F1-102

United States Department of the Interior

U.S. GEOLOGICAL SURVEY

Water Resources Division
MS 480
345 Middlefield Rd.
Menlo Park, CA 94025

July 28, 1997

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DWR WAREHOUSE

Kate Hansel
CALFED Bay-Delta Program
1416 Ninth St., Suite 1155
Sacramento, CA 95814

Dear Ms. Hansel,

Enclosed are ten copies of a proposal in response to the CALFED Category III RFP. The proposal title is: The Status of Mercury as a Stressor to Habitats and Species of the San Francisco Bay-Delta Ecosystem. The project is a three year assessment of mercury concentrations, cycling, and bioaccumulation in representative habitats and biota of the San Francisco Bay-Delta system. Our goal is to provide CALFED with the scientific information needed to implement cost effective and scientifically sound Hg remediation actions, and to provide the baseline measurements needed to assess the effectiveness of any remediation strategies that are employed in the future.

In anticipation of a number of related mercury proposals being submitted during this funding round, we have coordinated with the research group from UC Davis (T. Suchanek et al) to propose a forum for all funded mercury projects to be integrated. This integration will include twice yearly meetings of all mercury groups to share data and ideas, to maximize collaborations, and minimize duplication of effort. Please instruct reviewers that this current proposal should be considered in conjunction with this larger integration effort. The title of the integration proposal is: Integration of Mercury Studies and Results on the San Francisco Bay-Delta System, Applicants: T.H. Suchanek, D.G. Slotton, and B.S. Johnson.

On behalf of my colleagues, we thank the CALFED agencies for their consideration of this proposal.

Sincerely,

Mark Marvin-DiPasquale

Mark Marvin-DiPasquale
USGS, Menlo Park, CA

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F1-102

The Status of Mercury as a Stressor to Habitats and Species of the San Francisco Bay-Delta Ecosystem

A Proposal to the
CALFED BAY-DELTA PROGRAM
(July 28, 1997)

Primary Applicant: **Mark C. Marvin-DiPasquale (USGS, Menlo Park,CA)**
in collaboration with:
Samuel Luoma, James Cloern, Ronald Oremland, David Krabbenhoft, James Kuwabara, Michael Saiki, Thomas May, George Aiken, Carol Kendall, Laurence Miller, Byeong-Gweon Lee, Robin Bouse, and Charles Armor

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The Status of Mercury as a Stressor to Habitats and Species of the San Francisco Bay-Delta Ecosystem

Primary Applicant: Mark C. Marvin-DiPasquale

Project Description

Sediments and biota of the San Francisco Bay (SFB) and Delta are contaminated with mercury (Hg) as a result of 150 years of Hg mining in the surrounding coastal mountains and from particulate inputs resulting from hydraulic gold and silver mining conducted in the mid- to late-1800's. The presence of Hg, and particularly methyl-Hg (MeHg) which is the form most readily accumulated in aquatic food webs, poses a heath risk to humans who consume Hg-contaminated fish. The effectiveness of plans to restore sport and commercial fisheries may be limited without a clearer understanding of the sources, reactivity and distributions of Hg in the SFB-Delta ecosystem. We propose a detailed assessment of the extent of Hg contamination in the water, sediment, and biota of the SFB-Delta, in order to provide the information required to formulate cost effective Hg remediation strategies. We will evaluate the environmental factors controlling Hg reactivity, transport, MeHg production and degradation, and bioaccumulation in the food-web. Additionally, we will assess the impact of two other proposed restoration actions- selenium (Se) remediation and habitat restoration via flooding - as they affect Hg reactivity and bioaccumulation. Either of these actions could exacerbate Hg contamination in the SFB-Delta. Our objective is to provide the CALFED agencies with the necessary scientific information needed to prioritize Hg as a stressor; assess potential management strategies aimed at Hg remediation; assess the ramifications of potentially competing bay restoration actions; and to provide a baseline measure of Hg contamination against which the effectiveness of future remediation actions may be evaluated.

Approach/Tasks/Schedule

We will use an integrated ecosystem approach that considers the biological, geological, physical, and chemical processes of the SFB-Delta as they affect Hg reactivity, transformations and bioaccumulation. The three year field sampling component will focus on nine sites within the tidal estuary which represent distinctly different habitat types within the system. Water, sediment, and a detailed cross section of the estuarine food-web will be sampled for Hg species (i.e. Hg^{+2}, MeHg, Hg^0) and concentration. Rates of microbial production and decomposition of MeHg will be measured to determine which estuarine regions are net sources or sinks of reactive Hg and which environmental variables control microbial Hg dynamics. The pathways and extent of Hg contamination within the estuarine food-web will be defined by analyzing a wide spectrum of estuarine species for Hg/MeHg content. We will focus on the pathways that bioaccumulate Hg in the priority fish species as designated by CALFED. Results will be related to trophic status and feeding mode. The bioavailability and reactivity of Hg will be compared among SFB-Delta habitats. Suspended particulate Hg concentrations from riverine sources will be compared to sediment dissolved Hg efflux to assess which process dominates the input of reactive Hg along the estuarine salinity gradient (i.e. new input or the recycling of previously deposited Hg). Sediment origin (i.e. coastal Hg mines versus Sierra Nevada hydraulic mine sources) will be determined by distinct geochemical "signature" analysis. We will assess whether areas receiving hydraulic mine inputs have a greater propensity to generate bioavailable MeHg. Mesocosm experiments will be conducted with sediment and soil from areas that are candidates for habitat restoration via flooding to assess the potential for Hg remobilization and bioaccumulation in these regions. Selenium content will be measured in biota to determine if Se suppresses Hg accumulation in the SFB-Delta food-web, as noted in other ecosystems. Laboratory measurements of Hg uptake in phytoplankton and invertebrates under a range of Se concentrations will determine the critical levels of Se required for this suppression. Predictive models of Hg bioaccumulation in key organisms at the base of the food web will be constructed based on field and

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laboratory results. These models will then be used to forecast changes in Hg accumulation throughout the food web that may result from various remediation strategies. Annual reports of results and conclusions will be submitted at the end of years 1 and 2, and a final report with specific recommendations regarding Hg remediation will be submitted at the end of year 3.

Justification for Funding

Little is known about the factors that control Hg reactivity, transport and bioaccumulation in estuaries. The limited data indicate that a wide range of species from the SFB-Delta and its associated watershed contain Hg body burdens that approach or exceed concentrations that pose a public health risk. However, because of very limited systematic sampling, neither the extent of Hg contamination throughout the SFB food-web nor the sources of Hg are adequately known. The factors responsible for Hg input, cycling and bioaccumulation should be identified prior to the implementation of management strategies directed at Hg remediation if we are to avoid limited effectiveness of remediation efforts, unnecessary or excessive financial expenditure, or possibly a worsening of Hg contamination within key habitats and biota due to conflicting effects of other restoration actions (e.g. habitat restoration via flooding or selenium remediation).

Budget Costs

This multi-year comprehensive ecosystem assessment will require the combined effort 14 primary investigators and their associated staff. All of the major instrumentation, resources, and logistical support for the proposed project are currently in place. Costs will be shared among the USGS, CA Dept. of Fish and Game, and CALFED. The total project cost will be $5,339,000. The portion of funding requested from CALFED is $3,782,000 (71 % of the total).

Applicant Qualifications

This ecosystem-wide assessment requires a collaboration of scientists having expertise across a diversity of disciplines. This broad expertise is divided among the team of USGS investigators who collectively have a long history involving both mercury and San Francisco Bay research. The USGS is uniquely qualified to conduct such a comprehensive integrated assessment of Hg dynamics in the SFB estuary due to its historical involvement in this system and its extensive scientific resources.

Coordination with other Programs / Compatibility with CALFED objectives

In addition to Hg remediation, this proposal integrates many CALFED objectives including: Se remediation, habitat restoration, and species of concem. The project will be coordinated with a number of ongoing USGS initiatives, the CA Dept. of Fish and Game sampling survey, and several complementary CALFED proposals submitted this funding round. These proposals include: a) The Role of Upstream Hg Loading and Speciation on Localized Downstream Bioaccumulation (Suchanek et al., UC Davis); b) The Effects of Wetland Restoration on the Production of MeHg in the SFB-Delta System (Suchanek et al., UC Davis); c) Selenium Cycling and Remediation in the SFB-Delta (Luoma et. al., USGS). In addition to the complimentary Hg proposals cited above, a number of other Hg projects are being proposed this round. To minimize duplication of effort and maximize effective collaborations in this important area of SFB-Delta research, we will join together with all funded Hg projects during a series of meetings to be held twice yearly to share current data and ideas. To this end a separate proposal has been submitted this round that details this commitment. This proposal in entitled: Integration of Hg Studies and Results on the SFB-Delta system (Suchanek et al, UC Davis).

I-002258

The Status of Mercury as a Stressor to Habitats and Species of the San Francisco Bay-Delta Ecosystem

A Proposal to the
CALFED BAY-DELTA PROGRAM

Primary Investigator: Mark C. Marvin-DiPasquale[1]

Co-Investigators: Samuel Luoma, James Cloern, Ronald Oremland, David Krabbenhoft, James Kuwabara, Michael Saiki, Thomas May, George Aiken, Carol Kendall, Laurence Miller, Byeong-Gweon Lee, Robin Bouse, and Charles Armor

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RFP Project Group: Other Services

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Submitted: July 28, 1997

A. Project Description and Approach

The project consists of a three year field sampling component and supplementary controlled laboratory experiments designed to provide a detailed assessment of Hg cycling and bioaccumulation dynamics in the San Francisco Bay (SFB) estuary. The goal is to explain where, why and in what biota Hg contamination is greatest. The field component will assess the extent of Hg contamination across the wide range of habitats and hydrologic/biological conditions that occur in the complex SBF-Delta ecosystem. The sampling design is based on the presumption that rates of MeHg production and incorporation into the food-web are highly variable in time and space, and that most of this variability results from variations in: (1) the pool size of reactive Hg available for methylation; (2) chemical properties that limit microbial transformations; (3) the availability and origin (composition) of organic matter to fuel microbial transformations; and (4) habitat types that support different food-web structures. Our main objectives are to determine: (1) the extent of Hg contamination within important representative regions of the estuary and for a detailed cross section of the food-web. (2) the major processes which control Hg cycling, food-web incorporation, and trophic transfer within these regions. (3) the importance of Hg source with respect to reactivity and bioavailability. (4) the potential for bioavailable Hg remobilization which may result from wetlands reclamation (5) if existing levels of Se mitigate Hg bioaccumulation within the food-web. Below we outline the specific approaches that will be taken to address the objectives:

1. What is the extent of Hg contamination in the Bay-Delta ecosystem?

The concentrations of major Hg species (i.e. Hg^{+2}, MeHg, and Hg^0) will be measured in sediment and water column samples at nine sites (Fig. 1) which represent distinct habitat types, from tidal freshwater to coastal marine, in order that we may discern the dominant spatial patterns of Hg concentration and speciation for a range estuarine habitats. Table 1 describes the sampling sites and identifies two or three conditions (extremes in river flow and/or algal production) under which samples will be taken. By sampling each site and condition at least twice, functional relationships in Hg species concentration, microbial transformations and trophic transfer can be described with the data set measured under at least 46 different environmental conditions.

Total Hg and MeHg will also be measured in biota representing a range of trophic levels and feeding modes within the estuarine benthic/pelagic food-web. Table 2 lists the invertebrate organisms and feeding modes that will be targeted for collection at each site. Fish collection will be conducted by the California Department of Fish and Game as part of their routine sampling (see attached Letter of Commitment). The fish sampling design will address whether Hg contamination in fish 1) varies in time and space, 2) varies among life stages, 3) varies among fish trophic levels and feeding modes, 4) is affected by Se concentrations in fish (see below). Selected fish species (Longfin smelt, Staghorn sculpin, and Striped bass), representing distinct trophic levels and feeding modes (planktivores, benthic feeders, and piscivores, respectively), will be sampled intensively in five estuarine regions (Table 3). We will determine the pathways that accumulate Hg in species of concern (e.g. Delta smelt, sturgeon, Chinook salmon,) by focusing temporal/spatial studies on these more abundant surrogate species which occupy similar trophic positions. Additional species (including threatened species) will be sampled less frequently to supplement the estuarine food web assessment and to determine if the degree of Hg accumulation is comparable among fish from similar trophic levels. A range of sizes (age) classes of the surrogate species will be collected to assess cumulative Hg contamination among trophic levels. Threatened or endangered fish species (e.g. sturgeon and salmon) will be sampled live with the use of tissue "plugs" (Waddell & May 1995) which allow for the safe return of the fish to the environment after sampling.

Biota trophic position will be assessed by stable isotope and gut content analysis. The stable isotope approach has been successfully used in other estuaries (Hesslein et al. 1991, Peterson & Fry 1987) to describe food-web structure, and is based on the well-established observation that the isotopic signatures of C, N, and S are a strong indicator of the isotopic composition of an organism's food source, from herbivorous invertebrates to top predators. A limited application of this approach has been previously used in San Francisco Bay (Canuel et al. 1995). However, a systematic application of this technique has not been undertaken to define the trophic linkages that exist in the different estuarine habitats. We propose here such a systematic application as a step towards defining the pathways by which Hg is moved from food to consumers in the SFB-Delta. Thus, by analyzing a wide spectrum of estuarine species for Hg content, and relating these results to trophic status and feeding mode, we will discern the primary pathways and extent of Hg contamination within the estuarine food-web.

Two landward to seaward transects samplings will be conducted which include eight additional stations along the salinity gradient (Fig. 1). One transect will be conducted during summer (low flow) when greater sediment recycling of Hg is expected; and one will be conducted during winter (high flow) when larger riverine inputs of Hg are expected. Plotting the sediment and water Hg data against salinity will allow for a traditional conservative mixing analysis from which we will determine if a) riverine inputs of Hg are simply diluted by ocean water, b) Hg is trapped in the estuary, and/or c) reactive Hg is derived internally via sediment recycling.

Strict "ultra-clean" protocols (Fitzgerald & Watras 1989) will be used for the collection and preservation of samples (water, sediment and biota) for Hg analysis. Hg species will be analyzed using cold vapor atomic fluorescence spectrophotometry (Bloom & Fitzgerald 1988, Horvat et al. 1993, Watras & Bloom 1992).

2. What factors control MeHg production and degradation in the estuary?

Bacterial production of MeHg from inorganic Hg^{+2} occurs most extensively in anoxic sediments. Benthic microbial MeHg production and degradation rates will be measured at the study sites using standard radiolabel tracer ($^{203}Hg^{+2}$ and $^{14}CH_3Hg^{+}$) techniques (Gilmour & Riedel 1995, Marvin-DiPasquale & Oremland 1997). Rate measurements of microbial sulfate reduction (Jørgensen 1978) and methanogenesis (Marvin-DiPasquale and Oremland 1997) will be made in parallel, as these two bacterial groups are involved in biogeochemical Hg cycling (Gilmour et al. 1992, Oremland et al. 1991). The temporal and spatial distribution of these rates will be assessed in terms of concurrently measured estuarine gradients in organic matter, sulfate, and sediment redox conditions, which impact these microbial processes (Marvin 1995). Processes which control the microbial availability of Hg will also be assessed. These include abiotic Hg complexation with organic matter and sulfur ligands (Dyrssen & Wedborg 1989, Hogfeldt 1983), photochemical and enzymatic volatile Hg^0 production (Amyot et al. 1994, Mason et al. 1995), and photochemical MeHg degradation (Sellers et al. 1996). This latter suite of measurements, in conjunction with those above, will be used to assess which areas of the SFB-Delta are net sources (or net sinks) of bioavailable MeHg, and which estuarine variables are most important in controlling Hg dynamics. Thus, regions of the SFB-Delta that deserve remediation priority status will be identified.

3. What are the pathways through which Hg is incorporated into the food-web base?

Benthic and pelagic invertebrates at the food-web base represent a food source for lower-trophic-level fish, and the entry point for Hg transfer from the abiotic, microbial and algal strata. The stable isotope food-web assessment will provide preliminary information as to which feeding modes and trophic components at the food-web base readily incorporate Hg. Laboratory studies will be conducted, using radiolabeled tracers (i.e. $^{203}Hg^{+2}$ and $CH_3{}^{203}Hg^{+}$), to examine these critical entry points in detail and to assess relative uptake rates of Hg/MeHg among organisms and feeding modes (Table 2). Uptake from water and food by invertebrates will be compared among primary consumers (mysids, copepods, amphipods, bivalve molluscs, and polychaetes) and among food types. Food will include phytoplankton and natural particle assemblages with different Hg/MeHg amendments or from sites with different Hg sources and reactivities. Assimilation efficiencies, gross uptake and gross loss rates of Hg/MeHg will be determined under different environmental conditions following the approach of Luoma et al. 1992 and Wang et al. 1996. Bioaccumulation models for Hg and MeHg will be developed for each major group of consumer organisms. These models will be used to project Hg contamination levels available to higher trophic level consumers if Hg concentration/reactivity at the base of the food-web is changed due to restoration.

4. Do Hg concentrations in water and sediments reflect external or internal sources?

Sediment sources will be investigated at each site by analysis of geochemical and isotopic signatures. Studies of sediment cores in the bay and source rocks have shown that differences in Sr and Nd isotope ratios and Cr and Ni concentrations occur among sediments and suspended particulates originating from the Coast Range, different regions of the Sierra Nevada, and from sediments released by hydraulic mining (Bouse et al. 1996). Sediments of the Sacramento River and SFB-Delta are composed of variable mixes of these sources under different flow regimes. Recent evidence suggests that Hg containing sediments derived from hydraulic mining activity may have a greater propensity to release reactive/bioavailable Hg than do sediments derived from Hg mining activity (D. Slotton, pers. comm.) Sediment signatures at different sites and seasons will be related to Hg concentrations and MeHg production dynamics to determine if sediments from different sources have different Hg-methylation potentials once they enter the bay. Priorities for remediation of sources may be (re)evaluated if such differences are evident. The quantification of Hg input associated with external sources will be compared to rates of local (internal) benthic Hg recycling (see below) to determine where and when external or internal processes dominate the input of reactive Hg.

5. How do the estuarine gradients in organic matter composition and sulfide concentration influence the magnitude and direction of benthic Hg flux?

Both dissolved sulfides and dissolved organic matter (DOM) exist in the water column at concentrations that can potentially control the bioavailability of Hg in the SFB-Delta (Kuwabara & Luther 1993). The concentrations of both sulfides and DOM, as well as the composition and source of DOM, vary seasonally and along the estuarine gradient. If net Hg-methylation increases directly with benthic sulfate reduction, then dissolved Hg benthic flux should be consistently positive (out of the sediment), mimicking sulfide, and should be dominated by the variability in microbial sulfate reduction. However, if net Hg-methylation is controlled by other processes (e.g., the dissolution rate of insoluble HgS), then dissolved Hg benthic flux may shift in direction (into sediment) and be dominated by the variability in overlying water and pore-water DOM composition which mediates HgS dissolution (Aiken, unpublished data). To determine which of these two scenarios most accurately describes the control of dissolved Hg benthic flux in SFB we will a) determine the magnitude and direction of benthic Hg flux at a number of the study locations, and compare these results to the flux of cadmium (Cd) and copper (Cu) measured simultaneously, b) examine the role of microbial sulfate reduction in regulating the magnitude and direction of Hg benthic flux, c) quantify the relationship between Hg flux and the flux of dissolved sulfides and DOM, and d) characterize DOM with respect to dominant functional groups which are known to compete with sulfides for Hg binding. The geochemical factors that control the benthic flux of Cd and Cu have been studied in the SFB estuary (Kuwabara et al. 1996), and these elements will provide a comparative model to assess Hg benthic flux. Characterization of DOM at the study sites will provide a range of purified organic substrate for laboratory HgS dissolution experiments which will be conducted to supplement the benthic flux field work. The characterization of DOM along the esturaine gradient will also compliment and be coordinated with similar ongoing DOM characterization studies in the delta, conducted by G. Aiken et al. (USGS).

6. What will be the effect of wetlands restoration via flooding on Hg remobilization and bioaccumulation?

The flooding of soils for the purposes of fish habitat restoration may potentially remobilize sequestered reactive Hg and result in enhanced Hg bioaccumulation in local and regional food webs. Simulated flooding events will be conducted in mesocosms containing soils collected from a number of designated habitat restoration sites to assess this remobilization potential. Together, CALFED and the

USGS will determine appropriate sampling sites based on locations proposed for habitat restoration through this RFP. The geochemical/isotopic signature methods, described above, will be used to determine soil origin at these sites. Upon mesocosm flooding, the availability of reactive Hg^{+2} and the production of MeHg will be monitored over 2-4 weeks. Zooplankton and benthic infauna will be used to assess Hg bioaccumulation potentials. Soil collected from the Yolo Bypass during the dry season will be used as an experimental control. Hg remobilization and bioaccumulation potentials resulting from mesocosm flooding of this substrate will be compared to field concentrations measured in sediment, water and biota at this site during seasonal flooding. These mesocosm studies will provide CALFED critical information regarding which proposed areas, if flooded, may worsen Hg contamination at both local and regional scales.

7. Does a significant Hg-Se relationship exist in the SFB-Delta food-web?
At what Se concentrations is Hg bioaccumulation mitigated in low trophic level organisms?

Both field and laboratory studies will assess the magnitude of the potential Hg-Se interaction in the SFB-delta. In-situ Se concentrations will be determined in all seston, invertebrate and fish samples collected as part of the field program. Hg and Se concentration data will be analyzed to determine if a statistically significant Hg-Se interaction exists, either across the spectrum of species sampled or within various components of the food-web. In addition, controlled experiments will be conducted to determine at what Se concentrations the assimilation of Hg and/or MeHg is mitigated in lower trophic level organisms. Results from laboratory experiments will be compared with in-situ Hg and Se concentrations measured in invertebrates. This information may then be used in setting appropriate Se remediation target concentrations.

B. Location / Geographical Boundries

Figure 1 indicates the location of all sampling sites for the field effort. This project focuses on the tidal estuary and does not extend into the non-tidal watershed. Hg dynamics in this latter region will be the main focus of the complementary research effort by Suchanek et al (see proposal in this round), with whom we will be coordinating (see below). The geographical area of overlap for the two projects (i.e. the Delta) provide a unique opportunity for both projects to validate methods and approaches. Together, both projects will provide a complete, and nearly seamless, assessment of Hg dynamics and bioaccumulation from sources, in the non-tidal fresh watershed (Suchanek et al), to the estuary proper (our project).

The central and south Bay sampling locations (sites 8 & 9, Fig. 1), while outside of the stated area of primary interest for CALFED, will be critically important biological and geochemical estuarine end-member locations. Their inclusion provides us with the full range of estuarine conditions (chemical, physical, geochemical, and biological) which will be needed to determine which environmental factors have the most pronouced affect on Hg cycling in this system. The exclusion of these sites would limit our ability to determine which estuarine variables control Hg cycling and bioaccumulation in the SFB-Delta.

C. Expected Benefits

The scientific information resulting from this project will allow the CALFED agencies to prioritize Hg remediation in the hierarchy of proposed SFB-Delta restoration initiatives. Specific strategies focused on limiting Hg input and bioaccumulation can then be proposed if it is determined that Hg remediation should be given priority status. These strategies may include actions that limit a) the amount of Hg entering the Bay/Delta, b) the degree to which inorganic Hg is microbially methylated, c) the transfer of MeHg into the food-web base, or d) the bioconcentration of MeHg from lower to higher trophic levels. This information will also allow future remediation resources to be effectively concentrated in specific SFB-Delta regions where it has been determined that MeHg production and/or incorporation into the food-web base is greatest. Restrictions on fish consumption could be modified if Hg contamination is seasonal or location specific. Once the impact on Hg cycling and bioaccumulation has been assessed in

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terms of habitat restoration and Se remediation, action with respect to these latter two CALFED initiative can be either proposed, enhanced or reevaluated.

The wealth of Hg concentration and MeHg production data collected as part of this project will provide critical baseline information to CALFED which will be used to determine the effectiveness of subsequently implemented remediation actions. The Hg/MeHg bioaccumulation models that will be constructed for organisms at the food web base will be especially valuable to ecosystem managers as tools for predicting the effects of specific Hg remediation initiatives. The two interim year-end reports and final report, that will be submitted as part of this project, will provide specific recommendations as to cost effective Hg remediation strategies base on our assessment of Hg cycling and bioaccumulation dynamics in the SFB-Delta.

D. Background / Justification

Unlike other estuaries, the drainage basin of the SFB is associated with one of the worlds largest natural deposits of Hg ore (primarily HgS), located along the northern California coast. The Hg mined from these deposits was purified to elemental Hg^0 and used for the extraction of silver and gold from hydraulic mining sites in the Sierra-Nevada mountains during the late 1800's. Most coastal Hg mines ceased operation during 1950 - 1970, but contamination from abandoned mining areas continues to be a source of input to the SFB-Delta (Bouse et al. 1996). As the estuary also receives freshwater input from the Sierra-Nevada mountains, the potential input of naturally occurring, remobilized and anthropogenic Hg is exceptionally large. However, the relative current contributions from these various sources is unknown, as is the magnitude and biological reactivity of these external inputs compared to the internal benthic recycling of previously deposited Hg.

The limited data available regarding Hg concentrations in biota from the SFB and its watershed indicate that a wide range of organisms contain Hg levels that approach or exceed those which pose a potential public health risk (Martin et al. 1984, SFBRWQCB 1995, SWRCB 1995, SWRCB 1996). However, sampling to date has not been extensive or systematic, and the full extent of Hg contamination throughout the SFB food-web is unknown. If remediation efforts should improve habitat sufficiently to restore fish populations, the value of those efforts will be limited if the fisheries remain contaminated with Hg at levels that exceed health standards.

The accurate knowledge of Hg sources, transport, and fate is essential for effective Hg remediation. This can only be achieved with a complete assessment of all Hg species in the dissolved, particulate and gaseous phases. Figure 2 shows a schematic of the important Hg species in aquatic ecosystems and their likely fate. The most reactive form of mercury occurs as charged inorganic Hg^{+2} which strongly associates with organic and inorganic particles, and is readily transported to the sediments (Bilinski et al. 1992). There, Hg^{+2} can be methylated by bacteria, forming MeHg (Compeau & Bartha 1985). It is this latter Hg species which most readily bioaccumulates in food-webs (Bloom 1992). Therefore, MeHg is the most important Hg species in the environment from a toxicological and bioaccumulative standpoint. Sites and rates of MeHg production, destruction, and bio-uptake are consequently a focus of most Hg studies. The overview of Hg dynamics in aquatic systems given in Fig. 2 provides a framework from which to assess Hg cycling within the SFB-Delta. However, the specific factors which control reaction kinetics, Hg speciation, and bioconcentration dynamics, are site specific and will undoubtedly vary among locations, as will the appropriate remediation strategies.

Many of the marshes in the Delta, Suisun and San Pablo Bays were created between 1850 and 1900 by inflows of sedimentary wastes from hydraulic mining (Peterson et al. 1993). Restoration of such areas via flooding could worsen Hg contamination in the SFB-Delta if these sites are contaminated with reactive Hg. Recent evidence has demonstrated that the flooding of Hg containing soils results in the remobilization of previously sequestered Hg, leading to enhanced Hg bioaccumulation (Kelly et al. 1997, Morrison & Thérien 1995). To date, Hg concentration, origin, reactivity and potential bioavailability has not been assessed for proposed habitat restoration areas.

A second proposed restoration initiative that may potentially enhance Hg bioaccumulation is the reduction of selenium (Se) concentrations in the SFB-Delta. Evidence from other aquatic systems indicates that a Hg-Se interaction exists, such that the presence of Se may mitigate the bioaccumulation of Hg in food-webs (Cuvin-Aralar & Furness 1991). The extent of such a Hg-Se interaction in the SFB-Delta food-web is unknown. However, the current degree of Hg bioaccumulation throughout this system may be somewhat lower than might otherwise be the case if Se concentrations were decreased.

E. Proposed Scope of Work

Table 4 describes the sequence and time frame for the components of this project. The majority of field work (water, seston, and sediment sampling) will be conducted during 1998 and 1999. Additional sampling will be conducted as needed during the spring/summer of 2000 to fulfill our goal of sampling each site and condition twice and based on earlier results. All supplemental laboratory work (including: mesocosm experiments of flooded soils, MeHg photodegradation, HgS dissolution by dissolved organic carbon, dissolved gaseous Hg^0 production, Hg/MeHg bioaccumulation, and Se interaction studies) will be conducted throughout the three year period, as fresh sample becomes available as part of the field effort. The assessment of Hg bioaccumulation in fish with respect to age will be conducted primarily during the first year. Subsequent yearly fish sampling will focus on regional differences in Hg accumulation. Bioaccumulation models of Hg/MeHg in organisms at the food web base will continually be constructed throughout the three year period as data becomes available. Annual reports, outlining preliminary results and progress to date, will be submitted to CALFED during years 1 and 2, and a final report, including specific recommendations for Hg remediation will be submitted at the end of year 3.

F. Monitoring and Data Evaluation

The relative percent difference (RPD) between duplicate sample measurements, for all analyses, must be within 10% to meet quality assurance objectives. A third sample will be assayed if the RPD exceeds 10%. Periodic inter-laboratory calibrations will be conducted between the Midwest Science Center (Columbia, MO) and the USGS-WRD laboratory (Madison, WI) for total Hg quantification in fish tissues. Stable isotope data will be analyzed with the "trophic position isotope spectrum" method (Monteiro et al. 1991) which quantifies the relative magnitude of dietary pathways. Auxiliary data regarding Se distribution and concentrations in biota will be made available from the Selenium Cycling and Bioconcentration project as proposed to CALFED by Luoma et al (see proposal in this round).

The project will be coordinated with a number of ongoing USGS initiatives, the CA Dept. of Fish and Game sampling survey, and several complementary CALFED proposals submitted this funding round. These proposals include: a) The Role of Upstream Hg Loading and Speciation on Localized Downstream Bioaccumulation (Suchanek et al., UC Davis); b) The Effects of Wetland Restoration on the Production of MeHg in the SFB-Delta System (Suchanek et al., UC Davis); c) Se Cycling and Remediation in the SFB-Delta (Luoma et. al., USGS). In addition to the complimentary Hg proposals cited above, a number of other Hg projects are being proposed this round. To minimize duplication of effort and maximize effective collaborations in this important area of SFB-Delta research, we will join together with all funded Hg projects during a series of meetings to be held twice yearly to share current data and ideas (see attached Letter of Committment). To this end a separate proposal has been submitted this round that details this commitment. This proposal in entitled: Integration of Hg Studies and Results on the SFB-Delta system (Suchanek et al, UC Davis). All scientific findings and conclusions resulting from this work will be submitted for publication in relevant peer reviewed journals.

G. Implementability

No permits or easements will be required to implement this project. All radiochemical assays will be carried out under currently held Nuclear Regulatory Commission radioisotope user licenses, and with strict adherence to established safety protocols.

A. Budget Costs

The cost of implementing this project will be shared among the USGS, California Dept. of Fish and Game (CDFG), and CALFED. Table 5 summarizes the budgets for each of eight investigator groups, and indicates how costs are shared among agencies. Table 6 summarizes the specific tasks associated with each investigator group. The budget summary (Table 5) is based on the detailed budgets submitted by each investigator group (Appendix A).

The majority of salaries and benefits of USGS Project Chiefs will be paid by the USGS, these include the following co-investigators: R. Oremland, J. Cloern, S. Luoma, J. Kuwabara, G. Aiken, C. Kendall and M. Saiki. In addition the USGS will pay the majority of salary and benefits for, L. Miller (Group I), M. Hornberger and C. Brown (Group II), J. Edmunds and B. Cole (Group III), B. Toppings and J. Koleis (Group IV), J. Hurley (Group V), and C. Chang (Group VII). Other salaries and benefits (postdoctoral associates, staff and technicians) will be paid by CALFED. The CDFG will pay the salaries and benefits for all of its employees (Group IX). The cost of fish collection (including boat time, crew and sampling gear) will be contributed by the CDFG ($31,936), to the degree that sampling is conducted as part of their ongoing monitoring program (see attached Letter of Committment). A supplemental fish sampling budget is requested from CALFED by CDFG ($5,000) in anticipation that additional sampling effort by CDFG will be needed to collect the minimum number select species* (Table 3) needed for statistical data analysis (n=10-20 per region per sampling). We request that this supplemental funding be paid directly to CDFG and not be part of the overall USGS funding by CALFED.

The USGS will pay all costs associated with field sampling aboard the research vessel (R/V) Polaris. These costs total $84,702 over the entire project, and include, boat time, fuel, crew, ship maintenance, and permanent shipboard sampling gear. Additional CALFED funding is requested for the fuel, transport and maintenance of the smaller vessel (25' Frontier Whaler) which will be needed to sample shallow water sites. In addition, salary and benefit funding is requested to hire one full time person to run and maintain this vessel. This person would also be available to all investigator groups to assist with field sample collection and processing. The USGS will also pay the fuel and maintenance costs for a mobile laboratory vehicle that will be used as an on-site facility during the collection and processing of shallow site samples and soils from wetlands restoration areas (Group I Budget). Fuel and maintenance of additional support vehicles will also be paid for by the USGS.

The total cost of the proposed Hg assessment will be $5,339,351 (Table 5). We are requesting $3,782,463 (70.8%) of this funding from CALFED, of which $3,777,463 will go to the USGS and $5,000 will go to CDFG.

B. Schedule Milestones

Table 4 details the schedule for the field and experimental components of this project. In addition, joint meetings between USGS and CALFED representatives will be held during February 1998 to discuss possible wetland restoration sites to be sampled for the Hg remobilization assessment. The interview and hiring of the unnamed postdoctoral associates, technicians, and support staff (Appendix A) will be completed by March 1998. Assuming multiple Hg projects are funded, joint meetings designed to share findings and develop collaborations will be held twice yearly with Hg other groups (see proposal this round from Suchanek et al. entitled: Integration of mercury studies and results on the San Francisco Bay-Delta system) Annual progress reports to CALFED will be submitted during December 1998 and 1999, with a final report due during December 2000 (Table 4). The fulfillment of this project according to the above schedule will be contingent upon the annual appropriation of funds from CALFED.

C. Third Party Impacts

There are no immediate third party impacts which would result from this proposed assessment. In the long term, public health may be positively affected as a result of our improved understanding regarding where, when and which fish species pose the greatest Hg contamination threats. Third parties proposing wetlands restoration projects may need to consider the potential for Hg remobilization as a result of our findings. Likewise, third parties proposing Se remediation projects may also need to consider the potential for exacerbating Hg contamination depending on our findings.

V. Applicant Qualifications

The strength of this proposed SFB-Delta Hg assessment lies in the qualification of the investigators involved. As a group, they bring together extensive experience in the areas of environmental mercury and trace metal cycling, estuarine ecology, organic and stable isotope geochemistry, biology and microbiology. While the accomplishments and qualificaitons of the researchers involved in this project are too numerous to expound upon here, the sum of individual biographies supplied in Appendix B attests to the groups credentials and expertise. Table 6 summarizes the involvement of all investigators in the various aspects of this project.

The principal investigator (M. Marvin-DiPasquale) will be responsible for the coordination, logistics, budget and annual reports to CALFED, in addition to his own scientific involvement (Table 6). Dr. Marvin-DiPasquale has been instrumental in two other successful multi-investigator, multi-discipline, ecosystem level research projects. The first was the NSF funded Chesapeake Bay - Land Margins Ecosystem Research (LMER) program (Kemp et al. 1997, Marvin 1995, Marvin-DiPasquale & Capone 1997), which focused on the temporal and spatial dynamics of nutrient and carbon cycling in the Chesapeake Bay estuary. The second is the current EPA/USGS funded Aquatic Cycling of Mercury in the Everglades (ACME) project (Marvin-DiPasquale and Oremland 1997). The ACME project is exploring many of the same issues in South Florida, regarding environmental controls on Hg reactivity and bioaccumulation, as will be addressed in the proposed SFB assessment. The ACME project is being directed and coordinated by D. Krabbenhoft, who is also a co-investigator on this proposal. Dr. Krabbenhoft is a leader in environmental Hg research and will be conducting the Hg speciation analysis in water, sediment, seston, and invertebrates for this project.

The Western Region USGS project chiefs participating in this assessment (J. Cloern, S. Luoma, J. Kuwabara, and R. Oremland) have a long history of involvement in SFB research which will prove invaluable in interpreting complex spatial and temporal Hg data with respect to local physical, chemical, geochemical and biological considerations. A number of the project investigators also have extensive experience with environmental Se research (S. Luoma, M. Saiki, T. May and R. Oremland). This background will be invaluable in assessing potential Hg-Se biotic interactions. Experimental studies of the mitigation of Hg bioaccumulation by Se will be conducted by S. Luoma and B.G. Lee. Analysis of Hg-Se interactions in biota will be conducted by M. Saiki and T. May. In addition M. Saiki will direct and coordinate the CDFG fish collection, and T. May will conduct the analysis of Hg and Se in fish tissue. Stable isotope analysis of biological samples will be conducted by C. Kendall, who is also involved in the food web analysis for the South Florida ACME project. The trophic food-web structure assessment will be directed by J. Cloern, who will also direct the collection and identification of pelagic and benthic invertebrates. The origins of sediment as determined by isotopic/geochemical signature analysis will be conducted by S. Luoma and R. Bouse. The characterization of benthic microbial processes, including Hg-methylation and MeHg degradation rate measurements, will be conducted by M. Marvin-DiPasquale, L. Miller and R. Oremland. Measurements of dissolved Hg benthic flux will be conducted by J. Kuwabara,

G. Aiken and D. Krabbenhoft. Characterization of dissolved organic matter will be conducted by G. Aiken.

VI. Compliance with standard terms and conditions

The Non-discrimination Compliance Statement is agreed to, signed and attached to the end of this proposal.

VII. References

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Table 1. Sampling site description. The conditions and corresponding monthly intervals listed for each site represent the extremes in fresh water flow and algal production characteristic of each site. Each site and condition will be sampled at least twice during the three year field program (see Table 4 and Fig. 1).

Site	Habitat Type	Representative of:	Condition 1	Condition 2	Condition 3
① Sacramento R. at Prospect Island	Tidal River (Sacramento)	Deep Habitat of the Sacramento River; Freshwater Biota; Sport fishery	High Flow [Jan-Apr]	Low Flow [Aug-Sept]	
② Newly Flooded Prospect Island	Freshwater Shallows	Model for Restored Shallow Water Habitat; freshwater biota	High Flow [Jan-Apr]	Low Flow [Aug-Sept]	
③ Yolo Bypass	Seasonal Wetland	Potential Site for Permanent Flooding; potential high activity	Dry [June-Oct]	Flooded [Jan-Apr of wet years]	
④ Suisun Bay at Ryer Island	Brackish/Low Salinity Estuary	Critical Nursery Habitat; Estuarine Biota; Sport fishery	High Flow [Jan-Apr]	Low Flow [Aug-Sept]	
⑤ Montezuma Slough	Brackish/Low Salinity Marsh	Critical Nursery Habitat Influenced by Marsh Exchanges; Estuarine Biota	High Flow [Jan-Apr]	Low Flow [Aug-Sept]	
⑥ Central Delta at IEP site D26	Tidal River (San Joaquin)	Deep Habitat of the San Joaquin River and Central Delta; Freshwater Biota; Sport fishery	Low Algal Biomass [Jan-Mar]	High Algal Biomass [June-Aug]	
⑦ Eastern San Pablo Bay	High Salinity Estuary	Deep Estuarine Habitat; Estuarine and Marine Biota; Sport fishery	High Flow [Jan-Apr]	Low Flow [Aug-Sept]	High Algal Biomass [May-June]
⑧ Richardson Bay	Coastal Marine	Coastal Habitat Influenced by Bay-Delta Processes; Marine Biota	High Flow [Jan-Apr]	Low Flow [Aug-Sept]	
⑨ South Bay at Redwood Ck.	Urbanized Marine	Deep Estuarine Habitat Strongly Influenced by Phytoplankton Blooms; Sport fishery	Low Algal Productivity [Nov-Jan]	High Algal Productivity [Mar-Apr]	Algal Bloom Termination [Apr-May]

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Table 2. Organisms at the food web base of the San Francisco Bay estuary to be collected as part of the proposed USGS Mercury field sampling program.

Feeding Mode	Species Type	Examples
Pelagic suspension feeders	calanoid copepods	Eurytemora, Acartia, Pseudodiaptomus, Sinocalanus
	cladocerans	Daphnia, Diaphanosoma, Bosmina
Pelagic carnivores	cyclopoid copepods	Cyclops, Limnoithona
	larval fish	
Benthic suspension/deposit feeders	bivalve molluscs	Potamocorbula, Corbicula, Mya, Tapes, Macoma
	amphipods	Corophium, Ampelisca
	polychaete worms	Streblospio, Heteromastus, Asychis, Capitella
Benthic carnivores	polychaete or annelid worms	Nereis, Limnodrilus
Epibenthic herbivores/omnivores	mysid shrimp	Neomysis, Acanthomysis
	harpacticoid copepods	
Epibenthic carnivores	bay shrimp	Crangon, Palaemon
	crabs	Cancer, Hemigrapsus
Intertidal grazers	gastropods	Ilyanassa

Table 3. Fish Sampling Design. The temporal and spatial variability of Hg (and Se) contamination in fish of various trophic levels will be determined by sampling five distinct geographic Bay areas for the fish species indicated. The primary sampling effort will be targeted for species designated with (*) . The additional species listed may be collected when available to supplement our broad spectrum food web analysis and to compare Hg contamination among species within a given trophic level . Fish sampling will be conducted during the periods indicated in Table 4. For each species*/region n=10-20. Adults of species in brackets [ ] use the Bay/Delta primarily as a migratory corridor and may not accurately reflect the bioavailability of Hg in the local environment.

TROPHIC LEVEL	DELTA	SUISUN BAY	SAN PABLO BAY	CENTRAL BAY	SOUTH BAY
Planktivore (forage on zooplankton)	Longfin smelt* Delta smelt Threadfin shad	Longfin smelt* Delta smelt	Longfin smelt* Northern anchovy	Longfin smelt* Northern anchovy	Longfin smelt* Northern anchovy
Benthic Feeder / Primary Consumer (Forage on plants or detritus)		Jacksmelt	Jacksmelt	Topsmelt Jacksmelt	Topsmelt Jacksmelt
Benthic Feeder / Secondary & Tertiary Consumers (Forage on invertebrates)	Staghorn sculpin* Striped bass (juvenile)* Starry flounder Yellowfin goby White sturgeon Green sturgeon Splittail Chinook salmon (juvenile) Steelhead (juvenile)	Staghorn sculpin* Striped bass (juvenile)* Starry flounder Yellowfin goby White sturgeon Green sturgeon Splittail Shiner perch Leopard shark White croaker Chinook salmon (juvenile) Steelhead (juvenile)	Staghorn sculpin* Striped bass (juvenile)* Starry flounder Yellowfin goby White sturgeon Green sturgeon Splittail Shiner perch Leopard shark White croaker Chinook salmon (juvenile) Steelhead (juvenile)	Staghorn sculpin* Striped bass (juvenile)* Starry flounder Yellowfin goby White sturgeon Green sturgeon Shiner perch Leopard shark White croaker Chinook salmon (juvenile) Steelhead (juvenile)	Staghorn sculpin* Striped bass (juvenile)* Starry flounder Yellowfin goby White sturgeon Green sturgeon Shiner perch Leopard shark White croaker Steelhead (juvenile)
Piscivore (forage on fish)	Striped bass (subadult & adult)* [Chinook salmon (adult)] [Steelhead-(adult)]	Striped bass (subadult & adult)* [Chinook salmon (adult)] [Steelhead (adult)]	Striped bass (subadult & adult)* [Chinook salmon (adult)] [Steelhead (adult)]	Striped bass (subadult & adult)* [Chinook salmon (adult)] [Steelhead (adult)]	Striped bass (subadult & adult)* [Steelhead (adult)]

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Table 4. Project Schedule

Task	1998				1999				2000			
	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter	Spring	Summer	Fall	Winter
Field Sampling[a]	7&9	1-7	9	1-7	7&9	1-7	9	1-7	1-9 (as needed)			
Fish Sampling[b]		x		x		x			x			
Transect Cruise[c]		x		x								
Benthic Flux[d]		x		x		x		x	x			
Analytical[e]		x				x				x		
Flooding[f] Simulation			x			x			x			
Hg/MeHg Uptake[g,h]			x			x			x			
Se-Hg Exper.[g,h]			x			x			x			
HgS Dissolution[g]			x			x			x			
MeHg[g] Photodegradation			x		x		x					
Hg^0 Production[g]			x		x		x					
Annual Report				x				x				
Final Report												x

[a] Field Sampling : collection of sediment, water and invertebrates for Hg/MeHg analysis; benthic microbial rate assays / Numbers refer to sites given in Table 1.
[b] Fish Sampling: conducted by the California Dept. of Fish and Game, see Table 3 for species and regions of collection.
[c] Transect Cruise: includes primary field sites plus additional locations along the estuarine salinity gradient (see Fig. 1).
[d] Benthic flux measurements: conducted at a subset of primary sampling locations.
[e] Includes analysis of all Hg species, Se, stable isotopes, DOC, etc… in all samples collected during the field component.
[f] Laboratory mesocosm experiments conducted with soil collected from proposed wetlands restoration sites and the Yolo Bypass.
[g] laboratory experiments
[h] Experiments with invertebrate organisms at the food web base.

Table 5. Budget Summary - Based on detailed investigator group budgets given in Appendix A. Tasks corresponding to specific investigator groups are given in Table 6.

Investigator Group	Funding Agency	Direct Salary & Benefits[1]	Materials[2]	Other Direct Costs[3]	Indirect Costs[4]	Total Costs
I	USGS	85,765	30,000	7,500	69,644	192,909
II	USGS	137,477	37,500	8,000	103,382	286,359
III	USGS	120,164	0	6,500	71,565	198,229
IV	USGS	172,869	18,000	20,000	119,141	330,010
V	USGS	42,451	31,500	0	41,782	115,733
VI	USGS	49,305	12,000	0	34,638	95,943
VII	USGS	22,538	15,000	7,500	25,446	70,484
VIII	USGS	0	96,000	0	54,579	150,579
Boat-1 [5]	USGS	34,125	17,500	2,500	30,581	84,706
					Total USGS Contribution =	**$1,524,952**
					Percent of Total Cost =	**28.6%**
IX	CDFG	20,124	3,920	1,920	5,972	31,936
					Total CDFG Contribution =	**$28,738**
					Percent of Total Cost =	**0.6%**
I	CALFED	342,036	42,500	17,500	227,150	629,186
II	CALFED	381,350	25,000	6,000	232,978	645,328
III	CALFED	236,487	22,000	16,000	155,085	429,572
IV	CALFED	227,560	36,500	42,500	173,206	479,766
V	CALFED	332,280	32,625	32,000	224,251	621,156
VI	CALFED	99,382	18,000	12,000	73,100	202,482
VII	CALFED	168,985	38,000	6,000	120,336	333,321
VIII	CALFED	120,747	18,050	1,500	79,268	219,565
IX	CALFED	0	0	4,065	935	5,000
Boat-2 [6]	CALFED	112,214	16,500	10,000	78,373	217,087
					Total CALFED Funding Requested =	**$3,782,463**
					Percent of Total Cost =	**70.8%**
					Project Total Cost =	**$5,339,351**

[1] From Sections A and B in detailed budgets; Appendix A.
[2] From Sections C and D in detailed budgets; Appendix A.
[3] From Sections E, F and G in detailed budgets; Appendix A.
[4] From Section J in detailed budgets; Appendix A.
[5] Funds for boat time on the R/V Polaris (USGS), see detailed budget: Boat-1
[6] Funds for boat time on the R/V Frontier (USGS) and one full time position, see detailed budget: Boat-2

Table 6. Project involvement of investigator groups. Roman numeral for group corresponds to summary budget groups (Table 5). Detailed budgets for each group are given in Appendix A. Individual investigator biographies are given in Appendix B.

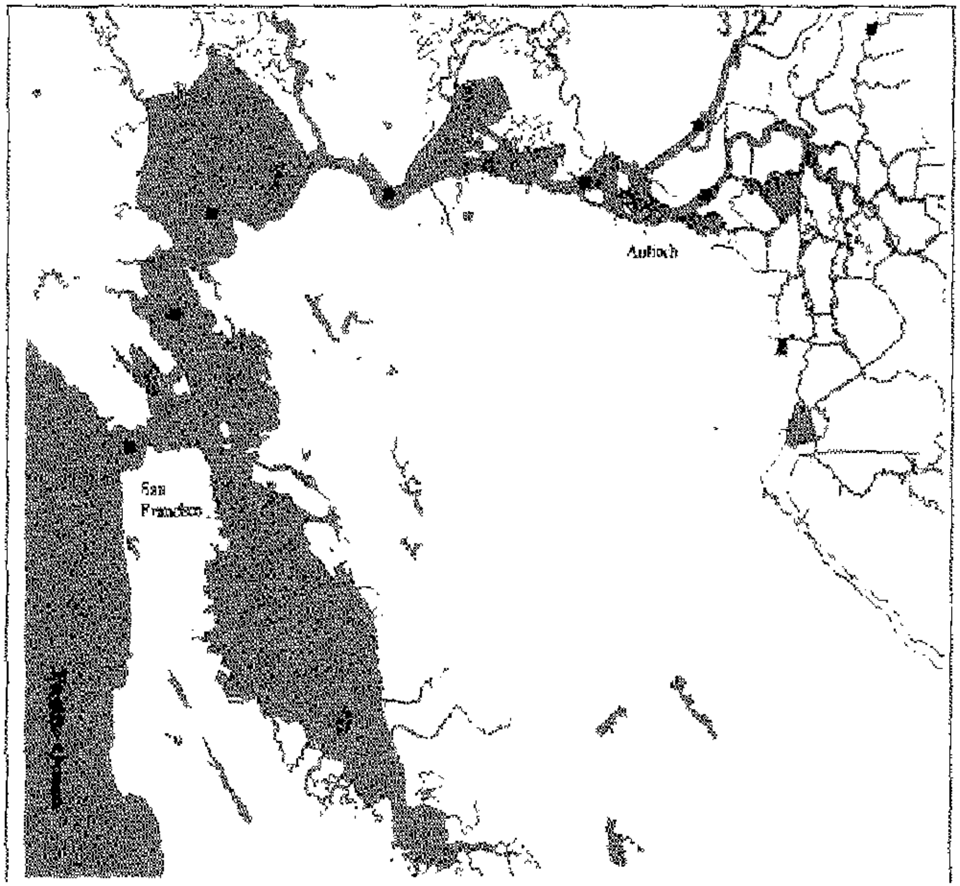
GROUP	INVESTIGATOR(S)	PROJECT INVOLVEMENT
I	**Mark Marvin-DiPasquale** (Microbial Ecologist) **Laurence Miller** (Oceanographer) **Ronald Oremland** (WRD Project Chief) USGS - Menlo Park, CA	microbial Hg-methylation and MeHg-degradation rates, benthic microbial processes (sulfate reduction and methanogenesis), sediment and porewater characterization (redox, nutrients, DOC, DIC); Hg remobilization in restored wetlands - mesocosm experiments
II	**Samuel Luoma** (WRD Project Chief) **Byeong-Gweon Lee** (Biogeochemist) **Robin Bouse** (title) USGS - Menlo Park, CA	sediment origin geochemical signature assessment; Hg uptake by invertebrates - laboratory experiments; Se-Hg interactions at the food web base - laboratory experiments; sediment and water column Se analysis
III	**James Cloern** (WRD Project Chief) USGS - Menlo Park, CA	trophic dynamics / food web assessment, water column and surface sediment characterization, benthic/pelagic invertebrate collection and characterization
IV	**James Kuwabara** (WRD Project Chief) USGS - Menlo Park, CA **George Aiken** (WRD Project Chief) USGS - Boulder, CO	dissolved Hg benthic flux; Hg complexation reactions with dissolved organic carbon and sulfur ligands; dissolved organic matter characterization
V	**David Krabbenhoft** (WRD Project Chief) USGS - Madison, WI	Hg speciation analysis in water, sediment and biota; photochemical MeHg degradation and Hg^{+2} reduction (dissolved gaseous Hg^0 production) experiments

continued....

Table 6. (continued)

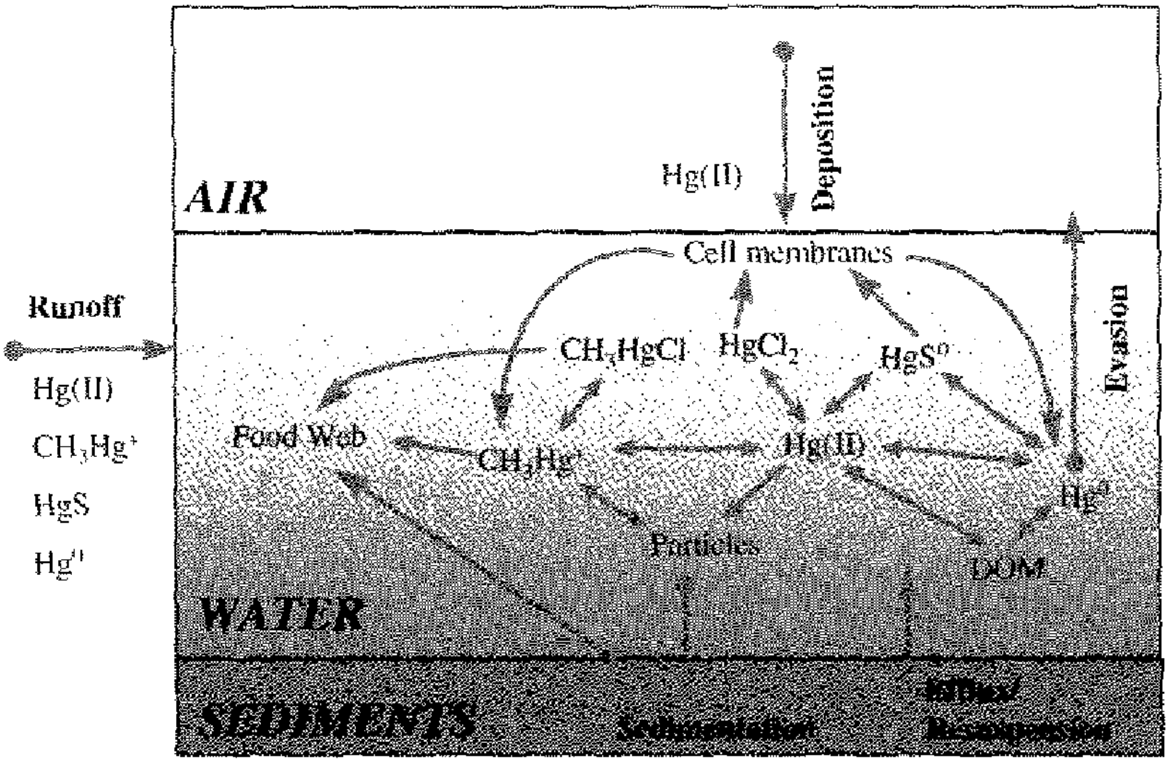
GROUP	INVESTIGATOR(S)	PROJECT INVOLVEMENT
VI	**Michael Saiki** (Fisheries Biologist) USGS-BRD, Dixon, CA	bioaccumulation of Hg in fish, fish collection coordinator; fish gut content analysis; tissue preparation
VII	**Carol Kendall** (WRD Project Chief) USGS - Menlo Park, CA	stable isotope analysis; trophic dynamics / food web assessment
VIII	**Thomas May** (Research Chemist) USGS-BRD Columbia, MO	bioaccumulation of Hg in fish; Total Hg and Se analysis in fish tissue
IX	**Chuck Armor** CA Dept. of Fish and Game Stockton, CA	Fish collection

Figure 1. Locations of sampling sites for assessment of mercury concentrations in water, sediments, seston, and biota. *Numbers indicate primary sampling sites.* Black squares indicate additional sites to be sampled (water and sediment only) during the two 1998 transect cruises. See *Table 1 for site descriptions*



① Sacramento River at Rio Vista; ② Shallows at Prospect Island; ③ Yolo Bypass; ④ Suisun Bay at Ryer Island; ⑤ Montezuma Slough; ⑥ San Joaquin River at IEP station D26; ⑦ Eastern San Pablo Bay; ⑧ Richardson Bay; ⑨ South San Francisco Bay

Figure 2. A generalized model of the mercury cycle in aquatic systems.



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APPENDIX A.

Detailed Budgets for Individual Investigator Groups

APPENDIX A. Detailed Budget **Funds Contributed by the USGS**

Investigator Group: I

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigator(s)					
a. Ronald Oremland (GS 15)	5 of 10	6,700	6,700	6,700	20,100
b. Laurence Miller (GS 13)	20 of 25	13,169	13,545	13,922	40,636
2. Others					
a. Allana Burns (GS 9)	5 of 10	1,691	1,746	1,800	5,237
TOTAL SALARIES		21,560	21,991	22,422	65,973
B. BENEFITS					
1. Principal Investigator(s)					
a. Ronald Oremland (GS 15)		1,005	1,005	1,005	6,030
b. Laurence Miller (GS 13)		3,951	4,064	4,176	12,191
2. Others					
a. Allana Burns (GS 9)		507	524	540	1,571
TOTAL BENEFITS		5,463	5,592	5,721	19,792
C. PERMANENT EQUIPMENT*		10,000	10,000	5,000	30,000
D. EXPENDABLES		0	0	0	0
E. TRAVEL		0	0	0	0
F. PUBLICATIONS		0	0	0	0
G. OTHER COSTS					
a. Vehicles: (lab truck & suburban)		3,000	3,000	1,500	7,500
TOTAL OTHER COSTS		3,000	3,000	1,500	7,500
I. TOTAL DIRECT COSTS (A-G)		40,023	40,583	34,643	123,265
J. INDIRECT COSTS (@ 56.5 % of direct costs)		22,613	22,929	19,573	69,644
K. TOTAL COSTS (I +J)		62,636	63,513	54,216	192,909

* In-kind contribution of existing equipment

APPENDIX A. Detailed Budget **Funds Contributed by the USGS**

Investigator Group: II

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigator(s)					
a. Samual Luoma (GS 15)	15 of 20	16,230	16,230	16,230	48,690
2. Others					
a. Michelle Hornberger (GS 11)	35 of 40	15,120	15,120	15,120	45,360
b. Cynthia Brown (GS 11)	15 of 20	6,480	6,480	6,480	19,440
TOTAL SALARIES		37,830	37,830	37,830	113,490
B. BENEFITS					
1. Principal Investigator(s)					
a. Samual Luoma (GS 15)		1,948	1,948	1,948	5,843
2. Others					
a. Michelle Hornberger (GS 11)		4,234	4,234	4,234	12,701
b. Cynthia Brown (GS 11)		1,814	1,814	1,814	5,443
TOTAL BENEFITS		7,996	7,996	7,996	23,987
C. PERMANENT EQUIPMENT*		15,000	15,000	7,500	37,500
D. EXPENDABLES		0	0	0	0
E. TRAVEL		0	0	0	0
F. PUBLICATIONS		2,000	3,000	3,000	8,000
G. OTHER COSTS					
TOTAL OTHER COSTS		0	0	0	0
I. TOTAL DIRECT COSTS (A-G)		62,826	63,826	56,326	182,977
J. INDIRECT COSTS (@ 56.5% of direct costs)		35,496	36,061	31,824	103,382
K. TOTAL COSTS (I +J)		98,322	99,887	88,150	286,359

* In-kind contribution of existing equipment

APPENDIX A. Detailed Budget **Funds Contributed by the USGS**

Investigator Group: III

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigator(s)					
a. James Cloern (GS 15)	15 of 20	15,757	16,229	16,716	48,702
2. Others					
a. Jody Edmunds (GS 9)	15 of 20	5,394	5,556	5,723	16,673
b. Brian Cole (GS 13)	15 of 20	10,754	11,077	11,410	33,241
TOTAL SALARIES		31,905	32,862	33,848	98,615
B. BENEFITS					
1. Principal Investigator(s)					
a. James Cloern (GS 15)		2,127	2,191	2,257	6,575
2. Others					
a. Jody Edmunds (GS 9)		1,618	1,667	1,717	5,002
b. Brian Cole (GS 13)		3,226	3,323	3,423	9,972
TOTAL BENEFITS		6,972	7,181	7,396	21,549
C. PERMANENT EQUIPMENT					0
D. EXPENDABLES					0
E. TRAVEL					0
F. PUBLICATIONS		1,000	2,500	3,000	6,500
G. OTHER COSTS					
I. TOTAL DIRECT COSTS (A-G)		39,877	42,543	44,245	126,664
J. INDIRECT COSTS (@ 56.5% of direct costs)		22,530	24,037	24,998	71,565
K. TOTAL COSTS (I +J)		62,407	66,579	69,243	198,229

APPENDIX A. Detailed Budget **Funds Contributed from the USGS**
Investigator Group: IV

	%Effort	Year 1 ('97-'98)	Year 2 ('98-'99)	Year 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigators					
a. George Aiken (Chemist, GS 14)	25 of 30	18,291	18,820	18,820	55,931
b. James Kuwabara (Hydrologist, GS 14)	25 of 30	19,828	19,828	20,379	60,035
2. Others					
a. Brent Topping (Hydrologist, GS7)	25 of 30	6,850	7,071	7,291	21,212
b. Janece Koleis (Hydrologist, GS7)	15 of 20	3,425	3,535	3,646	10,606
TOTAL SALARIES		48,394	49,254	50,136	147,784
B. BENEFITS					
1. Principal Investigators					
a. George Aiken (Chemist, GS 14)		2,451	2,522	2,522	7,495
b. James Kuwabara (Hydrologist, GS 14)		2,657	2,657	2,731	8,045
2. Others					
a. Brent Topping (Hydrologist, GS7)		2,055	2,121	2,187	6,364
b. Janece Koleis (Hydrologist, GS7)		1,027	1,061	1,094	3,182
TOTAL BENEFITS		8,190	8,361	8,534	25,085
C. PERMANENT EQUIPMENT		8,000	-	-	8,000
D. EXPENDABLES		4,000	4,000	2,000	10,000
E. TRAVEL (Personnel and equipment)		1,000	1,000	2,000	4,000
F. PUBLICATIONS	Kuwabara >	500	500	1,000	2,000
	Aiken >	1,000	1,000	1,000	3,000
G. OTHER					
a. analytical expenses		5,000	5,000	1,000	11,000
I. TOTAL DIRECT COSTS (A-G)		76,084	69,115	65,670	210,869
J. INDIRECT COSTS (56.5% of direct costs)		42,987	39,050	37,104	119,141
K. TOTAL USGS CONTRIBUTIONS (I + J)		119,072	108,165	102,774	330,010

APPENDIX A. Detailed Budget **Funds Contributed by the USGS**

Investigator Group: V

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigator(s)					
a. David Krabbenhoft (GS 14)	10%	7,248	7,466	7,689	22,403
2. Others					
a. Jim Hurley (Univ. of Wisc.)	5%	3,750	3,788	3,825	11,363
TOTAL SALARIES		10,998	11,254	11,514	33,766
B. BENEFITS					
1. Principal Investigator(s)					
a. David Krabbenhoft (GS 14)		1,450	1,493	1,538	4,481
2. Others					
a. Jim Hurley (Univ. of Wisc.)		1,388	1,402	1,415	4,204
TOTAL BENEFITS		2,837	2,895	2,953	8,685
C. PERMANENT EQUIPMENT*		10,500	10,500	10,500	31,500
D. EXPENDABLES					0
E. TRAVEL					0
F. PUBLICATIONS					0
G. OTHER COSTS					0
I. TOTAL DIRECT COSTS (A-G)		24,335	24,649	24,967	73,951
J. INDIRECT COSTS (@56.5% of direct costs)		13,749	13,927	14,106	41,782
K. TOTAL COSTS (I +J)		38,084	38,575	39,073	115,733

* In-kind contribution of existing equipment

APPENDIX A. Detailed Budget **Funds Contributed by the USGS**

Investigator Group: VI

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigator(s)					
a. M.K. Saiki	20 of 25	13,734	14,284	14,856	42,874
TOTAL SALARIES		13,734	14,284	14,856	42,874
B. BENEFITS					
1. Principal Investigator(s)					
a. M.K. Saiki		2,060	2,143	2,228	6,431
TOTAL BENEFITS		2,060	2,143	2,228	6,431
C. PERMANENT EQUIPMENT*		7,500	0	0	7,500
D. EXPENDABLES		1,500	1,500	1,500	4,500
E. TRAVEL					0
F. PUBLICATIONS					0
G. OTHER COSTS					0
I. TOTAL DIRECT COSTS (A-G)		24,795	17,927	18,584	61,306
J. INDIRECT COSTS (@ 56.5 % of direct costs)		14,009	10,129	10,500	34,638
K. TOTAL COSTS (I +J)		38,803	28,055	29,085	95,943

* In-kind contribution of existing equipment

APPENDIX A. Detailed Budget **Funds Contributed by the USGS**

Investigator Group: VII

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigator(s)					
a. Carol Kendall (Hydrologist, GS-14)	5 of 10	3,952	4,070	4,192	12,214
2. Others					
a. Cecily Chang (Hydrologist, GS-12)	5 of 10	2,667	2,747	2,829	8,242
TOTAL SALARIES		6,618	6,817	7,021	20,456
B. BENEFITS					
1. Principal Investigator(s)					
a. Carol Kendall (Hydrologist, GS-14)		407	419	432	1,258
2. Others					
a. Cecily Chang (Hydrologist, GS-12)		267	275	283	824
TOTAL BENEFITS		674	694	715	2,082
C. PERMANENT EQUIPMENT*		5,000	5,000	5,000	15,000
D. EXPENDABLES					
E. TRAVEL					
F. PUBLICATIONS		2,000	2,500	3,000	7,500
G. OTHER COSTS					
I. TOTAL DIRECT COSTS (A-G)		14,292	15,010	15,736	45,038
J. INDIRECT COSTS (@ 56.5% of direct costs)		8,075	8,481	8,891	25,446
K. TOTAL COSTS (I +J)		22,366	23,491	24,626	70,484

* In-kind contribution of existing equipment

APPENDIX A. Detailed Budget — **Funds Contributed by the USGS**
Investigator Group: VIII

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
TOTAL SALARIES		0	0	0	0
B. BENEFITS					
TOTAL BENEFITS		0	0	0	0
C. PERMANENT EQUIPMENT*		52,500	26,600	17,500	96,600
D. EXPENDABLES					
E. TRAVEL					0
F. PUBLICATIONS					0
G. OTHER COSTS					0
I. TOTAL DIRECT COSTS (A-G)		52,500	26,600	17,500	96,600
J. INDIRECT COSTS (@ 56.5% of direct cost)		29,663	15,029	9,888	54,579
K. TOTAL COSTS (I +J)		82,163	41,629	27,388	151,179

* In-kind contribution of existing equipment

APPENDIX A. Detailed Budget **Contributions from CA Dept. of Fish and Game**
Investigator Group: IX

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigator(s)					
a. Charles Armor	5	4,500	2,250	2,250	9,000
2.Others					
a. Boat Operator	3	1,408	704	704	2,816
b. Deckhand	3	1,104	552	552	2,208
c. Crew	3	728	364	364	1,456
TOTAL SALARIES		7,740	3,870	3,870	15,480
B. BENEFITS					
1. Principal Investigator(s)					
a. Charles Armor		1,395	698	698	2,700
2.Others					
a. Boat Operator		422	211	211	845
b. Deckhand		331	166	166	662
c. Crew		218	109	109	437
TOTAL BENEFITS		2,367	1,184	1,184	4,644
C. PERMANENT EQUIPMENT*		1,000	500	500	2,000
D. EXPENDABLES		960	480	480	1,920
E. TRAVEL		160	80	80	320
F. PUBLICATIONS					0
G. OTHER COSTS		800	400	400	1,600
I. TOTAL DIRECT COSTS (A-G)		13,027	6,514	6,514	25,964
J. INDIRECT COSTS (@ 23% of direct costs)		2,996	1,498	1,498	5,972
K. TOTAL COSTS (I +J)		16,023	8,012	8,012	31,936

* In-kind contribution of existing equipment

APPENDIX A. Detailed Budget **Funds Contributed by the USGS**
Investigator Group: Boat-1 **The R/V Polaris**

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
a. Boat Operator	5	4,500	4,500	2,250	11,250
b. crew	5	6,000	6,000	3,000	15,000
TOTAL SALARIES		10,500	10,500	5,250	26,250
B. BENEFITS					
a. Boat Operator		1,350	1,350	675	3,375
b. crew		1,800	1,800	900	4,500
TOTAL BENEFITS		3,150	3,150	1,575	7,875
C. PERMANENT EQUIPMENT*		2,000	2,000	1,000	5,000
D. EXPENDABLES		5,000	5,000	2,500	12,500
E. TRAVEL					0
F. PUBLICATIONS					0
G. OTHER COSTS		1,000	1,000	500	2,500
I. TOTAL DIRECT COSTS (A-G)		21,650	21,650	10,825	54,125
J. INDIRECT COSTS (@ 56.5% of direct costs)		12,232	12,232	6,116	30,581
K. TOTAL COSTS (I +J)		33,882	33,882	16,941	84,706

* In-kind contribution of existing equipment

APPENDIX A. Detailed Budget **Funds Requested From CALFED**

Investigator Group: 1

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigator(s)					
a. Ronald Oremland (GS 15)	5 of 10	6,700	6,700	6,700	20,100
b. Mark Marvin-DiPasquale (GS 11)	100	48,842	50,162	51,482	150,486
c. Laurence Miller (GS 13)	5 of 25	6,585	6,773	6,961	20,318
2. Others					
a. Technician (GS 5)	100	21,601	22,321	23,042	66,964
b. Allana Burns (GS 9)	5 of 10	1,691	1,746	1,800	5,237
TOTAL SALARIES		85,419	87,701	89,985	263,105
B. BENEFITS					
1. Principal Investigator(s)					
a. Ronald Oremland (GS 15)		2,010	2,010	2,010	6,030
b. Mark Marvin-DiPasquale (GS 11)		14,653	15,049	15,445	45,146
c. Laurence Miller (GS 13)		1,975	2,032	2,088	6,095
2. Others					
a. Technician (GS 5)		6,480	6,696	6,913	20,089
b. Allana Burns (GS 9)		507	524	540	1,571
TOTAL BENEFITS		25,626	26,310	26,995	78,931
C. PERMANENT EQUIPMENT		5,000	-	-	5,000
D. EXPENDABLES		15,000	15,000	7,500	37,500
E. TRAVEL		5000	5000	2500	12,500
F. PUBLICATIONS		1000	2000	2000	5,000
G. OTHER COSTS					
a. Vehicles: (lab truck & suburban)		USGS	USGS	USGS	USGS
TOTAL OTHER COSTS		0	0	0	0
I. TOTAL DIRECT COSTS (A-G)		137,044	136,012	128,980	402,036
J. INDIRECT COSTS (@ 56.5 % of direct costs)		77,430	76,847	72,874	227,150
K. TOTAL COSTS (I +J)		214,474	212,858	201,854	629,186

APPENDIX A. Detailed Budget **Funds Requested From CALFED**

Investigator Group: II

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigator(s)					
a. Samual Luoma (GS 15)	5 of 20	5,410	5,410	5,410	16,230
b. Robin Bouse (GS 11)	70	30,000	31,000	32,000	93,000
c. Byeong-Gweon Lee (GS 12)	100	48,886	50,352	51,863	151,101
2. Others					
a. Michelle Hornberger (GS 11)	5 of 40	2,160	2,160	2,160	6,480
b. Cynthia Brown (GS 11)	5 of 20	2,160	2,160	2,160	6,480
c. student (GS 7)	50	11,000	11,000	11,000	33,000
TOTAL SALARIES		99,616	102,082	104,593	306,291
B. BENEFITS					
1. Principal Investigator(s)					
a. Samual Luoma (GS 15)		649	649	649	1,948
b. Robin Bouse (GS 11)		6,000	6,200	6,400	18,600
c. Byeong-Gweon Lee (GS 12)		14,666	15,106	15,559	45,330
2. Others					
a. Michelle Hornberger (GS 11)		605	605	605	1,814
b. Cynthia Brown (GS 11)		605	605	605	1,814
c. student (GS 7)		2,500	2,500	2,500	7,500
TOTAL BENEFITS		24,375	25,015	25,669	75,059
C. PERMANENT EQUIPMENT					0
D. EXPENDABLES		10,000	10,000	5,000	25,000
E. TRAVEL		2,000	2,000	2,000	6,000
F. PUBLICATIONS		USGS	USGS	USGS	USGS
G. OTHER COSTS					
TOTAL OTHER COSTS					0
I. TOTAL DIRECT COSTS (A-G)		135,991	139,097	137,262	412,350
J. INDIRECT COSTS (@ 56.5%)		76,835	78,590	77,553	232,978
K. TOTAL COSTS (I +J)		212,827	217,687	214,814	645,328

APPENDIX A. Detailed Budget **Funds Requested from CALFED**

Investigator Group: III

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigator(s)					
a. James Cloern (GS 15)	5 of 20	5,252	5,410	5,572	16,234
2. Others					
a. Postdoctoral Associate (GS 12)	100	48,886	50,352	51,863	151,101
b. Jody Edmunds (GS 9)	5 of 20	1,798	1,852	1,908	5,558
c. Brian Cole (GS 13)	5 of 20	3,585	3,692	3,803	11,080
TOTAL SALARIES		59,521	61,306	63,146	183,973
B. BENEFITS					
1. Principal Investigator(s)					
a. James Cloern (GS 15)		709	730	752	2,192
2. Others					
a. Postdoctoral Associate (GS 12)		14,666	15,106	15,559	45,331
b. Jody Edmunds (GS 9)		539	556	572	1,667
c. Brian Cole (GS 13)		1,075	1,108	1,141	3,324
TOTAL BENEFITS		16,990	17,500	18,024	52,514
C. PERMANENT EQUIPMENT		5,000			5,000
D. EXPENDABLES		7,000	8,000	2,000	17,000
E. TRAVEL		6,000	7,000	3,000	16,000
F. PUBLICATIONS		USGS	USGS	USGS	USGS
G. OTHER COSTS					
TOTAL OTHER COSTS					0
I. TOTAL DIRECT COSTS (A-G)		94,511	93,806	86,170	274,487
J. INDIRECT COSTS (@ 56.5 % of direct costs)		53,399	53,000	48,686	155,085
K. TOTAL COSTS (I +J)		147,910	146,806	134,856	429,572

APPENDIX A. Detailed Budget **Funds Requested from CALFED**

Investigator Group: IV

	%Effort	Year 1 ('97-'98)	Year 2 ('98-'99)	Year 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigators					
a. George Aiken (Chemist, GS 14)	5 of 30	3,658	3,764	3,764	11,186
b. James Kuwabara (Hydrologist, GS 14)	5 of 30	3,966	3,966	4,076	12,007
2. Others					
a. Brent Topping (Hydrologist, GS7)	5 of 30	1,370	1,414	1,458	4,242
b. Janece Koleis (Hydrologist, GS7)	5 of 20	228	236	243	707
d. Graduate Student, GS7 (Menlo Park)	100	26,755	27,647	28,539	82,941
e. Graduate Student, GS5-7 (Boulder)	100	20,898	25,885	26,748	73,531
f. Oscar Mace (Biologist, GS7)	10	2,676	2,765	2,854	8,294
g. Jane Caffrey (UC Santa Cruz)		4,100	4,100	4,100	12,300
TOTAL SALARIES		63,651	69,776	71,782	205,209
B. BENEFITS					
1. Principal Investigators					
a. George Aiken (Chemist, GS 14)		490	504	504	1,499
c. James Kuwabara (Hydrologist, GS 14)		531	531	546	1,609
2. Others					
a. Brent Topping (Hydrologist, GS7)		411	424	437	1,273
b. Janece Koleis (Hydrologist, GS7)		68	71	73	212
d. Graduate Student, GS7		2,047	2,115	2,183	6,345
e. Graduate Student, GS7		1,599	1,980	2,046	5,625
f. Oscar Mace (Biologist, GS7)		803	829	856	2,488
g. Jane Caffrey (UC Santa Cruz)		1,100	1,100	1,100	3,300
TOTAL BENEFITS		7,049	7,556	7,747	22,351
C. PERMANENT EQUIPMENT	Kuwabara >	8,000	-	-	8,000
	Aiken >	5,000	2,500	-	7,500
D. EXPENDABLES	Kuwabara >	4,000	4,000	2,000	10,000
	Aiken >	5,000	5,000	1,000	11,000
E. TRAVEL (Personnel and equipment)	Kuwabara >	1,000	1,000	2,000	4,000
	Aiken >	7,500	7,500	5,000	20,000
F. PUBLICATIONS		500	500	1,000	2,000
G. OTHER					
1. Shipping (Equipment transport)		2,500	2,500	500	5,500
2. Analytical Expenses		5,000	5,000	1,000	11,000
I. TOTAL DIRECT COSTS (A-G)		109,199	105,332	92,029	306,560
J. INDIRECT COSTS (56.5% of direct costs)		61,698	59,512	51,996	173,206
K. TOTAL COSTS (I + J)		170,897	164,844	144,025	479,766

APPENDIX A. Detailed Budget **Funds Requested from CALFED**

Investigator Group: V

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigator(s)					
a. David Krabbenhoft (GS 15)	20%	14,496	14,931	15,378	44,805
2. Others					
Mark Olson (GS 12)	50%	29,250	30,128	31,031	90,409
John Dewild (GS 9)	50%	21,060	21,691	22,343	65,094
Barb Scudder (GS 12)	25%	14,940	15,388	15,850	46,178
Jeff Steuer (GS 11)	10%	6,000	6,180	6,365	18,545
Shane Olund (Student Hourly)	15%	3,840	3,955	4,074	11,869
TOTAL SALARIES		89,586	92,273	95,041	276,900
B. BENEFITS					
1. Principal Investigator(s)					
David Krabbenhoft		2,899	2,986	3,076	8,961
2. Others					
Mark Olson (GS 12)		5,850	6,026	6,206	18,082
John Dewild (GS 9)		4,212	4,338	4,469	13,019
Barb Scudder (GS 12)		2,988	3,078	3,170	9,236
Jeff Steuer (GS 11)		1,200	1,236	1,273	3,709
Shane Olund (Student Hourly)		768	791	815	2,374
TOTAL BENEFITS		17,917	18,455	19,008	55,380
C. PERMANENT EQUIPMENT		10,500			10,500
D. EXPENDABLES		14,125	5,000	3,000	22,125
E. TRAVEL		10,000	10,000	5,000	25,000
F. PUBLICATIONS		2,000	2,000	3,000	7,000
G. OTHER COSTS					
I. TOTAL DIRECT COSTS (A-G)		144,128	127,728	125,049	396,905
J. INDIRECT COSTS (@56.5% of direct costs)		81,432	72,166	70,653	224,251
K. TOTAL COSTS (I +J)		225,561	199,894	195,702	621,156

APPENDIX A. Detailed Budget
Investigator Group: VI

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
		Funds Requested from CALFED			
A. SALARIES					
1. Principal Investigator(s)					
M.K. Saiki	5 of 25	3,434	3,571	3,714	10,719
2. Others					
Technician (GS 5)	100	21,601	22,321	23,042	66,964
TOTAL SALARIES		25,035	25,892	26,756	77,683
B. BENEFITS					
1. Principal Investigator(s)					
M.K. Saiki		515	536	557	1,608
2. Others					
Technician (GS 5)		6,481	6,697	6,913	20,091
TOTAL BENEFITS		6,996	7,233	7,470	21,699
C. PERMANENT EQUIPMENT		5,000	0	0	5,000
D. EXPENDABLES		5,000	5,000	3,000	13,000
E. TRAVEL		2,500	2,500	2,500	7,500
F. PUBLICATIONS		1,000	1,500	2,000	4,500
G. OTHER COSTS					
I. TOTAL DIRECT COSTS (A-G)		45,531	42,125	41,726	129,381
J. INDIRECT COSTS (@ 56.5 % of direct costs)		25,725	23,800	23,575	73,100
K. TOTAL COSTS (I +J)		71,255	65,925	65,301	202,482

APPENDIX A. Detailed Budget **Funds Requested From CALFED**

Investigator Group: VII

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigator(s)					
a. Carol Kendall (Hydrologist, GS-14)	5 of 10	3,952	4,070	4,192	12,214
2. Others					
a. Postdoctoral Associate (GS-12)	50	24,443	25,176	25,932	75,551
b. Cecily Chang (Hydrologist, GS-12)	5 of 10	2,667	2,747	2,829	8,242
b. Technician (GS-6)	50	14,502	14,937	15,385	44,824
TOTAL SALARIES		45,563	46,930	48,338	140,831
B. BENEFITS					
1. Principal Investigator(s)					
a. Carol Kendall (Hydrologist, GS-14)		407	419	432	1,258
2. Others					
a. Postdoctoral Associate (GS-12)		7,333	7,553	7,780	22,665
b. Cecily Chang (Hydrologist, GS-12)		267	275	283	824
b. Technician (GS-6)		1,102	1,135	1,169	3,407
TOTAL BENEFITS		9,109	9,382	9,664	28,154
C. PERMANENT EQUIPMENT		5,000			5,000
D. EXPENDABLES		10,000	11,000	12,000	33,000
E. TRAVEL		2,000	2,000	2,000	6,000
F. PUBLICATIONS		USGS	USGS	USGS	
G. OTHER COSTS					
I. TOTAL DIRECT COSTS (A-G)		71,672	69,311	72,002	212,985
J. INDIRECT COSTS (@ 56.5% of direct costs)		40,495	39,161	40,681	120,336
K. TOTAL COSTS (I +J)		112,166	108,472	112,682	333,321

APPENDIX A. Detailed Budget **Funds Requested from CALFED**

Investigator Group: VIII

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigator(s)					
T. W. May	25	16,038			16,038
T.W. May	10		6,415	6,415	12,830
2. Others					
technician (GS 9)	75	26,350			26,350
technician (GS 9)	40		14,053		14,053
technician (GS 9)	20			7,027	7,027
Contractual technician	50	9,360			9,360
Contractual technician	25		4,680		4,680
Contractual technician	10			1,872	1,872
TOTAL SALARIES		51,748	25,148	15,314	92,210
B. BENEFITS					
1. Principal Investigator(s)					
T. W. May		2,236			2,236
T.W. May			894	894	1,788
2. Others					
technician (GS 9)		9,041			9,041
technician (GS 9)			4,822		4,822
technician (GS 9)				2,411	2,411
Contractual technician		4,847			4,847
Contractual technician			2,423		2,423
Contractual technician				969	969
TOTAL BENEFITS		16,124	8,139	4,274	28,537
C. PERMANENT EQUIPMENT		1,650			1,650
D. EXPENDABLES		10,000	6,400	0	16,400
E. TRAVEL					
F. PUBLICATIONS		500	500	500	1,500
G. OTHER COSTS					
I. TOTAL DIRECT COSTS (A-G)		80,022	40,187	20,088	140,297
J. INDIRECT COSTS (@ 56.5% of direct cost)		45,212	22,706	11,350	79,268
K. TOTAL COSTS (I +J)		125,234	62,893	31,438	219,565

APPENDIX A. Detailed Budget **Funds Requested from CALFED**

Investigator Group: IX

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
1. Principal Investigator(s)					
a. Charles Armor	5	CDFG	CDFG	CDFG	CDFG
2.Others					
a. Boat Operator	3	CDFG	CDFG	CDFG	CDFG
b. Deckhand	3	CDFG	CDFG	CDFG	CDFG
c. Crew	3	CDFG	CDFG	CDFG	CDFG
TOTAL SALARIES		0	0	0	0
B. BENEFITS					
1. Principal Investigator(s)					
a. Charles Armor		CDFG	CDFG	CDFG	CDFG
2.Others					
a. Boat Operator		CDFG	CDFG	CDFG	CDFG
b. Deckhand		CDFG	CDFG	CDFG	CDFG
c. Crew		CDFG	CDFG	CDFG	CDFG
TOTAL BENEFITS		0	0	0	0
C. PERMANENT EQUIPMENT		CDFG	CDFG	CDFG	CDFG
D. EXPENDABLES		CDFG	CDFG	CDFG	CDFG
E. TRAVEL		CDFG	CDFG	CDFG	CDFG
F. PUBLICATIONS					0
G. OTHER COSTS*		2,000	1,035	1,030	4,065
I. TOTAL DIRECT COSTS (A-G)		2,000	1,035	1,030	4,065
J. INDIRECT COSTS (@ 23% of direct costs)		460	238	237	935
K. TOTAL COSTS (I +J)		2,460	1,273	1,267	5,000

* Supplemental funds requested for additional sampling, above and beyond CDFG's routine sampling effort, that may be needed to fulfill the minimal fish catch per region (n=10-20) requirement anticipated for this project.

APPENDIX A. Detailed Budget **Funds Requested from CALFED**
Investigator Group: Boat-2 **Frontier (25' Whaler w/ Cabin)**

	% Effort	YEAR 1 ('97-'98)	YEAR 2 ('98-'99)	YEAR 3 ('99-'00)	TOTAL
A. SALARIES					
a. Hydrologic Field Tech (GS 9)	100	33,712	34,723	17,883	86,318
TOTAL SALARIES		33,712	34,723	17,883	86,318
B. BENEFITS					
a. Hydrologic Field Tech (GS 9)		10,114	10,417	5,365	25,895
TOTAL BENEFITS		10,114	10,417	5,365	25,895
C. PERMANENT EQUIPMENT					
D. EXPENDABLES		6,000	7,000	3,500	16,500
E. TRAVEL		4,000	4,000	2,000	10,000
F. PUBLICATIONS					
G. OTHER COSTS*					
I. TOTAL DIRECT COSTS (A-G)		53,826	56,140	28,747	138,713
J. INDIRECT COSTS (@ 56.5% of direct costs)		30,411	31,719	16,242	78,373
K. TOTAL COSTS (I +J)		84,237	87,859	44,989	217,085

APPENDIX B.

Curriculum Vitae for Individual Investigators

(alphabetical)

CURRICULUM VITAE: George Aiken

U.S. Geological Survey, 3215 Marine St., Boulder, CO 80303
Phone: (303) 541-3063 , Fax: (303) 447-2505 graiken@servrcolkr.cr.usgs.gov

Education

Colorado School of Mines, Ph.D. 12/91, Applied Chemistry
University of Colorado,M.S. 6/79, Analytical Chemistry
Rutgers, The State University,B.A. 6/73, Chemistry

Professional experience

Project Chief National Research Program, Water Resources Division, U. S. Geological Survey (presently)

National Research Program, U.S. Geological Survey, WRD, since January 1981. Conducting research on the analysis and chemistry of naturally occurring organic compounds aquatic systems.

Research Assistant, Dartmouth College 1/80-12/80. Studied effects of acid rain on soil chemistry in the Adirondacks.

National Research Program, U.S. Geological Survey, WRD, 1/76-12/79. Conducted research on chromatographic techniques for isolating humic substances from water, also studied the movement of organic solutes in groundwater and the effects of humic substances on water purification.

Professional societies

American Chemical Society
American Geophysical Union
Phi Lambda Upsilon, Honorary Chemical Society

Awards and honors

USGS Sustained Special Achievement Award, 1988

Relevant Publications

Aiken, G. R.,McKnight, D. M., Thorn,K.A., and Thurman, E. M., 1992, Isolation of hydrophilic acids from water using macroporous resins. Organic Geochemistry, vol. 18, pp. 567-573.

McKnight, D. M.,Bencala, K. E.,Zellweger, G. W.,**Aiken, G. R.**,Feder, G. L., and Thorn, K. A., 1992, Sorption of dissolved organic material by hydrous aluminum and iron oxides occurring at the confluence of Deer Creek with the Snake River, Summit County, Colorado: Environmental Science and Technology, vol. 26, pp. 1388-1396.

Aiken, G.,Capel, P., Furlong, E.,Hult, M. and Thorn, K., 1992, Mechanisms controlling the fate and transport of organic chemicals in groundwater: In Mallard, G. E., and Aronson, D. A.,eds.,U. S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the Technical Meeting, Monterey, California, March 11-15, 1991, Water Resources Investigations Report 91-4034, pp. 633-637.

Wershaw, R. L.,**Aiken, G. R**, and Imbrigiotta, T. E , 1992, Characterization of high molecular weight colored compounds in groundwater at the Picatinny Arsenal, New Jersey: In Mallard, G. E., and Aronson, D. A.,eds.,U. S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the Technical Meeting, Monterey, California, March 11-15, 1991, Water Resources Investigations Report 91-4034, pp. 726-730.

Goldberg, M. C.,Cunningham, K. M.,**Aiken, G. R** and Weiner, E. R., 1992, The aqueous photolysis of apinene in solution with humic acid: Journal of Contaminant Hydrology, vol. 9, pp. 79-89.

Aiken, G. R, 1992, Chloride interference in the analysis of dissolved organic carbon by the wet oxidation method: Environmental Science and Technology, vol. 26, pp. 2435-2439.

McKnight, D. M., **Aiken, G. R.**, Andrews, E. D., Bowles, E. C., and Harnish, R. A., 1993, Dissolved organic material in Dry Valley Lakes: A comparison of Lake Fryxell, Lake Hoare, and Lake Vanda. In Dry Valley Lakes, W. J. Green, ed., American Geophysical Union Monograph, vol. 59, 119-133.

Aiken, G. R. and Leenheer, J. A., 1993, Isolation and characterization of dissolved and colloidal organic matter, Chemistry and Ecology, vol. 8, pp. 135-151.

Chin, Y., **Aiken, G.** and O'Loughlin, E., 1994, On the molecular weight, polydispersity and spectroscopoic properties of aquatic humic substances, Environmental Science and Technology, vol. 28, pp. 1853-1858.

Wershaw, R. L., **Aiken, G. R.**, Imbrigotta, T. E., and Goldberg, M. C., 1994, Displacement of soil pore water by trichloroethylene: Journal of Environmental Quality, Vol. 23, pp. 792-798.

McKnight , D. M., Andrews, E. D., Spaulding, S. A., and **Aiken, G. R.**, 1994 Aquatic fulvic acids in algal rich antarctic ponds and comparison with samples from other environments: Limnology and Oceanography, Vol. 39, pp. 1972-1979.

Aiken, G. R., McKnight, D. M., Wershaw, R. L., and Harnish, R., 1996, Geochemistry of aquatic humic substances in the Lake Fryxell basin, Antarctica: Biogeochemistry, Vol. 34, pp. 157-188.

Miller, L. G. and **Aiken, G. R.**, 1996, Stable isotope and tritium hydrology of Lake Fryxell, Taylor Valley, Antarctica: Limnology and Oceanography, Vol. 41, p. 966-976.

Aiken, G. R., 1996, Studies on the molecular size of dissolved organic carbon fraction downgradient of the oil body at Bemidji, Minnesota, In Morganwalp, D.W., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the Technical Meeting, Colorado Springs, Colorado, September 20-24, 1993: U.S. Geological Survey Water-Resources Investigations Report 94-4014.

Cozzarelli, I. M., Baedecker, M. J., **Aiken, G.** and Phinney, C., 1996, Small scale chemical heterogeneities in a crude oil contaminated aquifer, Bemidji, Minnesota, In Morganwalp, D.W., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the Technical Meeting, Colorado Springs, Colorado, September 20-24, 1993: U.S. Geological Survey Water-Resources Investigations Report 94-4014.

Metge, D. W., Harvey, R. W., **Aiken, G. R.**, and Barber, L. B., 1996, Use of static column experiments to identify factors affecting bacterial attachment in contaminated aquifer sediments from Cape Cod, Massachusetts, In Morganwalp, D.W., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the Technical Meeting, Colorado Springs, Colorado, September 20-24, 1993: U.S. Geological Survey Water-Resources Investigations Report 94-4014.

Reddy, M., **Aiken, G**, Schuster, P., Gunther, C., Charlton, S., and Tregellas, J. 1996, Summary of Data from On site and Laboratory Analyses of Surface Water and Marsh Porewater from South Florida Water Management District Water Conservation Areas, the Everglades, South Florida, March, 1995 U. S. Geological Survey Water Supply, electronic distribution on World Wide Web.

Reddy, M. M., Schuster, P. F., Gunther, C., Charlton, S., and **Aiken, G.** 1996, Summary of major ion chemical data from onsite and laboratory analysis of groundwater samples from the surficial and deep artesian aquifers, Las Vagas, Nevada, April and August 1993, U. S. Geological Survey Water Supply, electronic distribution on World Wide Web.

Breault, R. F., Colman, J.A., **Aiken, G.R.**, and McKnight, D. M., 1996, Copper speciation and binding by organic matter in stream water: Environmental Science and Technology, Vol.30, pp.3477-3486.

CURRICULUM VITAE: Charles Armor

Bay-Delta and Special Water Projects Division, CA Dept. of Fish and Game
4001 North Wilson Way, Stockton, CA 95205
(209) 948-7800, Fax: (209) 946-6355, carmor@delta.dfg.ca.gov

Education

M.A. Biological Sciences, 1976, California State University, Chico
B.A. Biological Sciences, 1971, California State University, Chico

Professional Experience

Senior Biologist - Supervisor, 1991 to present, CA Dept. of Fish and Game, Stockton, CA
Associate Fishery/Marine Biologist, 1985-1991, CA Dept. of Fish and Game, Stockton, CA
Biologist, Fishery/Marine, 1980-1985, CA Dept. of Fish and Game, Stockton, CA
Water Quality Biologist, 1977-1979, CA Dept. of Fish and Game, Long Beach, CA

Research Interests

Estuarine fish and macro invertebrate community dynamics

Memberships

American Fisheries Society 1980-present
Estuarine Research Federation 1984-present

Relevant Publications

Jassby, A. D., W. J. Kimmerer, S. G. Monismith, C. **Armor**, J. E. Cloern, T. M. Powell, J. R. Schubel and T. J. Vendlinski. 1995. Isohaline position as a habitat indictor for estuarine populations. Ecol. Appl. 5:272-289.

California Department of Fish and Game. 1992. Estuary dependent species. Exhibit 6, entered for the State Water Resources Control Board 1992 Water Quality/Water Rights Proceedings on the San Francisco Bay and Sacramento-San Joaquin Delta. 97 pp.

California Department of Fish and Game. 1987. Delta outflow effects on the abundance and distribution of San Francisco Bay fish and invertebrates, 1980-1985. Exhibit 60, entered for the State Water Resources Control Board 1987 Water Quality/Water Rights Proceeding on the San Francisco Bay and Sacramento-San Joaquin Delta, 345 pp.

Armor, C. and P. L. Herrgesell. 1985. Distribution and abundance of fishes in the San Francisco Bay estuary between 1980 and 1982. Hydrobiologia 129:211-227.

CURRICULUM VITAE: Robin M. Bouse

U.S. Geological Survey, 345 Middlefield Rd., MS 465, Menlo Park, CA 94025
Phone: (415) 329-4448, FAX (415) 329-4463, rmbouse@usgs.gov

Education

University of Arizona, Tucson AZ, Ph.D. in Geosciences, 1995
University of Rhode Island, Kingston, RI, M.S. in Geology, 1988
Duke University, Durham, NC, B.S. in Geology, 1981

Professional Experience

Physical Scientist, USGS, Water Resources Division, Menlo Park, CA, 1994 to present
Geochemist, Branch of Isotope Geology, USGS, Geologic Division, Menlo Park, CA, 1990-1993
Geologist, Branch of Atlantic Marine Geology, USGS, Geologic Division, Woods Hole, MA, 1986-1990
Physical Science Technician, Branch of Pacific Marine Geology, USGS, Geologic Division, Menlo Park, CA, 1981-1986

Memberships in Professional Societies

American Geophysical Union, 1988 to present
Geological Society of America, 1984 to present

Relevant Publications

Bouse, R. M., Hornberger, M. I., and Luoma, S. N., 1996, Sr and Nd compositions and trace element concentrations in San Francisco Bay cores distinguish sediment deposited from hydraulic gold-mining and mercury mining: (Abstract) Eos, Transactions, American Geophysical Union 1996 Fall Meeting, v. 77, p. 201.

Bouse, R. M., Hornberger, M. I., and Luoma, S. N., 1996, Geochemical signatures from mercury mining and hydraulic gold-mining in San Francisco Bay sediments, (Abstract) Third Biennial State of the Estuary Conference, San Francisco, p. 41.

CURRICULUM VITAE: JAMES E. CLOERN

U.S. Geological Survey, MS 496, 345 Middlefield Rd., Menlo Park, CA 94025
telephone: 415-329-4594, FAX: 415-329-4327, email: jecloern@usgs.gov

Education

University of Wisconsin-Madison, B.S. 1970, Zoology
University of Wisconsin-Milwaukee, M.S. 1973, Zoology
Washington State University, Ph.D. 1976, Zoology

Research and Professional Experience

1976-present	Research Scientist, U.S. Geological Survey, Menlo Park, CA
1997	Lecturer, University of California-Santa Cruz
1997	Consulting Professor, Stanford University
1993-1994	Directeur de Recherche, Université d'Aix-Marseille, France

Research Interests

Ecology and biogeochemistry of estuaries and lakes, with focus on phytoplankton. Team leader of a 20-year investigation of San Francisco Bay that has included study/measurement of: primary production, algal and zooplankton community dynamics, net ecosystem metabolism, the carbon budget, light and nutrient limitation of algal growth, grazing by benthic suspension feeders, disturbance by introduced species, impacts of climatic/hydrologic variability, phytoplankton bloom dynamics, biogeochemical significance of algal blooms, benthic and pelagic nutrient regeneration, use of stable isotopes and lipid biomarkers to characterize sources of organic matter, variability at time scales from hours to decades and spatial scales from meters to kilometers.

Highlights

Steering Committee, 1997 Aquatic Sciences Meeting, Santa Fe
Fulbright Research Scholar, 1993-94 (Centre d'Océanologie de Marseille)
U.S. Department of Interior Meritorious Service Award, 1991
Editorial Board, *Limnology and Oceanography*, 1989-1992
Associate Editor, *Estuaries*, 1989-1994
Program Chair, 1991 Estuarine Research Federation Meeting, San Francisco
National Science Foundation Advisory Panels for Ocean Sciences Research, 1988, 1992

Relevant Publications

Cloern, J.E., 1991, Tidal stirring and phytoplankton bloom dynamics in an estuary: Journal of Marine Research, v. 49, p. 203-221.

Alpine, A.E., and **Cloern, J.E.**, 1992, Trophic interactions and direct physical effects control phytoplankton biomass and production in an estuary: Limnology and Oceanography, v. 37, p. 946-955.

Jassby, A.D., **Cloern, J.E.**, and Powell, T.M., 1993, Organic carbon sources and sinks in San Francisco Bay: variability induced by river flow: Marine Ecology Progress Series, v. 95, p. 39-54.

Canuel, E.A., **Cloern, J.E.**, Ringelberg, D., Guckert, J., and Rau, G., 1995, Molecular and isotopic tracers used to understand sources of organic matter and trophic relationships in the San Francisco Bay estuary: Limnology and Oceanography, v. 40, p. 67-81.

Cloern, J.E., 1996. Phytoplankton bloom dynamics in coastal ecosystems: A review with some general lessons from sustained investigation of San Francisco Bay, California: Reviews of Geophysics, Vol. 34, No. 2, p. 127-168.

Jassby, A.D., Cole, B.E., and **Cloern, J.E.**, 1997. Towards the design of sampling networks for characterizing water quality change in estuaries: Estuarine, Coastal and Shelf Science (in press).

CURRICULUM VITAE: Carol Kendall

United States Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025
tel: 415-329-4576, fax: 415-329-5590, e-mail: ckendall@usgs.gov

Education

Ph.D., Geology, 1993, University of Maryland, College Park
M.S., Geology, 1976, University of California, Riverside
B.S., Geology, 1973, University of California, Riverside

Professional Experience

1990 to Present: Project Chief: Isotope tracers of hydrologic and biogeochemical processes, USGS, WRD, Menlo Park, CA.

1980-1990: Research Hydrologist in Isotope Fractionation Project, USGS,WRD, Reston, VA.

1976-1979: Geochemist at the Department of Geology, California Institute of Technology.

1973-1976: Staff research associate at the Institute of Geophysics and Planetary Physics, University of California, Riverside.

Research Interests

watershed biogeochemistry, tracing sources of nutrients and pollutants using stable isotopic methods, stormflow runoff mechanisms, foodweb determinations

Memberships

AGU (1985-present; member of Water Quality Committee, 1991-present; Chair,1995-1997)

Relevant Publications

Kendall, C., Mast, A.M., and Rice, K.C., 1992, Tracing watershed weathering reactions with Delta C-13, In: Kharaka, Y.K., and Maest, A.S. (eds), Proceedings of the 7th International Symposium on Water-Rock Interactions, Park City, Utah, July 13-18, 1992, p. 569-572.

Kendall, C. and McDonnell, J.J., 1993, Effect of intrastorm heterogeneitiesof rainfall, soil water and groundwater on runoff modeling, In: Peters, N.E. et al. (eds) Tracers in Hydrology, Intern. Assoc. of Hydrol. Sc. Pub. #215, July 11-23, 1993, Yokohama, Japan, p. 41-49.

Krabbenhoft, D.P., Bowser, C.J., **Kendall, C.**, and Gat, J.R., 1994, Use of oxygen-18 and deuterium to assess the hydrology of ground-water/lake systems, In: Baker, L.A. (ed.) Environmental Chemistry of Lakes and Reservoirs, American Chemical Society Advances in Chemistry Series #237, p. 67-90.

Kendall, C., Campbell, D.H., Burns, D.A., Shanley, J.B., Silva, S.R., and Chang, C.C.Y., 1995, Tracing sources of nitrate in snowmelt runoff using the oxygen and nitrogen isotopic compositions of nitrate: In: Tonnessen, K. et al (eds) Biogeochemistry of Seasonally Snow-covered Catchments, Intern. Assoc. of Hydrol. Sc. Pub., July 11-12, 1995, Boulder, CO, p. 339-347.

Kendall, C., Sklash, M.G., and Bullen, T.D., 1995, Isotope tracers of waters and solute sources in catchments, In: Trudgill, S.T., (ed), Solute Modeling in Catchment Systems, Chapter 10, John Wiley, p. 261-303.

Bullen, T.D., Krabbenhoft, D.P., and **Kendall, C.**, 1996, Kinetic and mineralogic controls on the evolution of groundwater chemistry and 87Sr/86Sr in a sandy silicate aquifer, northern Wisconsin, Geochem. Cosmoch. Acta, v. 60, p. 1807-1821.

Bullen, T.D., and **Kendall, C.**, Tracing weathering reactions and water flowpaths: a multi-isotope approach, In: **Kendall, C.** and McDonnell, J.J. (eds) In: Isotope Tracers in Catchment Hydrology, Chapter 19, Elsevier, 50 pp., (in press).

Kendall, C., Sources and cycling of nitrogen, In: **Kendall, C.** and McDonnell, J.J. (eds) In: Isotope Tracers in Catchment Hydrology, Chapter 17, Elsevier, 60 pp., (in press).

CURRICULUM VITAE: David P. Krabbenhoft

U.S. Geological Survey, Water Resources Division, 8505 Research Way, Madison, Wisconsin 53562
phone: 608-821-3843, fax: 608-821-3817, dpkrabbe@usgs.gov

Education

1988 Univ. of Wisconsin - Madison, Ph.D., Hydrogeology/Geochemistry (major) Civil Engineering (minor)

1984 University of Wisconsin - Madison, M.S., Geochemistry (major)

1982 North Dakota State University, B.S., Geology (major) Chemistry (minor)

Professional Experience

Research Hydrologist, July 1988 to present. USGS, WRD, Madison, Wisconsin.

Associate Editor, *Water Resources Research* (Published by the American Geophysical Union) October, 1993 to October 1996.

Assistant Professor, Wright State University, Dayton, Ohio, January to July 1987. Served as an adjunct assistant professor during a sabbatical leave.

Research Interests

General interests in environmental chemistry, with specific interests in the biogeochemistry of mercury in the environment.

Memberships

Sigma Xi (1987 to present).
National Well Water Association (1984 to present)
American Geophysical Union (1986 to present)

Relevant Publications

Krabbenhoft, D.P., and C.L. Babiarz, 1992, Role of groundwater transport in aquatic mercury cycling, Water Resources Research, vol. 28, no. 12, 3119-3128.

Hurley, J.P., **Krabbenhoft, D.P.**, Babiarz, C.L., and Andren, A.W., 1994, Cycling processes of mercury across sediment/water interfaces in seepage lakes, *in* Baker, L.A. ed., Environmental Chemistry of Lakes and Reservoirs: Advances in Chemistry Series, American Chemical Society, Washington, D.C., pp. 426-449.

Krabbenhoft, D.P., J.M. Benoit, C.L. Babiarz, J.P. Hurley, and A.W. Andren, 1995, Mercury Cycling in the Allequash Creek Watershed, *Water, Air, and Soil Pollution*, v. 80, p. 425-433.

D.P. Krabbenhoft, C.C. Gilmour, J.M. Beniot, C.L. Babiarz, A.W. Andren, and J.P. Hurley, 1997, Methylmercury Dynamics in Littoral Sediments of a Temperate Seepage Lake, (manuscript in press at *Canadian Journal of Fisheries and Aquatic Sciences*)

D.P. Krabbenhoft, J.P. Hurley, M.L. Olson, and L.B. Cleckner, 1997, Diurnal Variability of Mercury Phase and Species Distributions in the Florida Everglades, (manuscript accepted at *Biogeochemistry*).

Hurley, J.P., **D.P. Krabbenhoft**, L.B Cleckner, M.L. Olson, G. Aiken, and P.J. Rawlik, 1997, System controls on aqueous mercury distribution in the northern Everglades (manuscript accepted at *Biogeochemistry*).

Olson, M.L., **D.P. Krabbenhoft**, J.P. Hurley, and L.B. Cleckner, Resolution of matrix effects on analysis of total and methyl mercury in aqueous samples from the Florida Everglades, (manuscript accepted at *Journal of Analytical Chemistry*)

CURRICULUM VITAE: James S. Kuwabara

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Education

Ph.D. Environmental Engineering Science, 1980, California Institute of Technology, Pasadena, CA
M.S. Environmental Engineering Science, 1976, California Institute of Technology, Pasadena, CA
B.S. Civil Engineering, 1975, University of Hawaii, Honolulu, HI

Professional Experience

Hydrologist, 1982-present, U.S. Geological Survey, Menlo Park, CA
NRC Postdoc, 1980-1982, U.S. Geological Survey, Menlo Park, CA
NSF Graduate Fellow, 1976-1980, California Institute of Technology, Pasadena, CA

Research Interests

trace metal speciation and toxicity; process-interdependent solute transport models

Memberships

Estuarine Research Federation (1991- present)
American Geophysical Union (1982-present)
American Society of Civil Engineers (1984-present)
Phycological Society of America (1980-present)

Relevant Publications

Kuwabara, J.S., Chang, C.C.Y., Khechfe, A.I. and Hunter, Y.R., 1996, Importance of dissolved sulfides and organic substances in controlling the chemical speciaton of heavy metals in San Francisco Bay, in Hollibaugh, J.T., ed., San Francisco Bay - the Ecosystem: American Association for the Advancement of Science, Pacific Division, San Francisco, p. 157-172.

Caffrey, J., Hammond, D., **Kuwabara, J.**, Miller, L. and Twilley, R., 1996, Benthic processes in San Francisco Bay: the role of organic inputs and bioturbation, in Hollibaugh, J.T., ed., San Francisco Bay - the Ecosystem: American Association for the Advancement of Science, Pacific Division, San Francisco, p. 425-442.

Kuwabara, J.S., Hunter, Y.R. and Chang, C.C.Y., 1996, Distributions and benthic flux of dissolved sulfides in the oxic water column of San Francisco Bay, California, inMorganwalp, D.W., and Aronson, D.A., eds., U.S. Geological Survey Toxic Substances Hydrology Program -- Proceedings of the Technical Meeting, Colorado Springs, Colorado, September 20-24, 1993: U.S. Geological Survey Water-Resources Investigations Report 94-4015, p. 747-751.

Wood, T.M., Baptista, A.M., **Kuwabara, J.S.** and Flegal, A.R., 1995, Diagnostic modeling of trace metal partitioning in south San Francisco Bay: Limnology and Oceanography, v. 40, p. 345-358.

Hunter, Y.R. and **Kuwabara, J.S.**, 1994, Ionic strength and DOC determinations from various freshwater sources to the San Francisco Bay: Bulletin of Environmental Contamination and Toxicology, v. 52, p. 311-318.

Kuwabara, J.S. and Baker, J.E., 1993, Trace contaminants and nutrients in estuaries: The importance of process interdependence : Estuaries, v. 16, p. 383-384.

Kuwabara, J.S. and Luther, G.W., III, 1993, Dissolved sulfides in the oxic water column of San Francisco Bay, California: Estuaries, v. 16, p. 567-573.

Kuwabara, J.S. and Harvey, R.W., 1990, Application of a hollow-fiber tangential-flow device for sampling suspended bacteria and particles from natural waters: Journal of Environmental Quality, v. 19, p. 625-629.

Kuwabara, J.S., Chang, C.C.Y., Cloern, J.E., Fries, T.L., Davis, J.A. and Luoma, S.N., 1989, Trace metal associations in the water column of South San Francisco Bay, California: Estuarine Coastal and Shelf Science, v. 26, p. 307-325.

Chang, C.C.Y., Davis, J.A. and **Kuwabara, J.S.**, 1987, Adsorption of Zn(II) onto TiO in defined media with low suspended particle concentrations: Estuarine Coastal and Shelf Science, v. 24, p. 419-424.

CURRICULUM VITAE: Lee, Byeong-Gweon

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Education

Ph.D. Coastal Oceanography, 1993; State University of New York (SUNY), Stony Brook
M.S. Marine Environmental Science Program, 1990; SUNY, Stony Brook, NY

Professional Experience

Postdoctoral Associate, 1993- present, USGS, Menlo Park, CA-SUNY, Stony Brook,NY
Research Assistant, 1986-1993, Research Foundation of SUNY, Stony Brook, NY

Research Interests

Trace metal biogeochemistry, bioaccumulation and trophic transfer of metals

Memberships

American Society of Limnology and Oceanography, 1990 - present
American Geophysical Union, 1994-present
American Chemical Society, 1996-present

Relevant Publications

Lee, B.-G. and N. Fisher. 1992. Degradation and elemental release rates from phytoplankton debris and their geochemical implications. Limnol. Oceanogr. **37**: 1345-1360.

Lee, B.-G. and N. Fisher. 1992. Decomposition and release of elements from zooplankton debris. Mar. Ecol. Prog. Ser. **88**: 117-128.

Lee, B.-G. and N. Fisher. 1993. Release rates of trace elements and protein from decomposing planktonic debris. 1. Phytoplankton debris. J. Mar. Res. **51**: 391-421.

Lee, B.-G. and N. Fisher. 1993. Microbially mediated cobalt oxidation in seawater revealed by radiotracer experiments. Limnol. Oceanogr. **38**: 1593-1602.

Lee, B.-G. and N. Fisher. 1994. Effects of sinking and zooplankton grazing on the release of elements from decomposing planktonic debris. Mar. Ecol. Prog. Ser. **110**: 271-281.

Wang, W.-X., J.R. Reinfelder, **B.-G. Lee**, and N.S. Fisher. 1996. Assimilation and regeneration of trace elements by marine copepods. Limnol. Oceanogr. **41**: 70-81.

Luoma, S.N., A. van Geen, **B.-G. Lee**, and J.E. Cloern. submittd. Metal uptake by phytoplankton during a bloom in south San Francisco Bay: Implications for metal cycling in estuaries. Limnol. Oceanogr.

Lee, B.-G. and S.N. Luoma. submitted. Bioavailability of Cd, Cr, and Zn to bivalves in south San Francisco Bay. Limnol. Oceanogr.

CURRICULUM VITAE: SAMUEL N. LUOMA

US Geological Survey, MS465, 345 Middlefield Road, Menlo Park, CA 94025
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Highest Education

1972-74 PhD Marine Biology, Dept. of Zoology, University of Hawaii, Honolulu, HI.

Recent Professional Experience

1976 - , Project Chief, Water Resources Division, US Geological Survey, Menlo Park, CA
1985-87, Chief, Branch of Western Region Research, WRD, USGS Menlo Park,
1992 - , Senior Research Hydrologist (ST-3104-1) USGS, WRD, Menlo Park, CA

Research Interests

Trace element bioavailability, trophic transfer and effects in estuaries. SF Bay Ecosystem studies.

Recent Selected Experience

1989 Department of Interior Distinguished Service Award
1990- Editorial Advisor: *Marine Ecology Progress Series*
1991-93 Society Environmental Toxicology and Chemistry - Board of Directors
1992- USEPA Science Advisory Board Subcommittee on Sediment Quality Criteria
1993- Editor, *Marine Environmental Research*
1994- Chair, Science Advisory Group, Interagency Ecological Studies Program, S FBay
1994- Chair, Science Advisory Committee, Water Res. Div., USGS/Senior Staff, WRD, USGS
1994- Sci. Advisory Committee, Center for Environmental Health Research, Univ. Calif. Davis
1994- Comm. Science Advisors, San Francisco Estuary Institute

Invited Participation

Book reviews (4), invited chapters for books (7), Text: *Introduction to Environmental Issues*, 1984, MacmillanPublishing Co.

Frequent invited talks or plenary lectures to scientific or public audiences. Frequent invited participation in workshops on contamination problems or SF Bay issues.

Selected Recent Publication

Nichols, F. H., Cloern, J. E., **Luoma, S. N.**, & Peterson, D. H., 1986, The modification of an estuary, *Science*, 231, 567-573.

Luoma, S. N., 1989. Can we determine the biological availability of sediment-bound trace elements? *Hydrobiologia* v. 176/177,379-396.

Luoma, S. N., C. Johns, N. S. Fisher, N. A. Steinberg, R. S. Oremland, and J. Reinfelder, 1992, Determination of selenium bioavailability to a benthic bivalve from particulate and solute pathways: *Environ. Sci. Technol.* 26: 485 - 491.

Luoma, S. N. and Carter, J. L. 1993. Understanding the toxicity of contaminants in sediments: beyond the bioassay-based paradigm. *Environ. Toxicol. Chem.* 12: 793-796.

Luoma, S. N. and Ho, K. T. 1993, The appropriate uses of marine and estuarine sediment bioassays, p. 193 - 227 in Calow, P., ed. *The Handbook of Ecotoxicology*, Blackwell Scientific, London.

Luoma, S. N. 1995. Limitations to applications of bioassays and toxicity tests. Review invited by the International Union of Pure and Applied Chemistry, p. 610 - 659 in "*Metal Speciation and Bioavailability*" (A. Tessier & D. Turner, eds.), John Wiley & Sons Press, London.

Wang, W.-X., Fisher, N. S. and **S. N. Luoma,** 1996. Kinetic determinations of trace element bioaccumulation in the mussel *Mytilus edulis. Mar. Ecol. Prog. Series* 140: 91 - 113.

Luoma, S. N. and Fisher, N. S. Uncertainties in assessing contaminant exposures from contaminated sediments. In *Ecological Risk Assessments of Contaminated Sediments*, C. Ingersoll, G. Biddinger, T. Dillon (eds), SETAC Press, Pensacola (in press).

Luoma, S. N., 1996. The developing framework of marine ecotoxicology: Pollutants as a variable in marine ecosystems? *J. Exptl. Mar. Biol. Ecol.* 200: 29-55.

Overall approximately 110 publications in peer reviewed literature.

CURRICULUM VITAE: Thomas W. May

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Education

M.S., Bioloigical Sciences, 1974, George Washington University, Washington, D.C.
B.S., Chemistry, 1969, University of Alabama, Tuscaloosa, AL.

Professional Experience

Research Chemist, Midwest Science Center, 1 yr, USGS-BRD, Columbia, MO.
Research Chemist, 3 yrs, National Biological Service, Columbia, MO.
Research Chemist, 17 yrs, U.S. Fish and Wildlife Service, Columbia, MO.

Research Interests

Development and refinement of chemical preparation and instrumental methodology for the optimal investigation of elemental environmental contaminants.

Memberships

Society of Environmental Toxicology and Chemistry (1990-present).

Relevant Publications

Saiki, M.K., D.T. Castleberry, **T.W. May**, B.A. Martin, and F.N. Bullard. 1995. Copper, cadmium, and zinc concentrations in aquatic food chains from the upper Sacramento River (California) and selected tributaries. Archives of Environmental Contamination & Toxicology 29:484-491.

Waddell, B.; **May, T.** 1995. Selenium concentrations in the razorback sucker (Xyrauchen texanus): substitution of non-lethal muscle plugs for muscle tissue in contaminant assessment. Archives of Environmental Contamination and Toxicology 28:321-326.

Wiedmeyer, R.H.; **May, T.W.** 1993. Storage characteristics of three selenium species in water. Archives of Environmental Contamination and Toxicology 25(1):67-71.

Coyle, J.J.; Buckler, D.R.; Ingersoll, C.G.; Fairchild, J.F.; **May, T.W.** 1993. Effect of dietary selenium on the reproductive success of bluegills (Lepomis macrochirus) Environmental Toxicology and Chemistry 12(3):551-565.

Saiki, M.K., M.R. Jennings, and **T.W. May**. 1992. Selenium and other elements in freshwater fishes from the irrigated San Joaquin Valley, California. Science of the Total Environment 126:109-137.

Ingersoll, C.G.; Dwyer, F.J.; **May, T.W.** 1990. Toxicity of inorganic and organic selenium to Daphnia magna (cladocera) and Chironomus riparius (diptera) Environmental Toxicology and Chemistry 9(9):1171-1181.

Saiki, M.K.; **May, T.W.** 1988. Trace element residues in bluegills and common carp from the lower San Joaquin River, California, and its tributaries. Science of the Total Environment 74:199-217.

Wiener, J.G.; Jackson, G.A.; **May, T.W.**; Cole, B.P. 1984. Longitudinal distribution of trace elements (As, Cd, Cr, Hg, Pb, and Se) in fishes and sediments in the upper Mississippi River. Contaminants in the Upper Mississippi River - Proceedings of the 15th Annual Meeting of the Mississippi River Research Consortium:139-170.

CURRICULUM VITAE: Mark C. Marvin-DiPasquale

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Phone: (415)-329-4442, Fax: (415)-329-4463, mmarvin@usgs.gov

Education

Monroe Community College, Rochester, NY. 1982-85. A.S., Chemistry.
State University of N.Y., Stony Brook, NY. 1985-87. B.S., Chemistry.
University of Maryland, Chesapeake Biological Laboratory, Solomons, MD. 1987-95. Ph.D., Marine and Estuarine Environmental Sciences. Research Focus: Marine Microbial Ecology

Honors

Gloria Glass Scholarship, Monroe Community College. 1984
Chesapeake Bay Yachts Club Association Graduate Award, Univ. Maryland. 1988.
Senatorial Scholarship, Univ. Maryland. 1989-93.
Chesapeake Biological Lab Graduate Student Fellowship, Univ. Maryland. 1990-92.
Amer. Soc. Microbiol., R.W. Saber Fellowship Award, 1993.

Professional Experience

Undergraduate Laboratory Technician, Monroe Comm. Coll., 1983-85.
Graduate Research Assistant, Univ. of Maryland/CBL, 1987-1995.
National Research Council Associate, USGS, Menlo Park, CA, 1995-present.

Research Interests

aquatic microbial ecology, biogeochemistry of estuaries, mercury biogeochemistry

Memberships

American Chemical Society (1988-present)
American Society of Limnology and Oceanography (1989-present)
Oceanography Society (1989-present)
American Society of Microbiology (1990-present)
Estuarine Research Federation (1995-present)

Relevant Publications

Boynton, W.R.; W.M. Kemp, J.M. Barnes, J.J.W. Cowan, S.E. Stammerjohn, L.L. Matteson, F.M. Rolhand, **M. Marvin,** and J.H. Garber. 1990. Long-term characteristics and trends of benthic oxygen and nutrient fluxes in the Maryland portion of Chesapeak Bay. In: New Perspectives in the Chesapeake System: A Research and Managemant Partnership. Proceedings of a Conference. Chesapeake Research Consortium publication No. 137.

Marvin, M.C., 1995. Controls On The Spatial And Temporal Trends Of Benthic Sulfate Reduction And Methanogenesis Along The Chesapeake Bay Central Channel. Ph.D. Dissertation. University of Maryland, College Park, MD.

Kemp, W.M., E.M. Smith, **M. Marvin-DiPasquale,** and W.R. Boynton. 1997. Organic carbon balance and net ecosystem metabolism in Chesapeake Bay. Mar. Ecol. Prog. Ser. 150: 229-248.

Marvin-DiPasquale, M. and D.G. Capone. 1997. Benthic sulfate reduction along the Chesapeake Bay central channel. I. Spatial Trends and Controls. Mar. Ecol. Prog. Ser. (submitted)

Marvin-DiPasquale, M. and R.S Oremland. 1997. Bacterial methylmercury degradation potentials in Florida Everglades peat sediment. Biogeochemistry. (submitted)

CURRICULUM VITAE: Laurence G. Miller

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Education

MS, Geological Sciences, University of Southern Califonia, Los Angeles
BS, Marine Science, Southampton College, Southampton, NY

Professional Experience

Oceanographer/Chemist, 13 yr., USGS, Menlo Park, CA (present position)
Oceanographer, 3 yr., University of Washington

Research Interests

Microbial Biogeochemistry, Trace Gases, Stable Isotope Geochemistry

Memberships

AAAS 18yrs, AGU 13 yrs, ACS Geochemistry Division 11 yrs

Relevant Publications

Caffrey J. M., Hammond, D.E., Kuwabara, J.S., **Miller, L.G.**, and Twilly, R.R. 1996. Benthic processes in South San Francisco Bay: The role of organic inputs and bioturbation. In San Francisco Bay: The Ecosystem. Ed. J.T. Hollibaugh. AAAS.

Caffrey J.M. and **Miller, L.G.** 1995. A comparison of two nitrifiacation inhibitors used to measure nitrification rates in estuarine sediments. FEMS Mibrobiol. Ecol. 17, 213-220.

Oremland, R. S., **Miller, L.G.**, Dowdle, P. Connell, T. And Barkay, T. 1995. Methylmercury oxidative degradation potentials in contaminated and pristine sediments of the Carson River, Nevada. Appl. Environm. Microbiol., 61, 2745-2753.

Oremland, R.S., **Miller, L.G.**, and Strohmaier, F. E. 1994. Degradation of methyl bromide in anaerobic sediments. Wnv. Sci. & Technol., 28, 514-520.

Miller, L.G., Coutlakis, M.D., Oremland, R.S., and Ward, B.B. 1993, Selective inhibition of ammonium oxidation and nitrification-linked N_2O formation by methyl fluoride and dimethyl ether. Appl. Environm. Microbiol., 59, 2457-2464.

Kiene, R.P., Oremland, R.S., Catena, A., **Miller, L.G.**, and Capone, D.G. 1986. Metabolism of reduced methylated sulfur compounds in anaerobic sediments and by a pure culture of an estuarine methanogen. Appl. Environm. Microbiol., 52, 1037-1045.

Hammond, D. E., Fuller, C.C., Harmon, D. Hartman, B. Korosec, M., **Miller, L.G.**, Rea. R., Warren, S., Berrelson, W., and Hager, S.W. 1985. Benthic fluxes in San Francisco Bay. Hydrobiologia, 19, 69-90.

CURRICULUM VITAE: Ronald S. Oremland

USGS, Water Resources Division, MS 480, 345 Middlefield Road, Menlo Park, CA 94025
Phone: (415) 329-4482; Fax: (415) 329-4463; roremlan@usgs.gov

Education

PhD, 1976, Marine Microbiology, Rosenstiel School of Marine & Atmospheric Sciences
University of Miami, Florida
BS, 1968, Biology, Rensselaer Polytechnic Institute, Troy, NY

Professional Experience

Project Chief, Microbial Biogeochemistry, USGS, Menlo Park, CA, 20 years
National Research Council Postdoctoral Associate, NASA Ames Research Center, Moffett Field, CA (1 year)
US Naval Reserve, Active duty, 1969 - 1971, salvage & diving officer, USS Utina

Research Interests

microbial biogeochemistry, redox reactions and methylation/demethylation studies on selenium, arsenic, and mercury; formation and destruction of greenhouse gases like methane and other hydrocarbons, halocarbons, and methyl halides; quantification of anaerobic processes (denitrification, sulfate-reduction, methanogenesis); hypersaline/alkaline environments; exobiology.

Memberships

Chairman, Executive Board, International Symposia on Environmental Biogeochemistry
American Society for Microbiology
American Geophysical Union
American Society for Limnology and Oceanography
American Chemical Society

Relevant Publications

Oremland, R.S., and J.P. Zehr. 1986. Formation of methane and carbon dioxide from dimethyl selenide in anoxic sediments and by a methanogenic bacterium. Appl. Environ. Microbiol. 52: 1031 - 1036

Zehr, J.P., and **R.S. Oremland.** 1987. Reduction of selenate to selenide by sulfate-respiring bacteria: Experiments with cell suspensions and estuarine sediments. Appl. Environ. Microbiol. 53: 1365 - 1369.

Oremland, R.S., R.P. Kiene, I. Mathrani, M. Whiticar, and D. Boone. 1989. Description of an estuarine methylotrophic bacterium which grows on dimethylsulfide. Appl. Environ. Microbiol. 55: 994 - 1002.

Oremland, R.S., J.T. Hollibaugh, A.S. Maest, T.S. Presser, L. Miller, and C. Culbertson. 1989. Selenate reduction to elemental selenium by anaerobic bacteria in sediments and culture: Biogeochemical significance of a novel, sulfate-independent respiration. Appl. Environ. Microbiol. 55: 2333 - 2343.

Oremland, R.S., N.A. Steinberg, A.S. Maest, L.G. Miller, and J.T. Hollibaugh. 1990. Measurement of *in situ* rates of selenate removal by dissimlatory bacterial reduction in sediments. Environ. Sci. Technol. 24: 1157 - 1164.

Dubrovsky, N.M., J.M. Neil, R. Fuji, **R.S. Oremland**, and J.T. Hollibaugh. 1990. Influence of redox potential on selenium distribution in ground water, Mendota, Western San Joaquin Valley, California. USGS Open File Report 90-138, Sacramento, CA.

Steinberg, N.A., and **R.S. Oremland.** 1990. Dissimilatory selenate reduction potentials in a diversity of sediment types. Appl. Environ. Microbiol. 56: 3550 - 3557.

Oremland, R.S., C.W. Culbertson, and M.R. Winfrey. 1991. Methyl mercury decomposition in sediments and bacterial cultures: Involvement of methanogens and sulfate reducers in oxidative demethylation. Appl. Environ. Microbiol. 57: 130 - 137.

Oremland, R.S., N.A. Steinberg, T.S. Presser, and L.G. Miller. 1991. *In situ* bacterial selenate reduction in the agricultural drainage systems of western Nevada. Appl. Environ. Microbiol. 57: 615 - 617.

Steinberg, N.A., J. Switzer Blum, L. Hochstein, and **R.S. Oremland.** 1992. Nitrate is a preferred electron acceptor for growth of freshwater selenate-respiring bacteria. Appl. Environ. Microbiol. 58: 426 - 428.

Oremland, R.S., and C.W. Culbertson. 1992. Importance of methane oxidizing bacteria in the methane budget as revealed by the use of a specific inhibitor. Nature 356: 421 - 423.

Luoma, S.N., C. Johns, N.S. Fischer, N.A. Steinberg, **R.S. Oremland,** and J.R. Reinfelder. 1992. Determination of selenium bioavailability to a benthic bivalve from particulate and solute pathways. Env. Sci. Technol. 26: 485 - 491.

Oremland, R.S. 1994. Biogeochemical transformations of selenium in anoxic environments. p. 389 - 419 in Selenium in the Environment, W.T. Frankenberger, Jr. and S. Benson (eds.), Marcel Dekker, NY.

Oremland, R.S., J. Switzer Blum, C.W. Culbertson, P.T. Visscher, L.G. Miller, P. Dowdle, and F.E. Strohmaier. 1994. Isolation, growth and metabolism of an obligately anaerobic, selenate-respiring bacterium, strain SES-3. Appl. Environ. Microbiol. 60: 3011 - 3019.

Oremland, R.S.. L.G. Miller, P. Dowdle, T. Connell, and T. Barkay. 1995. Methylmercury oxidative degradation potentials in contaminated and pristine sediments of the Carson River, Nevada. Appl. Environ. Microbiol. 61: 2745 - 2753.

Laverman, A.M., J. Switzer Blum, J.K. Schaefer, E.J. Philips, D.R. Lovley, and **R.S. Oremland**. 1995. Growth of strain SES-3 with arsenate and other diverse electron acceptors. Appl. Environ. Microbiol. 61: 3556 - 3561.

Dowdle, P.R., A.M. Laverman, and **R.S. Oremland.** 1996. Bacterial dissimilatory reduction of arsenic (V) to arsenic (III) in anoxic sediments. Appl. Environ. Microbiol. 62: 1664 - 1669.

Stolz, J.F., T. Gugliuzza, J. Switzer Blum, **R. Oremland**, and F.M. Murillo. 1997. Differential expression of cytochromes and reductases in *Geospirillum barnesii* SeS3. Arch. Microbiol. 167: 1 - 5.

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Over 85 peer-reviewed papers published

CURRICULUM VITAE: Michael K. Saiki

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Education

Ph.D., Biology, 1976, University of Arizona, Tucson.
M.S., Fishery Biology, 1973, University of Arizona, Tucson.
B.A., Zoology, 1971, University of Hawaii, Honolulu.

Professional Experience

Fishery Biologist (Research), 1 yr, USGS-BRD, Dixon, CA.
Fishery Biologist (Research), 3 yrs, National Biological Service, Dixon, CA.
Fishery Biologist (Research), 15 yrs, U.S. Fish and Wildlife Service, Dixon, CA.

Research Interests

Bioaccumulation and toxicity of heavy metals and other trace elements in fish and fish-forage organisms, relation of water quality and other environmental variables to fish distribution and abundance, and life history and ecology of fish.

Memberships

American Fisheries Society (1975-present).
American Institute of Fishery Research Biologists (1988-present).
Society of Environmental Toxicology and Chemistry (1990-present).

Relevant Publications

Saiki, M.K. 1984. Environmental conditions and fish faunas in low elevation rivers on the irrigated San Joaquin Valley floor, California. California Fish & Game 70:145-157.

Saiki, M.K., and C.J. Schmitt. 1985. Population biology of bluegills, *Lepomis macrochirus*, in lotic habitats on the irrigated San Joaquin Valley floor. California Fish & Game 71:225-244.

Saiki, M.K. 1987. Relation of length and sex to selenium concentrations in mosquitofish. Environmental Pollution 47:171-186.

Saiki, M.K., and T.P. Lowe. 1987. Selenium in aquatic organisms from subsurface agricultural drainage water, San Joaquin Valley, California. Archives of Environmental Contamination & Toxicology 16:657-670.

Saiki, M.K., and D.U. Palawski. 1990. Selenium and other elements in juvenile striped bass from the San Joaquin Valley and San Francisco Estuary, California. Archives of Environmental Contamination & Toxicology 19:717-730.

Saiki, M.K., M.R. Jennings, and R.H. Wiedmeyer. 1992. Toxicity of agricultural subsurface drainwater from the San Joaquin Valley, California, to juvenile chinook salmon and striped bass. Transactions of the American Fisheries Society 121:78-93.

Saiki, M.K., M.R. Jennings, and T.W. May. 1992. Selenium and other elements in freshwater fishes from the irrigated San Joaquin Valley, California. Science of the Total Environment 126:109-137.

I-002321

Saiki, M.K., M.R. Jennings, and W.GBrumbaugh. 1993. Boron, molybdenum, and selenium in aquatic food chains from the lower SanJoaquin River and its tributaries, California. Archives of Environmental Contamination & Toxicology 24:307-319.

Saiki, M.K., D.T. Castleberry, T.W. MayB.A. Martin, and F.NBullard. 1995. Copper, cadmium, and zinc concentrations in aquatic food chains from the upper Sacramento River (California) and selected tributaries. Archives of Environmental Contamination & Toxicology 29:484-491.

Saiki, M.K., andR.S. Ogle. 1995. Evidence of impaired reproduction by westemosquitofish inhabitingseleniferous agriculturaldrainwater. Transactions of the American Fisheries Society 124:578-587.

NONDISCRIMINATION COMPLIANCE STATEMENT

COMPANY NAME
United States Geological Survey

The company named above (hereinafter referred to as "prospective contractor") hereby certifies, unless specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code of Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and the development, implementation and maintenance of a Nondiscrimination Program. Prospective contractor agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, disability (including HIV and AIDS), medical condition (cancer), age, marital status, denial of family and medical care leave and denial of pregnancy disability leave.

CERTIFICATION

I, the official named below, hereby swear that I am duly authorized to legally bind the prospective contractor to the above described certification. I am fully aware that this certification, executed on the date and in the county below, is made under penalty of perjury under the laws of the State of California.

OFFICIAL'S NAME
Mark Marvin-DiPasquale

DATE EXECUTED
27 July, 1997

EXECUTED IN THE COUNTY OF
San Mateo

PROSPECTIVE CONTRACTOR'S SIGNATURE
Mark Marvin DiPasquale

PROSPECTIVE CONTRACTOR'S TITLE
Microbial Ecologist

PROSPECTIVE CONTRACTOR'S LEGAL BUSINESS NAME
United States Geological Survey

STATE OF CALIFORNIA—THE RESOURCES AGENCY PETE WILSON, Governor

DEPARTMENT OF FISH AND GAME
Bay-Delta and Special Water Projects Division
4001 North Wilson Way
Stockton, California 95205-2486
(209) 948-7800

July 24, 1997

Mark Marvin-DiPasquale
U.S. Geological Survey
345 Middlefield Road
Bldg. #15, MS 480
Menlo Park, California 94025

Dear Mr. Marvin-DiPasquale:

The Interagency Ecological Program (IEP) via the Delta Outflow/San Francisco Bay Study will provide fish and macro invertebrate samples to the U.S. Geological Survey San Francisco Bay Mercury Project. These samples will consist of specimens collected as a normal part of the IEP Delta Outflow/San Francisco Bay Study monthly sampling program. If this sampling were done as a separate sampling effort the cost would be $32,000. It is anticipated that the routine sampling will yield all the specimens needed for analysis. Since there is no guarantee that the monthly sampling program will collect all the specimens needed, additional sampling may be required. To cover this contingency, the Bay-Delta and Special Water Projects Division of the California Department of Fish and Game is requesting $5,000 to cover any additional sampling.

Sincerely,

Charles Armor
Senior Biologist
Bay-Delta and Special Water
Projects Division

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To Mark Marvin-DiPasquale	From Chuck Armor
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DIVISION OF ENVIRONMENTAL STUDIES | DAVIS, CALIFORNIA 95616

23 July 1997

Dr. Mark Marvin-DiPasquale
U.S. Geological Survey
Water Resource Division
Bldg. 15, MS-480
345 Middlefield Rd.
Menlo Park, CA 94025

Dear Dr. Marvin-DiPasquale,

We are pleased to state our strong interest in collaborating with you on your proposed project to CALFED (*The Status of Mercury as a Stressor to Habitats and Species of the San Francisco Bay-Delta Ecosystem*). Your project will be highly complementary with one that we are submitting on mercury loading to the Bay-Delta (*The Role of Upstream Mercury Loading and Speciation on Localized and Downstream Bioaccumulation: A Regional Assessment of Sources and Fates of Mercury Throughout the Bay-Delta Watershed*) by Suchanek and Slotton et al.. We feel that the complementary nature of our collective studies will yield extremely valuable information on the sources of bioavailable mercury from upper watershed regions (our U.C. Davis studies) and the fate of that mercury once it reaches the Bay-Delta system (your U.S.G.S. studies).

In terms of specific areas of collaboration, we have identified two topic areas that we feel would benefit the most from our combined efforts. First, if existing U.S.G.S. cores do not sufficiently provide an accurate depositional history of mercury within Bay-Delta sediments, we are prepared to analyze additional sediment cores to provide those data. Second, in terms of understanding mercury cycling and contamination within the Bay-Delta, your detailed studies involving methylation processes would be extremely useful in interpreting the results of methyl mercury production in our core tube microcosms, allowing the development of more specific options for remediation.

Should both of our projects receiving funding, we are anxious to enter into a collaborative arrangement with your U.S.G.S. group. We feel that the combination of talents within our two groups will result in a synergy that will yield invaluable insights into the cycling of mercury within the Bay-Delta system and ultimately improve the water quality of this impacted ecosystem.

Most sincerely,

Tom Suchanek

Tom Suchanek

Darell Slotton

Darell Slotton

U.C. Davis Mercury Group