,000	Delta modeling
Sunnyvale and Palo Alto	$60,000	Hydrodynamic modeling of South Bay sloughs
State Water Board (via R2)	$300,000	Scenario modeling
SF Bay Regional Water Quality Control Board (Supplementary Environmental Projects)	$240,000	Biogeochemical model development
FY2017 total:	$1 million	

<u>FY18 Fundraising Objectives</u>

Fundraising objectives for FY18 include building on new and existing partnerships to achieve the following:

- Secure funding for un-funded special projects of particular interest to existing stakeholders.
- Work with partners in the POTW community and elsewhere (e.g. SFEP, IRWM) to identify funding sources to pilot and plan for green infrastructure-based management activities, or other management alternatives (i.e. nutrient recovery, wastewater recycling and concentrate management, integration of holistic approaches that integrate optimization and upgrade alternatives with other multi-benefit approaches.
- Identify and submit a minimum of two (2) significant funding proposals involving either science & monitoring or alternatives analysis & enhanced regional coordination for potential implementation strategies.

Desired fundraising outcomes for FY18 include:

1. Secure funding for at least two (2) unfunded projects from the FY18 Program Plan.
2. Submit at least two (2) funding applications to either a) fund high priority science/monitoring projects; and/or b) conduct additional alternatives analysis - potentially including enhanced regional coordination for potential implementation strategies, demonstration projects, and regulatory outreach to identify permitting strategies for green infrastructure-based nutrient reduction strategies.

Task 3: Regional Monitoring Coordination

Among the priorities established in FY17 for outreach, to expand the scale of the science and monitoring activities of the NMS, was to coordinate and influence existing monitoring programs to achieve economies of scale, collect necessary data with limited funds, and enhance regional collaboration. In FY17, this translated into making linkages at the Bay-Delta interface through coordinated model development and information sharing. FY18 presents a unique opportunity to build these linkages due to monitoring program updates in support of potential changes to San Joaquin River flow and southern Delta water quality objectives and program of implementation included in the *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* (Bay-Delta Plan).

In FY18, priorities include developing closer ties to monitoring programs in the Delta and advancing a 21st century monitoring program that more closely aligns monitoring activities throughout the Estuary (i.e. IEP and USGS activities). Particular activities include:

1. Foster closer relationships with SF Estuary monitoring agencies to build strategic partnerships to increase the level of scientific coordination or alignment of scientific efforts, and identify opportunities for in-kind or matching support for work.
2. As the State Water Board considers updates to the Bay-Delta Plan and Water Right Decision 1641 (D-1641), a 1999 decision which governs monitoring requirements for the SWP and CVP, integrated nutrient management monitoring shall be advocated for across the Bay-Delta interface.
3. Leverage funding and monitoring resources through state and federal agencies and consortiums (i.e. USGS, NOAA, Interagency Ecological Program (IEP) and Delta Science Program).
4. Formalize monitoring partnerships resulting in quantifiable improvements to the NMS monitoring program.
5. Identify opportunities for closer coordination with agencies conducting oceanic monitoring and assessment to achieve scientific and management objectives related to outer coast processes (e.g. NOAA, CA DFW, universities).

P.8 Management Alternative Evaluation
FY18 Estimated NMS Cost = $20,000
Collaborators: SFEI, Ian Wren

In FY17, program coordination efforts included the identification of priority management objectives associated with potential nutrient reduction actions. These included a strong preference for achievement of multiple benefits, in the event significant public investment is needed to reduce nutrient loading to SF Bay. Primary management actions included the desire to explore nutrient load reduction potential associated with wastewater recycling and treatment via green infrastructure-based approaches (i.e. treatment wetlands, horizontal levees, landscape/agricultural irrigation). This led to conceptual-level examination of the potential for treatment wetlands in the vicinity of wastewater sources, indicating strong potential for cost-effective regional-scale load reductions.

Low-level support for this effort could enhance support for, and ease regulatory- and public perception-based hurdles associated with, integrated planning for wetland restoration, wastewater recycling and traditional optimization and upgrades to existing wastewater infrastructure. This effort is expected to take on greater significance in coming years, though on-going support will ensure planning progresses and opportunities for funding and partnerships are secured as they arise.

FY18 activities shall include, subject to stakeholder revision:

- Stakeholder review of data and documentation associated with the report developed in FY17 (*Treatment Wetlands for Nutrient Removal in the Bay Area: Screening-Level Opportunities and Constraints Analysis*);
- Maintain coordination with ReNUWIt to inform the NMS process and management alternatives;
- Scoping and development of a regional approach for site-specific assessment of multi-benefit based approaches to nutrient management (i.e. green infrastructure and wastewater recycling). Analysis and documentation to take place in FY19 or beyond;
- Develop enhanced coordination with the SF Bay Area Integrated Regional Water Management (IRWM) program to foster closer coordination with implementing entities of wetland restoration and wastewater recycling projects. In FY17 the IRWM indicated a strong potential for Prop 1 funding to achieve mutually-beneficial goals, which could serve to enhance regional planning efforts for multi-benefit nutrient management, and;
- Outreach to stakeholders to identify fundraising opportunities for fulfillment in P.7. Opportunities include Prop 1 funding to support regional multi-benefit analysis and demonstration projects; public/private funding to identify regulatory approaches for wetlands as a nutrient management tool; public/private funding for evaluation of wastewater recycling strategies and concentrate disposal options.

Optional activities, subject to additional support:

- Outreach to regulators and key stakeholders to identify processes for streamlining implementation of treatment wetlands (establish consistent criteria, monitoring, maintenance)
- Conceptual-level assessment of opportunities and constraints to enhanced wastewater recycling in the Bay Area to achieve nutrient load reductions. This was identified as high priority from some stakeholders in FY17, though treatment wetland assessment was considered higher priority;

P.9 High-resolution biogeochemical mapping (e.g., South Bay)
FY18 Estimated NMS Cost = $72,000-$109,000
Collaborators: SFEI, USGS biogeochemistry group (Sacramento)

See description above under P.5. Project total cost depends on number of measurement days.

Deliverables:
- QA'd dataset
- Summary of results in FY18 annual report.
- Application and interpretation of results within model development and calibration (C.3), and within moored sensors (C.2).

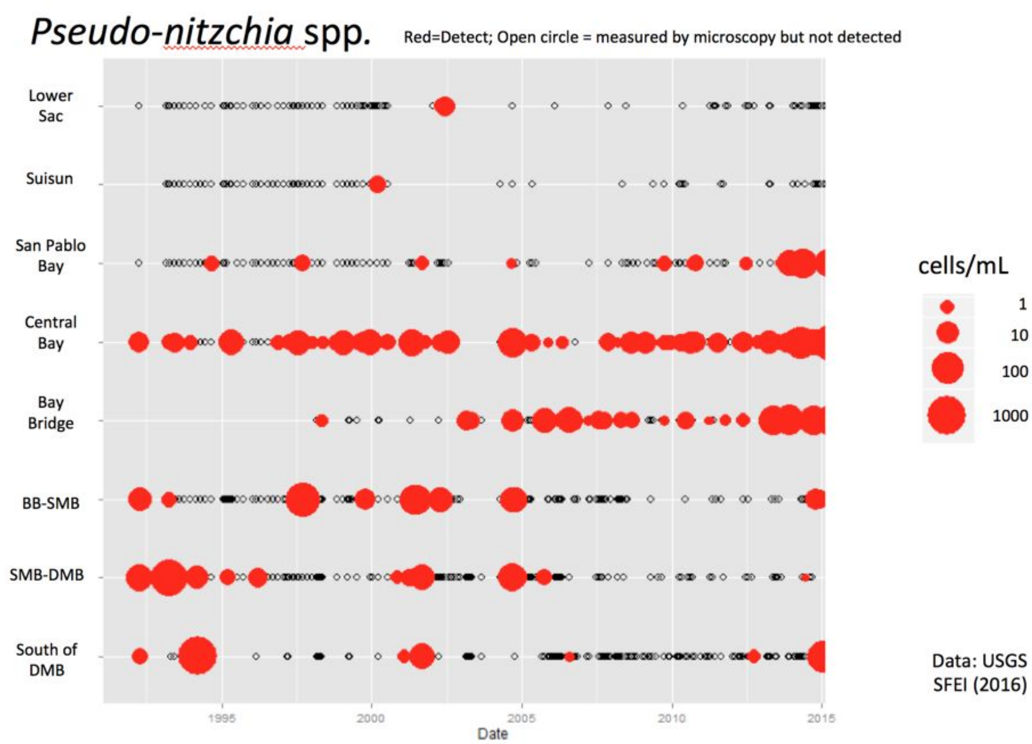
Budget Justification: Field work, data QA, logistics (USGS, $40k-60k for 5-8 measurement days); data management, data interpretation (SFEI staff, 0.2-0.3 FTE, $29k-45k); discrete samples for nutrients and chl-a ($3000-$4000).

P.10 Mechanistic Harmful algae bloom investigation
FY18 Estimated NMS Cost = $20,000-$200,000 (Year 1 of a multi year study)
Collaborators: SFEI, UCSC, USGS

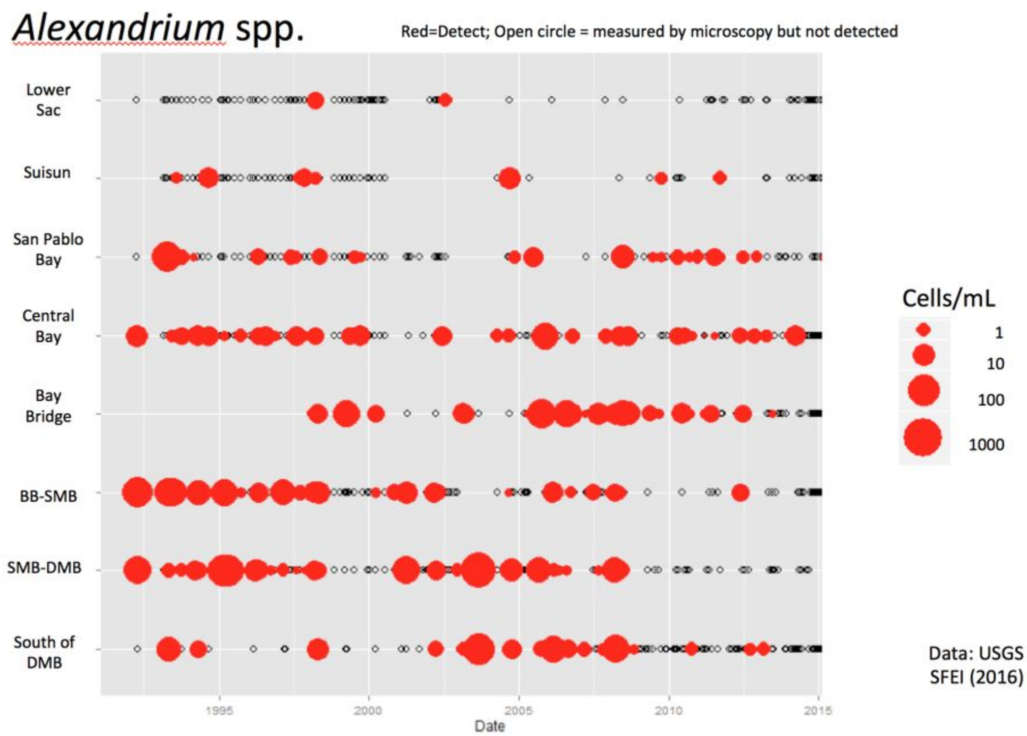
Goals:

- Continue building the NMS' to reliably and efficiently monitor for phytoplankton assemblage in general, and HAB-organisms specifically
- Develop improved understanding of the source(s) of HAB-forming organisms and toxins in SFB
- Through a combination of observational data or experiments, characterize the growth requirements and toxin production of priority HAB-forming organisms, and identify conditions that have inhibited large-scale blooms from developing in SFB

The record-setting and long-lived toxic algae bloom (*Pseudo-nitzchia spp.*; *P-N*) along the US west coast in Spring/Summer 2016 clearly illustrated the severe impacts of harmful algal blooms (HABs; McCabe et al., 2017). It also illustrated how the factors that lead to HABs developing and persisting are complex and difficult to predict, and that they occur episodically. The fact that a major *P-N* bloom did not occur in the Bay in 2015 is noteworthy, given that: the coastal event created the opportunity for a sustained source of *P-N* cells to the Gulf of Farallones and SFB; Central and South Bay conditions (T, nutrients, salinity) are generally considered quite favorable for *P-N* (Cochlan et al., 2008); *P-N* are commonly detected in San Francisco Bay, as is the toxin they produce, domoic acid, albeit at lower concentrations than they were along the coast in 2015.



In addition, other harmful algae and their toxins (e.g., *Alexandrium spp.*, and saxitoxin) are also commonly detected in the Bay. For both *P-N* and *Alexandrium*, the factors that lead to bloom formation and toxin production are complex, and, especially for SFB, they are poorly known. This type of information is nonetheless essential for assessing the risk of major HAB events occurring, both now and under future conditions.



Possible focus topics (FY18 and beyond) for mechanistic HAB investigations have been discussed extensively over the past two years with experts (collaborators and advisors), including at a May 31-Jul 1 2017 HAB workshop sponsored by the NMS. The exact activities for FY18 will be identified and work plans developed once the overall project concept has been provisionally authorized by the NMS SC and if funding has been secured. Projects under consideration for FY18 activities are described below.

1. ***Expanded biota sampling for improved understanding of toxin sources, spatio-temporal variability, and food web exposure. Two studies, discussed during the May 31- Jun 1 2017 HAB workshop, are summarized below.***

    a. *Measure toxin concentrations in SFB anchovies.* Anchovy are planktivorous fish that acquire food through filter-feeding and therefore have an analogous exposure to phycotoxins as bivalves. However, unlike most of the mussels measured thus far in NMS projects (collected from floating docks), anchovies tend to acquire their food in the open bay, where conditions are often quite different than along the shoreline. Anchovies may thus serve as complementary bioindicators of phycotoxin levels in a distinct zone of SFB. In this pilot study, anchovies will be obtained from one or more fish monitoring efforts in SFB (e.g., CA DFW; UC-Davis; Marine Science Institute) from several representative stations in SFB on a monthly basis. Toxin measurements will be performed on anchovy viscera (i.e., gut), since they tend to contain much higher phycotoxin concentrations than in muscle or other tissue (Lefebvre et al. 1999; McCabe et al 2016). Year 1 pilot project cost estimate: $50,000.

b. _Comparison of harmful algae and toxin levels in SFB and Tomales Bay._ The California Current transports similar water masses to the mouths of both SFB and Tomales Bay (TB). To the extent that marine harmful algae (HA) such as *Pseudo-nitzchia*, *Alexandrium*, or *Dinophysis* are being primarily transported into SFB from the coast (i.e., not growing within SFB), SFB and TB should have similar HA abundances and phycotoxin concentrations. A thorough “case-control” study to thoroughly investigate and compare HA and toxin levels in SFB and TB would be a major undertaking and a multi-year study. However, it is possible to get valuable information from a much more limited pilot study design. In this study bivalves would be collected from Tomales Bay and analyzed for a suite of marine phycotoxins (e.g., domoic acid, saxitoxin, and others) and compared with those in Central Bay bivalves already being collected through P.1. To increase the pilot study’s efficiency, sampling would initially be focused during times when maximum toxins would be expected (SFB domoic acid and saxitoxin measurements suggest this would occur in May-October). Biweekly samples will be collected at several sites in TB from early-July through October 2017, and analyzed for relevant toxins. Depending on observed toxin levels, additional sampling may be carried out in spring 2018, and/or further parameters may be added to the study (e.g., phytoplankton enumeration). Year 1 cost estimate: $30,000.

2. ***Identify major sources of microcystins to SFB:*** Microcystins are commonly detected in water and biota samples collected throughout SFB, including at levels in bivalve tissue that exceed human consumption thresholds (SFEI 2015, 2016; Gibble et al., 2016). Freshwater cyanobacteria are generally considered to be the primary source of microcystins, making the widespread detection of microcystins in SFB initially somewhat surprising, and suggesting that the sources are nontrivial. Two example studies, aimed initially at identifying (toward an eventual goal of quantifying) the primary microcystin sources are below.

a. _Measure microcystins at, and estimated microcystin fluxes from, suspected watersheds in the Bay Area._ High levels of microcystins have been detected in multiple lakes and reservoirs around the Bay Area over the past several years. In this study microcystins will be measured either at the lake or reservoir outlet or where streams or creeks enters SFB. Integrated passive samplers (i.e., SPATT) have been used to measure microcystins effectively in other studies with similar goals (Kudela 2011; Gibble and Kudela 2014), and are likely the most cost-effective approach for acquiring initial information about source watersheds. Once sources are narrowed down to a manageable number, the approach can be refined to more accurately estimate mass fluxes. Year 1-2 cost estimate, for identifying major sources using SPATT: $100,000.

b. _Measure microcystins in clam samples from Suisun Bay and Delta_ Results from a NMS pilot study (FY2015) indicate that the invasive clam, *Potamocorbula amurensis*, from Suisun Bay accumulates elevated concentrations of microcystins during late summer and fall. Given the strongly-seasonal pattern, the microcystins were presumably produced in the Delta during warm summer months, and accumulated in the clams as microcystins-containing water exited the Delta. Although microcystin concentrations in tissue do not translate readily to water column concentrations, measuring the tissue concentrations allows for an integrated measure of concentration, and facilitates direct estimates of exposure to other organisms via the food web. At a later date, additional studies will be needed to help translate the clam concentrations to water column concentrations and mass flux. Year 1 cost estimate: $20,000.

3. ***Continuous deployment of the Imaging Flow CytoBot (IFCB) in Central Bay: building moored capacity and establishing a coastal end-member signal.*** The IFCB is an automated flow cytometer and image-capture instrument for counting phytoplankton down to the genus level, estimating biovolume, and characterizing phytoplankton community composition. Through a joint proposal funded by NOAA (UCSC [PI: Kudela], SFEI, USGS), two IFCB's have been acquired for application in SFB nutrient and phytoplankton monitoring efforts. Although IFCBs have been successfully used in other coastal systems, and early results from measurements aboard the USGS R/V Peterson in SFB are encouraging, substantial effort needs to be directed toward testing the IFCB with SFB's high suspended particulate matter samples; training its image recognition algorithms for the SFB phytoplankton community; developing field and QA/QC protocols for moored applications; and data interpretation. This project aims to build IFCB deployment capacity while simultaneously developing a Central Bay deployment site that can, over time, serve to monitor the coastal ocean phytoplankton signal entering SFB. Possible deployment sites include the Exploratoreum Wired Pier and the Fort Point Pier. Funding could be used to support: a partial-FTE postdoctoral researcher working jointly between UCSC, USGS, and SFEI, or could support; or to cover the cost of additional measurements (e.g., pigments, molecular/DNA methods) or ancillary parameters (e.g., deploying a nitrate sensor). Estimated cost: $25k-$50k

4. ***Determine whether SFB hosts internal sources of Alexandrium in the form of cysts in sediments.*** *Alexandrium* forms resting stages, or cysts, that can survive for long periods in sediments. Detecting high *Alexandrium* cyst densities in sediments could suggest that SFB hosts an endemic population of *Alexandrium*. Work would include collecting and preserving surface sediment grab samples from locations in Central Bay, South Bay, and Lower South Bay. Samples could be analyzed by microscopy after staining, or using molecular techniques that can also differentiate between toxigenic and

nontoxigenic strains. The RMP is already sampling and preserving sediments from Lower South Bay and South Bay margin sites (Summer 2017), and subsamples could be obtained from that effort. Therefore cost would be limited to laboratory analysis and data interpretation. Estimated pilot project cost: $50,000

5. ***Determine if coastal P-N isolates can grow in SFB, or face obstacles beyond low-light and strong-mixing.*** The fact that *P-N* failed to bloom in SFB during the major coastal event in 2015 could be due to high turbidity and strong vertical mixing, or it could also just be dumb luck. It could also be that SFB's waters are, for one reason or another, inhospitable to *P-N*. For example, many HAB species, including some P-N strains, are unable to synthesize essential B-vitamins yet have high B-vitamin requirements which can limit their ability to grow (Tang et al., 2010). Other factors limiting growth could be high concentrations of trace metals or viruses (Carlson et al 2016). A 'simple' experiment to test whether SFB has inherent resistance to *P-N* blooms (beyond low-light and strong-mixing) would be to add P-N strains, isolated from other coastal areas, and try to grow them in SFB water. If, for example, multiple P-N strains grow easily in SFB water, other growth-limiting factors are not the cause. But, if multiple P-N strains grow poorly, an unidentified growth-limiting factor could be contributing. Although this may sound like a risky experiment (i.e., high likelihood of failure), the potential payoff of learning quickly that SFB somehow limits P-N growth is enormous. Cost estimate: $50k for initial studies.

6. ***Identify the species and/or strains of Pseudo-nitzchia and possibly other HAB-forming organisms that occur in SFB.*** If SFB hosts an endemic population of P-N, it is possible that the population is comprised of a unique strain compared to populations that might be simultaneously occurring along the coast. Work woul During routine monthly cruises, collect additional samples for analysis by molecular techniques for detecting these organisms down to species, and possibly strain, level. Test for toxigenic and non-toxigenic strains (for *Alexandrium*; probes not available for *Pseudo-nitzchia*). Determine if strains differ consistently as a function of space (or time), and whether there is evidence of strains endemic to SFB. Compare with species and strains identified in other systems, and, to the extent possible, develop first-order estimates of growth characteristics.

Deliverables: Progress report (June 2018) describing findings to date, and recommendations for specific work to be continued in Years 2-3.

P.11	Modeling Advisory group	Convene Modeling Advisory Group to solicit input on modeling plans and direction to date. Deliverables: Summary report from Modeling Advisory Group
P.12	Coastal export	A sizable proportion (e.g. 50% or more, depending on season) of the nutrients that enter SFB exit via the Golden Gate to the coast ocean. The fate of those nutrients, and their effects on the GoF and coastal habitats are poorly known. This project could be either a field investigation, e.g., installing instruments on an existing GoF mooring if other work is occurring in the region (high-end of cost range), or analysis of remote-sensed data, or modeling. Cost estimates: $100k-200k.
P.13	Additional Monitoring Pilot Projects	a. Molecular techniques (amplicon sequencing, qPCR) for phytoplankton analysis have the potential to achieve one or more of the following: provide more sensitive/precise measurements especially for HABs; augment the NMS phytoplankton/HAB monitoring; improve efficiency. This project will test molecular techniques alongside other current approaches (microscopy, IFCB, pigments). Low cost will involve mostly data collection; high cost will allow for comparison with other methods. If only low cost pursued in FY2018, interpretation could be funded in subsequent year budget. Estimated cost = $50k-100k/yr for 2 years. b. Quantifying zooplankton grazing rates. Microzooplankton and mesozooplankton have the potential to strongly regulate phytoplankton biomass accumulation and shape community composition by size-selective grazing. Howver, no zooplankton grazing rates have been performed in South Bay for more than 2 decades. This 1-2 year pilot study would characterize zooplankton community structure and grazing rates, focused primarily on Central, South, and Lower South Bays (b/c grazing data is available for the northern estuary). Estimated cost = $80,000/yr for 2 years.
P.14	Data management	A data management plan, and initial implementation, is funded in FY17. This FY18 funding would support on-going implementation of the data management plan. Low cost would support ~0.25 FTE. High cost would allow for bringing a shared staffer (0.5 FTE) on board who could be part of the long-term data management effort, and, for example, increase data accessibility (ability for stakeholders and external scientists to independently access and download data), which is an eventual goal but is further out in time at the current pace. Estimated cost: $40k-80k.
P.15	Biogeochem field studies	To date the NMS has undertaken little work related to measuring the rates of important biogeochemical processes (oxygen demond/respiration, denitrification, nitrificaiton, phytoplankton growth, etc.). This data is needed (eventually) both for mechanistic interpretations and for model calibration/validation. This project would be an initial step toward collecting some of the highest priority data, and would need to be part of a multi-year project