NMS Draft FY18 Program Plan: Background and Request for NTW Feedback

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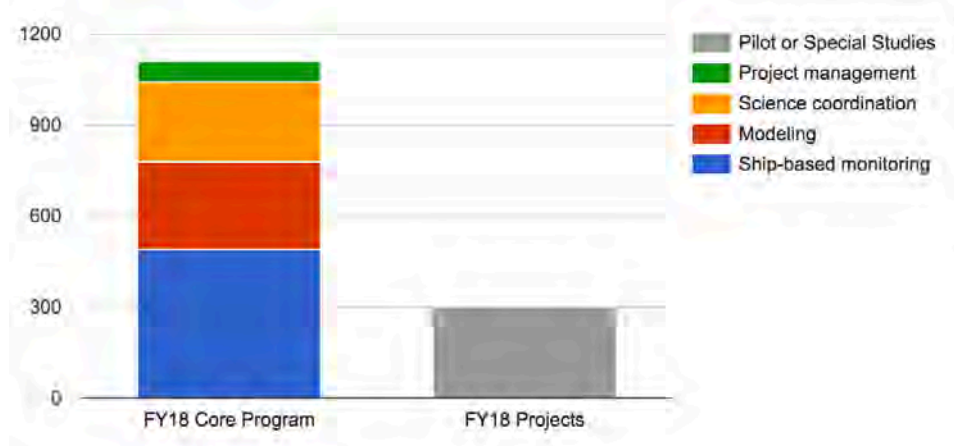
- After funding Core Program activities, we expect $300-400k will be available to support projects in FY18.
- For NTW Discussion: Please think ahead and come with talking points related to the following
  - Do you agree with the proposed prioritization for FY18 projects?
  - If not, what would you change?
  - What project(s) would you rank higher or lower? Are there projects you would add to this list?
  - Why?

Strawman FY18 Program Plan

Anticipated Revenue ($1,000s)	
Nutrient Permit	880
RMP CY2018 *	500
Total Revenue	***1,380***
Costs ($1,000s)	
1. Core Program	
1.1 Monitoring	
Channel Monitoring	160
Moored sensors	340
1.2 Modeling **	
Core model development and application	290
1.3 Program Coordination	
Science Program coordination	260
Program Management	70
Subtotal - Core Program	***1,100***
2. Projects	
Potential funding available for FY18 Projects (including assumed reserve ~100k)	300-400



Note: Monitoring cost does not include in-kind USGS contribution for ship-based monitoring (est. 900k)

* Upper bound estimate

** Several new modeling projects, started in FY17 with additional funding, work underway but are considered FY17 projects and not included here.

Strawman FY18 Program Plan: Project Alternatives

		FY18 Estimated Cost			Program Area			Work Category and/or Type of Activity						
		Low	High	Running total, Low	Nutrients	DO biomass	Phytos HABs	Monitoring: program expansion	Monitoring: Efficiency, Better Information	Mechanistic study, process, rates	biological indicators, beneficial uses	AF, protective conditions: synthesis, testing, refining	Modeling	Future scenarios
P.1	MonitoringPilot: Toxins in mussels	$100,000	$150,000	$100,000			X	X						
P.2	MonitoringPilot: Imaging flow cytobot, data interp.	$80,000	$80,000	$180,000			X	X	X	X				
P.3	MonitoringPilot: in situ sensor calibration/validation	$50,000	$200,000	$230,000	X	X	X		X					
P.4	Synthesis, incl. AF	$150,000	$200,000	$380,000		X	X					X		
P.5	MonitoringPilot: Shoal mooring, South Bay	$100,000	$130,000	$480,000	X	X	X	X						
P.6	Biological indicators, DO	$50,000	$200,000	$530,000		X					X	X		
P.7	Expanded Program Coordination	$50,000	$100,000	$630,000										
P.8	Exploring management alternatives	$50,000	$100,000	$680,000										
P.9	MonitoringPilot:lateral sampling/monitoring, shoals	$50,000	$100,000	$580,000	X	X	X	X	X				x	
P.10	HAB investigations	$50,000	$200,000	$730,000			X			X		X		
P.11	MonitoringPilot: DNA based techiques, phytos	$20,000	$100,000	$750,000			X	X	X					
P.12	Coastal export	$100,000	$200,000	$850,000			X	X		X			X	
P.13	Data management	$40,000	$80,000	$890,000	X	X	X							
P.14	Biogeochem field studies	$100,000	$300,000	$990,000	X	X				X			X	
		$990,000	$2,140,000											

FY18 Priority Level

Higher

Lower

- As we did with the FY17 Program Plan, we will seek authorization from the NMS SC to move forward on all projects, pending funding.
  - We will then pursue additional funding from other sources.
  - In FY17, we raised an additional ~$900k beyond the NMS and RMP resources. So, projects that
- Colors represent draft prioritization for FY18. Only high-priority activities are listed here – so, the prioritization is relative among these already high-priority studies.
  - Blue = highly likely to proceed in FY18 with NMS funds;
  - Green = moderate likelihood of moving forward with NMS funding;
  - Yellow, Orange, Red = Unlikely to move forward in FY18 without additional funding

NTW Discussion: ***Please think ahead and come with talking points related to the following***

- Do you agree with the proposed prioritization for FY18 projects?
- If not, what would you change?
  - What project(s) would you rank higher or lower? Are there projects you would add to this list?
  - Why?

NOTE: Developing and implementing the NMS Observation Program (Monitoring) is among our highest priorities over the next several years. The 6 project ideas under monitoring are potential pilot projects to support during FY18, in addition to current monitoring program. Read about monitoring program design here . Also, see supplementary slides in this document

Project Blurbs: Additional descriptions for several of the Core Program activities and Projects are described

			FY18 Estimated Cost	
		Description	Low	High
P.1	MonitoringPilot: Toxins in mussels	Continue current mussel sampling and toxin measurements. Possibly pilot the use of deployed mussels and SPATT to improve interpretability	$100,000	$150,000
P.2	MonitoringPilot: Imaging flow cytobot, data interp.	An Imaging Flow Cytobot (IFCB) is now being used on USGS cruises. 2 instrument obtained through collaborative grant with UCSC and USGS, one for ship and one for mooring. NMS will inherit IFCBs. Funding would support a scientist to work with IFCB data and develop the program for the purposes of achieving NMS goals (low = 0.5 FTE, High = 1 FTE)	$80,000	$160,000
P.3	MonitoringPilot: in situ sensor calibration/validation	The Bay-Delta has numerous independent efforts using moorings/in situ sensors. If, through coordination and data-QA this data can be used by the NMS, it will be an enormous cost-savings. There is little to no coordination among the groups, no standard operation or interacalibration. This project would test the accuracy/precision of in situ sensors (experiments, discrete samples) and begin the development of protocols and partnerships.	$50,000	$200,000
P.4	Synthesis, incl. AF	Analyze and synthesize new or historic data collected through monitoring, including applying this to assessment framework testing, development, or refinement, specific topics to be determined. Low cost will support ~1 FTE scientist over the course of 1 year; high cost would in addition support external collaborators/advisors and coordination with stakeholder process.	$150,000	$200,000
P.5	South Bay, Shoal Mooring	Install a mooring on eastern shaol in South Bay. A pilot deployment was carried out in Mar-Apr 2017. High/low cost diferences are related to specific equipment installed and/or level of data interpretation included within budget	$100,000	$130,000
P.6	Biological indicators, DO	An extensive fish surveying effort has been underway in Lower South Bay, funded currently by San Jose and previously by the salt pond restoration program. The low cost project would allow for expanded interpretation of the fish data to explore DO-related questions (SFEI collaborating with UCDavis/Hobbs). The high cost project would include the expanded interpretation, and also allow for 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.	$50,000	$200,000
P.7	Expanded Program Coordination	Continue to support expanded stakeholder engagement, and support expanded strategic planning, fundraising, and coordination/cooperation with other agencies working in the Bay/Delta	$50,000	$100,000
P.8	Exploring management alternatives	Two major Work Elements of the Nutrient Management Strategy are Control Strategies (i.e., management alternatives) and Regulatory Approaches. Although this work is as important as the within-Bay science, they have received limited attention thus far. This project would continue some of the management alternatives work that began in FY17 (trading approaches, wetland treatment) and also develop a multi-year workplan that identifies the highest priority uncertainties and scenarios and an approach for exploring those issues to inform decisiosn.	$50,000	$100,000

Project Blurbs (cont'd)

P.9	MonitoringPilot: Lateral sampling/monitoring, shoals	The broad shoals in South, Lower South Bay, San Pablo, and Suisun Bays are areas where conditions are expected to be much different than the deep channel; yet little or no observations take place there. This project will begin developing the NMS approach for shoal sampling. Low cost will focus only in South Bay and limited number of cruises; higher cost will have either more cruises or explore a second subembayment.	$50,000	$100,000
P.10	HAB investigations	To date, the NMS is not pursuing any studies (beyond monitoring) to understand the factors that control HABs or HAB risk in the Bay. Potential studies include those outlined in the FY17 program plan, none of which were funded.	$50,000	$200,000
P.11	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 a mooring in the GoF (monitoring), or a ship-based study), analysis of remote-sensed data, or modeling.	$100,000	$200,000
P.12	MonitoringPilot: DNA based techiques, phytos	Molecular/Genetic 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.	$20,000	$100,000
P.13	Data management	A data management plan, and initial implementation, is funded in FY17. This FY18 funding support on-going implementation of the data management plan. Low cost would support ~0.25 FTE, so base level. 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/or, for example, increased data accessibility (ability for stakeholders and external scientists to independently access and download data)	$40,000	$80,000
P.14	Biogeochem field studies	To date little work has been done in the Bay to measure the rates of important 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	$100,000	$300,000

Core Program

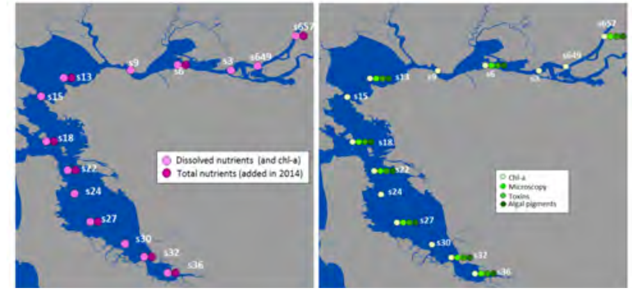
Monitoring

- C.1 Ship-based sampling and sample analysis
- C.2 Moored sensors

Modeling

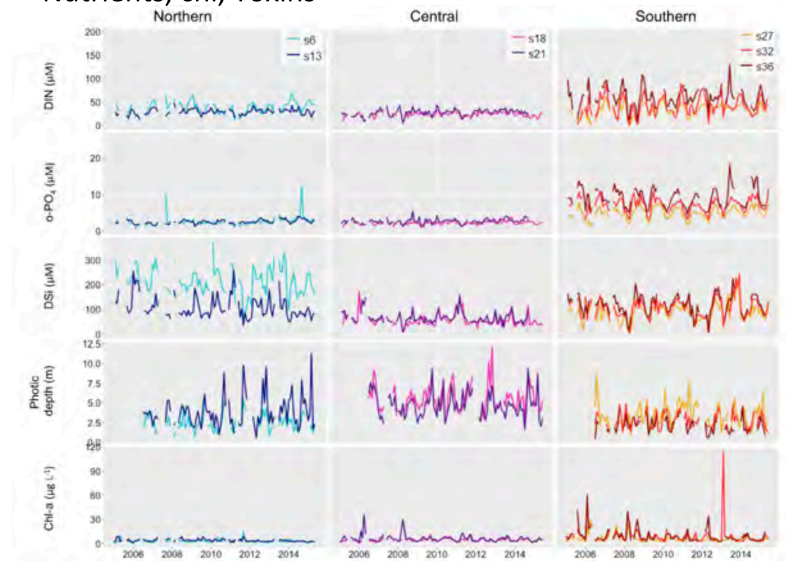
- C.3 Core Modeling

C.1 Ship-based sampling and sample analysis
FY18 Estimate ~ $150,000



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.

Nutrients, chl, Toxins



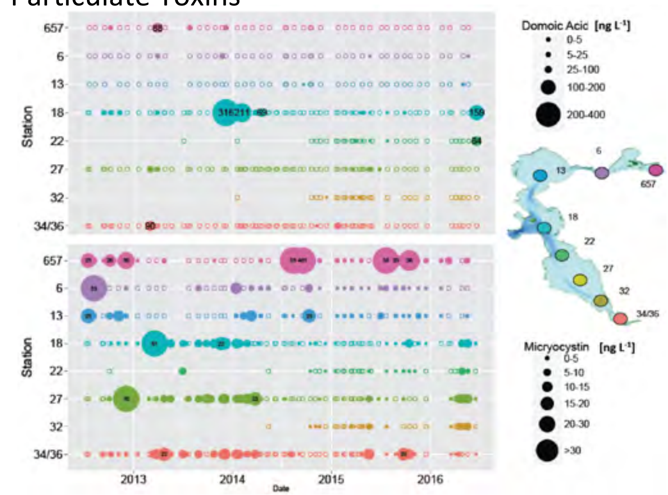
Costs covered by NMS

- 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.

Particulate Toxins



Deliverables:

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

Budget Justification: Nutrient analyses for 300 station-date samples ($40k; ammonium, nitrate + nitrite, reactive phosphorous, dissolved silicate; total N and total P only measured in ~half the samples); Taxonomy on ~200 samples for phytoplankton community composition and biovolume ($45k); toxin and algal pigment measurements ($50k); Additional staff support for field work and basic reporting ($25k).

C.2 Open-Bay and slough moored sensors

FY17 work will focus on the following:

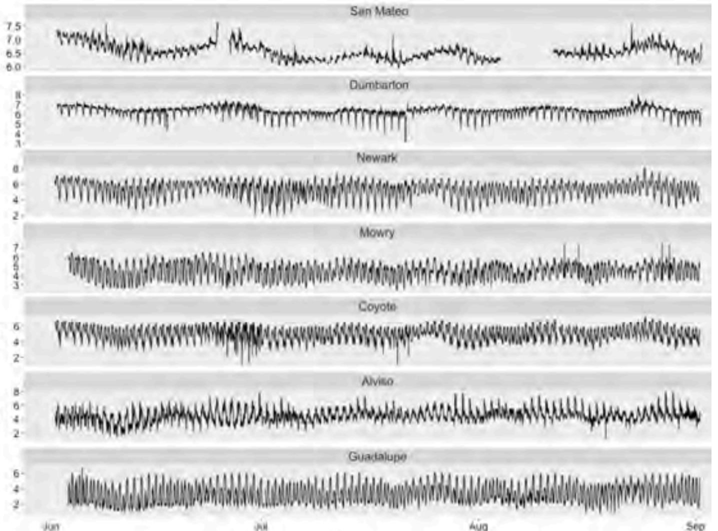
- Continue work into Year 5 of open bay stations (San Mateo, Dumbarton Bridges) and Alviso Slough
- Continue work into Year 3 of slough/creek deployments, including spring-summer-fall of the extremely wet Water Year 2017.
- Data analysis, with a major focus on quantitative mechanistic interpretation to identify factors contributing to observed DO conditions, possibly including the use of simplified reactive-transport models
- Sensor network maintenance, and Data management and QA/QC related to the above.

Deliverables:

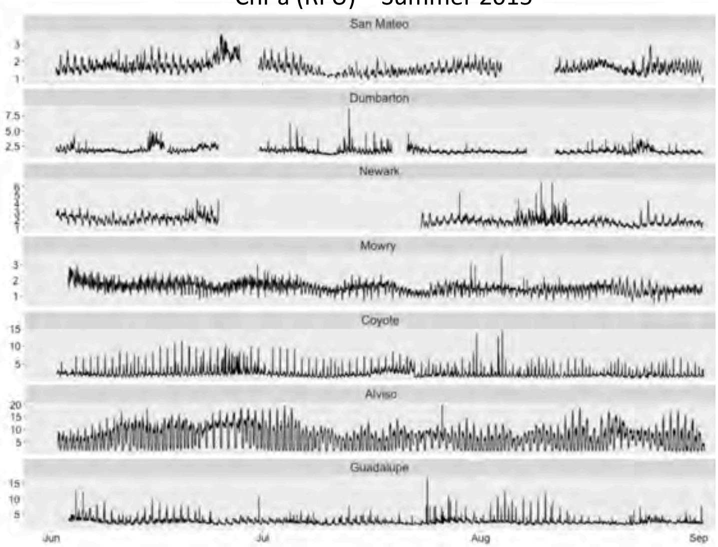
- Summary of major observations in the NMS FY18 Annual Report
- One or more technical appendices to that report characterizing, e.g.,
    - Mechanistic interpretations of factors contributing to periodically low DO at slough sites and physical and biogeochemical factors. The goal is to submit this report 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: 2 staff (0.8 FTE, 0.65 FTE; $233,000) for field work, data management, data analysis, interpretation, and report preparation. Field support and additional technical support (including boat, fuel, field technicians; $80k); equipment/supplies ($30k, replacement sensors, maintenance).

Dissolved Oxygen (mg L^{-1}) – Summer 2015



Chl-a (RFU) – Summer 2015

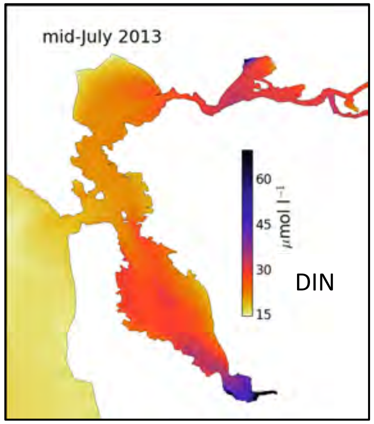


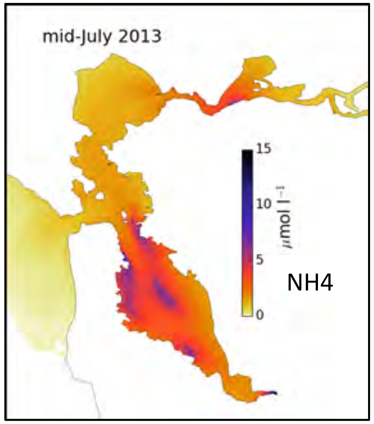
C.4 Core Biogeochemical and hydrodynamic model development

Focus in FY18
- Refining phytoplankton model, aiming to improve and test the model's ability to reproduce major features in the observational record, e.g.:
  - seasonal chl-a and nutrient trends;
  - longitudinal (Lower South vs. South) differences in phytoplankton biomass, and differences in channel and shoal biomass;
  - large phytoplankton blooms observed during some years; trend of increasing fall chl-a.
- Continued work on coupling with coastal ocean, through collaboration with UCLA/SCCWRP project.

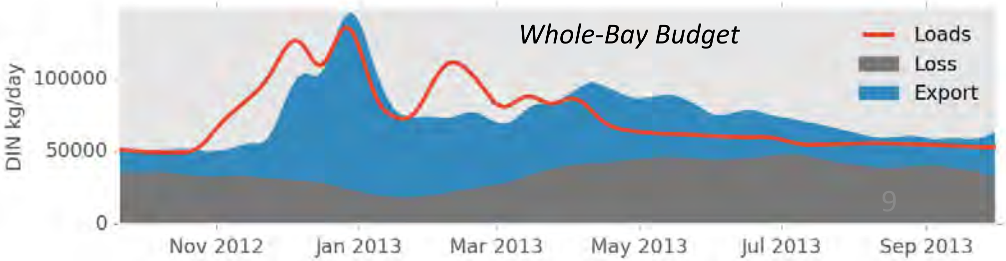
Deliverables:
- Progress report on hydrodynamic and nutrient model calibration, Summer 2017
- Hydrodynamic and nutrient model calibration and validation report
- Nitrogen budget/mass balance for San Francisco Bay, which will be developed as journal manuscript.
- Summary of recent findings and progress included in FY2018 annual report

Budget Justification: 1 FTE modeler ($225k); Deltares, technical assistance and model development ($35k); regional collaborators and technical advisors ($30k)





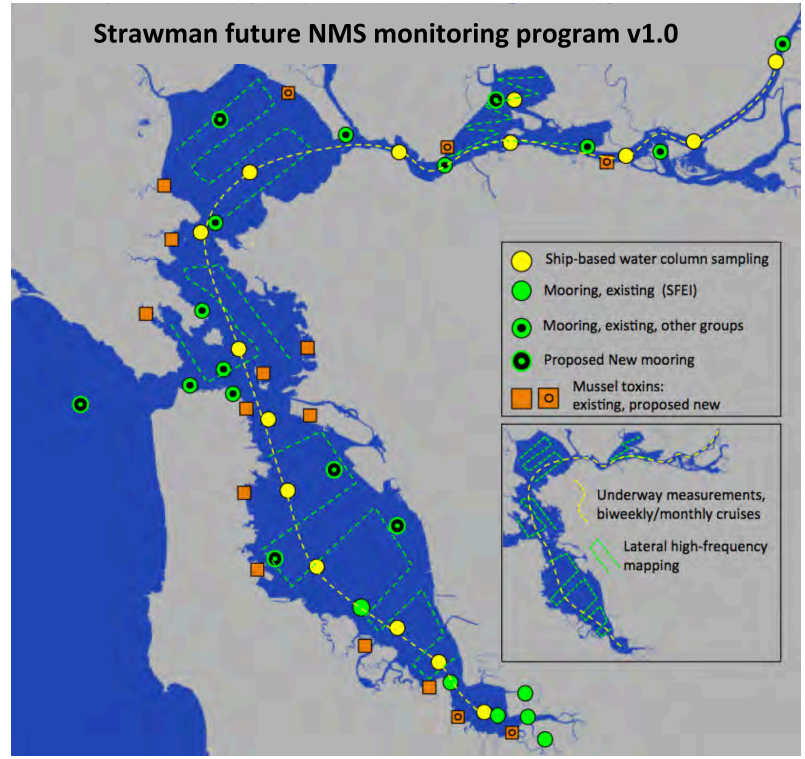
Predicted mid-July 2013 DIN and NH4 concentrations (above), and whole-Bay DIN budget (below) using the v1.0 nutrient cycling model



Potential Projects

P.1, 2, 3, 5, 9, 11:
Pilot Projects for Expanded Monitoring

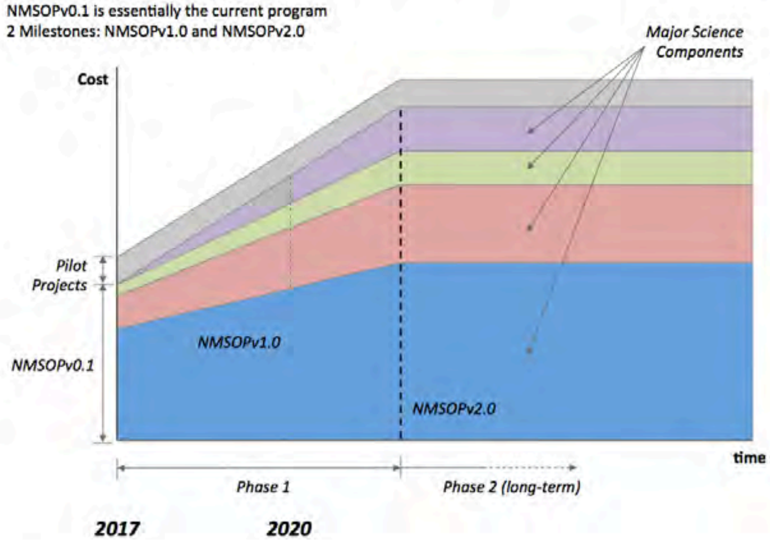
See description of monitoring program design and plan here .



Nutrient Management Strategy Observation Program (NMSOP)

Approach:

- *Strawman* Program Design based on current understanding of data needs
- Test
- Iteratively refine and gradually grow.
- NMSOPv0.1 is essentially the current program
- 2 Milestones: NMSOPv1.0 and NMSOPv2.0



Ship-based sampling, Basic: biweekly to monthly cruises

Profiles: CTD, DO, chl, OBS, PAR

Underway: $PAR_{surface}$, salinity, T, D, chl, OBS, F_v / F_m, SPATT

Discrete:
- NO_{3+2}^-, NH_4^+, o-PO_4, TN, TP, TDN
- DO, chl-a, pheo, SSC
- phyto-pigments
- microscopy + IFCB
- PTOX (DA, MCY, SAX)

Advanced:
- SUNA-NO3: CTD, underway
- Productivity
- DOC+POC, BOD
- pCO_2, pH: CTD, underway

Moorings

Basic:
- Single depth,
- CTD, DO, chl, turbidity, fDOM

Advanced:
- SUNA-NO3, PAR, ADCP, IFCB
- multiple depths

Biological sampling, toxins

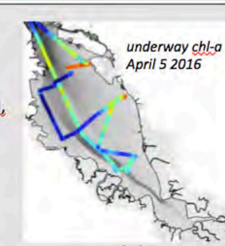
Basic:
- native bivalves, biweekly
- toxins: DA, MCY, SAX
- basic WQ parameters

Advanced:
- other toxins: OA, others.
- co-deployed SPATT
- deployed mussels

Lateral mapping

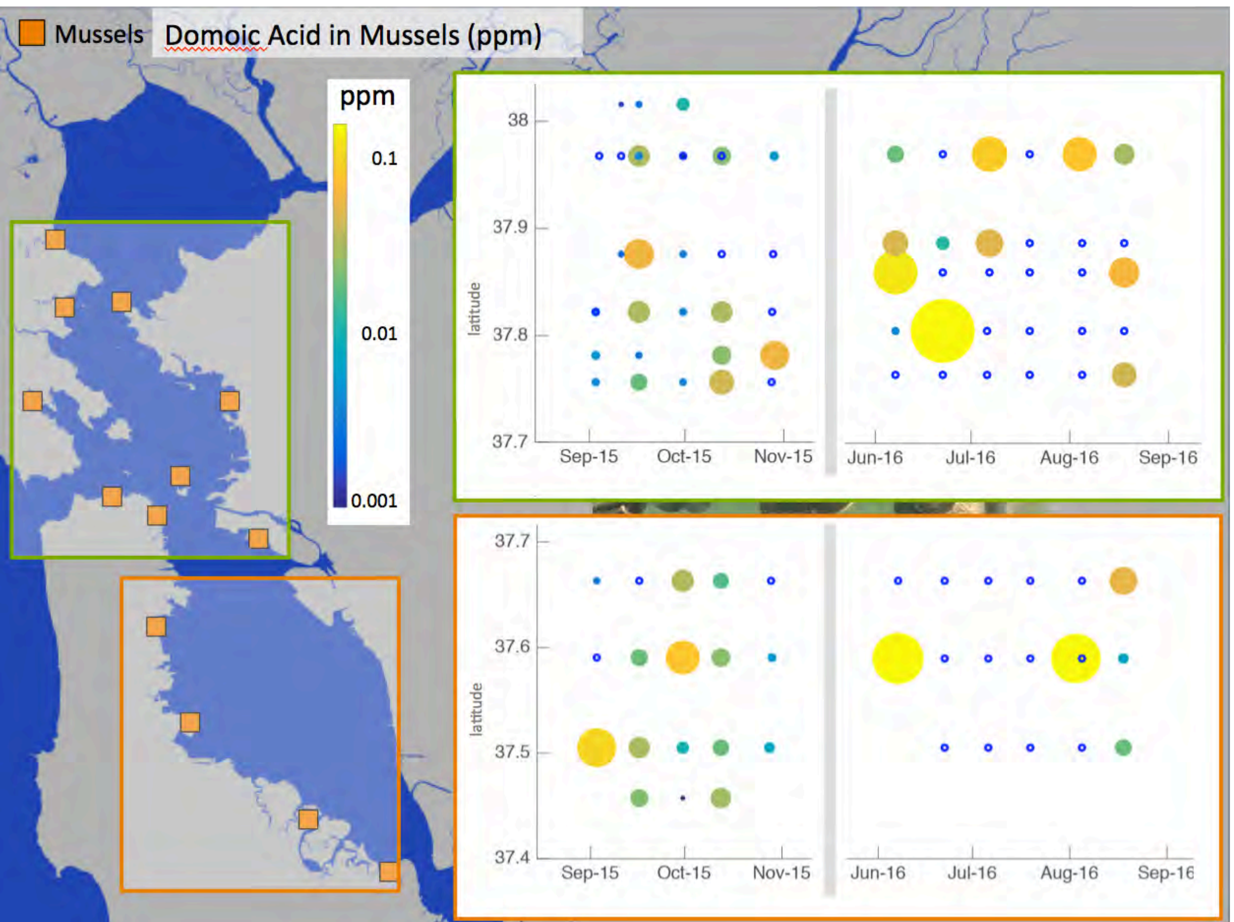
Basic:
- Monthly
- SpC, T, DO, chl, turbidity, fDOM, SUNA-NO3

Advanced:
- Additional parameters, e.g., pigments, H_2O isotopes, NH4.



P.1 Toxins in mussels

Continue biweekly sampling of naturally-occurring mussels from floating docks around the Bay, and measurement of multiple toxins. Over the past year we have also begun inexpensively collecting water quality data from in situ sensors and discrete samples; we expect this data to provide low-cost valuable information pertaining to nutrient-related condition in areas distant from the Bay's shipping channel (where most other water quality data is collected) and ancillary data for interpreting mussel toxin levels. Depending on time and funding, we will also pilot the co-deployment of other tools for measuring toxins as part of identifying the best future monitoring program directions (e.g., SPATT, or well-characterized "Mussel-watch" type mussels). Data for Domoic Acid, a neurotoxin produced by *Pseudo-nitzchia* spp. and responsible for amnesiac shellfish poisoning, is presented below for Sep 2015 - Aug 2016.



Work Products/Deliverables

The $100k funding level covers the cost of field work, sample analysis, and basic reporting, and will yield the following deliverables:

- Toxin concentration datasets
- Water quality datasets
- Summary of results in FY18 annual report.

Additional analysis and interpretation of toxin data would be carried out under other tasks will be carried out under other tasks.

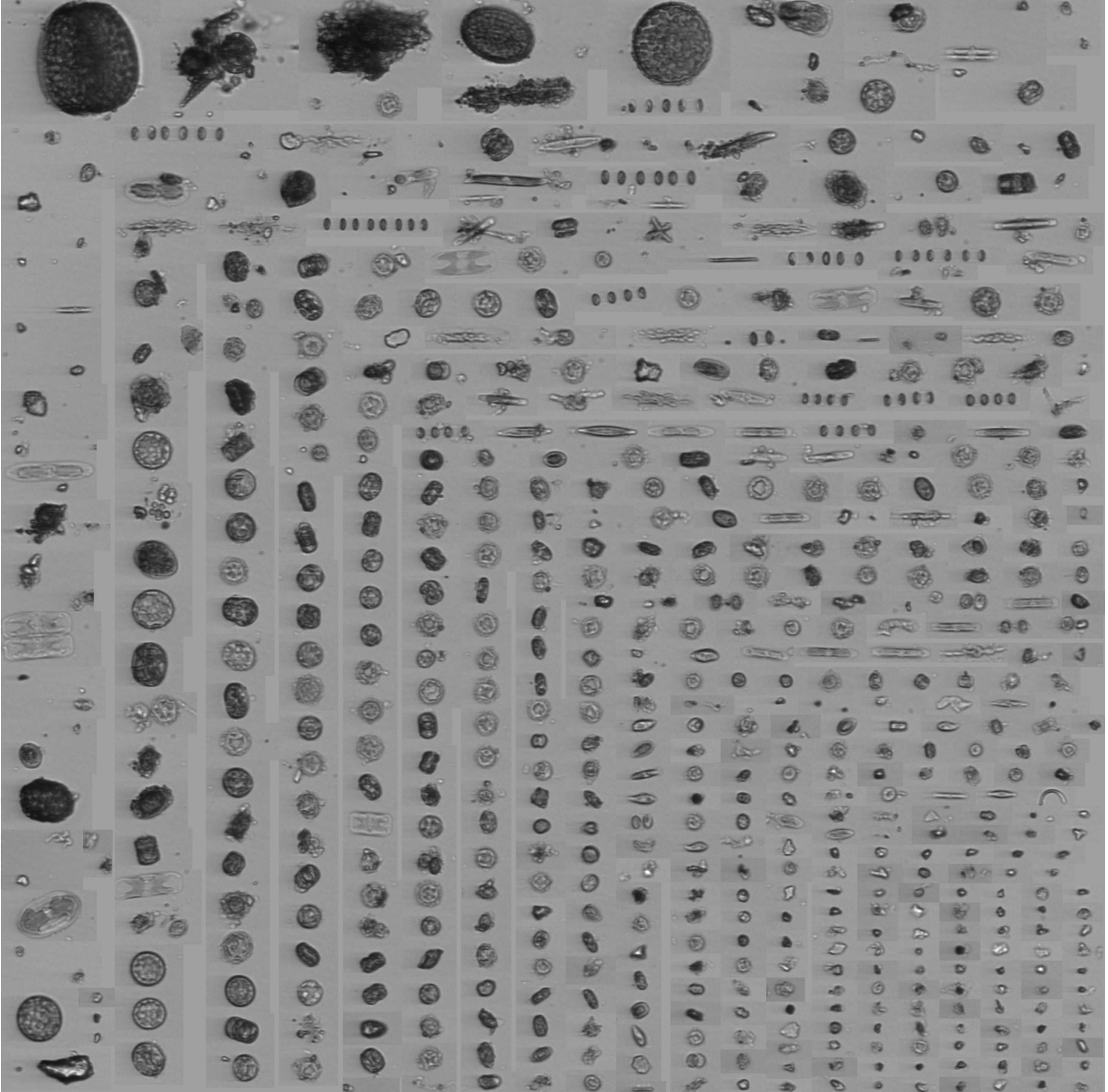
Left: Domoic acid concentrations (ppm) in mussels. Symbol color and size represent concentration. Open-circles indicate that measurements were made and no DA detected.

P.2 Imaging Flow Cytobot (IFCB)

An Imaging Flow Cytobot (IFCB) is now being used on USGS cruises, since Oct 2017. Samples are automatically collected and imaged while the ship cruises (~7min/sample). 2 instruments were obtained through a collaborative grant with UCSC and USGS, one for ship-based work in SFB, and one for use at a mooring site. NMS will ultimately inherit the IFCBs.

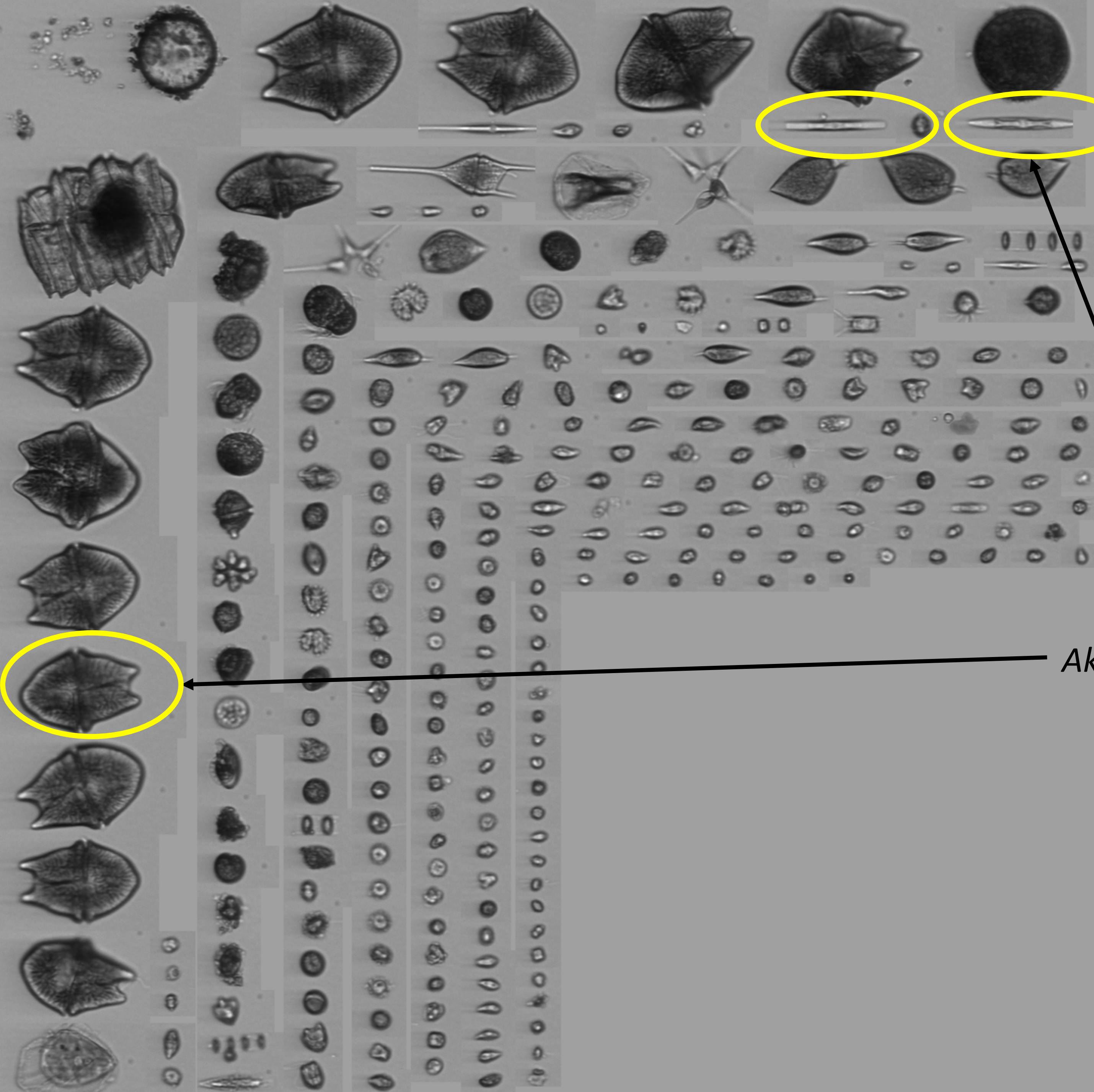
Although the ship-based instrument is now operating, there is currently no person dedicated to the IFCB in support of NMS program goals. Funding would support a scientist (0.5 FTE-1 FTE, depending on funding level) to interpret the IFCB data, and develop monitoring program protocols and collection of ancillary data to maximize the effectiveness of this data.

See next two slides for graphics.



Date:
October 17 2016

Location:
Lower South Bay



Date:
October 17 2016

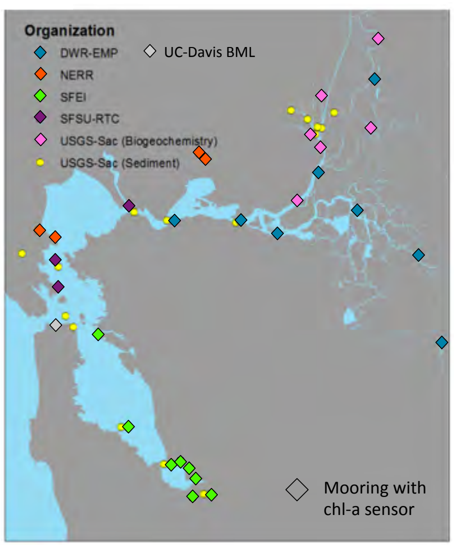
Location:
Lower South Bay

P.3 Regional coordination and intercalibration: *in situ* chlorophyll sensors

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 extremely valuable data for model calibration, improved understanding of mechanisms regulating productivity, and real-time information on condition in the estuary. Moreover, the possibility of 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 data, and standardized method and rigorous *in situ* calibration and data analysis are needed for data to be reliable. 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 and 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 this initial data analysis effort prove promising, this project will be continued in a second year, undertaking field experiments to further test and improve the accuracy and precision of sensor-derived estimates (e.g., side-by-side deployments, photo-quenching, suspended sediment interference, calibration protocols). To the extent possible (e.g., depending on the level of matching contributions from other programs), this experimental work could also begin in FY18.

A



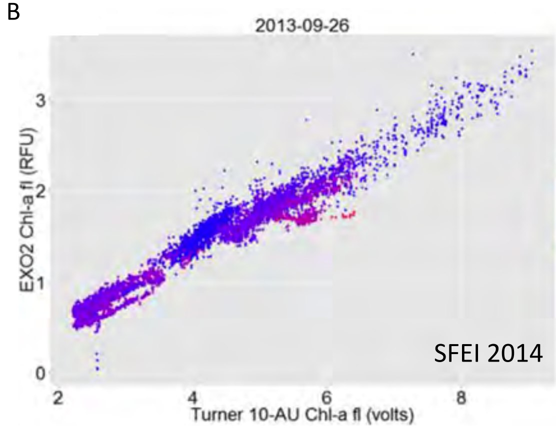
Work Products/Deliverables:

Deliverables related to the combined funding ($50k NMS + $50k DRMP) will include

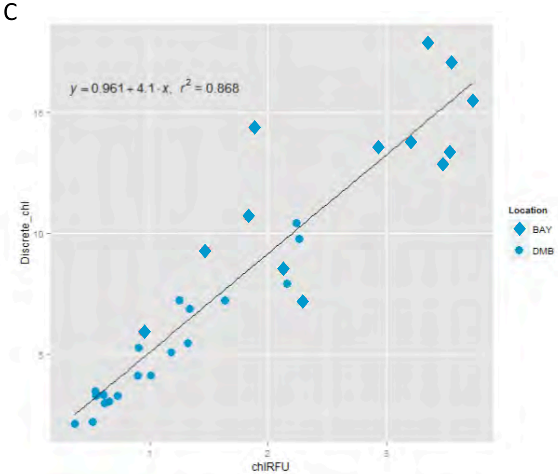
- One or more technical working group meetings and meeting summaries
- Combined electronic datasets, and field method descriptions from each cooperating program
- Technical report describing the findings from the data analysis

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.

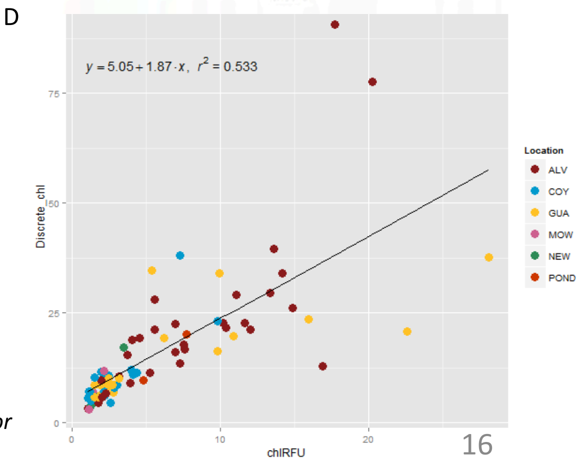
B



C



D



P.4 Data analysis and synthesis/interpretation

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.

In addition to analyzing the data, these projects need management at the technical level (i.e., beyond budgets and deliverables), including engaging with collaborators and stakeholders.

This funding will support staff effort to carry out these activities. Focus areas include:

- HAB, toxin, and phytoplankton community data interpretation
- Examining long-term trends in Bay water quality data
- Managing monitoring program data, including through the lens of program development
- Interpreting data through the lens of developing or refining an assessment framework

Deliverables:

- NMS Annual Report
- Contributions to technical reports and technical appendices
- 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:
1 FTE scientist

P.5 South Bay eastern shoal mooring
P.9 High-resolution biogeochemical "mapping"

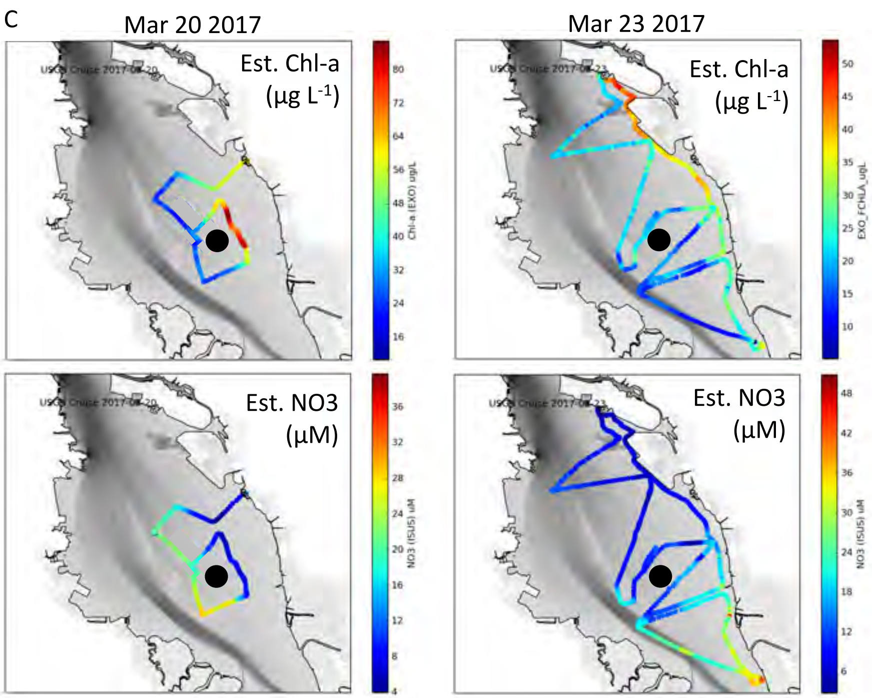
Past studies have shown that South Bay's broad shoals are areas where phytoplankton biomass is commonly much greater than in the deep channel (Fig A and B). However, measurements along the shoals are not part of routine monitoring, limiting our ability to accurately assess condition and to calibrate models. These projects will begin developing the NMS approach for shoal sampling.

A pilot study was carried out in Mar-Apr 2017 for both mapping and mooring work (Fig C). Mapping work yielded interesting results, with elevated chl-a concentrations co-occurring with decreased NO3 concentrations, consistent with NO3 drawdown during phytoplankton growth. The mooring was retrieved on April 25 and data have not yet QA'd and analyzed.

For P.5, a water quality mooring (chl-a, NO3, salinity, T, turbidity) will be installed along South Bay's eastern shoal. Cost range is related to types of instruments deployed, owning vs. renting instrumentation, and level of data interpretation within the project budget.

For P.9, high-res biogeochemical mapping will be conducted along South Bay shoals in FY18. Work will include 7-15 survey days, depending on funding level.

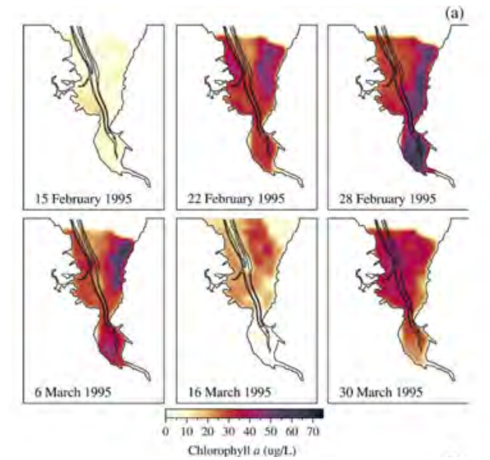
C



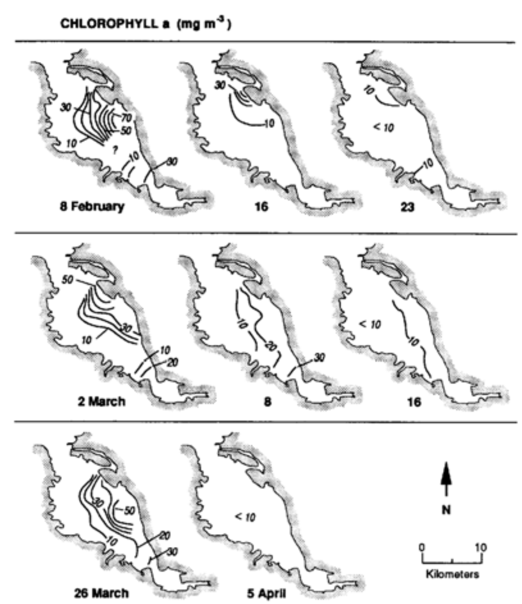
Work Products/Deliverables:
- QA'd dataset
- Summary of results in FY18 annual report
- Application and interpretation of results within model development (C.3) and calibration, and within moored sensor (C.2)

● Approximate mooring location Mar-Apr 2017

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

P.6 Biological indicators, DO in Lower South Bay

Dissolved oxygen condition in Lower South Bay is a major focus of the NMS. In addition to the NMS moored sensor focus in LSB, an extensive fish surveying effort has been underway, funded currently by San Jose and previously by the salt pond restoration program. On 4/27-4/28 a DO-habitat workshop was held to gather expert input on the following issues:

- Characterizing DO spatial and temporal variability in LSB (x,y,z,t)
- Characterizing fish and benthos community variability (x,y,z,t)
- Defining "habitat" in the highly-dynamic and highly-altered LSB, and evaluating DO-related habitat quality in
- Identifying high-priority uncertainties

In general, the workshop feedback and recommendations pointed to several possible project directions (specific ideas will be discussed further at the meeting):

- Expanded interpretation of existing fish data to explore DO-related questions
- Enhanced coordination on-going field efforts: fish surveys (UC Davis) and DO data collection (SFEI)
- Additional biota surveys, alongside on-going work, to better target DO related questions.

Estimated costs:

- Additional analysis of existing fish monitoring data: $50k
- Enhanced coordination between UC-Davis and SFEI data collection, including limited additional data collection: $25-50k
- Additional targeted fish monitoring: $50-100k

P.10 HAB investigations

To date, the NMS has not undertaken studies (beyond monitoring) to understand the factors that control HABs or HAB risk in the Bay.

Potential studies include:

- A comparison study between SFB and other nearby coastal systems, e.g., Tomales Bay and others, to test whether the multiple-toxin/multiple-HAB issue is unique to SFB or is common to CA estuaries: microscopy, water column toxins, toxins in biota.
- Those outlined in the FY17 program plan, none of which were funded. (See below).
- A HAB-toxin workshop is being held at SFEI on May 31-June 1. During that workshop we will be soliciting input from experts on monitoring and scientific study needs, and expect that additional ideas will be generated during that meeting.

P.10 Mechanistic Harmful algae bloom investigation
FY17 Estimated NMS Cost = $175,000 (Year 1 of a multi year study)
Collaborators: SFEI, UCSC, USGS

Goals:

- Continue building the NMS program's capacity to reliably and efficiently monitor for phytoplankton assemblage 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). 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.*, andsaxitoxin) are also commonly detected in the Bay. For both *Pseudo-nitzchia* spp. and *Alexandrium* spp., there is limited information about factors that would stimulate rapid (or slow) growth and high (or low) toxin production. This type of information is essential for assessing the risk of major HAB events occurring, both now and under future conditions. However, it is well known that strains differ substantially in their growth and toxin production characteristics, meaning that system-studies and studies on individual strains may be needed.

The possible focus in FY17 for this project has been discussed extensively with advisors and collaborators. The exact activities for FY17 will be identified and work plans developed once the project concept has been provisionally authorized by the NMS SC and funding has been secured. Projects under consideration for FY17 activities are described below.

A. Lab and field testing of the Imaging Flow CytoBot (IFCB) to help ensure near-term field-readiness for ship-based sampling.

- The IFCB is an automated flow cytometer and image-capture instrument for counting phytoplankton down to the species level, estimating biovolume, and characterizing phytoplankton community composition. Through a joint proposal funded by NOAA (UCSC, SFEI, USGS; PI: Kudela, UCSC), two IFCB's have been purchased for application in phytoplankton related studies in SFB, including the ship-based monitoring with USGS and at a mooring site. One instrument recently arrived at UCSC.

- Although the instrument has been successfully used in other estuaries, substantial effort needs to be directed toward testing the IFCB in SFB's high suspended sediment concentrations; training its image recognition algorithms for the SFB phytoplankton community; developing field and QA/QC protocols; and data interpretation.
- Funding would be used to support a postdoctoral researcher working jointly between UCSC, USGS, and SFEI, focused on
    - IFCB application in SFB
    - Testing and validating IFCB results, including by comparing IFCB results with those from other techniques, including: microscopy, pigments/CHEMTAX; and molecular techniques (e.g., qPCR)

B. Conduct basic "grow-out" experiments in San Francisco Bay water to assess the extent of Pseudo-nitzchia and Alexandrium growth under in situ conditions.

- During regular USGS cruises, collect water from a subset of stations where these organisms have been most commonly detected
- Return samples to the laboratory, and measure t = 0 abundances of *Pseudo-nitzchia* and *Alexandrium* using the IFCB
- Incubate samples at *in situ* temperatures and light levels for 24-72 hours. Reanalyze samples using IFCB to determine whether counts increase, stay the same or decrease.
- For a subset of samples, also use molecular techniques (e.g. Amplicon sequencing) to test for *Pseudo-nitzchia* and *Alexandrium*, along with a broad semi-quantitative scan of entire eukaryote community (18s) and cyanobacterial (16s) communities. Compare results from molecular techniques with IFCB to determine
- Both the IFCB and Amplicon sequencing can also detect and quantify zooplankton, especially microzooplankton. Therefore, if already being conducted for phytoplankton, this combination of techniques could be used as a cost-effective approach to characterizing the zooplankton community (potentially important grazers on phytoplankton) in regions of the Bay where no zooplankton monitoring is occurring. On a subset of samples, microzooplankton grazing rates could also be measured to
- In addition to this serving a relatively low-cost / low-effort initial test of growth potential of *Pseudo-nitzchia* and *Alexandrium*, this work will contribute to testing of the IFCB and training its image recognition software.

C. Determine whether there SFB is maintaining 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. In addition, *Alexandrium* occurs as both toxigenic and non-toxigenic strains.
- Collect surface sediment grab samples from a predetermined set of locations in Lower South and South Bay, and extract DNA.
- Test for and quantify gene copies of *Alexandrium* at the genus level (all strains, all species) using qPCR.
- In positive samples, use additional molecular techniques (e.g, Amplicon sequencing) to distinguish between toxigenic and nontoxigenic strains. If warranted, use additional techniques to explore whether there is significant variability in strains as a function of space, and in particular along a S-N transect, which may suggest the presence of distinct populations inside the Bay relative to the coast.

- Time and budget permitting, incubate *Alexandrium*-positive sediment samples under a range of conditions (temperature, light, nutrients) and identify factors that contribute to *Alexandrium* migrating from the sediments to the overlying water. Measure *Alexandrium* in overlying water using IFCB

D. Identify the species, and possibly strains, of Pseudo-nitzchia, Alexandrium, and possibly other HAB-forming organisms (Karlodinium, Dinophysis, etc.) that occur in SFB

- 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.

E. Determine the growth characteristics of Pseudo-nitzchia or Alexandrium strains, isolated from SFB, in controlled laboratory experiments

- Isolate one or more strains of HAB-forming organisms
- Identify species and strains using molecular techniques
- Conduct a series of experiments to determine growth rates and toxin production under varying light, T, and nutrient concentrations
- Compare growth characteristics with organisms isolated from other systems, in particular Pseudo-nitzchia isolated along the CA coast during the 2015 event.
- Based on the growth characteristics identify conditions in space and time when these organisms could, and could not, either sustain their populations at low levels or develop into harmful blooms. This work could, for example, be carried out at Romberg Tiburon Center, building upon 2015-2016 work with *Pseudo-nitzchia* isolates from the CA coast (W Cochlan), with toxins measured at UCSC.

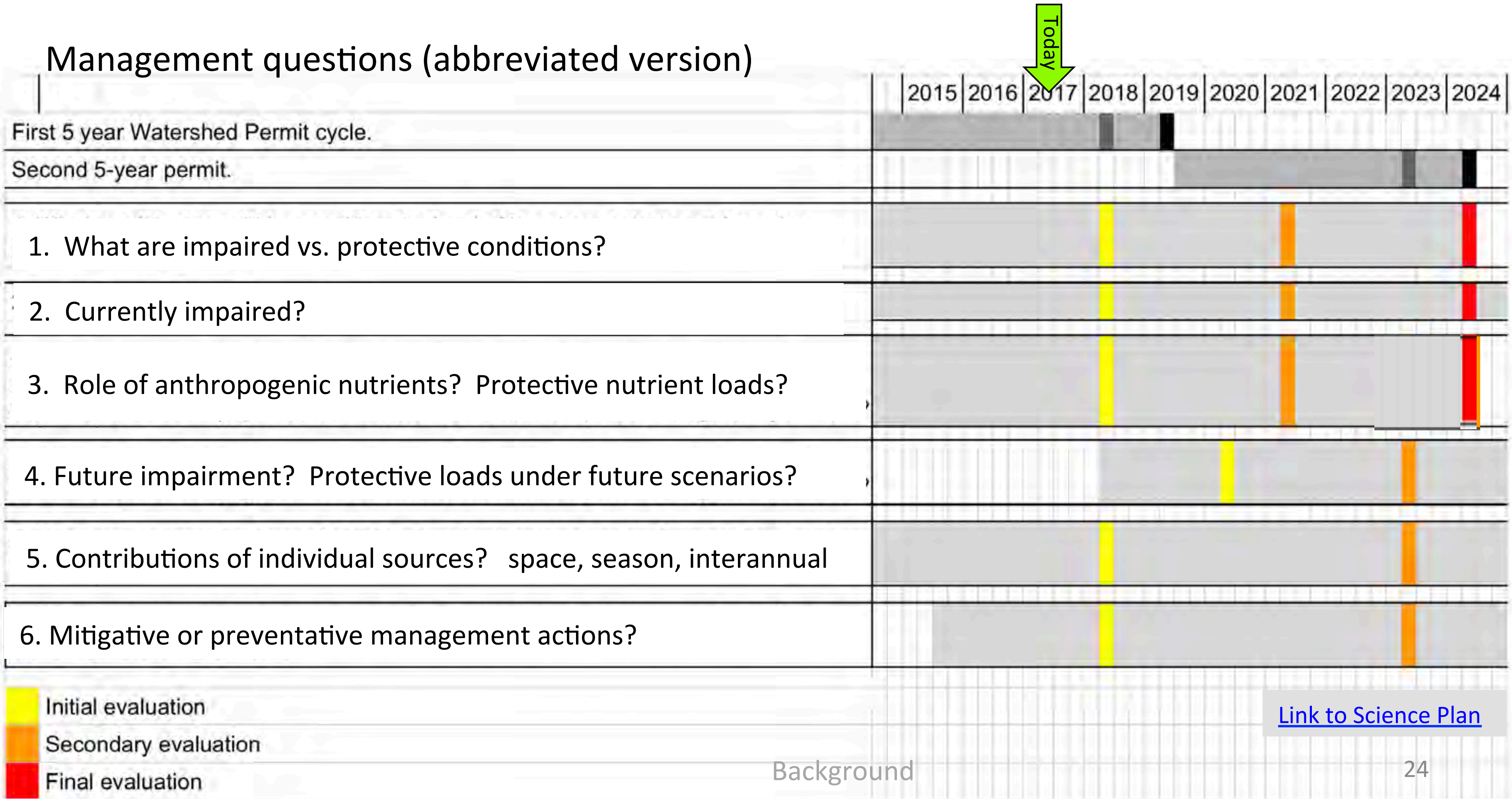
Deliverables: Progress report (June 2017) describing findings to date, and recommendations for specific work to be continued in Years 2-3.

Budget Justification: The following approximate costs are based on the assumption that one major project moves forward: 1 FTE postdoctoral researcher ($100k); collaborators/advisors ($30k); lab/field/travel ($45k). Depending on the project (alignment with IFCB work), a portion of the postdoc salary could be covered by NOAA funds to UCSC.

Key Assumption for Science Plan v1.0: Water Board's goal of 'Standards by 2024'

Approximate Timeline for addressing major management questions, laid out in Science Plan (when plan development began ca. 2015)

- Realistic time for science and process, and realistic assessment of work that is needed.
- Assumes work proceeding in parallel on all fronts.
- 'Answers' are reached iteratively, with increasing level of confidence over time (yellow, orange, red below)
- Plan not constrained by budget – it aims to illustrate the work that's needed to answer questions within the available time-frame.



Link to Science Plan

Studies identified in Science Plan to be undertaken in FY16-FY18 (Table 5.7 from Science Plan)

Circles at left qualitatively indicate the actual rate of effort (or rate of funding) in FY16-17 relative to what's needed.

Symbols indicate level of alignment between project and focus aea and subembayment

● Directly aligned

◉ Moderately aligned

○ Limited alignment

	Project	Cost/yr ($1000s)	Start Date	Length (yr)	Program Area Focus 1	2.1	2.2	3.1	3.2	3.3	4	Subembayment Focus LSB	SB	CB	SPB	SUI
1	On-going ship-based monitoring. Costs for basic analytes	100	Jul 2015	3+	●	●	●	●	●	●	◉	●	●	●	●	●
2	Measure new analytes, core monitoring: pigments, toxins , bivalves/biota	100	Jul 2015	3+	●	●	●	●	●	◉		●	●	●	●	●
3	Moored sensor monitoring	250	Jul 2015	3+	●	●	●	◉	◉	○	○	●	●	◉	◉	◉
4	DO in margin habitats	250	Jul 2015	3	●	●	●	◉	◉			●	●		○	○
5	Modeling	450	Jul 2015	3+	●	●	●	◉	◉	●	◉	●	●	●	●	●
6	Load estimates (incl. hydrological modeling for watersheds)	150	Sep 2015	3	●	◉	◉	◉	◉	◉	○	●	●	●	●	●
7	Statistical analysis of phytoplankton composition, toxin data, and physical/chemical factors	150	Sep 2015	2	●			●	●			●	●	●	●	●
8	Lower South Bay and South Bay integrated investigation: processes, field measurements	300-600	Sep 2015	3	●	●	●	●	●	○	○	●	●	○	○	○
9	Interpretation of pigment, toxin, nutrient, and physical/chemical condition in LSB	60	Jul 2015	1	●	●	●	●	●			●	●	○	○	○
10	Identifying protective DO levels FY17 project P.3	200	Sep 2015	2		●	●					●	●	●	●	●
11	Identifying protective toxin levels for SFB habitats FY17 project P.4	100	Sep 2015	2				●	●			●	●	●	●	●
12	Identifying protective food quality for SFB	50	Jan 2016	2					●			●	●	●	●	●
13	Workshop: science needs and experiments for phytoplankton comp, food quality, NH4 inhibition	50	Sep 2015	1				●	●	●	◉	○	○	○	●	●
14	Continued data synthesis: identify protective conditions, develop/test/refine AF indicators	100	Jan 2016	2				●				●	●	●	●	●
15	Monitoring Program: analysis of existing data to refine/optimize program	100	Sep 2015	2	●	●	●	●	●	●	●	●	●	●	●	●
16	Science Program Management	100	Jul 2015	3	●	●	●	●	●	●	●	●	●	●	●	●
	Total	3,000														

How are we doing?

Take home: NMS projects for FY16 and FY17 have been well-aligned with the Science Plan recommendations, working within current funding levels.

Since this table originally only included activities for FY16-18, some major activities, slated to begin after FY18, were not included.

Some priorities have evolved since this table was originally developed (mid-2015); Additional topics are noted to the right.

- Expanded monitoring program: design, implementation, and funding stability
- On-going data analysis, and synthesis
- Coastal exports: nutrient fate and effects
- Biological surveys: fish, benthos, DO
- Exploring management alternatives
- Future Scenarios

Science Plan Management Questions (actual wording)

Table 2.1 Management questions targeted by the NMS Science Plan

1. What conditions in different SFB habitats would indicate that beneficial uses are being protected versus experiencing nutrient-related impairment?
2. In which subembayments or habitats are beneficial uses being supported? Which subembayments or habitats are experiencing nutrient-related impairment?
3.a To what extent is nutrient over-enrichment, versus other factors, responsible for current impairments? 3.b What management actions would be required to mitigate those impairments and protect beneficial uses?
4.a Under what future scenarios could nutrient-related impairments occur, and which of these scenarios warrant pre-emptive management actions? 4.b What management actions would be required to protect beneficial uses under those scenarios?
5. What nutrient sources contribute to elevated nutrient concentrations in SFB subembayments or habitats that are currently impaired, or would be impaired in the future, by nutrients?
6. When nutrients exit SFB through the Golden Gate, where are they transported and how do they influence water quality in the Gulf of Farallones or other coastal areas?
7. What specific management actions, including load reductions, are needed to mitigate or prevent current or future impairment?

Link to Science Plan

Science Program Structure: Major Program Areas, Work Categories

Table 2.2 Science Plan structure

Major Program Areas	Work Categories
1. Nutrients (loads, cycling/transformations)	A. Synthesis B. Monitoring C. Special Studies D. Modeling (current conditions) F. Identify Protective Conditions F. Modeling condition under plausible future scenarios
2. High biomass and low dissolved oxygen	
2.1 Deep subtidal	
2.2 Shallow margin habitats	
3. Phytoplankton community composition	
3.1 HABs/toxins	
3.2 Food quality (due to N:P, NH4, etc.)	
4. Low productivity	
5. Program-wide Activities	
5.1 Monitoring	Future monitoring program design, including considerations of science requirements, logistics, institutional agreements, and funding
5.2 Modeling	Base model development, model documentation, model maintenance
5.3 Protective Conditions/Assessment Framework	Iteratively refine framework based on new data.
5.4 Program Management	Science communication, stakeholder engagement, coordination among projects, fundraising

Link to Science Plan

Work Categories and types of Activities (projects and core program)

Table 2.3 Work Categories within the Major Program Areas

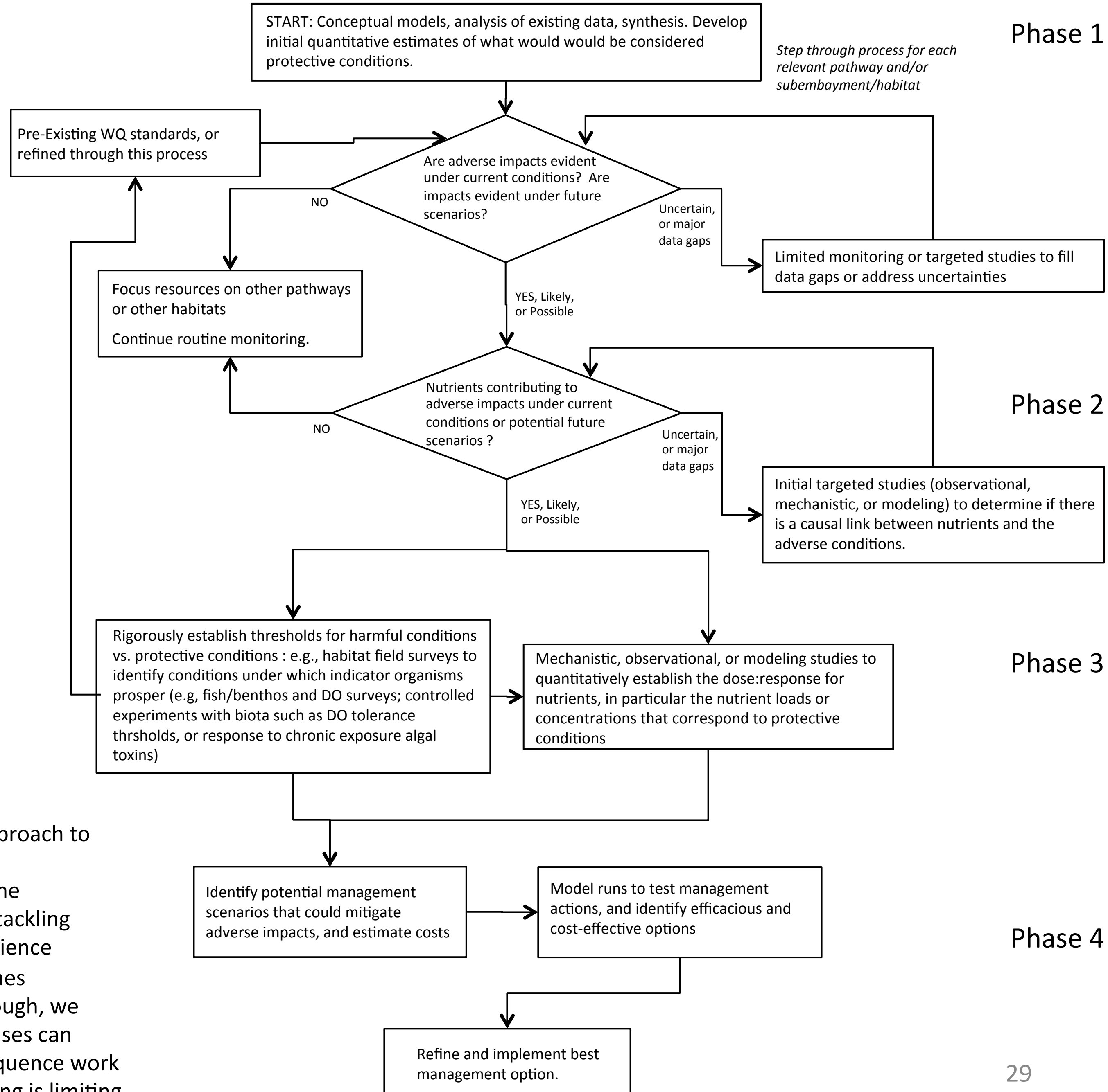
Work Categories	Types of activities
A. Synthesis	• Analyzing/synthesizing new results from past studies, developing conceptual models, etc., to identify science needs • Analyzing/synthesizing new data from monitoring and special studies to inform next steps in science plan implementation • Workshops to identify highest priority science questions and experiments
B. Monitoring	• Current ship-based monitoring, Bay-wide…nutrients, phytoplankton biomass, phytoplankton composition, physical observations (salinity, temperature, SPM, etc.) • Moored sensors…biogeochemical data, physical data (T, salinity, stratification, velocities, etc.) • Future monitoring program design: data analysis and expert input on spatial/temporal resolution, blend of ship-based vs. fixed-station continuous monitoring, new measurements, etc.

C. Special Studies	• Field investigations to
	  ○ measure biogeochemical processes: e.g., primary production, nutrient transformations (water column, benthic), DO consumption (water column, benthic)
	  ○ collect physical observations (T, sal, velocities, light levels) to quantify mixing, transport, and stratification
	  ○ study processes or test hypotheses at the ecosystem-scale (e.g., factors that influence HABs or toxin production)
	• Mechanistic studies in the laboratory
	• Pilot studies related to monitoring program development, including data analysis

D. Modeling	• Biogeochemical (Water Quality) and hydrodynamic model development and application to quantitatively explore:
	  ○ Transport of nutrients and biomass
	  ○ Growth of phytoplankton, grazing by pelagic and benthic grazers, growth of different types of phytoplankton
	  ○ Nutrient and organic matter biogeochemical transformations and losses
	  ○ Hydrodynamics, effect of physics (e.g., stratification) on env'l processes

E. Identify Protective Conditions	• Levels of DO, chl, and toxins, or characteristics of phytoplankton assemblages that are protective of beneficial uses • Identify the beneficial uses potentially impacted by nutrients. In the case of aquatic life uses, specifically identify the organisms to be protected. • Literature review to identify these levels, modeling (trophic transfer, HAB or toxin bloom size) • Nutrients, loads or concentrations that will protect beneficial uses.
F. Future scenarios	• Identify high priority environmental change scenarios to test • Identify load reduction or management scenarios. • Simulate ecosystem response under future scenarios

Link to Science Plan



Revised from NMS Science Plan: Phased approach to pursuing science questions and addressing uncertainties. In an ideal world, with no time constraints, work would proceed in series, tackling increasingly complex and costly topics or science investigations if and when that work becomes necessary. Given NMS time constraints, though, we need to pursue topics in parallel. These Phases can nonetheless serve as guideposts to help sequence work and prioritize between projects when funding is limiting.