San Francisco Bay Nutrient Management Strategy

FY2023 Program Plan

May 2022

SFEI Contribution #1324

SFEI San Francisco Estuary Institute

San Francisco Bay
Nutrient Management Strategy
FY2023 Program Plan

May 03 2022

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1. INTRODUCTION

This document presents the Nutrient Management Strategy (NMS) Program Plan for FY2023, for review and approval by the NMS Steering Committee at its May 3, 2022, meeting. The FY2023 NMS Program Plan was developed following the approach outlined in **Box 1.**

An overview of the FY2023 Program Plan budget (Table 1) is presented in Section 2, including the including revenue sources and costs of individual Core Program and Project activities. The FY2023 Core Program activities and Projects are presented in more detail in Section 3, including: high level project description; recent progress or related work activities; FY2023 work; work products; and budget justification. Each project description also includes a schematic summarizing how the work aligns with NMS science/management priorities (See Science Plan Background for details).

Section 3 and Table 1 include only projects for which new FY2023 funding is being used. There are a number of other projects that were originally identified as high priority work for FY2023, but for which there is insufficient revenue available at this time. A subset of the high-priority unfunded projects are presented in Section 4. For those projects, NMS-SC approval is being sought to pursue those projects in the event that sufficient funding can be obtained.

Box 1 Process for Developing FY2023 Program Plan An initial set of FY2023 science and project priorities were identified by consulting the NMS SciencePlan2.0's multiyear workplan. The NMS SciencePlan2.0 was developed through priority-setting discussions with the NMS Steering Committee in 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. Using SciencePlan2.0 as a guide, a set of potential FY2023 projects was identified. Those projects were used as the basis for the discussions with the NMS Steering Committee (December 2021) and the NMS Nutrient Technical Workgroup (March 2022), where stakeholder feedback was gathered on science priorities and trade-offs. Additional SciencePlan2.0 background and details (program structure, management questions, science priorities, multi-year workplan) are available here, including instructions for navigating an expandable/collapsible version of SciencePlan2.0 and the FY2023 Program Plan.

2. FY2023 PROGRAM PLAN BUDGET

Table 1 provides an overview of the NMS FY2023 Program Plan Budget. Anticipated FY2023 revenue is $2,300,000 (row 4), coming from three sources (rows 1-3): NMS FY2023 Permit Funds; RMP Status and Trends funds for ship-based monitoring; and RMP special study funds.

Work for FY2023 is organized into Core Program (rows 5-8) and Projects (rows 10-15). For each Core Program activity and Project, the following information on cost and source of funds is provided:

A. Total FY23 Work:	total cost of work to be carried out in FY2023.
B. FY22 Carryover:	funds remaining from prior years (from the same or related project) that will be used to support continuation of work in FY2023.
C. Other Funds:	funds to be reallocated from a previously-approved project, to support different work in FY2023.
D. New FY23 Funds:	new FY2023 funding [D = A - (B + C)].

"Other Funds" in the budget would come from reallocating funding from a FY2021 project (P20 Future Scenarios: Workplan Development) and used to augment funding for three priority FY2023 projects (assessment framework, P3; two synthesis projects, P5 and P6). The pros/cons of this option will be discussed at the May 3 NMS Steering Committee meeting.

The FY2023 work requires $2,350,000 in New FY23 Funds. This cost exceeds New FY23 Revenue by $50,000. The end-of-year (FY2022) project balance and other elements of the NMS FY2023 operating budget were, however, estimated with conservative margins that we anticipate will offset this difference.

Table 1 FY2023 Program Plan Budget

	FY2023 REVENUE					
						New FY23 Revenue
1	R1	FY2023 Permit Funds				$1,800,000
2	R2	RMP ship-based monitoring				$250,000
3	R3	RMP special study funds *				$250,000
4		***Total***				**$2,300,000**
	COSTS		**A**	**B**	**C**	**D**
			Total FY23 Work	**FY22 carryover**	**Other Funds**	**New FY23 Funds**
	Core Program					
5	C1	Monitor: ship-based sampling	$400,000	$0	$0	$400,000
6	C2	Monitor: moored sensor network	$450,000	$0	$0	$450,000
7	C3	Core Modeling	$500,000	$0	$0	$500,000
8	C4	Science Program Coord. & Program Mngmnt	$700,000	$0	$0	$700,000
9		***subtotal***	***$2,050,000***	***$0***	***$0***	***$2,050,000***
	Projects					
10	P1a	Biogeochemistry Rate Measurements: South Bay	$60,000	$0	$0	$60,000
11	P2	Assessment Framework OpenBay (chl, DO, HABs)	$150,000	$70,000	$0	$80,000
12	P3	Assessment Framework LSB slough/creek DO	$115,000	$5,000	$35,000	$75,000
13	P4	Model Advisory Group	$25,000	$0	$0	$25,000
14	P5	Developing High-level Synthesis Products	$95,000	$35,000	$10,000	$50,000
15	P6	Technical Synthesis	$50,000	$0	$40,000	$10,000
16		***subtotal***	***$495,000***	***$110,000***	***$85,000***	***$300,000***
17		***Total***	***$2,545,000***	***$110,000***	***$85,000***	***$2,350,000***

* RMP special study funding decisions are generally finalized in Jul/Aug 2022. While this amount is consistent with RMP long-term planning, the amount remains uncertain.

3. FY2023 PROGRAM PLAN: CORE PROGRAM and PROJECTS

C1 Monitoring: Ship-Based Sampling	**Total FY23 Work**	**Estimated FY22 carryover**	**Other Funds**	**New FY23 Funds**
Team: USGS, UCSC, Bend Genetics, SFEI	$400,000	$0	$0	$400,000

Project Description

This project supports biweekly-to-monthly ship-based water quality cruises along San Francisco Bay's (SFB) deep channel. Work is pursued through an on-going collaboration with the USGS aboard the *R/V* Peterson, continuing the USGS' long-term SFB water quality measurements. The overall program is jointly funded by USGS, the RMP, and the NMS.

Progress in FY2022

- While the pandemic continued to impact cruise frequency and survey-area during the first couple months of FY2022, cruises returned to their pre-pandemic frequency and survey-area by September 2022. There will be a total of 19 cruises in FY2022 (compared to ~22/yr pre-pandemic), half full-Bay cruises and half South+Central Bay cruises.
- Measurements were performed using in-situ sensors, and discrete samples were collected and the following measurements performed: inorganic and organic nutrients; chlorophyll-*a*; phytoplankton taxonomy by microscopy; dissolved harmful algae (HA) toxins using SPATT; and molecular techniques for quantifying phytoplankton taxa (18s, 16s sequencing; targeted used of qPCR).
- USGS management of the ship-based sampling program was transferred in 2021 to the USGS Water Science Center (USGS-WSC) in Sacramento. A new collaborative agreement between SFEI (RMP + NMS) and USGS-WSC was developed and went into effect in October 2021. Staff from both organizations have met monthly during FY2022 to identify science priorities and opportunities for maximizing the program's effectiveness.
- In addition, SFEI staff collaborated with USGS-WSC staff on two successful USGS proposals (internal). The work, totaling $1.2M, targets science questions that are closely aligned with NMS priorities.

Plans for FY2023

- Ship-based samples from channel cruises will be collected and analyzed for the suite of nutrient-related parameters listed above.
- The number of cruises and regions sampled during FY2023 are anticipated to be similar to prior years (pre-COVID).
- Continuation of monthly-bimonthly strategic planning meetings (USGS-WSC, SFEI).

Alignment with NMS Priorities

Target				Science Focus Area						Program Area						Subembayment				
A AF	B Cond	C Link	D Mngmt	Nutri-ents	phyto DO open	phyto DO marg	HABs	Coast	Future Scen/ Risk	monit	model	spec study	Synth	AF	Prog Mgmt Coord	Suisun	San Pablo	Central	South	Lower South

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 $400,000 in funding includes both RMP (R2) and NMS (R1) funds. Approximately $250k from the RMP goes directly toward supporting 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 support for SFEI staff related to science coordination, project management, and data management ($25k). In-kind programmatic funds from the USGS cover the following: ship captain and direct costs (fuel, ship maintenance, transportation); program management support; and remaining technician costs (field, lab, data-management).

C2 Moored Sensor Network	Total FY23 Work	Estimated FY22 carryover	Other Funds	New FY23 Funds
Team: SFEI, USGS-BGC, USGS-MarFac	$450,000	$0	$0	$450,000

Project Description

Through this project, high-frequency water quality data (15-min) will be collected at the SFEI-NMS network of 12 mooring sites distributed throughout South Bay and Lower South Bay. Work includes:

- Monthly maintenance trips to each site (~2 boat days/month).
- Instrument maintenance and calibration.
- Data QA/QC and data management, along with refinements to data management tools.

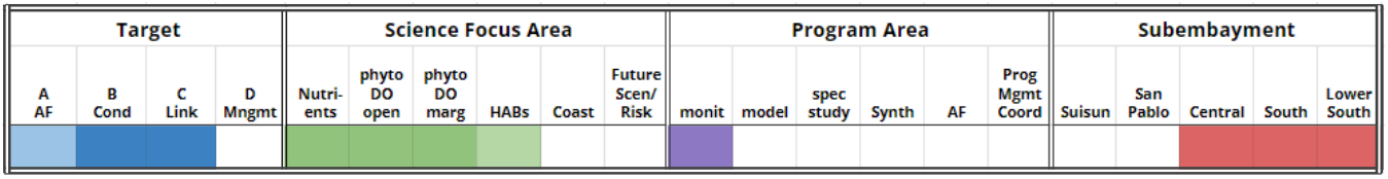
Work in FY2022

- Collected high-frequency sensor measurements at 9 existing stations, along with discrete monthly samples at 4 of those stations for sensor validation.
- Conducted monthly calibration and servicing of water quality instruments.
- In addition to continued data collection at SFEI's long-term sites in Alviso Slough and Guadalupe Slough, sensors were installed for dissolved oxygen and temperature measurements at 2 additional locations (one in each slough) to support additional condition assessment beginning September 2021.
- Data management codebase was restructured and streamlined.
- Developed QA/QC pipeline for new oxygen/ temperature sensors.

Plans for FY2023

- Continue water quality measurements at the 12 existing stations (9 "full" stations having multi-parameter instruments, 2 "mini" stations with oxygen sensors deployed) in South Bay and Lower South Bay for July 2022 – June 2023, including maintenance trips at 3-4 week intervals.
- Data QA/QC and data management, including incremental improvements to data management and QA/QC pipelines for sondes, nitrate sensors, oxygen sensors, turbidity sensor, and wave sensor.
- As part of an expanded data QA/QC effort, visualize and compare data across multiple stations and time periods.

Alignment with NMS Priorities



Work Products

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

Budget Justification

The mooring program cost for FY23 is ~15% higher cost than prior years. The higher cost results from: 1) increased overall program effort due to program expansion over past few years (new shoal location, new sensors, new slough locations); 2) cost increases due to inflation or cost-of-living (affecting SFEI labor and subcontracts); 3) higher direct costs in FY2023 to replace aging instrumentation and other equipment; and 4) more types of sensors and data streams requiring additional QA/QC effort. Costs include:

- Field support contracts with: USGS-Pacific Marine Facility (MARFAC), boat support for LSB servicing trips ($35k); USGS-CA Water Science Center, boat support for South Bay servicing trips, instrument coordination, sampling, sample processing, and interpretive/analytical support ($140k)
- SFEI labor for field and laboratory work, fieldwork planning and logistics, documentation, and overall project management ($140k)
- Data processing, review, and report outs ($75k)
- Replacement instrument (one EXO), reagents, equipment, and other direct expenses ($60k)

C3 Core Modeling	**Total FY23 Work**	**Estimated FY22 carryover**	**Other Funds**	**New FY23 Funds**
Team: SFEI, Four Peaks, RMA	$500,000	$0	$0	$500,000

Project Description

NMS Core Modeling work focuses on the development and application of three-dimensional hydrodynamic-biogeochemical models to predict or forecast water quality in San Francisco Bay. The 5-year modeling workplan presents the overall science and management questions, and provides a high-level overview of proposed modeling activities (2019-2024), with work organized into three broad categories: model development (hydrodynamics, biogeochemistry); model studies or applications to address management/science questions; and model maintenance/documentation and tools.

Progress in FY2022

- See also overview of modeling progress (2016-2019, Jan 2019 - Mar 2022)

Model Development

- Developed a technique for assessing modeling performance at predicting stratification and mixing layer depth, and applied the approach to WYs 2013, 2017 and 2018
- Continued improvements to light extinction coefficient (K_D) estimates, including: numerical experiments to evaluate biogeochemical model sensitivity to K_D at various space/time scales (lateral gradients K_D; temporal averaging - hourly, subtidal, daily, multi-day); quantifying uncertainty in predicted light extinction coefficients; convened an expert panel to guide next steps for refining K_D.
- Extended aggregated grid biogeochemistry model to simulate WY2013-WY2018
- Biogeochemical model upgrades, tuning, and sensitivity analysis over wy2013-2018,, including: calibrating sediment flux model initial conditions and diagenesis rates; adding a second phytoplankton class with different growth-setting optima; testing the incorporation of benthic grazers in addition to zooplankton (pelagic vs. benthic grazer top down controls); sensitivity analysis for key parameter sets, both to inform model tuning and priority field data needs.
- Validated model performance against high-frequency chl-a, DO and NO3 data in addition to USGS cruise data
- Writing a technical report documenting development work undertaken since completing the prior update (SFEI 2020).
- Applied the current-best parameter sets from aggregated grid model explorations to full-resolution model and evaluated model performance across WY2013, WY2017, WY2018.
- Major modifications to and testing of the Delta-Suisun BGC model (link to Report)

Model Application

- Using the updated model calibration described under *Model Development, e*xtended the analysis related to nutrient cycling/fate (transport, transformations) and ecosystem response (production, metabolism, oxygen levels) from the August 2020 modeling update report (SFEI 2020, see Section 5) to additional water years and subembayments, and to coastal exports. Technical reports are under development, with drafts to be completed during summer 2022.
- Developed interpretations of key sensitivities and drivers of primary production including light, grazers and transport
- Using the Delta-Suisun model: evaluated the importance of nutrients, light and grazers [pelagic and benthic (freshwater and saltwater)] on primary production and overall nutrient cycling in Suisun Bay and Delta (SFEI 2021b); characterized nutrient cycling and fluxes (within Delta, and downstream fluxes to SFB), including the influence of Delta Cross Channel operation and pumping rates on DIN transport pathways; and changes in nutrient loads from the Regional San upgrade (SFEI 2021a)

Modeling Planning, Documentation, and Infrastructure

- Worked with the NMS-SC Modeling Subcommittee to develop approach for convening the Model Advisory Group, developed technical materials (reading, meeting materials), and participated in the first MAG workshop in late March 2022 (SFEI labor covered under C2, support for MAG Chair MAG member honoraria covered by a different NMS project).
- *Computing Capacity:* Increased in-house computing capacity with purchase of three new Linux workstations from Aspen Systems. Each machine has 16 AMD EPYC 7282 2.8GHz cores with 64MB cache, 128GB RAM, 1 Tb SSD, and 20Tb HDD, and is running Ubuntu 20.04 LTS. SFEI also recently upgraded its local area network (other funds, not NMS) from 1Gb/s to 10Gb/s, allowing our four machines and archival disk to share large datasets, such as the ~500 Gb output of our hydrodynamic simulations.
- 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.

Plans for FY2023

Note: The following are provided as examples. The primary focus areas for FY2023 work will be finalized during summer 2022 based on feedback from the MAG process.

Model Development

- Extension of hydrodynamic and biogeochemical simulations to WYs 2019 and 2020 was originally planned for FY22, but will now be completed in FY23. This will 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 improvements to light extinction coefficient estimates incorporating input from expert panel received in FY22.
- Extend full resolution biogeochemistry simulations to WY2014-2016 and WY2019-WY2020.
- Targeted investment into O_2 related processes and model performance predicting DO.
- Model refinements and model validation updates based on: (1) MAG feedback from workshops 1 (completed) and workshop 2 (planned mid- to late-summer 2022); (2) model performance in WY2019-WY2020. The refinements will continue to advance a "global" calibration that works across multiple water years covering a range of hydrological and meteorological conditions.

Model Application

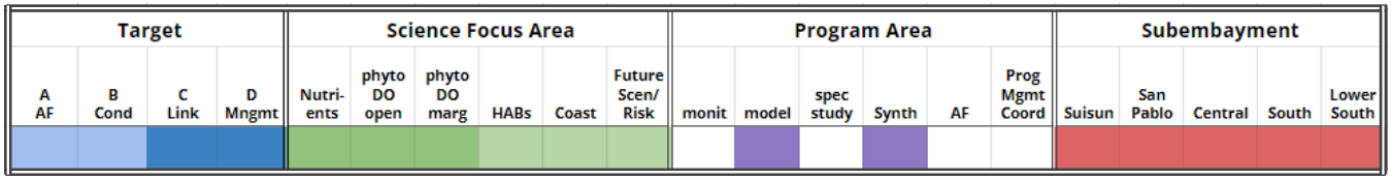
- Continue with in-depth mechanistic/quantitative interpretations of multi-year biogeochemistry simulations using both the aggregated and full resolution models. Work that is currently underway in FY22 is focused primarily on nutrient cycling, primary production, and assessing mixed-layer-depth prediction, with draft technical reports completed during summer 2022. Those technical reports will be integrated into the MAG process, and will be further refined for submission to peer-reviewed journals.
- Pursuing priority modeling application studies, both as part of continued/iterative model development/improvement and to provisionally address NMS science/management questions. Specific applications may be related to: source apportionment and/or subembayment or Management Unit delineation (e.g., next steps from SFEI 2021); quantitatively exploring/testing hypotheses for explaining observed changes in ecosystem response (e.g., changes in suspended sediment concentration i.e., K_D; changes in benthic grazer abundance); simulating extreme events or potential future scenarios; evaluating the importance of, or sensitivity to, ocean boundary conditions (e.g., upwelling and its influence on DO and DIN concentrations/net-flux); generate multi-year time-series of freshwater and nutrient export flux through the Golden Gate -- explore key drivers of interannual/seasonal variability, and pass output to coastal modeling effort for simulation of coastal response (collaborators: SCCWRP, UCSC, UCLA); developing a framework for model uncertainty assessments in answering science and management questions from the context of key decision variables for nutrient management in SFB.

Modeling Planning, Documentation, and Infrastructure

- Model Advisory Group process: preparing for MAG workshops #2 (late-summer or early-fall 2022) and #3 (winter 2023), and responding to MAG feedback from workshop #1-#3; working with the NMS Modeling Subcommittee MAG Chair on MAG feedback, and designing/preparing for upcoming workshops.

- Optimizing Computing Resource Utilization: The modeling team will look for ways to take advantage of the additional computational capacity by utilizing parallelization capabilities within DFM/DWAQ to the extent feasible, and centralize storage to optimize disk space requirements and data transfers over the network.
- Continued investment in model documentation, and systematic/semi-automated approaches for model setup and post-processing, consistent with ultimately making models, model-utilities, and data publicly available.

Alignment with NMS Priorities



Work Products

- NMS Modeling Status Report, July 2022, including technical updates on the FY22 Model Development work described above
- Multiple technical reports on model applications: nutrient cycling and mass balances; phytoplankton production, source/sink regions, factors regulating production/blooms, full-bay model; phytoplankton production, source/sink regions, factors regulating production/blooms, Suisun-Delta model; evaluating mixed-layer-depth prediction. Two or more of these will also be refined and submitted as journal manuscripts.
- Modeling products (updated model versions, datasets, etc.; documentation in technical report will be subsequent year's model update report): WY2019-2020 hydrodynamic results; next iteration of improved K_D; setup/run/evaluation of new biogeochemical simulations of WY2019-2020, WY2003, WY2006 (including updated K_D);
- Report-outs from MAG.
- Model documentation, code for pre-/post-processing (ongoing)

Budget Justification

The Core Modeling funding will be distributed as follows (approximately): Model Development ($200k); Model Application ($250k); model documentation ($25k); and preparation for Model Advisory Group meetings (up to $25k). Funds will support core modeling team labor (SFEI, Four Peaks; ~2.3 FTE).

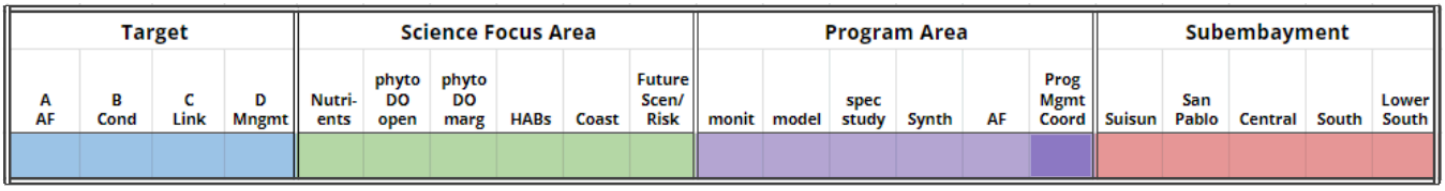
C4 Science Coordination and Program Management	**Total FY23 Work**	**Estimated FY22 carryover**	**Other Funds**	**New FY23 Funds**
Team: SFEI	$700,000	$0	$0	$700,000

Project Description

This funding covers the costs associated with overall science program coordination and NMS program management. Work includes:

- Science oversight for all aspects of the NMS, including multi-year science planning, study design, scientific contributions to projects, review of work products, and identifying on-going NMS science priorities.
- Effectively engaging stakeholders through planning for and leading official NMS meetings and work groups (Steering Committee, Planning Subcommittee, Nutrient Technical Workgroup, other subcommittees), and additional stakeholder engagement, including regulators (Water Board, EPA), dischargers, and other stakeholders.
- Managing workflow and resource allocation for NMS technical projects to produce high quality work products and meet deliverable schedules.
- Project and program budget tracking, developing and managing external contracts, accounting/invoicing, and quarterly budget updates.
- Fundraising

Project Alignment with NMS Priorities



Budget Justification:

Funding for C4 supports the following: 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)]; full-time program manager [budgets, overall project management/workflow/deliverables, stakeholder engagement)]; partial support for a field program manager [0.2 FTE; science oversight and integration across NMS field activities]; internal program management [0.3 FTE, distributed over ~8 staff, to support participating in internal meetings, joining NMS-SC and other stakeholder meetings, contributing to annual work plans]; accounting/financial-management/contracting (0.25 FTE), additional stakeholder engagement support (Wren, ~0.1 FTE), and travel ($5k).

P1a Biogeochemistry Rate Measurements: South Bay, cont'd	**Total FY23 Work**	**Estimated FY22 carryover**	**Other Funds**	**New FY23 Funds**
Team: Stanford, UMCES, USGS	$60,000	$0	$0	$60,000

Project Description

This project is a continuation of a multi-year NMS study launched in FY2020 (SFEI 2019, 2020). The study is targeting important data gaps related to key biogeochemical process rates in South Bay and Lower South Bay, with a particular emphasis on rates occurring within the sediments or at the sediment:water interface (e.g., denitrification, oxygen demand, N and P fluxes). Field studies were designed with input from expert advisors, and carried out in collaboration with researchers from Stanford and UMCES. FY2023 will be the final year of the project, with the conclusion of a final report and/or manuscript.

Progress in FY2022

- The combined sediment field sampling and lab incubation program was successfully carried out on two dates (Aug and Nov 2021), with incubation experiments conducted with sediment cores from 8-10 sites per date. Results from these two new dates will be combined with results from the three prior coring/incubation surveys (Oct 2020, Feb 2021, May 2021).
- Measurements in Aug 2021 and Nov 2021 included: sediment transformations (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.).
- Water column field sampling and incubations were also completed on two dates (July and October 2021) at 8-10 sites per date. Measurements included: water column transformations (nitrification, oxygen demand, production) and water column characteristics (nutrient concentrations, chlorophyll, microbial communities etc.).
- The postdoc at Stanford processed most of the samples from the field and lab sampling and started to analyze the data generated from the study. The preliminary analyses were presented at the Joint Aquatic Sciences Meeting in May.

Plans for FY2023

- The rest of the samples collected will be analyzed, with a focus on metagenomic analysis of the microbial samples (additional funding through Stanford).
- Share remaining data with the NMS modeling team so it can be used to calibrate the biogeochemical model.

- Results will be summarized in one or more technical report(s) and corresponding manuscript(s) for peer-review.

Project Alignment with NMS Priorities

Target				Science Focus Area						Program Area						Subembayment				
A AF	B Cond	C Link	D Mngmt	Nutri-ents	phyto DO open	phyto DO marg	HABs	Coast	Future Scen/ Risk	monit	model	spec study	Synth	AF	Prog Mgmt Coord	Suisun	San Pablo	Central	South	Lower South

This project primarily targets mechanisms and/or developing *Links* between nutrients and response variables, including through incorporating data into (or helping tune) numerical models. The results are directly applicable to multiple Focus Areas (via nutrient cycle/availability), including *Nutrients* (rate data for estimating denitrification (i.e., assimilation), *Phytoplankton-DO in open-Bay habitats* (oxygen demand in response to prior phytoplankton blooms). The work is primarily Special Study and Synthesis, related to nutrient cycling and metabolism, however a key motivation for pursuing this work was for the results to be integrated into Modeling. *Subembembayments:* directly relevant to conditions in South Bay, Central Bay, and Lower South Bay, with indirect strong benefits for Suisun and San Pablo.

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:

Project funding will support a six month extension of the postdoc position at Stanford ($60k) to provide adequate time for data analysis, interpretation, and report/manuscript writing.

P2 Assessment Framework: Deep Subtidal / Open-Bay Habitats	**Total FY23 Work**	**Estimated FY22 carryover**	**Other Funds**	**New FY23 Funds**
Team: SFEI, SCCWRP	$150,000	$70,000	$0	$80,000

Project Description

The primary goal of this project is to further develop and refine a nutrient-related assessment framework (AF) for SFB: rigorously-developed set of indicators, metrics, and numeric criteria (a 'yardstick'), integrated within a decision framework for evaluating whether beneficial uses are being attained.

Work during FY2021-FY2022

- Meetings with the NMS AF Subcommittee to identify and discuss stakeholder and regulator priorities for continued AF development. This planning process culminated in the development of a draft Assessment FrameworkDevelopment Workplan (SFEI 2022).
- Pursuing technical work (data collection, analysis/synthesis) that will be used in the development of Deep-Subtidal/OpenBay Assessment Framework 2.0, including: method development (statistical) for characterizing/quantifying temporal trends in indicators such as chl-a, dissolved oxygen, and gross primary productivity; application of those techniques to detect or quantify changes in those indicators at locations throughout Central, South, and Lower South Bays (1992-2019 or 1980-2019); developing and testing molecular techniques for improved detection and quantitation of HAB-forming taxa; analysis/synthesis of HAB-related datasets collected over the past 5+ years (abundance of HAB-forming taxa; toxins in water and bivalves; ancillary data); expanding monitoring activities to characterize space-time variability of relevant indicators in data-limited regions/habitats (e.g., monitoring conditions in shoal habitats of South Bay; use of high-frequency in-situ DO sensors at channel and shoal locations).
- Developing a detailed plan for deep subtidal AF work during May 2022 - Nov 2023 (to be completed Jun-July 2022).

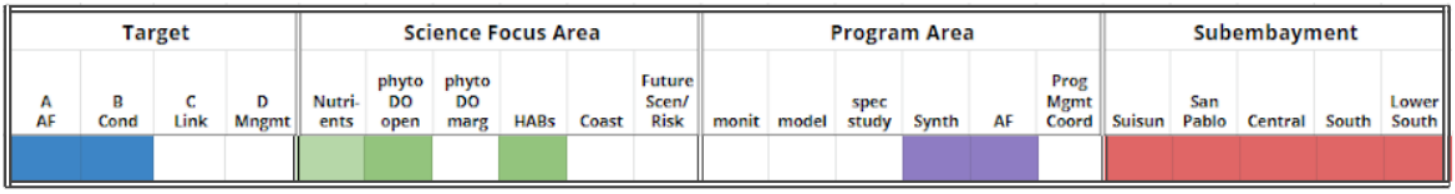
Plans for FY2023

- Hold a series of meetings with Water Board staff (May-August 2022) to further clarify anticipated use-cases for the deep subtidal AF; specific goals/needs stemming from those use cases. Meetings with the full NMS AF Subcommittee will also be held during this time to gather stakeholder feedback on the evolving (and narrowing) set of technical priorities and project timeline.
- A primary motivation of this goals- or needs-defining process is to shape that information into a strawdog structure for the SFB deep subtidal AF, including narrowed-down or prioritized set of potential indicators (relative to the list in SFEI 2022

Figure 6); regulator and stakeholder priorities and/or concerns, organized into a set of charge questions that will be used to shape an upcoming AF expert workgroup meeting.

- As the above process is moving forward, develop the technical resources that are needed to inform, catalyze or focus discussion at the expert workgroup meeting, including: assemble and visualize long-term data and newly-collected AF-related data (past several years); develop a shortlist of proposed statistical approaches/analyses for identifying numeric thresholds for the potential indicators and metrics, and (time permitting) test a subset of these techniques.
- Convene an expert meeting (e.g., #1 Sep 2022) focused on reviewing and providing recommendations for priority work over the subsequent 9-12 months (Oct 2022 - Jun 2023) for exploring indicator-metrics, informed by needs/goals communicated by regulators and stakeholders. The expert team may be convened for additional workgroup meetings later in FY2023.
- Capture expert feedback (relative to charge questions) and recommendations. Report-out to WB and AF Subcommittee in Sep-Oct 2022 with an updated strawdog AF structure. Begin pursuing the highest priority analyses, with the aim of generating a draft technical report by July 2023. Based on feedback from expert workgroup, WB, and stakeholders, the report will be refined and shared as a final report by November 2023.

Alignment with NMS Priorities



Work Products

- Strawdog deep-subtidal AF structure, revised at various junctures based on expert, WB, and stakeholder input.
- Technical report fleshing out: details of the deep subtidal AF structure, results from data analysis (and/or literature review, or expert best professional judgment), and recommendations (priority indicators,options for numeric thresholds). Draft: July 2023; Final: Nov 2023.

Budget Justification:

The project's $150,00 budget is for work carried out Jul 2022 - Jun 2023. [work prior to Jul 2022 will be supported by the FY2022 budget; and post Jun 2023 would be covered by FY2024 funding). Costs include: $110k for SCCWRP (~55k) and SFEI (~55k) labor; $30k for expert honoraria; and $10k travel/lodging, 1-2 in-person meeting(s)

P3 Assessment Framework: DO in LSB Sloughs and Creeks	**Total FY23 Work**	**Estimated FY22 carryover**	**Other Funds**	**New FY23 Funds**
Team: SFEI, SCCWRP, UC Davis, Princeton, Tetra Tech, UC Berkeley	$115,000	$5,000	$35,000	$75,000

Project Description

The primary aim of this project is to develop the scientific basis for identifying protective dissolved oxygen (DO) conditions for LSB margins and sloughs using multiple lines of evidence. Work has been moving forward on developing 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 analyses following the concepts and structure laid out in the Virginia Province Approach (VPA); ii) analysis of multi-stressor approach(es), i.e., temperature, 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. The FY2022 and FY2023 work are aligned with the overall plan laid out in the Assessment Framework Workplan.

Progress in FY2022

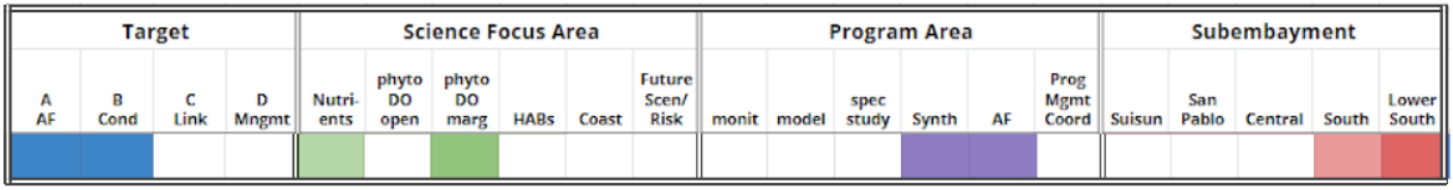
- Met regularly with the AF subcommittee to gather input and to keep stakeholders informed of progress.
- Convened several meetings with experts to identify recommended approaches for three complementary lines of evidence: Virginia Province Approach; analysis/interpretation of fish survey data; and a metabolic index approach (T-dependent variability in DO requirements).
- Collaborators/consultants at Tetra Tech continued to develop the VPA analysis, including meeting with stakeholders and presenting updates at AF subcommittee meetings for input.
- Levi Lewis refined the statistical modeling approach for the fish community data based on expert input. He has started to draft a technical report summarizing updated analysis.
- Supported UC Davis to conduct intensive sampling of fish communities in the summer based on recommendations from experts.
- Met with a subset of experts to advance metabolic index approach, and to identify how it will support other lines of evidence. Made progress with the scoping effort and identified possible ways to apply the analysis in delimit protective oxygen concentrations.

Plans for FY2023

- Complete the development of the VPA and refine based on stakeholder and expert input.
- Refine statistical modeling approach. Analyze fish abundance data, including intensive summer dataset, to determine protective DO concentrations for biota

- Continue metabolic index analysis for LSB fish species and develop crosswalk to the VPA criteria.
- 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.

Alignment with NMS Priorities



Work Products

- Technical report summarizing application of the VPA to characterize habitat condition in LSB sloughs and creeks
- Technical report summarizing the intensive summer sampling dataset (Aug/Sept 2021) and recent updates to the GAM analysis of fish abundance data
- Summary report detailing the multi stressor work and analysis of fish abundance data, including results from analyses to-date, data needs, potential usage within regulatory or management decision frameworks, crosswalk to the VPA, and recommended next steps.

Budget Justification:

Approximately 25% ($30k) of funds will support external collaborators working on these projects, 15% ($17k) will support guidance and input from Martha Sutula, <10% ($8k) will go to expert who join expert meetings, and 50% ($61k) will support SFEI staff on data analysis/interpretation, reporting, and managing the overall project.

P4 Model Advisory Group (MAG)	Total FY23 Work	Estimated FY22 carryover	Other Funds	New FY23 Funds
Team: SFEI, Four Peaks, SCCWRP	$25,000	$0	$0	$25,000

Project Description

Convene the second and third meetings of the NMS Model Advisory Group (MAG) in late-summer/early-fall 2022 and Feb-Mar 2023.

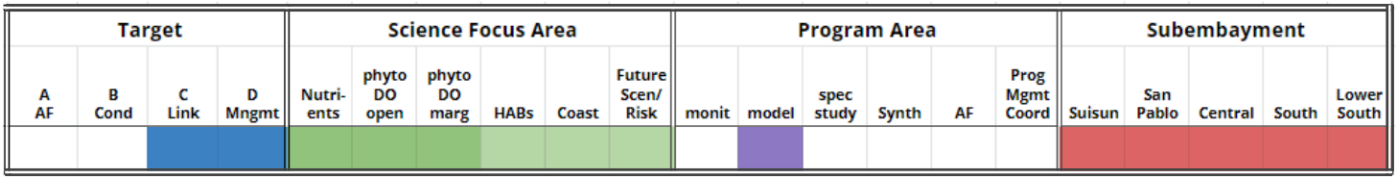
Progress in FY2022

- SFEI staff worked with the NMS Modeling Subcommittee to develop the approach and charge for convening the Model Advisory Group (MAG).
- The first MAG workshop was held March 29-30, 2022 (remote, half-days). The workshop focused on introducing the MAG to the NMS modeling goals (management questions, technical/science issues in SFB); exploring the approach taken for NMS model development (NMS Modeling Workplan), and status of modeling effort; and reviewing the NMS modeling team's approach to evaluating model performance, and providing feedback relative to the intended NMS science and management questions.

Plans for FY2023

- The second MAG workshop (summer/early-fall 2022) will focus on assessing model performance and interpretations from early model applications.
- The third MAG workshop (winter/spring 2023) will focus on a subset of prioritized model applications.

Alignment with NMS Priorities



Work Products

- MAG presentations (SFEI effort funded through C2 Core Modeling)
- Report-outs/Feedback from MAG to stakeholders.

Budget Justification:

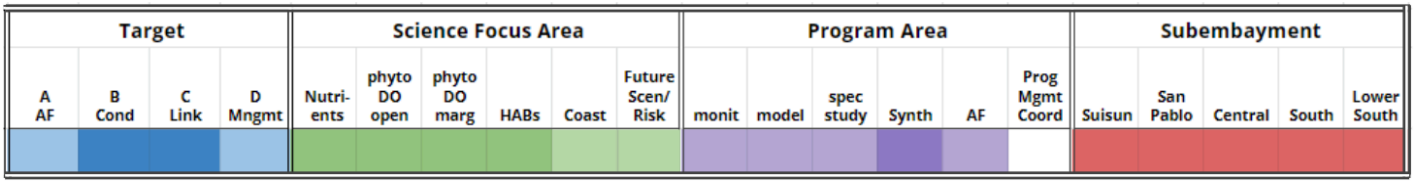
The original round of funding covered MAG honoraria for the first two workshops, and the MAG Chair's support for workshop one and partial support for workshop two. The $25k will be directed toward the following: additional support for the MAG Chair (workshops 2 and 3); MAG honoraria for workshop 3; travel and lodging, if workshops 2 and 3 are in person. Additional funding may be needed if both upcoming workshops are in-person.

P5 Developing High-level Synthesis Products	Total FY23 Work	Estimated FY22 carryover	Other Funds	New FY23 Funds
Team: SFEI	$95,000	$35,000	$10,000	$50,000

Project Description

This project will focus on developing work products (reports, documents, memos) that provide high-level report-outs on NMS Science Program activities/initiatives and findings. While there have been a number of recent technical reports analyzing/synthesizing NMS results (e.g., links in Table 3, FY2021 Annual Report), NMS Steering Committee members and other stakeholders have recently emphasized the value of higher-level synthesis documents that summarize priority or new findings related to our evolving understanding of nutrient-related conditions in San Francisco Bay.

Alignment with NMS Priorities



Work Products

Two types of high-level synthesis reports are planned for FY2023

- *Multiyear Report*: ($65,000) A graphics-rich report highlighting major NMS activities, key findings, and science advancements over the prior 1-3 years. This project was approved for FY2022, but was underfunded ($35,000), and work did not yet begin. Those funds are being carried-forward to FY2023, and will be supplemented with $30,000 from FY2023.
- *High-level synthesis (or summaries) of NMS findings* ($30,000): The specific focus of these write-up(s) will be determined over the next few months. Examples include: update to the NMS *State of the Science* ; status of NMS monitoring program development ; developing, compiling, and integrating 'executive-summaries' from recent high-priority technical reports.

Budget Justification:

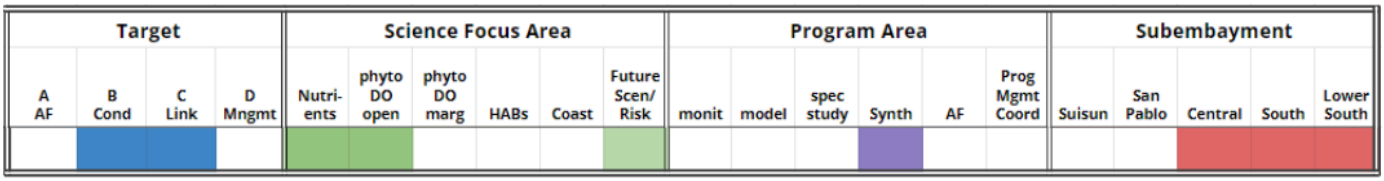
Funds for this project come from three sources: rolling-over $35k from FY2022 P22 (Multiyear Report); $10,000 from the redistribution of FY2022 P20 (Future Scenarios Workplan Development); and $50,000 in new FY2023 funding.

P6 Technical Synthesis	Total FY23 Work	Estimated FY22 carryover	Other Funds	New FY23 Funds
Team: SFEI	$40,000	$0	$40,000	$0

Project Description

Pursue the interpretation of observational data in South Bay or Lower South Bay. Funds will be used to support one of the following: analysis/synthesis and write-up related to a narrowly-defined (achievable with $40k) yet still priority topic (e.g., recently collected dataset; focused science question or hypothesis); augment an on-going synthesis study, work that would benefit either from more comprehensive or deeper investigation, or the funds could support more completely writing-up/documenting the work (e.g., FY21 P12 high biomass events; or FY21 P13 LSB synthesis/interpretations; or shoal synthesis;, whichever is most promising, or needs it most).

Alignment with NMS Priorities



Work Products

- One or more Technical Reports

Budget Justification:

Funds will support SFEI labor, and potential engagement of external collaborator(s) or expert advisor(s).

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4. OTHER HIGH-PRIORITY PROJECTS: PURSUE IN FY2023, FUNDS PERMITTING

P7 Lateral Variability: Shoal Mapping	**Funding Needed**
Team: SFEI, USGS-BGC	$185,000

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 P7 aims to standardize spatial characterization of shoal water quality as part of the Bay monitoring program. The project will support 4-6 (spring 2022 thru fall 2022) high-speed biogeochemical mapping surveys, 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 FY2022

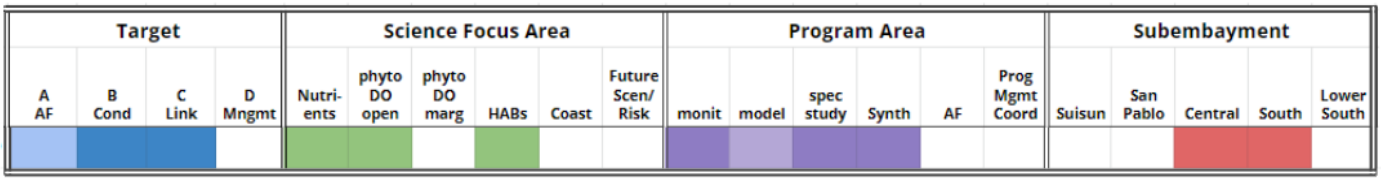
- Three spring/summer water quality mapping trips to supplement data from newly deployed shoal-monitoring stations.
- Standardization of mapping logistics; approach/coordination between SFEI and USGS-BGC
- Deployment of three shoal moorings to complement water quality mapping.

Plans for FY2023

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

- Synthesize/interpret mapping data, alongside other datasets.

Alignment with NMS Priorities



Work Products

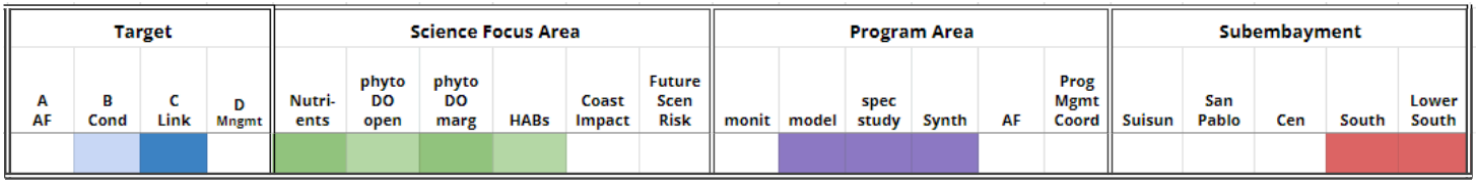
- Three mapping cruises in South Bay, yielding one or more two-dimensional water quality maps per trip.
- Corresponding discrete sample data from 10-15 locations per cruise: nutrient, chlorophyll-a and sediment samples; phytoplankton assemblage (including HABs).
- Data analysis and interpretation, bringing together results and interpretations with those from a related synthesis project (FY21 P10), and write-up as a technical report.

Budget Justification

Project budget will cover the following costs: mapping boat preparation, field time, and data curation (USGS-BGC: $120k, 5-6 surveys @ $20k/survey); discrete sample analysis [$20k: nutrients, chl-a (CBL); phytoplankton by 18s/16s sequencing (Bend Genetics)]; SFEI survey-related labor (joining subset of cruises, post-survey sample processing, data curation, and project management ($15k); and data analysis/interpretation and report preparation ($50k).

P1b Biogeochem Field Study: Lower South Bay	**Funding Needed**
Team: SFEI, others TBD	$100,000

[coming soon]

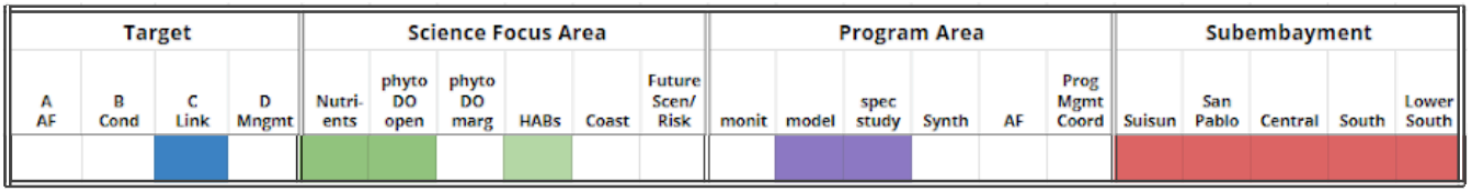


Alignment with NMS Priorities

P3 Predicting/Estimating Suspended Sediment Concentration (Kd) (modeling)	**Funding Needed**
Team: SFEI, RMA, others	$100,000

Results from NMS modeling work indicate that space-time variations in water column light extinction coefficients (K_D) are among the most important data gaps with regard to predicting both phytoplankton production and nutrient cycling. In general, the main control on K_D in SFB is suspended sediment concentration (SSC; k_att proportional to 1/SSC). This project will address this critical data gap by pursuing: i) empirical/semi-empirical approaches for predicted K_D (x,y,t) (potentially including remote-sensed data products); ii) making an incremental investment in the development of a sediment transport model.

Alignment with NMS Priorities



Evidence from NMS studies indicate that the interaction between Lower South Bay's (LSB's) high nutrient concentrations and tidal exchange with restored salt ponds can have substantial near-field effects on water quality in adjacent sloughs, e.g., high phytoplankton biomass and low dissolved oxygen (SFEI 2015, SFEI 20188, SFEI 2021a, SFEI 2021b). While the effects are most pronounced in sloughs that tidally-exchange with restored ponds, high biomass and related oxygen demand may also be affecting water quality in open-bay habitats of LSB.
A key NMS science and management priority is to quantitatively characterize the relationship between nutrients (loads, concentrations), transport/exchange-with ponds, excess biomass production, and effects on dissolved oxygen (i.e., C Link). Building this quantitative understanding will require a combination of technical approaches, including targeted field measurements, numerical modeling/simulations, and synthesis, and will be a multi-year undertaking. IIn FY2022, two projects were launched, one a field/synthesis study and the other a model development study were NMS projects were launched.
This project (FY2023 P1b) would build upon and continue that work. The specific direction and approach for the next round of work will be informed by the findings and recommendations from the FY2022 studies (available summer/fall 2022). Options include:

- A combination of synthesis of existing data and numerical model simulations to quantify physical exchange or transport and transformations.
- Targeted data collection
- Additional model improvements.
- A combination of the above.

Section 3 and Table 1 include only projects for which new FY2023 funding is being used. There are a number of other projects that were originally identified as high priority work for FY2023, but for which there are insufficient funds available at this time. A subset of the high-priority unfunded projects are presented in Section 4. For those projects, NMS-SC approval is being sought to pursue those projects in the event that sufficient funding can be obtained. The additional high-priority projects are included in Table A1, which also provides an at-a-glance overview of the how the full set of FY2023 work aligns with NMS science/and management priorities.