San Francisco Estuary National Water Quality Monitoring Network Pilot Study Report

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San Francisco Estuary Institute

In collaboration with San Francisco Estuary partners including:
Heather Kerkering[1], Chris Farrar[2] and Collin Eagles-Smith[2]
1 Central and Northern California Ocean Observing System
2 U.S. Geological Survey

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Table of Contents

Index of Figures

Index of Tables

1. Introduction

1.1 Statement of Purpose

This report represents the culmination of the National Water Quality Monitoring Network (NWQMN or Network) San Francisco Estuary Pilot Study (Pilot or SF Bay Pilot). The Network design, produced by the National Water Quality Monitoring Council as called for in the U.S. Ocean Action Plan and with guidance from the President's Council on Environmental Quality and the National Science and Technology Council, is available at http://acwi.gov/monitoring/network/design.

As a pilot study we were asked to:

1. **Inventory**
   Inventory current ongoing environmental monitoring programs within the study area that collect data at a scale similar to that proposed in the Network design. The inventory should include information about locations of monitoring sites, frequency of monitoring, parameters measured (or derived), and institutional responsibilities. (Section 3)
2. **Data Management Issues**
   Investigate data comparability and data sharing issues in the study area and recommend procedures for their resolution. This includes comparing meta-data and data sharing issues among existing programs within the study area and how they link to State and/or National data management and data access services. (Section 4)
3. **Gap Analysis**
   Identify gaps between existing monitoring and that indicated by the Network design. (Section 5)
4. **Management Issues**
   Identify management issues in the study area that would be better addressed if the monitoring gaps noted in item 3 above were filled and data were more comparable and accessible. Examples of such management issues could include habitat impairment, limits on existing uses of the water body, loss of wetlands, or excess nutrients. (Sections 2 and 6 address management issues and how the Network would address these issues, respectively)
5. **Cost Estimate**
   Estimate costs of on-going monitoring and costs to fill identified gaps. (Section 8)

1.2 Overview of Study Area

The San Francisco Estuary (Estuary) is the largest estuary on the west coast of the United States. It drains a watershed that is approximately 68,600 mi^2 (Figure 1.1) and covers 40 percent of California's land area[1], which receives nearly 50% of the state's runoff [2]. The San Joaquin and Sacramento Rivers transport approximately 95% of the freshwater that enters the Estuary, and much of the flow from these rivers is diverted for water use across the state. The Sacramento-San Joaquin Delta (Delta), a complex mosaic of wetlands, farmland, and urban land use where these two rivers meet, is managed for water quality, levee integrity, water supply, and ecosystem restoration[3]. The Delta supplies 24 million Californians located in both Northern and Southern California with a portion of their water[4]. Approximately 80% of the diverted water is used by agriculture[5].

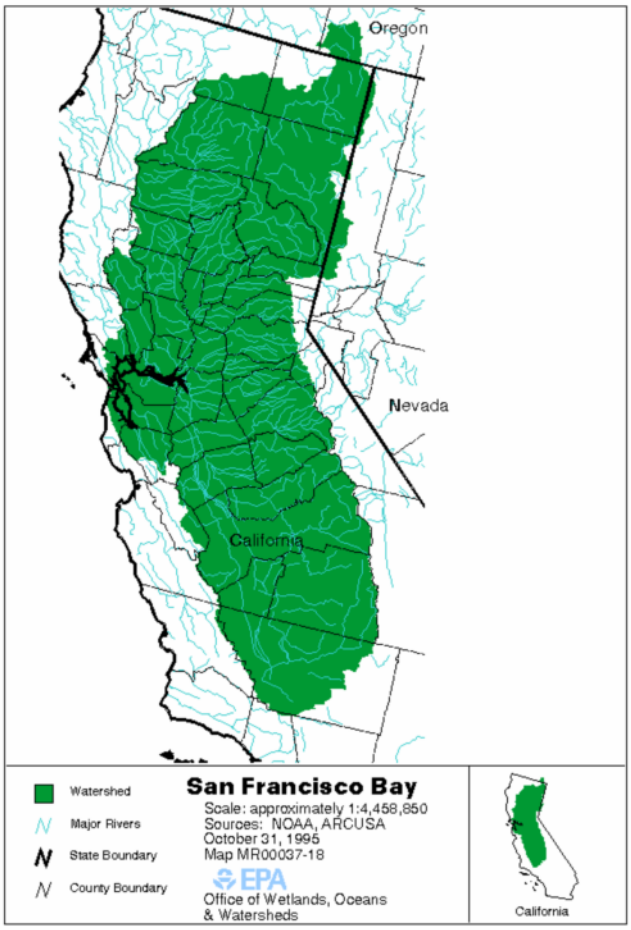

Figure 1.1 San Francisco Estuary Watershed[12]

The watershed includes nine Bay Area counties (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma), the Delta, and the Central Valley, encompassing both highly urbanized and agricultural regions. The 2006 population estimate for the highly urbanized nine Bay Area counties was 6.9 million[6]. The 2000 population estimates for the Delta and Central Valley were 0.5 and 4 million, respectively[7].

Land use in the watershed is separated into urban, agricultural, and undeveloped land areas (Table 1.1). Urban land use dominates the areas immediately surrounding the Bay; however, agricultural land comprises the bulk of the nine Bay area counties[8]. The Delta is largely agricultural[9]. The Central Valley, which accounts for nearly a quarter of U.S. agricultural production[10], is largely undeveloped[11] because this area also includes large parts of the Sierra Nevada Mountains.

In addition to these urban and agricultural influences, the Estuary is also impacted by extensive historic mercury mining in the region, including the former New Almaden mercury mine located in the Lower South Bay watershed and Coast Range mercury mining, as well as gold mining in the Sierras, which utilized mercury. Contaminants of current concern include legacy contaminants such as mercury, PCBs, and pesticides, as well as emerging contaminants such as PBDEs. Contamination from many sources remains a major management concern for the Estuary.

Table 1.1 Major Land Use in the Pilot Study Area (percent, acres in gray, and totals in boldface).

	Urban	Agricultural	Undeveloped
San Francisco Bay Counties	26%	49.2%	24.2%
	1,143,000	2,163,000	1,081,000
Delta	9%	58%	10%
	64,000	425,700	75,000
Central Valley and Sierra Nevada	3.2%	19.7%	75.4%
	880,000	5,456,000	20,913,000
SF Estuary Watershed	**6.5%**	**25.0%**	**68.5%**
	2,087,000	**8,044,700**	**22,069,000**

Another significant management issue in the region is the protection and restoration of Bay Area wetlands. San Francisco Bay was originally surrounded by extensive wetlands, much of which were subsequently diked and drained for use as farmland and industrial salt ponds. This resulted in a loss of more than 85% of the pre-1800 tidal marshes of the Bay so that only 73,000 acres of tidal baylands remain with 139,000 acres of diked baylands. Now, the site of the largest west coast tidal wetland restoration effort, the South Bay Salt Pond Restoration Project (SBSPRP) plans to restore 15,100 acres of salt ponds to tidal wetlands. Baywide, nearly 67,000 acres of wetlands, including the SBSPRP, have been acquired and are in the process of being restored[13]. A total of 11,800 acres around the Bay have been opened to tidal action thus far[14].

The San Francisco Estuary NWQMN Pilot Study sample frame targeted the Sacramento-San Joaquin Delta (as defined by California Water Code Section 12220), Suisun Bay, Carquinez Strait, San Francisco Bay, and the adjacent waters outside of the Golden Gate. The region that was the main focus of the information gathering effort for the Pilot Study is shown by the dotted line in Figure 1.2. Additional information compiled for this study that related specifically to pathogen studies at beaches in the region and the Integrated Ocean Observing System (IOOS) extend further north and south from the Golden Gate than the other information gathering efforts related to the other environmental compartments. Table 1.2 summarizes the key watershed, population, and land use characteristics for the Pilot Study region.

Table 1.2 Summary Characteristics Summary characteristics of the SF Bay Pilot Study area and partners involved in the Pilot Study effort.

	San Francisco Bay
Watershed area	32,200,700 acres (~ 68,600 mi^2)
Surface area of estuary	548 mi^2 [15]
Major Tributaries	Sacramento and San Joaquin Rivers
Groundwater importance	Important but extent of flow into, and influence on, the Estuary is unknown
Major land uses in watershed	Agricultural and urban with large regions of undeveloped land in the Central Valley (Table 1.1)
Population in watershed	In the urbanized nine Bay Area counties, the population estimate is 6.9 million. Total estimate of watershed population is 11.4 million.
Studies included in Pilot Study	Forty-seven different on-going monitoring projects are represented (Table 3.1).
Partners included in Pilot Study	Twenty different monitoring organizations are represented (Table 3.2).

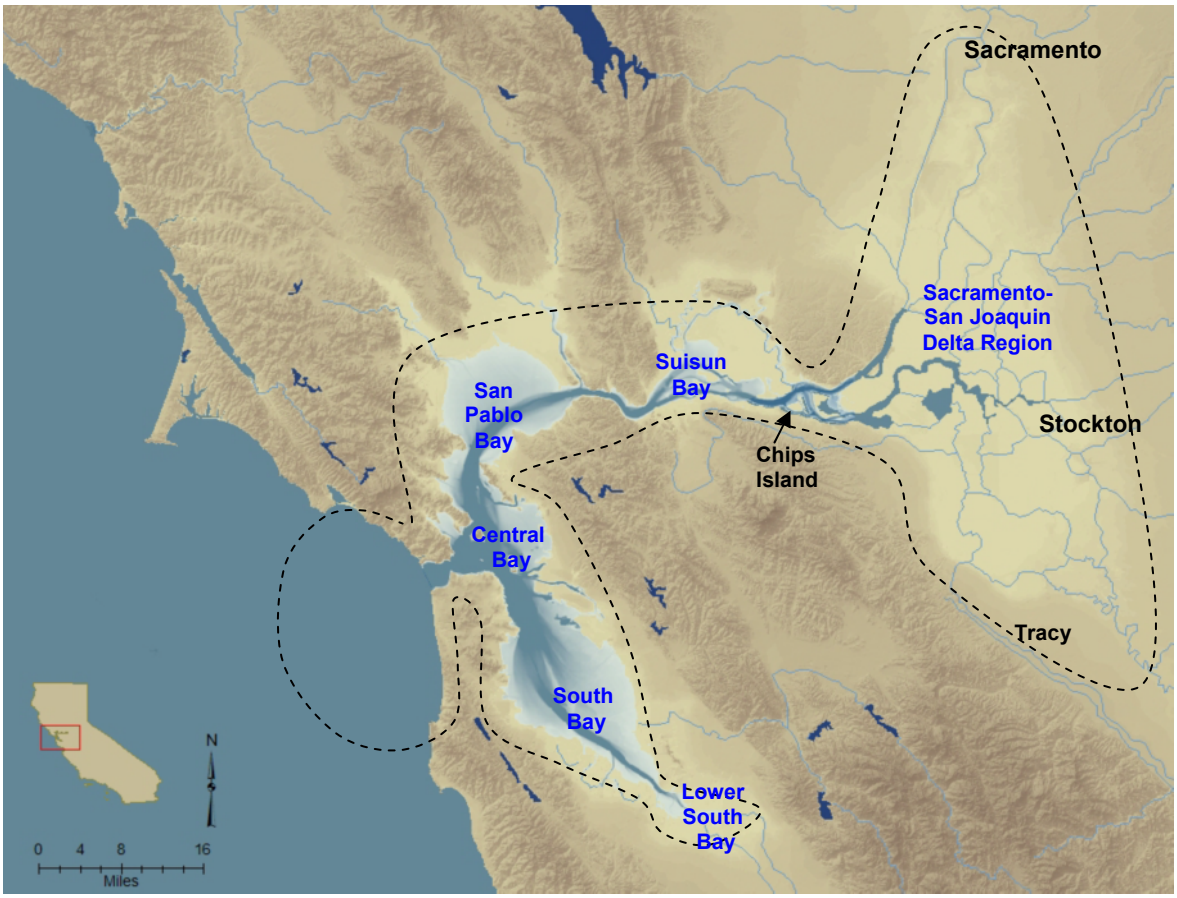

Figure 1.2 San Francisco Estuary Pilot Study Sample Frame Targeted region which was the focus of this NWQMN Pilot Study report is depicted by the dotted line.

2. Major Management Issues

The San Francisco Estuary Project provides a forum to articulate and address some of the major management issues facing the Bay. Recently, the San Francisco Estuary Project completed an update to its 1993 Comprehensive Conservation and Management Plan (CCMP), based on input from more than 80 representatives from federal and state agencies, local governments, environmental groups, business and industry, academia, and the public. This revised 2007 CCMP is the best consensus statement on the major management issues facing the Bay that would be relevant to a NWQMN analysis.

To relate these management issues to the Network design, we developed brief statements describing the CCMP goals. These goals are listed in Table 2.1 and are organized by subject area. The subject areas are: aquatic resources, wildlife, wetlands, water use, pollution prevention and reduction, dredging and waterways modification, and land use management. The goals are identified by a subject area abbreviation and number (e.g., **DW-1** refers to the first Dredging and Waterways Modification goal: eliminating unnecessary dredging activities) and referred to throughout the summaries below. In addition, we have provided a key management question within each category that is important to San Francisco Bay.

Table 2.1 San Francisco Bay Management Goals (SFEP, 2007)[16].

Aquatic Resources (AR)
1. Stem and reverse the decline in the health and abundance of estuarine biota (indigenous and desirable non-indigenous), restoring healthy natural reproduction. 2. Restore healthy estuarine habitat to the Bay-Delta, taking into consideration all beneficial uses of Bay-Delta resources. 3. Ensure the survival and recovery of listed (and candidate) threatened and endangered species, as well as other species in decline. 4. Manage the fish and wildlife resources of the Estuary to achieve the goals stated above.
Wildlife (WDL)
1. Stem and reverse the decline of estuarine plants and animals and the habitats on which they depend. 2. Ensure the survival and recovery of listed and candidate threatened and endangered species, as well as special status species. 3. Optimally manage and monitor the wildlife resources of the Estuary.
Wetlands (WTL)
1. Protect and manage existing wetlands. 2. Restore and enhance the ecological productivity and habitat values of wetlands. 3. Expedite a significant increase in the quantity and quality of wetlands. 4. Educate the public about the values of wetland resources.
Water Use (WU)
1. Develop and implement aggressive water management measures to increase freshwater availability to the Estuary.
Pollution Prevention and Reduction (PP)
1. Where pollution prevention is not possible, control and reduce pollutants entering the Estuary. 2. Clean up toxic pollution throughout the Estuary. 3. Protect against toxic effects, including bioaccumulation and toxic sediment accumulation. 4. Promote restoration and enhancement of stream and wetland functions to enhance resiliency and reduce pollution in the Estuary and its watersheds.
Dredging and Waterways Modification (DW)
1. Eliminate unnecessary dredging activities. 2. Maximize the beneficial reuse of dredged material. 3. Conduct dredging activities in an environmentally sound fashion. 4. Continue to develop and implement a comprehensive Sediment Management Strategy for "dredging and waterway modification." 5. Manage modification of waterways to avoid or offset the adverse impacts of dredging, flood control, channelization, and shoreline development and protection projects.
Land Use Management (LU)
1. Establish and implement land use and transportation patterns and practices that protect, restore, and enhance watershed processes and functions, the Estuary's open waters, wetlands, tributary waterways, and essential upland habitats. 2. Coordinate and improve planning, regulatory, and development programs of local, regional, state, and federal agencies to protect natural resources and improve the health of the Estuary and its watersheds. 3. Adopt and utilize land use policies, including transportation patterns that provide incentives for more active participation by the public and the private sector in cooperative efforts that protect and improve the Estuary and its watersheds.

2.1 Nutrients and Harmful Algal Blooms

While ambient nutrient concentrations in the Bay are comparable to concentrations observed nationally, light limitation caused by sediment resuspension has generally mitigated concerns about this issue[17]. Unlike many other areas in the country, the Bay has very low primary production available for fisheries (especially for the endangered native pelagic fish, Delta smelt (**WDL-2, Table 2.1**)), because of light limitation and elevated grazing rates by invasive clams[18].

Phytoplankton blooms have recently become more persistent and frequent. Spring blooms are larger than in past decades, and autumn blooms, which were not observed in the past, began occurring in the late 1990s[19]. One possible explanation is that decreasing sediment loads to the Bay are decreasing suspended sediment concentrations and increasing light penetration[20].

In the last several years, harmful algal blooms of *Microcystis*, a toxic blue-green alga in the Delta and red tide blooms in the Bay and offshore have become more frequent (**AR-1, Table 2.1**)[21].

Management Question: Are programs to improve primary productivity in the Delta and minimize harmful algal blooms in the Bay, such as tougher limits on ammonia concentrations in wastewater, successful?

2.2 Contaminants

Impairment of the San Francisco Bay (i.e., portions of the Bay not meeting water quality objectives) has generally focused on legacy contaminants such as mercury, PCBs, dioxins, and chlorinated pesticides (**PP-1, PP-2, Table 2.1**). Unlike many states, the most sensitive drivers of these listings have been concentrations in bird eggs and small prey fish[22]. For instance, studies have shown that Forster's tern populations near planned salt marsh restoration projects are potentially at risk from mercury contamination.

In addition to these legacy problems, there is a concern that emerging contaminants represent a threat in the Bay. Rapidly increasing concentrations of PBDEs, a bioaccumulative common flame retardant that has been detected in San Francisco Bay fish, birds, and marine mammals (**PP-3, Table 2.1**), has caused the state to ban two of the three major formulations of this product[23].

Management Question: Are adaptive management plans to meet TMDL target goals succeeding and are new TMDLs necessary?

2.3 Biology

San Francisco Bay provides habitat for many threatened and endangered species. In the last few years populations of several key fish species have collapsed, including the endangered Delta smelt. The crash of the Delta smelt population has elicited drastic changes in water management in attempts to minimize additional losses. The most controversial management issue affecting the Bay is whether water supply management strategies can improve this and other management situations (**WU-1, Table 2.1**).

Habitat loss, contaminants, and other factors have impacted Estuary organisms, including endangered species. Providing habitat for the endangered California clapper rail, which only breed in San Francisco Bay, and salt marsh harvest mouse has been one of the primary goals of

the ambitious tidal marsh restoration initiatives in the region. Much of the biological value of the Bay is a result of its importance to the Pacific flyway, the North-South route used by birds migrating from Alaska to Patagonia. Management initiatives for wetlands restoration, habitat protection, and pollution reduction are strongly driven by the importance to bird populations (**WDL-2, Table 2.1**). Managers are striving to minimize the remobilization of contaminants during restoration through proper design and staging of projects.

Management Questions: Is the status of Bay threatened and endangered species improving? Will restoration actions harm non-endangered species?

2.4 Beaches and Recreational Water Use

While average water temperatures varying between 50 and 66 °F make water use less significant in the Bay Area than Southern California, light wetsuits allow for year round water exposure. Most Bay Area cities (except San Francisco) have separate sewer systems so pathogen issues are generally not significant except during large winter rainstorms. However, recent lawsuits have exposed the incidence of raw sewage discharges at several locations around the Bay (**PP-1, Table 2.1**). Additionally, flowing streams can contribute to pathogen loads, especially after storms[24]. In addition, there is increasing concern about pathogen loads in dry weather, urban stormwater flows. Pathogens have been listed by the Regional Water Quality Control Board for several tributaries to the Bay, largely as a result of dairy farms in the watershed.

Management Question: What are the temporal and spatial trends of pathogen contamination in the Bay?

2.5 Habitat Degradation

2.5.1 San Francisco Bay Wetland Restoration

Wetlands restoration (**WTL1-4, Table 2.1**) is a major management goal for the Bay with a quantitative goal of restoring 100,000 acres. While wetland restoration tracking has focused on total acres restored, there is increasing interest in the quality of the restoration and developing a way to assess overall wetlands quality in the Bay Area. The use of landscape scale assessment (Level 1), rapid qualitative assessment (Level 2), and intensive quantitative assessment (Level 3) methods developed in collaboration with EPA is an attempt to address this issue (**WTL-2, WTL-3, Table 2.1**).

Management Questions: Can we continue to restore and protect San Francisco Bay wetlands as the human population in the region grows and sea level rises?
What role will restoration play in the bioaccumulation of mercury in Bay food webs?
Is the type and quality of wetlands in the Bay Area responding to restoration efforts[25]?

2.5.2 Delta Habitat Restoration

In addition, habitat restoration in the upstream reaches of the Delta and its tributaries are underway to improve the status of anadromous fisheries, particularly salmon, herring, and sturgeon (**AR-2, WDL-2, DW-3, LU-1, Table 2.1**).

Management Question: How will CalFed management actions affect Delta habitat quality and quantity?

2.5.3 San Francisco Bay Sediment Management

The Subtidal Habitat Goals Project, led by NOAA and the Bay Conservation and Development Commission, is developing restoration goals for the Bay's sediment habitat (**AR-2, Table 2.1**). During the Gold Rush, sediment loads to the Bay increased hundredfold, thereby harming much of the benthic habitat.

Management Question: Is the area of eelgrass beds and oyster reefs increasing due to Bay management strategies?

2.6 Groundwater

Groundwater issues have generally focused more on habitat issues (stream flow volumes in wet and dry seasons and salinity patterns in the Bay) than pollution loading (**WU-1, AR-2, Table 2.1**). Western water rights make groundwater a locally controlled resource, resulting in the absence of a cohesive groundwater monitoring network[26]. Past groundwater overdraft has caused subsidence in the South Bay and worsened flood problems.

Management Question: What goals are necessary for Bay Area groundwater?

2.7 Atmospheric Deposition

Most air masses arrive in the Bay Area after traveling long distances over the Pacific Ocean. Except for the impact of large fires and vehicle exhaust on Bay polycyclic aromatic hydrocarbon loadings[27], atmospheric deposition has not generally been linked to a significant percentage of loadings to the Bay[28]. Recently, there has been some interest as to whether local combustion sources (crematoria-mercury or wood stoves-dioxins) could be significant sources. For the most part, these issues have had more of a local than regional focus.

Management Question: What water quality issues may be significantly affected by atmospheric deposition?

2.8 Invasive Species

Biological invasions are a major global environmental problem. Studies of the San Francisco Bay and Delta ecosystem have documented both a large number of exotic species that dominate many habitats in terms of number of species, number of individuals, and biomass, and a high and accelerating rate of invasion[29]. San Francisco Bay is the most highly invaded estuary in the country[30]. These invasive species have had dramatic impacts on basic food chain dynamics in the Bay, including very low levels of primary and secondary production, particularly in the Delta[31]. The rate of invasion into the soft-bottom communities of the San Francisco Estuary appears to have increased over the last one to two decades and many of the new introductions have become dominant[32]. Exotic species account for more than 90 percent of the species, individuals, or biomass in several habitats in the San Francisco Estuary. Some individual invaders, such as the Asian clam (*Corbula amurensis*), have by themselves substantially altered the ecosystem[33].

Management Questions: Have ship ballast water management actions slowed the rate of exotic species invading San Francisco Bay?
How will non-native species invasions alter the structure of biological communities, and will affects cascade across habitats and trophic levels?

2.9 Oxygen depletion

Oxygen depletion has not been a serious concern in the Bay for the last 20 years[34]. However, in the process of restoring salt marshes there have been some small fish kills with the release of waters with low oxygen. The Stockton Deep Water Ship Channel has also suffered from low oxygen and is now being aerated.

Management Questions: How extensive are dissolved oxygen problems at the Bay margins?

3. Inventory

The San Francisco Bay Pilot Study (SF Bay Pilot or Pilot Study) inventory was conducted using a variety of approaches to identify and characterize only the major, on-going monitoring efforts within the designated sample frame. Limiting the inventory to these specific criteria, the Pilot Study effort identified 47 significant studies in the region that collect environmental measures related to the Network target constituents including pollutants of concern, biological conditions, and physical characteristics.

The SF Bay Pilot used local knowledge of major programs, web-searches, queries to lead program managers, and Central and Northern California Ocean Observing System's (CeNCOOS) inventory of local monitoring to develop a draft list of studies, frequency of sampling, station location, and parameters measured (where accessible). A Pilot Study workgroup meeting was held on November 14, 2007 where invited local scientists and managers representing EPA, USGS, the Regional Water Quality Control Board, and universities were in attendance. SFEI staff presented a brief summary of the Network design and the NWQMN workgroup documents to the Pilot Study workgroup. CeNCOOS staff also presented their efforts and an overview of Integrated Ocean Observing System (IOOS). The presentation included reviewing maps of identified San Francisco Estuary monitoring study sampling locations and a list of those studies in an effort to identify any gaps and gauge the completeness of the inventory reconnaissance effort. The goals of the meeting were 1) to get feedback on our initial information gathering effort, 2) to identify additional studies not already captured, and 3) to identify gaps in the collective scientific monitoring effort in the Pilot Study sample frame as related to the proposed Network design. A secondary goal was to address important local scientific monitoring and environmental management needs. The workgroup discussion helped SFEI frame the issues compiled in this report.

The SF Bay Pilot Study compiled a list of 47 on-going monitoring efforts categorized by the following study types:

- atmospheric deposition (air mass and wet),
- bioaccumulation (in fish, birds, and bivalves),
- community studies (fish, birds, benthos, zooplankton, phytoplankton, and intertidal),
- habitat mapping (mapping historic and current ecological condition and landuse),
- pathogen monitoring for beach condition,
- water and sediment quality monitoring for nutrients, physical condition (employing both continuous monitoring and discrete sampling methods), and
- water, sediment, and tissue monitoring for regulated and emerging contaminants.

Please note that individual monitoring programs/projects may be represented in more than one study type as warranted.

Table 3.1 lists the studies by study type, study (and sampling frequency), and indicates whether the study is a major or minor monitoring effort as defined by the Network design[†]. Table 3.2 lists the agencies and organizations leading monitoring efforts and whether the efforts

[†] "In particular, the states will have some level of responsibility for every compartment except, perhaps, the off-shore coastal waters. If a state or federal agency collects and interprets data themselves or is involved in a partnership to provide funds for others to collect and interpret data, the table should reflect that level of effort as either major or minor. Conversely, if the state or federal agency is primarily involved in an oversight role, the table could show NA and the oversight role could be explained in the text." (G. Mallard. 8 November 2007. pers. comm.)

undertaken by each organization are major or minor as defined by the Network design. Per the NWQMN guidance, decisions about whether an effort was major or minor were based on at least two of the following factors: cost, duration, and geographic extent. In the SF Bay Pilot Study the decision of whether a study is a major or minor monitoring effort was made using duration and geographic extent rather than cost.

Table 3.1 List of ongoing monitoring studies inventoried for the SF Bay Pilot Study by study type and resource components monitored. "++" indicates major monitoring effort, "+" indicates minor monitoring effort, "NA" indicates no monitoring effort underway. Note that a study may appear in more than one Study Type depending on the type of monitoring conducted.

		Resource Component							
Study Type	**Study (sampling frequency)**	**Estuary/ Embayment**	**Near-shore coast**	**Off-shore coast**	**Rivers**	**Groundwater**	**Atmospheric Dep.**	**Wetlands**	**Beaches**
Deposition Air Mass	California Ambient Dioxin Air Monitoring Program (CADAMP)						++		
Deposition Air Mass	CARB Air Monitoring Network (Continuous-Monthly; Ambient Air)						++		
Deposition Wet	Mercury Deposition Network/National Atmospheric Deposition Program (Weekly; 2000-2006; *inactive*)						N A		
Bird Bioaccumulation	SFEI RMP Bird Egg - Cormorant & Tern (Every 3-Years)	+			+				
Bivalve Bioaccumulation	SFEI RMP Bivalve (Annual)	+			+				
Fish Bioaccumulation	SFEI RMP Small Fish (Annual)	+							
Fish Bioaccumulation	SFEI RMP Sport Fish (Every 3-Years)	+							
Fish Bioaccumulation	Southwest Ocean Outfall RMP Demersal Fish (Annual)		+						
Fish Community	CalCOFI (4 times annually)			++					
Fish Community	CDFG Bay-Delta 20 mm Net Survey-Delta Smelt (8-10 times annually)	++			++				
Fish Community	CDFG Bay-Delta Fall Midwater Trawl Survey - Stripped Bass (monthly in fall)	++			++				
Fish Community	CDFG SF Bay Study - open water trawl (monthly)	++			++				
Fish Community	CDFG Summer Townet Survey (6 biweekly events per year)	++			++				
Fish Community	Southwest Ocean Outfall RMP Demersal Fish Community & Histopathology (Annual)		+						
Fish Community	UC Davis Suisun Marsh Fisheries Monitoring (Monthly)	++							
Fish Community	USFWS Juvenile Salmon Monitoring (Weekly +)	++			++				
Fish Community	USFWS Midwater Salmon Trawl Monitoring (Weekly +)	++			++				
Benthos	DWR Env. Monitoring Program Benthos (Monthly)	++			++				
Benthos	Southwest Ocean Outfall RMP Benthos (Annual)	+	++						
Intertidal	PISCO intertidal (Annual)	+	++						
Phytoplankton	DWR Env. Monitoring Program Phytoplankton (Monthly)	++			++				
Zooplankton	DWR Env. Monitoring Program Zooplankton (Monthly)	++			++				
Pathogen	East Bay Regional Parks (weekly Apr-Oct)								++
Pathogen	Marin Environmental Health Services (weekly Apr-Oct)								++
Pathogen	San Mateo Rec. Water Quality Program (weekly Apr-Oct)								++
Pathogen	Sonoma County Environ. Health Division (weekly Apr-Oct)								++
Pathogen	Southwest Ocean Outfall Beach Monitoring - NPDES Permit (weekly)								++
Sediment Quality	SFEI RMP Sediment Quality (Annual:47 sites/Yr)	++			+				
Sediment Quality	Southwest Ocean Outfall RMP Sediment Quality (Annual)	+	++						
Toxicity	SFEI RMP Aquatic Toxicity (Every 5-Years)	+			+				
Toxicity	SFEI RMP Sediment Quality (Annual:27 sites/Yr)	++			+				

		Resource Component							
Study Type	**Study (sampling frequency)**	**Estuary/ Embayment**	**Near-shore coast**	**Off-shore coast**	**Rivers**	**Groundwater**	**Atmospheric Dep.**	**Wetlands**	**Beaches**
Habitat Mapping	SFEI Historical Ecology (Habitat mapping)								
Water Quality	CalCOFI (4 times annually)			++					
Water Quality	CDIP (real-time water sampling)		+						
Water Quality	CICORE Water Quality Monitoring (Realtime)	+							
Water Quality	CICORE Water Quality Monitoring (Weekly)	+							
Water Quality	COCMP (real-time water sampling)	+	+						
Water Quality	DWR CDEC (real-time water sampling)	++	+		++				
Water Quality	DWR Env. Monitoring Program Discrete Water Quality (Monthly)	++			++				
Water Quality	National Marine Sanctuary Program		+						
Water Quality	NDBC (real-time water and air)		+						
Water Quality	NWLON (Tide gauge)	+							
Water Quality	PISCO (real-time water sampling)		+						
Water Quality	Ports (real-time water and air)	+							
Water Quality	SFEI RMP Water Quality (Annual: 22 sites/Yr)	++	+		+				
Water Quality	SFNERR (real-time water and air)	+							
Water Quality	SFNERR (weekly)	+							
Water Quality	USGS Continuous Monitoring (Continuous)	++							
Water Quality	USGS Water Quality Monitoring (Monthly)	++			+				

Table 3.2 Inventory Summary Table by Agency/Organization "++" indicates major monitoring effort, "+" indicates minor monitoring effort, "NA" indicates no monitoring effort underway.

	Resource Component							
Study Agency/Organization	**Estuary/ Embayment**	**Near-shore coast**	**Off-shore coast‡**	**Rivers**	**Groundwater**	**Atmospheric Dep.**	**Wetlands**	**Beaches**
California Air Resources Board (CARB) & Bay Area Air Quality Management District (BAAQMD)						++		
California Department of Fish and Game	++		++	++				
California Department of Water Resources	++	+		++				
California State University	+							
Coastal Data Information Program		+						
Coastal Ocean Currents Monitoring Program	+	+						
East Bay Regional Parks								++
Marin Environmental Health Services								++
Mercury Deposition Network/National Atmospheric Deposition Program (MDN/NADP) (2000-2006; *inactive*)						NA		
National Estuarine Research Reserve System	+							
National Marine Sanctuary Foundation		+						
National Oceanic and Atmospheric Administration	+	+	++					
Partnership for Interdisciplinary Studies of Coastal Oceans	+	++						
San Francisco Estuary Institute (SFEI) Region Monitoring Program (RMP)	++			+				
San Francisco Public Utilities Commission	+	++						++
San Mateo County Health Department								++
Scripps Institution of Oceanography			++					
Sonoma County Environmental Health Division								++
U.S. Fish and Wildlife Service	++			++				
U.S. Geological Survey	++			+				
U.S. Army Corps of Engineers								
University of California Davis	++							

‡ These agencies form the partnership CalCOFI (California Cooperative Oceanic Fisheries Investigations).

4. Data Management Issues

Many of the on-going, long-term monitoring programs in the state are required to report their results to either the state's central data management services or the EPA web exchange database. There is a renewed effort to make that task a routine process for most environmental monitoring projects in the state.

Recently, the California State Grants Program and the State's Surface Water Ambient Monitoring Program (SWAMP) have been required to make their results publicly available in standardized formats, with specific quality assurance/quality control (QA/QC) documentation. SWAMP has been working with other state, scientific, and educational agencies for several years to develop a distributed data management system whereby systematically formatted ambient monitoring data (of the kind that the Network is interested in) will be loaded into distributed data management systems and routed to the California Environmental Data Exchange Network (CEDEN). CEDEN is currently functioning under the Bay Delta and Tributaries (BDAT) Project. BDAT contains environmental data relevant to the San Francisco Bay-Delta, including biological, water quality, and meteorological data, and provides public access to that data[35]. Over 50 organizations contribute data voluntarily to this project.

Many of the on-going monitoring studies, described in this Pilot Study report, provide their data electronically through the CEDEN/BDAT web service. Table 4.1 summarizes data access, search, and retrieval methods and availability of metadata (e.g., project and data descriptions) for the programs/studies identified by the SF Bay Pilot Study. A list of the 47 studies, their sampling frequency, type of monitoring, and their website URLs are presented in the Appendix.

Meta-data for many of the programs/projects listed in the Pilot Study are available either on the program's website or through the California Environmental Resources Evaluation System (CERES). However, as with many metadata databases, CERES is not necessarily updated on a regular basis and the issue of developing an easy to use, updated program/project inventory for environmental monitoring data is a current task being addressed by the CEDEN, CERES, IOOS, and other State programs. The issue will be to evaluate current metadata portals, determine the minimal requirements needed to provide adequate program/project coordination and management at the state level, and coordinate data management efforts for maximum information access.

Table 4.1 Data Access, Management, and Delivery Number of programs and percentage of all programs with specific attributes relative to data access, management, and delivery. Items in boldface type are the most desired characteristics of a Network data system.

	Definition	Number of Programs	% of all programs
Access Method			
Unknown	Not able to determine from a brief web search	7	15
Not available	Access is limited to the originator and close collaborators.	Unknown	Unknown
Hard copy	The data are available in a format not readily usable by a computer.	0	0
Digital	Data are available in a tab-delimited or regularly-formatted structure, and may be selected for such elements as location and time. (upon request)	7	15
Web services	**Available for automatic machine-to-machine transfers.**	**33**	**70**
Search/Retrieval			
Unknown	Not able to determine from a brief web search	7	15
Hidden	Data can not be found by conventional searches.	Unknown	Unknown
Portal	The user may discover the existence of a database, but must gain access to the individual database to make further queries.	7	15
Location - Data Summary	The user may discover sampling sites; only data summaries (e.g., such as “nutrients” or “pesticides,” often with period-of-record information) are available. Data available in the form of a geospatial coverage fits this category.	0	0
Location - Value	**The user may discover sampling sites; result values are available.**	**32**	**70**
Metadata level			
Unknown	Not able to determine from a brief web search	8	17
Undocumented	Metadata information is not available.	1	2
Database	Metadata information is available that pertains to the database as a whole, but individual entries have minimal documentation.	38	81
ACWI - Partial	Any individual result can be partially documented to ACWI recommendations.	Unknown	Unknown
ACWI - Full	**Any individual result can be fully documented to ACWI recommendations.**	**Unknown**	**Unknown**
Archive method			
Unknown	Not able to determine from a brief web search	25	53
At risk	No formal procedures exist for ensuring the data are preserved for future use.	Unknown	Unknown
Preserved	Data are stored in a secure archive at a single geographic location, therefore prone to catastrophic failure. Retrieval of archived information in the event of catastrophic failure may be problematic.	Unknown	Unknown
Redundancy	**Data are preserved in a failure-resistant system, stored in multiple geographic locations, where they can be dependably retrieved at any time.**	**22**	**47**

5. Gap Analysis

5.1 Methods

The gap analysis was conducted by compiling summary information about each of the 47 ongoing monitoring studies included in the SF Bay Pilot Study (e.g., number of stations, station locations, frequency of sampling, parameters measured, etc). The monitoring efforts were separated into relevant groups as initially outlined by the NWQMN Pilot Workgroups (nutrients, contaminants, biology, and physical characteristics). Sampling stations were segregated by environmental compartment (estuary embayment, near-shore, off-shore, rivers, groundwater, atmospheric deposition, wetlands, and beaches, see details in the Appendix). Using this combined, summary information, SFEI staff estimated the percentage of ongoing monitoring that completed the Network design goals for each of the major groups (water, sediment, nutrients, contaminants, biology, and physical characteristics) as outlined in the first row of Table 5.1 for each environmental compartment.

5.2 Estuary Embayment

Section 5.2 covers all the estuary embayment columns in Table 5.1: condition, transport, short-term variability, and other monitoring.

The studies evaluated for the gap analysis for this section include:
Condition: SFEI RMP Sediment and Water
Transport: USGS Water Quality Monitoring
Short-Term Variability: USGS Continuous Monitoring
Other: SFEI RMP Bivalve, Sport Fish, and Small Fish; DWR Environmental Monitoring Program Discrete Water Quality Monitoring; USGS Bird Monitoring; does not include PRBOConservation Science or Regional Parks Bird Community Monitoring but these are on-going monitoring efforts.

5.2.1 Nutrients

Nutrient monitoring in the estuary embayments, both for condition and transport, is lacking several key analytes as identified by both the Network design and local needs: total nitrogen and phosphorus, particulate phosphorus and nitrogen, dissolved orthophosphate, total dissolved nitrogen, and particulate carbon. Total nitrogen and phosphorus, especially, are high priorities locally. Temporal coverage of randomly distributed nutrient monitoring is also needed. Current efforts monitor random sites annually; however, the Network design calls for monthly monitoring of nutrients once every five years. Increased temporal coverage of nutrient monitoring is also a high local priority.

5.2.2 Contaminants

Contaminant condition monitoring is considered sufficient for local needs. Monitoring of water and sediment occurs at 17 and 40 probabilistic sites annually, respectively; the sites change each year. Trends are analyzed over the long-term. Sixty percent of the analytes included in the contaminant workgroup design are either monitored annually or were part of a survey in 2002-3 and found to be below water quality criteria levels. An additional survey of the currently unmonitored analytes would inform any additions to continued monitoring. Although the

Network design calls for monitoring of contaminants as part of the monthly transport component, this is not a high local priority; decadal scale trends are the primary concern of managers. There are several studies that focus on transport of contaminants into the Estuary from tributaries and major sources. Changes in contaminant trends are slow and best captured over the multi-year scale rather than monthly. One gap that could be addressed by the Network is additional monitoring of wet season and high-flow events, to supplement the existing dry season contaminant monitoring. Because California has a Mediterranean climate that is dominant by a dry season from May to November in which no precipitation occurs and a wet season from November to April in which quite dramatic rainfall events may occur. As a result, additional wet season sampling could assist in understanding contaminant flow during high precipitation events and the impact of these events on biota. This additional monitoring would increase understanding of contaminant transport into and through the Estuary, but monthly monitoring is not a priority.

Monitoring of contaminants in biota is largely focused on bivalves, birds, and fish. A local gap in monitoring of sensitive species is birds. Waterbirds are sensitive indicators of contaminant exposure and wildlife risk in estuaries because they often forage at high trophic levels and in areas where contaminant exposure and risk are greatest. Recent USGS research has shown substantial risk of mercury and other contaminants to waterbirds in San Francisco Bay. Scientists with the USGS Western Ecological Research Center have been monitoring avian contaminant exposure and bioaccumulation throughout the San Francisco Bay Delta for more than ten years. However, a more thorough, systematic evaluation of contaminant burdens and risk to avian communities has been ongoing since 2004. The recent monitoring efforts have focused on three of the most abundant waterbird species breeding in the region: Forster's terns, black-necked stilts, and American avocets. Intensive monitoring of adults, eggs, and chicks has primarily occurred at breeding colonies in the South Bay region, with other sites around the Bay being monitored more opportunistically.

Contaminant concentrations in numerous colonies and species throughout the Bay are still not consistently monitored on an annual basis, nor is there a monitoring program of contaminant exposure in the approximately 1.5 million wintering birds that spend substantial time in the Estuary before migrating to their breeding grounds continent-wide. This is a critical link in evaluating the overall ecological risks that contaminants pose in the Estuary and should be the cornerstone of any comprehensive monitoring program.

5.2.3 Biology

Biological monitoring in the Estuary does not meet the Network design. Biological monitoring in the Estuary focuses on sentinel species (e.g., marine mammals, birds, and fish), bird community assessments, fish and shellfish landings, presence of non-indigenous species, and endangered species. In the Estuary, there is no on-going monitoring of disease and deformities in fish, seagrass cover, macro-algea, chlorophyll a and ocean color by satellite or aircraft, or habitat mapping of shoreline. Recent funding has added benthos monitoring within the Estuary, which is anticipated to be an ongoing monitoring element. A key local and Network design biological gap is monitoring of zooplankton and phytoplankton. Samples are collected and preserved, but there is no funding or personnel to process the samples.

Biological monitoring of San Francisco Bay should consider its unique support of eight million waterbirds annually, including listed and endangered species such as the California clapper rail, the California least tern, and the western snowy plover. It also supports tens of thousands of breeding waterbirds such as Forster's terns, black-necked stilts, and American avocets. These birds are heavily dependent on the quantity and quality of aquatic habitat, and through their dietary needs are directly linked to water quality. Moreover, several species have been shown to be at substantial risk to reproductive impairment due to their contaminant levels. With the government's recent acquisition of most of the salt ponds that ring the San Francisco Bay a goal for the Estuary has been to enhance and restore nearly 16,000 acres of salt ponds back into tidal marsh and other wetlands. This extensive restoration will have dramatic effects on waterbirds and their response should be monitored. USGS Western Ecological Research Center scientists have been monitoring the reproductive success of several waterbird species in the region for nearly five years, though a comprehensive program should include additional species and locations. Additionally, in collaboration with California Waterfowl Association, University of California-Davis, and the Department of Fish and Game, USGS scientists have monitored the reproductive biology of waterfowl in the Suisun Marsh for over 20 years. Unfortunately, this critical long-term monitoring effort was stopped in 2005 due to a lack of funds. This monitoring effort should be restarted soon since the Suisun Marsh resides at a critical juncture within the San Francisco Estuary between the Delta and the Bay ecosystems.

Other on-going bird community censuses include seasonal shorebird monitoring by the East Bay Regional Parks District and PRBO Conservation Science.

5.2.4 Physical Characteristics

Physical characteristic monitoring in the Estuary is extensive; however, the Network design calls for additional temporal coverage of physical characteristics at random stations. Current efforts monitor physical characteristics at random sites annually, not monthly as the Network design specifies. Additionally, there are several parameters that are not monitored as part of the condition monitoring.

Local needs have identified additional buoys/fixed stations as a critical gap in understanding water flow through the Estuary. An extensive network of fixed stations continually monitors physical parameters in the Estuary; however, due to the large scale and complexity of the system, there are several key locations which are not currently monitored that could provide valuable data for modeling efforts and loading estimates. Another local gap that could be filled with a buoy is monitoring sediment and contaminant loads. The physical measurement (flow, velocity profiles, and sediment) provide data for contaminant flux measurements.

5.2.5 Summary of Estuary Embayment Gaps

Nutrient monitoring in the estuary embayment, both for condition and transport, is lacking several key analytes as identified by both the Network design and local needs. Increased temporal coverage of nutrient monitoring is also a high local priority.

Contaminant monitoring is lacking 40% of the analytes; periodic surveys of analytes not routinely monitored, including emerging contaminants, would help determine which need to be

incorporated into regular monitoring. Additional monitoring of wet season and high-flow events could supplement the existing contaminant monitoring.

Biology monitoring does not include monitoring of zooplankton and phytoplankton. There is also no monitoring of disease and deformities in fish, seagrass cover, macro-algea, chlorophyll a and ocean color by satellite or aircraft, or habitat mapping of shoreline. Local gaps include bird community monitoring at key locations.

Physical characteristic monitoring lacks several analytes. Additional buoys/fixed stations are needed locally to better understand water flow.

5.3 Near-Shore Coast

Section 5.3 covers both the near-shore columns in Table 5.1, condition and other monitoring.

The studies evaluated for the gap analysis for this section include:
Condition: EPA National Coastal Assessment
Other Monitoring: Southwest Ocean Outfall Regional Monitoring Program,
PISCO (realtime water quality monitoring stations),
CDIP (realtime water quality monitoring stations)
National Marine Sanctuary Program

Existing near-shore coast monitoring consists of EPA's National Coastal Assessment, formerly called Western Environmental Monitoring and Assessment Program (WEMAP). This monitoring effort occurs on a five-year cycle and thus falls short of the annual monitoring that the Network design has requested.

5.3.1 Summary of Near-Shore Coast Gaps

Near-shore monitoring only occurs every five years. The parameters to be monitored have not been fully defined, but assuming that they are similar to the Estuary Embayment parameters there are missing elements for nutrients, contaminants, and especially biology.

5.4 Off-Shore Coast

The California Cooperative Oceanic Fisheries Investigations (CalCOFI) are a unique partnership of the California Department of Fish and Game, the NOAA Fisheries Service and the Scripps Institution of Oceanography. The organization currently samples 75 stations off-shore from Point Conception to the Mexican boarder quarterly. However, at various times in the past the sample frame has extended north to regions off-shore of San Francisco Bay[36]. The sample frame extends from near-shore to up to ~400 miles off-shore[37]. Parameters measured include conductivity-temperature-depth (CTD) fitted with sensors to measure pressure, temperature, salinity, dissolved oxygen, nitrate, photosynthetically active radiation, fluorescence, and transmissivity. Analytical tests are conducted for salinity, oxygen, chlorophyll and phaeopigments, phosphate, nitrate, nitrite, ammonium, silicate and primary productivity. Net tows include the CalBOBL, manta tow, and pairovet. Data are distributed to the community online at www.calcofi.org. The focus of the monitoring is to study the marine environment off the coast of California for the management of its living resources. It is unknown if there are additional, ongoing, off-shore monitoring efforts in the CeNCOOS region.

5.5 Rivers

The studies included in this section of the gap analysis include: DWR Environmental Monitoring Program Discrete Water Quality; DWR CDEC; SFEI RMP Water and Sediment; ___
The State's Surface Water Ambient Monitoring Program (SWAMP) is an ongoing monitoring effort that is currently being redesigned to integrate with local storm water programs where they plan to sample several stations at the base of some of the smaller tributaries in the region to assess water and other ecological indicators of condition. At this point, it is unclear what parameters will be measured, or the sample frame and frequency, but this study will provide ongoing monitoring information about the ecological condition at the base of smaller tributaries and storm drains.

5.5.1 Nutrients

Nutrient monitoring of the Sacramento and San Joaquin Rivers occurs monthly at 12 stations, including Chipps Island, at the confluence of the two rivers. Analyte gaps include total nitrogen, dissolved ammonium, total dissolved nitrogen, particulate nitrogen and phosphorus, and some related response and ancillary parameters. Locally, nutrient monitoring of the Rivers is a critical gap. The needs include more upstream sampling of the rivers and complete suite of parameters. Additionally, there is a need to monitor storm drain discharges for nutrients; although not strictly rivers, storm drains do drain the watershed and discharge into the Estuary.

5.5.2 Contaminants

SWAMP is planning on statewide sampling of bioaccumulation in rivers and wadeable streams on approximately a 5 year cycle. This would provide coverage of the major rivers in the Valley and probably some Bay Area rivers and streams.

Contaminant monitoring of the rivers occurs annually at the base of the Delta as part of the RMP Estuary monitoring effort. This is a significant gap relative to the design, which calls for monthly and high-flow sampling. Some pilot studies have looked at loadings from high-flow events, but focused on a limited list of analytes.

5.5.3 Biology

Biology monitoring of the rivers occurs annually at the base of the Delta as part of the RMP Estuary monitoring effort and has similar gaps. There are extensive surveys of fish throughout the Delta.

5.5.4 Physical Characteristics

Monitoring of physical characteristics of the rivers is achieved through fixed stations and monthly sampling. The Delta is a highly managed water system with 88 fixed realtime stations. Additionally, there are 15 sites (12 Department of Water Resources and 3 USGS) that are sampled monthly, including one at Chipps Island.

5.5.5 Summary of Rivers Gaps

Contaminant monitoring only occurs annually in the summer.
Biology monitoring is missing several key parameters targeted by the Network design.
Physical characteristic monitoring is missing several parameters, but is generally complete.

5.6 Groundwater

The following is a regional groundwater expert's response to the NWQMN's groundwater survey.

5.6.1 Is the Network Design document's section on groundwater clear?

The document is clear as to the role of groundwater in contributing to changes in water quality in coastal areas and the relevant points to consider in assessing the relative importance of groundwater in contaminant loads. The document provides general observations and discussion of factors to be considered in Network design. Although brief, this is sufficient for a "local groundwater expert" to follow and develop a network design.

5.6.2 Is groundwater of significance in the San Francisco Bay region based on criteria in the document?

The Atlantic, Gulf, and Southern California coasts are cited throughout the discussion as having at least potential to be important in the contribution to contaminant loads. It is worth noting that the discharge of groundwater from aquifers along the Central California coast and within the San Francisco Bay Estuary may also be significant to the total inventory of contaminants reaching coastal waters. Although quantification of groundwater discharge to the estuary and coastal waters as well as the influx of sea water into aquifers is poorly known throughout the SF Bay region, numerous studies have recognized the continuation of aquifers from land to beneath saline coastal waters and groundwater gradients are generally toward the coast or bay shoreline. Examples include the Santa Cruz area, East SF Bay, southern San Francisco Peninsula, and Napa and Sonoma Valleys. This point ties closely into the next point.

5.6.3 If it is important, what kind of data would be required to address groundwater?

Loads are the product of volume flow rates and the mass carried. Groundwater flow rates are generally very poorly known especially compared to surface water. A considerable level of effort might be necessary to establish the quantities of groundwater which discharge to coastal waters. This task is probably not so much one of Network design or monitoring but more of a one time effort to use existing data to estimate flows or design specific studies to determine flows. However, it should not be presumed that the groundwater flow is constant. Flows may change seasonally, inter-annually, and in response to changes in groundwater pumping and other resource utilization. In order to address this variability issue, it may be decided that a network of wells should be established that provide data on changes in groundwater level gradients. Related to this is the issue of inter-aquifer exchanges and the importance of knowing the vertical movement of groundwater which could be addressed by a water-level monitoring network. To some extent such networks may be active at present by DWR, counties, cities, and water districts (http://wdl.water.ca.gov/gw/hyd/rpt_basin_data1thru3_CF.cfm). An inventory of what groundwater monitoring is being done would be an important starting point. Some of these same entities are also collecting routine water quality data, however in general the frequency of sampling and the number of constituents being analyzed are few and may not include critical substances. Here again an initial inventory would be required to understand the present state of monitoring. The ongoing USGS Groundwater Ambient Monitoring Assessment program funded by the SWRCB (http://ca.water.usgs.gov/projects/gama.html) has already sampled groundwater in several of the relevant basins around San Francisco Bay and other coastal areas. The number

of constituents analyzed is extensive, although this is really more of a snapshot in time than long-term monitoring, the results could be a starting point to understand if groundwater might contribute significant quantities of a broad range of substances to coastal waters.

Wells are our eyes into the groundwater system but most wells are constructed to obtain water supplies and often the construction design is such that critical hydraulic and geochemical data and interpretations are thwarted. In many instances a contaminant or natural constituent is present in the water in one aquifer but not in another aquifer immediately above or below. Wells designed for maximizing supply often tap more than one aquifer and therefore samples for hydraulic head or water quality are mixtures of more than one aquifer. Relying on wells that tap more than one aquifer to determine hydraulic head and water quality may not reveal what is going on in the aquifer system. Therefore locating the best wells to include in a monitoring network will require consideration of the construction design and what part of the system is being accessed through the well.

5.6.4 What data gaps exist for the Pilot area?

A) Quantification of groundwater volumes and velocities moving through the system and discharging to waters of interest. This is true for most if not all the area of interest.
B) In many areas the vertical movement of groundwater between aquifers is not well known and in most areas not well quantified.
C) What are the properties and processes in the aquifers that may cause changes in quality as water moves along the hydraulic gradient? For example: if we sample at point A, can we know what the concentration of a specific constituent is at the discharge location off-shore?

Looking at the inverse of this question – what information do we already have?
We have a good idea of where and what the principal aquifers are around SF Bay region. We have a good idea of how much water is used from these aquifers. The general flow directions and gradients are known. Areas of known or potential sea-water intrusion have been identified. A fairly complete inventory of substances (natural and human-derived) in groundwater has been made. Inventories of the types of substances used locally that may get into groundwater are available.

5.7 Atmospheric Deposition

Monitoring of atmospheric deposition is not extensive enough to meet local needs or the Network design.

The studies included in section 5.7 are the California Ambient Air Board Air Monitoring Network and Mercury Deposition Network/National Atmospheric Deposition Program.

5.7.1 Nutrients

Nutrient deposition monitoring, both wet and dry, is absent in the area.

5.7.2 Contaminants

Monitoring contaminant atmospheric deposition consists of ambient air quality monitoring and a currently inactive Mercury Deposition Network/National Atmospheric Deposition Program site. Ambient air quality, including organics and trace elements, are captured by the California

Ambient Air Board Air Monitoring Network and the Bay Area Air Quality District. The MDN/NADP site has been inactive since 2006. Mercury is a local management issue and capturing the contribution from air deposition would improve understandings of mercury movement.

5.7.3 Summary of Atmospheric Deposition Gaps

There is no on-going monitoring of wet or dry deposition of nutrients or contaminants.

5.8 Wetlands

The studies included in section 5.8 are:
Level 1: Wetlands Regional Monitoring Program Prop 50 grant mapping
Level 2: Wetlands Regional Monitoring Program Prop 50 grant reference network and California Rapid Assessment Method (Ambient surveys and 401 project certifications)
Level 3: South Bay Salt Ponds Restoration Project; Hamilton Wetlands Restoration; and Montezuma Wetlands Restoration Project

There are a large number of estuarine wetland restoration projects around the Bay including about 36,000 acres of former marshland that have already been acquired for restoration. The most extensive effort is the 16,000 acre South Bay Salt Pond Restoration Project. Given these large-scale restoration efforts and the numerous, simultaneous, small-scale loss of wetlands due to shoreline erosion and development, it is challenging to track net changes in wetland quality and quantity. A 3-level approach is being used in the Bay Area for wetlands assessment, monitoring and tracking.

The National Network design for wetlands has not yet been completed. Bay Area wetlands researchers and managers are heavily involved in the 2011 National Wetlands Assessment conducted by the Office of Wetlands Oceans and Watersheds. Any regional monitoring program is expected to be consistent in design with this initiative and conform to the Level 1-2-3 approach. The 2011 initiative will use Level 1 tools for selected status and trends plots within which Level 2 tools will be used to assess condition. The complex relationship between wetlands condition and water quality is not fully understood and is a current area of extensive research. This may be one of the biggest challenges for wetlands monitoring for the National Network.

Level 1 maps of the extent of wetland habitat are currently being completed for the nine counties of the Bay Area. A gap exists in terms of generating similar Level 1 assessments for the Delta. Although several monitoring efforts exist in support of large-scale wetlands restoration, there are no fully funded, sustained Level 2 or Level 3 long term monitoring programs. No programs meet the expected Network design criteria of sampling frequency of 1 year and sampling repetition every five years.

5.8.1 Summary of Wetlands Gaps

Since the network design for wetlands is not complete no relative gaps can be identified.

5.9 Beaches

The studies included in section 5.9 are East Bay Regional Parks, Marin Environmental Health Services, San Mateo Recreational Water Quality Program, Sonoma County Environmental Health Division, and Southwest Ocean Outfall Beach Monitoring.

California beaches are monitored in accordance with AB411 – the Beach Bathing Water Quality Standards and Public Notification Program. California requires public health agencies to monitor beaches with 50,000 annual beach visitors and potential sources of fecal pollution at least weekly for *Enterococcus*, fecal coliform, and total coliform from April 1 though October

31. Many less heavily used beaches are monitored consistent with AB411 guidelines. These requirements exceed Federal regulations. There is, however, significant recreational activity throughout the year beyond Bay Area beaches that are designated for monitoring where people may be exposed to pathogens – e.g. Candlestick Point, Flying Tiger. These areas are not currently monitored and are not addressed in the network design and may be candidates for carefully designed periodic sampling according to a probabilistic design based on usage and source. The scope of beach monitoring may fail to protect the public because of the seasonal and spatial constraints of the monitoring. Conversely, beach conditions can change quite rapidly so that in some cases conditions will have recovered even before an exceedance is posted. In an effort to improve monitoring and to define better indicators (e.g., *Bacteroides*) of fecal pollution in receiving waterbodies, scientists are developing and testing new methods. Scientists and the State Water Resources Control Board, along with local and the water quality monitoring groups are reviewing these methods and making recommendations. Robust network design will have a goal of consistency of frequency, distance from source, and rainfall and/or water flow at the source, exceedance criteria, and notification protocols.

5.9.1 Summary of Beaches Gaps

Although the Network design for beaches is not complete, we generally conclude that, based on California's ongoing extensive beach monitoring, there are no gaps relative to the network design.

Table 5.1 Gap analysis of San Francisco Estuary Pilot Study
W=Water; S=Sediment; N=Nutrients; C=Contaminants; B=Biology; P=Physical Characteristics

Note that there are two NOAA estuaries within San Francisco Bay (see table 3-3 of design report): (1) Central San Francisco/San Pablo/Suisun Bays and (2) San Francisco Bay. Thus the number of sites for condition (50 per estuary), transport (15 per estuary), and short-term variability (2 of the transport sites are to be instrumented for continuous monitoring) shown in columns 2, 3, and 4 are multiplied by 2.

	Estuary embayment *Condition*	**Estuary embayment** *Transport*	**Estuary embayment** *Short-term*	**Estuary embayment** *Other*	**Near-shore coast** *Condition*	**Near-shore coast** *Other*	**Off-shore coast**	**Rivers** (Monitor stream gauges at downstream point)	**Groundwater**	**Atmospheric Deposition**	**Wetlands**	**Beaches**
Network Design	**N, P:** 100 randomly-selected sites sampled monthly 1 year out of 5 (W) **C:** 100 randomly-selected sites sampled 1 year out of 5 (W,S) **B:** 100 randomly-selected sites sampled 1 year out of 5	**N, C, P:** 30 sites distributed along 2 gradients (15 sites per estuary) sampled monthly every year (W)	**P:** continuous monitoring (ex: depth of water, salinity, dissolved oxygen, pH, etc.) 2 sites along each of the gradients in transport (total 4 sites)	Other existing monitoring not specified in Network design and not captured in columns 2-4. For example buoys, shipboard cruises, remote sensing, etc	**N, C, B, P:** 50 randomly selected sites per IOOS region, sampled once per year. (See table 3-1 of design report)	Other existing monitoring not specified in Design and not captured in column 6 using buoys, shipboard cruises, or remote sensing, etc	IOOS monitoring	Sacramento & San Joaquin Rivers **N, C:** monthly & high flows (~15x per yr) **B:** once per year **P:** stage & stream flow measured continuously; other characteristics measured monthly & high flows	Evaluate groundwater design. Is groundwater significant in the area based on the Design? If important, what kind of data would be required to address groundwater in the area? What data gaps exist for the Pilot?	**N, C:** 1 wet & 1 dry deposition station monitored weekly per waterbody		
% Complete	**N:** 6% **C:** 60% **B:** 20% **P:** 8%	**N:** 75% **C:** 0% **P:** 100%	**P:** 100%	**C:** bioaccumulation in bivalves; monitoring of fish (small fish for identifying hotspots & sport fish for human health); monitoring of bird eggs **B:** endangered species monitoring of fish and birds; avian community assessments	**N:** 20% **C:** 60% **B:** 20% **P:** 20%	**N:** **C:** demersal fish histopathology (annual) **B:** demersal fish community (annual); bird community **P:** 13 realtime stations	**N:** 0% **C:** 0% **B:** 0% **P:** 0%	**N:** 40% **C:** 7% **B:** 40% **P:** 100%	See text.	**N:** 0% **C:** 0%	See text.	100%
% Need additional stations	**N:** 0% **C:** 0% **B:** 50% **P:** 0%	**N:** 0% **C:** 100% **P:** 0%	**P:** 0%		**N:** 0% **C:** 0% **B:** 0% **P:** 0%		**N:** 100% **C:** 100% **B:** 100% **P:** 100%	**N:** 0% **C:** 0% **B:** 0% **P:** 0%		**N:** 100% **C:** 100%		0%
% Need increased frequency	**N:** 69% **C:** 0% **B:** 50% **P:** 87%	**N:** 0% **C:** 100% **P:** 0%	**P:** 0%		**N:** 80% **C:** 80% **B:** 80% **P:** 80%		**N:** 100% **C:** 100% **B:** 100% **P:** 100%	**N:** 20% **C:** 93% **B:** 0% **P:** 0%		**N:** 100% **C:** 100%		0%
% Need additional parameters or change detection limit	**N:** 25% **C:** 40% **B:** 50% **P:** 5%	**N:** 25% **C:** 100% **P:** 0%	**P:** 0%		**N:** 25% **C:** 40% **B:** 50% **P:** 0%		**N:** 100% **C:** 100% **B:** 100% **P:** 100%	**N:** 55% **C:** 100% **B:** 60% **P:** 0%		**N:** 100% **C:** 100%		0%
Existing monitoring to address local needs beyond Network Design	**N:** **C:** **B:** **P:**	**N, P:** 7 more sites (37 sites total)	**P:** 49 more buoys or fixed stations (53 realtime sites total)		**N:** **C:** **B:** **P:**		75 sites quarterly Pt. Conception to Mexican Boarder for: **N:** various **B:** fish trawl & chlorophyll & phaeo-pigments **P:** CTD +	**N:** 12 sites monthly **B:** 125 fish sampling events (Delta smelt, salmon, stripped bass); 6 benthic community, 9 phytoplankton, 12 zooplankton sampling events **P:** 88 realtime stations; 15 sites monthly		**N, C:** Ambient air quality is measured at 14 stations around the Bay		Monitor *enterococci*, fecal coliform, & total coliform

6. Implemented Network Would Improve Ability to Address Management Issues

Each of the proposed improvements to the San Francisco Bay Area monitoring network would improve the ability of managers to make decisions about the Bay.

6.1 Nutrients

A more complete set of parameters will help managers assess the nutrient loads and total productivity of the Estuary.

6.2 Contaminants

Specimen banking will help managers understand the history of new contamination appearing in the Bay's biota, water, and sediments. This ability has already proven successful in the assessment of PBDE history in the Bay, allowing scientists to determine how quickly concentrations were increasing in the Bay.

6.3 Biology

6.3.1 Bird Reproduction and Density

The San Francisco Bay provides nesting habitat for a number of waterbirds, including threatened and endangered species. While there is some consistent monitoring of reproductive output for certain species in a few locations, there are still key locations and species for which monitoring gaps exist. The status in the Pacific flyway is also one of the major ecological values of San Francisco Bay and Delta. This important ecological habitat is not adequately characterized currently.

6.3.2 Zooplankton & Phytoplankton Composition

The decline of endangered pelagic fishes in the Delta has been a function of low primary and secondary productivity. Much of the concern has centered around the disappearance of "good" phytoplankton and zooplankton species for fishery productivity.

6.3.3 Benthic Invertebrates

Preliminary data show that sediment quality in the Bay often fail to meet the proposed State Sediment Quality Objectives. In a recent state-wide survey, it was noted that on average sediment of similar chemistry tends to be more toxic in San Francisco Bay relative to other sites located in the state. The status of benthic invertebrates could drive future Bay pollution allocations.

6.4 Physical

The proposed buoy at Chipps Island will provide an important understanding of the river loadings to the Bay and Delta of nutrients and contaminants. This addition will allow managers to understand the extent to which upstream Delta sources are contributing to downstream Bay impacts.

6.5 Beaches

While beach coverage is good, there is significant exposure to pathogens by swimmers, wind surfers, and kayakers who use the Bay year-round. This is a significant user group with the ability to warn their members about water quality problems through the internet.

6.6 Air Deposition

Mercury tops the TMDL concerns in the Bay, and atmospheric deposition may be an important source. Monitoring of air deposition would help managers better understand sources of mercury and implement appropriate management actions.

6.7 Data Management

Our pilot study has shown there are significant ongoing monitoring efforts in the Estuary, Delta, and near-shore regions. But the overall availability of data for interpretation across programs and between compartments (regions) needs more coordination. Ensuring that the data are in electronically accessible in comparable formats will make it easier to combine data sets and evaluate overall environmental health of the region. To this end the California Ocean Observing Programs, California Environmental Data Exchange Network (CEDEN) clients, California Environmental Resources Evaluation System (CERES), and other environmental data management centers that manage program/project information (meta-data), real-time, and discrete monitoring data will need to coordinate with data standard centers such as the Marine Metadata Interoperability Project (MMI), California Environmental Information Catalog (CEIC, NSDI, CERES), and the California Environmental Data Exchange Network (CEDEN), and others to ensure that relevant data and meta-data are up to federal standards, comparable across programs, and easily accessible. While efforts are ongoing towards coordinating program information and data access between programs on a shoestring budget, this is a major information management gap.

6.8 Other

6.8.1 Ocean pH

Models from the Monterey Bay Aquarium Research Institute (MBARI) chemists suggest that declining pH could be one of the significant impacts of increasing carbon dioxide.

6.8.2 MODIS satellite imagery

MODIS imagery provides a quick way to assess the primary production status of the Delta and Bay, an issue that has been considered as a major cause in the decline of endangered pelagic fishes.

7. Relevance to IOOS

The Integrated Ocean Observing System (IOOS) is a multidisciplinary system designed to provide ocean and coastal data in formats, scales, and rates required by users. Currently, IOOS is gathering these disparate data sources into an integrated system, giving users access to data links from all sources. In addition, IOOS is deploying new technology to fill in the gaps in measurements and to ensure users have access to the best available information. IOOS is a community evolving program that is designed to be flexible and respond to new technology and user needs. The national program consists of the contributions of federal agencies, coordinated through an interagency office, and a network of regional programs designed to meet the diversity of users around the country. IOOS is the U.S. contribution to the Global Ocean Observing System (GOOS) and to the Global Earth Ocean System of Systems (GEOSS).

Similar to the Network, IOOS was created as a result of the national Ocean Action Plan. The Ocean Action Plan was the Administration's response to the 2004 U.S. Ocean Commission and the Pew Commission reports on Ocean Policy. Both reports recommended the development of entities designed to coordinate ocean information and improve data access and integration to improve understanding and management of our oceans. The Ocean Commission report suggests that the national monitoring network be closely linked with IOOS. Each of the eleven Regional Associations within IOOS works to meet the seven national societal goals and address more specific regional issues.

Components of the developing NWQMN are ideally suited to contribute to and enhance IOOS. As part of the NWQMN, the San Francisco Bay Pilot Project is a regional pilot for water quality monitoring in the Central and Northern California Ocean Observing System (CeNCOOS). San Francisco Bay is one of the most populated areas in California and the people live an existence very much contributing to and affected by the health of the Bay. Within and outside of the Bay, there are tens of organizations responsible for monitoring the Bay and making decisions that benefit the health of the people and the ecosystem. The NWQMN and CeNCOOS will join forces to build a comprehensive and cost-effective monitoring program that utilizes current assets, links system components to serve regional needs, contributes to the societal goals established by IOOS, and provides data access and information to regional stakeholders. The programs will share information and resources such as stakeholder research, system design ideas and proposals, identified high priority issues and specific resource management goals, and data management strategies and systems.

Comparable data and an integrative approach to water quality monitoring are essential in an area with high contaminant load, dynamic oceanographic process highly influenced by tidal currents, a watershed that extends deep into California, an active marine recreational community, expanding urban areas, and an economically essential port system.

To date, IOOS has successfully contributed assets in response to water quality issues. An ocean observing system can monitor core variables when analyzed or alone can provide information to assist with water quality concerns. For example, the following is a list of assets recently used to track and predict contaminant flow in the Southern California Ocean Observing System (SCCOOS) region:

- HF Radar real-time surface current maps for tracking discharge plumes
- Wave-driven current maps
- Boat sampling (phytoplankton; nutrient)
- Satellite images (SST and ocean color)
- Wind forecasts
- Trajectory models to forecast and predict fate and transport of plumes
- Pier sampling stations
- Ocean buoys; AUVs; gliders
- In-situ chemical analysis: Land-Ocean Biogeochemical Observatory (LOBO) and the Environmental Sampling Processor (ESP).
- Shipboard and hand sampling
- Moorings and piers

CeNCOOS can also apply these resources, making the Regional Association a fundamental tool for monitoring, understanding, and ultimately predicting HABs and other the flow other nutrients or contaminants. Additionally, CeNCOOS can contribute to flow and movement information once it has hit the coastal system and provide these data to the state agencies responsible for monitoring permits.

The costs for implementing the ocean observing system along the west coast of the United States as described above have been estimated at $4,000,000 per 200 km of coastline to install and $3,000,000 per year per 200 km of coast to operate the system. For the CeNCOOS domain extending from Point Conception to the Oregon border, this comes to $20,000,000 to install and $15,000,000 per year to operate the complete system.

A NWQMN-CeNCOOS collaboration presents an opportunity to build and improve relationships with state and federal initiatives, specifically in terms of data management efforts. Existing data management initiatives at the state level, such as CEDEN and at the federal level, such as the USEPA Water Quality Exchange (WQX) database, need to be coordinated with the national IOOS Data Management and Communications (DMAC) and Regional Association plans. CeNCOOS is already building a program that can be greatly enhanced by the SF Bay Pilot Project. For example, CeNCOOS created a metadata inventory, OceanObs (http://oceanobs.org), for all ocean observing programs in the region, in collaboration with the Monterey Bay National Marine Sanctuary (MBNMS). OceanObs provides easy access to the where, what, and who of data collection for the entire SF Bay Pilot Project area. Sharing our resources will enhance developing data programs and eliminate redundant efforts. Beyond the inventory, the NWQMN and IOOS data management efforts include building an interactive data access server that provides users with data (historical and in real-time) and products associated with their specific management issue. The SF Bay Pilot Project will be heavily involved in the existing CeNCOOS efforts to integrate observing programs and build a user-friendly server. Additionally, the SF Bay Pilot Project will be made aware of and requested to participate in future CeNCOOS proposals that address data management for the region. This collaborative effort will again improve communication with existing state and federal agency data management initiatives. To ensure successful data management and improve awareness of existing and planned initiatives, the SF Bay Pilot Project and CeNCOOS will communicate frequently with and align initiatives with the California Ocean Protection Council.

Water quality is a great concern for the CeNCOOS region. In response, CeNCOOS has completed and is pursuing a number of actions that can enhance the SF Bay Pilot Project. For example, CeNCOOS submitted a proposal to NOAA, *CeNCOOS Bays*, aimed at addressing water quality concerns in all regional bays, but specifically San Francisco Bay. Much research and time was spent designing a system that would collect adequate information, address a multitude of user needs, and become available to all users. CeNCOOS is also very active in water quality projects in neighboring regions, such as the Synthesis, Assessment and Management (SAM) project in the MBNMS. By working with both the SAM and NWQMN projects, CeNCOOS can serve as a link to expand efforts to the entire region. In addition to aligning data management efforts, CeNCOOS can:

- Share stakeholder surveys regarding water quality in SF Bay
- Share information and assets in the water, directly outside the SF Bay and along the surrounding coasts.
- Provide expertise on where and what to monitor in the bay to create a link between the physiological/chemical parameters to the biological parameters and health of the Bay.
- Use existing data and information from CeNCOOS partners to aid in establishing baselines for the Bay.
- Provide expertise on creating environmental indicators for the Bay and support science-based policy and informed decision-making.
- Provide information to distinguish between natural and anthropogenic impacts in the Bay.

The people and health of San Francisco Bay serve to greatly benefit from a strong, collaborative effort between the SF Bay Pilot Project under NWQMN and CeNCOOS. All of the NWQMN and IOOS resources can greatly benefit each program. It is hoped that the NWQMN efforts can be aligned with IOOS as a potential long-term program rather than one separate entity with an uncertain future. The efforts and activities of the SF Bay Pilot Project also serve to greatly contribute to the CeNCOOS conceptual design.

8. Cost Estimates

This estimate is for preliminary budget purposes. More extensive cost estimates can and will be produced for the implementation of additional monitoring. Exact monitoring costs were not easily available in the categories required for the Network and thus are estimates.

Table 8.1 Cost Estimates These estimates are for a year in which all of the possible sampling occurs. Many of these monitoring efforts are scheduled for once every five years, but rather than spread the cost over five years we calculated the costs for a year in which the monitoring takes place. Estimates are of the comprehensive cost of monitoring including cost of collection, boats and other equipment, staff, QA/QC, and management.

Environmental component	Annual cost of existing monitoring as specified by Network design	Annual incremental costs of monitoring needed to fill gaps	Annual cost of existing monitoring beyond Network design as determined by local needs and local experts
Estuaries	$3,700,000	$870,000	$2,500,000
Near-shore[§]	$1,000,000	$15,000,000	Unknown
Off-shore[§]	$0		Unknown
Rivers	$5,900,000	$400,000	$3,500,000
Groundwater	Undefined	Undefined	$0
Atmos. Deposition	$0	$50,000	$3,000,000
Wetlands	$2,000,000[**]	Undefined	Undefined
Beaches	$700,000	$0	$0
Data Management	Data management costs are included in estimates above as 30% of direct costs.		

[§] Cost estimates are for CeNCOOS region not just off-shore and near-shore region near San Francisco Bay.

[**] The wetlands cost estimate represents aggregate funding for wetlands monitoring that occurs as part of many projects. Since these funding sources vary by year, this figure does not represent a continuously funded wetlands monitoring program.

9. Summary

This Pilot Study has served a useful function in identifying the surprisingly large number of ongoing monitoring studies in the San Francisco Bay Area that partially comply with the goals of the National Monitoring Network. Together these efforts collect data about the Bay, its tributaries, and coastal waters at a cost of several tens of millions of dollars. Each of the studies provides significant input to managers and stakeholders making informed decisions. However, with a few notable exceptions, the data are not stored in a consistent format nor easily integrated to contribute to a national interpretive summary without significant local efforts. Both the state and some federal agencies are working to allow easy exchange between their water quality-related databases, but more progress is needed.

In addition to data management issues, where coordination of formats would provide an important next step, the national parameters could be further developed to be relevant to all estuaries. For instance, because of the importance of the Pacific flyway as one of the key ecological functions of San Francisco Bay, one of the dominant water quality parameters in the Bay Area is mercury concentrations in the eggs of key bird species. The impact of mercury on egg hatching and bird reproductive success is one of the key water quality indicators in the Bay. While some research has shown similar problems in other estuaries around the country, this indicator is most developed in San Francisco Bay. Other biological parameters, such as coverage by eelgrass or macroalgal populations, have much less impact currently on Bay managers than in other parts of the country. To the extent that uniform biological measures are important to a national water quality assessment, it will be necessary to provide significant funding to provide consistent data. Given the ongoing developmental status of atmospheric deposition measurements, groundwater, and wetlands, these areas would also require significant national investment for uniformity. Within the San Francisco Bay pilot study, water quality measurements of pathogens, nutrients, and contaminants come the closest to meeting the national sampling requirements and could be brought into compliance with the National Water Quality Monitoring Network with small investments of additional funds. In addition a specimen bank that would enable managers to evaluate the historical status of emerging contaminants would be a cost effective improvement.

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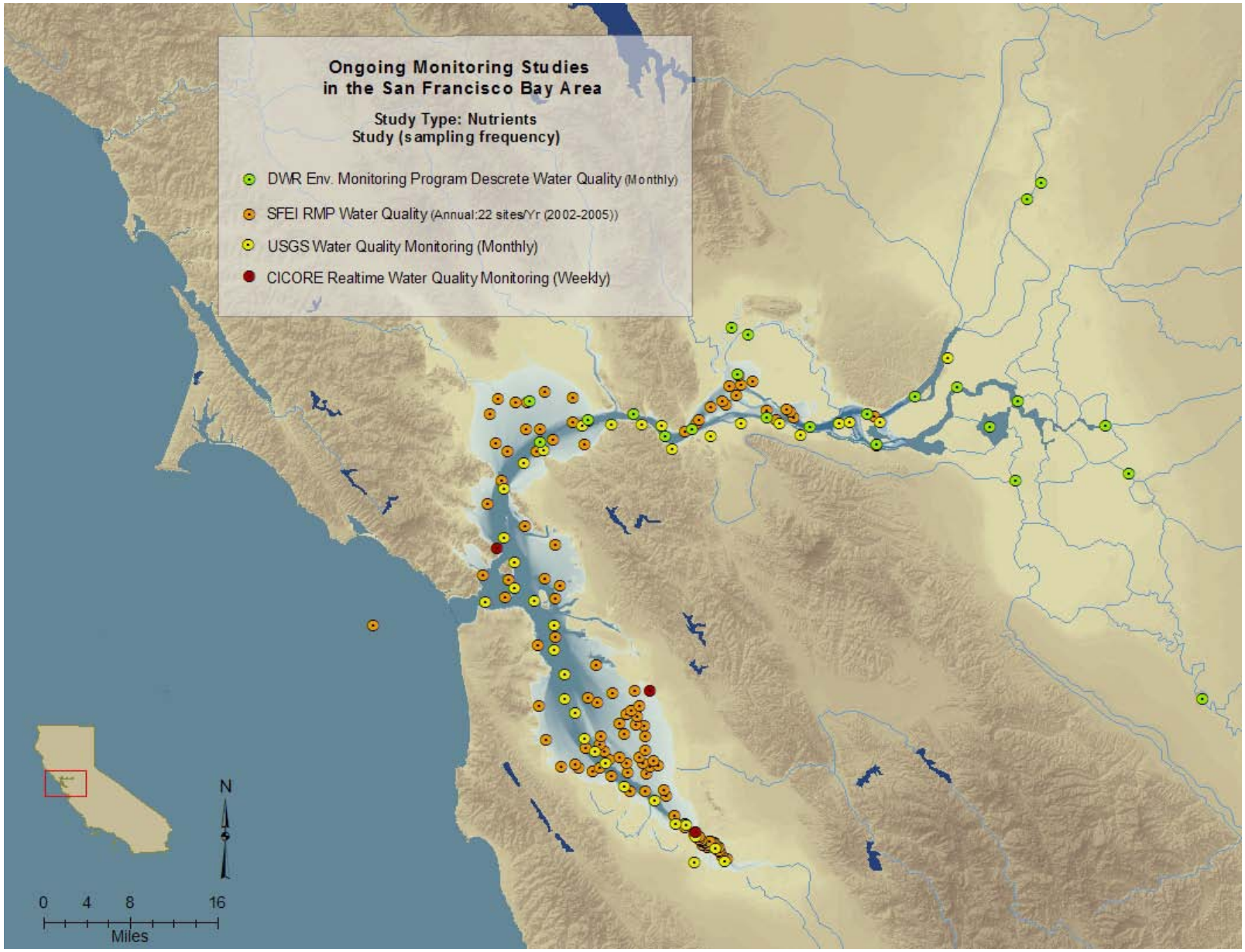
APPENDIX

Table of contents for Appendix

Appendix for Section 3. Inventory

In order to create the gap analysis, summary information for each NWQMN workgroup was compiled. This Appendix for the Inventory section of the report is separated by study type (nutrients and physical characteristics, contaminants, biology, beaches, wetlands, and atmospheric deposition). It contains the prioritized list of the targeted parameters recommended by each workgroup (only in the cases that such a list was available at the time of report compilation) along with a summary of the number of stations that monitor for the targeted parameter within each of the environmental compartments defined by the NWQMN (estuary embayment, near-shore coast, off-shore coast, rivers). Also included are maps of the sampling stations by study type and any additional pertinent information that was compiled for building the SFBay Pilot Study report.

Work Group: Nutrients & Physical Characteristics



Inventory table of nutrients and physical characteristics. Summary of the number of stations that measure each targeted NWQMN nutrient and physical characteristic by environmental compartment.

WG Priority: Tier 1

StudyType	Event Type	Parameter Type	Parameter	Number of Stations in each Region: Not in Frame or 0 = Not measured	Encl. Bay	Near Shore	River
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Dissolved ammonium		145	1	5
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Dissolved nitrate + nitrite		156	1	17
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Dissolved ortho phosphate		11		12
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Dissolved silica		156	1	17
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Total dissolved phosphorus		2		
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Total Nitrogen	0			
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Total Phosphorus		13		12

WG Priority: Tier 2

StudyType	Event Type	Parameter Type	Parameter	Number of Stations in each Region: Not in Frame or 0 = Not measured	Encl. Bay	Near Shore	River
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Particulate nitrogen	0			
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Particulate phosphorus	0			
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Total dissolved nitrogen	0			
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Total dissolved phosphorus		143	1	5

WG Priority: Real-time

StudyType	Event Type	Parameter Type	Parameter	Number of Stations in each Region: Not in Frame or 0 = Not measured	Encl. Bay	Near Shore	River
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	RealTime: Water - Flow,	75	53	13	88

WG Priority: Ancillary/Response Measures

StudyType	Event Type	Parameter Type	Parameter	Number of Stations in each Region: Not in Frame or 0 = Not measured	Encl. Bay	Near Shore	River
NUT/PHYSCHAR	AirQuality	PhysicalCondition	Photosynthetically active		2		
NUT/PHYSCHAR	SedimentQuality	PhysicalCondition	pH		139		2
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Dissolved inorganic carbon		1		
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Dissolved organic carbon		108	1	2
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	DO		153	1	17
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Particulate carbon	0			
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	pH		108	1	2
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Temp, Sal/Conductivity,		159	1	17
NUT/PHYSCHAR	WaterQuality	PhysicalCondition	Total suspended solids		11		12
NUT/PHYSCHAR	WaterQuality	Plant	Chlorophyll a		154	1	17

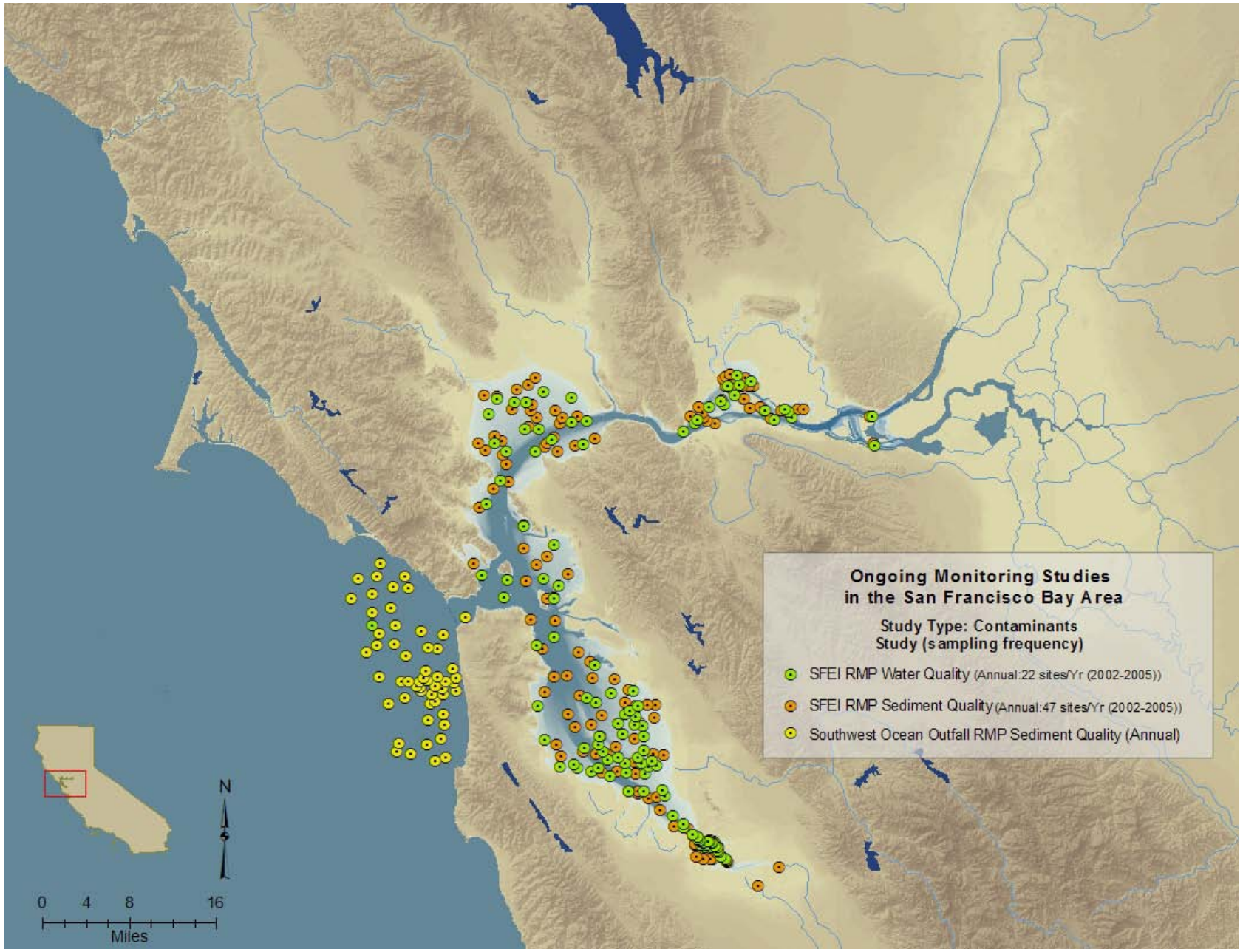
WG Priority: Sediment Measures

StudyType	Event Type	Parameter Type	Parameter	Number of Stations in each Region: Not in Frame or 0 = Not measured	Encl. Bay	Near Shore	River
NUT/PHYSCHAR	SedimentQuality	PhysicalCondition	Total ammonia (sed)		139		2
NUT/PHYSCHAR	SedimentQuality	PhysicalCondition	Total nitrogen (sed)		140	55	2
NUT/PHYSCHAR	SedimentQuality	PhysicalCondition	Total organic carbon (sed)		140	55	2
NUT/PHYSCHAR	SedimentQuality	PhysicalCondition	Total sulfide (sed)		139		2

Summary table of NWQMN target nutrient parameters. Network detection limit requirements and existing San Francisco Estuary nutrient study detection limits are listed. RMP refers to the Region Monitoring Program for Water Quality's Status and Trends Monitoring Program (annual sampling). USGS refers to USGS Water Quality Monitoring which occurs monthly along a transect of the Bay.

	Performance Requirements		San Francisco			
Analyte	**NWQMN Range**	**NWQMN Detection limit**	**RMP Range**	**RMP Detection Limit**	**USGS Range**	**USGS Detection Limit**
Tier 1						
Dissolved Ammonium	0.7-140 µg N L^{-1}	0.7 µg N L^{-1}	20-250 µg N L^{-1}	1-10 µg N L^{-1}	0.8-292.6 µg N L^{-1}	0.7 µg N L^{-1}
Dissolved Nitrate+Nitrite	0.7-700 µg N L^{-1}	0.7 µg N L^{-1}			0.14-1914 µg N L^{-1}	0.7 µg N L^{-1}
Dissolved Nitrate			10-4650 µg N L^{-1}	3 µg N L^{-1}		
Dissolved Nitrite			0-130 µg N L^{-1}	0-8 µg N L^{-1}	0.14-37.5 µg N L^{-1}	0.7 µg N L^{-1}
Dissolved ortho Phosphate	1.55-155 µg P L^{-1}	1.55 µg P L^{-1}				
Dissolved Silicate	2.8 – 4000 µg Si L^{-1}	2.8 µg Si L^{-1}	370-871 µg Si L^{-1}	1-28 µg Si L^{-1}	21.6-9370.4 µg Si L^{-1}	2.8 µg Si L^{-1}
Total Nitrogen	0.03-5.00 mg N L^{-1}	0.03 mg N L^{-1}				
Total Phosphorus	0.01-2.00 mg P L^{-1}	0.01 mg P L^{-1}				
Tier 2						
Particulate Nitrogen	0.01-100 %	0.01%				
Particulate Phosphorus						
Total Dissolve Nitrogen	1.4 – 900 µg N L^{-1}	1.4 µg N L^{-1}				
Total Dissolved Phosphorus	0.01-2.00 mg P L^{-1}	0.01 mg P L^{-1}				
Total Dissolved Phosphate			9-1192 µg P L^{-1}	0.5-4.1 µg P L^{-1}	11.5-617.9 µg P L^{-1}	1.5 µg P L^{-1}
Response Variables						
Chlorophyll a	0.01-150 µg L^{-1}	0.01 µg L^{-1}	0.97-36.82 µg L^{-1}	0.01-0.03 µg L^{-1}	0.1-149.9 µg L^{-1}	0.1 µg L^{-1}
Phaeophytin			0.41-22.66 mg/m^3	0.01-0.08 mg/m^3		
Chlorophyll a/a+PHA					0.14-1	
Dissolved Oxygen	0-15 mg L^{-1}	0.1 mg L^{-1}	4.33-9.90 mg L^{-1}	0.30 mg L^{-1}	4.2-14.6 mg L^{-1}	2%
Conductivity/ Salinity	0-100 mS cm^{-1}	1 -100 µS cm^{-1}	2.00-33.21 psu	2.00 psu	0.04-32.32 psu	
Ancillary Analyses						
Total Suspended solids	4-20,000 mg L^{-1}	10 mg L^{-1}	0.79-329.60 mg L^{-1}	0.05-1.85 mg L^{-1}		
Total Suspended particulate matter					1-847 mg L^{-1}	0.10 mg L^{-1}
Dissolved Organic Carbon	0.22 – 50 mg C L^{-1}	0.22 mg C L^{-1}	0.87-7.4 mg C L^{-1}	0.025-0.081 mg C L^{-1}		
Dissolved Inorganic Carbon						
pH	1-12 pH	0.01 pH	7.70-8.32 pH	0.01-0.10 pH		
Particulate Carbon	0.01-100 %	0.01%				
Photosynthetically Active Radiation	0.01-10,000 µmol s^{-2} m^{-2}	0.01 µmol s^{-2} m^{-2}				

Work Group: Contaminants



Inventory table of contaminants. Summary of the number of stations that measure each type of contaminant parameter by study/event type and environmental compartment.

WG Priority: *Tier 1*

StudyType	Event Type	Parameter Type	Parameter	Number of Stations in each Region: Not in Frame or 0 = Not measured	Encl. Bay	Near Shore	River
Bioaccumulation	BirdBioaccumulati	ORG	Dioxins, emerging, etc		16		1
Bioaccumulation	BirdBioaccumulati	ORG	PBDE		16		1
Bioaccumulation	BirdBioaccumulati	ORG	PCB		16		1
Bioaccumulation	BirdBioaccumulati	ORG	PESTICIDES		16		1
Bioaccumulation	BirdBioaccumulati	TE	Metals and/or As & Se		16		1
Bioaccumulation	BivBioaccumulation	ORG	PAH		9		2
Bioaccumulation	BivBioaccumulation	ORG	PCB		9		2
Bioaccumulation	BivBioaccumulation	ORG	PESTICIDES		9		2
Bioaccumulation	FishBioaccumualti	ORG	Dioxins, emerging, etc		5		
Bioaccumulation	FishBioaccumualti	ORG	PAH			12	
Bioaccumulation	FishBioaccumualti	ORG	PBDE		5	12	
Bioaccumulation	FishBioaccumualti	ORG	PCB		5	12	
Bioaccumulation	FishBioaccumualti	TE	Metals and/or As & Se		19	12	
Contaminants	SedimentQuality	ORG	PAH		140	55	2
Contaminants	SedimentQuality	ORG	PBDE		139		2
Contaminants	SedimentQuality	ORG	PCB		140	55	2
Contaminants	SedimentQuality	ORG	PESTICIDES		140	55	2
Contaminants	SedimentQuality	TE	Metals and/or As & Se		140	55	2
Contaminants	WaterQuality	ORG	PAH		108	1	2
Contaminants	WaterQuality	ORG	PBDE		108	1	2
Contaminants	WaterQuality	ORG	PCB		108	1	2
Contaminants	WaterQuality	ORG	PESTICIDES		108	1	2
Contaminants	WaterQuality	TE	Metals and/or As & Se		108	1	2

WG Priority: *Ancillary/Response Measures*

StudyType	Event Type	Parameter Type	Parameter	Number of Stations in each Region: Not in Frame or 0 = Not measured	Encl. Bay	Near Shore	River
Bioaccumulation	BirdBioaccumulati	PhysicalCondition	Tissue Moisture		16		1
Bioaccumulation	BivBioaccumulation	PhysicalCondition	Tissue Moisture		9		2
Bioaccumulation	FishBioaccumualti	PhysicalCondition	Tissue Moisture		19	12	
Contaminants	SedimentQuality	PhysicalCondition	Descrete: Sediment -		140	55	2
Contaminants	SedimentQuality	PhysicalCondition	Descrete: Water - DO, Temp,		139		2
Contaminants	WaterQuality	PhysicalCondition	Descrete: Water - DO, Temp,		108	1	2

Table of targeted NWQMN contaminants and ancillary paramters. Columns Water, Fish Tissue, and Sed indicate if a specific parameter is specified by the workgroup. Columns RMP-Water, RMP-BivTiss, and RMP-Sed indicate if a specific parameter is monitored by the RMP. The column CTR-Water indicates if a specific parameter was measured in the RMP's Special Study: California Toxics Rule survey (2002-2003).

	Water	RMP-Water	CTR-Water	Fish Tissue	RMP-BivTiss	Sed	RMP-Sed
Trace Metals and Metaloids							
Aluminum				X		X	X
Antimony			X	X		X	
Arsenic		X		X		X	X
Cadmium	X	X		X		X	X
Calcium							
Chromium III	X			X		X	
Chromium IV	X			X		X	
Copper	X	X		X		X	X
Iron	X	X		X		X	X
Lead	X	X		X		X	X
Magnesium	X						
Manganese	X	X		X		X	X
Mercury	X	X		X		X	X
Methylmercury	X	X				X	X
Nickel	X	X		X		X	X
Potassium	X						
Selenium	X	X		X		X	X
SEM - Silver						X	
SEM-Cadmium						X	
SEM-Copper						X	
SEM-Lead						X	
SEM-Mercury						X	
SEM-Nickel						X	
SEM-Zinc						X	
Silver	X	X		X		X	X
Thallium			X			X	
Tin				X		X	
Zinc	X	X		X		X	X
Carbon, total and dissolved							
Total inorganic carbon	X					X	
Total organic carbon	X					X	X
Total carbon	X					X	
Dissolved organic carbon	X	X					
Particulate carbon	X	X					
Bulk organics							
	X						
Volatile organic compounds (VOCs)							
2,3,5-trimethylnaphthalene		X			X	X	X
2,4-Dinitrophenol	X		X	X			

	Water	RMP-Water	CTR-Water	Fish Tissue	RMP-BivTiss	Sed	RMP-Sed
2,4-Dinitrotoluene	X		X	X			
2,6-Dinitrotoluene	X		X				
2-Methyl-4,6-dinitrophenol	X		X	X			
2-Nitrophenol	X		X				
3-Chlorophenol	X						
3-Methyl-4-chlorophenol	X						
4-Nitrophenol	X		X				
Acrolein	X		X	X			
Acrylonitrile	X		X	X			
Azinphos-methyl	X						
Benzidine	X		X	X			
Bis(2-ethylhexyl) phthalateX	X		X	X			
Butylbenzyl phthalateW	X		X				
C1-Decalin				X			
C1-Dibenzothiophenes		X		X	X	X	X
C2-Benzothiophene				X			
C2-Decalin				X		X	
C2-Dibenzo(a,h)anthracene				X			
C2-Dibenzothiophenes		X		X	X	X	X
C3-Decalin				X		X	
C4-Decalin				X		X	
Carbon tetrachloride	X		X				
Decalin				X			
Dibenzofuran				X		X	
Diethyl phthalateW	X		X	X			
Dimethyl phthalateW	X		X	X			
Di-n-butyl phthalateW	X		X	X			
Dinitrophenols	X			X			
Di-n-octyl phthalate	X		X				
Ethylbenzene	X		X	X			
Methylmercury	X	X					X
Nitrobenzene	X		X				
Nitrosamines	X						
Nitrosodibutylamine, N	X						
Nitrosodiethylamine, N	X						
Nitrosopyrrolidine, N	X						
N-Nitrosodimethylamine	X		X				
N-Nitrosodi-n-propylamine	X		X	X			
Nonylphenol	X						
Pentachlorobenzene	X			X		X	
Phenol	X		X	X			
Tetrachlorobenzene,1,2,4,5-	X						
Toluene	X		X				
Toxaphene	X						

	Water	RMP-Water	CTR-Water	Fish Tissue	RMP-BivTiss	Sed	RMP-Sed
Tribuyltin	X		X	X		X	
Trichloroethylene	X		X	X			
Vinyl chloride	X		X	X			
Pesticides							
2,4'-DDD		X		X	X	X	X
2,4'-DDE		X		X	X	X	X
2,4'-DDT or o,p'-DDT		X		X	X	X	X
4,4'-DDD	X	X		X	X	X	X
4,4'-DDE	X	X		X	X	X	X
4,4'-DDT or p,p'-DDT	X	X		X	X	X	X
Acetochlor ethane sulfonic acid (ESA)	X						
Acetochlor oxanilic acid (OA)	X						
Alachlor ethane sulfonic acid (ESA)	X						
Alachlor oxanilic acid	X						
Aldrin	X	X		X	X	X	X
Atrazine	X						
beta.-Endosulfan (Endosulfan II)	X	X				X	
beta-Endosulfan	X	X					
Bifenthrin	X						
Chlordane	X			X			
Cyanide	X		X	X			
Dacthal monoacid	X	X					
Delta-Hexachlorocyclohexane		X			X	X	X
Demeton	X						
Diazinon	X	X					
Dieldrin	X	X		X	X	X	X
Endosulfan sulfate	X	X		X		X	
Endrin	X	X		X	X	X	X
Endrin aldehyde	X			X			
gamma-BHC (Lindane)	X			X			
Heptachlor	X	X		X	X	X	X
Heptachlor-epoxide	X	X		X	X	X	X
Hexachlorobenzene	X	X		X	X	X	X
Lindane	X			X		X	
Malathion	X						
Methoxychlor	X						
Methyl bromide	X		X				
Methyl chloride	X		X				
Metolachlor	X						
Metolachlor ethane sulfonic acid (ESA)	X						
Metolachlor oxanilic acid							
Mirex	X	X		X	X	X	X
Monobutyltin				X		X	
Parathion	X						

	Water	RMP-Water	CTR-Water	Fish Tissue	RMP-BivTiss	Sed	RMP-Sed
Trans-chlordane				X			
Tribenuron-methyl	X						
Tributyltin				X			
Halogenated hydrocarbons							
Delta-Hexachlorocyclohexane	X	X		X	X		X
1,1,1,2-Tetrachloroethane	X						
1,1,1-Trichloroethane	X		X				
1,1,2,2-Tetrachloroethane	X		X	X			
1,1,2-Trichloroethane	X		X	X			
1,1-Dichloroethane	X		X				
1,1-Dichloroethylene	X		X	X			
1,2,3,4-Tetrachlorobenzene				X		X	
1,2,4-Trichlorobenzene	X		X				
1,2-Dichlorobenzene	X		X				
1,2-Dichloroethane	X		X				
1,2-Dichloropropane	X		X	X			
1,2-Diphenylhydrazine	X		X	X			
1,2-Trans-Dichloroethylene	X		X	X			
1,3-Dichlorobenzene	X		X	X			
1,3-Dichloropropene	X			X			
1,4-Dichlorobenzene	X		X	X			
2,3,4,6-Tetrachlorophenol	X						
2,3,7,8-TCDD	X		X	X			
2,3-Dichlorophenol	X						
2,4,6-Trichlorophenol	X		X	X			
2,4-Dichlorophenol			X	X			
2,4-Dimethylphenol	X		X	X			
2,5-Dichlorophenol	X						
2,6-Dichlorophenol	X						
2-Chloroethylvinyl Ether	X		X				
2-Chloronaphthalene	X		X	X			
2-Chlorophenol	X		X				
3-Chlorophenol	X						
3-Methyl-4-chlorophenol	X		X				
3,3'-Dichlorobenzidine	X		X	X			
3,4-Dichlorophenol	X						
4-Bromophenyl phenyl ether	X		X				
4-Chlorophenol	X						
4-Chlorophenyl phenyl ether	X		X				
Alpha-hexachlorocyclohexane		X		X	X	X	X
beta-BHC	X						
beta-HCH		X		X	X	X	X
Bis(2-chloroethoxy) methane	X		X				
Bis(2-chloroethyl) ether	X		X	X			

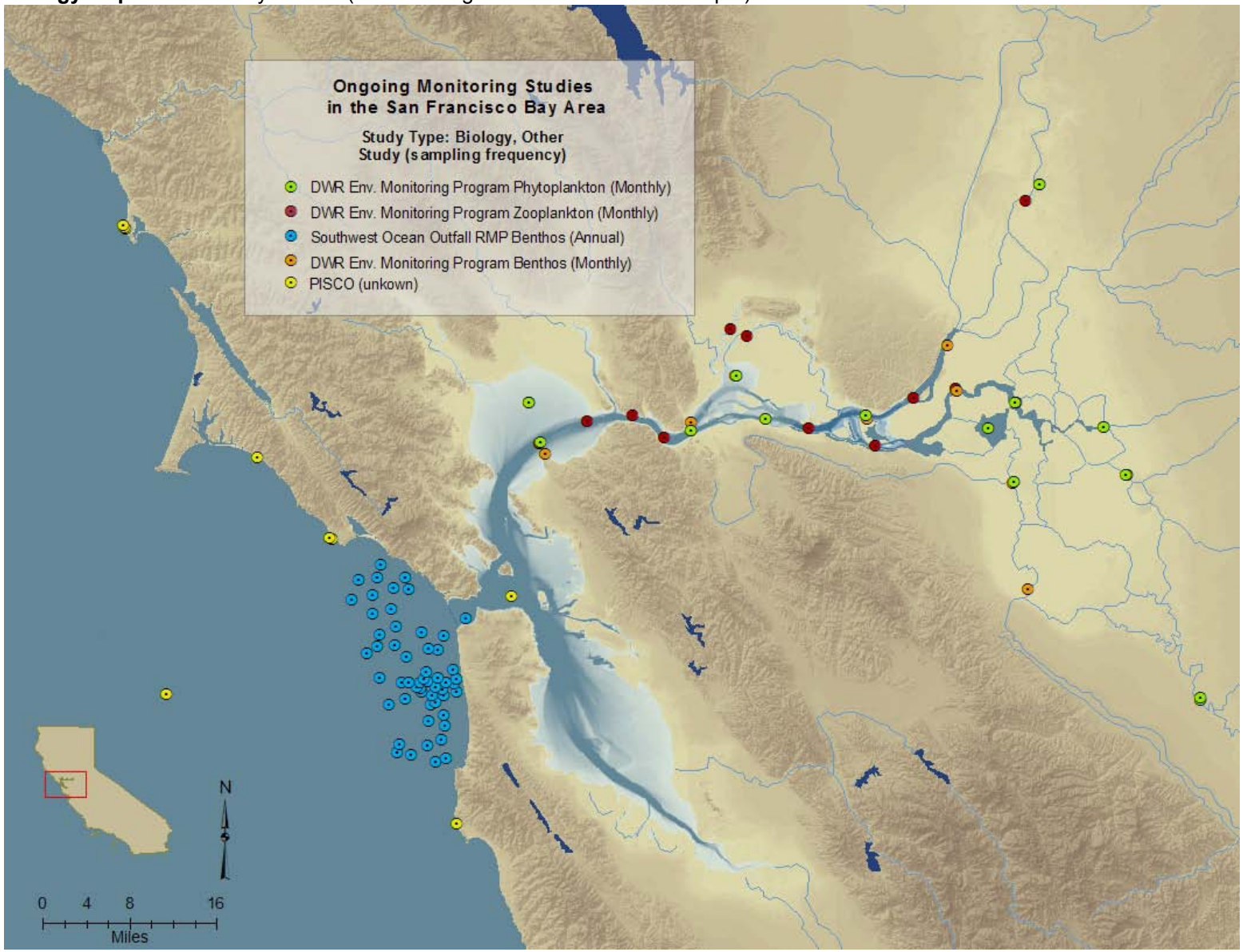
	Water	RMP-Water	CTR-Water	Fish Tissue	RMP-BivTiss	Sed	RMP-Sed
Bis(2-chloroisopropyl) ether	X			X			
Bromoform	X		X	X			
Chloroethane	X		X				
Chloroform	X		X				
Chlorophenoxy herbicide (2,4,5,-TP)	X			X			
Chlorophenoxy herbicide (2,4-D)	X						
Chloropyrifos	X	X					
delta-BHC	X						
Dichlorobromomethane	X		X	X			
Methylene chloride	X		X	X			
Octachlorostyrene				X			
Pentachloronitrobenzene				X			
Pentachlorophenol	X		X	X			
Polychlorinated biphenyls (PCBs)	X	X		X	X		X
Tetrachloroethylene	X			X			
Polycyclic aromatic hydrocarbons (PAHs)							
1-Methylphenanthrene		X		X	X	X	X
1,6,7-Trimethylnaphthalene				X		X	
2-Methylanthracene						X	
2-Methylnaphthalene		X		X	X	X	X
2,6-Dimethylnaphthalene		X		X	X	X	X
3,6-Dimethylphenanthrene							
9,10-Dimethylanthracene						X	
9-Methylanthracene						X	
Acenaphthene	X	X	X	X	X	X	X
Acenaphthylene		X	X	X	X	X	X
Anthracene		X		X	X	X	X
Benz[a]anthracene		X	X	X	X	X	X
Benzene	X		X				
Benzo[a]anthracene				X		X	
benzo[a]pyrene	X	X	X	X	X	X	X
Benzo[b]fluoranthene	X	X	X	X	X	X	X
Benzo[e]pyrene		X		X	X	X	X
Benzo[g,h,i]perylene	X	X	X	X	X	X	X
Benzo[k]fluoranthene		X	X	X	X	X	X
Biphenyl		X		X	X	X	X
C1-benzo(a)anthracenes/chrysenes						X	
C1-Benzothiophene				X			
C1-Chrysenes		X		X	X	X	X
C1-fluoranthenes/pyrenes		X		X	X	X	X
C1-fluorenes		X		X	X	X	X
C1-naphthalenes		X		X	X	X	X
C1-Naphthobenzothiophene				X			
C1-phenanthrenes/anthracenes		X		X	X	X	X

	Water	RMP-Water	CTR-Water	Fish Tissue	RMP-BivTiss	Sed	RMP-Sed
C2-benzo(a)anthracenes/chrysenes						X	
C2-Chrysenes		X		X	X	X	X
C2-fluoranthenes/pyrenes				X		X	
C2-fluorenes		X		X	X	X	X
C2-naphthalenes		X		X	X	X	X
C2-Naphthobenzothiophene				X			
C2-phenanthrenes/anthracenes		X		X	X	X	X
C3-benzo(a)anthracenes/chrysenes						X	
C3-Benzothiophene				X			
C3-Chrysenes		X		X	X	X	X
C3-Dibenzo(a,h)anthracene				X			
C3-Dibenzothiophenes		X		X	X	X	X
C3-Fluoranthenes/pyrenes				X		X	
C3-fluorenes		X		X	X	X	X
C3-naphthalenes		X		X	X	X	X
C3-Naphthobenzothiophene				X		X	
C3-phenanthrenes/anthracenes		X		X	X	X	X
C4-benzo(a)anthracenes/chrysenes						X	
C4-Chrysenes		X		X	X	X	X
C4-naphthalenes		X		X	X	X	X
C4-phenanthrenes/anthracenes		X		X	X	X	X
Chlorobenzene	X		X	X			
Chlorodibromomethane	X		X	X			
Chrysene		X			X	X	X
Dibenz(a,c)anthracene							
Dibenzo(a,h)anthracene	X	X	X	X	X	X	X
Dibenzothiophene		X		X	X	X	X
Fluoranthene	X	X	X	X	X	X	X
Fluorene	X	X	X	X	X	X	X
Hexachlorobutadiene	X		X				
Hexachlorocyclo-hexane-Technical				X			
Indeno[1,2,3-c,d]pyrene	X	X		X	X	X	X
Naphthalene	X	X		X	X	X	X
Naphthobenzothiophene				X			
Perylene		X		X	X	X	X
Phenanthrene	X	X		X	X	X	X
Pyrene	X	X		X	X	X	X
trans-Nonachlor		X		X	X	X	X

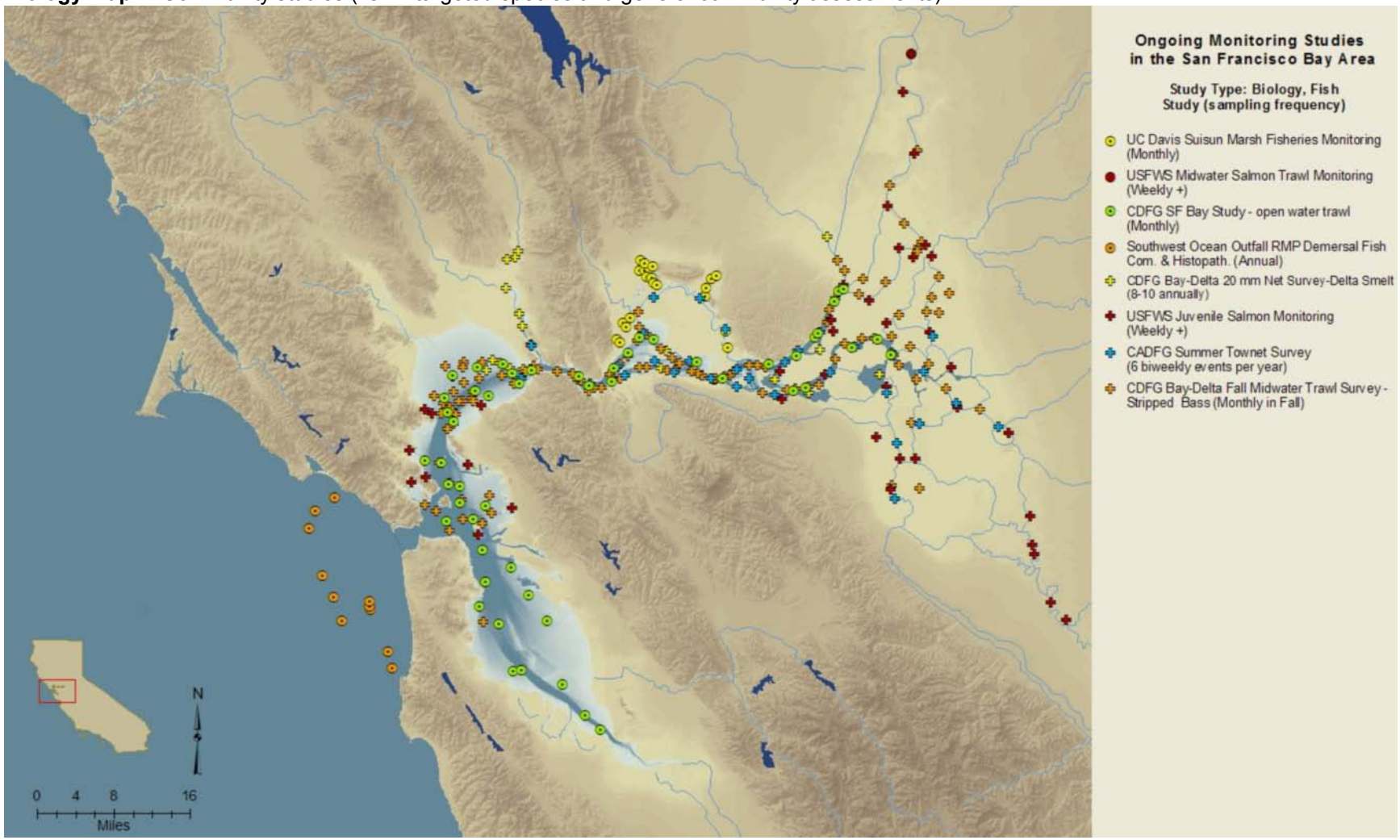
TOTAL of Target lists	158			150		111	
Total done by RMP in matrix targeted (if target=X and RMP=X)		105			59		75
Percent Complete	57%						

Work Group: Biology

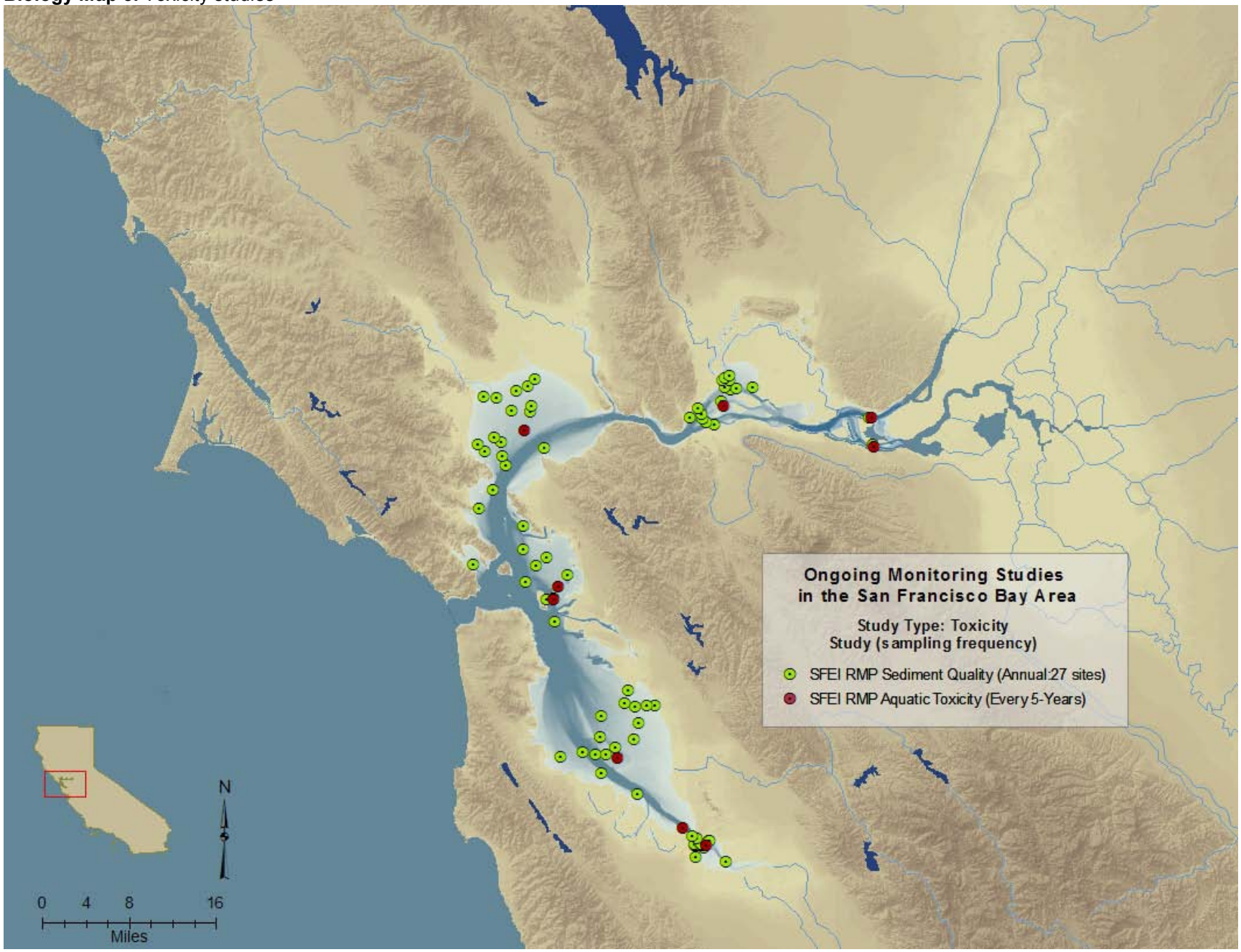
Biology Map 1. Community studies (not including fish communities see map 2)



Biology Map 2. Community studies (fish – targeted species and general community assessments)



Biology Map 3. Toxicity studies



Inventory table of targeted NWQMN biology parameters. Summary of the number of stations that measure each type of biology parameter by study/event type and environmental compartment.

WG Priority: *Tier 1*

StudyType	Event Type	Parameter Type	Parameter	Number of Stations in each Region: Not in Frame or 0 = Not measured	Encl. Bay	Near Shore	River
Biology Fish	FishCommunity	Effects	Disease & Deformities in			12	
Biology Other	HabitatMapping	Habitiat	Seagrass Cover	0			
Biology Other	PlantCommunity	Plant	Macro-Algae	0			
Biology Other	WaterQuality	Plant	Chlorophyll a & Ocean color	0			
Contaminants	SedimentQuality	Effects	Sediment Quality TRIAD		73	55	2
Nutrients	WaterQuality	PhysicalCondition	Descrete: Water - DO, Temp,	0			
PhysicalCharacter	HabitatMapping	Habitat	Habitat Mapping of Shorline	0			
Toxicity	Toxicity	Effects	SedTox		72		2
Toxicity	Toxicity	Effects	WaterTox		7		2
Toxicity	Toxicity	PhysicalCondition	Descrete: Sediment -		72		2

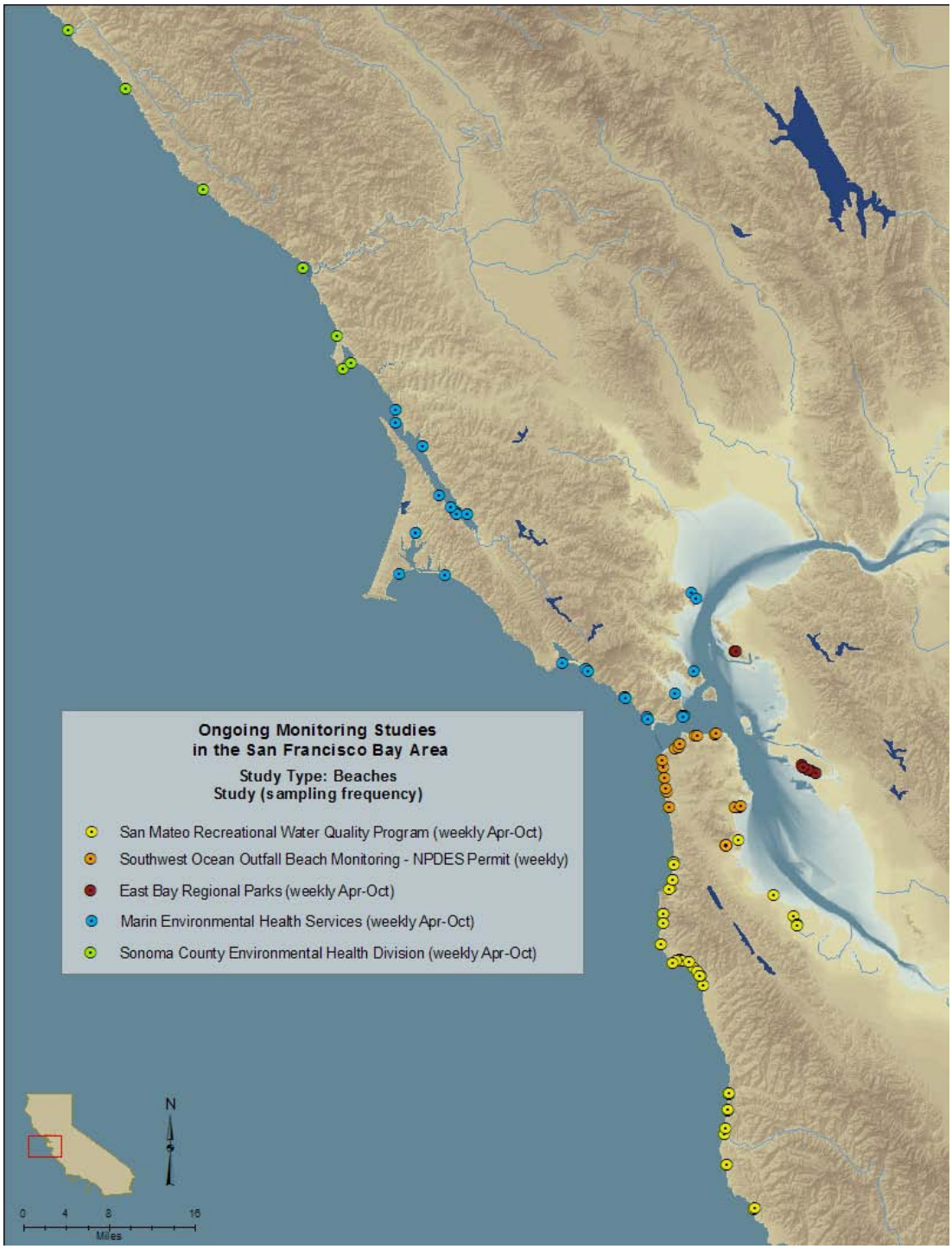
WG Priority: *Tier 2*

StudyType	Event Type	Parameter Type	Parameter	Number of Stations in each Region: Not in Frame or 0 = Not measured	Encl. Bay	Near Shore	River
Biology Fish	FishCommunity	Community	Community		76	12	29
Biology Fish	FishCommunity	Community	Community Delta Smelt	3	23		22
Biology Fish	FishCommunity	Community	Community Salmon	2	10		31
Biology Fish	FishCommunity	Community	Community Striped Bass		69		43
Biology Fish	FishCommunity	Community	Habititat-Focus on Species	5	178	12	125
Biology Other	Benthos	Community	Habititat-Focus on Species		5	55	6
Biology Other	Intertidal	Community	Community		1	8	
Biology Other	Intertidal	Community	Habititat-Focus on Species		1	8	
Biology Other	Phytoplankton	Community	Community		5		9
Biology Other	Phytoplankton	Community	Habititat-Focus on Species		5		9
Biology Other	PlantCommunity	Plant	Epiphytes	0			
Biology Other	WaterQuality	Plant	Chlorophyll a		157	1	17
Biology Other	Zooplankton	Community	Community		11		12
Biology Other	Zooplankton	Community	Habititat-Focus on Species		11		12

WG Priority: *Special*

StudyType	Event Type	Parameter Type	Parameter	Number of Stations in each Region: Not in Frame or 0 = Not measured	Encl. Bay	Near Shore	River
Biology Other	Benthos	Community	Community Macrobenthos		77	55	8
Biology Other	Benthos	Effects	Presence of Non-Indegenous		77	55	8
Biology Other	BirdCommunity	Community	Community Birds	0			
Biology Other	FishCommunity	Community	Fish & Shelfish Landings	0			
Biology Other	None	Effects	Water, Coastal & Sediment	0			

Work Group: Beaches



Inventory table of beach parameters. The number of stations that measure pathogens by environmental compartment.

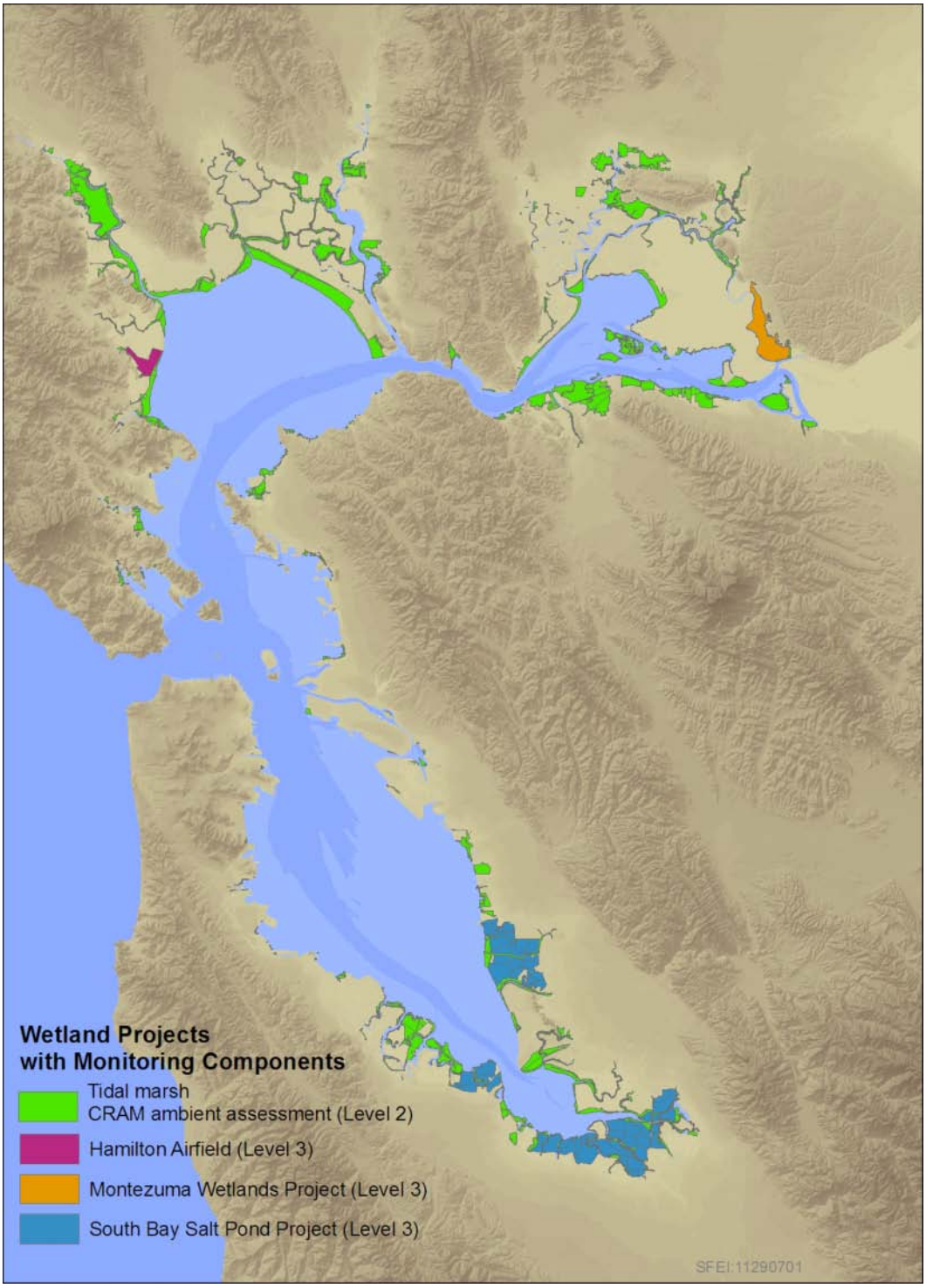
WG Priority: *Tier 1*

Number of Stations in each Region

StudyType	*Event Type*	*Parameter Type*	*Parameter*	*Not in Frame or 0 = Not measured*	*Encl. Bay*	*Near Shore*	*River*
Beaches	Pathogen	Pathogens	Coliform & Enterococus		31	70	0

Work Group: Wetlands

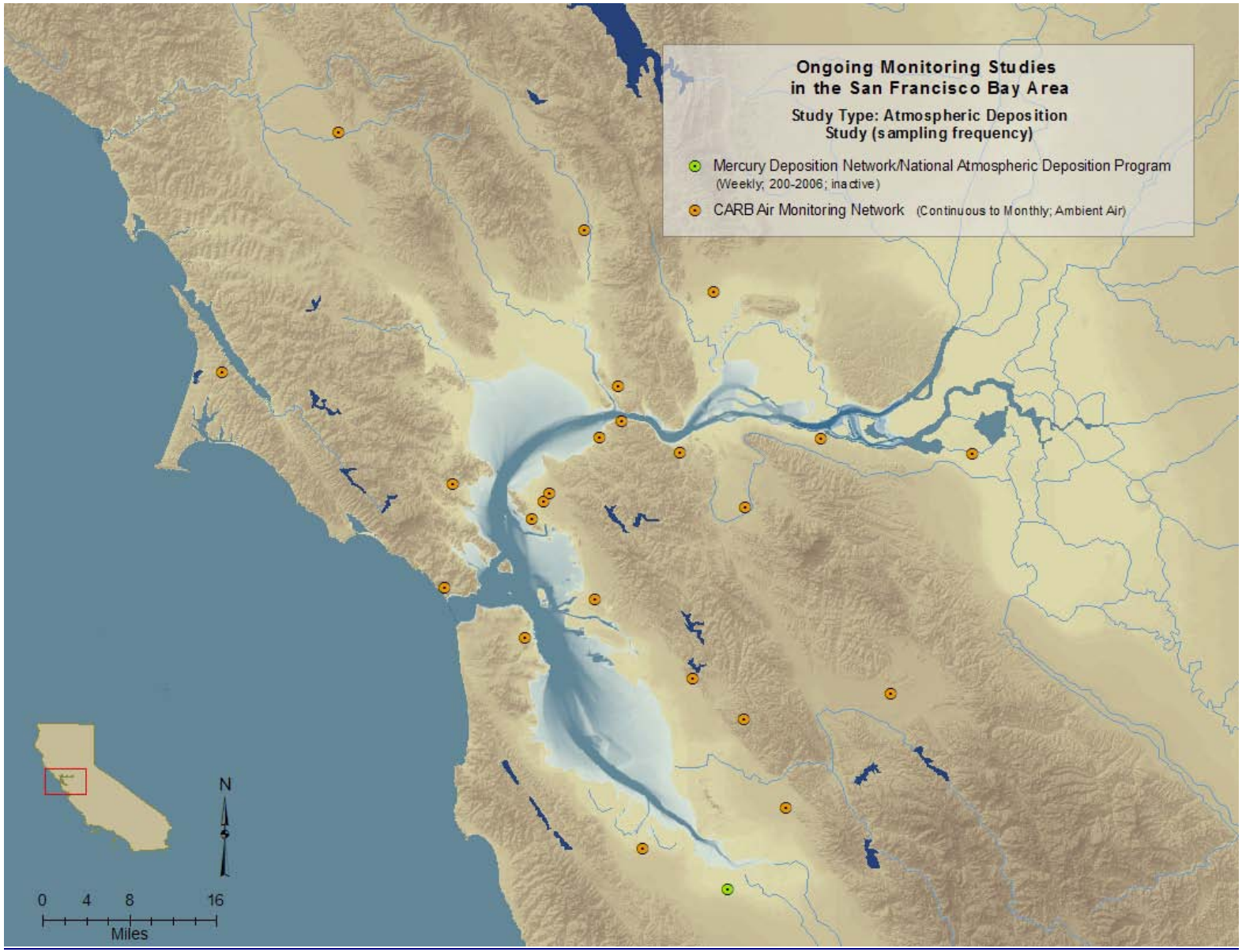
There are no fully funded, sustained Level 2 or Level 3 long term monitoring programs. Ambient assessments were completed in 2005 and 2007 for Bay Area wetlands. No programs meet the expected Network design criteria of sampling frequency of 1 year and sampling repetition every five years. Level 3 monitoring efforts exist in support of three large-scale wetlands restoration.



Inventory table of wetlands monitoring Level 1 and Level 2 parameters.

StudyType	*EventType*	*ParamType*	*Parameter*	*Number of Stations*
Wetlands	Ambient Survey	Level 1 - Lanscape Profile	Size-Frequency	
Wetlands	Ambient Survey	Level 1 - Lanscape Profile	Acreage	
Wetlands	Ambient Survey	Level 1 - Lanscape Profile	Fragmentation	
Wetlands	Ambient Survey	Level 1 - Lanscape Profile	% change in Size-Frequency	
Wetlands	Ambient Survey	Level 1 - Lanscape Profile	% change in acreage	
Wetlands	Ambient Survey	Level 2 - Rapid Assessment	Buffer-landscape condition	30
Wetlands	Ambient Survey	Level 2 - Rapid Assessment	Physical structure	30
Wetlands	Ambient Survey	Level 2 - Rapid Assessment	Hydrology	30
Wetlands	Ambient Survey	Level 2 - Rapid Assessment	Biotic structure	30
Wetlands	Ambient Survey	Level 2 - Rapid Assessment	Site condition	30

Work Group: Atmospheric Deposition



Inventory table of atmospheric deposition parameters measured by CARB. Summary of the number of stations that measure each type of atmospheric deposition parameter by environmental compartment.

WG Priority: *Not Specfied*

StudyType	Event Type	Parameter Type	Parameter	Number of Stations in each Region: Not in Frame or 0 = Not measured	Encl. Bay	Near Shore	River
Atmospheric	Deposition Air	ORG	Aldehyde	9	11	2	1
Atmospheric	Deposition Air	ORG	Dioxin/Furans/PDBEs/PCBs		4		
Atmospheric	Deposition Air	ORG	GaseousOrganics	9	11	2	1
Atmospheric	Deposition Air	PhysicalCondition	Crit.Pollutants: CO, SO2,	9	11	2	1
Atmospheric	Deposition Air	PhysicalCondition	non-Crit.Pol.: CH4, THC,	9	11	2	1
Atmospheric	Deposition Air	PhysicalCondition	Particulates	9	11	2	1
Atmospheric	Deposition Air	TE	Cr6+ &As	9	11	2	1
Atmospheric	Deposition Air	Weather	Meteorology	9	11	2	1
Atmospheric	Deposition Wet	TE	Mercury		1		

San Francisco Bay Area Atmosphic Deposition Details. Table of Air Deposition Monitoring in SF Bay Pilot Study region. Sampling is either continuous or monthly (http://www.arb.ca.gov/html/ds.htm).

ParamType	Parameter	Number of Stations Sampled	Bethel Island Road	Concord	Crockett-Kendall Avenue	Fairfield-Chadbourne	Fort Cronkhite	Fremont-Chapel Way	Gilroy-9th Street	Hayward	Livermore - Rincon	Los Gatos	Martinez-Jones Street	Napa-Jefferson Avenue	Oakland-Filbert Street	Pittsburg-10th Street	Redwood City	Richmond-7th Street	Richmond-Point Richmond	Rodeo-Third St	San Francisco-Arkansas Street	San Jose - Jackson St	San Jose - Tully Road	San Leandro	San Martin	San Pablo-Rumrill	San Rafael	Santa Rosa	Sunnyvale-Ticonderoga	Vallejo
CriteriaPollutants	CO	13	X	X				X			X			X		X	X				X	X				X	X	X		X
CriteriaPollutants	H2S	3																X	X	X										
CriteriaPollutants	NO2	13	X	X				X			X			X		X	X				X	X				X	X	X		X
CriteriaPollutants	O3	20	X	X		X		X	X	X	X	X		X		X	X				X	X		X	X	X	X	X	X	X
CriteriaPollutants	SO2	9	X	X	X								X			X		X			X					X				X
NonCriteriaPollutants	CH4	5		X				X			X										X	X								
NonCriteriaPollutants	NMHC	1									X																			
NonCriteriaPollutants	THC	4		X				X													X	X								
MeterologicalSensors	HWS	10	X	X		X			X		X			X											X	X		X		X
MeterologicalSensors	OT	10	X	X		X			X		X			X											X	X		X		X
MeterologicalSensors	RH	7	X	X					X		X			X											X					X
MeterologicalSensors	SolarRad	4	X								X														X			X		
MeterologicalSensors	WD	10	X	X		X			X		X			X											X	X		X		X
PM10	HighVolSSI_Ions	14	X	X				X			X			X		X	X				X	X	X			X	X	X		X
PM10	HighVolSSI_Mass	14	X	X				X			X			X		X	X				X	X	X			X	X	X		X
PM2.5	BAM	7									X			X	X		X				X	X								X
PM2.5	Mass	10		X				X	X		X						X				X	X	X					X		X
PM2.5	Spec.	1																				X								
ToxicCompounds	GaseousOrganics	20	X	X	X		X	X			X		X	X	X	X	X	X			X	X		X		X	X	X	X	X
ToxicCompounds	TSP_LowVol_Aldehyde	3						X													X	X								
ToxicCompounds	TSP_LowVol_CR6+	3						X													X	X								
ToxicCompounds	TSP_LowVol_Metals(As)	3						X													X	X								
ToxicCompounds	Dioxins/PDBEs/PCBs (CADAMP program)	3			X										X						X	X								

Appendix for Section 4. Data Management

This Appendix provides additional data access information for the forty seven ongoing monitoring studies described in this Pilot Study report. The list includes: monitoring studies, website links, frequency of sampling, and years of record. It also indicates which NWQMN workgroup the study relates and how many stations are sampled within the targeted NWQMN environmental compartments.

Additional Information for Data Access: List of 47 on-going monitoring studies (and sampling frequency) by event type, number of stations sampled, data access information, years of record, relevant NWQMN workgroup, and total number of stations (N), No. outside of Pilot Study sample frame (<>), No. in Enclosed Bay (EB), No. in Nearshore region (NS) and No. in Rivers (R) region.

Event Type	Study (sampling frequency)	Data Available to Download	Website (URL)	Freq-uency	Atmospheric Deposition	Beaches	Biology	Contaminants	Nutrients	Physical Characteristics	Years Of Record	N	<>	EB	NS	R
Benthos	DWR Env. Monitoring Program Benthos (Monthly)	CEDEN/BDAT	http://www.baydelta.water.ca.gov/emp/Metadata/benthos_metadata.html	Monthly			X				1980s-current	10		4		6
Benthos	Southwest Ocean Outfall RMP Benthos (Annual)	By Request	http://sfwater.org/detail.cfm/MC_ID/20/MSC_ID/357/C_ID/3102/ListID/1	Annually			X				1997-2005	56		1	55	
Bird Bioaccumulation	SFEI RMP Bird Egg - Cormorant & Tern (Every 3-Years)	By Request	http://www.sfei.org by request	Every 3 years				X			2002 - Current	17		16		1
Bivalve Bioaccumulation	SFEI RMP Bivalve (Annual)	SFEI	http://www.sfei.org/rmp/rmp_data_access.html	Annually				X			1993-2003	11		9		2
Deposition Air Mass	California Ambient Dioxin Air Monitoring Program (CADAMP)	California Air Resources Board	http://www.arb.ca.gov/aaqm/qmosopas/dioxins/dioxins.htm	Unknown	X						2003-2006	4		4		
Deposition Air Mass	CARB Air Monitoring Network (Continuous to Monthly; Ambient Air)	AQMIS-2	http://www.arb.ca.gov/aqd/aqinfo.htm	Continuous or Monthly	X						1967-2007	29	15	11	2	1
Deposition Wet	Mercury Deposition Network/National Atmospheric Deposition Program (Weekly; 2000-2006; inactive)	National Atmospheric Deposition Program	http://nadp.sws.uiuc.edu/sites/siteinfo.asp?id=CA72&net=MDN	Weekly	X						2000-2006	1		1		
Fish Bioaccumualtion	SFEI RMP Small Fish (Annual)	By Request	http://www.sfei.org by request	Annually				X			2005 - Current	14		14		
Fish	SFEI RMP Sport Fish	SFEI	http://www.sfei.org/rmp/rmp_dat	Every 3				X			1996 -	5		5		

Event Type	Study (sampling frequency)	Data Available to Download	Website (URL)	Freq-uency	Atmospheric Deposition	Beaches	Biology	Contaminants	Nutrients	Physical Characteristics	Years Of Record	N	<>	EB	NS	R
Bioaccumu altion	(Every 3-Years)		a_access.html (CSV File)	years							Current					
Fish Bioaccumu altion	Southwest Ocean Outfall RMP Demersal Fish (Annual)	By Request	http://sfwater.org/detail.cfm/MC_ID/20/MSC_ID/357/C_ID/3102/ListID/1	Annually				X			1997-2005	12			12	
Fish Community	CalCOFI (Water Quality and Fish trawls)	CalCOFI	http://www.calcofi.org/newhome/info/info.htm	Seasonal			X		X	X	1949 - current		75			
Fish Community	CDFG Bay-Delta 20 mm Net Survey-Delta Smelt (8-10 annually)	CEDEN/BDAT	http://www.delta.dfg.ca.gov/data/20mm/	Part time (Monthly)			X				Many years	48	3	23		22
Fish Community	CDFG Bay-Delta Fall Midwater Trawl Survey - Stripped Bass (monthly in Fall)	CEDEN/BDAT	http://www.delta.dfg.ca.gov/data/mwt/	Part time (Monthly)			X				Many years	112		69		43
Fish Community	CDFG SF Bay Study - open water trawl (monthly)	CEDEN/BDAT	http://www.delta.dfg.ca.gov/baydelta/monitoring/baystudy.asp	Monthly			X				Many years	52		40		12
Fish Community	CDFG Summer Townet Survey (6 biweekly events per year)	CEDEN/BDAT	http://bdat.water.ca.gov/Metadata/TNS_Metadata.htm	Part time (Twice weekly)			X				1996-current	32		15		17
Fish Community	Southwest Ocean Outfall RMP Demersal Fish Com. & Histopath. (Annual)	By Request	http://sfwater.org/detail.cfm/MC_ID/20/MSC_ID/357/C_ID/3102/ListID/1	Annually			X				1997-2005	12			12	
Fish Community	UC Davis Suisun Marsh Fisheries Monitoring (Monthly)	CEDEN/BDAT	http://bdat.water.ca.gov/Metadata/mwtr.html	Monthly			X				1996-current	21		21		
Fish Community	USFWS Juvenile Salmon Monitoring (Weekly +)	CEDEN/BDAT	http://www.iep.ca.gov/metadata/DBMS/trawls/usfws.pdf	Weekly			X				1996-current	52	13	9		30
Fish	USFWS Midwater	CEDEN/BDAT	http://bdat.water.ca.gov/Metadat	Daily			X				1996-current	1		1		

Event Type	Study (sampling frequency)	Data Available to Download	Website (URL)	Freq-uency	Atmospheric Deposition	Beaches	Biology	Contaminants	Nutrients	Physical Characteristics	Years Of Record	N	<>	EB	NS	R
Community	Salmon Trawl Monitoring (Weekly +)		a/usfws_ci_mwtr.html; http://bdat.water.ca.gov/Metadata/midwater_trawl.html													
Fish Community	USFWS Midwater Salmon Trawl Monitoring (Weekly +)	CEDEN/BDAT	http://bdat.water.ca.gov/Metadata/usfws_ci_mwtr.html; http://bdat.water.ca.gov/Metadata/midwater_trawl.html	Weekly			X				1996-current	1				1
Habitat Mapping	SFEI Historical Ecology (Habitat mapping)	By Request	http://www.sfei.org/HEP/projects_2.html	NA			X					0		0		
Intertidal Community	PISCO intertidal (Annual)	Web services	http://www.piscoweb.org/data: http://www.piscoweb.org/data/catalog/intertidal_community	Annually			X				?	9		1	8	
Pathogen	East Bay Regional Parks (weekly Apr-Oct)	EARTH911	http://www.healthebay.org/brc/textlist.asp?map=11	Weekly		X					Many years	8		8		
Pathogen	Marin Environmental Health Services (weekly Apr-Oct)	EARTH911	http://www.earth911.org/waterquality/default.asp?cluster=6041	Weekly		X					Many years	30	1	7	22	
Pathogen	San Mateo Recreational Water Quality Program (weekly Apr-Oct)	EARTH911	http://www.earth911.org/waterquality/default.asp?cluster=6081	Weekly		X					Many years	46	5	5	36	
Pathogen	Sonoma County Environmental Health Division (weekly Apr-Oct)	EARTH911	http://www.healthebay.org/brc/textlist.asp?map=12	Weekly		X					Many years	7			7	
Pathogen	Southwest Ocean Outfall Beach Monitoring - NPDES Permit (weekly)	EARTH911	http://sfwater.org/detail.cfm/MC_ID/20/MSC_ID/357/C_ID/3102/ListID/1; http://www.healthebay.org/brc/textlist.asp?map=11	Weekly		X					Many years	17		11	6	
Phytoplankton	DWR Env. Monitoring Program Phytoplankton (Monthly)	CEDEN/BDAT	http://www.baydelta.water.ca.gov/emp/Metadata/phytoplankton_metadata.html	Monthly			X				1980s-current	14		5		9

Event Type	Study (sampling frequency)	Data Available to Download	Website (URL)	Freq-uency	Atmospheric Deposition	Beaches	Biology	Contaminants	Nutrients	Physical Characteristics	Years Of Record	N	<>	EB	NS	R
Sediment Quality	SFEI RMP Sediment Quality (Annual:47 sites/Yr (2002-2005))	SFEI	http://www.sfei.org/rmp/rmp_data_access.html	Annually				X	X	X	2002-2005	47		45		2
Sediment Quality	Southwest Ocean Outfall RMP Sediment Quality (Annual)	By Request	http://sfwater.org/detail.cfm/MC_ID/20/MSC_ID/357/C_ID/3102/ListID/1	Annually				X			1997-2005	112		2	110	
Toxicity	SFEI RMP Aquatic Toxicity (Every 5-Years)	SFEI	none	Every 5 years			X				1993-2005	9		7		2
Toxicity	SFEI RMP Sediment Quality (Annual:27 sites/Yr (2002-2005))	SFEI	http://www.sfei.org/rmp/rmp_data_access.html	Annually			X				2002-2005	27		25		2
Water Quality	CalCOFI (Water Quality and Fish trawls)	CalCOFI	http://www.calcofi.org/newhome/info/info.htm	Seasonal			X		X	X	1949 - current		75			
Water Quality	CDIP (real-time water sampling)	?	From Tom Wadsworth UCSC CeNCOOS (http://cdip.ucsd.edu/?nav=recent□=observed&stn=142&stream=p1&xitem=pm)	Continuous						X	?	1			1	
Water Quality	CICORE Water Quality Monitoring (Realtime)	CICORE (SFBEAMS and CSU)	http://sfbeams.sfsu.edu/download.htm; http://www.sci.csueastbay.edu/cicore/	Continuous							2002-current	3		3		
Water Quality	CICORE Water Quality Monitoring (Weekly)	CICORE (SFBEAMS)	http://sfbeams.sfsu.edu/download_nut_page.htm	Weekly					X	X	2003-current	1		1		
Water Quality	COCMP (real-time water sampling)	Unknown	http://www.norcalcurrents.org/COCMP/data.html	Continuous						X	2005-current	7		4	3	
Water Quality	DWR CDEC (real-time water sampling)	CEDEN/BDAT	From Tom Wadsworth UCSC CeNCOOS (http://cdec.water.ca.gov/)	Continuous						X	Many years	187	75	21	3	88
Water Quality	DWR Env. Monitoring Program Descrete Water	CEDEN/BDAT	http://www.baydelta.water.ca.gov/emp/Metadata/discreteWQ_m	Monthly					X		1980s-current	46		22		24

Event Type	Study (sampling frequency)	Data Available to Download	Website (URL)	Freq-uency	Atmospheric Deposition	Beaches	Biology	Contaminants	Nutrients	Physical Characteristics	Years Of Record	N	<>	EB	NS	R
	Quality (Monthly)		etadata.html													
Water Quality	National Marine Sanctuary Program	Unknown	From Tom Wadsworth UCSC CeNCOOS; http://nmsfocean.org/nmsp/nmsp_gf.asp	Continuous						X	?	2			2	
Water Quality	NDBC (real-time water and air)	NOAA National Data Bouy Center	From Tom Wadsworth UCSC CeNCOOS (http://www.ndbc.noaa.gov/station_page.php?station=46026)	Continuous						X		1			1	
Water Quality	NWLON (Tide gauge)	NOAA Tides and Currents	From Tom Wadsworth UCSC CeNCOOS (http://tidesandcurrents.noaa.gov/sfports)	Continuous						X		5		5		
Water Quality	PISCO (real-time water sampling)	?	From Tom Wadsworth UCSC CeNCOOS (http://www.piscoweb.org/data/catalog/phys_ocean)	Continuous						X		3			3	
Water Quality	Ports (real-time water and air)	NOAA Tides and Currents	From Tom Wadsworth UCSC CeNCOOS (http://tidesandcurrents.noaa.gov/sfports)	Continuous						X		6		6		
Water Quality	SFEI RMP Water Quality (Annual: 22 sites/Yr (2002-2005))	SFEI	http://www.sfei.org/rmp/rmp_data_access.html	Annually			X	X	X	X	2002-2005	22		19	1	2
Water Quality	SFNERR (real-time water and air)	CDMO	http://cdmo.baruch.sc.edu/QueryPages/data_metadata_select.cfm	Continuous						X		2		2		
Water Quality	SFNERR (weekly)	CDMO	http://cdmo.baruch.sc.edu/QueryPages/data_metadata_select.cfm	Weekly					X			2		2		
Water	USGS Continuous	USGS	http://sfbay.wr.usgs.gov/sedime	Continuous						X	1989-current	13	4	9		

Event Type	Study (sampling frequency)	Data Available to Download	Website (URL)	Freq-uency	Atmospheric Deposition	Beaches	Biology	Contaminants	Nutrients	Physical Characteristics	Years Of Record	N	<>	EB	NS	R
Quality	Monitoring (Continuous)		nt/cont_monitoring/index.html	or Weekly												
Water Quality	USGS Water Quality Monitoring (Monthly)	USGS	http://sfbay.wr.usgs.gov/access/wqdata/	Monthly			X		X		1969-current	74		68		6
Zooplankton	DWR Env. Monitoring Program Zooplankton (Monthly)	CEDEN/BDAT	http://www.baydelta.water.ca.gov/emp/Metadata/discreteWQ_metadata.html	Monthly			X				1980s-current	23		11		12