San Francisco Bay Nutrient Management Strategy

FY2022 Program Plan

June 2021

SFEI Contribution #1323

SFEI San Francisco Estuary Institute

NMS FY2022 Program Plan

June 4 2021

Table of Contents

1. Background

This document describes the Nutrient Management Strategy (NMS) FY2022 Program Plan, including Core Program work and Projects.

The FY2022 Program Plan is based on the multi-year workplan laid out in the NMS SciencePlan2.0. SciencePlan2.0 was developed in through a series of priority-setting discussions with the NMS Steering Committee during 2018-2019, as part of planning for the second NMS 5-year permit. The goal of that planning process was to develop a multi-year set of projects that targeted the highest priority management questions, science needs, and updated goals for Permit #2. Additional SciencePlan2.0 background and details (program structure, management questions, science priorities, multi-year workplan) are available here, including instructions for navigating an interactive version of SciencePlan2.0 and the FY2022 Program Plan.

Document Organization

Table 1 in Section 2 summarizes the FY2022 budget for Core Program and Project work. Funding is broken into three columns:

- *NMS FY2022 Permit Funds*: This is the amount of FY2022 NMS Permit Funds being requested to support work that would go forward in FY2022.
- *Other Funds*: For most of the projects, work will be partially supported by other funds (i.e., not FY2022 NMS Funds). The other funding sources include: Funding from the RMP for shipbased monitoring, and RMP Special Studies funding (anticipated) for NMS-related work; Carry-forward funds from NMS projects that were approved and launched prior to FY2022; and Funds from external grants or contracts. Additional information on the funding sources included under *Other Funds* is included in the justification section at the end of each project description (Section 4).
- Total FY22 Work: This is the sum of *FY2022 NMS Funds NEW* and *Other Funds*, and represents the funding level to support all the work in FY22.

Section 3 summarizes anticipated FY2022 Revenue.

In Section 4, descriptions of the Core Program and Project work are presented. The project descriptions include: High level project description; Progress or recent work activities related to the project (e.g., in year-1 of a two-year study, or on prior related projects); FY2022 work; Project objectives, and project relevance to NMS science priorities (*Target*: management or science priorities being addressed; *Science Focus Area*; and Program Area; see Science Plan Background for details); Work Products; and Budget Justification.

Process for Developing FY2022 Program Plan

Using the SciencePlan2.0 workplan as a guide, a set of proposed FY2022 projects was identified and served as a first-draft FY2022 Program Plan. The project set consisted of both new projects (supported by FY2022 NMS Permit Funds) and continuation projects (e.g., previously approved and underway, with additional FY2022 Permit Funds proposed). That batch of projects was used as the draft FY2022 Program Plan going into the early-May 2021 NMS Nutrient Technical Workgroup meeting, where stakeholder feedback was gathered on science priorities and trade-offs.

Although based on the SciencePlan2.0 workplan, the draft FY2022 Program Plan's budget substantially exceeded anticipated FY22 funding. We subsequently developed a scaled-back set of proposed FY2022 activities that more closely matched anticipated funding. The scaling back process involved both decreasing proposed FY22 funding across a number of projects, and, in several cases, zeroing-out FY22 funds. The tradeoffs and/or potential impacts of those scope reductions or postponements on progress toward or timing of achieving NMS goals will be discussed at the June NMS SC meeting.

Additional Materials: Appendix A and B

Table 1 and Section 4 include only those projects for which FY2022 NMS Permit Funds are being used. There are several additional NMS-related projects moving forward in FY2022 that are not supported by FY2022 NMS Permit Funds. In order to provide the NMS SC with a fuller overview of NMS-related work in FY2022, Appendix A summarizes several projects supported only by "Other Funds".

Appendix B presents: the full list of projects presented to the May 2021 NTW meeting; the initial high-low estimated range for the 'first-draft' proposed FY2022 Program Plan; and the difference between current NMS FY2022 Permit Funds (this document) and average of the min-max range.

Note: The projects in Appendix A are included here to provide a holistic view of overall NMS program work in FY2022. Since these projects are already approved, they are not the focus of the authorization/approval decision at the June meeting. The NMS SC's decision on the FY2022 Program Plan is related to the projects summarized in Table 2 and discussed in Section 4.

2. Budget Table -- FY2022 Program Plan

	Project / Activity	TOTAL FY22 Work ($1000s)	FY2022 NMS Permit Funds ($1000s)	Other Funds ($1000s)	Target	A AF	B Cond	C Link	D Mgmt	Focus Area	Nuts	phyto DO open	phyto DO marg	HABs	Coast	Risk	Program Area	monit	model	spec study	Synth	AF	Prog Mgmt Coord
						Target					Science Focus Area							Program Area						
C1	Monitor: ship-based sampling	400	150	250																			
C2	Monitor: moored sensors	390	80	310																			
C3	Modeling	500	500	0																			
C4a&b	a. Program mngmnt; b. Science program coord.	500	440	60																			
P1a	Biogeochem field study: South Bay	400	400	0																			
P1b	Biogeochem field study: Lower South Bay	115	100	15																			
P3	Light attenuation model input	100	25	75																			
P4	Lateral variability: shoal mapping	75	75	0																			
P6	Mussels/toxins	100	50	50																			
P7	Phyto-HAB monitoring development	60	30	30																			
P11	Trends: synthesis (continued)	65	25	40																			
P13	LSB synthesis: metabolism, mechanisms	20	20	0																			
P14	HAB synthesis	125	50	75																			
P15	AF: Trend analysis	75	25	50																			
P16	AF-Deep subtidal: priority analyses	150	30	120																			
P17	AF-DO in LSB sloughs/creeks: priority analyses	140	70	70																			
P19	Coastal nutrient exchanges/fluxes	175	175	0																			
P20	Future scenarios/risks	85	60	25																			
	sum	**$3,475**	**$2,305**	**$1,170**																			

Description and definitions for Target, Science Focus Area, and Program Area can be found here

3. FY2022 Revenue

The primary sources of new revenue for FY2022 are summarized below

FY2022 NMS Permit Funds	$2,200,000
RMP support for ship-based monitoring	$250,000
RMP Special Study Funding	$250,000
Total, New Revenue	$2.700,00

Beyond new revenue, the FY2022 Program Plan also incorporates ~$1,000,000 in ‘other funds’, the vast majority of which comes from continuation or carry-forward of funding from previously approved projects.

Strictly speaking, this is not new revenue. However, it is being used in combination with new FY2022 revenue to jointly support projects in the FY2022 Program Plan (e.g., multi-year projects that were only partially funded in FY2021, and will be continuing into FY2022, with their budgets augmented by new FY2022 revenue). Where relevant, details about the other funding sources are summarized in the project budget justifications in Section 4.

4. FY2022 Program Plan: Core Program and Project Descriptions

C1 Monitoring: Ship-Based Sampling	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: USGS, UCSC, Bend Genetics, SFEI	$400,000	$250,000	$150,000

Project Description

This project continues biweekly to monthly ship-based water quality cruises along San Francisco Bay's (SFB) deep channel. This work is carried out collaboratively with the USGS, continuing the USGS long-term SFB water quality measurements. The overall program is jointly funded by USGS, the RMP, and the NMS, with the NMS funds supporting several nutrient-specific measurements and additional field tech support.

Progress in FY2021

- The pandemic impacted the frequency and spatial extent of cruises in FY2021. Cruises were cancelled during the last four months of FY2020 (Mar-Jun 2021), but restarted in Jul 2021. Instead of the typical ~20 cruises per year (roughly twice monthly, one South Bay and one full bay), there were 13 extended South Bay cruises in FY2021 (spatial coverage was from Lower South Bay to mid-San Pablo Bay). In addition, SFEI staff were not able to join FY2021 cruises due to COVID restrictions.
- During the 13 cruises aboard the *R/V* Peterson, discrete samples and in-situ sensor measurements were collected. Measurements included inorganic and organic nutrients; phytoplankton taxonomy by microscopy; dissolved harmful algae (HA) toxins using SPATT; targeted use of molecular techniques for quantifying phytoplankton taxa including HAs (18s, 16s sequencing; qPCR); and measurement of particulate HA toxins when warranted (LC-MS or ELISA).
- During FY2021 SFEI staff continued planning discussions with USGS about the potential for establishing a multi-year collaborative agreement to continue ship-based monitoring work with the *R/V* Peterson. We learned in early May that USGS has agreed to continue funding the *R/V* Peterson, and that program management will be transferred to the USGS Water Science Center (USGS-WSC) in Sacramento.

Plans for FY2022

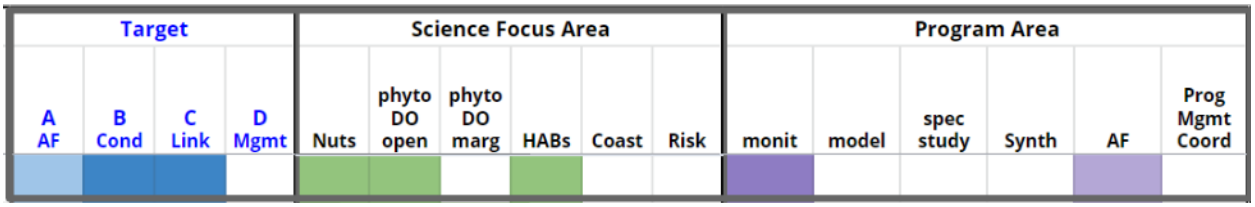
- Ship-based samples from channel cruises will be collected and analyzed for the suite of nutrient-related parameters listed above. During the first few months of FY22, cruises will likely follow the current schedule, which calls for a continuation of 'extended South Bay' cruises (5 cruises are currently scheduled for July - September 2021). We anticipate that once COVID restrictions are lifted field work will return to the prior level of effort, including allowing for a SFEI staff member to join cruises.
- Discussions are underway related to developing a new collaborative agreement between SFEI (RMP + NMS) and USGS-WSC, which would go into effect in October 2021 (the current agreement runs through Sep 2021).

Objectives

- Measure nutrient-related parameters in the SFB channel to characterize water quality.

- Contribute to sustaining the long-term water quality record that dates back to the 1970s.
- Generate monitoring data that can be used for modeling, condition assessment and Assessment Framework development.

Project Relevance



Datasets resulting from ship-based monitoring address multiple management issues or Targets and multiple Science Focus Areas.
Targets: Condition measurement; exploring quantitative links between nutrients and response variables through data analysis and model calibration; and Assessment Framework development.
Focus Areas: important data source for Nutrients, Phytoplankton-DO in open-Bay habitats; and HABs.
Program Areas: Significant monitoring effort and part of the Assessment Framework development.

Work Products

- Datasets for nutrients, chlorophyll-a, phytoplankton community, and toxins, which will be made publicly available either through the USGS website or through the NMS.
- Results summarized in NMS Multi-year Report.
- Data will be used in other NMS program areas (model calibration, condition assessment, Assessment Framework development).

Budget Justification

The overall program is supported by multiple funding sources. Approximately $250k from the RMP (included as 'other funds' above) will go directly to USGS to support 1-1.5 FTE USGS technicians who carry out the field work, analyze a subset of samples (chl-a, SPM, etc.), and manage much of the data. Funds from the NMS ($150k) support the following: nutrient measurements (~300 station-date samples: ammonium, nitrate + nitrite, reactive phosphorus, dissolved silicate; total N and total P measured in approximately half of the samples; $40k); phytoplankton taxonomy by microscopy (~200 samples, $45k); dissolved toxin measurements, molecular techniques for detecting and quantifying HA abundance and further characterizing phytoplankton assemblage (18s,16s amplicon sequencing; qPCR) and particulate toxins on an as-needed basis (UCSC for SPATT dissolved toxins and potential particulate toxins, $25k; Bend Genetics for sequencing/qPCR and potential particulate toxins, $25k); and additional staff support for field work ($25k). In-kind programmatic funds from the USGS cover the following: ship captain and direct costs (fuel, ship maintenance, transportation); program management support; and the remaining technician costs (field, lab, data-management).

C2 Moored Sensor Network	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: SFEI, USGS-Sac, USGS-MarFac	$390,000	$310,000	$80,000

Project Description

Through this project, high-frequency water quality data (15-min) will be collected at a network of 9 mooring sites distributed throughout South Bay and Lower South Bay.
Work includes

- Sensor calibration, and monthly maintenance trips to each site (~2 boat days/month, technician support)
- Program and project management
- Development and improvement of data management tools.
- Data processing and review.

Progress in FY2021

- Addressed major data gaps by establishing three moorings on the South Bay shoal
    - Converted pilot shoal station to permanent shoal buoy, including SUNA nitrate sensor.
    - Addition of two new shoal stations at San Leandro and Hayward shorelines (fall 2020).
    - Integration of new stations into existing data pipeline.
    - Discrete sampling at new shoal stations and San Mateo Bridge station.
- Deployment of SUNA nitrate sensor at Dumbarton Bridge in January 2021.
- Updated data management pipeline, including integrating data from three new stations and developing QAQC pipeline for SUNA data.
- Restructured servicing approach to cost-effectively integrate new shoal stations in NMS monitoring program.
- Continued measurements at existing LSB stations.

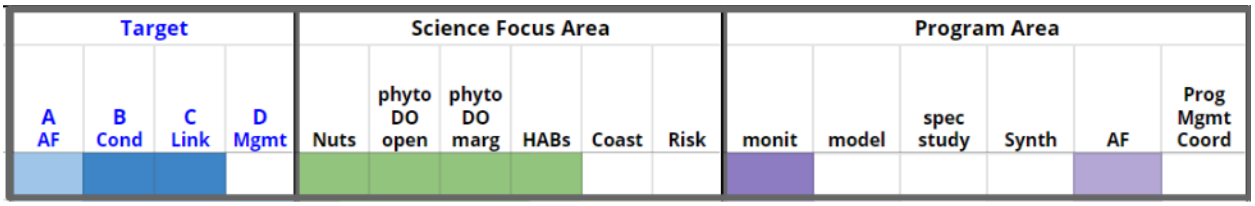
Plans for FY2022

- Continued water quality measurements at the 9 existing stations in South Bay and LSB for Jul 2021-Jun 2022, including maintenance and data management
- Final round of software updates to QAQC codebase.
- Install new oxygen monitoring stations in Alviso and Guadalupe Sloughs to support additional condition assessment.
- Potential coordination and cost-sharing with the RMP sediment workgroup on expanded suspended sediment monitoring in the South Bay, with 2 new shoal sediment monitoring stations between the Dumbarton and San Mateo Bridges.
- Program and /project management

Objectives

- Provide data to support condition assessment and modeling needs.
- Advance NMS goal of maintaining a sustainable monitoring program.

Project Relevance



Work Products

- Curated 15-minute dataset of water quality parameters at nine sites.
- Curated 15-minute dataset of dissolved oxygen and temperature data from two new stations.
- Updated QAQC scripts and documentation, maintained and versioned on GitHub.

Budget Justification

- Field support contracts with:
    - USGS-Pacific Marine Facility; boat support for LSB servicing trips ($44k)
    - USGS-CA Water Science Center; boat support for South Bay servicing trips, instrument coordination, sampling, sample processing, and interpretive/analytical support ($125k)
- Project management hours for SFEI staff ($60k)
- Field and lab time for SFEI technician staff ($80k)
- Development and improvement of data management tools ($30k)
- Data processing and review ($40k)

The total project cost is expected to be $390k, a $20,000 increase from the fiscal-year 2021 budget of $370,000. This increased cost is associated primarily with expanded dissolved oxygen monitoring requested by the Water Board. The equipment costs associated with this expansion will be offset by FY2020 project funds to support the expansion of the mooring program (about $5k from P4). Increased costs will be further offset by the remainder of prior year C2 funding ($56,000). This project is anticipated to be supported by approximately $250,000 in Regional Monitoring Program funding.

C3 Core Modeling	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: Four Peaks, SFEI	$500,000		$500,000

Project Description

The core modeling program entails the development and application of coupled three-dimensional hydrodynamic-biogeochemical models of the San Francisco Bay. The 5-year modeling workplan presents the overall science and management questions, and provides a high-level overview of modeling activities (2019-2024), with work organized into four broad categories: model development (hydrodynamics, biogeochemistry); model studies or applications to address management/science questions; model maintenance/documentation and tools; external advising and review.

Progress in FY2021

Model Development

- Extending hydrodynamic model simulations to WYs 2014, 2015, 2016, 2018, which when combined with WY2013 and WY2017, spans 6 consecutive water years. In addition to the 6 individual water years, we developed 6-year continuous biogeochemical runs using the aggregated grid model
- Improved representation of light attenuation (K_D; empirical, hourly, spatially-varying longitudinally)
- Evaluated model ability to reproduce stratification and mixed layer depth, summarized in a technical report (June 2021)
- Continued application of fast-running aggregated model to characterize sensitivity, and improved the representation of important processes, e.g., improved sediment diagenesis, water column nutrient transformations (related to org-N, org-P), focusing on both individual years and across the continuous 6-yr simulation
- Improvements to sediment flux model initial conditions
- Extended Delta-Suisun biogeochemical simulations to include WY2016; sensitivity analysis and model tuning for Delta-Suisun model across WY2011 and WY2016; and produced initial/draft model validation report for WY2016 in the Delta/Suisun region (link to report)

Model Applications

- Developed source apportionment methodology and initial application to assess DIN footprints within the Bay (technical report, June 2021)
- Continued analysis of nutrient cycling and fate, by extending the control volume analysis initially implemented for south bay in WY2013 (presented in the FY20 Modeling Update) to WY2017, and extended spatially to Central Bay, San Pablo Bay, and Suisun Bay. Update will be presented in December 2021 modeling progress report
- Used the Suisun-Delta model to explore nutrient cycling and mass balances within Suisun Bay and the Delta, with a focus on characterizing the influence of water management operations (Delta Cross Channel, pumping) on nutrient sources and transport, and the influence of the Regional San upgrade on nutrient delivery to the interior Delta and San Francisco Bay (WY2016 Suisun-Delta Report, draft).

Plans for FY2022

Model Development

- Extend hydrodynamic and biogeochemical simulations to WYs 2019 and 2020, in order to allow additional biological and high frequency water quality data from these water years to be used for the next round of model calibration and validation. Extending the model to these new water years requires developing and/or assembling model inputs including freshwater inflows (hydrological model simulations), POTW nutrient loads, wind, light field attenuation coefficients, and other boundary conditions.
- Continued refinements/improvements to biogeochemical model, which may include: validation of the model against additional high frequency data from the channel and South Bay shoal (portions of WY18, and WYs 19-20); testing the inclusion of benthic grazing in the model, and refining zooplankton and benthic grazing predictions, aided by newly available mesozooplankon (late WY18 thru early-WY20) and clam data (WYs 13-18) that will become available in summer-fall 2021; incorporation of the next set of improvements to spatio-temporally variable light extinction coefficients, and associated refinements to biogeochemical parameterization necessary to adequately reproduce water column and sediment observations; improvements to sediment flux model, including in-depth evaluation of sediment initial conditions and sediment model parameterizations by incorporating past and recently collected data (from 2020-2021); integrate the advancements identified above into a “global” calibration providing the best validation for all the water years simulated, and use relevant model skill metrics to evaluate model performance; with the updated calibration, begin (and potentially complete, time and budget permitting) a formal model sensitivity analysis to characterize the key uncertainties, inform priorities for on-going model improvements, and guide the development of an uncertainty analysis workplan.
- Pursue other priority model development or application work identified through discussions with and feedback from the Model Advisory Group (MAG) that will be convened during FY2022.

Model Application

- Source Apportionment Analysis -- Build upon source apportionment work carried out in 2020-2021, including: work with regulators and dischargers to narrow down a set of high priority science questions and data/modeling needs to inform upcoming decisions, and develop a workplan for the source apportionment work in FY2022 that targets those needs; validate and refine the proof of concept approach used in 2020-2021 (using a fast running aggregated model) through a select set of full resolution model simulations (slow running but more precise; refine workplan and approaches above based on MAG feedback as necessary.
- Using the updated model calibration described under *Model Development, e*xtend the analysis and interpretations related to nutrient cycling/fate (transport, transformations) and ecosystem response (production, metabolism, oxygen levels) from the August 2020 report (Section 5) as follows: develop interpretations for Central, San Pablo and Suisun Bays and export to the coastal ocean for WY13, WY17; to; as time and budget permit, develop interpretations for all subembayments for additional water years, and explore dominant and/or influential physical processes (residual circulation, flushing/exchange rates, factors regulating ‘high-production-zones’, episodic transport between channel and shoal); develop a

draft technical report (and eventual manuscript) for MAG review and feedback.

- Uncertainty Analysis Workplan: The Modeling Workplan calls for exploring uncertainty during FY23-FY24. Time and budget permitting, we will develop a workplan for characterizing/quantifying model uncertainty on predictions and interpretations.

Model Infrastructure and Documentation

- *Computing Capacity:* Over the past year, on a number of occasions our in-house computing capacity has started to become the rate-limiting step on efficiently moving modeling work forward. We anticipate bumping up against this constraint more frequently in FY22-FY24 unless that capacity is increased. We therefore propose to increase the in-house computing capacity, and have included funding to support this effort (researching best options, purchasing hardware, installing/networking, etc.).
- Continued investment in model documentation, and systematic/semi-automated approaches for model setup and post-processing, consistent with the aim of ultimately making the model, model-utilities, and data publicly available.

Objectives

- Improve the capabilities of the San Francisco Bay Biogeochemical Model by utilizing additional data to validate the model over multiple water years.
- Address science and management questions on effects of nutrient contribution from individual sources; characterization of source footprints in space and time; and, assess impacts of source reduction actions.
- Develop interpretations of model outputs to support refinement of overall conceptual model of nutrient cycling in San Francisco Bay.
- Develop and maintain documentation of pre- and post-processing scripts and data sources to help ensure NMS work is available as a regional science and management resource.

Project Relevance

Target				Science Focus Area						Program Area					
A AF	B Cond	C Link	D Mgmt	Nuts	phyto DO open	phyto DO marg	HABs	Coast	Risk	monit	model	spec study	Synth	AF	Prog Mgmt Coord

Linkages: quantifying dominant nutrient cycling pathways and relative importance of nutrient sources; developing quantitative dose: response relationships between nutrients and important response variables (indicators).

Management: examining a range of management scenarios, e.g., how nutrient load reductions would influence ecosystem response.

Focus Areas: Nutrient cycling, Phytoplankton/DO response (openBay, margins/sloughs/creeks). Models also serve as essential tools or generate needed input data for Coastal investigations and Risk/Scenario evaluation.

Work Products

- Annual Status Report (12/21), including technical updates on the Model Development and Model Application work described above (specifics below)
- Validation of WY2019-2020 hydrodynamic model runs: section in the 12/21 progress update
- Updated/improved biogeochemical model calibration WY13-WY20, and Sensitivity Analysis: section in 12/21 progress update; validation report with model skill assessment 6/22)
- Application: Nutrient cycling and mass balances, and nutrient-related responses: section in the 12/21 progress update, final technical report in 6/22
- Source Apportionment, version 2, Technical Report (6/22)
- Workplan for Uncertainty Analysis (6/22)
- Model documentation, code for pre-/post-processing (ongoing)

Budget Justification

The majority ($455k) of the core modeling funding will support SFEI labor (~2.3 FTE) focused on Model Development ($215k), Model Application ($220k), and model documentation ($25k). (Other NMS-related modeling projects, funded by other sources, will support the remaining 1.7 modeling FTEs). The cost for upgrading computing capacity is estimated to be $40,000 ($25k hardware, $15k labor for researching, purchasing, and setup within the SFEI network).

C4 a. NMS Science Program Coordination C4 b. NMS Program Management	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
	$500,000	$60,000	$440,000

Project Description

This funding covers the costs associated with overall program management and science program coordination. Work includes the following: managing science projects and providing scientific oversight for all aspects of the program; program management including stakeholder engagement through the NMS (NMS Steering Committee, Planning Subcommittee, other subcommittees, Nutrient Technical Workgroup) and other stakeholders; fundraising; and financial management and contracting.

Progress in FY2021

- SFEI hired a new Program Manager/Senior Scientist to lead program management (0.5 FTE)
- Began to implement more streamlined procedures for budget tracking, resource allocation, and project tracking

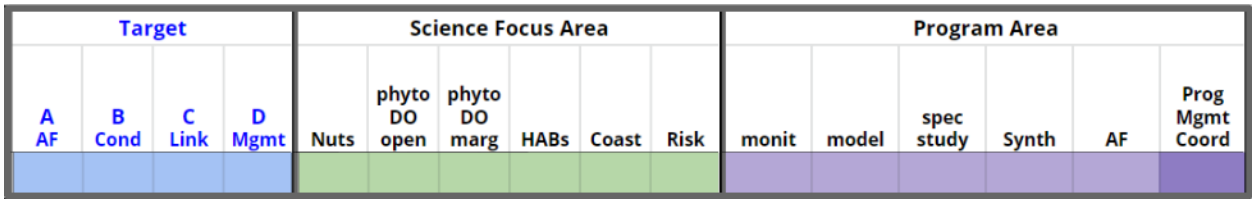
Plans for FY2022

- Manage program workflow and staff, technical oversight of projects, and technical contributions to NMS work
- Engage with stakeholders through regular meetings as well as work groups, seminars, and workshops
- Transfer workflow and program management responsibilities to Program Manager, project managers and other team members
- Free up Program Director/Lead Scientist's time to focus on science work, technical review, stakeholder engagement, and overall program guidance
- Update NMS website

Objectives

- Manage program workflow and resource allocation effectively to produce high quality work products and meet deliverable schedules
- Actively engage with stakeholders, solicit input, and clearly communicate decision making needs and issues that arise
- Engage with the scientific community and recognized experts to incorporate best scientific knowledge and practices into project work
- Ensure that all work products are scientifically rigorous and technically accurate

Project Relevance



Work Products

- Planning for and leading official NMS meetings (4 Steering Committee; 12 Planning Subcommittee; subcommittees and expert workgroups.
- Additional stakeholder engagement, including WB, dischargers, and other stakeholders; presentations; fundraising; etc.
- Scientific contributions to projects, review of work products, and overall science program oversight
- Project/Program management
- Contracts
- Financial management and quarterly financial reports

Budget Justification:

Funds cover NMS lead scientist's effort across all scientific activities of the NMS and for overall program coordination, stakeholder engagement, and NMS management (work distribution: 60% hands-on science and/or directing projects; 40% program coordination (fundraising, stakeholder engagement, NMS and PS process)). Funds also cover a program manager (0.5 FTE), and science oversight and program/project management management by other staff (0.5 FTE, distributed across several staff). Funding is also included for financial management/contracting (0.25 FTE), a consultant to assist in stakeholder engagement, and for regional travel ($5k). Approximately ~$100k in remaining funds from FY2021 will be rolled over to FY2022, so the FY2022 request is $400k.

P1a Biogeochemistry Field Study: South Bay	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: Stanford, UMCES, USGS, SFSU	$400,000	0	$400,000

Project Description

This project is a continuation of a multi-year project that began in FY2020 with the aim of measuring biogeochemical process rates in the South Bay and Lower South Bay (SFEI 2019, 2020). Field studies were designed with input from expert advisors and collaborations with Stanford and UMCES were set up to carry out the work. FY2022 will be the final year of the project, with the conclusion of the fieldwork and a final report and/or manuscript.

Progress in FY2021

- Field sampling plan and lab study design were finalized, and a postdoc began working at Stanford, focused on carrying out the field and lab studies.
- The combined field sampling and lab incubation program was successfully carried out on three dates (October 2020, February 2021, May 2021), with incubation experiments carried out on sediment cores from 8-10 sites per date.
- Measurements included: sediment transformations (nitrification, denitrification, N and P fluxes to/from the sediments, and sediment oxygen demand) and sediment characteristics (grain size, organic carbon, total nitrogen, microbial communities etc.)

Plans for FY2022

- Field sampling and analyses will be conducted for 3-4 more dates (summer 2021, fall 2021, and 1-2 dates in winter-spring 2022).
- Water column rate measurements (nitrification and respiration/oxygen demand) will also be made in the summer and fall
- All collected samples will be analyzed
- Results will be summarized in a technical report and a corresponding manuscript for peer-review will be drafted

Objectives

- Advance our understanding of nutrient dynamics in SFB through observational studies that target priority data gaps, including quantifying nutrient-related transformation rates.
- Use study results to refine and calibrate a biogeochemical model under development by the NMS, which will be used to inform upcoming nutrient management decisions.

Project Relevance

Target				Science Focus Area						Program Area					
A AF	B Cond	C Link	D Mgmt	Nuts	phyto DO open	phyto DO marg	HABs	Coast	Risk	monit	model	spec study	Synth	AF	Prog Mgmt Coord

Target: field and lab measurements to yield improved quantification of Linkages between Nutrients and Phytoplankton-DO in open Bay habitats; and Nutrient transformation rates and mechanisms/factors regulating those rates. Data will be important inputs for calibrating biogeochemical models for exploring phytoplankton and nutrient dynamics, and for evaluating management options.

Work Products

- QA/QC'd dataset for water column and sediment processes for use in model calibration
- Results will be summarized in a technical report
- Postdoc will lead a peer-reviewed paper

Budget Justification:

The full cost of this multi-year project was estimated to be $750k over 3 years. So far, $350k has been allocated (FY20+FY21). The remaining $400k is being requested from FY22 funds. Approximately 80% of overall project funding will support external collaborators on fieldwork, analysis, and interpretation; 20% of funds will support SFEI staff to participate in and coordinate project(s). Costs include a postdoc at Stanford ($145k, including support for faculty advisor); remaining equipment construction ($20k); fieldwork including training, personnel and boat time ($50k); water column sample analysis ($30k); sediment sample analysis ($75k); staff support for project management and reporting ($80k). Due to the COVID pandemic, labor costs in FY 2020 and 2021 were higher than expected, and it is possible that additional funds in FY23 will be required to offset those costs and complete the full scope of work, including adequate time for data analysis and interpretation.

P1b Biogeochem Field Study: Lower South Bay	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: SFEI; Cal Maritime Academy; USGS-MarFac	$115,000	$15,000	$100,000

Project Description

The objective of this multi-year project is to advance the mechanistic understanding of nutrient, phytoplankton, and oxygen dynamics in LSB and develop quantitative estimates for how nutrient loads affect phytoplankton production and oxygen levels in LSB slough and salt pond habitats The work is motivated by two key management questions: *What role do anthropogenic nutrients play, in conjunction with salt pond restoration/operation, in causing low dissolved oxygen (DO) in LSB sloughs? How would DO-condition respond to changes in nutrient loads (decreases, increases)?* We will address these "big picture" questions through both field data collection (P1b) and modeling efforts (P2), and expect this to be an ongoing analysis over multiple years. In FY22, P1b field efforts will focus on quantifying and elucidating patterns in nutrient fluxes into ponds and biomass fluxes out of ponds at tidal time scales. Early field work in summer 2021 will involve conducting 1-3 iterations of "sampling blitzes" aimed at characterizing tidal-time-scale patterns in nutrients and algae into/out of salt ponds. Results from these pilots (both logistical refinement and data results) will be used to inform a set of spring 2022 experiments. We will also explore the potential for using remote sensing tools to characterize algal biomass in LSB restored salt ponds.

Progress in FY2021

- During FY21, the work directly related to this field study was limited to planning (including coordination with collaborators) and designing the first phase of the FY22 field work that will be carried out Jul-Aug 2021.
- Related work included data analysis, interpretation, and report preparation for two technical reports (draft manuscripts for submission to peer reviewed journals): Study and Report #1 detailing the linkage between phytoplankton production in restored salt ponds and elevated oxygen consumption rates in the surrounding sloughs (SFEI 2020a); Study and Report #2 Examining the response of slough/salt pond habitats to multiple days of low light levels during smokey days in September 2020 (sustained low DO), confirming the vulnerability of some LSB habitats to elevated oxygen consumption rates. (SFEI 2020b)

Plans for FY2022

- Collect data in and around LSB restored salt ponds to:
    - More directly measure nutrient fluxes into salt ponds.
    - More directly measure biomass fluxes from salt ponds into LSB sloughs.
    - Characterize conditions within one or more restored salt ponds in salt ponds, including assessing how nutrient increases/decreases might affect production.
    - Lay the groundwork for next-steps data collection and modeling efforts.
- Pilot exploration of remote sensing tools for characterizing patterns in LSB phytoplankton dynamics.

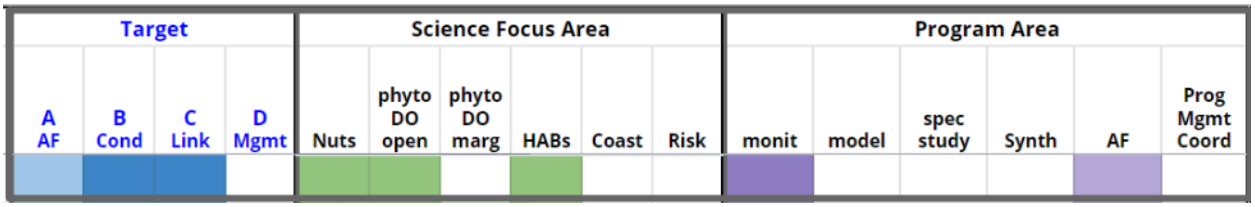
To facilitate the intensive sampling in summer 2021, pilot studies of field data collection efforts will be carried out in summer 2021 by interns from Cal Maritime Academy, jointly supervised by SFEI staff

and Professor Alex Parker (Cal Maritime Academy). Findings from these pilot studies will be used to design a next round of field measurements in spring 2022.

Objectives

- Directly measure fluxes of nutrients into restored salt ponds.
- Directly measure effluent of algal biomass out of restored salt ponds.
- Quantify degree of nutrient limitation in restored salt ponds to better understand nutrient-biomass dose response.
- Inform next-steps data collection and modeling efforts to quantify nutrient-oxygen linkages in LSB sloughs.

Project Relevance



Work Products

- Multiple datasets of discrete samples and sensor measurements characterizing water quality fluxes into/out of restored salt ponds adjacent to Alviso and Guadalupe Sloughs.
- Technical report detailing outcomes of pilot studies (summer 2021), a spring study (spring 2022), and how the results will guide next-steps monitoring and modeling.

Budget Justification

SFEI staff time will support project planning, intern management, and data management ($48k). Interns during summer 2021 will be given stipends of $5,000 for eight weeks of project support ($15k estimated with overhead). Additional funds will support lab processing of samples and boat time ($32k). Approximately one month of effort ($20k) will go toward the remote sensing pilot work, (gathering, standardizing, and analyzing remote sensed estimates of LSB salt pond chlorophyll-a).

P3 Light Attenuation Model Input	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: SFEI; RMA; Deltares; Four Peaks	$100,000	$75,000	$25,000

Project Description

Recent NMS modeling work indicates that space-time variations in water-column light extinction conditions are among the most important data gaps with regard to predicting both phytoplankton production and nutrient cycling. In general, the main control on light attenuation in SFB is suspended sediment concentration. This project aims to build on work in FY2021 aimed at improving the characterization of space-time light attenuation conditions represented in the SFEI biogeochemical model, and ultimately yield a standardized approach for modeling efforts going forward.

Progress in FY2021

- Refined the statistical approach for generating semi-empirical light attenuation coefficients , extended that approach to multiple water years; and generated continuous multi-year model input files at multiple time resolutions.
- Worked with a contractor to obtain results from an established sediment transport model for SFB (UnTRIM, Anchor-QEA; 1-year, hourly, near-surface suspended sediment concentrations) and evaluated those results.
- Conducted a targeted model:model comparison study to evaluate the utility of SFEI's in-house DFM-DWAQ model (with fetch limited waves) at predicting suspended sediment concentrations, compared to predictions from a more sophisticated (and computationally-expensive) sediment transport model and observations (to be completed in June 2021).
- Analysis of biogeochemical model sensitivity to scales of space-time variability in light attenuation conditions.

Plans for FY2022

- Synthesize results of in-house sensitivity analysis and Deltares DWAQ sediment transport model evaluation to generate a recommendation for next-steps approach to characterizing light attenuation conditions.
- Convene expert work group to refine approach.
- Carry out recommended approach for "next generation" light field, which will likely be one of the following :
    - In-house or consultant-led development and application of a sediment transport model; or
    - Further refinement of semi-empirical approaches.

Objectives

- Adequately represent light attenuation conditions in the SF Bay biogeochemical model to improve confidence in model-based insights about SF Bay nutrient cycling.

Project Relevance

Target				Science Focus Area						Program Area					
A AF	B Cond	C Link	D Mgmt	Nuts	phyto DO open	phyto DO marg	HABs	Coast	Risk	monit	model	spec study	Synth	AF	Prog Mgmt Coord

Work Products

- Model input files of light attenuation conditions.
- Concise technical report detailing approach to estimating light attenuation conditions.

Budget Justification

The budget will support: SFEI staff time evaluating results of the FY2021 and synthesizing a recommendation for FY2022 (~$10k); convening an expert working group ($5k honoraria; $5k prep); carrying out the decided-upon approach for estimating light attenuation conditions ($80k). The distribution of funds among these tasks may shift depending on synthesis of FY2021 work.

P4 Lateral Variability: Shoal Mapping	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: SFEI; USGS-BGC; SFSU; BSA	$75,000	$0	$75,000

Project Description

Early SFB studies in the 1980s and 1990s (e.g., Huzzey et al. 1990; Thompson et al., 2008) along with more recent NMS studies (moorings, 'high-speed mapping'; SFEI 2017, SFEI 2019) have shown that phytoplankton biomass and nutrient concentrations on South Bay's broad shoals can differ considerably from conditions in the adjacent deep channel. Measurements along SFB's shoals are not part of routine ship-based monitoring, and expanding monitoring to include shoal areas remains a high priority NMS program goal (SFEI 2014; SFEI 2016). In FY2021 three new moorings were deployed on the eastern shoal of South Bay. Two pilot water quality mapping studies were performed in spring 2021 (with a third planned for June 2021). The combined temporal characterization from the new moorings and spatial characterization from the mapping cruises are providing valuable insights into shoal ecosystem dynamics, and point to the importance of continued shoal monitoring.

Project P4 aims to standardize spatial characterization of shoal water quality as part of the Bay monitoring program. The project will support three (fall 2021, winter and spring 2022) high-speed biogeochemical mapping cruises, collecting a combination of flow-through optical sensor data (e.g., chl, nitrate, turbidity, temperature, salinity) along with discrete samples for subsequent measurement in the laboratory (e.g., nutrients, phytoplankton community including HABs). Mapping cruises may be timed to coincide with USGS R/V Peterson cruises, allowing comparisons between shoal and channel measurements. To the extent possible, mapping cruises will also be timed to coincide with satellite flyovers, to explore the potential utility of remote-sensed data for some relevant parameters (e.g., turbidity/SSC, chl-a).

Progress in FY2021

- Three spring/summer water quality mapping trips to supplement data from newly deployed shoal-monitoring stations.
- Standardization of mapping logistics; approach/coordination between SFEI and USGS-BGC
- Deployment of three shoal moorings to complement water quality mapping.

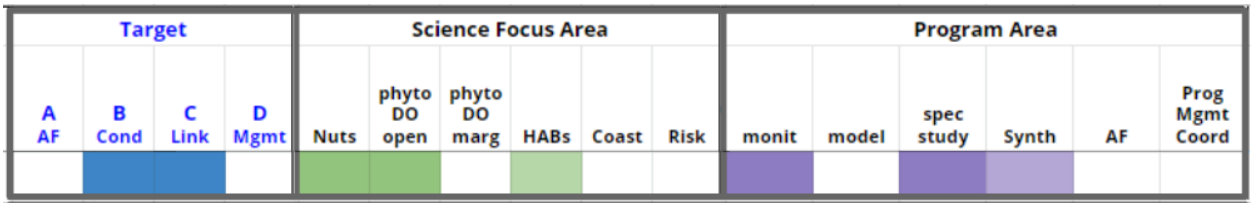
Plans for FY2022

- Three water quality mapping and sampling trips in South Bay.

Objectives

- Characterize spatial patterns in South Bay water quality not captured by standard channel cruises.
- Supplement mooring sensor data with sampled analytes.

Project Relevance



Work Products

- Three mapping cruises in South Bay, yielding one or more two-dimensional water quality maps per trip.
- Corresponding discrete sample data from 10-15 locations per cruise: nutrient, chlorophyll-a and sediment samples; phytoplankton assemblage (including HABs).
- Data will be interpreted/utilized within other projects (P7, P9, P12).

Budget Justification

Project budget will support mapping boat preparation, field time, and data curation (primarily USGS-BGC partner at $45k). SFEI staff will be supported to manage the project, direct cruises in the field, collect and filter samples, and curate sample data ($20k). Sample analysis will be contracted to partners at SFSU, BSA, and Bend Genetics ($10k).

P6 Mussels/Toxins	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: SFSU, UCSC, CDPH	$100,000	$50,000	$50,000

Project Description

This project will continue work that began in FY2016, measuring phycotoxins in naturally-occurring bivalves harvested from floating docks at locations in Central Bay and South Bay. Mussel tissue is tested for concentrations of domoic acid, saxitoxin, and microcystins. Basic water quality parameters are also measured at these sites (T, salinity, nutrients, chl-a).

In addition, samples from FY2022 will continue a 2-yr pilot study (approved by the NMS in FY2021) to also measure phycotoxins in mussels from Tomales Bay, to explore whether toxin signatures in Tomales and San Francisco Bays are comparable or differ substantially. The California Current transports similar water masses to the mouths of both SFB and Tomales Bay (TB). If marine harmful algae (HA) such as Pseudo-nitzchia, Alexandrium, or Dinophysis are being primarily transported into SFB from the coast (i.e., as opposed to growing within SFB), SFB and TB would have similar HA abundances and phycotoxin concentrations.

Progress in FY2021

- Mussel samples were collected every two weeks from eight floating docks around San Francisco Bay (one sampling trip in early July 2020 was missed due to COVID restrictions). Water quality parameters were measured at all sites at the time of mussel collection (T, S, DO with in-situ sensor; water samples were also collected for subsequent chl-a and nutrient concentrations measurements).
- A collaboration was initiated with the CDPH shellfish monitoring laboratory that receives mussel samples weekly from Tomales Bay as part of the state's shellfish monitoring program. CDPH shared an aliquot of Tomales homogenized mussel samples.
- Work is underway measuring mussel tissue samples from both estuaries for domoic acid, saxitoxin, and microcystins.

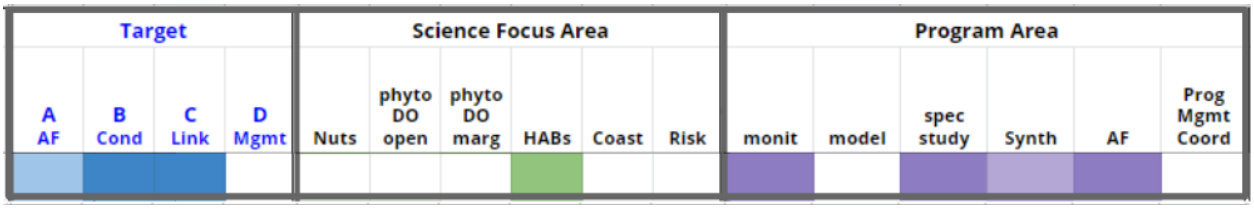
Plans for FY2022

- Continue collection and analysis of mussel samples from SF Bay and Tomales Bay
- Continue water quality sampling at mussel collection sites
- Analysis and interpretation of data will be included in a synthesis of HAB data

Objectives

- Sample mussels from SFB to measure their uptake of biotoxins, including domoic acid, saxitoxin, and microcystins
- Provide spatial and temporal information about HAB events and their effect on the SFB food web
- Resolve potential sources of HA by comparing toxin concentrations along the coast and in the Bay

Project Relevance



This project will continue the collection of spatial and temporal information about HAB-related Condition in SFB. Comparisons of toxin profiles of mussels harvested from SFB and Tomales Bay will allow for evaluating the role of the coastal ocean in transporting HABs and toxins in these estuaries, as opposed to internal production within the estuary, which is key information for disentangling potential roles of anthropogenic nutrients.

Work Products

- Dataset with HA concentrations in mussel tissue, from the two estuaries
- Dataset with water quality conditions at time of sample collection
- Analysis and interpretation of data will be included in the HAB synthesis (P14)

Budget Justification:
SFSU-EOS ($45k) will be responsible for biweekly collection and processing of mussel samples from SFB; analysis of nutrient and chl-a samples; coordinating sample pickup from CA-DPH; and shipping mussel samples for analysis. Samples will be analyzed at UCSC ($42k). SFEI will manage the project ($13k). Other funds for this project will come from remaining RMP funds from prior years ($50k).

P7 Phyto-HAB Monitoring Development	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: SFEI; Bend Genetics; UCSC; USGS	$60,000	$30,000	$30,000

Project Description

This project will continue to explore and assess the suitability of using molecular techniques to detect and quantify harmful algae (HA) taxa and phytoplankton assemblage, with a major objective being to develop a recommendation for monitoring these organisms in SF Bay. Molecular techniques (16S and 18S Amplicon sequencing, qPCR, particulate toxin analysis) have the potential to be sensitive, accurate, and cost-effective approaches for detecting HA/toxins and characterizing phytoplankton assemblages. A recent NMS pilot study (see SFEI 2020) found that detections and relative abundances of multiple HA taxa differed considerably between molecular techniques and microscopy, with molecular techniques appearing to be more sensitive and/or less prone to misclassification than microscopy. The molecular results also revealed the presence of numerous phytoplankton taxa that have not previously been reported in SFB, including some that may contribute non-trivially to biomass. To the aim of developing a recommended monitoring approach, work will include some or all of the following: i) deeper analysis of molecular data collected so far; ii) targeted lab analyses (16S, 18S sequencing, qPCR, particulate toxins) to improve the quality, interpretability, and comparability of data between different methods; iii) development of a tiered, decision-tree process for monitoring HA taxa in a timely, cost-effective manner through collaboration with one or more expert workgroups; and iv) assessment of environmental factors (nutrients, physical forcings) as causal drivers for changes in the presence and abundance of HA/ toxins and phytoplankton assemblage.

Progress in FY2021

- Development of a region-specific sequencing reference metagenome database
- Development and inclusion of a mock phytoplankton community analysis to verify the accuracy of molecular lab techniques
- Updated the technical report by adding another ~150 samples; descriptions of the regional database and results of the mock community analysis; reanalysis of all 330 samples using the new database; and in-depth comparison of results from molecular techniques and paired microscopy counts (report available June 2021).
- Preparation and molecular analysis (16S, 18S sequencing, qPCR) of a next round of samples collected during USGS ship-based sampling cruises between Aug 2018 - Mar 2020 (~100 samples).

Plans for FY2022

- Conduct bioinformatics of molecular data obtained by analyzing Aug 2018- Aug 2020samples,, and combine these results with larger dataset.
- Targeted lab analyses (16S, 18S sequencing, qPCR, particulate toxins) to improve the quality, interpretability, and comparability of data between different methods. Focus around the weaker areas identified in the report (pico-/nano-plankton and dinoflagellates).
- Development of a recommended approach for detecting and quantifying HA/toxins and phytoplankton in SF Bay using molecular techniques. Recommendation will be based on findings from the comparison report, NMS monitoring program needs and goals (including

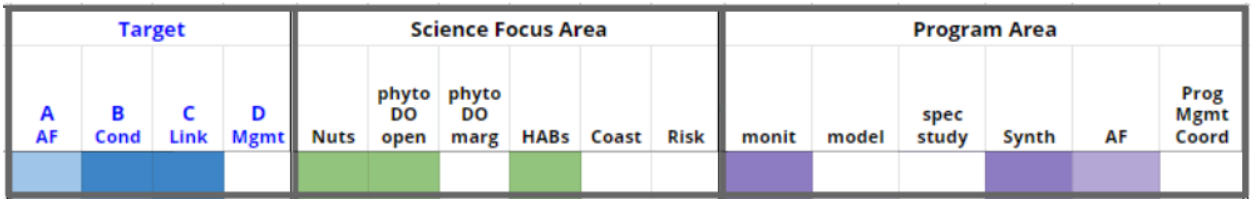
meeting AF and other regulatory needs), time/ cost considerations, consistency with best practices (including on-going CA statewide SWAMP work), and input from an expert working group. To the extent possible, we will merge and/or coordinate this expert working group effort with that of P14.

- Data analysis and interpretation of HAB and overall phytoplankton ecology (abundance vs. space, time, and potential environmental forcings).

Objectives

- Develop a recommended monitoring approach for HA and phytoplankton in SF Bay.
- Characterize phytoplankton and cyanobacteria ecology and their relations to changes in environmental factors within SF Bay.

Project Relevance



This project is a continuation of work that began in FY2019 to develop well-informed and realistic recommendations for detecting and quantifying HAs and for characterizing phytoplankton assemblage. These actions are essential for the following Target areas: measuring Condition in SF Bay, creating a meaningful Assessment Framework, and making inferences about mechanistic Linkages between causal factors (nutrients, physical forcings) and HA/ toxin occurrence and phytoplankton assemblage. The work will also yield new insights into SFB's phytoplankton community and how it varies spatially, seasonally, and in response to environmental drivers.

Work Products

- Data from the analysis of samples for Amplicon sequencing, qPCR for specific HA taxa (as warranted), and phycotoxins (as warranted). Data combined with long-term, multi-year dataset and delivered in Excel.
- Update to the spring 2021 technical report on method comparison, which may include addition of recent data or refinement of the current interpretations, as needed.
- Brief technical report detailing recommendations for detection and quantification of HA and phytoplankton.
- Technical report focused on phytoplankton ecology interpretations using the molecular data.This will either be a stand-alone technical report or will be included with the HAB synthesis in P14.

Budget Justification

Bend Genetics ($40k): sample analysis, data analysis/interpretation, report preparation. Other collaborators (UCSC, USGS: $10k): technical input, recommendations for data analysis and interpretation, contributions to report preparation. SFEI ($10k): data analysis/interpretation, report preparation, project management. The estimated carry-over funds from FY2021 are $20k in Bend Genetics and $10k in unspecified subs (reserved for UCSC collaborator Raphe Kudela and/or other experts). The addition of $30k in FY2022 would add $20k to support Bend Genetics and $10k to support SFEI staff in data analysis/ interpretation, report preparation, and project management.

P11 Trends Synthesis (continuation from FY21)	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: SFEI, Tampa Bay Estuary Partnership (Marcus Beck) and UC Berkeley (Perry de Valpine)	$65,000	$40,000	$25,000

Project Description

This project will continue to explore how various metrics associated with key water quality parameters (chlorophyll-a concentration, DO concentration and saturation, and gross primary production) have varied in time and space in San Francisco Bay. The next phase of the project will be to look at the potential mechanisms for those changes, particularly if different variables are driving changes in the three subembayments of interest: Central Bay, South Bay, and Lower South Bay. A related project, P15, is focused on developing and refining the methodologies for detecting and quantifying trends.

An FY2020 Trends project was launched as a 1.5-2 year $100k project. When the FY2020 Program Plan was approved, $50k of this project's costs were deferred to FY2021. This project is the continuation of the approved FY2020 trends project.

Progress in FY2021

- Explored spatial and temporal patterns in mean water quality metrics from 1991 to 2019, including through applying the statistical approaches developed over the prior 1-2 years.
- Periodically updated the shared web-utility, including with refinements to the statistical modeling approach; addition of new parameters (GPP, DO (mg/L), DO (%sat) (in addition to chl-a); and addition of new metrics (variance, max, min).
- Developed a technical report documenting approach (focused on chl-a as an example) for combining generalized additive model (GAM) output with a second-stage seasonal analysis that propogates uncertainty, and submitted that report as a manuscript to a peer reviewed journal.
- Documented approach in an R package, available on github.
- Generated additional metrics using the generalized additive model developed as part of companion project P16.
- Compiled datasets to evaluate mechanisms driving change in time and space.
- Developed a draft technical report describing space-time variability in chl-a, GPP, DO(mg/L), and DO (%sat) (June/July 2021).

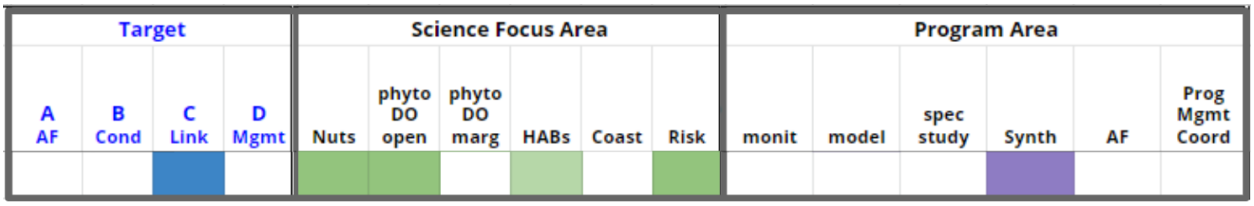
Plans for FY2022

- Revise/finalize draft trends synthesis report/manuscript
- Analyze mechanisms driving change
- Draft/revise/finalize mechanisms report/manuscript

Objectives

- Synthesize water quality data from the USGS cruises to assess changes in water quality parameters over space and time
- Explore which mechanisms are likely driving changes throughout the system and in individual subembayments

Project Relevance



This work will contribute to the development of the Assessment Framework and associated indicators and metrics for assessing water quality in San Francisco Bay.

Work Products

- Trends synthesis technical report/manuscript
- Change mechanism technical report/manuscript
- Updated web tool

Budget Justification:

SFEI will be the technical lead on the project ($50k) with support from our expert technical collaborators with expertise in statistical analyses and tool development (P de Valpine, UC Berkeley; M Beck, TBEP; $15k). Remaining funds from FY21 ($40k) and additional funds from FY22 ($25k) will be used to complete this phase of the project.

P13 LSB Synthesis: metabolism, mechanisms	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: SFEI; UCSB; UCD; U of Michigan	$25,000	$5,000	$20,000

Project Description

Peripheral habitats in the LSB regularly see concerningly low dissolved oxygen concentrations, particularly in the tidal sloughs surrounding restored/semi-restored salt ponds. These habitat areas have complex physical dynamics and sharp biogeochemical gradients, making it challenging to arrive at straightforward interpretations or reach confident quantitative inferences about drivers of dissolved oxygen dynamics. In Fall 2020, a manuscript was submitted that quantifies seasonal patterns in oxygen consumption rates in two LSB tidal sloughs. This project will support refinement of this analysis in response to reviewer comments.

Progress in FY2021

- Technical report detailing metabolic rate patterns in Newark and Alviso sloughs, and refinement and submission as a manuscript for peer review.
- Analysis of conditions in sloughs during high-smoke day in September 2020; and write-up as technical report

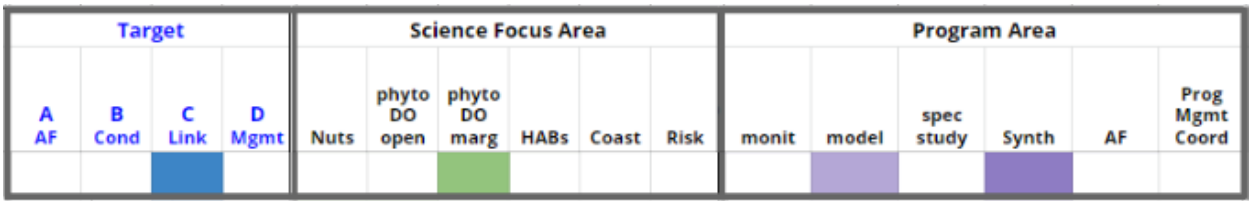
Plans for FY2022

- Refine analyses in technical report #1 in response to peer review, and re-submit for publication
- Refine analyses in technical report #2 and submit as a manuscript to a peer reviewed journal

Objectives

- Characterize metabolic rate patterns in LSB sloughs to improve understanding of linkages between wastewater-nutrient loads and oxygen condition.
- Finalize peer-review and publication of LSB slough rate estimates.

Project Relevance



Work Products

- Published manuscript detailing LSB slough metabolic rates.

Budget Justification

This budget will support SFEI staff time to refine the analysis of LSB slough metabolic rates, submit two articles for publication, and finalize any revisions. Additional staff time will be contributed through overhead (50/50). Co-authors at UC Santa Barbara, UC Davis, and the University of Michigan will be involved at no cost.

P14 HABs Synthesis	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: SFEI, UCSC, Bend Genetics, USGS, others TBD	$125,000	$75,000	$50,000

Project Description

Over the past ~5 years, the NMS has substantially increased data resources related to HABs and toxins, in response to science/management priorities. This project will invest in synthesizing and interpreting recent and longer-term HA and toxin data, including identification and quantification of HA's using both microscopy and molecular analysis, detection of phycotoxins in mussels and anchovies, and SPATT. This will be a holistic synthesis of multiple lines of evidence to characterize algal toxins and their sources, and assess ecosystem health impacts from toxins and their effects on wildlife. Mechanistic data interpretation will evaluate the factors that influence the presence and abundance of HA. Spatial and temporal trends will be assessed, including evaluation of recent shoal data compared to channel data and potential source areas for HA.

An expert working group will be convened to advise on and contribute to analysis and interpretation of data, and to inform approaches for analyzing those data with respect to Assessment Framework development/refinement.

Progress in FY2021

Although this project was partially funded in FY21, we decided to not begin synthesis work due to overall limited staff capacity. HAB data collection and synthesis did move ahead within P7, including sample analysis and the interpretation in the recently-completed technical report, and the mussel toxin work in P6. moved forward though, has been awaiting collection of additional data.

Plans for FY2022

- Compile and summarize recent data, with basic data visualization to explore spatial and temporal trends and explore potential hypotheses
- Develop preliminary interpretation and synthesis approach for expert review
- Convene expert panel to review approach and make recommendations
- Begin data synthesis and interpretation

Objectives

- Evaluate factors that contribute increased abundance of HABs in SFB
- Analyze spatial and temporal trends, and identify potential source locations of HA
- Assess impacts of HA on ecosystem health

Project Relevance

The primary goal of this effort will be to improve understanding of mechanistic Linkages between HA/toxin occurrences and potential causal factors. Through exploring those issues, we also expect to extract valuable information related to Condition measurement (monitoring) and Assessment Framework development.

Work Products

- Expert working group, and report-out on feedback and recommendations
- Technical report developed in the form of a manuscript to be submitted to a peer-reviewed journal.

Budget Justification:

This project was partially funded in FY21 with $75K, and an additional FY22 funding will bring the total to $125K. $15K will be dedicated to the expert review panel (honoraria and travel), with an additional $10K to support project management and workshop planning. Up to $25K may also support collaboration with recognized expert(s) to help guide the synthesis work and potentially assist with the analysis. The synthesis work will be led by a collaborator (TBD) with support from SFEI staff. The combined funding level noted above ($125k) is lower than the originally planned amount (150-175k).

P15 Assessment Framework: Trend Analysis - application to condition assessment	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: SFEI, Tampa Bay Estuary Partnership (Marcus Beck), UC Berkeley (Perry de Valpine)	$75,000	$50,000	$25,000

Project Description

This project expands on the work done thus far developing statistical methods for assessing trends in water quality data in San Francisco Bay. This work is related to and builds on work being carried out under P11 Trends Synthesis. However, whereas P11 focuses on interpretations, P15 will be directed toward further testing, refining, and applying the trend analysis techniques within a condition assessment context. We will convene a stakeholder subgroup to gather input on needs or goals for tracking trends, use that input to identify priorities for further development, and then carry out the highest priority development work. Specific work may include further testing or refining the current approach (for which development focused primarily on chla) for applications to other relevant indicators (e.g., DO%sat, DOmgL, GPP); developing techniques or guidance for objectively identifying the most appropriate or meaningful time-window for trend detection; or developing guidance or techniques for balancing the tradeoffs between trend magnitude, time-window (or early-warning), and confidence depending on the management questions or goals of the analysis.

Progress in FY2021

Note: Both P15 and P11 are building on and branching from the same prior work carried out during FY20-FY21 project. So the the progress described is the same as presented above for P11.

- Refined the generalized additive model structure to generate estimates of water quality values in time and space.
- Explored spatial and temporal patterns in mean water quality metrics from 1991 to 2019, including through applying the statistical approaches developed over the prior 1-2 years.
- Periodically updated the shared web-utility, including with refinements to the statistical modeling approach; addition of new parameters (GPP, DO (mg/L), and DO (%sat), in addition to chl-a); and addition of new metrics (variance, max, min).
- Developed a technical report documenting approach (focused on chl-a as an example) for combining generalized additive model (GAM) output with a second-stage seasonal analysis that propogates uncertainty, and submitted that report as a manuscript to a peer reviewed journal.
- Documented approach in an R package, available on github.
- Generated additional metrics using the generalized additive model.
- Developed a draft technical report describing space-time variability in chl-a, GPP, DO(mg/L), and DO(%sat) (June/July 2021).

Plans for FY2022

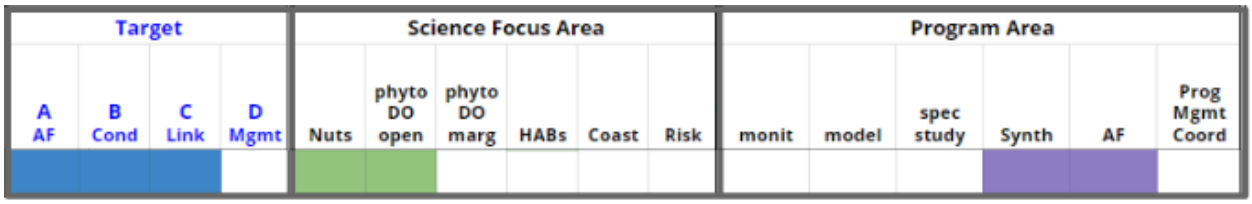
- Hold stakeholder (subgroup) meetings to better define management needs with respect to trends, and identify priorities for trend tool development given management applications..
- Work with expert collaborators to conduct additional method development for trend

evaluation to address stakeholder input.
- Update web-utilities to include the refined or new analyses, and produce a technical brief on trends in WQ indicators in San Francisco Bay using time intervals pertinent to management questions.

Objectives

- Identify priorities for further trend analysis development given management priorities, and carry out the highest priority development work.
- Test, refine, and extend current approach(es) to other priority indicators
- Develop implementable guidance or techniques for balancing key tradeoffs (e.g., between trend magnitude, time-window, and confidence) depending on the management questions or goals of the analysis.
- Continue to update the trends webtool as new metrics and trend detection methods are developed

Project Relevance



This work will contribute to the development of the Assessment Framework and associated indicators and metrics for assessing water quality in San Francisco Bay.

Work Products

- Updated web tool
- Brief Technical Report describing updated trend detection methods

Budget Justification:

SFEI staff will lead this overall process ($50k), working with external technical collaborators with expertise in statistical analyses (P de Valpine, UC Berkeley; M Beck, TBEP; $25k). Remaining funds from FY21 ($50k) and additional funds from FY22 ($25k) will be used to complete this phase of the project. This project was launched in FY2020 and is instrumental to developing the metrics and indicators for the Assessment Framework.

P16 Assessment Framework: Deep Subtidal	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: SFEI	$150,000	$120,000	$30,000

Project Description

During FY2021, SFEI has been working on drafting a report on the “test drive” that compared observed data on water quality parameters in SFB from 1977-2015 to criteria previously identified in AF 1.0, and provides recommendations for future work. SFEI has also been working with a subcommittee of the NMS-SC to gather stakeholder input to be incorporated into an Assessment Framework Workplan. This project will pursue a subset of the highest priority analysis or other work identified in the AF Workplan. An early step of this effort will likely involve convening an expert group, to identify specific types of analysis to explore.

Progress in FY2021

- Meetings with AF Subcommittee to identify and discuss stakeholder and regulator priorities and goals for AF development.
- Developed an AF Deep Subtidal Workplan (available June 2021)
- Developed a draft technical report on “Assessment Framework 1.0 Test Drive” (available June 2021)
- The major technical work related to Deep Subtidal AF that moved forward in FY2021 included Trend Analysis (see discussions in P15 and P11) and HAB detection/quantification (see discussion under P7).

Plans for FY2022

- Finalize workplan after AF subcommittee and SC review
- Expert review of test drive report
- Pursue no-regrets data analysis related to AF Deep Subtidal development, including to develop materials and prepare for expert meetings (below). Some of the technical work relevant to AF Deep Subtidal development will be moving forward under other projects, including: HAB synthesis work (P14); HAB detection/quantification (P7); and trends in chl-a, DO, and GPP (P15, P11)
- Convene one or more expert meetings focused on (i) reviewing and providing recommendations based on the AF Deep Subtidal Workplan; (ii) selection of indicators and metrics; and(iii) technical approaches for developing/refining indicator-metrics
- Workshop on addressing uncertainty in indicators (stakeholders and experts)
- If time and budget permit, may get started on a pilot set of webtools for visualizing long-term data, and visualizing comparisons of past and current water quality relative to potential numeric criteria.

Objectives

- Establish indicators and metrics based on best available science
- Evaluation of historical and recent water quality conditions based on new indicators and metrics

Project Relevance

Focused on Assessment framework development in deep subtidal habitats for phytoplankton/DO and HABs.

Work Products

- Final workplan
- Final “test drive” report using AF 1.0 metrics
- Expert panel recommendations report
- Test drive report using new metrics

Budget Justification:
Approximately $35K would be distributed to external collaborators/experts over multiple document reviews and meetings/workshops. and approximately $115K would support 2-3 SFEI staff members for managing the overall project, coordinating expert and stakeholder meetings, conducting data analysis, and writing reports.

P17 Assessment Framework: DO in LSB Sloughs and Creeks	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: UC Davis, UW, SCCWRP, Tetra Tech, UC Berkeley	$140,000	$70,000	$70,000

Project Description

Work has been moving forward over the past year on developing a workplan for an Assessment Framework for DO in LSB slough/creek habitats, where DO concentrations can drop very low in some sloughs. Multiple lines of evidence are being pursued to support the development of an AF in these habitats. Priorities for this project include: i) pursue analys es following the concepts and structure laid out in the Virginia Province Approach (VPA); ii) scoping level analysis of multi-stressor approach(es), i.e., T, DO and biota metabolism, including a literature review, and exploration of data needs, data availability, and feasibility; iii) scoping level analysis of fish trawl data to identify the types of analyses or interpretations that current data can support.

Progress in FY2021

- Met regularly with the AF subcommittee to gather input and to keep stakeholders informed of progress.
- Convened several meetings with an expert working group to identify recommended approaches for three complementary lines of evidence: Virginia Province Approach; analysis/interpretation of fish survey data; and a metabolic index approach (T-dependent variability in DO requirements)
- Developed a work plan for a step-wise, iterative approach for pursuing VPA analysis, with input from experts/collaborators and the AF Subcommittee. Collaborators/consultants at Tetra Tech recently completed preliminary analyses that were then used to develop a detailed draft work plan identifying options for next steps.
- Refined statistical modeling approach for the fish community data, including technical report summarizing updated analysis
- Met with a subset of the expert workgroup to identify priority next steps and a work plan for the analysis of the fish data, and gather input on high priority fieldwork activities, refined plan to conduct sampling in the summer
- Met with a subset of experts to advance metabolic index approach, and to identify how it will support other lines of evidence
- Conducted preliminary analysis of environmental data in LSB sloughs and compared to metabolic requirements of several fish species

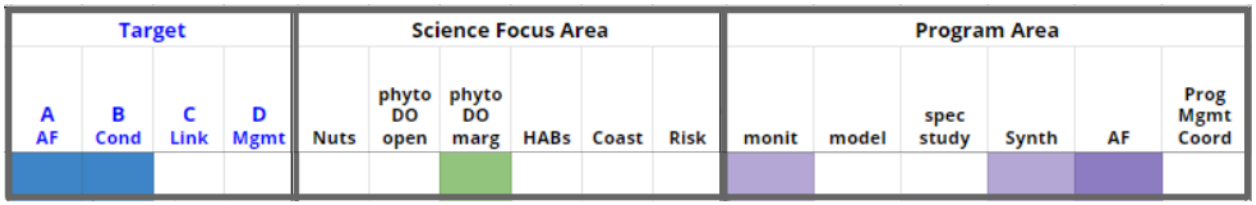
Plans for FY2022

- Complete the development of the VPA
- Refine statistical modeling approach, analyze fish abundance data to determine protective DO concentrations for biota
- Develop metabolic index analysis for LSB fish species
- Convene expert workgroup to review progress to date and to discuss integrating the different approaches
- Continue to update the AF subcommittee and engage them in the AF development process

Objectives

- Determine protective DO conditions for LSB margins and sloughs using multiple lines of evidence
- Assess protective dissolved oxygen thresholds under future conditions

Project Relevance



Work will Target Assessment Framework development and Condition assessment in LSB slough and creek habitats, focused on DO. The proposed approach based on expert input will establish several lines of evidence for establishing protective DO objectives for LSB slough and creek habitats.

Work Products

- Technical report summarizing application of the VPA to characterize habitat condition in LSB sloughs and creeks
- Technical report on the multi stressor work, including results from analyses to-date, data needs, potential usage within regulatory or management decision frameworks, and recommended next steps.
- Technical report on analysis of fish abundance data

Budget Justification:

Total: $140k ($70k is being carried forward from FY2021). Exact distribution of funds across the three main tasks will depend on additional information about effort required for some types of work. Approximately 50% ($70k) of funds will support external collaborators working on these projects, and 50% ($70k) will support SFEI staff on data analysis/interpretation and managing the overall project.

P19 Coastal Nutrient Exchanges/Fluxes	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: UCLA, UCSC, SCCWRP, SFEI	$175,000	$0	$175,000

Project Description

A sizable proportion (e.g. 50% or more, depending on season) of the nutrients that enter SFB exit via the Golden Gate to the coastal ocean. This project will fund year 3 of a 3 -year project joining an on-going study (collaborators SCCWRP/UCLA/UCSC) to explore the fate of nutrients leaving SFB. The project aims to determine boundary condition estimates for nutrients entering SFB. [Project already approved by NMS-SC, Mar 2019; see FY2020 Program Plan]

Progress in FY2021

- Completed model construction, configuration, atmospheric forcing, SF Bay outflow forcing, passive tracer implementation
- Tests conducted with 2000 (no SF Bay forcing) & 2005 (with SF Bay forcing)
- Model-data comparison with 2011-2014 (physics)
    - Physics-only runs to assess transport and fate of SF Bay buoyant outflow
    - Observations: satellites, gliders, HF radar currents
    - Model captures major features and stratification is overall quite good fit with observations
- Prepared draft technical report

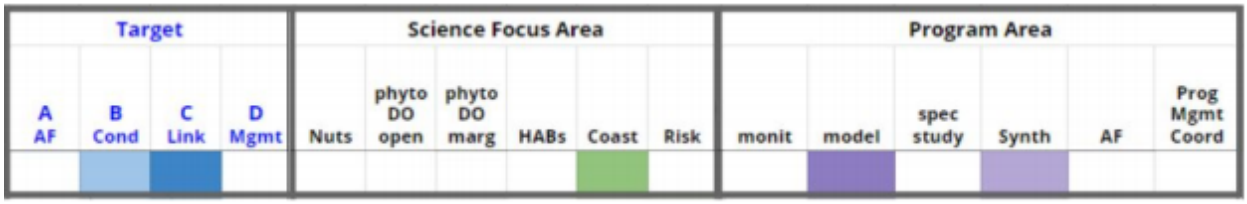
Plans for FY2022

- Continue analysis and refinement of model, with a focus on the biogeochemical module
- Further model-data comparison (biogeochemical tracers)
- Evaluate ecosystem response to the combined effects of SF Bay freshwater (stratification) and nutrient loads to the coast

Objectives

- Quantitatively characterize the influence of SFB-nutrients on coastal conditions (dissolved oxygen, acidification, HABs)
- Establish ocean boundary conditions for SFB model (nutrients entering Bay)
- Evaluate how nutrient loads from SFB affect coastal ecosystem structure, including changes to primary production, phytoplankton concentrations, and community structure

Project Relevance



This study examines the Link between nutrient exports via the Golden Gate and potential adverse impacts along the Coast (OA, hypoxia, harmful algal blooms).

Work Products

- Technical report at the end of Year 3 (June 2022)
- One or more manuscripts for submission to peer-reviewed journals.

Budget Justification:
Project costs for FY22 will be $175,000, and cover postdoc and faculty advisor (UCSC/UCLA), additional support for generating forcings or other datasets, and support for SFEI staff on project management (~10k total over three years, previously funded).

P20 Future Scenarios / Risks	FY22 Work Total Cost	Other Funds	NMS FY22 Funds
Collaborators: SFEI, Four Peaks	$85,000	$25,000	$60,000

Project Description

Although nitrogen and phosphorus concentrations in SFB are elevated relative to those in many other US estuaries, those levels were thought to pose little ecological-health risk in SFB because of physical and biological factors that limit nutrient conversion into phytoplankton biomass (SFBRWQCB, 1975). However, multiple recent studies have documented how physical and biological drivers of ecosystem response have changed over the past ~20 years (Cloern et al., 2007, 2010; Schoellhamer 2011), leading some areas of the Bay to exhibit greater sensitivity, or responsiveness, to ambient nutrient concentrations, as evidenced by increasing chl-a concentrations in South Bay (Cloern et al., 2007) and other subembayments. Climate change predictions suggest that additional changes are ahead (Cloern et al. 2011). The magnitudes and combined influence of those changes on ecosystem responses to nutrients have not been quantitatively explored. In addition, the 2015 harmful algal bloom along the entire US west coast served as a stark reminder that “atypical” conditions, or events, can have widespread, unforeseen impacts and that nutrient-related responses may need to be evaluated in a risk-based framework. Since any large-scale nutrient management actions in SFB will take years to decades to implement, NMS guidance documents call for exploring ecosystem response under both current conditions and plausible future conditions (Strategy document; NMS Science Plan; NMS Conceptual Model). Although characterizing likelihood, or risk of occurrence, of future scenarios and SFB response under these future scenarios is of paramount importance, so far the vast majority of NMS work has been focused on current conditions.

In this project, we will develop a risk-based framework for evaluating nutrient-related effects in SFB, and begin the work of quantitatively examining scenarios within this framework. Future scenarios for detailed exploration will be identified and prioritized through input from experts and stakeholders, starting with the environmental change scenarios and management scenarios considered in the Scientific Foundation for the San Francisco Bay Nutrient Management Strategy. Scenarios will be explored through a combination of hydrodynamic and water quality models, as well as empirical predictive methods such as the causal analysis that is currently underway (see P7 in this Program Plan) using historical data. This is anticipated to be a 3-4 year study that was previously approved with a small amount of initial funding to begin developing a framework in FY21. In FY21 the focus was on continued development and refinement of tools that will feed into the future scenario analysis, such as further calibration, validation, and sensitivity analysis of numerical models, and developing methods for causal analysis. We also co-hosted a series of model uncertainty seminars and workshops to explore methods to incorporate probability/uncertainty analysis in future scenario predictions.

In FY22, we will incorporate some of the concepts that came out of these workshops to develop a workplan for identifying and evaluating future scenarios using the biogeochemical model. Given the uncertainties associated with future predictions and the cost implications of decisions made to manage future conditions, it is essential that the analysis framework be developed with

heavy stakeholder and expert input, and is expected to be an iterative process. Therefore, in FY22 we will work closely with stakeholders and experts to lay out the future scenarios framework that will form the underpinnings of the work plan and cost estimates for implementation over the next few years.

Progress in FY2021

Although funds for this project were not drawn on, much of the modeling and data analysis work accomplished in FY21 will feed directly into development of the future scenarios analysis, including:

- Calibration and validation of numerical models that will be utilized in future predictions
- Sensitivity analysis to identify model uncertainties in predicting nutrient cycling, which is relevant to both current and future conditions
- Long terms trends analysis and development of framework for causal analysis
- Planning and co hosting seminars and workshop on model uncertainty

Plans for FY2022

- Solicit stakeholder and expert input on potential future scenarios to evaluate, including nutrient load reductions as well as other planned actions (eg SBSP restoration, water operations changes) and climate change scenarios
- Initial ranking of scenarios/parameters/forcings for inclusion, with rankings based likelihood and magnitude of impacts using evidence from NMS findings, other SFB research, and studies from other regions
- Evaluate predictive tools for potential parameters/forcings to include
- Develop preliminary approach and conduct review by expert group
- Develop conceptual framework guided by expert recommendations and stakeholder input
- Develop workplan and cost estimates for implementation

Objectives

- Establish future scenarios to be evaluated, and time frame to be considered
- Select the parameters/forcings that are expected to have biggest impact and likelihood regarding adverse consequences of nutrient dynamics (eutrophication, DO depletion, HABs, phytoplankton ecology, etc)
- Establish a quantitative framework for evaluating future scenarios and their impacts
- Develop scope of work and cost estimates for implementation
- Solicit input from stakeholders and experts at multiple steps of developing the framework

Project Relevance

This project examines the Linkages between high Nutrients and the Risk of major adverse-impact events in the future (phyto blooms, DO, HABs), as a result of shifts in environmental forcings.

Work Products

- Initial list of potential future scenarios to consider
- Initial list and ranking of parameters/forcings expected to have greatest magnitude and likelihood of impact
- Preliminary approach for review by expert workgroup
- Expert workgroup recommendations
- Conceptual framework for stakeholder and expert review
- Work plan and cost estimates for implementation

Budget Justification:
The current funding level ($25k in FY2021 plus $60k in FY2022 for a total of $85k) would allow for an iterative process with heavy involvement of both stakeholders and experts. Funding under other FY22 projects will allow for continued development and refinement of the tools that will be utilized for the future scenarios analysis. $200K is a rough estimate of the work to implement the future scenarios analysis, with the understanding that much of the work that feeds into it will be supported under other projects. The cost estimate for implementation will be refined on completion of the work plan.

Appendix A: Additional NMS-Related Projects Moving Forward in FY2022 (no NMS FY2022 Permit Funds)

Proj #	Project	Total FY22 Work	NMS FY2022 Permit Funds	Other Funds	Notes
P2	**LSB Model Development**	$85,000	$0	$85,000	Continuation from FY2021. FY2022 funds originally proposed to make more progress on hydrodynamic refinements and also with early model applications, but cut to $0. FY2022 will focus primarily on improvements to hydrodynamics (including salt pond exchange), with perhaps limited pilot applications, to inform next steps
P9	**Optimize Monitoring Program**	$25,000	$0	$25,000	Continuation from FY2021. FY2022 funds originally proposed to target more substantial goals (expert input, data analysis to identify 'optimized' program design, planning), but cut to $0. Work in FY2022 will instead focus primarily on planning, including developing approach to shared science program management with USGS-Sac.
P10	**Synth: Synthesis/Interpretation of HF mooring data**	$70,000	$0	$70,000	Continuation from FY2021. FY2022 funds originally proposed to target more substantial goals, but cut to $0. FY2022 work will target analysis/interpretation of South Bay shoal data (C2 mooring data, P4 mapping data). Exact focus will be determined after carrying out first-stage hypothesis-generating analyses (e.g., differences in channel-shoal GPP; factors regulating periodic increases in shoal productivity; empirical assessment of nutrient-limitation potential
P12	**Synth: High biomass event causes cont'd**	$30,000	$0	$30,000	Continuation from FY2021. FY2022 funds originally proposed to allow to extend FY21 work to better informing understanding and project-planning related to future scenarios. Cut to $0. FY2022 work will focus on completing technical report and potential manuscript.
P18	**AF: LSB slough/creek DO, fish field work**	$40,000	$0	$40,000	Continuation from FY2021. FY2022 funds originally proposed to support (if needed) broader or longer field campaigns, augmenting UC Davis' other funding sources for related work in LSB. For FY2022 work, UCDavis researches will use currently allocated funds to pursue targeted surveys that address a major data gap/uncertainty.
P21	**Model Advisory Group**	$50,000	$0	$50,000	Continuation from FY2021. No FY2022 funds requested. Funding will support planning for and convening a Model Advisory Group, and developing post meeting report out
P22	**Synthesis: Multi-year report**	$35,000	$0	$35,000	Continuation from FY2021. No FY2022 funds requested. FY2022 funds will support developing and finalizing the multi-year report, including some investment in graphic design / layout support
P23	**Suisun -- Delta Modeling**	$300,000	$0	$300,000	Three distinct funding sources but with complementary goals and regional focus; not from NMS annual permit funds. No FY2022 funds requested. Funding will support: improvements to model implementation in the Suisun-Delta region, including an emphasis on improving implementation of clam and zooplankton grazing (which will also have direct benefits for work in other regions of SFB); model application, including interpretations focused on improved understanding of nutrient-light-phytoplankton-grazer dynamics in Suisun Bay, and predicting Delta-->Suisun nutrient loads considering Regional San load reductions.
	sub-Total	**$635,000**	**$0**	**$635,000**	

Appendix B: Comparison of 'first-draft' (May 4) and 'current' (Jun 4) Total FY2022 Work

	Full Project Set (pre-constraints for budgeting)	Low Estimate: Total FY22 Work (first-draft, May 4)	High Estimate: Total FY22 Work (first-draft, May 4)	Total FY22 Work (current, Jun 4)	Difference: Current (Jun 4) minus Avg_of_LowHigh
C1	Monitoring: Ship-Based	$400,000	$425,000	$400,000	-$12,500
C2	Monitoring: Moored Sensor Network	$370,000	$370,000	$390,000	$20,000
C3	Core Modeling	$500,000	$550,000	$500,000	-$25,000
C4	Program Management/Coordiation	$500,000	$500,000	$500,000	$0
P1a	Biogeochem Field Study: South Bay*	$150,000	$250,000	$400,000	$200,000
P1b	Biogeochem Field Study: Lower South Bay	$160,000	$210,000	$115,000	-$70,000
P1c	Biogeochem Field Study: northern SFB (Suisun, San Pablo)	$75,000	$100,000	$0	-$87,500
P2	LSB Model Development	$150,000	$200,000	$85,000	-$90,000
P3	Generating light attenuation model input (model, or other)	$150,000	$225,000	$100,000	-$87,500
P4	Lateral (shoal) water quality mapping (South Bay)	$100,000	$100,000	$75,000	-$25,000
P5	Quantifying microzoop, mol/IFCB	$50,000	$150,000	$0	-$100,000
P6	Mussels/Toxins (SFB, continue Yr2 w/ Tomales)	$75,000	$100,000	$100,000	$12,500
P7	Phyto-HAB monitoring development (molecular, approach)	$70,000	$95,000	$60,000	-$22,500
P8	Perimeter monitoring study	$40,000	$75,000	$0	-$57,500
P9	Optimize Monitoring Program (planning, analysis)	$75,000	$100,000	$25,000	-$62,500
P10	Synth: Synthesis / interpretation of HF mooring data	$100,000	$100,000	$70,000	-$30,000
P11	Trend synth cont'd	$65,000	$90,000	$65,000	-$12,500
P12	Synth: High biomass event causes (cont'd)	$70,000	$95,000	$30,000	-$52,500
P13	Synth: LSB synth/interp (mechanisms)	$25,000	$75,000	$20,000	-$30,000
P14	HAB synthesis	$125,000	$175,000	$125,000	-$25,000
P15	AF Deep Subtidal: Trends (methods, regulatory/mngmt application)	$75,000	$100,000	$75,000	-$12,500
P16	AF: Deep subtidal, priority analyses, work groups, etc.	$175,000	$250,000	$150,000	-$62,500
P17	AF: LSB slough/creek DO, priority analyses, work groups, etc.	$170,000	$220,000	$140,000	-$55,000
P18	AF: LSB slough/creek DO, fish field work	$65,000	$90,000	$40,000	-$37,500
P19	Coastal N flux, impacts	$150,000	$200,000	$175,000	$0
P20	Future Scenarios/Risk: develop work plan, launch project	$125,000	$175,000	$85,000	-$65,000
P21	Model Advisory Group	$50,000	$50,000	$50,000	$0
P22	Synthesis: Multi-Year Report	$38,000	$38,000	$35,000	-$3,000
P23	Suisun-Delta Modeling (other funds) **	$220,000	$220,000	$300,000	$80,000
P24	Zooplankton Data analysis	$25,000	$50,000	$0	-$37,500

*P1a is the third year of a 3-year study that was previously approved by the NMS-SC. The primary reason for the much higher current NMS FY2022 Permit Funds is that our initial estimates for the May 4 first-draft were substantial underestimates of remaining costs that would be incurred in FY2022. The total cost of the 3-yr project is unchanged; so a Difference closer to 0 (white) more accurately reflects the change.

**Total Funding available is $300,000, but not all will be spent in FY2022. In addition, some work is more directly relevant to Delta.