San Francisco Bay Nutrient Management Strategy

FY2024 Program Plan

May 2023

SFEI Contribution #1325

SFEI San Francisco Estuary Institute

San Francisco Bay
Nutrient Management Strategy
FY2024 Program Plan

May 12, 2023

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1. INTRODUCTION

This document presents Nutrient Management Strategy (NMS) Program Plan for FY2024, which was reviewed and approved by the NMS Steering Committee at its May 12, 2023, meeting. The FY2024 NMS Program Plan was developed following the approach outlined in **Box 1.**

An overview of the FY2024 Program Plan budget (Table 1) is presented in Section 2, including revenue sources, and costs of individual Core Program work and Projects. The FY2024 Core Program activities and Projects are presented in more detail in Section 3, including: high level project description; recent progress or related work activities; FY2024 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 projects for which new FY2024 Permit (or RMP) funding is being used in FY2024.

Section 4 summarizes additional projects, organized into a few categories: i) Additional science priorities for FY2024 that are currently unfunded due to insufficient funds; ii) new or upcoming projects that address NMS science priorities but are funded by other funding sources (no new funds requested in the FY2024 Program Plan); and iii) Major projects funded during FY2023 that will be continuing into FY2024 (no new funding). For the unfunded projects (i), NMS-SC authorization is being sought to pursue that work should sufficient funding become available.

Box 1 Process for Developing FY2024 Program Plan An initial set of FY2024 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 FY2024 projects was identified. Those projects were used as the basis for discussion during the March 2023 NMS Steering Committee meeting, 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 FY2024 Program Plan.

2. FY2023 PROGRAM PLAN BUDGET

Table 1 provides an overview of the NMS FY2024 Program Plan Budget.

Estimated FY2024 Revenue: Estimated revenue is $2,475,000 (row 6), coming from four sources: NMS FY2023 Permit Funds; RMP Status and Trends funds for ship-based monitoring (row 3); and RMP special study funds (row 4); and carry-forward funds (row 5; from FY2023 C4, to be applied to FY2024 C4).

FY2024 Expenses: Work for FY2024 is organized into Core Program (rows 5-8) and Projects (rows 6-9) and sums to $2,443,000, leaving an estimated balance of 32,000.

Note: The Projects included in Table 1 are a subset of the priority science work originally identified for FY2024, and represent the highest priority work that can be pursued with current FY2024 revenue estimates. See Section 4 for additional high priority projects.

Table 1 FY2024 Program Plan Budget

	FY2024 REVENUE (Estimated)		
			Revenue
1	**R.1**	Nutrient Permit: FY2024 Funds [1]	1,800,000
2	**R.2**	RMP CY2024 special study funds [2]	250,000
3	**R.3**	RMP Contribution to ship-based monitoring [3]	250,000
4	**R.4**	Carry-forward funds, from FY2023 C4[4]	175,000
5		**FY2024 Total Revenue**	**2,475,000**
	FY2024 EXPENSES (Proposed)		
			Expenses
	1. PROGRAM		
	Monitoring		
6	**C1**	Ship-based channel monitoring: sampling, analysis	519,000
7	**C2**	Mooring Network: data analysis, interpretation, maintenance	490,000
	Modeling		
8	**C3**	Biogeochemical model development and application	500,000
	Program coordination		
9	**C4**	Science Program Coordination	559,000
10		***Program subtotal***	***2,068,000***
	2. PROJECTS		
11	**P1**	Assessment Framework, LSB DO, wrap-up	110,000
12	**P2**	Central Bay water quality mooring	100,000
13	**P3**	Model Advisory Group, continuation	40,000
14	**P4**	Monitoring water quality analysis: program evaluation	75,000
15	**P5**	Shoal Mapping: South/Central Bays	50,000
16		***Projects subtotal***	***375,000***
17		**FY2024 Total Expenses**	**2,443,000**
18		**FY2024 Balance**	**32,000**
	[1] NMS Permit Funding available for FY2024		
	[2] RMP contribution (from RMP Special Studies) has generally been ~$250,000, and has been used to offset C2 Mooring program costs. RMP will finalize funding decisions in Jul/Aug 2024.		
	[3] This funding goes directly to USGS to support ship-based monitoring, and offsets costs under C1.		
	[4] Carry-forward funds from FY2023 C4, applied to FY2024 C4 budget		

3. FY2024 PROGRAM PLAN: CORE PROGRAM and PROJECTS

3.1 CORE PROGRAM

C1 Monitoring: Ship-Based Sampling	Total FY24 Work	Other Funds	FY24 Permit Funds
Team: USGS, UCSC, Bend Genetics, BSA, SFEI	$519,000	$250,000*	$269,000

*Other Funds: RMP Status and Trends funding for water quality cruises

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 FY2023

- FY2023 is on track to have a total of 19 R/V Peterson cruises, half full-Bay cruises and half South+Central Bay cruises. One cruise in December 2022 was canceled due to engine issues with the *R/V* Peterson.
- 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).
- The collaborative agreement between SFEI (RMP + NMS) and the USGS Water Science Center (USGS-WSC) continued in FY23. Staff from both organizations have met monthly to identify science priorities and opportunities for maximizing the program's effectiveness.
- Additional sampling was conducted in August 2022 in response to the HAB event. Extra samples were collected during the scheduled South Bay cruise, and an additional South Bay cruise was conducted with expanded sampling locations on the shoal.

Plans for FY2024

- 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 FY2024 are anticipated to be similar to FY2023.
- 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

a. Datasets for nutrients, chlorophyll-a, phytoplankton community, and toxins, which will be made publicly available either through the USGS website or through the NMS.

b. Results summarized in NMS Multi-year Report.

c. Data will be used in other NMS program areas (model calibration, condition assessment, Assessment Framework development).

Budget Justification:

The $519,000 in funding includes both RMP and NMS 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. NMS funds ($269k) will support the following: nutrient measurements (ammonium, nitrate + nitrite, reactive phosphorus, dissolved silicate; total N and total P measured in approximately half of the samples; CBL, $25k); phytoplankton taxonomy by microscopy (BSA, $58k); dissolved toxin measurements (UCSC, $36k); molecular techniques for detecting and quantifying HA abundance and further characterizing phytoplankton assemblage (18s,16s amplicon sequencing; qPCR; Bend Genetics, $25k); and support for SFEI staff related to science coordination, project management, and data management ($6k).

USGS in-kind programmatic funds cover the following: ship captain and direct costs (fuel, ship maintenance, transportation); program management support; and remaining technician costs (field, lab, data-management).

Note that the estimated cost of $519,000 represents a $119,000 cost increase over prior years (FY2021-FY2023). The majority of the cost increase is related to the R/V Peterson work's shift to the USGS Water Science Center (in general, less USGS hard-money support). NMS funds will be used to cover the FY2024 cost increase. During FY2024, SFEI and USGS will be reviewing science priorities, costs, and opportunities for maximizing cost-effectiveness (i.e., maximizing priority science & monitoring with available funds) .

C2 Moored Sensor Network	Total FY24 Work	Other Funds	FY24 Permit Funds
Team: SFEI, USGS-BGC, USGS-MarFac	$490,000	$250,000*	$240,000

*Other Funds: RMP Special Study funds (estimated)

Project Description

This project will support the collection of high-frequency water quality data (15-min) 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 (~3 boat days/month).
- Instrument maintenance and calibration.
- Data QA/QC and data management, along with refinements to data management tools.

Work in FY2023

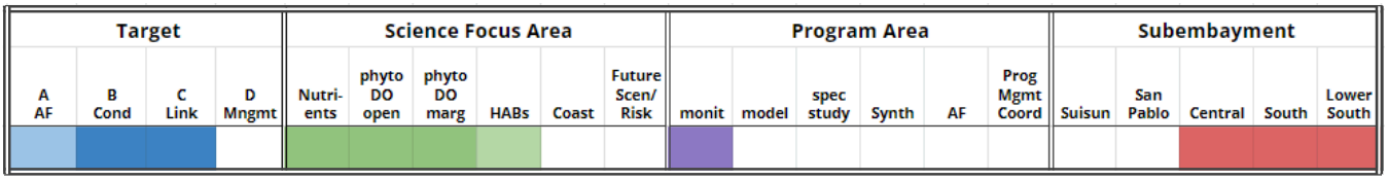
- Collected high-frequency sensor measurements at 12 existing stations (9 "full" stations with multi-parameter instruments, 2 "mini" stations with oxygen sensors, and 1 turbidity station), along with discrete monthly samples at 5 of those stations for sensor validation.
- Conducted monthly calibration and servicing of water quality instruments.
- Added salinity sensors to miniDOT DO stations in Guadalupe and Alviso Sloughs to more accurately calculate O_2 concentrations.
- Added DO sensors at two additional depths at the Dumbarton Bridge (DMB) and San Mateo Bridge in August to capture vertical DO patterns in the channel.
- Started collecting discrete nitrate samples at DMB for instrument calibration in March 2023.
- Piloted conducting more frequent servicing trips to reduce fouling of sensors and the associated data loss.
- Continued improvement of data management codebase, including a despiking algorithm and automatic removal of data at very low water levels (<0.5m).
- Added salinity sensors to the QA/QC pipeline for miniDOT stations.

Plans for FY2024

- Continue water quality measurements at 12 existing stations in South Bay and Lower South Bay, including maintenance trips at 3-4 week intervals.
- Addition of one SUNA V2 nitrate sensor to Alviso to help quantify nitrogen export from the sloughs.
- 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

d. Curated 15-minute dataset of water quality parameters from nine stations.

e. Curated 15-minute dataset of nitrate data from three stations.

f. Curated 15-minute dataset of dissolved oxygen, temperature and salinity data from two stations.

g. Curated 15-minute dataset of turbidity from one station.

h. Updated QAQC scripts and documentation, maintained and versioned on GitHub.

i. Short quarterly reports summarizing status of stations, data QAQC and data visualizations.

Budget Justification

The mooring program cost for FY24 include:

- Field support contracts with: USGS-Pacific Marine Facility (MARFAC) for boat support for LSB servicing trips ($58k); USGS-CA Water Science Center for boat support for South Bay servicing trips, instrument coordination, sampling, sample processing, and interpretive/analytical support ($96k)
- Analysis of discrete samples ($4k)
- SFEI labor for field and laboratory work, fieldwork planning and logistics, documentation, and overall project management ($172k)
- Data processing, review, and report outs ($100k)
- Replacement instruments and sensors, reagents, equipment, and other direct expenses ($60k)

C3 Core Modeling	Total FY24 Work	Other Funds	FY24 Permit Funds
Team: SFEI, Four Peaks, RMA	$500,000	$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 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 FY2023

The substantial (and unanticipated) fraction of modeling effort during the first half of FY2023 was was directed toward investigating the August 2022 HAB event (see December 2022 rescoping), which slowed progress on the originally planned FY2023 modeling activities. Nonetheless, some of the originally planned modeling activities have either been completed or are currently moving forward, including:

Open Bay Model Development, Validation and Application

- Incorporated improved light attenuation coefficients into model simulations based on an analysis of uncertainty in the GAM model predictions used for filling in missing data and other inputs used to derive light extinction coefficient
- Completed a series of sensitivity analyses to better understand model performance based on metrics that are relevant for answering NMS management and science questions
- Drafted a Model Validation Report that documented hydrodynamic model validation for WY2014-WY2016, an evaluation of hydrodynamic model's ability to simulate stratification, biogeochemical model improvements and validation for 3 water years for the full resolution model (WY2013, WY2017 and WY2018) and 6 water years for aggregated grid model (WY2013-WY2018), and findings from biogeochemical model sensitivity analyses.
- Extended full resolution model simulations to WY2014, WY2015 and WY2016, such that full resolution model results are now available for WY2013-WY2018.
- Continued model refinements post-MAG workshop 2 based on feedback received from MAG (see below)
- Presently developing interpretations of N-cycling using control volume analysis.
- Presently developing interpretations of primary production and DO drivers based on sensitivity analyses.

Modeling Related to 2022 HAB Event

- Developed a hydrodynamic model simulation for 2022 summer conditions
- Performed tracer-based hypotheses testing to understand the origin and spread of the HAB event
- Added BGC model simulations to investigate the magnitude of bloom event, conditions of bloom termination, and associated DO demand within South Bay
- Presented initial findings to MAG in November 2022, and incorporated improvements suggested by MAG, including investigating different hypotheses for physical and biogeochemical "windows of opportunities" that could have triggered the bloom event
- Present additional findings during MAG workshop in February 2023 to determine potential interpretations and applications of the BGC model to assess HAB-like high biomass events

MAG Engagement

- A 4-hour conference call was held with the MAG in November 2022 to seek initial input on approaches used for evaluating the 2022 HAB event, including the suitability and caveats on using the long-term BGC model for this purpose. MAG provided input on potential ways to test and apply the model to simulate high biomass events, which were incorporated as discussed above.
- A 2-day workshop was held in February 2023 to continue the MAG engagement process for the long-term NMS BGC model development, validation and application. The workshop focused on BGC model validation and readiness of the model for application to answer science and management questions. The workshop also focused on the suitability of the BGC model to simulate HAB-like high biomass events and potential considerations when applying the model for this purpose.

Supporting Materials and Work Products

- See April 2024 MAG report
- See also overview of modeling progress (2016-2019, Jan 2019 - Mar 2022)
- See 2023 NMS Modeling Update Report

Plans for FY2024

Note: Exact focus of Work during FY2024 is being finalized, informed by recent MAG feedback and through discussions with Water Board and BACWA, to identify work most pertinent to informing on-going planning for Permit #3. The following general topics are expected to be major priorities:

- Based on MAG feedback and recommendations, pursuing the following:
  - refinement/testing of several priority processes (e.g., water column respiration vs. sediment respiration, refining production module(s))
  - continued model validation and analysis/interpretation of key processes (e.g., mass balances, nutrient cycling, production), including writing this up jointly in the form of a manuscript(s) for submission to a peer review journal.
- applying the model to explore management and environmental change scenarios

The following Model Development and Model Application projects are provided as examples, with the primary focus areas for FY2024 to be finalized during May-July 2024.

Model Development

- Extension of hydrodynamic and biogeochemical simulations to WYs 2019-WY2022. 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 a sediment expert panel received in FY22.
- Targeted investment into O_2 related processes and improvements to model performance in predicting DO.
- Begin collaboration with SCCWRP to assess and improve ocean forcings for the NMS model based on SCCWRPs coastal model predictions.
- Model refinements and model validation updates based on: (1) MAG feedback from workshops 1 (completed), workshop 2 (completed in February 2023) and workshop 3 (planned in Winter/Spring 2024); (2) model performance in WY2019-WY2022. 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. The model interpretations will be integrated into the MAG process (workshop 3 planned for Winter/Spring 2024), 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 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

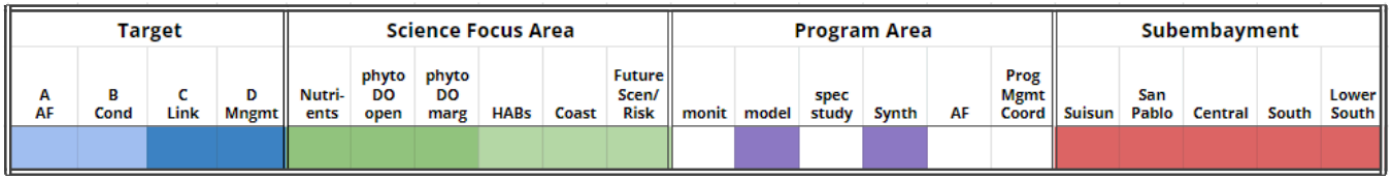
decision variables for nutrient management in SFB.

- Convening WB and other stakeholders for periodic (e.g., quarterly, or bimonthly) meetings related to model application: evaluation of runs, planning on-going work.

Modeling Planning, Documentation, and Infrastructure

- Model Advisory Group process: Planning/Convening 1-2 MAG meetings.
- Updating Modeling versions for running coupled hydrodynamics-biogeochemistry, including potential for achieving faster run-times through using other computing approaches.
- 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

- 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.
- Presentations and meeting briefs for WB/stakeholder meetings.
- Report-outs from MAG.
- Model documentation, code for pre-/post-processing (ongoing)

Budget Justification

Funds will be used to support core modeling team labor (~2.3 FTE), along with $10k in direct costs for computing costs (e.g, cloud computing.)

C4 Science Coordination and Program Management	Total FY24 Work	Other Funds	FY24 Permit Funds
Team: SFEI	$559,000	$175,000*	$384,000

***Other funds: carryover funding from FY23**

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.
- Pursuing fundraising to support NMS work, if suitable opportunities arise during FY2024.

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

Budget Justification:

Funding for C4 supports the following: NMS lead scientist's effort across all scientific activities of the NMS (contributing to individual projects, science oversight, planning), stakeholder engagement, and overall NMS management (roughly 60% science, 40% program management); contributions from several SFEI/NMS staff working on a range of program management activities, including additional science oversight (e.g., management/oversight of the NMS field/monitoring program) and stakeholder engagement, project management, and contract/financial management; and website content management. Remaining funds from FY2024 C4 are forecasted to be ~$175,000, and will be carried forward to support FY2024 C4.

3.2 PROJECTS

P1 Central Bay Mooring	Total FY24 Work	Other Funds	FY24 Permit Funds
Team: SFEI, USGS-BGC	$100,000	$0	$100,000

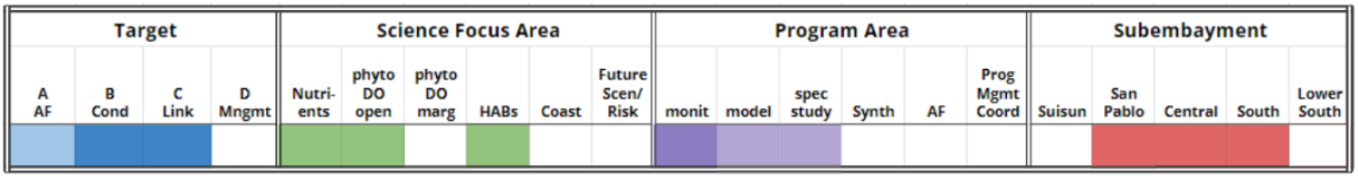
Project Description

This project will support the addition of 1-2 high frequency sensors in the Central Bay, an area of the Bay that is monitored by ship based monitoring and mapping but with no moored sensor stations. The number and type of additional stations will depend on several factors, including location and the ability to augment existing USGS monitoring stations which would significantly reduce costs. Data will be used in other NMS program areas, including model calibration, condition assessment, synthesis, and Assessment Framework development.

Plans for FY2024

- Deploy one to two moored sensors in the Central Bay to collect high-frequency water quality data (15-min).
- Conduct maintenance trips to service instruments and download data at 3-4 week intervals.
- Data QA/QC and data management.

Alignment with NMS Priorities



Work Products

j. Curated 15-minute dataset of water quality parameters from one to two stations.

Budget Justification:

Central Bay Mooring funding will cover the purchase of new sensors and equipment; field support contracts with USGS-WSC for boat support for servicing trips; SFEI labor for deployment planning and logistics, field and laboratory work, data QAQC, data management, and overall project management. Exact cost for each item will depend on the location and configuration of the sensor/s.

P2 Assessment Framework: DO in LSB Sloughs and Creeks	Total FY24 Work	Other Funds	FY24 Permit Funds
Team: SFEI, SCCWRP, UC Davis, Princeton, Tetra Tech, UC Berkeley	$110,000	$0	$110,000

Project Description

The primary aim of this project is to develop the scientific basis for identifying protective dissolved oxygen (DO) conditions for biota in LSB sloughs and creeks using multiple lines of evidence. This analysis will contribute to the development of an Assessment Framework (AF) 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 identify the DO levels needed to support biota in these habitats. Priorities for the final year of this project include: i) finalize the development of acute and chronic criteria using the Virginia Province Approach (VPA); ii) summarize findings of analysis using fish abundance data and multi-stressor approaches to determine biological DO requirements; iii) synthesize results of all analyses and compare to DO conditions in the system. Input will be solicited from stakeholders and experts through several meetings. The FY2024 work is aligned with the overall plan laid out in the Assessment Framework Workplan.

Progress in FY2023

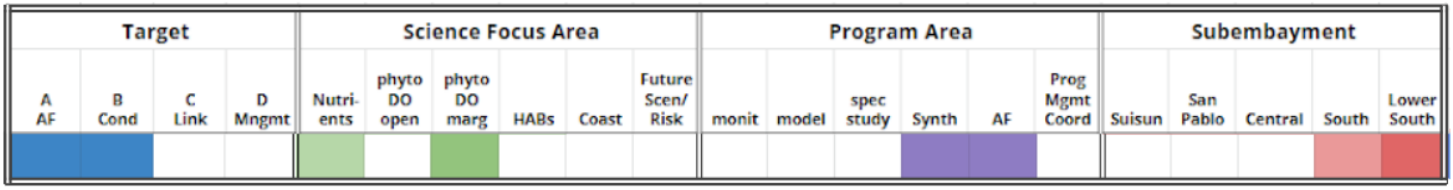
- Met with the AF subcommittee to gather input on directions for future work and to keep stakeholders informed of progress.
- Convened an expert meeting to identify recommended next steps for the VPA and analysis/interpretation of fish survey data.
- Identified high priority next steps for the VPA development and analysis of fish abundance data based on input from experts and stakeholders.
- Collaborators/consultants at Tetra Tech continued to develop the VPA analysis, including completing drafts 1 and 2 of the VPA report, and started work on the final VPA report.
- Levi Lewis refined the statistical modeling approach for the fish community data based on expert input. Lewis will complete a draft technical report summarizing updated analysis.
- Evan Howard concluded a pilot study of the metabolic index approach and summarized findings in a short report-out.

Plans for FY2024

- Complete the final VPA report.
- Convene expert workgroup to allow discussion between experts and stakeholders, and receive technical input on analysis for determining protective DO levels.
- Continue to update the AF subcommittee and engage them in the AF development process.
- Draft final report summarizing the VPA, analysis of fish abundance data, and metabolic index, comparing between the three distinct analyses and comparing to condition in the

system. Work on this task will depend on the expert/stakeholder meeting and findings of initial reports.

Alignment with NMS Priorities



Work Products

k. Final technical report summarizing application of the VPA to characterize habitat condition in LSB sloughs and creeks

l. Summary report with some or all of the following components, if recommended after the expert/stakeholder meeting:
    a. Report-out on the VPA, multi stressor work and analysis of fish abundance data, including results from analyses to-date
    b. Comparisons across different analyses
    c. DO sensitivities relative to conditions in the system
    d. Pros, cons and limitations of the different analyses
    e. Potential usage within regulatory or management decision frameworks
    f. Conceptual approach for determining framework for high to low conditions
    g. Recommended next steps

Budget Justification:

Approximately 25% ($30k) of funds will support external collaborators working on these projects, <5% ($5k) will go to direct costs related to expert meetings, and 70% ($75k) will support SFEI staff on expert/stakeholder engagement, data analysis/interpretation, reporting, and managing the overall project.

P3 Model Advisory Group (MAG)	Total FY24 Work	Other Funds	FY24 Permit Funds
Team: SFEI, Four Peaks, SCCWRP	$40,000	$0	$40,000

Project Description

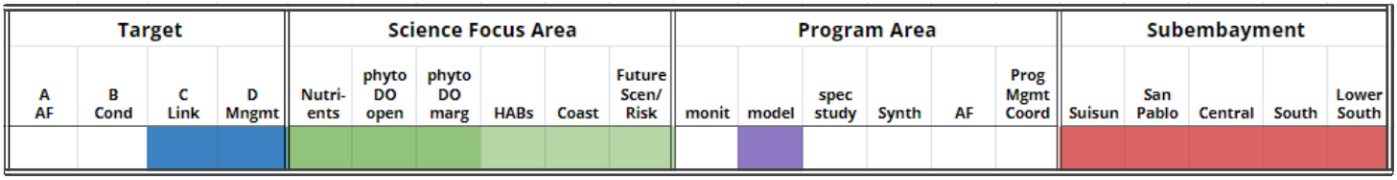
Model Advisory Group (MAG) meetings were held in March 2022, November 2022, and February 2023. (see MAG April 2023 report).

This project will support continued MAG engagement, including 1-2 meetings, and support for the MAG chair (planning, stakeholder engagement).

FY2024 MAG work will focus on one or more of following areas:

- follow-up and review of progress on prior MAG recommendations, e.g., model refinements/improvements, metrics and visuals for model performance evaluation, and model applications (nutrient budgets/cycling, phytoplankton production)
- technical advising on approach and review of results from scenario analysis (management scenarios, environmental-change/future scenarios)

Alignment with NMS Priorities



Work Products

m. MAG presentations (SFEI effort funded through C2 Core Modeling)

n. Report-outs/Feedback from MAG to stakeholders.

Budget Justification:

Funds will support 1-2 in-person and/or remote meetings (travel, honoraria), and support for the MAG chair (MAG planning/coordination with SFEI team, stakeholder engagement).

P4 Technical Synthesis	Total FY24 Work	Other Funds	FY24 Permit Funds
Team: SFEI and collaborators	$75,000	$0	$75,000

Over the last several years, NMS-funded field investigations and monitoring have been generating valuable multi-year datasets that address priority data and knowledge gaps. For a number of those efforts, funding thus has been directed primarily toward supporting data collection. This project will support the analysis and interpretation of SFB data to address NMS priority science and management questions of the NMS. Example technical topics include:

`1. Key drivers of space-time variability in phytoplankton (including HAB) and zooplankton community composition: Analyze phytoplankton and zooplankton community data collected during recent South and Central Bay biogeochemical mapping surveys (2021, 2022, 2023; six surveys per year, Mar-Oct [*]). Pursue this analysis in conjunction with the on-going analysis of shoal biogeochemical data, including factors influencing space-time variability in phytoplankton biomass productivity.

- Phytoplankton and zooplankton datasets include: DNA-metabarcoding for phytoplankton (18s, 16s) and zooplankton (18s) community composition and relative abundance (n ~270 samples, ~15 samples/survey); class-level biomass estimates, measured underway (flow-through system) during high-resolution mapping surveys (Fluoroprobe, multiple excitation wavelengths; classes: chlorophytes (greens), diatoms, cyanobacteria, cryptophytes).
- Results could be applied to focus on priority science/management questions and/or monitoring program design questions:
  - *science/management questions* - characterizing space-time variability in phytoplankton community composition, including HAB taxa, with particular focus on shoal-channel variability and deriving insights into key factors (physical, chemical, biological) that shape that composition; quantify pelagic grazer (zooplankton) relative abundance and space/time variability, along with estimate potential grazing rates (important data gap for numerical modeling, and for system-understanding of factors that help regulate phytoplankton production and biomass);
  - *monitoring program design*: based on spatial variability and the importance of that variability, determine the need for characterizing phytoplankton community (including HABs) along shoal-channel gradients, and compare the utility of different measurement approaches; and, to the extent possible, assess the potential for continued collection of these types of data to yield improved phytoplankton quantitation through remote sensing.

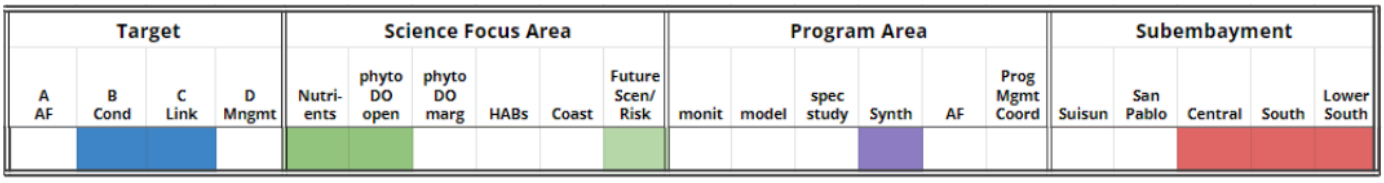
2. Monitoring program design: evaluation, optimization, and planning. Analyze a range of water quality datasets to advance some or all of the following science and management questions related to monitoring program design:

- characterize space-time variability (some measure of variance over space and time) of key parameters or indicators, including quantitatively representing the ‘true’ or ‘total’ variance;

- quantify the proportion of variance and/or important features/events captured by the current monitoring resources;
- identify the necessary spatial and temporal resolution (or scales) of data collection in order to meet the regulatory requirements for robust condition assessment to inform management decisions (working with regulators/stakeholders to define these needs); and to achieve the monitoring programs scientific goals (e.g., long-term condition assessment)
- quantitatively assess alignment between current monitoring work and monitoring goals, and use this assessment to identify:
  - 'blindspots' or 'thinspots' in current monitoring program data collection (e.g., insufficient space/time resolution), i.e., what program components need to be augmented or more intensively measured in order to match goals? ;
  - redundancies, or suboptimal allocation of monitoring resources or effort among program components (space, time, analytes);
  - highest-priorities (high-leverage) for augmenting monitoring program design and/or optimize resource allocation to maximize information collection with available resources.
- Potential datasets to include: long-term channel monitoring; water quality mooring; high-resolution biogeochemical mapping; remote-sensing; and output from water quality model simulations.

3) *Develop and apply techniques for estimating reaction/transformation rates open-Bay moorings*: Over the last few months, as part of interpreting HAB-event data, we have been developing and testing a method for quantifying Net Ecosystem Metabolism (NEM) – balance between respiration and gross primary production – at each South Bay mooring stations, four sites spanning the shallow shoal to the deeper channel, using only data collected by each mooring station. NEM was estimated as the slope of the time-varying concentration of three independent scalars: dissolved oxygen (DO), NO_3^-, and chl *a*, with DO further adjusted to account for gas transfer with the atmosphere, and converted to a common unit using basic stoichiometry (e.g., expressed in C units). So far the analyses have yielded remarkably similar volumetric NEM rates (among scalars and across sites). In this project we propose to continue refining and testing this and related approaches to produce an analysis toolbox for inferring biogeochemical rates from open-Bay moorings. While some of the work will involve method development and testing, the majority of the effort would go toward applying the technique over space/time, and writing both the approach and interpretations as a technical report and potential manuscript.

Alignment with NMS Priorities



Work Products

This work will yield one or more of the following products: (a) Augment work of an on-going project: support additional analysis and synthesis (beyond the original scope and budget), and integrate work into a single technical report and/or manuscript. (b) New project/report: data analysis/synthesis targeting priority science/management question(s). (c) Dataset publication: Publish NMS dataset(s) (i.e., doi, public repository), including metadata and finalizing QA/QC, and developing other relevant documentation (e.g., narrative dataset description, key graphics, etc.).

Budget Justification:

Funding will support SFEI staff labor, technical collaborator labor, and publication fees, if relevant

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P5 Shoal mapping, South Bay & Central Bay	Total FY24 Work	Other Funds	Permit FY24 Funds
Team: SFEI, USGS-BGC	$50,000	0	$50,000

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. Water quality mapping studies on the shoals were also performed in 2021 and 2022. 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 (SFEI in prep).

This project will continue shoal water quality monitoring through conducting high-resolution biogeochemical mapping surveys in South Bay and Central Bays. The overall plan is to support six mapping surveys in 2023, collecting a combination of flow-through optical sensor data (e.g., chl, nitrate, turbidity, temperature, salinity) along with discrete samples (e.g., nutrients, phytoplankton community including HABs). To the extent possible, mapping surveys will be timed to coincide with USGS R/V Peterson cruises or satellite flyovers to expand the NMS' capacity to calibrate/validate remote-sensed data for some relevant parameters (e.g., turbidity/SSC, chl-a).

The funds from P5 will be combined with funding from the recently funded EPA-WQIF project which includes support for mapping surveys, with the combined funding supporting a total of six mapping surveys.

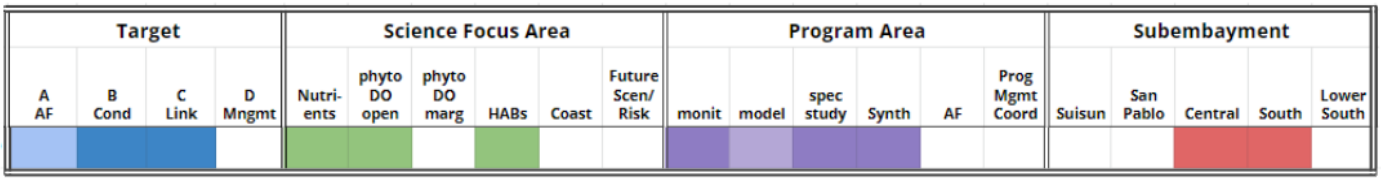
Progress in FY2023

- Six spring/summer water quality mapping trips to supplement data from moored sensor stations on the shoal.
- Five additional cruises in response to the summer HAB event (supported by HAB event project).
- Standardization of mapping logistics; approach/coordination between SFEI and USGS-BGC.
- Synthesis/interpretation of mapping data alongside other datasets.
- Validation of modeling data.

Plans for FY2024

- Four to six water quality mapping and sampling trips in South Bay.
- Characterize spatial patterns in South Bay water quality not captured by standard channel cruises, including mechanisms behind spatial variability in GPP, DIN, DO, pH.
- Match mapped and moored high-frequency data to allow cross-validation of the datasets.

Alignment with NMS Priorities



Work Products

a. Data from four to six mapping cruises, yielding one or more two-dimensional water quality maps per trip.

b. Corresponding discrete sample data from 15-20 locations per cruise: nutrient, chlorophyll-a and suspended sediment samples; phytoplankton assemblage (including HABs).

Budget Justification

Project budget will cover the cost of two mapping cruises, including: mapping boat preparation, field time, and data curation (USGS-BGC: $40k, 2 surveys @ $20k/survey); discrete sample analysis (nutrients, chl-a, phytoplankton by 18s/16s sequencing, $4k); SFEI labor (joining subset of cruises, post-survey sample processing, data curation, and project management, $6k). The cost of the remaining mapping cruises will be covered by project xP17 which is supported by external funding.

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4. OTHER PRIORITY PROJECTS & CONTINUING PROJECTS

Table 2 summarizes additional projects, organized into a few categories: i) Additional science priorities for FY2024 that are currently unfunded due to insufficient funds; ii) new or upcoming projects that address NMS science priorities but are funded by other funding sources (no new funds requested in the FY2024 Program Plan); and iii) Major projects funded during FY2023 that will be continuing into FY2024 (no new funding).

For the unfunded projects (i), NMS-SC authorization is being sought to pursue that work should sufficient funding become available.

The other projects included in Table 2 are included to provide the NMS Steering Committee with additional context about both the broader set of NMS work being pursued in FY2024, including at-a-glance overview of how the full set of FY2024 work aligns with NMS science and management priorities.

Brief descriptions of several projects are below, with blurbs for other projects included in the spreadsheet version here,

1) Shoal mapping, South Bay & Central Bay (WQIF Funding)
The WQIF project includes funds to support continuation of shoal mapping work. These funds will be used to support ~4 mapping surveys (and related sample analysis/data QA), with the remaining work supported by P5. See P5 description.

2) Sediment transport modeling (SEP & WQIF Funding)
(see WQIF background in xP19 blurb). NMS modeling work identified light attenuation coefficient data (Kd = f(SSC)) as an important data gap. This project -- funded by a combination of WQIF and SEP funds --will support the development and calibration/validation of a sediment transport model for SSC, driven by the NMS hydrodynamic model. This work is being pursued collaboratively the RMP's PCB modeling effort. Work on the overall project began spinning up Feb-Mar 2023 (SEP-funded thus far), initially focused on moving PCB-specific work forward; however much of the core development work will benefit both NMS and RMP-PCB science needs. NMS-focused sediment transport work will spin-up beginning in June 2023).

3) Nutrients modeling (WQIF Funding)
Substantial progress has been made within the NMS over the last several years on in-Bay numerical model development, including the implementation of a multi-year modeling plan. This project includes critical work necessary to predict the Bay's response to nutrient enrichment and the consequences of large investments in wastewater infrastructure upgrades to reduce nutrient loading. On-going modeling efforts of the NMS are beginning

to answer management questions surrounding acceptable levels of nutrient loading to the Bay, serving to inform the next iteration of the SF Bay Nutrient Watershed Permit. Outstanding high priority involve which wastewater facilities contribute the greatest load in each subembayment, whether particular management responses may yield quantifiable benefits, and what plausible scenarios can we expect, with regard to eutrophication risk.

With WQIF funding, the NMS shall apply additional resources towards the refinement of the coupled hydrodynamic and water quality model. Funding shall also contribute towards ensuring the model is open source, following best practices, to enable researchers, regulators, and practitioners to leverage the model to answer other water quality management questions not currently considered.

4) Bay Remote Sensing (WQIF Funding)

Remote sensing tools proved invaluable during the 2022 HAB bloom to track near-real-time status of the bloom magnitude and extent. Modelers in the region have also long known that remote sensing data for sediment and light attenuation enhances modeling capacity and accuracy. This project involves the development of remote sensing products to augment sediment and nutrient monitoring activities.

Anticipated outputs from this project, due in 2025, include:

- Broad-scale sediment and light attenuation estimates and trends
- Calibration data for in-Bay sediment model
- Resources permitting, chlorophyll-a calibration included for the in-bay nutrient model

5) HAB analysis/interpretation, machine learning (Stanford postdoc)

In Fall 2022, SFEI staff worked with Stanford faculty (O Fringer) to submit a proposal for an internal Standard RFP. The project was selected for funding, (supporting 18month postdoc), with work focused on exploring the utility of machine learning tools for predicting/understanding HAB events in SFB.

6) AF: deep subtidal (cont'd, wrap-up during FY2024)

The planned FY2023 Deep Subtidal AF work, which got underway early in the fiscal year, was postponed due to the HAB event. In addition to impacting the project timeline, the HAB event also impacted some of the projects goals and planned approach. (see December 2022 memo to SC). Work started again in January 2023, and will continue into and wrap up in FY2024. See FY2023 Program Plan for relevant project details.

7) Sediment monitoring project (RMP)

The collection of continuous suspended sediment concentration (SSC) and wave data in shallow areas of South and Lower South San Francisco Bay (SB and LSB, respectively) was funded by the South Bay Salt Pond Restoration Project in 2022 and the Regional Monitoring Program in 2023.

This past work enabled the development of preliminary turbidity-SSC calibrations for eight existing NMS stations spanning a range of Bay environments (channel, shoal, and slough) from the San Mateo Bridge to Alviso Slough.

This project supports continued data collection and calibration for an additional seven months in 2024, which is needed to develop robust turbidity-SSC relationships. Once completed, these site-specific calibrations will expand continuous SSC monitoring to shallow areas of the SB and LSB, which play an important yet understudied role in Bay sediment dynamics.

8) Pending funding (MERHAB)

In January 2023, SFEI, USGS-WSC, and other collaborators submitted a proposal to NOAA's Monitoring and Event Response for Harmful Algal Blooms (MERHAB) program for $3 million of funding for 2023-2028. The overall goal is to establish the technical foundation, program design, and strategic plan for implementing a robust system-wide HAB monitoring program. The work includes several projects that target NMS science priorities (including some that are unfunded in Table 2), including:

- Remote Sensing for spatially resolved and temporally rapid data delivery (see P7)
- Molecular monitoring of HAB taxa
- Three water quality monitoring stations in the Central Bay (see P6)
- Addition of telemetry infrastructure to moored sensors (see P10)
- High-resolution mapping surveys (3-4 surveys per year from 2023-2025) (see P9)

If funded, this grant would support some of the costs of P1 (Central Bay water quality mooring) and potential free-up some of those funds, and would provide support for P7 (early warning system, remote sensing), P10 (telemetry), and P10 (central/northern bay mapping surveys).

Table 2: FY2024 Program Plan. For a scrollable/expandable spreadsheet, click and download here (FY23ProgramPlan_and_SciencePlan2.0).
This table includes C1-C4 and P1a-P6 (from Table 1), and additionally includes:

- several projects that exceed available funding but were identified as High Priority / Priority work for FY2023 (P7-P14, P1b).
- presents alignment between projects and NMS Priorities (see next page for definition of Targets). Additional background on Science Focus Areas and Program Areas, along with background on the NMS SciencePlan2.0 can be found here

	Project	Total FY2024 Work	Other Funds	FY2024 Permit Funds	Target	Target: A AF	Target: B Cond	Target: C Link	Target: D Mngmt	Focus Area	Science Focus Area: Nutri-ents	Science Focus Area: phyto DO open	Science Focus Area: phyto DO marg	Science Focus Area: HABs	Science Focus Area: Coast Impact	Science Focus Area: Future Scen Risk	Progr Area	Subembay	Subembayment: Suisun	Subembayment: San Pablo	Subembayment: Cen	Subembayment: South	Subembayment: Lower South
A. Core Program																							
C1	Monitor: ship-based sampling	519,000	250,000	269,000																			
C2	Monitor: moored sensor network	490,000	250,000	240,000																			
C3	Core Modeling	500,000	0	500,000																			
C4	Program coordination	559,000	175,000	384,000																			
B. Highest Priority Projects																							
P1	LSB DO Assessment Framework	110,000	0	110,000																			
P2	Central Bay Mooring	100,000	0	100,000																			
P3	MAG continuation	40,000	0	40,000																			
P4	Monitoring water quality analysis: program evaluation	75,000	0	75,000																			
P5	Shoal mapping, South Bay & Central Bay	50,000	0	50,000																			
C. High Priority Projects (undertake if funding becomes available)																							
P6	DO sensors at deep moorings, DMB and SMB	60,000	0	60,000																			
P7	Early-Warning System: Remote-sensed chl-a, SSC	75,000	0	75,000																			
P8	HAB/toxins: Mussel toxin monitoring	200,000	0	200,000																			
P9	Water Quality Mapping: Central Bay, SPB, Suisun	150,000	50,000	100,000																			
P10	Telemetry at existing moorings	80,000	0	80,000																			
P11	LSB Biogeochemical study: field, analysis, modeling	200,000	0	200,000																			
P12	Zooplankton taxonomy, grazing (molecular)	50,000	0	50,000																			
P13	IFCB integration, data automation	87,500	0	87,500																			
P14	High-level Synthesis Products	50,000	0	50,000																			
P15	Expanding monitoring program	100,000	0	100,000																			
P16	South Bay Benthos (archive): count, grazing rate	50,000	0	50,000																			

	Project	Total FY2024 Work	Other Funds	FY2024 Permit Funds	Target	Target: A AF	Target: B Cond	Target: C Link	Target: D Mngmt	Focus Area	Science Focus Area: Nutri-ents	Science Focus Area: phyto DO open	Science Focus Area: phyto DO marg	Science Focus Area: HABs	Science Focus Area: Coast Impact	Science Focus Area: Future Scen Risk	Progr Area	Subembay	Subembayment: Suisun	Subembayment: San Pablo	Subembayment: Cen	Subembayment: South	Subembayment: Lower South
D. Other NMS Work: Other Funding (new) OR Continuation Projects																							
xP16	Shoal mapping, South Bay & Central Bay (WQIF)	100,000	100,000	0																			
xP18	Sediment transport modeling (SEP+WQIF)	135,000	135,000	0																			
xP17	Nutrients modeling (WQIF)	130,000	130,000	0																			
xP19	Bay Remote Sensing (WQIF)	60,000	60,000	0																			
xP20	HAB analysis/interpretation, machine learning (Stanford postdoc)	150,000	150,000	0																			
FY23	AF: deep subtidal (cont'd, wrap-up during FY2024)	135,000	135,000	0																			
FY23	Sediment monitoring project (RMP)	48,000	48,000	0																			

Targets A-B link back to the NMS Management Questions and SciencePlan2.0, and highlight which issues or management questions are being targeted by projects included in the FY2023 Program Plan.

A: **Assessment Framework:** Building the scientific foundation for Assessment Frameworks, the 'yard-stick(s)' against which condition will be evaluated, to determine whether protective conditions are being achieved.

B: **Condition:** Generating data on water quality, and synthesis of that data to characterize condition. In most cases this data will come from field measurements, i.e., water quality monitoring; in some cases the data may also come from models that predicts condition.

C: **Nutrient Linkage (dose:response):** Quantitatively characterizing the relationships between nutrient loads or concentrations and Responses (rows 1-6) -- *How will Response X change if nutrient loads increase or decrease by some amount?* This includes quantitatively characterizing nutrient sources, cycling, transport, and fate?

D: **Management Options:** Quantitatively estimating/predicting how various management options will influence nutrient concentrations and condition in SFB. This includes questions such as: *What would be the effect of future loads, e.g., if no management actions required and loads vary over time with population increases? To achieve a desired change in condition for Response X, what changes to nutrient loads/concentrations would be needed? What is the relative contribution of Nutrient_Source$_i$ to nutrient concentrations in a region, or contribution to Response X? What combination of management actions could achieve a desired change in condition and/or change in nutrient levels in a region of SFB?*