Wetlands Monitoring Data Sources for the San Francisco Bay/Delta:

Opportunities for Collaboration, Coordination, and Integration

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Introduction

The following is a compendium of descriptions of regional and sub-regional monitoring programs of significant duration and scope in the San Francisco Bay Area of California. The purpose of this document is that it may be used as a reference for Integrated Regional Wetlands Monitoring (IRWM) and other monitoring projects in order to better coordinate and integrate their efforts.

The projects are loosely ordered from more specific, with fewer monitoring targets over a smaller geographic area, to more general, with more monitoring targets over a larger geographic area and more scientific disciplines involved.

Information given here was gathered mainly from the official web sites of the monitoring programs described. Exceptions to this rule are noted in the text. An effort was made to preserve the prose of the original authors as much as possible.

United States Geological Survey (USGS),

Wetland Carbon and Sediment Studies

I. Wetland Fluxes of Dissolved Organic Carbon and Sediment at Browns Island, California: Balancing the Water Budget

Purpose

To measure carbon and suspended-sediment fluxes through tidal wetlands to improve understanding of dissolved organic carbon (DOC) and suspended-sediment transport.

Dates

May 2002 – present

Geographic Scope

Browns Island

Focus of Monitoring

Water, carbon, and suspended-sediment flux

Data availability

Not accessible at this time.

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Study Details

(Adapted from the 2004 CALFED Bay-Delta Program Science Conference abstract: Lionberger, M.A. , N.K. Ganju , D.H. Schoellhamer, B.D. Downing , B.A. Bergamaschi, G.A. Wheeler , Wetland Fluxes Of Dissolved Organic Carbon And Sediment At Browns Island, California: Balancing The Water Budget and earlier abstracts.)

Dissolved organic carbon (DOC) and sediment fluxes to and from tidal wetlands have the potential to affect water quality and ecosystem restoration; therefore, accurate

measurements of these fluxes are crucial. Certain forms of dissolved organic carbon (DOC) react with disinfecting chemicals used to treat drinking water, to form disinfection byproducts (DBPs), some of which are potential carcinogens. The contribution of DBP precursors by tidal wetlands is unknown. Sediment transport to and from tidal wetlands determines the potential for marsh accretion, thereby affecting habitat formation. This study measures net fluxes of DOC and sediment for Browns Island, an established tidal wetland in the Sacramento-San Joaquin River Delta.

Accurate measurements of DOC and sediment fluxes require high-intensity sampling and development of a water budget that accounts for all water that enters and then exits the island control volume during a tidal cycle. The U.S. Geological Survey continuously measures fluxes of water, DOC, and sediment for several weeks each season with an instrument package containing an acoustic Doppler current profiler, spectral photometer, colored-dissolved-organic-matter fluorometer, and a nephelometric turbidity sensor. Water flux is measured using the index-velocity method, and instruments are calibrated using velocity-weighted, cross-sectionally averaged water samples.

Initial measurements of tidally averaged water flux in the main channel of Browns Island indicated a flood-biased imbalance of 13%, resulting in biased calculated fluxes of sediment and DOC onto the island. We believed that a secondary channel connecting the main channel to New York Slough was responsible for this imbalance. Therefore, an instrument package was placed in both the secondary and main channels in Fall 2003. The combined tidally averaged water flux from both channels reduced the imbalance to 3%.

However, the magnitude of the imbalance is still significant as it may be a combination of groundwater seepage, overland flow, and minor creek flow. This imbalance is of minor consequence to suspended-sediment flux, because groundwater, overland flow, and minor creek flow carry low concentrations of suspended sediment. Nonetheless, the net flux of dissolved species such as DOC cannot be accurately determined without a complete water balance, as DOC concentrations in groundwater alone can be an order of magnitude greater than surface water concentrations. Therefore, the net sediment flux direction and magnitude can be reasonably estimated over the seasonal deployments, while the net DOC flux direction and magnitude cannot be resolved without a complete closure of the water balance. Future deployments will aim to resolve the total water balance.

II. Carbon Fluxes, Water Levels, and Related Environmental Data, Twitchell Island, Sacramento-San Joaquin Delta, California

Purpose

To determine the effects of different water management practices on the carbon mass balance and land-surface elevation of organic soils in restored wetlands in the Delta

Dates

November 1992 – September 1995

Geographic Scope

Twitchell Island

Focus of Monitoring

carbon flux, organic matter accretion, water usage

Data availability

Report accessible online: 2003 USGS Open–File Report 03-370 by Barry D. Kerr, Bronwen Wang, and Judy Z. Drexler, Sacramento, California.

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Study Details

Objectives

The overall objective is to determine the effects of different water management practices on the carbon mass balance and land-surface elevation of organic soils in restored wetlands in the Delta. Specific objectives of the study are to (1) quantify all carbon inputs and outputs under two different water level treatments; (2) identify biogeochemical processes controlling carbon input and output dynamics; (3) assess accretion processes of soil under the water level treatments, (4) determine the sources of gaseous carbon emissions, and (5) quantify the water budget.

Relevance and Impact

This project examines the effects of wetland reversion as a method to mitigate subsidence by slowing the loss of organic substrate, as well as the potential for reversing subsidence through organic matter sequestration. As CALFED plans to make major changes in the Delta ecosystem over the next several years, this study helps to determine the general costs and effects of wetland reversion projects in the region. It provides a basis for estimating water use by future wetland reversion projects, as well as an example of the effect of water depth on wetland plant communities, which serve as wildlife habitat. In this way, this research meets several USGS goals outlined in WRD Memorandum 95-44:

1. Providing data or results useful to multiple parties in potentially contentious interjurisdictional conflicts over water resources.
2. Providing water-resources information that will be used by multiple parties for planning and operational purposes.
3. Furnishing data or information that contribute to protection of life or property.

Strategy and Approach

Changes in the pond bottom elevations and gaseous carbon fluxes will be quantified and predominant biogeochemical processes will be identified under different water and land-management practices. Specific study elements include:

1. assessment of gaseous carbon fluxes by gas chromatography;
2. measurement of carbon inputs through biomass harvests and nondestructive turnover measurements;
3. evaluation of biogeochemical pathways from detailed isotope and decomposition studies;
4. assessment of organic matter accretion using sedimentation-erosion table measurements and coring combined with feldspar marker horizons; and
5. estimate of wetland water usage through measurements of inflow, outflow, and evapotranspiration.

Abstract

(from the 2003 USGS Open–File Report 03-370)

Most of the Sacramento-San Joaquin Delta was leveed, drained, and converted to agricultural use by the 1930s. Land-surface elevations have since subsided by more than 20 feet in some areas. Subsidence increases the likelihood of levee failure and flooding, which, in turn, jeopardizes water delivery and water quality in the Delta. This is of major concern because the Delta supplies water to two-thirds of California. Previous research has shown that oxidation of peat soils is the primary cause of subsidence in the Delta. Therefore, a possible strategy for remedying this situation is to convert drained agricultural fields back to wetlands, which are flooded at least part of the year. Rehabilitation of wetlands would promote the growth of peat, thereby mitigating and possibly reversing subsidence.

This report describes a study that evaluated this strategy. In three experimental enclosures or ponds, carbon inputs were measured in the form of plant biomass and outputs in the form of carbon dioxide (CO2) and methane (CH4) fluxes. Each of the ponds received one of the following water treatments: seasonally flooded, seasonally flooded and irrigated, or permanently flooded. Land-surface elevation, ground-water levels, and soil and air temperature also were measured. This report presents the data collected during the initial phase of the study, which ran from November 1992 through September 1995.

California Environmental Protection Agency
SAN FRANCISCO BAY REGIONAL
WATER QUALITY CONTROL BOARD

San Francisco Bay Regional Water Quality Control Board

(SFBRWQCB), Development of Sediment TMDLs for Local Streams

Purpose

To protect and enhance fish habitat.

Dates

2003 – Ongoing

Geographic Scope

Nine watersheds local to San Francisco Bay (see figure below)

Focus of Monitoring

Sediment loading of creeks

Data Accessibility

Data are not yet available, although reports are expected in 2005.

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Study Details

(Excerpted from Napolitano, M., S. Potter and D. Whyte. 2003. Conceptual Approach for Developing Sediment TMDLs for San Francisco Bay Area Streams.)

Nine Bay Area streams and their tributaries are on the 303(d) list as impaired by too much sediment (see figure below). These streams drain watersheds with a combined land area of 1100 square miles, or about one quarter of the total land area within the jurisdiction of the San Francisco Bay Regional Water Quality Control Board (Regional

Board). The nine streams are listed because: 1) habitat is degraded by fine sediment deposits; and 2) these streams are regionally significant from a conservation biology standpoint – they provide critical habitat for steelhead, salmon and other at-risk native fish and wildlife species.

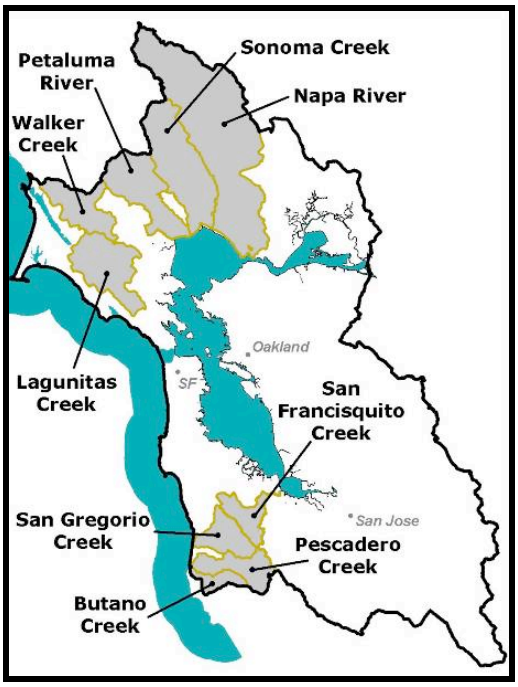
Our primary objective in developing and implementing sediment TMDLs is to protect and enhance fish habitat. Therefore TMDL analysis and implementation will include the following components:

1) Confirming the nature of impairment by identifying and ranking significant limiting factors for fish (using limiting factors analyses);
2) Evaluating sediment inputs and sources (using sediment budget analyses);
3) Evaluating causes of other limiting factors, such as habitat degradation, lack of baseflow, barriers, through watershed assessment;
4) Establishing narrative and numeric targets for water quality and habitat attributes needed to support fish in good condition (Moyle, 1998); and
5) Implementing measures to control sediment delivery to streams, enhance habitat conditions by increasing shade and habitat complexity and baseflow, and modifying or removing human-made structures to restore access for steelhead and salmon to suitable habitat areas.

We will use rapid sediment budget techniques to quantitatively estimate rates of sediment delivery to streams, and to distinguish natural and human contributions. In some cases, we will also analyze what happens to sediment once it enters channels in order to predict in greater detail how changes in sediment load will affect where, how much, and what sizes of sediment are deposited and how this in turn affects channel form and functions. The rapid sediment budget methodology which has been in wide use for more than a decade, has proven scientifically defensible and cost efficient. A sediment budget takes into account the type and location of major natural and management-related sediment sources, the magnitude of the sources, grain-size distribution of sediment, the volume of sediment in storage and the transport rate through streams and valleys.

When other limiting factors are identified besides sediment, a watershed assessment can be conducted to further identify how human activities and natural processes influence water quality and habitat attributes. The States of Washington and Oregon have developed approved methodologies for watershed analysis or assessment in rural watersheds. The California Resources Agency is currently developing an advisory document regarding approaches and tools for conducting watershed assessment in California that is intended to address the broad array of land use activities, physical settings, and social and biological communities found in California. This document is projected for completion in December 2003. The San Francisco Estuary Institute has developed the Bay Area Watershed Science Approach that has proven quite useful for assessment and management of small Bay Area watersheds (drainage area ≤ 20 mi^2) including several tributaries to the Napa River and Sonoma Creek.

Map of the nine streams impaired by excess sediment.



Further Information

Napolitano, M., S. Potter and D. Whyte. 2003. Conceptual Approach for Developing Sediment TMDLs for San Francisco Bay Area Streams

The Aquatic Pesticide Monitoring Program (APMP)

Purpose

To provide information on the effects of chemical and non-chemical aquatic pest control methods.

Dates

1 January 2002 – 28 February 2005

Geographic Scope

California

Focus of Monitoring

Water, sediment, and biotic tissues for pesticide concentrations and effects

Data Accessibility

Data are available at http://www.sfei.org/apmp/recent_pubs.html#Monitor

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Study Details

The Aquatic Pesticides Monitoring Program designed and implemented a monitoring plan and special studies to determine the potential effects of aquatic pesticides and their adjurants on environments throughout California. This data was used by the State Water Resources Control Board in its development of new aquatic pesticide NPDES permits.

Background

(Adapted from *NorCal SETAC News*, Volume 13, No. 2, Fall 2002)

The Aquatic Pesticide Monitoring Program (APMP) is investigating the behavior of aquatic pesticides in the environment throughout the state. This project will be

looking exclusively at pesticides applied directly to bodies of water and not at pesticides that were initially used on land.

In 2001, a legal decision of the U.S. Ninth Circuit court (Headwaters, Inc. v. Talent Irrigation District) applied Clean Water Act requirements to the application of pesticides, thereby requiring aquatic pesticide users to obtain National Pollution Discharge Elimination System (NPDES) permits prior to discharging pesticides to U.S. waters. Previously, pesticide use was governed only under federal pesticide law (FIFRA). A legal challenge to the California State Water Resources Control Board (SWRCB) emergency permit resulted in $2.7 million of funding for three years of research and monitoring to provide the SWRCB with information to develop the California NPDES permit.

The APMP utilized the USEPA Triad monitoring approach (chemical characterization, toxicity testing, and bioassessments) at a variety of sites throughout the State. In addition, a number of special monitoring and research projects were conducted to answer specific questions identified by the monitoring.

The Aquatic Pesticide Monitoring Program Alternatives Program was established as part of the APMP to develop practical recommendations for alternative aquatic pest control methods that may be used in California waters. The end-users of this information include the California State Water Quality Control Board, special interest groups, and the state, local, and private agencies that control aquatic plants. The APMP Alternatives Project aims to help understand the feasibility of non-chemical aquatic plant control methods as alternatives to chemical control in California waters. It includes three components:

1. A thorough review of alternative aquatic pest control methods for potential use in California waters
2. Research projects that evaluate effectiveness and potential environmental impacts of different control methods
3. Evaluation of the cost-effectiveness of different control methods, using a rigorous economic methodology

Further Information

APMP web site

Amphibian Research and Monitoring Initiative (ARMI)

Purpose

To monitor amphibian populations and research causes of decline.

Dates

1991 – Ongoing

Geographic Scope

Northern and Central California (Point Reyes Seashore, Yosemite National Park, Sierra foothills)

Focus of Monitoring

Amphibians

Data Accessibility

Data are not currently accessible.

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Study Details

(from the 2002 ARMI Report for Northern and Central California)

ARMI-funded work in northern and central California is conducted from the USGS field station at Point Reyes National Seashore. Research on declining amphibians has been on going in California since 1991, with the initial work funded by the National Park Service, and the most recent work funded through the USGS ARMI program. Originally, amphibian research entailed extensive, broad scale surveys to evaluate the distribution and abundance of amphibians throughout much of northern and central California, with emphasis on National Parks and National Forests. Work now being conducted under the ARMI program is now focused on a combination of field surveys (monitoring) and research into the causes of declines.

In 2002, surveys were conducted at Point Reyes National Seashore, Yosemite National Park, and in the Sierra foothills (mostly Forest Service lands). The table below summarizes the number of unique sites visited during 2002.

Point Reyes National Seashore	67 sites
Yosemite National Park	244 sites
Sierra foothills	35 sites

Some sites have been monitored on an annual (or more frequent basis) for 6-10 years. These sites will continue to be monitored as part of the ARMI program. In 2002, we visited 42 sites as part of this long-term monitoring.

Apex sites are monitored more intensively in order to obtain a better understanding of population dynamics throughout a season and to obtain more accurate estimates of population size. We utilized one apex site at Point Reyes NS during 2002 where we conducted repeated visits throughout the year. This part of our work will be expended to additional sites in 2003 (see below).

In order to understand the cause of amphibian declines in California, it is necessary to conduct focused research on the most likely factors. Our work has involved two related projects that examine the role of pesticides as the primary factor leading to the decline and loss of amphibian populations. Both projects described below were conducted in 2001 and repeated in 2002 in order to evaluate year-to-year variation.

- **Part 1.** We evaluated pesticide levels in the water, soil, and tissue of both adult and larval Pacific treefrogs (Hyla regilla) along 4 parallel transects that ran from Pacific Ocean to the crest of the Sierra Nevada Mountains. The endpoints for these transects were Lassen Volcanic NP, Lake Tahoe, Yosemite NP, and Sequoia NP. Along each transect, we sampled 1-3 ponds in each of 5 areas. These were near the ocean, on the west side of the Central Valley, east side of the Central Valley, low-elevation Sierra Nevada Mountain, and mid-elevation Sierra Nevada. On the Yosemite transect, we added a high-elevation site. Data from this work will allow us to evaluate the accumulation of pesticides in the environment and in the tissue of frogs across a wide portion of the state. This work is being done in collaboration with the researchers listed below.

- **Part 2.** Pacific treefrog tadpoles were raised in 3 locations (Lassen Volcanic, Yosemite, and Sequoia National Parks) in a field experiment designed and conducted by a doctoral student, Deborah Cowman (Texas A&M University). This work will allow us, for the first time, to evaluate the impact of pesticides on tadpoles exposed to natural levels of contaminants. Tadpoles collected in each park were divided into three random groups and then raised in field enclosures at 1 of the 3 parks listed above. The work was designed to determine whether local conditions affected the survival of tadpoles, and whether there were significant differences in tadpole survival in parks that naturally receive strikingly different

exposures to pesticides. The work will be followed by controlled lab experiments (see below) to further evaluate the role of contaminants in amphibian declines. This work is being done in collaboration with the researchers listed below.

Further Information

2002 ARMI Report for Northern and Central California

Interagency Ecological Program (IEP),

Delta Outflow/San Francisco Bay Study

Purpose

To determine the effects of freshwater outflow and outflow related mechanisms on the abundance and distribution of estuarine and marine fishes, brachyuran crabs, and caridean shrimp. These data are also used to refine life history models, advance understanding of how various species use the estuary, and to determine other causes (i.e. factors other than freshwater outflow, such as ocean temperature and currents) of population variation.

Dates

January 1980 to present for open water sampling, August 1980 through January 1987 for beach seine sampling, and May 1982 to December 1994 for ringnet sampling.

Geographic Scope

Within San Francisco Bay, south to immediately south of the Dumbarton Bridge, to just west of Alcatraz Island, north to the confluence of the Sacramento River and Steamboat Slough, and east to Old River Flats on the San Joaquin River.

Focus of Monitoring

Fish, shrimp, crabs, and related physical data at sampling locales.

Data Accessibility

Publicly accessible online: *http://www.iep.ca.gov/sf_bay_monitor/data.html*

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Study Details

(from Wim Kimmerer)

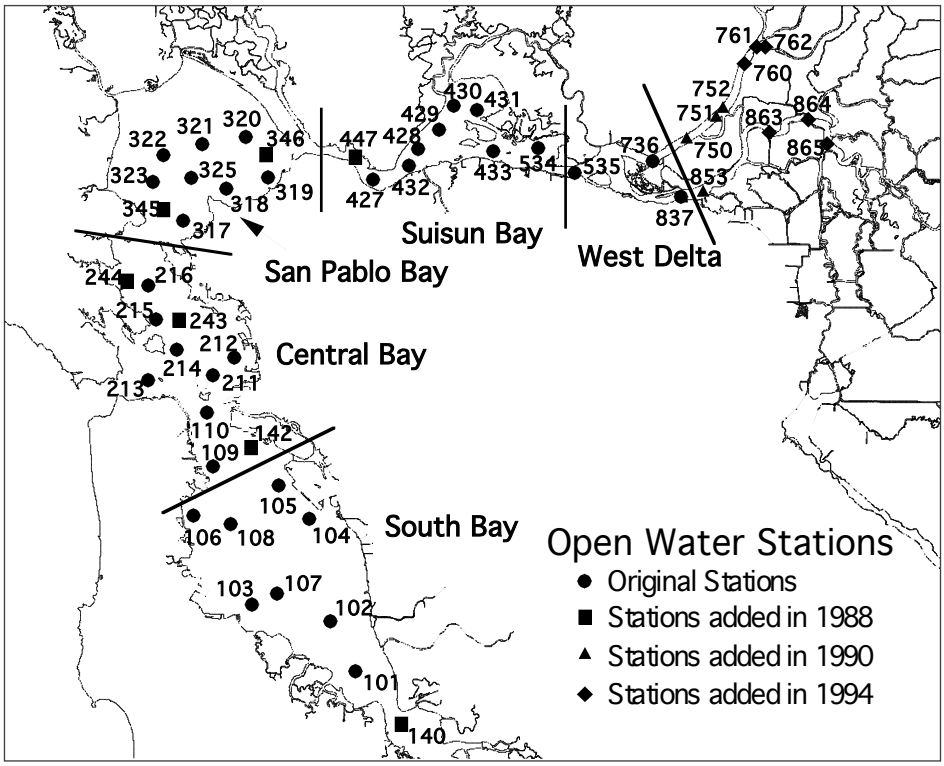
Since its inception, the Bay Study has sampled monthly every year, although in some years sampling was skipped in winter months. Data have been collected at 35 (historical) to 52

(current) stations throughout the estuary west of the central Sacramento-San Joaquin Delta. Samples have been taken with an otter trawl and midwater trawl and, in some years, a beach seine and a plankton net. Sampling methods have been consistent throughout the program, and some of the personnel have remained with the program for many years, ensuring continuity. The level of quality control in this program is high.

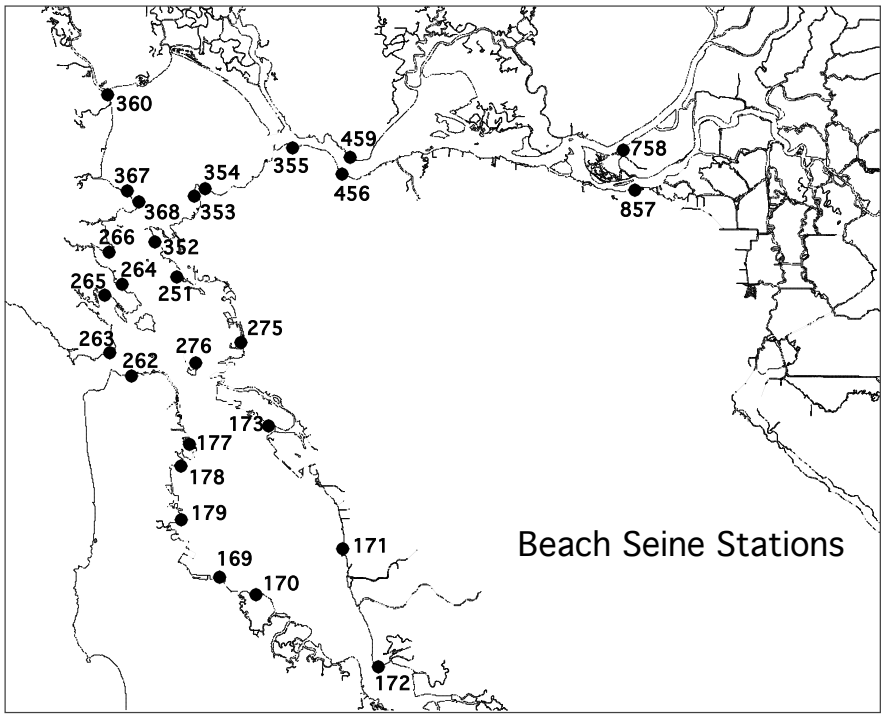
Other data sets are also available and may be valuable complements to the Bay Study data. The Summer Townet Survey is an annual survey in the Delta and Suisun Bay conducted every year since 1959. The Fall Midwater Trawl Survey has occurred in most years starting in 1967. This survey uses similar gear to the Bay Study but the sampling effort is concentrated from the delta through San Pablo Bay.

Other data that might be useful are: 1) IEP studies of phytoplankton, zooplankton, and water quality, which have received considerably more attention but are by no means completely understood (see section on IEP Environmental Monitoring Program); 2) monthly USGS transects up the axis of the estuary to measure chlorophyll and water quality variables; 3) various data sets from continuous monitoring stations for salinity and other variables; 4) hydrologic data sets, particularly the DAYFLOW accounting system for estimating daily freshwater flow into the estuary; 5) shorter-term studies of hydrodynamics, chemistry, and ecology of the estuary; and 6) fishery-dependent data, including historical data.

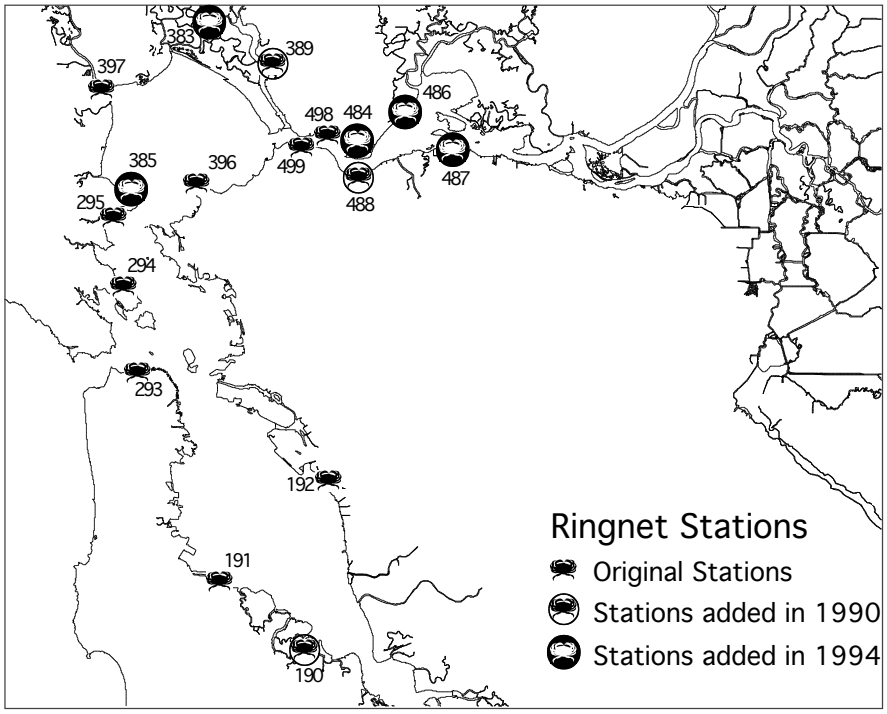
Boat (Open Water) sampling locations.



Beach seine sampling locations.



Ringnet sampling locations.



Further Information

http://www.iep.ca.gov/sf_bay_monitor/doc.html

United States Fish and Wildlife Service (USFWS) & USGS, Midwinter Waterfowl Surveys

Purpose

To identify winter waterfowl distribution and habitat use

Dates

1955 – Ongoing

Geographic Scope

The San Francisco Estuary is included in this nationwide annual survey

Focus of Monitoring

Waterfowl

Data Accessibility

Data from 1955 – 1999 are summarized in Appendix F of *Restoring the Estuary: An Implementation Strategy for the San Francisco Bay Joint Venture* (2001).

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Study Details

Midwinter aerial surveys are performed by USFWS personnel annual as part of a nationwide effort to provide a measure of the relative numbers or trends of duck populations. The USFWS collects the data using a repeatable protocol of standard transects. More intensive surveys were conducted in San Francisco Estuary (3 major embayments and salt ponds) over the winters of 1988-89 and 1989-90. This monitoring program has documented extensive use of the Bay by waterfowl.

Data summaries from Appendix F of *Restoring the Estuary: An Implementation Strategy for the San Francisco Bay Joint Venture* (2001).

Figure F-1:
Midwinter Indices for Scaup in the Pacific Flyway 1955–99

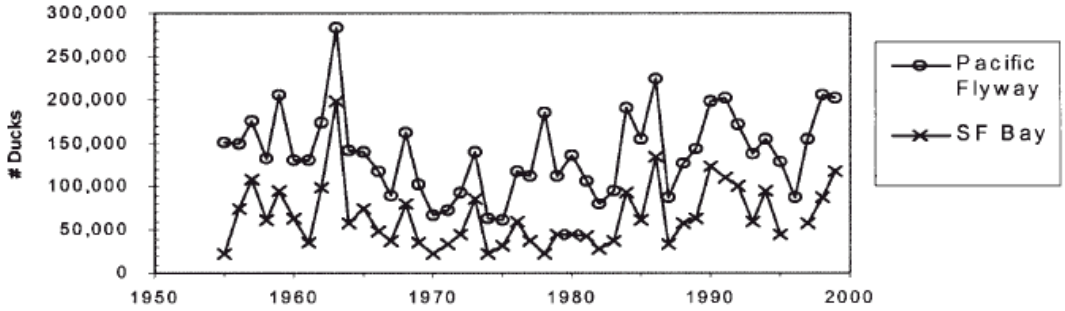


Figure F-2:
Midwinter Indices for Canvasbacks in the Pacific Flyway 1955–99

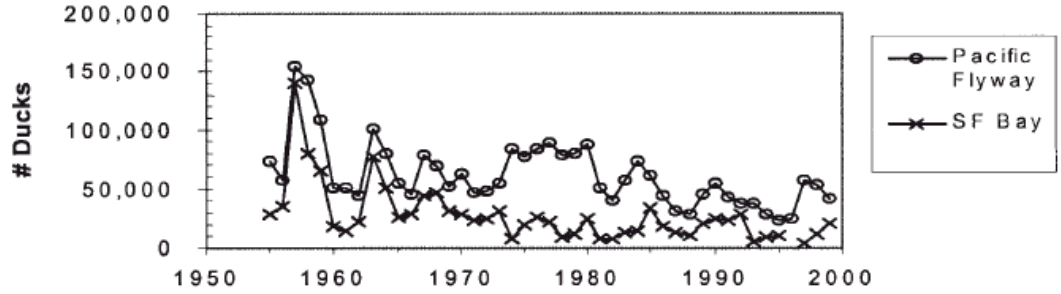
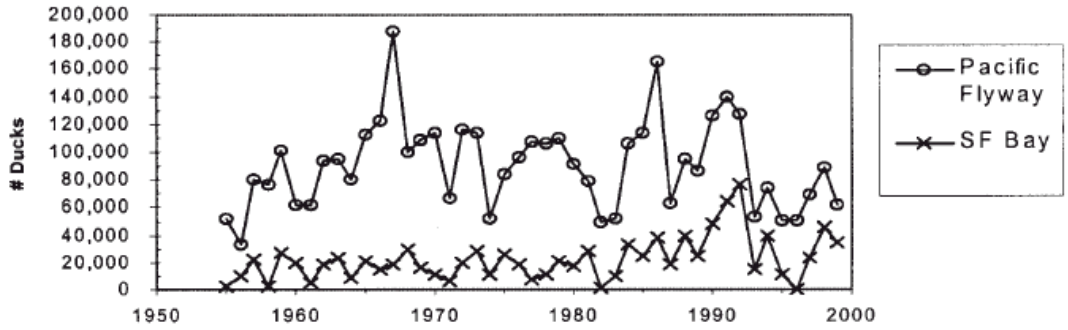


Figure F-3:
Midwinter Indices for Scoters in the Pacific Flyway 1955–99



Further Information

Findings from the surveys are summarized in Appendix C of *Restoring the Estuary: An Implementation Strategy for the San Francisco Bay Joint Venture* (2001).

Caveats regarding these data are discussed in Appendix F of *Restoring the Estuary: An Implementation Strategy for the San Francisco Bay Joint Venture* (2001).

United States Geological Survey (USGS), Priority Ecosystems Science Initiative (PES)

I. Science Support for Wetland Restoration in the Napa-Sonoma Salt Ponds

Purpose

To examine the ecological and hydrological function of the Napa-Sonoma salt ponds and their importance for waterbirds.

Dates

1999 - 2002

Geographic Scope

Napa-Sonoma salt ponds (see map below)

Focus of Monitoring

Primary productivity, plants, macroinvertebrates, fish, black-necked stilts

Data Accessibility

Not publicly accessible at this time.

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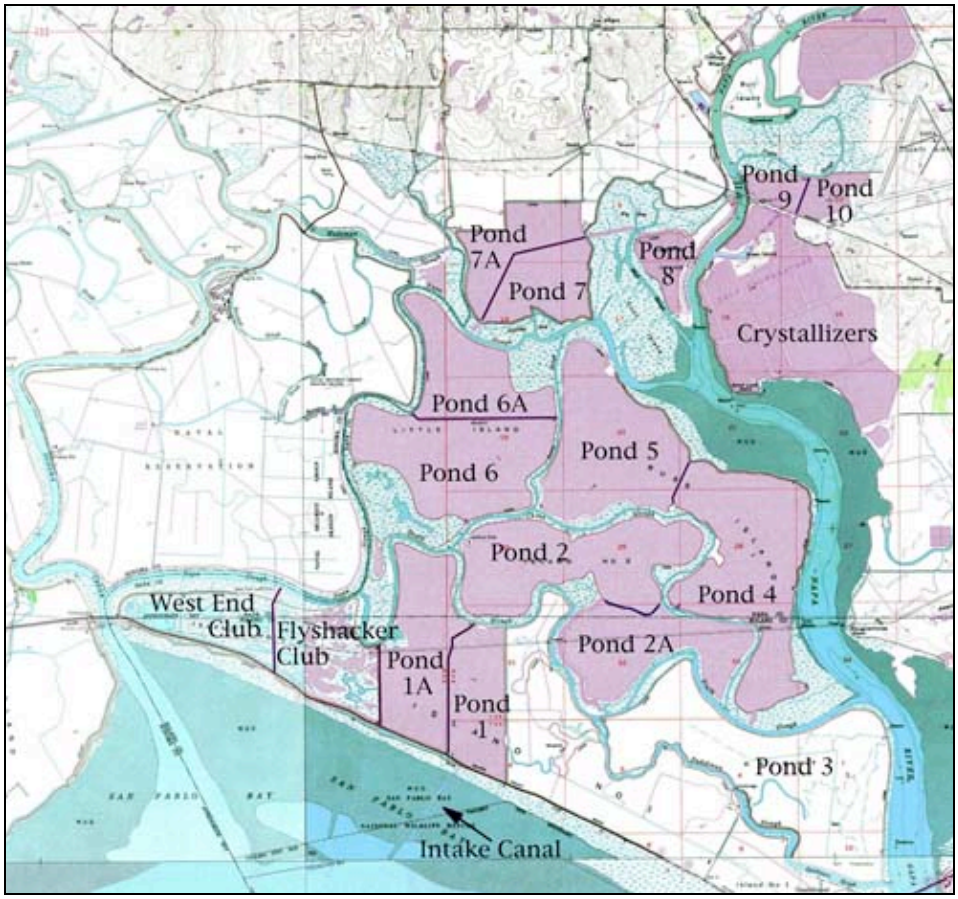
Study Details

The goal of this research project was to examine the ecological and hydrological function of the Napa-Sonoma salt ponds and their importance for waterbirds, including integrated studies on water quality, primary productivity, macroinvertebrates, plants, and fishes. During 3 years of

field work, we assessed nutrient concentrations, algal primary productivity, and zooplankton community composition in salt ponds of varying salinity ranging from 24 $g \cdot l^{-1}$ to 264 $g \cdot l^{-1}$ in relation to waterbird use. Specifically, black-necked stilts (*Himantopus mexicanus*) were radio-marked in order to determine their distribution, movements, and habitat use at the ponds. We also determined the ponds' importance as year-around habitats for forage fishes and as nurseries for larval or juvenile life stages, including fishes of recreational and commercial importance. In general, species diversity decreases with salinity, but the relationship between salinity and both biomass and species diversity followed quadratic relationships at upper trophic levels, probably because of superabundant invertebrate resources (*Artemia, Ephydra*) at the moderate hyperhaline range. We document that hyperhaline wetlands have unique trophic and physical attributes that in turn support large numbers of migratory birds. Some of the results of this work are in press in the journal Hydrobiologia, (*Salinity variation and trophic structure in salt evaporation ponds in the San Francisco Bay estuary* by Takekawa et al.). Monitoring is continuing on these ponds under a subcontract to CALFED.

Salt pond locations.



Further Information

http://sfbay.wr.usgs.gov/access/saltponds/index.html

II. Importance of South Bay Salt Ponds to Migratory Birds

Purpose

To determine trophic and hydrologic structure at selected South Bay salt ponds.

Dates

2002 – Ongoing

Geographic Scope

South Bay salt ponds

Focus of Monitoring

Primary productivity, invertebrate diversity, nutritive quality, and biomass; avian use and distribution

Data Accessibility

Not publicly accessible at this time.

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Study Details

Background

Projections for wetland restoration from a multi-agency team suggest that only a few hundred hectares of the more than ten thousand hectares of salt ponds throughout the estuary will likely remain during the next century. The remaining ponds probably will be converted or will return to tidal marsh once salt production is terminated. The potential implications of changes to the existing structure of ponds to the thousands of migratory birds that currently use them are unknown. Presently, we have a limited understanding of obligatory versus opportunistic use of the ponds by migratory birds. The prevailing consensus is to convert available land to tidal marsh to replace that lost to human encroachment. This consensus is driven largely by the concern for endangered species, but does not account for the possible obligatory use of salt ponds by migratory birds. A number of concerns face resource agencies responsible for managing or converting salt ponds to tidal marsh, e.g., lack of scientific guidelines for conversion or

management, deteriorating water-exchange capability, toxic hyper-saline water, levee integrity, invasive species, and so on.

Objectives

- Determine physical or water quality parameters that might influence structure of biota inhabiting south Bay salt ponds.
- Determine relationships between the hydrologic, morphologic, and biological components of the salt ponds.

Strategy and Approach

Our initial findings of the Napa-Sonoma salt ponds indicate significant avian use and conditions (e.g., habitat quality, prey abundance) that benefit migratory birds as well as unique invertebrate populations that are important forage for migratory birds. Salinity and depth seem to play an important role in invertebrate assemblage structure and subsequently avian use at different ponds. Pond 2A has breached levees that influenced heavily vegetated habitat. This pond supports far fewer migratory birds than the other ponds studied. A shortcoming of the Napa-Sonoma pond work was the inability to replicate sampling, i.e., each pond studied was physically and biologically unique. Study of salt ponds in other regions of the Bay might allow replication of North Bay research, and facilitate interpretation of results and inference derived from the Napa-Sonoma study.

Salinity and water surface elevation data collected monthly (February 1999 – present) on the Napa-Sonoma salt ponds are being used to calibrate a hydrological Salt Pond Box Model, known as SPOOM. SPOOM uses individual pond bathymetry, rainfall, evaporation, and water transfers to calculate daily pond volume and salinity values using the conservation of mass principle. Preliminary model outputs for ponds 3, 4, and 7 match the observed data reasonably well. The other ponds in the Napa-Sonoma salt pond complex are either tidally influenced, or were not sampled and are not being calibrated by the model. The effects of vertical mixing by wind waves on mixing and water quality of the ponds also are being evaluated.

Our continuing field efforts will focus primarily on 8 salt ponds in the South Bay that are or under USFWS management. The USFWS has very limited understanding of the ecology and physical dynamics of these ponds and requested assistance from USGS. Ponds A9 and A10 appear important for waterfowl, A9 and A14 important for shorebirds, and A11 – A13 apparently not as important. Trophic, geomorphic, and hydrologic study components will be combined to develop a conceptual model to provide a foundation for management or mitigation of these ponds and future wetland restoration in lieu of commercial salt pond operations. The SPOOM model will provide water and salt budgets for the ponds that will substantially aid interpretation of the ecological data, and eventual development of the conceptual model. These models also will be useful tools for other agencies planning restoration of the Napa and South Bay ponds.

We will use existing bird surveys and past and current data augmented with the proposed objectives to provide information needed by the USFWS to develop the best management decisions for South Bay salt ponds under their jurisdiction. We will help to identify those ponds and key habitat qualities that support highly diverse (abundance and species) avian communities with attention to avian species of concern, balanced with those ponds that likely might be converted to tidal marsh with the least impact of existing natural biological communities. We will continue limited monitoring of avian utilization and prey dynamics in the North Bay ponds that are subject to uncertain management regimes; such knowledge will increase our capability to predict changes at San Francisco Bay salt ponds. The goal of the continuing studies is to provide resource managers with a comprehensive assessment of the ecology of the San Francisco Bay salt ponds, such that optimal management strategies can be exercised that maximize benefits to wildlife.

Further Information

http://ca.water.usgs.gov/cgi-bin/influx/projectsapp.pl?preview=24

III. Ten Years of Continuous Suspended-Sediment Concentration Monitoring in San Francisco Bay and Delta

Purpose

To monitor the spatial and temporal variability of suspended sediment concentrations.

Dates

1991 – Ongoing

Geographic Scope

San Francisco Estuary (major embayments and the Delta)

Focus of Monitoring

Suspended sediment concentrations

Data Accessibility

Data are available on-line at http://sfbay.wr.usgs.gov/access/Fixed_sta/.

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Study Details

(From the abstract by David H. Schoellhamer, Paul A. Buchanan, and Neil K. Ganju. U.S. Geological Survey, Sacramento, CA. Turbidity and Other Sediment Surrogates Workshop, April 30 – May 2, 2002, Reno, NV)

Oceanographers began to commonly use optical sensors for measuring turbidity or suspended sediment concentration (SSC) in the 1980s on the continental shelf, in nearshore waters, and in estuaries. In December 1991, the U.S. Geological Survey (USGS) installed the first optical sensor for continuous monitoring of SSC in San Francisco Bay. Suspended sediment is an important component of San Francisco Bay and the tributary Sacramento-San Joaquin River Delta because it transports adsorbed toxic substances, provides habitat for benthic organisms, limits light availability and photosynthesis, contributes to wetland restoration, and deposits in ports and waterways that require dredging. In December 2001, SSC was monitored at 13 stations in the Bay and Delta. As of 2002, 159 sensor years of data have been collected, and the network is believed to provide the longest, continuous SSC time series collected in an estuary.

The SSC monitoring network is designed to capture the spatial and temporal variability of SSC. Stations were established in each major subembayment of San Francisco Bay and in the primary Delta channels. Bay stations originally were established in a deep channel (depth about 25 - 50 feet), often at salinity monitoring stations. Near-bottom and mid-depth optical sensors were deployed in the deep channel. In 1998 a shallow water station (mean lower low water depth about 6 feet) in San Pablo Bay was added to the network. Semidiurnal tides and lower-frequency tidal constituents drive temporal variability of SSC, so measurements are recorded every 15 minutes. In addition to the continuous monitoring network, we have deployed optical sensors at as many as 14 sites for periods of several months as part of focused studies of sediment transport in shallow subembayments and Bay locales of special interest.

Further Information

Project home page
USGS Technical Article
San Francisco Estuary and Watershed Science. 2004. Vol. 2, Issue 2, Article 1
Pulse of the Estuary 2003 (go to p. 21)

Point Reyes Bird Observatory (PRBO),

San Francisco Bay Tidal Marsh Project

Purpose

To assess population status and trends of tidal marsh bird species of concern.

Dates

1996 – Ongoing

Geographic Scope

San Francisco, San Pablo and Suisun Bays

Focus of Monitoring

Tidal marsh bird populations (Song Sparrows, Common Yellowthroats, Black Rails)

Data Accessibility

Data are not currently accessible online.

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Study Details

The tidal marsh bird project began in 1996 with funding from the USGS Species at Risk Program. The project seeks to assess population status and trends of the San Francisco Bay area tidal marsh bird species formerly listed as Category 2 candidates for Federal Endangered Species status and now considered Federal Special Concern species. These species are: Samuel's Song Sparrow (*Melospiza melodia samuelis*), Suisun Song Sparrow (*M. m. maxillaris*), Alameda Song Sparrow (*M. m. pusillula*), Salt Marsh Common Yellowthroat (*Geothlypis trichas sinuosa*) and California Black Rail (*Laterallus jamaicensis coturniculus*). The Black Rail is listed as a Threatened species by the State of California, while the rest are California Special Concern species. This study is the first to systematically examine the distribution and productivity of tidal marsh Song Sparrows and Common Yellowthroats on a long-term basis at a broad scale.

In addition, the project also seeks to model and predict the relative abundance and distribution of tidal marsh birds with respect to local habitat features, including vegetation and channel characteristics, as well as tidal marsh habitat configuration and surrounding landscape patterns. In recent years the project has made extensive use of GIS maps and spatial analysis.

Survey study sites for the passerine taxa include approximately 50 marshes and marsh fragments in the San Francisco Estuary (see map below). Of these, five were selected for intensive nest monitoring studies:

- San Pablo Bay: *China Camp State Park, San Rafael; Black John Slough, Novato; and the marsh outboard of Sonoma Baylands on the east side of the Petaluma River Mouth.*
- Suisun Bay: *Benicia State Park, Benicia; and Rush Ranch, Grizzly Island.*

For Black Rail studies, survey plots were selected independently, and correspond with sites selected for earlier studies of Black Rails. They include 26 marshes in San Pablo Bay, Suisun Bay and the outer coast (Tomales Bay, Bolinas Lagoon and Drake's Estero).

Methods

Point Count Surveys. Marshes are surveyed using the Variable Circular Plot point count method, which involves recording the distance of the detection from the observer. Vegetation within a 50m radius around each point count location is measured. Parameters include plant species, vegetation density and height and number and size of channels.

Nest Monitoring. Nest monitoring is conducted at each site in two subplots of at least 9 ha each. Nests are monitored at 2-4 day intervals and nestlings are banded with a unique color band combination 2 days before fledging. After nesting attempts are completed (nest failed or young fledged), measurements are taken of the nest substrate and within a 5m circular radius of the nest site.

Black Rail Surveys. Study areas are surveyed by broadcasting taped Black Rail calls. Elicited responses within 30 m are recorded and number of responses per listening station used to estimate a population density index.

Study sites for the songbird taxa.

Further Information

San Francisco Bay Tidal Marsh Project

Wetland Project Tracker

Purpose

To provide public access to information about wetland habitat projects in the San Francisco Bay Area.

Dates

2003 – Ongoing

Geographic Scope

San Francisco Bay (wetlands and mudflats within the historical limit of the tides from Carquinez Strait to Lower South Bay)

Focus of Monitoring

Wetland projects

Data Accessibility

An interactive map and list of projects with metadata are available at the Wetland Tracker web site: www.wetlandtracker.org

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Study Details

State and Federal regulatory review requires wetland projects to be monitored. Monitoring varies greatly between projects in terms of parameters monitored, methods, length of data records, access to data, etc. Some projects generate data that can contribute to a broader picture of condition.

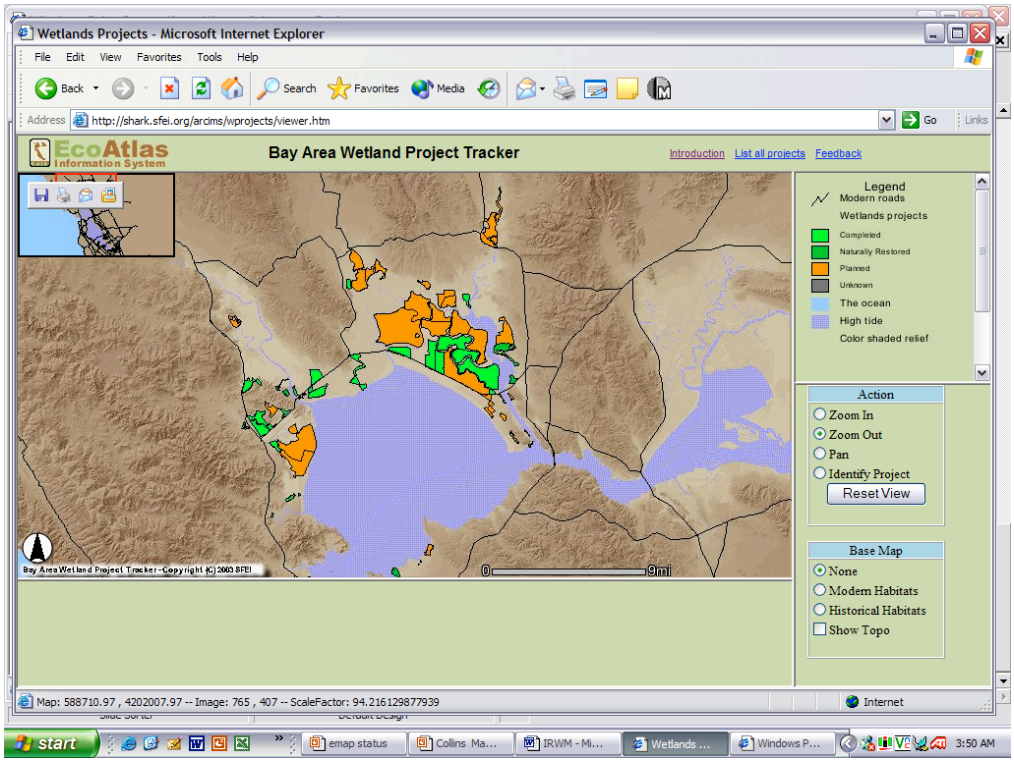
The Bay Area Wetland Project Tracker provides free public access to information about the location, size, sponsors, habitats, contact persons, and status of wetland restoration, mitigation, creation, and enhancement projects in the San Francisco Bay Area. Planned and completed wetland projects are displayed on an interactive regional map (see example below). Summary information is displayed alongside the map. More information is found on separate project information sheets. Each project can have files associated with it, such as reports, data,

photos, videos, other maps or commentary. Anyone can submit files with their browser and make them available for others to download. The current version of the Wetland Project Tracker uses US Geological Survey topographic maps and the Baylands maps of the Bay Area EcoAtlas as optional base maps. Additional base maps are being developed.

SFEI is now working with the National Wetlands Inventory of the US Fish and Wildlife Service to develop new maps of all the other kinds of wetland habitats in the Bay Area. This will allow us to expand the base map and project map to include all of the wetland projects in the region. The Wetland Project Tracker will grow over time as new projects are planned and constructed. SFEI is working with the San Francisco Bay Regional Water Quality Control Board and the San Francisco District of the US Army Corps of Engineers to develop a standard method for updating the map.

The current version of the Wetland Project Tracker was produced by the San Francisco Estuary Institute, Wetlands and Water Resources (WWR), and PRBO Conservation Science with funding to SFEI from the San Francisco Foundation, the San Francisco Estuary Project, the US Fish and Wildlife Service, and the US Environmental Protection Agency. It incorporates an earlier map of North Bay wetlands produced by WWR for CALFED.

Wetland projects of the North Bay, based on the Wetland Tracker of the Bay Area EcoAtlas Information System.



Projects shown in the above figure.

Project	Counties	Total area
American Canyon	Napa	623 acres
Edgerley Island Marina	Napa	9 acres
Huichica Creek Enhancement	Sonoma	106 acres
Napa River Flood Control	Napa	940 acres
Napa-Sonoma Salt Ponds Project	Napa	7322 acres
Petaluma Marsh Expansion	Marin, Sonoma	172 acres
Ringstrom Bay Enhancement	Sonoma	207 acres
SFO North Bay Project Area	Sonoma	5196 acres
Schellville	Sonoma	387 acres
Viansa Winery	Sonoma	94 acres
Bahia Lagoon	Marin	30 acres
Bel Marin Keys Unit 5	Marin	1564 acres
Green Point/Toy Marsh	Marin	57 acres
Hamilton Airfield	Marin	870 acres
Las Gallinas Ponds	Marin	68 acres
Marin Flood Control - Seasonal	Marin	343 acres
Marin Flood Control/CDFG - Perennial	Marin	309 acres
Miller Creek	Marin	12 acres
Novato Creek Antenna Field	Marin	134 acres
Novato Sanitary District	Marin	65 acres
Pacheco Pond	Marin	111 acres
Petaluma River Marsh	Sonoma	46 acres
Port Sonoma Marina Perimeter	Sonoma	9 acres
Rush Creek - Cemetery Marsh	Marin	272 acres
SFO North Bay Project Area	Sonoma	5196 acres
Scottsdale Marsh	Marin	46 acres
Simmons Slough Wildlife Corridor	Marin	186 acres
Sonoma Baylands	Sonoma	303 acres
Tolay Creek	Sonoma	306 acres

Tubbs Island Levee Setback	Sonoma	68 acres

Further Information

Wetland Tracker web site

SFBRWQCB, Wetland Ecological and Compliance Assessments

Purpose

To determine whether regulated wetland projects produce ecologically valuable systems and remain in compliance with their permits until project completion.

Dates

2003

Geographic Scope

San Francisco Bay Region (SWQCB Region 2)

Focus of Monitoring

Regulated wetland projects – vegetation, invertebrates, birds

Data Accessibility

A draft of the final report is available online, and a final version is published as below:

- Wetland Ecological and Compliance Assessments in the San Francisco Bay Region, California (Draft Final Report, August 1, 2003)
  (URL: http://www.swrcb.ca.gov/rwqcb2/download/wecareport0803.pdf)
- Breaux, A., S. Cochrane, J. Evens, M. Martindale, B. Pavlik, L. Suer, and D. Benner. 2005. Wetland Ecological and Compliance Assessments in the San Francisco Bay Region, California, USA. Journal of Environmental Management, 74:217-237.

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Study Details

The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) and the San Francisco District of the U.S. Army Corps of Engineers (U.S. ACOE) are looking for an expeditious means to determine whether regulated wetland projects produce ecologically

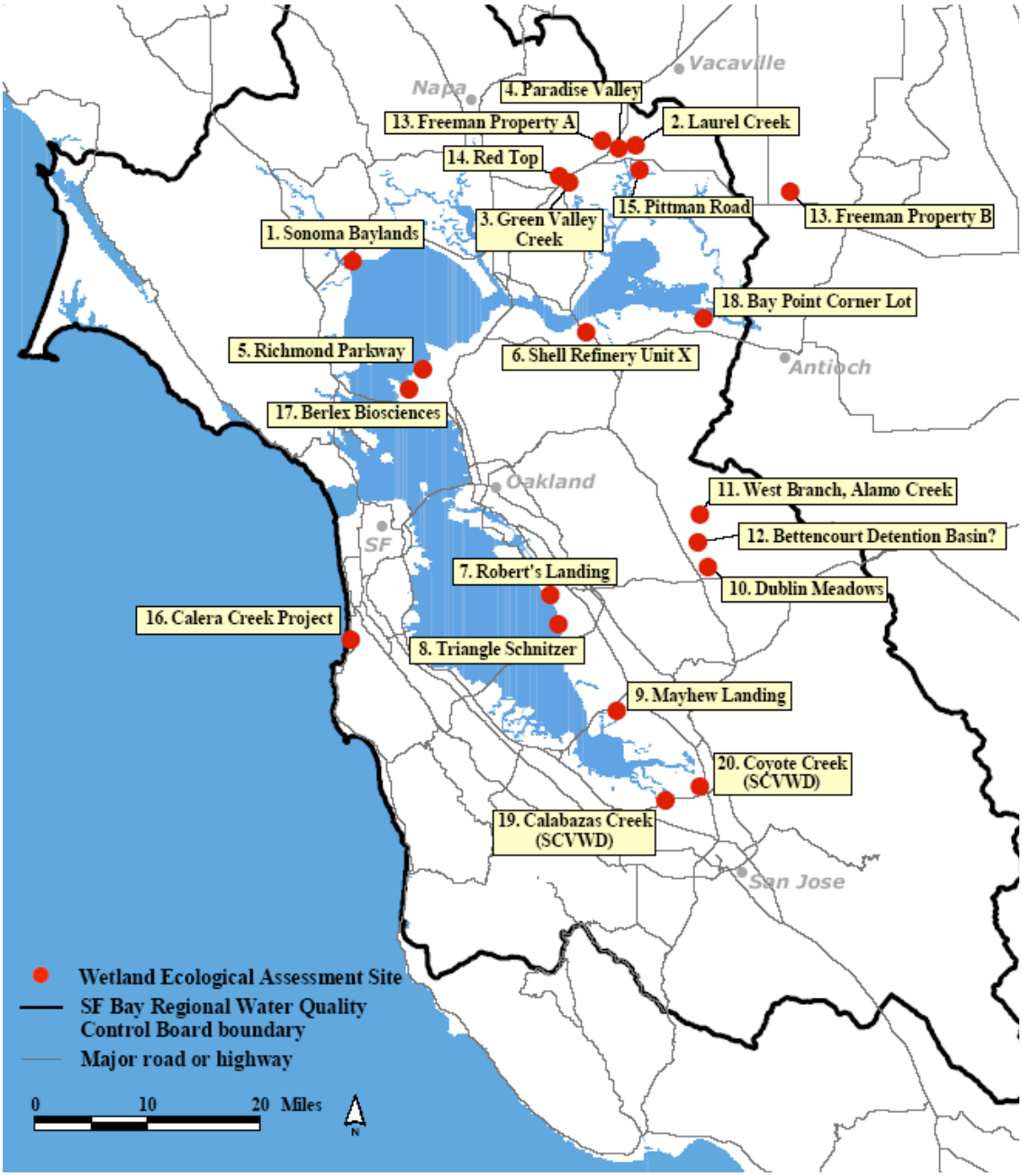
valuable systems and remain in compliance with their permits (i.e., fulfill their legal requirements) until project completion. A study was therefore undertaken in which twenty compensatory wetland mitigation projects in the San Francisco Bay Region were reviewed and assessed for both permit compliance and habitat function, and this was done using a rapid assessment method adapted for this purpose. Thus, in addition to determining compliance and function, a further goal of this study was to test the efficacy of the assessment method, which, if useful, could be applied not only to mitigation projects, but also to restoration projects and natural wetland systems. In addition to the State and Regional Water Boards, the results should prove useful to other state agencies such as the California Coastal Conservancy which is increasingly responsible for more and larger wetland acquisition and restoration projects.

Survey results suggest that most projects permitted five or more years ago are in compliance with their permit conditions and are realizing their intended habitat functions. The larger restoration sites or those situated between existing wetland sites tend to be more successful and to offer more benefits to wildlife than the smaller isolated ones. These results are consistent with regulatory experience suggesting that economies of scale could be realized both with (1) large scale regional wetland restoration sites, through which efforts are combined to control invasive species and share costs, and (2) coordinated efforts by regulatory agencies to track project information and to monitor the increasing number and size of mitigation and restoration sites.

Related Research

The State Water Board has a contract with UCLA Professor Richard Ambrose to study statewide 401 permit compliance on wetland compensatory mitigation and wetland functions assessment of mitigation sites. The results of this ongoing research are not yet available.

Map of wetlands projects assessed.



Further Information

Wetland Ecological and Compliance Assessments in the San Francisco Bay Region, California (Draft Final Report, August 1, 2003)

San Francisco Bay National Estuarine Research Reserve (SF Bay NERR)

Purpose

To promote integrated research, education, and stewardship programs in the San Francisco Estuary. Primary research foci include tidal marsh structure, function, and restoration and water quality monitoring.

Dates

27 August 2003 – Ongoing

Geographic Scope

San Francisco Estuary (2 sites: Rush Ranch and China Camp State Park)

Focus of Monitoring

Currently water quality; biomonitoring projects may also be established.

Data Accessibility

Data will be accessible at the NERR System-Wide Monitoring Program web site: http://cdmo.baruch.sc.edu/home.html. Please contact Dr. Drew Talley, SF Bay NERR Research Coordinator, for additional information at dtalley@sfsu.edu.

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Study Details

The National Estuarine Research Reserve system is a network of protected areas established for research, education and stewardship. The partnership program between the National Oceanic and Atmospheric Administration (NOAA) and the coastal states protects more than one million acres of estuarine land and water. The NERR sites provide essential habitat for

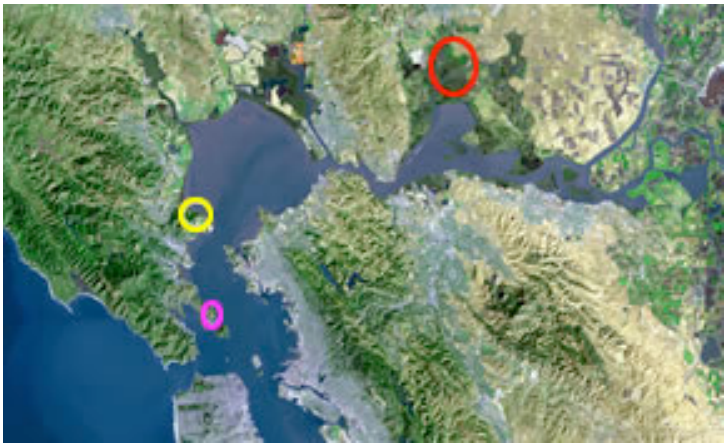
wildlife, offer education opportunities for students, teachers, and the public, and serve as living laboratories for scientists.

The SF Bay NERR is a partnership among NOAA, San Francisco State University, California State Parks, the Solano Land Trust, and the Bay Conservation and Development Commission. The 3,710 acres that comprise the SF Bay NERR include some of the highest quality remaining historical wetland and adjacent habitats in two large bays of the estuary: Suisun Bay (Rush Ranch site) and San Pablo Bay (China Camp site). Collectively the sites represent approximately 7 percent of the historic tidal marsh left in the San Francisco estuary. Both sites are also unique in that the surrounding uplands are undeveloped, providing an intact watershed in which to study tidal marsh systems in the Bay Area. The ecological value of these sites, coupled with the monitoring, research and education programs sponsored by the NERR System, create an opportunity for agencies to direct research priorities and benefit from scientific studies addressing key issues in the bay area.

The effectiveness of restoration can only be measured relative to the remaining relict tidal wetlands, such as those found within the SF Bay NERR. Thus, the two reserve sites are frequently used as reference sites against which enhanced, restored, or created wetlands are evaluated

Additionally, as part of the NERR system, the SF Bay NERR is participating in the System-Wide Monitoring Program (SWMP). The purpose of this nation-wide monitoring effort is to track long- and short-term variability in ecosystem processes to support effective coastal zone management decisions. As part of SWMP, permanent water quality monitoring stations will be established within the SF Bay NERR sites, with two at China Camp and two at Rush Ranch (within the Suisun marsh) initially. These stations record water temperature, specific conductivity, salinity, dissolved oxygen, depth, pH, and turbidity every fifteen minutes. Additional water samples are collected bi-monthly, and the levels of inorganic nitrogen, chlorophyll a, and phosphorous are determined. Data from these monitoring stations are available for scientists and coastal decision makers. Biomonitoring projects, such as crab population surveys and submerged aquatic vegetation monitoring, may also be established.

Key locations for the SF Bay NERR are the reserve sites at China Camp State Park near San Rafael in Marin County (yellow circle) and Rush Ranch Open Space Preserve near Fairfield and Suisun City in Solano County (red circle), and the administrative headquarters of the SF Bay NERR which are located at San Francisco State's Romberg Tiburon Center on the Tiburon peninsula in Marin County (pink circle).



Further Information

SFB NERR web site

California Bay-Delta Authority Fish Mercury Pilot Program

Purpose

To develop a pilot program for monitoring, stakeholder involvement, and risk communication relating to mercury in fish in the Bay-Delta watershed.

Dates

2005 – 2007

Geographic Scope

San Francisco Estuary and its watershed

Focus of Monitoring

Fish mercury contamination

Data Accessibility

Data have not yet been collected.

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Study Details

(Adapted from Issue 1 of the San Francisco Bay Mercury News, 2004.)

In August 2004, the Board of Directors for the California Bay-Delta Authority approved funding of a $4.5 million proposal to monitor mercury in fish in the Bay-Delta watershed, establish an organizational structure to allow stakeholder input on the monitoring, and conduct risk assessment and risk communication activities to raise public awareness about fish contamination issues with the goal of reducing human exposure to methylmercury in the watershed. Partners in this project include SFEI, UC Davis, Moss Landing Marine Lab, the California Department of Health Services, and the California Office of Environmental Health Hazard Assessment. This project will include monitoring of 1) sport fish to characterize human

exposure and spatial patterns and 2) small fish as an indicator of temporal and spatial patterns and exposure of piscivorous wildlife. The sampling will include trend monitoring sites, screening of areas in the watershed that have not recently been sampled, and monitoring of restoration projects. Availability of the funds is anticipated in early 2005. As soon as funds are available, a Steering Committee will be formed to guide the design of the monitoring program. Sampling will begin in summer of 2005.

Further Information

San Francisco Bay Mercury News, Vol. 1, No. 1, 2004

Vegetation Classification and Mapping Program (VegCAMP)

Purpose

To facilitate and oversee efforts to develop accurate and scientifically defensible maps and classifications of vegetation and/or habitat throughout the state.

Dates

2003 – Ongoing

Geographic Scope

California

Focus of Monitoring

Vegetation

Data Accessibility

Data are not currently available online. In the near future, data should be available from the California Vegetation Information System.

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Study Details

Program Overview

Vegetation is often considered to be the best single surrogate for habitat and ecosystems. Vegetation science has thus played an increasing role in wildlife and natural lands conservation and management over the years and is now among the principal tools involved in wildlands management and planning.

The Vegetation Classification and Mapping Program (VegCAMP) facilitates and oversees efforts to develop accurate and scientifically defensible maps and classifications of vegetation and/or habitat throughout the state. We do this in the effort to support conservation and management decisions at the local, regional and state level. Virtually all such efforts require

a map and concomitant classification of vegetation and habitats to help drive planning and long-range management processes. VegCAMP works with many branches of local and state-wide agencies and organizations involved with such efforts to help ensure the best, most effective methods to accomplish such work (for example, see link to the vegetation MOU committee below).

This program is a new one, formed in the spring of 2003 and has evolved from previous programs within WHDAB including the Natural Communities program within the California Natural Diversity Database and the Significant Natural Areas Program. VegCAMP is a synthesis of these two previous programs that enables more focused effort on developing and maintaining the maps and classification of all vegetation and habitats in the state. The staff at VegCAMP are professional ecologists with training in landscape, vegetation, plant, and animal ecology.

The principal roles of the program include:

- Developing and maintaining a standardized vegetation classification system for California
- Developing best methods of vegetation assessment including sampling, analyzing, reporting, and mapping vegetation at multiple scales
- Training resource professionals on these techniques and coordinating with other agencies and organizations to ensure a statewide, standardized approach toward collecting, reporting, and interpreting vegetation data
- Developing best practices for using these data for long-range conservation and management of natural lands in the state
- Conducting integrated vegetation assessments throughout the state in areas with high conservation and management interest to the Department of Fish and Game and other agencies
- Archiving and distributing quality vegetation data to all who need it
- Coordinating with other state, federal, and local agencies and organizations involved in vegetation assessment
- Integrating vegetation assessment with single species and habitat assessment for unified conservation assessments

Long-range goals of the program include:

- Completing and maintaining a state-wide vegetation map and classification in collaboration with other agencies and organizations
- Developing the most appropriate vegetation products for conservation planning and natural resources management within the state
- Integrating the program with similar ones from other states and countries to facilitate national and international conservation and management of natural resources

Be on the lookout in the near future for links on our web site with The California Vegetation Information System, an on-line database of vegetation sampling data useful for determining actual plant species composition, vegetation structure, and environmental data from

thousands of points throughout the state. Also upcoming: information on specific vegetation mapping projects and on-line reports and descriptions of vegetation.

Mapping San Francisco Bay-Delta Marshes

(From the IEP Suisun Marsh web site)

DWR and USBR have funded DFG to conduct triennial vegetation surveys in Suisun Marsh since the early 1980's. The primary purpose of the original surveys was to determine the amount of salt marsh harvest mouse habitat (pickleweed) in Suisun and monitor percent change over the years. In 1999, at the request of the Suisun Marsh Preservation Agreement agencies, DFG's Wildlfe Habitat and Analysis Branch developed a revised protocol and conducted vegetation mapping in the Suisun Marsh, This new protocol blends ground-based classification, aerial photo interpretation, and GIS editing and processing. The product of this effort is a GIS map identifying 103 vegetation classifications in Suisun. This information is currently be used for monitoring and project planning purposes. Change detection analysis will be conducted in the future to determine vegetation changes in Suisun.

Mapping of wetlands in the Sacramento-San Joaquin Delta is currently underway.

Further Information

VegCAMP homepage
IEP Suisun Marsh facts web page

California Rapid Assessment Method (CRAM)

Purpose

To assess the status and trends of the wetland ecosystems, measure the progress and effects of wetland projects, assess the efficacy of management actions, and otherwise account for the public investment in wetlands.

Dates

2002 – Ongoing

Geographic Scope

California

Focus of Monitoring

Wetland condition and stressors

Data Accessibility

This program is in development, and data are not yet available.

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Study Details

Background

In 2001, the National Research Council (NRC) reported on the status of wetland mitigation and monitoring in the report "Compensating for Wetland Losses under the Clean Water Act." The NRC report calls for replacing the current procedures of assessing wetlands with "science-based, rapid assessment procedures." More recently, a National Wetland Mitigation Action Plan and a related US Army Corps of Engineers Regulatory Guidance Letter have been issued which call for improvements in wetland monitoring, project tracking, and follow-through in evaluating compensatory mitigation. At the state level, Water Quality Control

Boards have initiated project oversight efforts to improve wetland mitigation. The development of a robust rapid assessment tool can help in all of these endeavors.

Structure

The technical framework for the California Rapid Assessment Method consists of three levels, and stems from EPA's general approach to comprehensive wetland monitoring, which is being applied in other states across the nation. Each level supports the other, as briefly described below.

Landscape Assessment (Level 1) uses remote sensing data and field surveys to inventory the wetlands of a region. A new statewide inventory is being produced by the USFWS through the California State Resources Agency.

Rapid Assessment (Level 2) uses field diagnostics and existing data to assess conditions at wetland sites. States developing or implementing Level 2 include Ohio, Pennsylvania, Delaware, Massachusetts, Washington, and California. In California, the Level 2 work is called CRAM (the California Rapid Assessment Method).

Intensive Site Assessment (Level 3) provides the field data necessary to validate the CRAM, characterizes reference condition, and tests hypotheses about the causes of wetland conditions as observed through Levels 1 and 2.

CRAM is being developed collaboratively by Regional Teams with oversight by a statewide Core Team of Federal and State agency representatives and academic researchers. The Regional Teams work together to make sure that CRAM reflects regional variation in wetland nature. The Core Team provides technical review and helps assure the relevance of CRAM to State and Federal wetland policies and programs.

Applications of CRAM

CRAM is being developed primarily as a rapid assessment tool to provide information about the condition of a wetland and the stressors that affect that wetland. CRAM is mainly intended for cost-effective ambient monitoring and assessment that can be performed on different scales, ranging from an individual wetland, to a watershed, or a larger region. Over time, wetland managers and scientists can develop a picture of reference condition for a particular wetland class or create a landscape-level profile of the condition of different wetlands within a region of interest. This information can then be used in planning wetland protection and restoration activities. Rapid methods of evaluating wetlands in use in Ohio and other states focus on assessing wetland condition in the context of human disturbances (or stressors) and valued ecosystem functions.

Our effort centers around the following three key objectives for the development of the California Rapid Assessment Method:

- Produce a rapid, cost-effective, science-based, repeatable method to evaluate wetland projects and sites relative to ambient conditions, reference conditions, and performance standards;

- Enable wetland managers to report on the overall distribution, abundance, and condition of wetlands within watersheds, regions, or across the state, based on routine summaries of assessment scores;
- Help wetland managers identify corrective measures to improve the conditions of wetlands.

Additional applications could include: (1) *preliminary assessments* to determine the need for more traditional intensive analysis or monitoring, (2) *providing supplemental information* during the evaluation of wetland condition to aid in regulatory review under Section 401 and 404 of the Clean Water Act, the Coastal Zone Management Act, Section 1600 of the Fish and Game code, or local government wetland regulations, and (3) *assisting in the monitoring and assessment* of restoration or mitigation projects by providing a rapid means of checking progress along a particular restoration trajectory. CRAM is not intended to replace any existing tools or approaches to monitoring or assessment, and will be used at the discretion of each individual agency to complement existing approaches.

Developing the Method

A major aspect of CRAM development is the selection and field testing of visible indicators of conditions that can be used to diagnose the level of beneficial uses or desired functions of a wetland, and to help identify corrective measures for impaired wetlands. Once the complete set of indicators has been chosen, CRAM development will involve 3 basic analytical steps for each major class of wetland: (1) *semi-quantitative verification* of the metrics based on best professional judgment of their suitability to describe wetland conditions in each region; (2) *quantitative calibration* using existing data to test for correlation between the metrics and levels of the highest priority functions in each region; and (3) *validation* based on comparisons between CRAM results and intensive site studies (level 3) at sites that collectively represent one or more stressor gradients. The CRAM will be based on readily visible conditions that indicate functional levels of support for high-priority beneficial uses and ecological services. In general, CRAM is being developed with the basic premise that a wetland is in good condition when its structure and form are unimpaired by stresses induced by human activity, such that the wetland's native biological diversity and supporting processes are likely to persist. Current funding from the US EPA supports CRAM development, and additional funding is being sought for implementation.

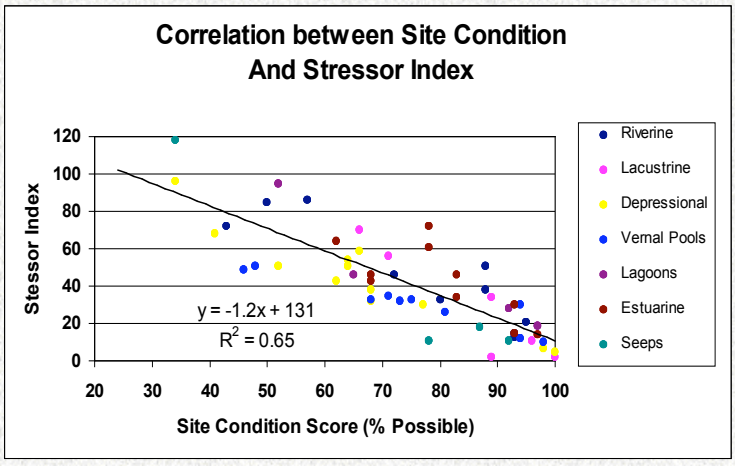
Example sample size of a regional verification effort. The distribution of CRAM development among wetland types reflects their relative abundance within a region.

Number of Verification Sites

Wetland Class	A Priori Classification of Wetland Sites			
	High Quality	Med. Quality	Low Quality	Total
Riverine	10	9	7	26
Depressional	8	12	13	33
Vernal Pools	(5)	(5)	(2)	(12)
Lacustrine	4	5	7	16
Lagoons	2	3	8	13
Estuarine	8	8	5	21
Seeps and Springs	5	3	1	9
Total	37	40	41	118

Example of correlation between stressor and wetland condition. Condition decreases with stress for each type of wetland.

Does Condition Relate to Stress?



Further Information

CRAM documents

Environmental Monitoring and Assessment Program (EMAP) - West

Purpose

To generate state and regional scale assessments of the condition of ecological resources in the western United States, and to identify stressors associated with the degradation of these resources.

Dates

1999 – 2005

Geographic Scope

EPA Regions 8, 9, and 10 (western USA)

Focus of Monitoring

Water, sediment, invertebrates, fish, habitat condition

Data Accessibility

Data from some EMAP components are available on-line

- http://www.epa.gov/emap/html/data.html

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Study Details

The U.S. Environmental Protection Agency created the Environmental Monitoring and Assessment Program (EMAP) to develop tools necessary to monitor and assess the status and trends of national ecological resources. The primary goal of the EMAP Western Pilot Study is to generate state and regional scale assessments of the condition of ecological resources in the western United States, and to identify stressors associated with the degradation of these resources. Beginning in 1999, EMAP is embarking on a five-year effort to demonstrate the application of core monitoring and assessment tools across a large geographical area of the western United States. The EMAP Western Pilot will encompass the states of EPA Regions 8, 9

and 10 (i.e., Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming).

EPA Region 9 Projects for Western EMAP

EMAP Western Pilot Study assessment efforts include three core components: coastal (estuaries and offshore waters), surface waters (streams and rivers) and landscapes. A probability-based sampling approach will be used to monitor the ecological condition of coastal and surface waters. The landscapes component will make use of remotely sensed imagery and utilize a census approach. All three components will produce regional-scale assessments of ecological condition. The coastal watersheds in Northern and Southern California are two special focus areas in Region 9 that have been selected for more intensive monitoring and assessment.

Coastal Waters

The overall objective of the coastal portion of the EMAP Western Pilot Study is to assess the ecological condition of estuarine and offshore waters of the Pacific Coast States (including Alaska and Hawaii). This will be accomplished by monitoring water column quality, sediment chemistry and toxicity, and benthic invertebrate and fish community structure. In Region 9, we are coordinating our efforts with the States of California and Hawaii.

Surface Waters

Perennial rivers and streams will be monitored for indicators of pollutant exposure and habitat condition in Arizona, California and Nevada. These indicators include aquatic macroinvertebrate, fish and periphyton assemblages, water quality, physical habitat structure and riparian condition. In Region 9, we are coordinating our efforts with the States of Arizona, California, Nevada, and affected tribes.

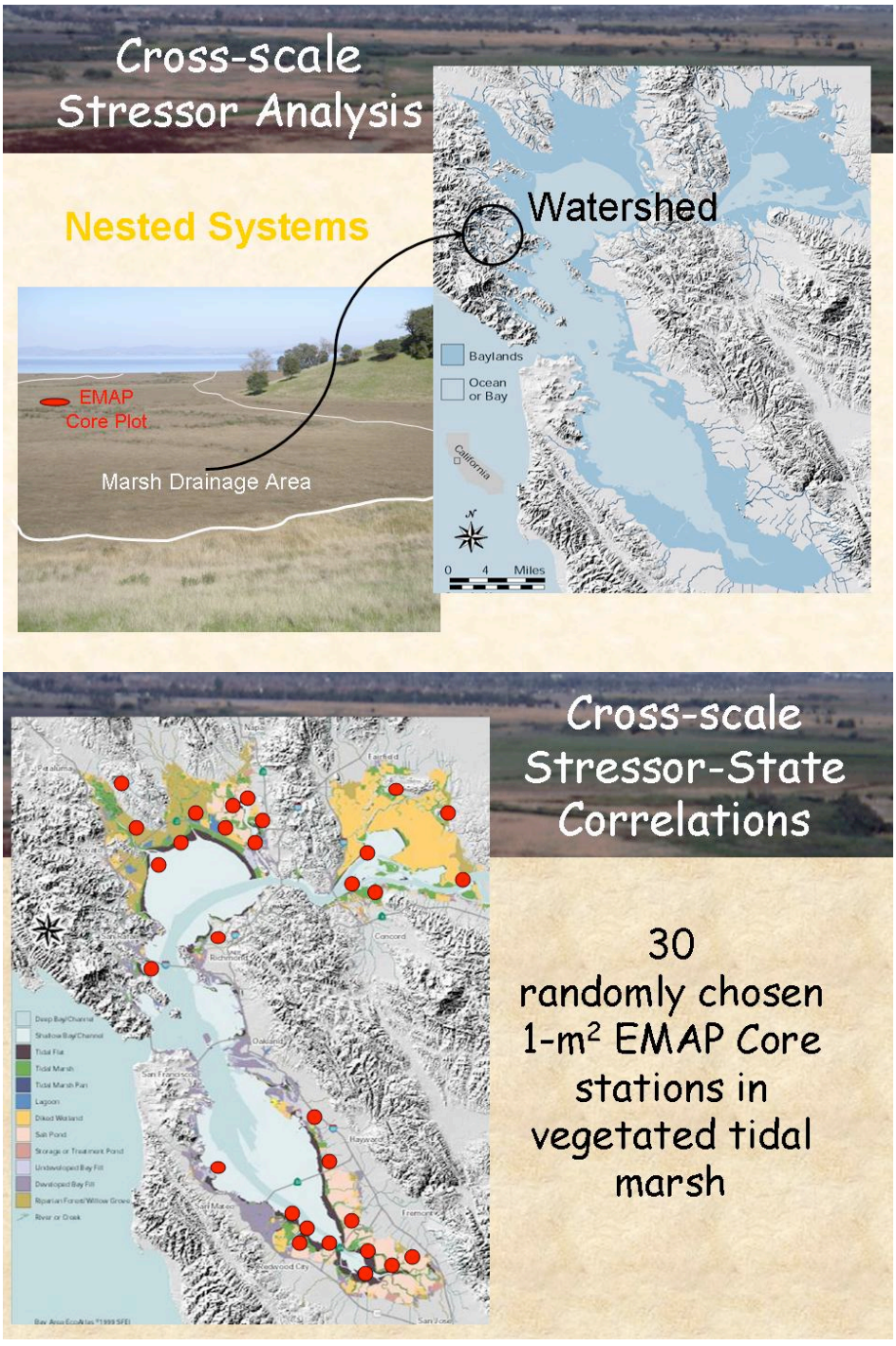
Landscapes

Landscape conditions will be assessed using a variety of indicators generated in a Geographic Information System (GIS) from spatial data derived from satellite imagery and other data sources. Results of the assessment should help environmental managers target those areas where aquatic resource conditions appear most vulnerable to impairment based on watershed-scale, landscape conditions. We anticipate collaboration with U.S. Geological Survey, U.S. Forest Service, Natural Resources Conservation Service and Bureau of Land Management.

Wetlands Intensification Project

In 2002, EMAP - Estuaries focused on tidal marshes and flats, with data intensification in the Southern California Bight and San Francisco Bay. The Intensification Projects tested correlations between stressors and marsh condition across scales from square-meter plots to watersheds.

Graphics from the prospectus of the wetlands tidal marsh project, which comprised a portion of the coastal intensification for San Francisco Bay.



Further Information

[EMAP homepage]
[EMAP-West homepage]

SFBRWQCB, Water Quality

Monitoring Programs

Purpose

To monitor the quality of water in Region 2 of the State Water Resources Control Board.

Dates

Ongoing

Geographic Scope

The San Francisco Estuary and local watersheds (9 counties: San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Solano, Napa, Sonoma, Marin)

Focus of Monitoring

Water, sediment, and bivalves

Data Accessibility

Data for certain programs are available on the Region 2 website:

- State Mussel Watch Program / Toxic Substance Monitoring Program Data
- Bay Protection and Toxic Cleanup Program Data

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Study Details

State Mussel Watch and Toxic Substances Monitoring Programs

In 1976, the state initiated the State Mussel Watch and State Toxic Substances Monitoring Programs to regularly monitor the concentration of pollutants in the tissue of aquatic organisms. Tissue levels reflect exposure over much longer periods of time than instantaneous water column samples and provide a field-based estimate for exposure of people, fish, and wildlife to pollutants in the food chain. The Mussel Watch Program uses resident and transplanted bivalves to monitor pollutant levels at coastal reference stations and selected sites in bays and estuaries to confirm potential toxic substance pollution. Periodic monitoring of bivalve

tissue conducted by the National Mussel Watch administered by the National Oceanic and Atmospheric Association (NOAA) and international surveys complements information from the State Mussel Watch Program.

Ground Water Monitoring Networks

Groundwater monitoring networks are established in several basins in the region. At present, there are networks in Livermore Valley, Niles Cone, Santa Clara Valley, Half Moon Bay Terrace, and Napa Valley. In addition, the U.S. Geological Survey and state Department of Water Resources maintain regional monitoring networks. Typically, monitoring is conducted at least annually for general mineral quality and water levels. This well data may be of use to determine the general potability of groundwater and the status of sea water intrusion control. The Regional Board is integrating the locations of monitoring well networks into its groundwater geographic information system. The water quality data generated from the networks will assist Regional Board staff in the refinement of beneficial use designations for groundwater basins.

Compliance Monitoring

A second component of the state's water quality surveillance and monitoring program relates specifically to discharges of pollutants at individual point and non-point sources. All entities holding Regional Board discharge permits must conduct regular sampling and analysis of waste released to surface and ground water. They must also analyze material to be dredged. The specific chemical and physical parameters, types (i.e., toxicity tests, bioaccumulation studies, waste stream sampling, etc.), frequency, and other information requirements are determined on a case-by-case basis according to the nature of the discharge and potential environmental effects. Each permit issued by the Regional Board describes the specific compliance monitoring requirements for that permit holder. Self-monitoring data are often supplemented by information obtained by Regional Board staff during site inspections (including waste analyses) and through special studies, such as those characterizing the variability of the discharge, pollutant levels in nearby receiving water and biota, and characterization of pollutant loads attributable to urban runoff.

Biennial Water Quality Inventory

The Regional Board prepares a biennial report on water quality (as required under Section 305(b) of the Clean Water Act, PL 92-500). This report includes: (a) a description of the water quality of major navigable waters in the state during the preceding years; (b) an analysis of the extent to which significant navigable waters provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife and allow recreational activities in and on the water; (c) an analysis of the extent to which elimination of the discharge of pollutants is being employed or will be needed; and (d) an estimate of the environmental impact and the economic and social costs necessary to achieve the "no discharge" objective of PL 92-500, the economic and social benefits of such achievement, and an estimate of the date of such achievement. Recommendations as to the programs that must be undertaken are provided, along with estimates of the cost.

Other Monitoring Programs

In addition to the state's surveillance and monitoring program, several other agencies in the Bay Area monitor water quality, including local city and county offices, federal agencies, and water supply districts. Local universities also conduct research and monitoring activities.

Further Information

SFBRWQCB Basin Plan web site

Surface Water Ambient Monitoring Program (SWAMP)

California Environmental Protection Agency
SAN FRANCISCO BAY REGIONAL WATER QUALITY CONTROL BOARD

Purpose

To assess the conditions of surface waters throughout the state of California.

Dates

2000 – Ongoing

Geographic Scope

California

Focus of Monitoring

Water, sediment, benthos, animal tissues.

Data Accessibility

A database is being constructed and should be accessible by the end of 2005.

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Study Details

The Surface Water Ambient Monitoring Program (SWAMP) is a statewide monitoring effort designed to assess the conditions of surface waters throughout the state of California. The program is administered by the SWRCB. Responsibility for implementation of monitoring activities resides with the nine RWQCB's that have jurisdiction over their specific geographical areas of the state. SWAMP also hopes to capture monitoring information collected under other State and Regional Board Programs such as the State's TMDL (Total Maximum Daily Load), Nonpoint Source, and Watershed Project Support programs when funding allows. SWAMP does not conduct effluent or discharge monitoring which is covered under National Pollutant Discharge Elimination System (NPDES) permits and Waste Discharge Requirements (WDR). The following existing surface water monitoring programs have been included as part of

SWAMP: State Mussel Watch, Toxic Substance Monitoring Program, Toxicity Testing Program, and Coastal Fish Contamination Program.

Steps are being taken to ensure that high quality data is produced by SWAMP efforts statewide. The SWAMP Quality Assurance and Quality Control Project Plan (QAPP) can be found at: http://www.swrcb.ca.gov/swamp/qapp.html. This QAPP is being used as the statewide standard for all surface water monitoring conducted under various State grant programs.

A database currently under development will serve as a central repository of all data collected by SWAMP. All data will eventually be fed to STORET, managed by the U.S. Environmental Protection Agency.

The goal of the SWAMP funded program in the San Francisco Bay Region is to monitor and assess water quality in all of the watersheds in the region to determine whether beneficial uses are protected. Specific objectives are as follows:

1. Measure environmental stressors (pollutants or other water quality parameters), biological effects (e.g., toxicity tests), and ecological indicators (e.g., benthic community analysis) to evaluate whether beneficial uses are being protected.
2. Use a design that allows for evaluation of spatial and temporal trends in the watersheds of the region.
3. Identify minimally disturbed reference conditions.
4. Determine if impacts are associated with specific land uses and/or water management.
5. Use standard sampling protocols, SWAMP QAPP procedures and the SWAMP database to provide statewide consistency and availability of data.
6. Evaluate monitoring tools in watersheds in order to develop a program that uses the best environmental indicators to achieve the goal of the program.
7. Generate data and associated information for the development of indices to evaluate ecological indicators (e.g., IBIs for macroinvertebrates).
8. Use a rotating watershed approach to collect data in each hydrologic unit at least once every 5 years.

Further Information

SWAMP homepage

Interagency Ecological Program (IEP),

Environmental Monitoring Program (EMP)

Purpose

To provide necessary information for compliance with flow-related water quality standards specified in the water right permits.

Dates

1971 – Ongoing

Geographic Scope

San Pablo and Suisun Bays, Sacramento-San Joaquin Delta

Focus of Monitoring

Water, plankton, benthos

Data Accessibility

Publicly accessible online:

- Discrete sample data – http://bdat.ca.gov/
- Continuous data – http://iep.water.ca.gov/dss/, http://cdec.water.ca.gov/, or http://bdat.ca.gov/

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Study Details

The Environmental Monitoring Program (EMP) for the Sacramento-San Joaquin Delta, Suisun Bay, and San Pablo Bay is conducted under the auspices of the Interagency Ecological Program (IEP).

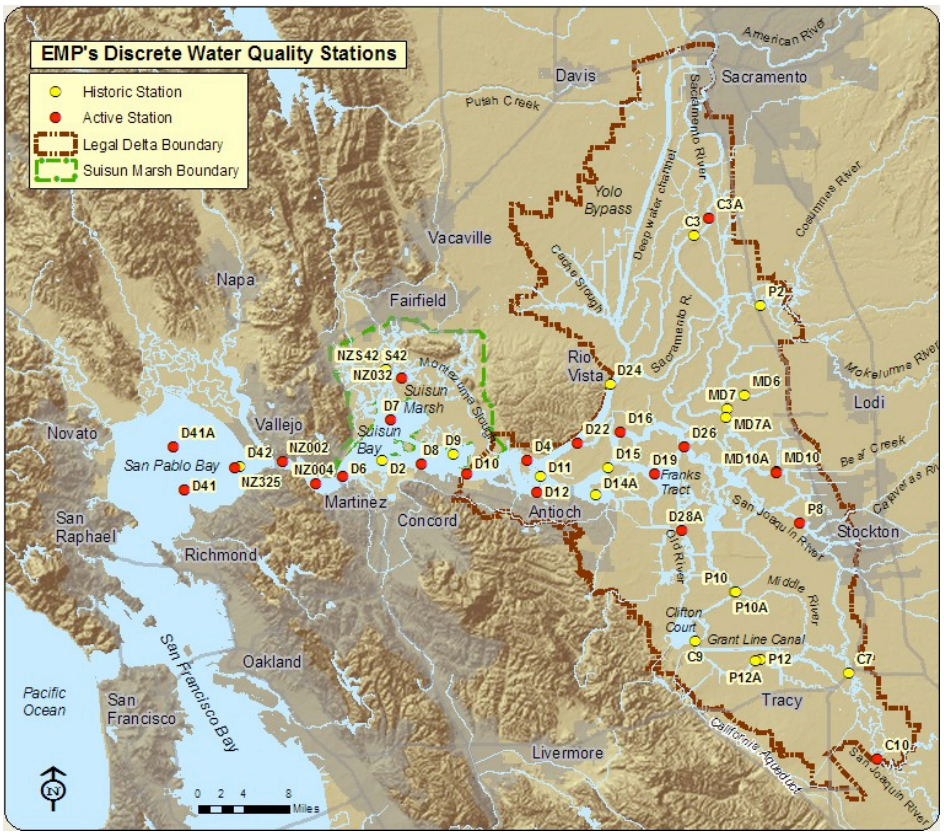
The EMP was initiated in 1971 in compliance with California State Water Resources Control Board (SWRCB) Water Right Decision D-1379 and continued from 1978 through 1999 under D-1485. Currently it is mandated by Water Right Decision D-1641. The program is carried out jointly by the two water right permittees operating the California water projects, the United

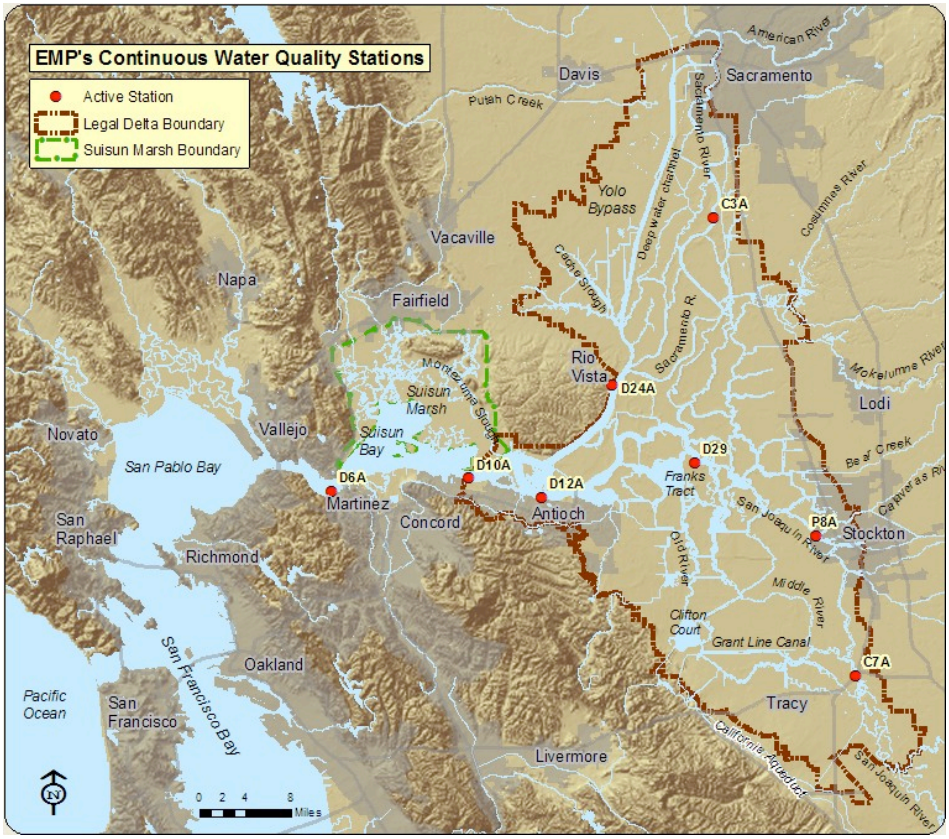
States Bureau of Reclamation (USBR) and the California Department of Water Resources (DWR). Assistance is provided by the California Department of Fish and Game (CDFG) and the United States Geological Survey (USGS).

The primary purpose of the IEP EMP is to provide necessary information for compliance with flow-related water quality standards specified in the water right permits. In addition, the EMP also provides information on a wide range of chemical, physical and biological baseline variables. Discrete water quality stations are sampled monthly using a research vessel and a laboratory van. Several constituents are also measured continuously at eight stations. In addition, the EMP collects and analyzes benthos, phytoplankton, and zooplankton samples. Stations listed as "continuous recorder sites" in D-1641 are not part of the EMP.

While some discrete sample processing is completed on board, most sample analyses are conducted by the Department of Water Resources Bryte Chemical Laboratory. The resulting data is entered in the DWR Field and Laboratory Information System (FLIMS). From there, it is transferred into the DWR Water Data Library and the EMP Discrete Water Quality database. After reviewing of the results for accuracy and completeness, data are sent to the publicly accessible Bay-Delta & Tributaries Database (BDAT). A subset of the continuous water quality data is available on a near real-time basis on-line through DWR's California Data Exchange Center (CDEC) and, once they have been checked, through IEP Hydrologic Engineering Center Data Storage System (HEC-DSS). Monitoring results are routinely analyzed and summarized in annual and occasional multi-year reports and in brief updates in the IEP newsletter. Currently, the EMP has a total budget of approximately two million dollars and up to 25 full and part time employees. EMP staff are responsible for carrying out the monitoring program and associated "special studies."

In the 30 years of its existence, the IEP EMP design has remained relatively unchanged. The greatest revisions came about in 1978 with the enactment of Water Right Decision D-1485 and after a major review of the program in 1995. The main goal of the 1995 revision was to streamline the existing program for more efficient budget and resource allocation. In consequence, discrete baseline sampling stations were reduced from 26 to 11 sites and contaminants monitoring was discontinued. In 2001-2002, the IEP EMP underwent another major programmatic review. Some of the materials linked to this web page were prepared for this review.


EMP's Discrete Water Quality Stations
Historic Station
Active Station
Legal Delta Boundary
Suisun Marsh Boundary
Davis
Sacramento
American River
Putah Creek
Sacramento River
Yolo Bypass
Deepwater channel
Cosumnes River
C3A
C3
Vacaville
Napa
Fairfield
Cache Slough
P22
NZS42
S42
NZ032
Montezuma Slough
Suisun Marsh
Rio Vista
D24
Mokelumne River
MD7
MD6
Lodi
D7
Vallejo
Suisun Bay
D16
D22
MD7A
Novato
D41A
D42
NZ002
D9
D8
D4
D26
Bear Creek
San Pablo Bay
NZ004
D6
D2
D10
D15
D19
MD10A
MD10
D41
NZ325
D11
Franks Tract
D14A
Martinez
D12
Concord
Antioch
San Joaquin River
Calaveras River
P8
Stockton
San Raphael
D28A
Old River
Richmond
P10
Middle River
P10A
Clifton Court
Grant Line Canal
San Francisco Bay
C9
P12
C7
P12A
Oakland
Tracy
Pacific Ocean
San Francisco
California Aqueduct
C10
Livermore
0 2 4 8
Miles


EMP's Continuous Water Quality Stations
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C7A
Oakland
Tracy
Pacific Ocean
San Francisco
California Aqueduct
Livermore
0 2 4 8
Miles

EMP Variables			
Category	**Variables**	**Sampling Frequency**	
		1971 - 1995	**1996 - Current**
Continuous Water Quality	Specific conductivity, pH, dissolved oxygen, turbidity, dissolved chloride, chlorophyll fluorescence, water temperature, air temperature, wind speed and direction, solar radiation (not all parameters at all stations).	Continuous (hourly data)	Continuous (hourly and 15' data)
Discrete Water Quality	Air and water temperature, specific conductivity , dissolved oxygen, turbidity, secchi depth, suspended solids, nitrate, nitrite, ammonia, organic nitrogen, silica, chlorophyll a	Monthly or biweekly	Monthly
	pH, water depth to 1% light level	Monthly or biweekly	Discontinued
	Metals and pesticides	Twice a year	Discontinued
Benthic macro-invertebrates	Count by species	Monthly	Monthly
Phytoplankton	Count by species, size measurements	Monthly	Monthly
Zooplankton	Count by species	Monthly	Monthly

Further Information

EMP home page

Coastal Intensive Site Network (CISNet)

Purpose

To design a monitoring network that is temporally and spatially adequate to provide advance warning of the ecological impacts of natural and anthropogenic stressors. This project is a pilot study.

Dates

January 1999 – March 2001

Geographic Scope

San Pablo Bay

Focus of Monitoring

Water quality and hydrodynamics, sediment, benthos, birds, fish

Data Accessibility

Publicly accessible online: *http://www.sfei.org/cmr/data/CISNetdata.htm*

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Study Details

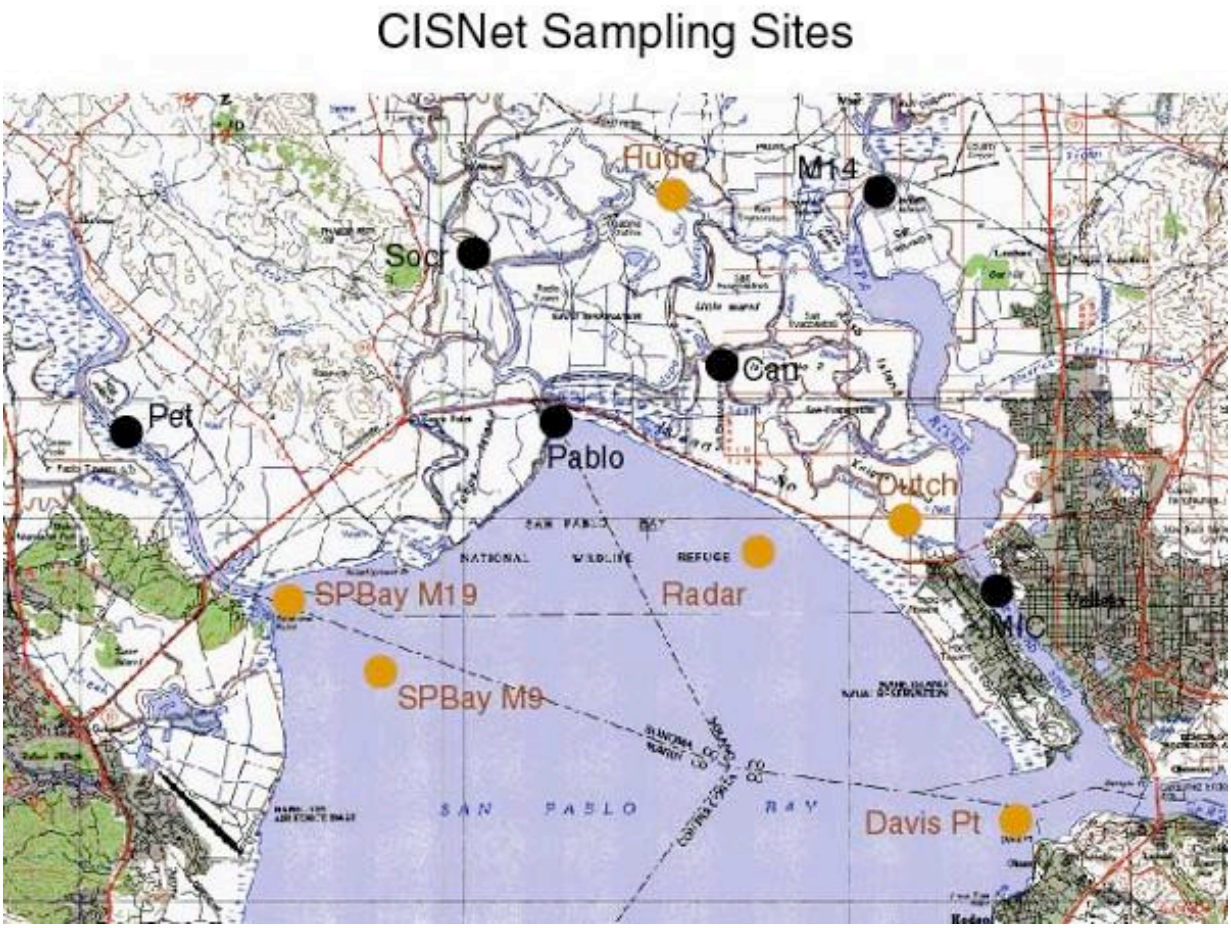
CISNet stands for Coastal Intensive Sites Network. It was envisioned that EPA and NOAA would establish such a network of monitoring sites through out the country. The primary objective is to design a monitoring network that is temporally and spatially adequate to provide advance warning of the ecological impacts of natural and anthropogenic stressors. A central hypothesis is that understanding fluxes and variations in stressors within the system at a range of time-scales will permit optimal selection of monitoring locations and temporal frequencies for long-term CISNet monitoring. This project represents a "pilot Study" for exploring a different way of monitoring by including watershed, wetland, and Bay sites, and sampling multiple "compartments" including higher trophic levels (fish and birds). It also represents a considerable amount of indicator development that will be directly applicable to the Regional Monitoring Program for Trace Substances.

A Coastal Intensive Site Network (CISNet) of 12 monitoring stations in San Pablo Bay, was established to provide hydrodynamic and water-quality observations during the period from January 1999 to March 2001. The monitoring stations were located in the major rivers feeding into the bay and in two marshes along the bay. Continuous measurements of velocity, depth, conductivity, temperature, and optical backscatterance (OBS) samples were collected at a 15-minute frequency at 7 of the 12 monitoring stations. In addition to the continuous monitoring at point locations, profiles through the water column were sampled at some of the sites using an acoustic Doppler profiler (ADP) and a conductivity-temperature-depth (CTD) profiler. An excellent range of temporal and spatial high-frequency data were collected during two 30-hour periods on July 1999 and July 2001 in the Napa River, which feeds into San Pablo Bay. Boat-mounted ADP and CTD-OBS profilers and bottom-mounted ADPs and CTD-OBS instruments were used to characterize the hydrodynamics of the river.

In 1999, the Point Reyes Bird Observatory initiated the Avian Reproductive Studies component of the CISNet San Pablo Bay Project. The study continued during spring of 2000 and 2001. Goals of this component were four-fold:

1) obtain samples of eggs of tidal marsh song sparrows breeding in tidal marshes of San Pablo Bay (both viable and unviable), to test for contaminants,
2) determine components of reproductive success (including hatchability of eggs) for marshes in San Pablo Bay,
3) compare parameter values for marshes in San Pablo Bay with values for adjacent habitat (song sparrows breeding in upland habitat as well as marshes in Suisun Bay), and
4) determine relationships between contaminant loads and reproductive parameters (e.g., Was hatching failure more likely for eggs or for marshes in which contaminant loads were greater?).

Other parameters examined included sediment contamination, sediment toxicity tests using resident organisms (Potamocorbula, Ampelisca), benthic invertebrates, cormorant egg contamination and resident fish tissue contamination. A final report is being prepared by the investigators.



Further Information

Avian monitoring report by PRBO (2001)
Details on project tasks and goals

California Bay-Delta Authority, Integrated Regional Wetlands Monitoring (IRWM)

Purpose

To evaluate how ecosystem restoration efforts may be affecting ecosystem processes at different scales and to prepare for subsequent longer-term monitoring

Dates

2003 – 2005

Geographic Scope

San Pablo and Suisun Bays and the Delta

Focus of Monitoring

Physical processes, landscape ecology, vegetation, birds, fish, invertebrates, primary production, and nutrient dynamics

Data Accessibility

Aerial imagery is available online: 2003 Aerial Imagery. A wide variety of other data types will be available later in 2005 (see Study Details for specifics on data types).

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Study Details

The Integrated Regional Wetland Monitoring (IRWM) Pilot Project is a CALFED-funded interdisciplinary research effort examining wetland restoration in the North Bay and Delta. The IRWM Pilot Project seeks to accomplish two goals on behalf of CALFED:

- to evaluate the underlying management question, how are ecosystem restoration efforts throughout the region affecting ecosystem processes at different scales?; and
- through application of adaptive monitoring strategy concepts, to prepare for subsequent longer-term monitoring.

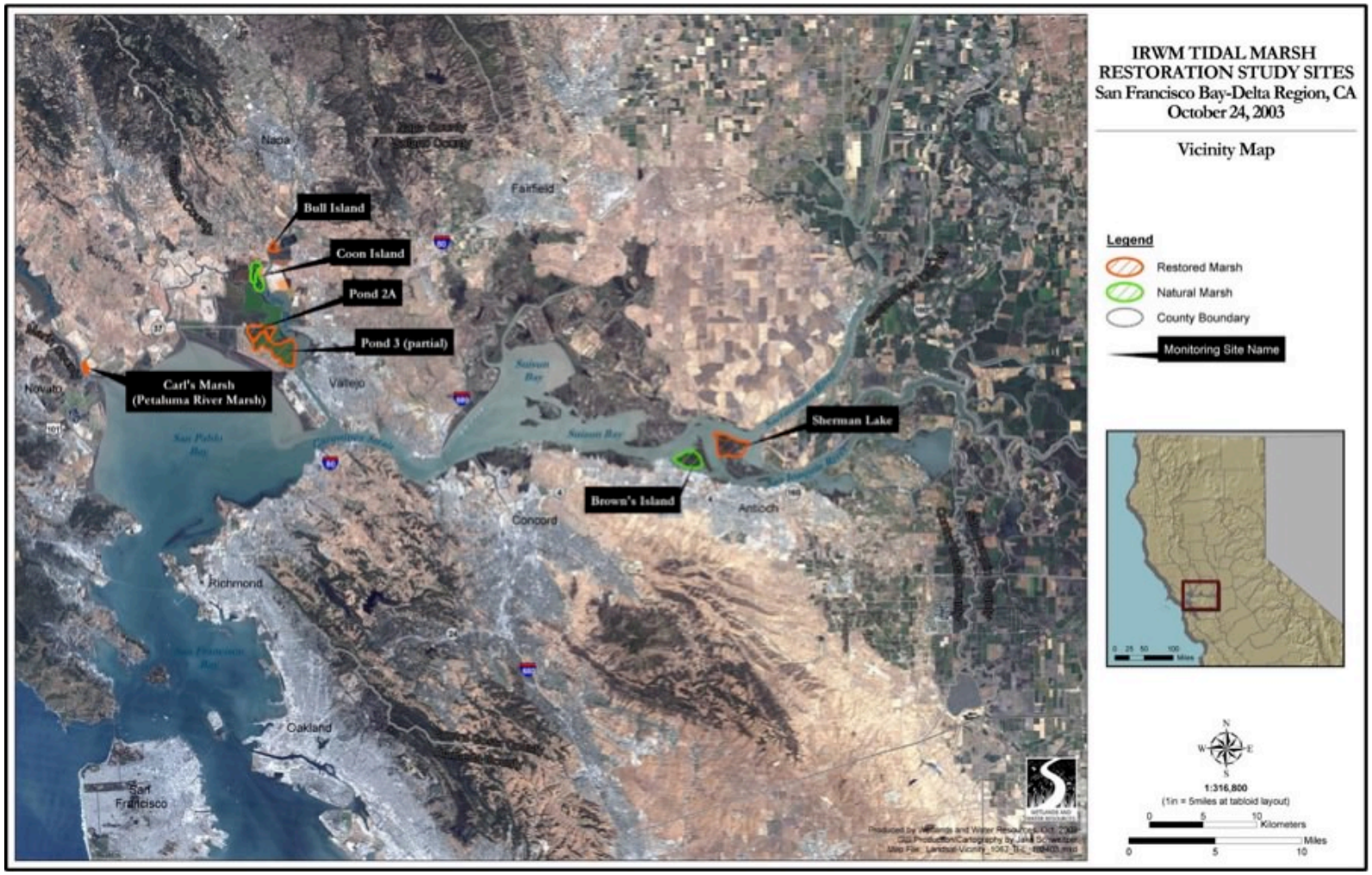
To achieve these two goals, multiple institutions have joined efforts to collect and analyze a variety of field-based ecological, physical, and geochemical data in restored and natural wetland sites in San Pablo Bay, Suisun Bay, and the Sacramento-San Joaquin River Delta.

To elucidate complex interactions and feedback mechanisms between physical, biological, and ecological processes in wetland sites and identify variations in structure and function over time, researchers are gathering data on an array of biotic, abiotic, and spatial metrics. Specific research teams are monitoring parameters relating to physical processes, landscape ecology, vegetation, avifauna, fish, invertebrates, primary production, and nutrient dynamics.

Selected sites are at variable stages of evolution and present a range of conditions for evaluating the status of tidal marshes and the consequences of restoration and other activities upon form and function as reflected in physical, biological, and ecological variables. Field-based measurements are being analyzed in conjunction with site and landscape scale spatial metrics of wetland features using aerial photographic data combined with Geographic Information Systems (GIS). The coordination of physiographic data and biological interpretation enhances comparative analyses and assessment of the effects of tidal marsh restoration upon ecosystem dynamics at multiple scales.

The IRWM Pilot Project is focused on the first two years of data collection and analysis, and places an emphasis on quality control, evaluation of indicators, sampling locations, sampling frequencies, as well as integration and comparison with existing data sets. The two-year monitoring period will allow for evaluating initial results and lay the foundation for ongoing focused monitoring that over time will provide data to better inform resource managers and guide management actions.

Map of IRWM monitoring sites and vicinity



Further Information

- IRWM homepage
- IRWM documents, including several posters from Third Biennial CALFED Science Conference, Oct 4-6, 2004

San Francisco Estuary Institute (SFEI), Regional Monitoring Program (RMP) for Trace Substances

Purpose

To describe patterns and trends in contaminant concentration and distribution; determine general sources and loading of contamination to the Estuary; measure contaminant effects on selected parts of the Estuary ecosystem; compare monitoring information to relevant water quality objectives and other guidelines; and synthesize and distribute information from a range of sources to present a more complete picture of the sources, distribution, fates, and effects of contaminants in the Estuary ecosystem.

Dates

1993 – Ongoing

Geographic Scope

San Francisco Estuary

Focus of Monitoring

The core RMP program monitors trace metals and organics, sediment and aquatic bioassays, and bivalve condition and survival.

Data Accessibility

Publicly accessible online:

- Status and Trends Monitoring Data – http://www.sfei.org/RMP/report
- Portal to other RMP data – http://www.sfei.org/rmp/data.htm

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Study Details

Overview

The Regional Monitoring Program for Trace Substances in the San Francisco Estuary (RMP) is the primary source of information used to evaluate chemical contamination in the Bay. The RMP is an innovative collaborative effort between SFEI, the Regional Board, and the regulated discharger community. In the RMP, financial resources (currently $3 million per year) from the discharger community are pooled and applied in a strategic, comprehensive manner toward understanding contaminant impacts on beneficial uses of the Bay. The RMP focuses on determining spatial patterns and long term trends through sampling of water, sediment, bivalves, and fish, effects on sensitive organisms, and chemical loading to the Bay, and seeks to synthesize RMP data with data from other sources to provide the most complete assessment possible of chemical contamination in the Bay.

Objectives

- Describe patterns and trends in contaminant concentration and distribution.
- Describe general sources and loading of contamination to the Estuary.
- Measure contaminant effects on selected parts of the Estuary ecosystem.
- Compare monitoring information to relevant water quality objectives and other guidelines.
- Synthesize and distribute information from a range of sources to present a more complete picture of the sources, distribution, fates, and effects of contaminants in the Estuary ecosystem.

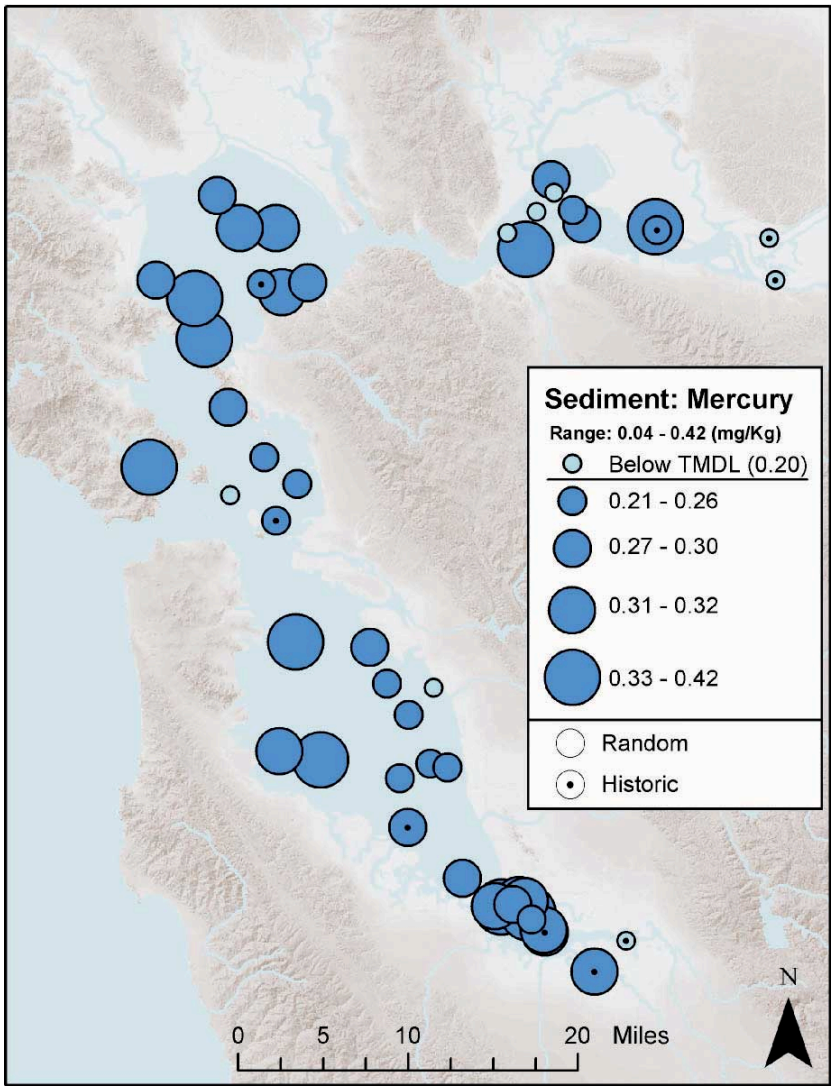
History

Chemical contamination in San Francisco Bay is governed by the San Francisco Bay Regional Water Quality Control Board (Regional Board) with oversight provided by USEPA. The Regional Board's authority is derived from the federal Clean Water Act and the State Porter-Cologne Water Quality Act. The Regional Board has a well-articulated framework for managing contamination in the Bay, contained in the Water Quality Control Plan for the San Francisco Bay Region (or "Basin Plan"). The Basin Plan classifies the valued attributes of the Bay as "beneficial uses" and establishes water quality objectives that are protective of these beneficial uses. The Basin Plan provides a definitive program of actions designed to preserve and enhance water quality and to protect beneficial uses in a manner that will result in maximum benefit to the people of California. Chemicals that are impairing beneficial uses are included on a list (the "303(d) list"), indicating the need for actions to reduce or eliminate the impairments. Listed chemicals are subject to the Total Maximum Daily Load (TMDL) process, where a maximum allowable loading to the Bay is determined and regulatory efforts are made to make sure this load is not exceeded. The Regional Monitoring Program for Trace Substances in the San Francisco Estuary (RMP) is the primary source of information used to evaluate beneficial use impairment in the Bay due to chemical contamination.

The RMP was created by the Regional Board in 1993 to provide the information needed to manage chemical contamination in the Estuary. The innovative structure of the RMP is a collaboration between the Regional Board, the regulated entities that fund the Program (currently

83 wastewater dischargers and dredgers), and SFEI, an independent non-profit scientific research organization

Map showing distribution of mercury contamination in SF Bay sediment compared to Mercury TMDL (from *Pulse of the Estuary* 2004), to give an indication of the RMP sampling sites.



Further Information

RMP homepage

Pacific Estuarine Ecosystem Indicator Research Consortium (PEEIR)

Purpose

To develop indicators of wetland ecosystem integrity and propose an approach for synthesizing indicators in assessments of wetland health along the Pacific coast.

Dates

1 March 2001 – 28 February 2006

Geographic Scope

Northern and Southern California (6 sites: Mugu Lagoon, Walker Creek and Toms Point in Tomales Bay, Stege Marsh and China Camp in San Francisco Bay, and Carpinteria Marsh)

Focus of Monitoring

Biotic and abiotic indicators of contaminant effects and other stressors on west coast salt marshes (see details in the description of each component of the PEEIR consortium)

Data Accessibility

EPA will create a web site for future public access to PEEIR data.

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Study Details

(from PEEIR web site)

Context of PEEIR in the EPA STAR EaGLe Program

The Environmental Protection Agency (EPA), through its Science to achieve Results (STAR) competitive grants research program, has established five regional Estuarine & Great Lakes (EaGLe) programs at major academic research institutions with strong expertise in coastal environmental science. Additionally, NASA is supporting associated remote sensing research at three of these institutions. The five national EaGLe programs are:

- PEEIR Pacific Estuarine Ecosystem Indicator Research Consortium
- ACE-INC Atlantic Coast Environmental Indicators Consortium
- ASC Atlantic Slope Consortium
- CEER-GOM Consortium for Estuarine Eco-indicator Research for the Gulf of Mexico
- GLEI Great Lakes Environmental Indicators Project

The researchers at these five regional centers will attempt to develop the next generation of environmental indicators to assess the biological health of coastal estuaries and the Great Lakes. Indicators evaluated and developed by the EaGLe programs will be used by the states in their long-term monitoring programs to establish the integrity and sustainability of the nation's coastal ecosystems.

Relationship of STAR EaGLe Program to other EPA programs

The STAR EaGLe Program is the extramural component of EPA's environmental Monitoring and Assessment Program (EMAP). EMAP's goal is to develop the scientific understanding for translating environmental monitoring data from multiple spatial and temporal scales into assessments of ecological condition and forecasts of the future risks to the sustainability of our natural resources. EMAP will transfer the approaches and technology developed by the EaGLe programs to the states which are responsible for water quality monitoring under the Clean Water Act.

The Pacific Estuarine Ecosystem Indicator Research (PEEIR) Consortium

The Pacific Estuarine Ecosystem Indicator Research (PEEIR) Consortium is led by the Bodega Marine Laboratory of the University of California at Davis, in partnership with the University of California at Santa Barbara. Collaborators include the University of Georgia, The Bay Institute, and the San Francisco Estuary Institute.

The overarching goal of PEEIR is to develop indicators of wetland ecosystem integrity and propose an approach for synthesizing indicators in assessments of wetland health along the Pacific coast. Because traditional ecosystem sampling, chemical analyses, and toxicity testing are not adequate to address responses to multiple stressors in wetland ecosystems, new indicators for specific plant, fish, and invertebrate population health, as well as indicators of toxicant-induced stress and bioavailability for wetland biota, will be developed. Specific local problems, including wetland degradation and fish declines in San Francisco Bay and in Southern California, mercury

contamination in Tomales Bay, invasions by exotic species, and pesticide contamination in Northern and Southern California watersheds will be addressed using these biological indicators. The remote sensing component seeks to establish landscape-level indicators of environmental stresses that can be routinely measured from airborne or spaceborne platforms. This approach will take advantage of the newer high spatial/spectral resolution instruments that are now available to better assess spatiotemporal aspects of ecosystem functioning.

The Consortium works to achieve the overall goal of developing wetland indicators through several components. The contributions of each component are described below, as taken from the most recent (Year 3) annual report.

Modeling & Integration Component

Key contributions include the development of indicators in marsh plants and animals at multiple spatial scales and levels of biological organization. These indicators are intended for various types of applications in marsh restoration, sediment quality protection, and management of specific contaminant inputs and threatened populations. There are three key integrated goals for our project. The first is the development of wetland plant indicators at multiple spatial scales and levels of organization, and the second is the development of fish and invertebrate indicators. A third theme is an emerging effort on nutrient dynamics. The products of our program will be devised at three levels of integration with the penultimate products including synthetic recommendations on salt marsh indicators at multiple scales with succinct case studies and a comparison of synthesis techniques including multivariate statistics, modeling, and application-based suites of measurements.

Ecosystem Indicators Component

Four approaches are used by teams of investigators from UC Davis and UC Santa Barbara to determine the impacts of stress from nutrient loading, pollution, and exotic species on wetlands from northern and southern California: 1) physiochemical monitoring, 2) biological monitoring, 3) toxicity biomarkers, and 4) statistical analysis and modeling. Research is conducted in concert with the Biochemistry & Bioavailability (BBC) team to characterize the physicochemical environment, including temperature, salinity, oxygen, submergence times, sediment grain size, nutrient inputs and toxic contaminant loads; the Biochemical Response to Contaminants (BRC) team to conduct toxicity biomarker assays in the field; and the Remote Sensing Component (RSC) team to ground-truth measurements taken at the ecosystem level.

Biological Responses to Contaminants Component

The overall aim of the proposed research of this section is to develop a suite of molecular, biochemical, cellular, and tissue level indicators which provide rapid assessment and advance warning of environmental stress in estuarine/coastal habitats. The particular emphasis of this section is assessment of reproductive parameters since rapid and accurate techniques are not readily available, biomarkers associated with reproductive impairment can be early warning indicators of stress, and reproductive impairment can be directly linked to effects on populations through modeling efforts. Biomarkers of reproductive impairment are important early warning indicators of ecosystem impacts, but they need complete characterization and validation in an ecosystem context as proposed in PEEIR.

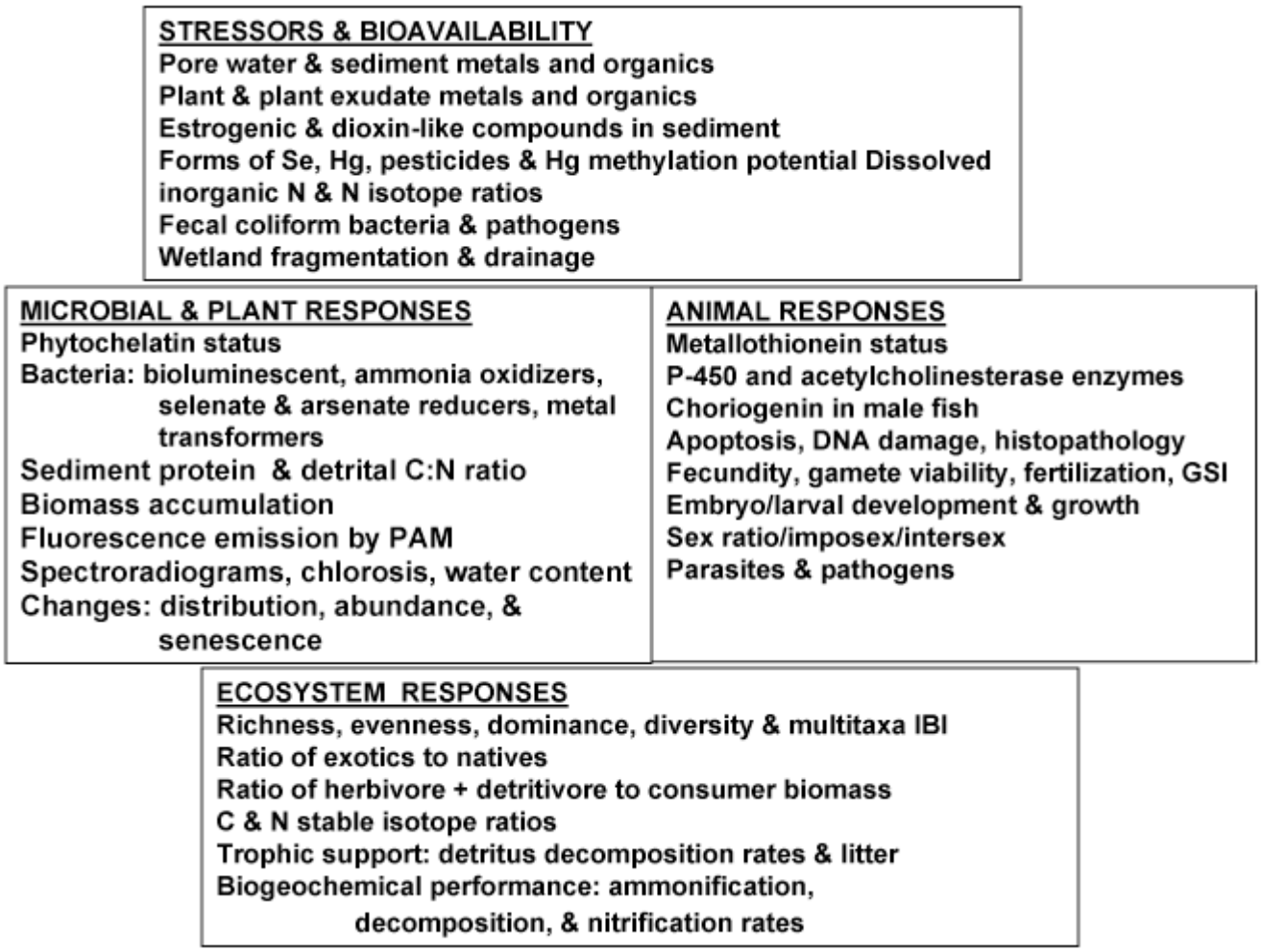
Biogeochemistry and Bioavailability Component

The overall aim of the proposed research of this section is to develop field indicators and the knowledge base to help assess the consequences of changes in chemical form of pollutants in tidal marshes. This section's particular emphasis is assessment of metals and organic pollutant bioavailability in relation to sedimentary lower trophic level biomarkers. This emphasis on rooted plants and sediment microbes is because they are often the entry point of pollutants into the food chain, and are major drivers of the biogeochemistry of the tidal marsh. The specific objective of this section is to uncover the chemical, biochemical, and biotic markers that herald the bioavailability, transport, and/or biotransformation of selected metal and organic pollutants. These markers, in appropriate concert with others generated by PEEIR, can comprise indicators of pollutant stress on marsh ecosystems.

Remote Sensing Component

Working at the largest spatial scale, the NASA-funded remote sensing team is using a variety of airborne sensors, such as the 224-band hyper-spectral AVIRIS instrument, to produce high spatial resolution data of the study sites. These images and other types of remotely sensed data are being used to characterize sites with respect to vegetation patch size, disturbance, plant species distribution, differences in biomass, and biochemical properties including content of chlorophyll and other plant pigments, canopy water content and dry plant litter. These data provide a previously unavailable means to characterize spatially distributed variability in plant species composition, physiological state, and abundance in wetlands that can be directly related to field-based chemical and physiological measurements. Understanding how these properties function as indicators is based on knowledge of physical factors like hydrologic and micro-topographic information, and biotic factors that are collected independently (e.g., using field survey techniques and LIDAR imagery). We have selected sites with varying levels of biomass, presence of contaminants, and history of disturbance within common habitats to provide a basis for comparison.

Summary of Potential Indicators and Measurements to be made by PEEIR.



Further Information

PEEIR web site: www.bml.ucdavis.edu/peeir/index.html
Summary of findings from years 1 and 2