Estuary Marine Protected Area

Monitoring Program Implementation Blueprint

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EMPA
Monitoring Program

OCEAN
PROTECTION
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Executive Summary and Recommendations

This document provides a roadmap for implementing the EMPA monitoring program. Building on the tools and protocols documented in the associated EMPA Monitoring Manual, this document provides options and recommendations necessary to support a long-term coordinated statewide monitoring program to help address key management questions. The following recommendations address issues of organization, governance, coordination and funding:

- Use a tiered governance structure that provides opportunities for all interested parties (e.g., regulators, resource managers, funders, practitioners, community organizations) to participate in some aspect of the monitoring program.
    - Overall program management should be assumed by an existing organization whose mission and expertise involve implementing regional or statewide monitoring programs.
    - Develop communication mechanisms between state, regional, and local monitoring programs
- Develop and maintain an integrated data management system based on electronic data flow from collection through dissemination. The data management system should have the following attributes:
    - Strive for an integrated, electronic data flow through all steps of the data management process from data collection through publication.
    - Manage data in a geospatial format to enhance data visualization and interpretation and facilitate data integration across programs; and
    - Embrace open data practices and use an open data format, which may include web services and application program interfaces (APIs), to facilitate data access and sharing.
    - Provide user-friendly, map-based tools to explore, access, and download data in readily transferable formats (e.g., csv).
- Develop tools to assist in program implementation and adoption (e.g., training material, templates). These tools should be readily available and interpretable and program management staff should be available to assist in their use.
- Pursue a diverse funding strategy to support program management, data management, data analysis, and communication and outreach.
- Monitoring program should be reviewed triennially to assess its efficiency, effectiveness, flexibility, and utility. Over time quantitative performance criteria should be developed to aid in program evaluation and adaptation.

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Introduction

The passage of the Marine Life Protection Act (MLPA) in 1999 directed California to implement an ecologically connected Network of Marine Protected Area (MPAs) to protect the state's diverse marine ecosystems and species. To evaluate the performance of the Network against the ecosystem-focused goals outlined in the MLPA, the state is mandated to conduct extensive monitoring in the coastal habitats both inside and outside MPAs. Although the MPA Network includes 23 estuarine MPAs, to date, the state's MPA Monitoring Program has lacked a focused, cohesive monitoring strategy for this habitat. The Estuary Marine Protected Areas (EMPA) Monitoring Program aims to address this critical gap.

California's estuaries are influenced by watershed land use, coastal infrastructure, water resource management, and other stressors. To address the monitoring needs of EMPAs, the California Ocean Protection Council (OPC) funded development of a monitoring framework and program to provide data and information necessary to answer critical management questions about both MPA and non-MPA estuaries statewide. The integrated estuarine monitoring framework, developed by a statewide technical team (working with a Management Advisory Committee), provides sampling design, standard protocols, and data management tools to facilitate collection, integration, and dissemination of biotic and abiotic data in a consistent and accessible manner. A monitoring manual and associated website provide details and documentation of the scientific basis and the tools necessary to implement the monitoring program. The technical team has also produced a data report to illustrate how data collected through the monitoring program can be used to answer scientific and management questions about estuary health and stressors, and how that information can inform management decisions.

This document focuses on the elements necessary to sustain long-term, cost-effective implementation of the monitoring program. This "implementation blueprint" provides options and recommendations that agencies and programs will need to consider if they want to provide the long-term data necessary to answer complex management questions. This document, together with its companion documents (the monitoring manual and data report) provide the technical, practical, and illustrative foundation necessary to develop and maintain a long-term statewide estuary monitoring program for California.

Objective of the Implementation Blueprint

This implementation blueprint is a set of recommendations that provides a roadmap for long-term implementation of statewide estuarine and EMPA monitoring in a manner that fosters partnership, maximizes access to data and information, and is adaptable and flexible over time. The blueprint can serve as a basis for discussion with decision makers and funders regarding implementation of the statewide program. Specific issues addressed by this blueprint include:

- What science and management questions should drive program implementation?
- How do we balance consistency and flexibility to accommodate California's diverse estuaries?
- How can the program best support local, regional, and statewide needs?

- What mechanisms will foster ownership and engagement among the scientific and practitioner communities?
- How can we best partner with and include local and tribal communities?
- What governance structure will support longevity of the program?
- How can the program develop stable funding over time?

Overview of the EMPA Monitoring Program

The overall goal of the EMPA Monitoring Program is to establish a monitoring framework, including standards and procedures for data collection, analysis, synthesis, and reporting to determine the health of estuaries in California and the efficacy of MPA designation in estuaries. A key element is the development of a standardized monitoring protocol that can be used not only by the California MPA Management Program, but by any program aimed at assessing estuary function, condition, or health based on data that can be easily compared across systems and between programs.

The EMPA Monitoring Program has developed a monitoring framework, protocols, and data tools needed to help estuary managers, funders, and regulators answer the key questions necessary for effective management and restoration of California's coastal confluences. The primary goals of the EMPA Monitoring Program are:

1. Assess the conditions (key species abundance, diversity, structure, function, and integrity) of estuarine ecosystems in EMPAs, with a focus on how EMPAs
    a. Provide effective nursery habitat for focal fisheries;
    b. Support biodiversity of California marine ecosystems;
    c. Are impacted by post-European activities;
    d. Represent the range of estuarine habitat types historically present along the coast;
    e. Are resilient to climate change.
2. Compare the conditions and anthropogenic stressors present in EMPAs to those in non-EMPA (control) estuaries
3. Relate the conditions in EMPAs to conditions in nearby offshore MPAs.
4. Build on previous efforts to identify key threats to estuarine conditions in EMPAs and control estuaries.
5. Inform strategies for future management and conservation actions in EMPAs.

The EMPA Monitoring Program is largely consistent with the California Wetland and Riparian Area Monitoring Program (WRAMP) developed by the California Water Quality Monitoring Council.[1] WRAMP, like the US Environmental Protection Agency's three-tiered monitoring and assessment framework, includes three levels of assessment and analysis, and provides a framework for analyzing the three levels together to assess of the overall condition of aquatic resources. The three levels are:

[1] See https://www.mywaterquality.ca.gov/monitoring_council/wetland_workgroup for more information.

- Level 1, which are map-based and/or remotely sensed inventories of aquatic resources and their attributes
- Level 2, which are rapid, field-based assessments such as the California Rapid Assessment Method (CRAM)
- Level 3, which are site-specific measure of specific resources.

The program presented here is built around Level 2 and Level 3 assessments, with the assumption that Level 1 assessments can be developed using existing geospatial data from local, state, and federal resources. OPC and its partners are currently developing a suite of Level 1 datasets (such as a new map of coastal wetland habitats) that will help support the development and interpretation of the Level 2 and 3 assessments within the EMPA Monitoring Program.

Framework Principles

The general design of the EMPA Monitoring Program Framework centers around four key principles: Flexibility, Comparability, Interpretability, and Practicality.

1. Flexibility: Assessing estuarine condition using a function-based approach

Focusing an assessment framework on ecological functions allows for the creation of linkages between assessment results and ecological services. Furthermore, an assessment framework built to evaluate ecological functions will have greater flexibility for application within the highly heterogeneous estuaries lining the west coast from the Oregon border in the north to the tip of Baja in the south. The species of plants and animals that are the components of and are used as indicators of ecological functions may change between regions and estuarine functional types, but the focal estuarine functions will remain as constant as practical. Flexibility of the function-based approach will ultimately allow comparative assessment across estuary type, regional differences, anthropogenic impacts, ultimately permitting assessment of management actions and protected area designations.

2. Comparability: Characterizing systems by geomorphic features

While each estuarine system is unique, there are underlying environmental similarities in watershed size, morphology, and mouth dynamics among estuaries that influence their resident biota and allow them to be grouped together into different typologies (e.g., Mahoney and Bishop 2018[2]). By classifying estuaries by geomorphic forms (embayments/bays, riverine, lagoons, etc.) and focusing on key landscape features (mudflats, marsh, subtidal channels, etc.), users will be able to make comparisons across systems.

3. Interpretability: Concentrating sampling in each area rather than diffusely across the site

Regional differences in annual precipitation, watershed and coastal geology, and land use drive tremendous variability in estuarine conditions and functions. To capture seasonal and interannual variation among and within sites, sampling protocols concentrate multiple measurements around sampling zones. Users establish a number of permanent sampling zones within their estuary in order to concentrate multiple sampling methods in a given area and have the ability to return to the area. This

[2] Mahoney, P.C. and M.J. Bishop. 2018. Are geomorphological typologies for estuaries also useful for classifying their ecosystems? Aquatic Conservation 28(5):1200-1208. doi.org/10.1002/aqc.2925

approach is favored over distributing measures more diffusely across the site; concentrating multiple measures will enhance the ability to interpret data.

4. Practicality: Accomplishing sampling within three days

To increase the feasibility of this sampling protocol and implementation of the overall framework, data collection has been limited to what can be reasonably accomplished in a three-day sampling campaign. A three-day campaign should reduce personnel costs and allow users to implement the protocol across multiple sites.

To ensure a strong connection between monitoring data and management actions, the EMPA monitoring program team established a Management Advisory Committee (MAC) of estuarine researchers, managers, policymakers and tribes with specific expertise in California estuaries. The MAC membership is built off existing working groups such as the Southern California Wetland Recovery Program as much as feasible to reduce duplication of effort. Over the course of program development meetings, the MAC assisted in the identification of key management and monitoring questions to be addressed by the program, and provided review and feedback on priority indicators, metrics, and sampling protocols. Members on the MAC include representatives from the National Estuary Program and National Estuary Research Reserves along with California State Parks. In partnership with CDFW, these three organizations are responsible for managing roughly two thirds of estuaries in California.

Geographic Scope

The EMPA Monitoring Program framework is designed to be able to accommodate all estuaries and coastal lagoons, including river mouth estuaries present in California and Baja. The framework and protocols accommodate the underlying differences in estuarine structure and form present in the region, while still allowing comparable intra-estuary comparisons of health and condition. Optimally, the monitoring program would include all 23 estuarine MPAs in California along with sentinel sites for long term monitoring, and “reference” or comparator sites that can be paired with the estuarine MPAs. The program design also allows for individual estuaries (e.g., restoration or management project sites) to be included and compared to data generated from the larger set of EMPA monitoring locations.

Indicators and Protocols

The function-based assessment framework is used to assess the condition of each estuary, where multiple indicators are used to assess a given ecological function. Given the ecological and hydrological complexity of California’s estuaries, there are a vast number of potential indicators one could use to evaluate the health and condition of these systems.

Biotic indicators have the advantage of often being the focal point of many management concerns within coastal waters and at the root of the policies that compel the condition assessment of estuaries. Conversely, many flora and fauna have similar responses to different types of disturbance, which makes them difficult to use for diagnosing stressors to the system. Assemblage-based indicators are the most traditional version of bioassessment and can be comprised of primary producers, secondary producers, and nekton. Abundance, or persistence of invasive or noxious taxa can be a useful indicator of ecosystem health.

Abiotic indicators are helpful in defining estuary state, especially in seasonally open/closed estuaries where functions may vary between open and closed conditions. They have the advantage of often being direct measures of the stressors an ecosystem is exposed to, though sometimes it is hard to make direct linkages of stressor exposure to a response in the ecosystem due to the resiliency of ecosystem components. Furthermore, in dynamic systems like estuaries, stressor exposure is often episodic and abiotic indicators may not track exposure over time. Measurements of the frequency of hypoxia/anoxia, nutrient concentrations, or sediment contaminants can serve as indirect indicators of estuarine health and direct measures of stressor exposure to resident fauna. Measures of the physical structure of an estuary like elevations/morphometry, sinuosity, marsh accretion/subsidence, habitat complexity (e.g., amounts of bare sediment, SAV, oyster reef, etc.), and water exchange rate can be useful indicators of estuary health and provide important information for scaling and contextualizing biotic indicators. Lastly, quantification of watershed characteristics, particularly % impervious cover and other non-natural landcover have been used to quantify/predict estuarine health (e.g., Holland et al. 2004; Pelletier et al. 2019).

Along with the landscape-scale, remotely sensed indicators, characterization of the physical and hydrodynamic structure of each estuary helps to provide an environmental context for each system, informing sampling design. These types of data can also be important for standardizing indicators of condition between different estuaries.

The Technical Team used three organizing principles to prioritize indicators for inclusion in the estuarine assessment framework:

1. key ecological functions
2. designated goals of the program
3. incorporation of indicators that are already being used in the region to assess estuary condition

The program team identified eleven priority ecological functions of estuarine MPAs around which an assessment framework could be built. The underlying principle is that all estuaries should provide a variety of ecological functions at some ideal rate in the absence of anthropogenic disturbance and alteration. The functions that were selected represent a mix of true ecological functions (processes with limited direct society value) as well as ecosystem services (processes with direct, often commodifiable, society value). To select the indicators of estuarine health, the potential biotic and abiotic indicators were then mapped to each function, creating an indicator applicability matrix (Table 1).

The last element for consideration in our selection of indicators for the assessment framework was the practical aspects of time, cost, and feasibility. Based upon the size of typical sampling teams and the geographic location of the estuarine sites, the technical team settled upon a 3-day time frame for each field sampling event. Based upon the desired 3-day time frame and the linkages of the indicators depicted in Table 1, the final list of estuarine indicators was established.

Building an assessment framework using indicators applicable to the three organizing principles allows for a framework grounded in sound ecological principles, clearly identifiable concepts, and applicability to the state's MPA programmatic goals.

Table 1. A function-based assessment will be used to assess the condition of each estuary, where multiple indicators can be used to assess a given ecological function. Green squares represent the indicators that can be used to evaluate function.

		Indicators												
		Water quality	Water nutrient concentration	General community composition (eDNA)	Sediment characteristics	Benthic infauna abundance/diversity	SAV/macroalgae distribution	Fish abundance/ diversity	Crab abundance/ diversity	Marsh vegetation distribution/ diversity/ invasives	Marsh plain elevation	Sediment accretion rates	Mouth dynamics	General habitat condition
Ecosystem Functions	Nekton Habitat	■	■				■	■	■					
	Primary Production			■	■		■			■	■	■		■
	Secondary Production					■	■			■				
	Protected Species Support	■		■			■	■	■	■	■		■	■
	Nutrient Cycling		■		■	■	■			■		■	■	
	SLR Amelioration									■	■	■	■	■
	Bird Habitat					■	■	■	■	■	■		■	■
	Shellfish Support	■	■	■	■	■	■							
	Nursery Habitat					■	■	■	■				■	
	Support Vascular Plants	■			■		■			■	■	■		■
	Wildlife Support	■	■	■			■			■	■			■

Flexibility and Adaptability

The modular nature of the EMPA Monitoring Program builds in flexibility and adaptability to accommodate many different programmatic needs by allowing users or managers to pick and choose the ecosystem functions to monitor based on specific programmatic needs or goals. Although the EMPA framework identifies eleven priority ecological functions, the selective framework allows users to prioritize and select specific ecological functions, select indicators to monitor those chosen functions, and then identify the areas within the estuary to sample. This flexibility in the framework provides users with opportunities to customize their own monitoring framework, while facilitating the comparability across multiple sites via the unified standard operating procedures and data management infrastructure. Additionally, due to the flexibility of the framework, users can add this framework on top of other ongoing efforts in their region. Some programs may have specific monitoring objectives and SOPs, and therefore cannot adopt a full suite of the EMPA program.

There are three main advantages to the modular framework:

1. It allows users to bundle functions in different ways to evaluate specific and targeted questions (e.g., restoration success, coastal resiliency, fisheries management, water quality).

One of the main advantages to a modular, function-based framework is it allows users to group functions by specific question. For example, if a reserve manager is most interested in evaluating how water quality impacts estuarine health, then they can select specific functions and indicators that would directly evaluate and measure water quality. In this example, managers may be most interested in the functions – 'nutrient cycling', 'nursery habitat', and 'nekton habitat' – because water quality would impact these three functions. Specifically, they may choose to select four indicators to help evaluate these functions (water quality [data sensors], water nutrient concentrations [water grabs], sediment grainsize [sediment cores], and fish abundance/diversity [fish seines and traps]). Using the function to feature table highlighted in the monitoring manual, managers can then also prioritize specific areas (landscape features) within the estuary to sample, allowing them to ask even more fine-scale questions (e.g., does water quality differ across different landscape features? Does water quality vary due to proximity to the estuary mouth and/or mouth state). The modular framework provides multiple crosswalks to help users understand which indicators can be used to assess which functions. By bundling functions together, users can start to answer more complex questions.

2. It provides the ability to partner with academic studies to ask specific questions that can feed back into the program.

The modular framework was created, edited, and refined by both the EMPA Project Team and the Management Advisory Committee (MAC). However, there are many aspects of the framework that can still be tested and validated. For example, to better understand the comparability across sampling efforts and types, more research should be conducted to understand how sampling effort can affect abundance and diversity metrics. Further method validation will better help users evaluate ecological functions and potential indicator thresholds allowing for more informed interpretation of data that are collected. Additionally, a key component to the EMPA program is data availability. Open access data will further

encourage engagement with academics, thereby encouraging further refinement to the program and framework.

3. It can continue to be revised and improved by identifying additional functions and indicators to meet regional and state needs.

The EMPA program was created as a collaborative effort with the ability to be revised and improved. Due to the scope of the initial project, the program's technical team only identified 11 priority functions and 15 SOPs. Due to this limitation, the program expects to add additional functions and indicators to the framework to meet regional and state needs. Current efforts are underway to add coastal resiliency indicators to the framework, as this is a priority for OPC and other state agencies.

Potential Implementation Mechanisms

Program Elements

Long-term implementation of the EMPA monitoring program will require a program structure that can facilitate and manage all implementation aspects, coordinate with other relevant state, regional and local monitoring programs, act as fiduciary to solicit and manage funding for the program, lead outreach and information dissemination, and take responsibility for any reporting requirements.

As an example, the San Francisco Estuary Wetlands Regional Monitoring Program (SF Estuary WRMP)[3] is implemented through four primary program elements that could also be adopted for the EMPA monitoring program (Table 2): Program Governance, Program Management, Science Management, and Data Management. **Program Governance** identifies a clearly defined structure (such as a Steering Committee) for making decisions about program science, administration, funding, staffing, and related implementation components. Implementing these decisions is the responsibility of **Program Management**, which also provides administrative support for program governance and science management. Program managers also coordinate outreach and engagement with stakeholders, monitoring partners, and the general public. **Science Management** includes the establishment of a workgroup or advisory committee and related technical workgroups, stewardship of the program's science framework, coordination and execution of monitoring activities (including any special studies), and the translation of monitoring data into information for decision-makers. **Data Management** includes development and maintenance of the necessary hardware and software systems to manage program data, including procedures for QA/QC, online access, and visualization. Because data management approaches must be consistent and compatible across space, time, and metrics, this program element will most likely be implemented or coordinated by a single institution.

[3] For more information, see https://www.wrmp.org.

Table 2. Primary program elements.

Program Governance:
• Develop the management questions that drive the Program and adapt the questions over time
• Approve an annual/biennial/etc. workplan and budget
• Allocate funds for key Program areas and special studies
• Track overall Program progress and effectiveness
• Review Program operations and peer review processes to ensure optimal performance, scientific excellence, objectivity, and independence
• Address other administrative, strategic planning and "big picture" issues as needed
Program Management:
• Serving as the fiduciary agent
• Grant writing and other fundraising
• Contract management
• Coordinating workgroups
• Managing outreach, communication, and stakeholder engagement
• Administrative presentation and reporting
Science Management:
• Coordination of place-based or methods-based pilot or case study projects that support broader Program goals and are "sponsored" by the program (special studies include priority monitoring areas that are implemented during a given performance period)
• Stewardship of the program science framework, including updates to monitoring questions, indicators, metrics, and SOPs
• Development of the monitoring site network, including coordinated regional ambient and project-based data collection, analysis, and interpretation
• Science presentation and reporting from monitoring and special studies
Data Management:
• Data acquisition including uploads and web services
• Data QA/QC
• Data assembly and organization
• Hardware/software support for data analysis, visualization, and delivery
• Coordination with federal/state open data platforms

The program structure should provide opportunities for all interested parties (e.g., regulators, resource managers, funders, practitioners, community organizations) to participate in some aspect of the monitoring program. The proposed tiered structure would allocate responsibilities and provide participation opportunities at multiple scales. The tiered structure would require mechanisms for ongoing coordination between the different levels (Figure 1). A charter would help define the responsibilities of and relationships between the organizations responsible for internal Program Governance, Program Management, Science Management, and Data Management, as well as for external coordination and participation.

Given the tremendous regional variability in estuarine management, and the diversity of stakeholders, Science Management may be most efficient and effective if regionalized, with different institutions responsible for managing science implementation in different regions. EMPA Monitoring Program science could be regionalized according to boundaries established by the California MPA system[4], by the boundaries of divisions of partner state agencies (e.g., CDFW, Regional Water Boards, Coastal Conservancy, Coastal Commission), or other jurisdictional/statutory boundaries. Nevertheless, overall program and data management should occur at the statewide scale and should provide mechanisms for coordinating among the regional programs in a way that allows local and regional data to be integrated to address statewide management questions.

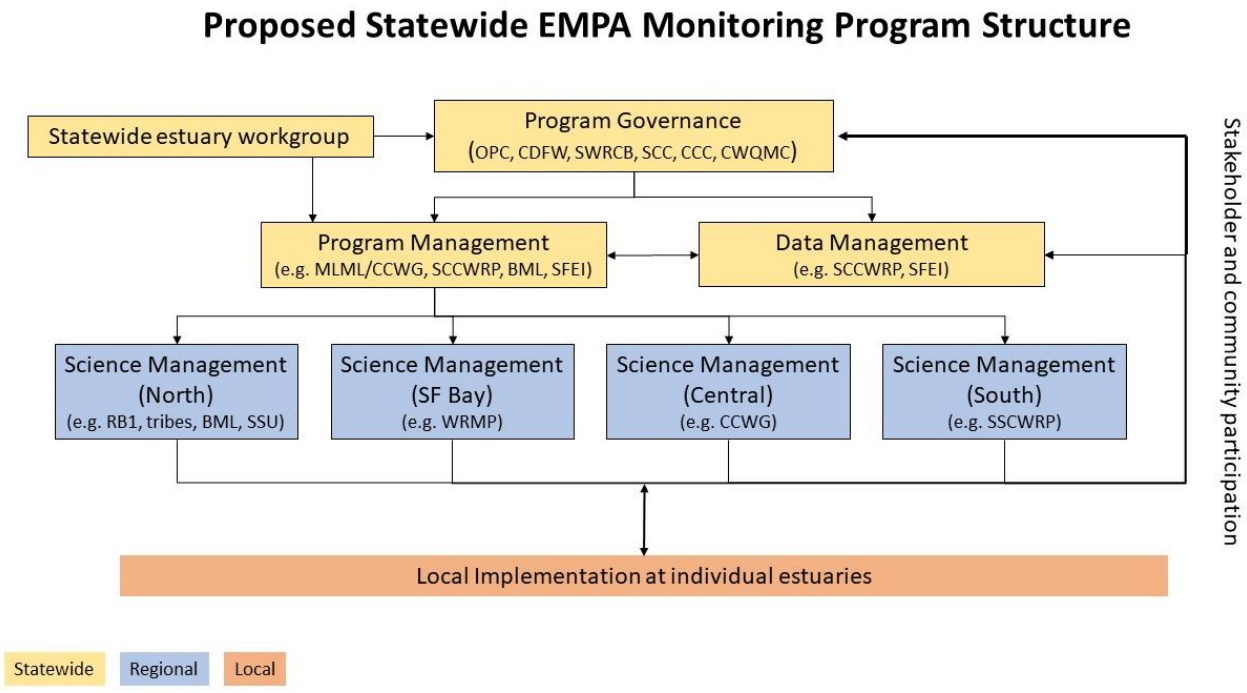

Figure 1. Tiered program structure showing how the key elements of a statewide EMPA Monitoring Program relate to each other with opportunities for stakeholder and community participation at all levels. Yellow cells are statewide, blue cell are regional, and orange cells are local.

[4] The California MPA system breaks the state into five regions: Northern California, North Central California, San Francisco Bay, Central California, and Southern California.

Program Management

To establish and maintain a statewide EMPA monitoring program, it's especially important to identify who will be responsible for Program Management. Options for statewide program management will depend on a variety of factors including end users of the data (e.g., landowners, project funders/planners, regulatory/resource agencies, tribes, community groups, science institutions, stewardship NGOs, etc.), participants who rely on the program to fulfill other requirements (e.g., permit-required monitoring, restoration effectiveness assessments), and beneficiaries of the outcomes of the monitoring, (e.g., existing regional or state cooperative entities, resource management entities). Potential statewide program management options include:

A. An existing state program or agency takes on EMPA monitoring management as a new responsibility (e.g., the Water Boards' Surface Water Ambient Monitoring Program (SWAMP)[5], OPC/CDFW MPA Monitoring Program[6]).

B. An existing organization or academic institution with expertise in statewide or regional monitoring assumes responsibility for program management (e.g., MLML, SCCWRP, SFEI)

C. EMPA monitoring is merged with an existing monitoring program (e.g., Bight regional monitoring program, SF Bay RMP, SF Estuary WRMP)

D. Forming a new entity, such as a new non-profit or joint powers agency to manage the program

The benefits and challenges of each option are briefly summarized in Table 3.

Table 3: Options for overall program management

Option	Benefits	Challenges
A. Existing state program or agency	Does not require development of new organizational structure. Can take advantage of existing program resources	Staffing and resources for existing programs is already limited and it may be difficult to take on additional responsibilities
B. Existing monitoring organization	Can take advantage of relevant expertise and capabilities of an organization focused on monitoring	Would require additional resources to allow the organization to accommodate the new program
C. Merge with another program	Can leverage capabilities of a similar program and could foster good coordination between programs	May dilute resources of the original program. EMPA program may be given lower priority than original program
D. Form a new entity	New entity would be focused on EMPA monitoring as its primary mission	Would need a cooperative agreement or MOU, staff, and organizational structure

[5] For more information, see https://www.waterboards.ca.gov/water_issues/programs/swamp/

[6] For more information, see https://wildlife.ca.gov/Conservation/Marine/MPAs/Management/Monitoring

The overlapping authorities related to estuary and EMPA management in California make identification of a singular monitoring program management entity under Option A challenging. Staffing and resources at state agencies such as OPC, the Regional Water Boards, and CDFW are limited, and the California budget process does not typically favor the establishment of new programs that require ongoing commitments of personnel and funds. Given the benefits and challenges of each option, ***we recommend Option B as the most practical.*** Potential program management leads under this option include MLML – CCWG, SCCWRP, SFEI, or a similar institution with demonstrated experience coordinating programs across technical disciplines and government agencies. This option would take advantage of existing expertise and infrastructure and provide for program management by an organization already focused on monitoring and assessment. This option would require dedicated funding be provided to the existing entity to allow them to grow their capacity and manage the additional responsibilities of the EMPA Monitoring Program. These funds could come from federal, state, and local agencies, grants, philanthropic institutions, or a combination thereof (see additional discussion in Budget and Funding Mechanisms, below). This structure echoes those of existing regional monitoring programs such as the Southern California Bight RMP, San Francisco Bay RMP, and SF Estuary WRMP.

Regardless of the program management lead, we recommend that the existing Management Advisory Committee (MAC) be maintained as a forum for statewide EMPA Monitoring Program governance and coordination, assuming continued participation in the MAC by key estuary regulatory and management agencies. The MAC composition may evolve over time, but it will continue to be an excellent mechanism for ensuring connection between the monitoring program and the management decisions it is trying to inform. Additional coordination can occur through groups such as the California Wetlands Monitoring Workgroup (CWMW), MPA Watch, and the MPA Collaborative Network. The California Wetland Monitoring Workgroup (CWMW) meets on a quarterly basis to provide input and recommendations to state agencies wetland managers in general on wetland monitoring in the State. MPA Watch trains volunteers to observe and collect unbiased data on coastal and marine resource use and currently has several survey tracks located near or adjacent to EMPAs. The MPA Collaborative Network established the Estuary Working Group in 2020 to provide a forum to discuss MPA designations, enforcement issues, outreach messaging unique to estuarine and wetland MPAs, and monitoring.

Relationship to Regional and Local Monitoring Programs

The power of a statewide monitoring program comes from its reciprocal support relationship with regional and local monitoring programs. The statewide program provides an overarching framework, structure, standard protocols, and data tools that can facilitate regional and local monitoring. In turn regional and local programs are critical data sources that support statewide assessments. Moreover, they provide opportunities for intensification and testing new methods and indicators. Finally, the statewide program provides context to help interpret regional findings, which in turn provides context to help interpret local results.

The overall program management entity would be responsible for establishing ongoing mechanisms to coordinate and leverage existing regional monitoring programs and develop new ones consistent with the EMPA monitoring program science framework (e.g. regionalization of science management). This would likely be through workgroups or subcommittees. The statewide program will also partner with existing regional and tribal efforts, such as the Southern California Bight RMP, San Francisco Bay RMP, the San

Francisco Estuary Wetland RMP, the Southern California Wetland Recovery Project, and the Tribal Marine Stewards Network to enhance compatibility, data sharing and common data interpretation approaches. This could be accomplished by having overall program management staff participate in regional program workgroups and visa-versa. Furthermore, there must be a mechanism for local/site specific programs (e.g., grant funded restoration projects, compensatory mitigation programs) and community organizations to participate in the state and regional programs. This can occur through regular outreach and training, and by partnering on data collection and interpretation. A list of current local partners is provided in Table 4.

Table 4. Local partners who can support EMPA monitoring.

MPA Region	Marine Protected Area	Local Partners/Monitoring Programs
North	South Humboldt Bay State Marine Recreational Management Area	Friends of the Dunes
	Ten Mile Estuary State Marine Conservation Area	The Nature Conservancy, California State Parks
	Big River Estuary State Marine Conservation Area	California State Parks
	Navarro River Estuary State Marine Conservation Area	California State Parks, Navarro River Resource Center, Navarro-by-the-Sea Center
	Russian River State Marine Recreational Management Area	Russian Riverkeeper, Russian River Watershed Association, Russian River RMP
	Estero Americano State Marine Recreational Management Area	The Wildlands Conservancy, Sonoma Land Trust
	Estero de San Antonio State Marine Recreational Management Area	Marin County RCD
	Estero de Limantour State Marine Reserve	Point Reyes National Seashore
	Drakes Estero State Marine Conservation Area	Point Reyes National Seashore
Central	Elkhorn Slough State Marine Reserve	Elkhorn Slough Foundation, Elkhorn Slough NERR
	Elkhorn Slough State Marine Conservation Area	Elkhorn Slough Foundation, Elkhorn Slough NERR
	Morro Cojo Slough State Marine Reserve	Elkhorn Slough Foundation, Elkhorn Slough NERR, Central Coast Wetlands Group
	Piedras Blancas State Marine Reserve[7]	California State Parks
	Morro Bay State Marine Recreational Management Area	Morro Bay NEP
	Morro Bay State Marine Reserve	Morro Bay NEP

[7] Footprint of SMR includes the Arroyo de la Cruz creek estuary.

MPA Region	Marine Protected Area	Local Partners/Monitoring Programs
South	Goleta Slough State Marine Conservation Area	Goleta Slough Management Committee
	Bolsa Bay State Marine Conservation Area	Bolsa Chica Conservancy, Amigos de Bolsa Chica
	Bolsa Chica Basin State Marine Conservation Area	Bolsa Chica Conservancy, Amigos de Bolsa Chica
	Upper Newport Bay State Marine Conservation Area	Newport Bay Conservancy
	Batiquitos Lagoon State Marine Conservation Area	Batiquitos Lagoon Foundation
	San Elijo Lagoon State Marine Conservation Area	San Elijo Lagoon Conservancy
	San Dieguito Lagoon State Marine Conservation Area	Friends of the San Deiguito River Valley
	Famosa Slough State Marine Conservation Area	Friends of Famosa Slough

Data Management

General Philosophy and Principles

Data management provides the mechanism for consolidating information between independent monitoring efforts, connecting estuary monitoring data to ancillary data sources to support analysis, and developing data visualizations and other data products aimed at translating data to information that can be used to support management decisions. Properties that will improve the success and longevity of data management systems include transparency, accessibility, integration, stability, and quality control. In developing a data management system, the following general considerations and practices are recommended:

- Strive for an integrated, electronic data flow through all steps of the data management process from data collection through publication (Figure 2);
- Manage data in a geospatial format to enhance data visualization and interpretation and facilitate data integration across programs;
- Embrace open data practices and use an open data format, which may include web services and application program interfaces (APIs), to facilitate data access and sharing; and
- Provide user-friendly, map-based tools to explore, access, and download data in readily transferable formats (e.g., csv).

Figure 2. Stages of electronic data flow

The California Open Data Handbook[8] provides guidelines to identify, review, prioritize and prepare publishable data for access by the public and government entities via an open data portal or open data site. A foundational emphasis in on value, quality, data and metadata standards, and governance. This handbook is meant to serve as a resource for organizations and is also freely offered to any party that may be interested in improving the online access of publishable and machine-readable data. It will also provide an understanding of the processes by which portal owners make data available for publishing. Additional resources can be found in the Internet of Water Principles [9] and the Findability, Accessibility, Interoperability and Reuse principles[10].

Data Management Approach

Integrated, electronic data flow is the foundation that enables all other desirable data management properties (e.g., accessibility, integration, and sustainability). Electronic data flow begins with **data collection**, where data is captured electronically using, for example, standardized web-based forms or data collectors. Built-in QA/QC procedures (such as drop-down menus and automatic range checkers) are necessary at the data collection stage – and throughout data entry and analysis – to ensure that information is captured correctly. The next component is the design – or **organization** – and maintenance of the database so that stored data can be readily used by state agency staff and partner agencies and organizations to answer identified questions. Ensuring standardized data fields, numerical formats (e.g., units), and naming conventions across all entries will facilitate later program-wide assessments. Data dictionaries provide important information about the data (i.e., metadata), including format, structure, and how it will be used. **Visualizing** data geospatially provides opportunities to summarize data around management questions, and link estuary monitoring data with other data layers to enhance data processing and interpretation. **Publication** includes outputs at different levels based on the uses of the data and public access to data. Publication may include raw data outputs, summary plots, report cards, or standardized reporting templates. Data should be readily accessible via web interface to allow it to be discovered and downloaded for scientific analysis and public interpretation.

Contemporary data management embraces a distributed data management approach whereby it is not necessary for all data to be uploaded to a central data repository. Embracing open data practices and electronic data management approaches, including standard data and metadata templates, as discussed above, facilitates linking and leveraging of data between data management systems. Moreover, effective data management practices should make data easily discoverable and accessible via multiple pathways

[8] https://handbook.data.ca.gov/
[9] https://internetofwater.org/internet-of-water-principles/
[10] https://www.go-fair.org/fair-principles/

(or portals). Nevertheless, having a designated data management entity is critical to ensure coordination, quality control, and incorporation of data into data portals.

As with all aspects of regional or statewide monitoring, data management must be ongoing and adaptive to accommodate changing needs and priorities. Long-term stewardship of data management systems is necessary to ensure lasting use and benefit of the data collected and compiled through monitoring programs. Ideally, stewardship should be done by a public entity with sustained resources and in-house expertise to manage the data, update data management systems to accommodate changing technology, and troubleshoot problems when they occur. Moreover, the data steward will often need to provide technical support and assistance to end-users to help ensure consistent data access. Monitoring budgets should account for staffing, infrastructure, and hardware/software costs associated with ongoing data management.

Data Infrastructure and Tools

The EMPA Monitoring Program has established a central project website and data portal[11] that provides an integrated, electronic data flow from collection through dissemination. The project website hosts all general project information, such as the project work plan, information on the EMPA Management Advisory Council (MAC), technical reports, and key presentations. Additionally, it hosts standard data templates for data collection and entry, as well as providing guidance on data management, including analysis, synthesis, and reporting.

To manage the EMPA data, a ESRI postgresQL geodatabase was created. Users can upload data into the database using an automated checker tool hosted on the EMPA website. The checker tool provides real time data QA/QC in order to provide ready to use, clean data. All data can be downloaded and accessed from the EMPA website using the data download application and query tools.

By building data management tools, the EMPA data is easily accessible and linked to other monitoring programs. To accomplish these goals, the EMPA portal embraces open data practices and uses an open data format and can be linked to other data portals, such as the California Natural Resources Agency Open Data Portal[12], Environmental Data Initiative[13], SF Estuary WRMP Geospatial Portal[14], and EcoAtlas[15] via application program interfaces (APIs) or other web services. This would allow related data sets to be linked and would provide multiple points of entry for data access and would reduce the need for a central data repository. The EMPA portal can also be used to host other project data that uses the EMPA framework, as long as those projects use the standard data templates. This structure will facilitate data sharing and dissemination through a variety of programs in the future.

[11] https://empa.sccwrp.org
[12] https://search.dataone.org/portals/CaliforniaMPA
[13] https://environmentaldatainitiative.org/
[14] http://data.wrmp.org
[15] https://www.ecoatlas.org/

Tools to Support EMPA Partners

Broad implementation and adoption of the statewide program can be fostered by development of tools and resources to assist in program implementation. These tools should be readily available and interpretable and program management staff should be available to assist in their use.

- ***Agency-specific guidelines*** that illustrate how the EMPA program relates to various regulatory, funding, and resource management programs. These guidelines can discuss how the program can fulfill or support regulatory, management or reporting requirements and can highlight any challenges or impediments to adoption by specific agency programs.
- ***Training, outreach, and online support materials*** that facilitate adoption of the program by users with a broad range of expertise. Support materials can aid data submission, analysis, synthesis, and visualization; use cases in decision-making, community engagement, and related needs. In addition to protocols and standard operating procedures, support materials can include field safety guides, lab procedures, etc.
- ***Data structures and standard data templates*** to support collection and submittal of data to the data portal. These data structures should support the cradle-to-grave electronic data submittal process. Data structures should also include data dictionaries and QA guidelines
- ***Monitoring templates and/or case-studies*** that can be used to readily translate data collected through the program to graphics or reports that can be submitted as part of permit or grant requirements or to support communication and outreach. Case studies are valuable in demonstrating the application and utility of the monitoring program to address specific management needs.

Budget and Funding Mechanisms

Funding Needs

Ongoing implementation of the EMPA monitoring program will require sustained and committed funding to support the following areas:

- ***Program governance and management:*** Funds will be necessary to support the statewide program management entity in its activities to administer, plan, and facilitate program implementation. These funds are also necessary to support financial management and reporting, outreach and communication, and MAC/TAC facilitation.
- ***Science management:*** Funds will be necessary to support data collection, QA/QC, analysis, synthesis, and reporting, as well as the transmittal of data and data products to the centralized data management platform.
- ***Data management:*** These funds will be necessary to cover ongoing management, upgrades, and troubleshooting of the data management system. These funds will also support QA activities and staff time to provide assistance to individuals or entities seeking to submit or obtain data
- ***Communications and Reporting*** – these funds will cover production of periodic reports and web content, data visualizations and presentations for a range of audiences and ad-hoc information

requests. This task will also support communication and outreach to local and community-based groups about the EMPA monitoring program.

Budget

The estimated annual cost to administer the program is $365,000 (Table 5). In addition, the estimated per-site cost to implement all EMPA protocols is $70,000 per site. The per-site cost can be scaled based on the specific protocols implemented.

Table 5. Annual budget for program implementation

Element	Annual Cost
Program management and facilitation	$65,000
Data management	$125,000
Data analysis	$150,000
Per-site monitoring costs	$70,000 per site
Communication and report	$25,000
Total	**$365,000 + $70,000 per site**

Potential Funding Mechanisms

A variety of funding strategies are available and will vary based on the governance structure selected. In reality, multiple funding strategies may need to be developed to support the program over the long term. Certain funding strategies may be more or less appropriate for different programmatic elements (e.g., program management, data management, site monitoring).

- ***Direct allocation of agency funds*** via administrative or legislative action (e.g., budget change proposal). This would be the most direct and efficient funding mechanism, but would require substantial upfront effort to establish.
- ***Optional monitoring payments*** for projects that require compliance monitoring associated with permits or as performance assessments associated with grant-funded restoration projects. This funding source may be somewhat intermittent and may involve additional regulatory requirements.
- ***Contracts and grants*** that directly support program management, data management or implementation aspects of the monitoring program. There are a variety of contract options, but many would require a competitive bid process that may only have marginal returns on the time invested pursing the funds.
- ***Participant dues*** from organizations that form a monitoring collaborative that supports regional assessments, sentinel site monitoring or other common monitoring needs. This funding source would require additional program management capacity for collecting and managing dues but may be a sustainable option once a consortium is established.

- ***Cost-sharing and in-kind services*** from a range of organizations. This model is used effectively by many regional monitoring programs and involves partner agencies funding specific elements of the monitoring program through cost-share agreements or in-kind services. This strategy typically has relatively low overhead costs but requires substantial coordination to ensure all priority aspects of the program are funded. Often this strategy is more appropriate for site monitoring and less appropriate for program management.
- ***Philanthropic donations***, endowments or grants from foundations have been done in the past for larger, mature regional monitoring programs and could be a periodic source of funding
- ***Supplemental Environmental Projects (SEPs) and other enforcement funds*** – SEPs are environmentally beneficial projects undertaken to offset a civil penalty as a result of a violation of the Clean Water Act. SEPs may be a funding source for certain activities that fall within the SEP policy but would need a clear nexus to the violation. Additional funds such as fines for enforcement actions by other agencies may also be a source of funding. These funds often require prior approval through a water board process.

Evaluation and Program Refinement Over Time

All monitoring should be adaptive, which involves regular review of the efficiency of the program and its effectiveness at answering the core management questions it was designed to evaluate. We recommend triennial reviews of the following criteria:

- Overall efficiency of program management, including fiscal health and accessibility of program management staff
- Data audit for quality and accessibility of data and ease of use for partners and target end-users
- Ability to answer core management questions
- Flexibility to accommodate evolving needs and questions
- Ease at which new partners at local or regional levels can engage and partner with the program, and robustness and diversity of existing partnerships
- Representativeness of a broad set of issues, questions, and constituencies
- Accessibility and understandability of information products to audiences with a range of technical expertise

Over time, quantitative evaluation criteria should be developed to provide systematic, objective, and quantifiable performance measures of the EMPA program. Measures could include function of EMPA sites relative to non-EMPA sites, trajectories over time in function or stress, number of projects funded, or regional changes in ecological communities of management importance. Adaptive measures should be identified to improve performance and to foster the program's evolution, as necessary. Results of the performance evaluation should be readily available to program managers, funders, and the public.