Section 1

1. Project Title: Impact of BDCP-Created Tidal Wetlands on Increased Fish Mercury Levels in the Delta

2. Applicant Name: San Jose State University Research Foundation on behalf of the Moss Landing Marine Laboratories at San Jose State University

3. Contact Person: Kenneth Coale, Principal Investigator
4. Address: Moss Landing Marine Laboratories 8272 Moss Landing Rd.
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9. Agency Type: Non-Profit Organization

10. Certified nonprofit: Yes, non-profit organization registration number: Not yet activated.

11. New grantee: No

12. Amount requested: $600,000

13. Total project cost: $600,000

14. Topic Area(s) --Water and Sediment Quality

15. ERP Project Type: Research primary, monitoring secondary

16. Ecosystem Element: Tidal perenial aquatic habitat primary, contaminants secondary

17. Water Quality Constituent: Mercury and Methyl Mercury

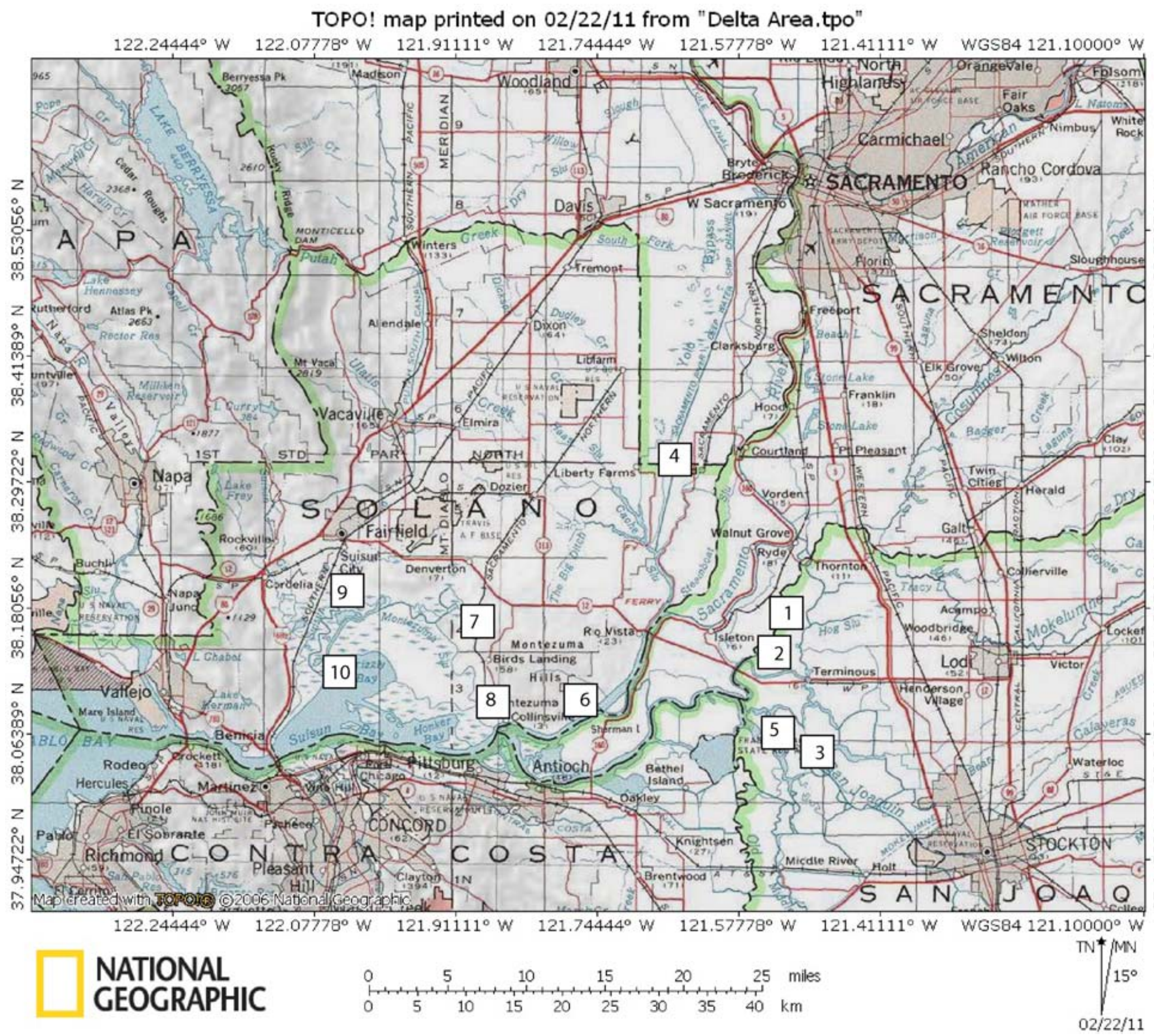
18. At risk species benefited: Delta Smelt; Least Terns, Salmon, Splittail, giant garter snake

19. Project Objectives:
Transplant fish and clams in wetland areas for calculation of area affected; Correlate result against other wetland parameters; Determine if area affected by increased MeHg in tissue varies seasonally; Make recommendations to BDCP about future wetlands

20. Time frame: Three years in duration from start of grant. Approximately 9/1/11-8/31/14.

Section 2: Location Information

Station locations in the Delta.



Site #	Site	Latitude	Longitude	USGS Quad Name	Township	Range	Section
1	Hog Slough	38.167039	121.489153	Thorton	T 4 N	R 5 E	30
2	Sycamore Slough	38.144064	121.501451	Isleton	T 5 N	R 5 E	6
3	Mandeville Point	38.05891	121.533668	Bouldin Island	T 4 N	R 5 E	6
4	Liberty I	38.26002	121.654059	Liberty Island	T 5 N	R 3 E	20
5	Twichell I	38.099059	121.654993	Jersey Island	T 3 N	R 3 E	20
6	Decker I	38.091934	121.706043	Jersey Island	T 3 N	R 2 E	25
7	Blacklock	38.179707	121.908012	Denverton	T 4 N	R 1 E	19
8	Grizzly I	38.135256	121.913654	Denverton	T 3 N	R 1 E	6
9	First Mallard Branch	38.182204	122.034195	Fairfield South	T 4 N	R 2 W	25
10	Suisun Slough	38.123084	122.123084	Vine Hill	T 3 N	R 2 W	8

Stations are plotted on USGS Quads at the end of this proposal in appendix A

3. Location description: The location is the Delta and Suisun Marsh (See maps section above)**.**
4. Counties: Yolo, Solano, San Joaquin, Contra Costa
5. Directions: All the sites will be accessed by boat and are on navigable waters (see maps in section 6)
6. Ecological Management Regions: Delta and Bay Regions
7. Ecological Management Zones: Sacramento San Joaquin Delta, Yolo Basin, Suisun Marsh and San Francisco Bay
8. Ecological Management Units: North Delta, East Delta, Central and West Delta, Suisun Marsh/North San Francisco Bay
9. Watershed Plans: There are no watershed plans recommending this proposed study
10. Project Area: 59,059 acres **(**239 square kilometers)
11. Land Use Statement—Multiple uses for the Delta-fish habitat, fishing, farming, drinking water, tourism, water for waterfowl, water for endangered species, water for wildlife and fish.
12. Project area ownership: % State 100
13. Project area with landowners support of proposal: Project is on state lands (water) only

Section 3. Landowners, Access and Permit

All work will be conducted on Public Land in Delta Waters

Section 4: Project Objectives

As they relate to ERP Strategic Goals and objectives:

Goal 4: Habitats Protect and/or restore functional habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics.
Objective 1: Restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes. These habitat types include tidal marsh (fresh, brackish, and saline), tidal perennial aquatic (including shallow water and tide flats), nontidal perennial aquatic, tidal sloughs, midchannel island and shoal, seasonal wetlands, riparian and shaded riverine aquatic, inland dune scrub, upland scrub, and perennial grasslands.

We propose to estimate the area affected by habitat restoration and creation of wetlands by determining increases of methyl mercury (MeHg) in tissue. This information will aid planners and agencies in addressing the mercury (Hg) bioaccumulation problem by receiving quantitative estimates of how much area if any will be affected by Hg when wetlands are created. We also propose to correlate area affected by wetland parameters such as volume of wetland, amount of water exchanged, concentration difference between wetland and adjacent waterways, dilution by adjacent channels and waterways, size of watershed around wetland, vegetation of wetland and type of sediments within wetland. Accomplishment of these two goals will enable us to recommend which types of newly created wetlands will adversely affect the Hg levels in fish the least. This information will allow agencies to mitigate any possible impacts of Hg on fish and humans and wildlife feeding on fish. Recommendations on types of wetlands that produce lesser amounts of MeHg will aid planners to design and site restoration efforts to minimize impacts of mercury.

Goal 6: Water and Sediment Quality Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife, and people.
Objective 1: Reduce the loadings and concentrations of toxic contaminants in all aquatic environments in the Bay-Delta estuary and watershed to levels that do not adversely affect aquatic organisms, wildlife, and human health.

We propose to calculate the area affected by increases in MeHg in tissue and to correlate area affected by wetland parameters such as volume of wetland, amount of water exchanged, concentration difference between wetland and adjacent waterways, and size of watershed around wetland, vegetation of wetland and type of sediments within wetland. Accomplishment of these two goals will enable us to estimate the magnitude of the mercury bioaccumulation problem and to recommend which types of newly created wetlands will export the least amounts of MeHg loads. This will benefit not only sports fish but small fish and fish eating birds by designing wetlands that have a minimal contamination impact. This will also help avoid delays in the regional water quality control boards (RWQCB) permitting process and costly monitoring programs mandated by the Central Valley Region Water Quality Control Board's (CVRWQCB) MeHg TMDL.

Section 5: Conflict of interest

Primary Contact for Proposal:
Kenneth Coale, Moss Landing Marine Labs (MLML), San Jose State University

Primary Investigator:
Kenneth Coale, Moss Landing Marine Labs (MLML), San Jose State University

Co-Primary Investigators:
Wes Heim, MLML, San Jose State University Research Foundation
Mark Stephenson, California Department of Fish and Game (DFG) (see also Subcontractor)

Supporting Staff:
Amy Byington, MLML, Research Technician
Adam Newman, MLML, Research Technician
John Negrey, MLML, Research Technician
Billy Jakl, MLML, Research Technician
Sean Mundell, MLML, Research Technician
Gary Ichikawa, DFG, Environmental Scientist

Subcontractor:
California Department of Fish and Game (Mark Stephenson)

No others helped with proposal development

Section 6: Project Tasks and Results Outline

1. Detailed Project Description

Proposal Title: Impact of BDCP-Created Tidal Wetlands on Increased Fish Mercury Levels in the Delta
Agencies and environmental groups have been asking mercury scientists about whether mercury (Hg) in Delta fish will increase as a result of and increase in tidal wetlands envisioned in drafts of the BDCP documents. They want to know whether wetlands export methyl mercury (MeHg) as the scientific literature infers and if so what is the magnitude of the problem. How much area is going to be affected by the exports and what areas of the Delta are going to be affected. This proposal addresses these questions and will aid BDCP in framing the mercury issues, addressing the magnitude of the problem, suggesting ways to mitigate the mercury bioaccumulation issues and monitoring mercury coming from wetlands. These results could be used by agencies proposing wetland creation to avoid years of delays in obtaining permits and demonstrating no discharge of MeHg from wetland as required in the CVRWQCB's Mercury TMDL.

Between 1850 and 1980 California was the nation's leading producer of mercury at about 100 million kilograms (Churchill, 2000). Inefficient Hg mine processing and placer and lode gold mining resulted in an estimated loss of 41 million kilos between the Coastal and Sierra ranges (Churchill, 2000). As a result there is widespread Hg contamination in fish, sediment, and water in the Central Valley and Sacramento-San Joaquin Delta (Delta) (Wiener et al 2004; Davis et al. 2008).

The mercury species of greatest concern to human and wildlife health in the Delta is monomethylmercury (MeHg). Consumption of MeHg contaminated fish and shellfish is a primary route of exposure and risk to human health (US EPA, 2001). Health advisories and interim health advisories have been posted in the Delta recommending no consumption of large striped bass and limited consumption of other sport fish (http://www.oehha.ca.gov/fishgen/eral/sfbaydelta.html). Davis et al. (2008) reported approximately half of the Delta has top level fish predator species (catfish, bass) above the EPA guidelines for Hg. Pregnant women and children are recommended to not consume these species. Elevated concentrations of MeHg in fish tissue also represent a hazard to piscivorous wildlife (Wiener et al., 2004; Ackerman et al., 2007). MeHg concentrations in some small fish species in Delta wetlands exceed concentrations reported to cause reproductive failure in loons. Loons are not present in the Delta. Little is known about the sensitivity to local bird species. Nonetheless, observations that some small fish species now exceed concentrations known to cause reproductive effects in loons should be a measure of local concern.

Wetland habitat has a high MeHg production potential (St. Louis et al., 1994, 1996; Hurley et al. 1995, Krabbenhoft et al. 1999, Rudd 1995). Many researchers fear increasing the percent coverage of wetland habitat through CALFED's Ecosystem Restoration and BDCP efforts could further increase mercury concentrations in fish and exacerbate what is already a human health threat. For example, see the discussion in the Total Maximum Daily Load (TMDL) report from the Central Valley Regional Water Quality Control Board to the U.S. EPA for methyl mercury in the Delta.

Currently about 60% of the MeHg loads come from the Delta Tributaries and 40% are produced within the Delta (Wood et al. 2010). Wetlands within the Delta are estimated to produce 19% of the MeHg (Wood et al. 2010) yet are only a couple of percent of the landmass.

As a result of the unacceptably high concentrations of mercury in fish the Central Valley Regional Water Quality Control Board (CVRWQCB) has adopted a Basin Plan amendment to control mercury bioaccumulation in the Delta (http://www.swrcb.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/delta_hg/index.shtml). The proposed amendment has several phases. The first phase requires sources of MeHg (including wetlands) to undertake studies to determine best management practices (BMPs) to reduce their loads. BMPs selected by wetland managers as a result of phase one studies would be implemented in phase two. At the moment there are no plans to control MeHg levels on the wetlands themselves, only loads discharged off the wetland to Delta channels. MeHg loads can be reduced by either decreasing the amount of discharge water and/or the MeHg concentration of the discharge water. The CVRWQCB will require monitoring and MeHg load reduction efforts for any newly created wetlands. They are concerned more wetlands will result in higher Hg concentrations in fish.

The proposed work would aid the efforts of BDCP to answer one of the main questions regarding creating more tidal wetlands “Will creation of tidal wetlands increase the concentrations of

MeHg in fish in the Delta?" By year 40, the BDCP goal is to have established 65,000 acres of tidal habitat, 5,000 acres of riparian habitat, and 10,000 acres of new seasonally inundated floodplain (BDCP 2010). In the near-term BDCP implementation period, actions to restore tidal habitat and riparian habitats will likely be directed at the Cache Slough, West Delta, Cosumnes / Mokelumne and Suisun Marsh Restoration Opportunity Areas (ROAs) in Conservation Zones 1, 2, 4, 5 and 11 (BDCP 2010). The CVRWQCB is concerned that 65,000 acres of tidal wetlands may significantly increase the Hg levels in sports and small fish.

There have been several efforts to determine the loads of MeHg from wetlands. Most of these studies are inconclusive. We have conducted studies on Blacklock in the Suisun area that suggests tidal wetlands may actually decrease MeHg loads but no load measurements were taken. This proposal would employ transplanted fish to evaluate the extent of MeHg increases in fish near the mouths of wetlands. It is envisioned that if the MeHg concentrations in the water in tidal wetlands are low as has been shown in Blacklock, the extent of export of MeHg to the adjacent waterways will be minimal. If this is the case the Water Quality Control Boards would likely be more receptive to BDCP efforts at creating wetlands

2. Background and Conceptual Models

As stated above there is a need to know if newly created tidal wetlands export MeHg and create a bioaccumulation problem. The traditional methodology for this evaluation consists of: 1) using non tidal wetland loads as a surrogate and scale proportionately to the newly created acreage (Wood et al. 2010); 2) conducting large scale studies with differing watersheds and correlating the levels of MeHg in water and/or fish to landscape features such as % of area with wetlands; 3) coupling acoustic Doppler current profilers with water samples of MeHg (Bergamaski et al. 2011; Stephenson et al. 2008); and 4) studying MeHg in water, sediment and fish before and after a tidal wetland creation. All of these methods have significant drawbacks that may limit the extrapolation of their results.

The first method involves using non tidal wetlands as a surrogate for tidal wetlands (Wood et al. 2010). Wood used MeHg load data from Stephenson et al. 2008a and b from data collected at Twichell I and Grizzly I. In the Twichell I study a continuous source of water was supplied to and experimental wetland which was largely covered with tule and cattails. The concentrations of MeHg exported from these wetlands were always high relative to the input water by a factor of 10 (often exceeding 1 ng/L MeHg in unfiltered water samples). In the Grizzly study, water was flooded on to fields in October that had been dry all summer. The water was continuously put on the fields from October to March for waterfowl. In this case water was put on fields that had dried weeds which proceeded to rot and create anoxic water which created and excellent situation for MeHg production (Compeau and Bartha, 1984; Fleming et al., 2006). The water exported from managed seasonal wetlands often exceeds 1 ng/L MeHg. Extrapolation of result from these non tidal wetlands to tidal wetlands may result in overestimation of export loads and concentrations. The evidence for this is from Blacklock where concentrations in water within the wetlands decreased from over 1 ng/L before conversion to tidal wetlands to 0.2 ng/L after conversion to tidal wetlands (Heim et al. 2011). In addition, we have found the concentrations in tidal wetlands to be low in several other wetlands (Sycamore Slough, Hog Slough, Mandeville Point, Little Break, and Suisun Slough) studied (Stephenson et al. 2008). The decrease in concentration within the wetland at Blacklock may mean that the export loads will be decreased.

Because tidal wetlands receive and export water every tidal cycle they are functionally different from managed wetlands which have a continuous flow during winter. This difference in water hydrology further makes extrapolating results from non tidal wetland to tidal wetlands somewhat problematic and probably leads to overestimation of exports when extrapolations are made.

The second approach, conducting large scale studies (analyzing Hg and MeHg in water) with differing watersheds and correlating the levels of MeHg in water and/or fish to landscape features such as % of area with wetlands (Wiener et al 2006; Negrey et al. 2011, Sellers et al 2001; Hurley et al. 1995; St. Louis et al 1996) has limitations also. These studies have been mainly used in upland non tidal areas. They are based upon correlations and compare one watershed vs. another. Because none of these were conducted in tidal situations extrapolations to tidal marshes remain speculative.

The third method involves coupling acoustic Doppler current profilers with water samples of MeHg (Bergamaski et al. 2011; Stephenson et al. 2008); the authors of this proposal have been involved with both these studies. These studies have used a combination of acoustic Doppler current measuring equipment and analysis of many water samples to address this question. The results from these studies are somewhat ambiguous in that the study methods can optimistically detect a 20% difference in MeHg in incoming and outgoing tides from a tidal wetland. Out of 6 areas studied by Stephenson et al. 2008 only 1 of 6 wetlands was found that had consistent loads that were greater than 20%. This wetland was the mouth of Suisun Slough where we found a net import of MeHg in 5 of 6 of the 24 hour diel studies. Unfortunately to get a good estimate of annual net import/export of MeHg would require 20 or so diel studies per year (Chris Enright, personnal communication). These studies are very expensive. We estimate the cost for each wetland to be about $600,000 per year. The proposed methodology using fish will allow us to evaluate 10 wetlands for about $600,000 and the ability to detect small export loads will be much better than the previously used methodology.

The fourth method is to study MeHg in water sediment and fish before and after a tidal wetland creation. This method gives good estimates of what happens inside a wetland area after it is converted to tidal habitat. For example, at Blacklock the fish decreased from 0.2 to 0.05 after conversion to tidal wetlands (Figure 1). Water MeHg decreased from > 1 to 0.2 ng/L (Figure 2). These decreases give good evidence that the waters and fish inside the wetland have decreased due to the restoration efforts but do not answer the question of whether the wetland just became a net exporter of MeHg instead of the material bioaccumulating *in situ*. As previously mentioned, the new MeHg control plan for the Delta does not allow a net increase in MeHg export from new wetland. The only way to determine if there are export loads is to measure them directly with water samples and current profilers as discussed above or use an alternative approach as we are proposing. Another drawback of this methodology is there are only a few wetlands scheduled to be converted to tidal waters and these may be years away, thus limiting the opportunities for studies. Once completed, it is often difficult and expensive to change the restoration plan for the wetland.

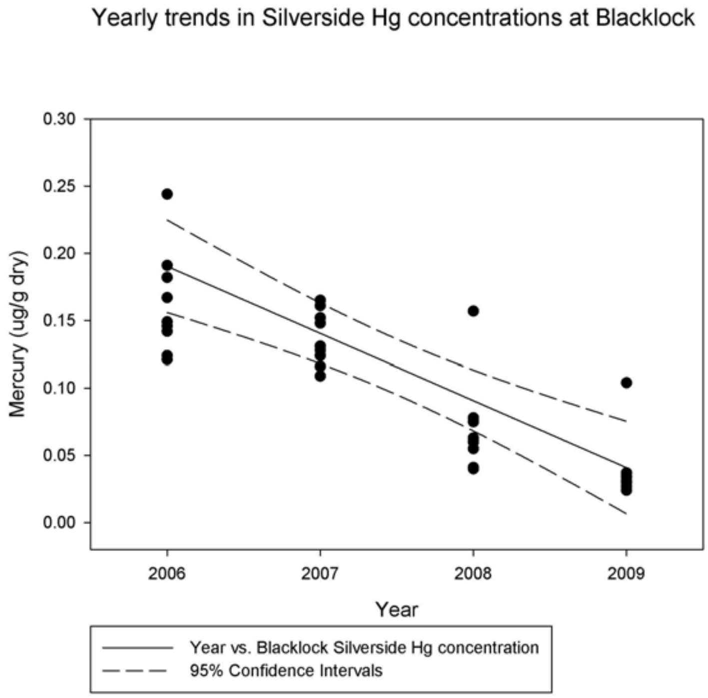


Figure 1. Trends in Fish (Silversides) pre and post breach at Blacklock. Pre breach collections were on 7/26/2006 and post breach collections were on the dates after 7/26/2006.

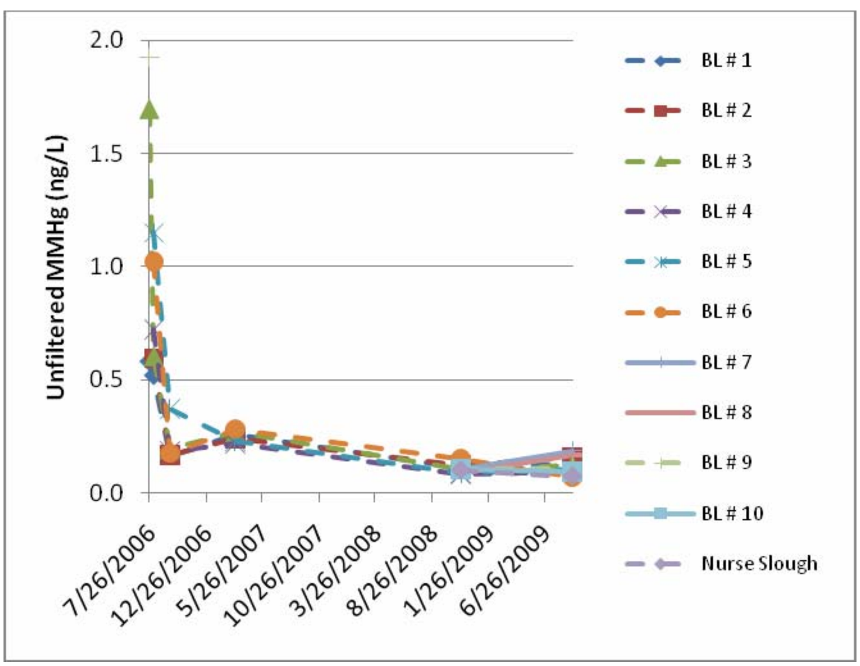
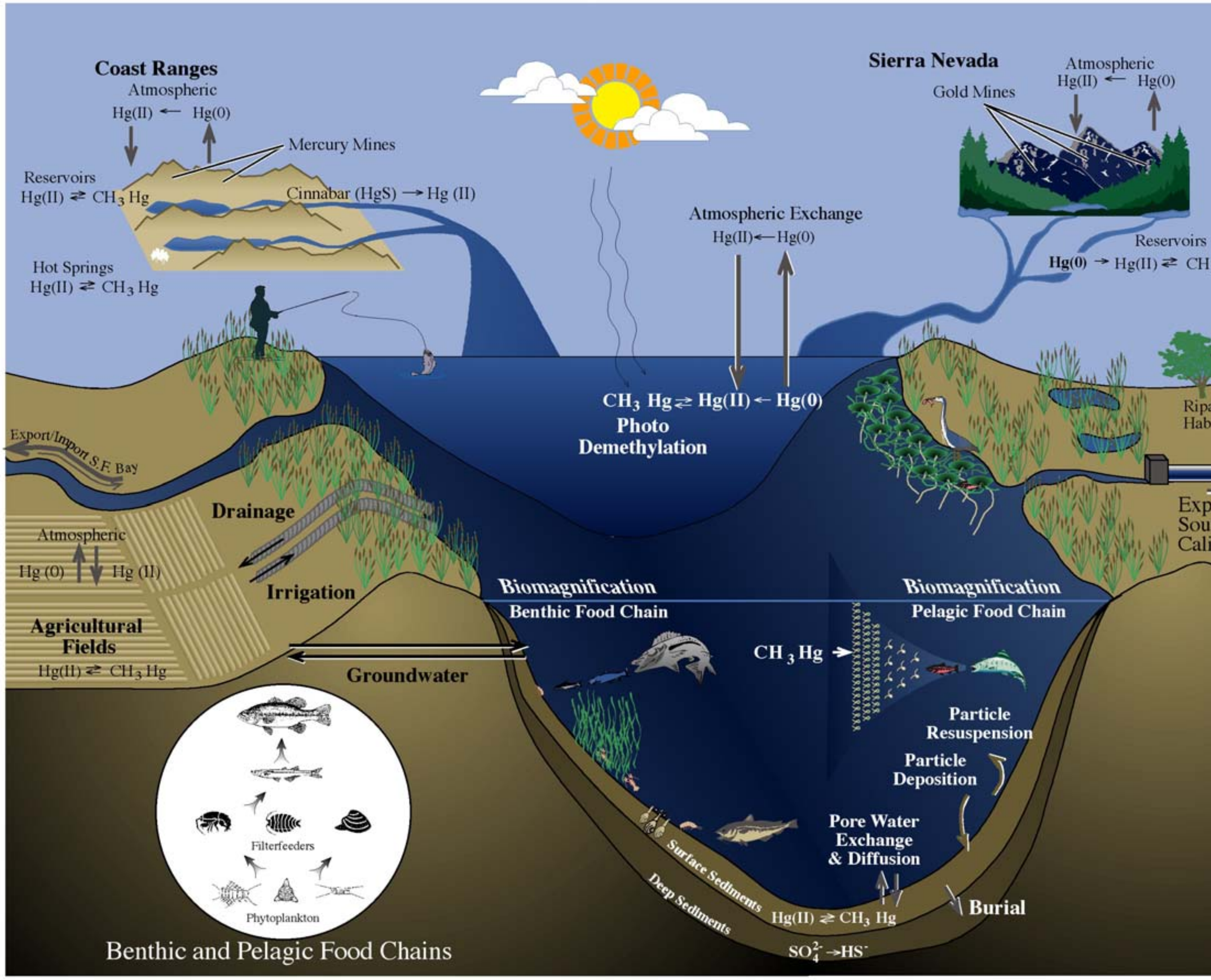


Figure 2. Blacklock methylmercury unfiltered water concentrations. Pre breach collections were on 7/26/2006 and post breach collections were on the dates after 7/26/2006.

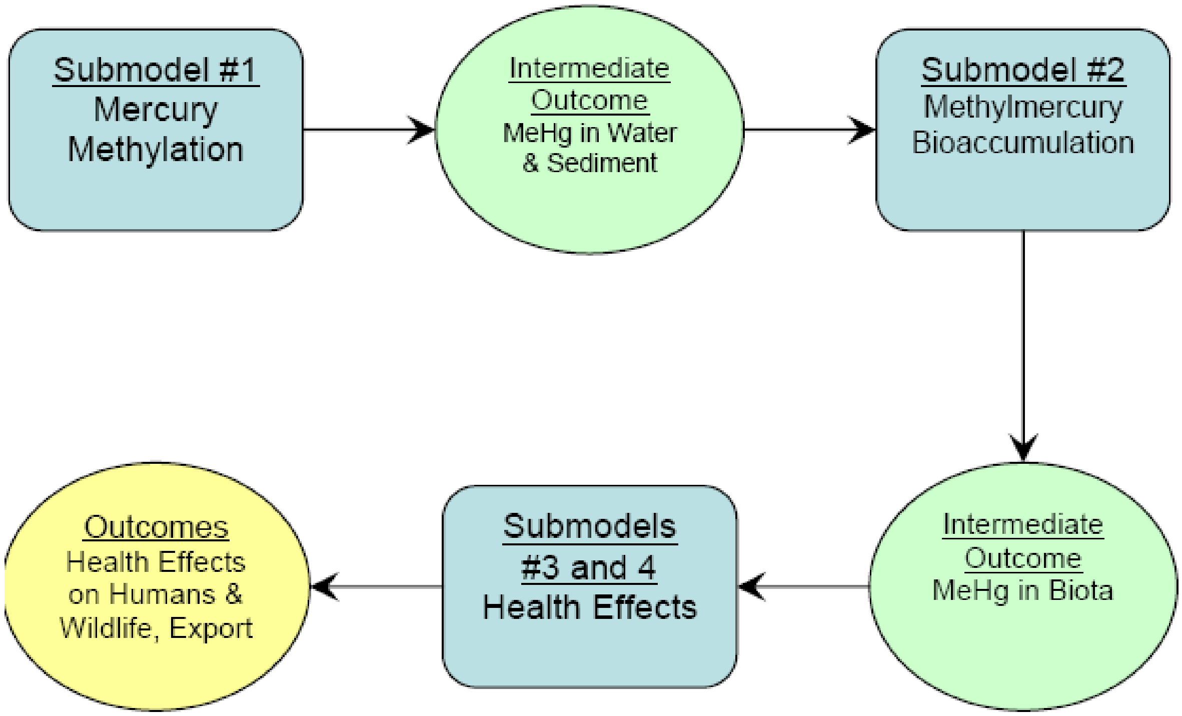
An alternative to the previously mentioned 4 methodologies is what we are proposing here: to assess the extent of mercury contamination with the use of transplanted caged biota. Although this methodology does not give an estimate of export loads in grams per day, it does determine whether the wetland is a net importer or exporter of MeHg and the aerial extent of the impact. Arguably this may be more relevant biologically than the coinage used by the TMDL report to the U.S. EPA. This is a low cost method of evaluating the impacts of MeHg due to restoration efforts and has the ability to detect very small changes. In addition, sufficient wetlands will be studied to obtain data on which types of wetlands export the most MeHg which will aid in future wetland design. This approach has recently be developed and tested for fish by USGS (Ackerman et al. 2010) and for clams by Foe et al. (2003).

The conceptual model for this work will be described verbally with reference to a picture and a diagram (from DRERIP) (see below). Methyl mercury is continuously made by sulfate reducing bacteria in sediment and degraded by sunlight or other microbes. The remaining MeHg binds to algae which is ingested by filtering organisms such as zooplankton or clams which in term are consumed by small and large fish. The result is that large fish in the Delta often have 1 to 10 million times more MeHg in them, on a weight basis, than the water they inhabit. Instead of measuring all the gain and lost terms and developing a mass balance model, we are providing an alternative, low cost way of measuring the extent of export of Hg and MeHg to the adjacent Delta waterways. The methodology proposed will simply use transplanted fish and clams to estimate the area affected by the net import/export of mercury species. The concentration of mercury in fish has been shown to be correlated with the concentration of methylmercury in water (Foe et al. 2008). This allows us to use fish as an integrator where biocumulation is reflective of average water concentrations of the bioavailable forms of mercury. Since fish are going to be transplanted in transects from the mouths of wetlands to far away from the mouth the area that has significant bioaccumulation can be estimated. In the picture model bioaccumulation is indicated by the fish and the human and bird fishing. In the diagram DERIP model bioaccumulation is pictured in the upper right. The small fish integrate all the processes from MeHg production to the intermediate outcomes of MeHg in fish and water thus significantly decreasing the amount of work and scientific interpretation required to complete the objectives of this study.

Delta Conceptual Model Picture.



DRERIP Conceptual Model Diagram (Figure 1 in DRERIP Mercury model).



3. Approach and Scope of Work

The goal and objectives of this study are listed below:

Goal: Estimate the amount of area near existing wetlands that have significantly more MeHg in fish tissue.

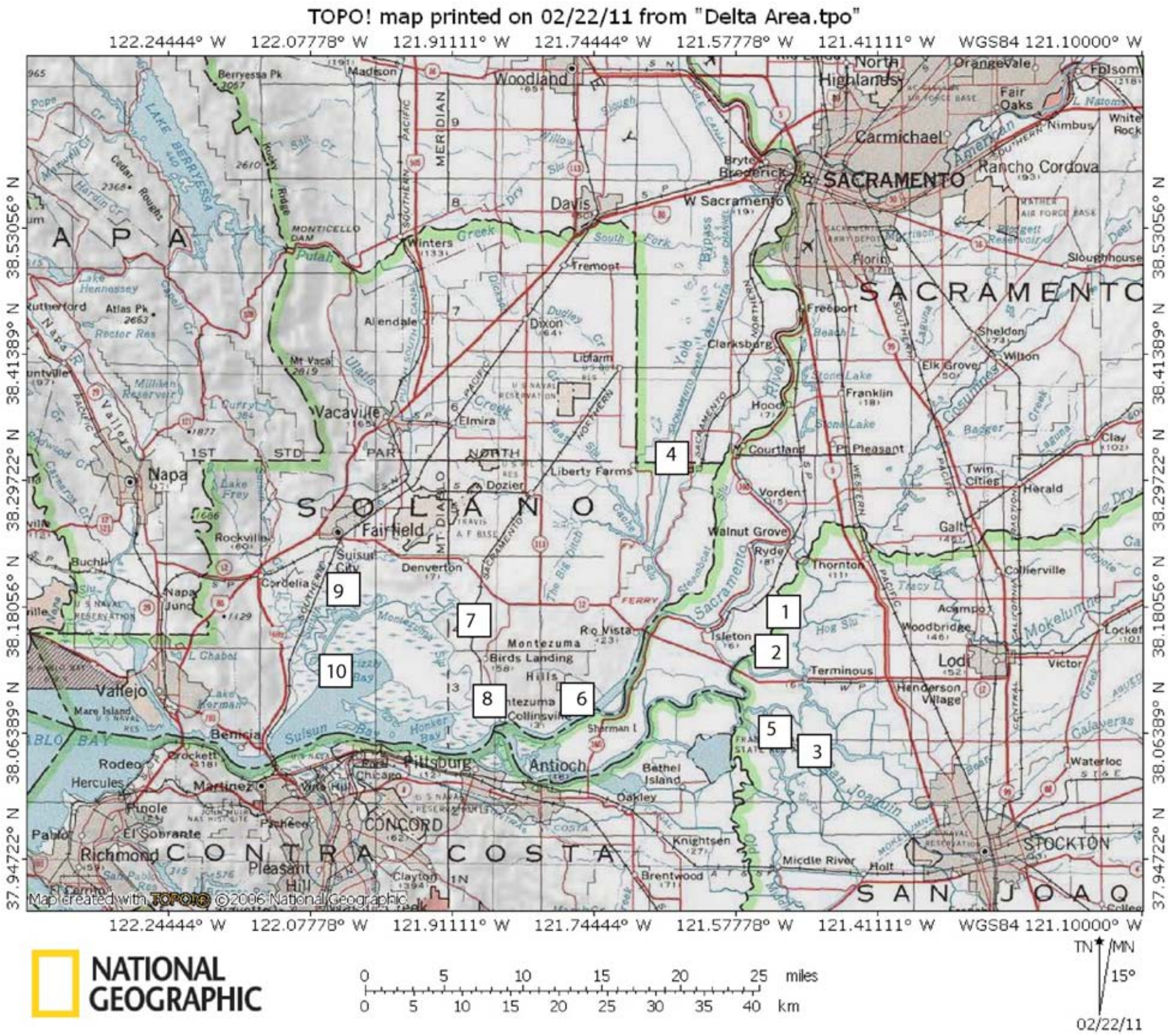
- Objective 1. Transplant fish and clams to 10 wetland areas
- Objective 2. Calculate area affected by increases in MeHg in Fish and Clams
- Objective 3. Correlate area affected by wetland parameters such as volume of wetland, amount of water exchanged, concentration difference between wetland and adjacent waterways, and size of watershed around wetland, vegetation of wetland and type of sediments within wetland.
- Objective 4. Recommend to BDCP ways to mitigate the methyl mercury bioaccumulation problem

This method requires fish and clams be put in cages and transplanted to areas where monitoring is needed. Approximately 20 inland silversides 2 to 3 inches in length will be measured, weighed and placed in cages 14 x14x 24 inches in dimension using methods developed by Ackerman et al. (2010). Approximately 20 clams (Corbicula) 25-30mm in shell length will also be also placed in cages using methods developed by Foe et al. (2003). They will be transplanted to the location specified and left for one month. Ackerman et al. (2010) for fish and Foe et al. (2003) for clams have shown significant bioaccumulation occurs with these species in 1-2 months. At the end of the transplant period the fish will be removed from the cages, measured, weighed and frozen until Hg analysis. In the laboratory the fish and clams will be thawed and analyzed using <u>US EPA Method 7473</u>. A condition index (length/weight) will be calculated for

each fish to estimate the condition of the fish and clams before and after the transplant period. Approximately 10 wetlands will be studied. Biota will be transplanted to 3 stations inside each wetland in a transect from near to furthest from the mouth. In addition, biota will be transplanted to 5 stations away from the mouth of the wetland in open water. At each station 3 replicate cages will be transplanted for each type of biota. The 10 stations in the adjacent channel will be approximately 100, 200, 400, 800 and 1600 m from the mouth during the first year. Each site will be slightly different and the distances may have to be adjusted somewhat. Tidal wetlands will be targeted but two non tidal seasonal managed wetlands (Twichell I and Grizzly I) will also be monitored to provide a contrast and also because the loads from these two sources have already been estimated (Stephenson et al 2008 ab). The proposed wetland monitoring will occur on Liberty Island, Decker Island, Blacklock, First Mallard Branch in Suisun, Sycamore Slough, Hog Slough, Mouth of Suisun Slough, and Mandeville Point (Figure 3). The transplants will take place 2 times per year: once in the winter when river flows are high and once in summer when winter flows are at their lowest. Three to 4 wetlands will be studied each year of the 3 year study. Ten silversides and clams will be analyzed as a composite in each cage collection. The first year both clams and fish will be transplanted. After an evaluation of the results of the first year the study design may be modified based on the survival rate and methyl mercury accumulation rate of both fish and clams. Depending on the wetland studied one or the other species may prove more useful and be used exclusively during subsequent years.

The area affected will be estimated by determining which stations are significantly different from the control stations furthest from the mouth of the wetland. The liner length of the distance from the significantly different stations from the mouth will be estimated.

Seasonal differences in area affected will be estimated by comparing amount of area affected 2 times per year.



Site #	Site
1	Hog Slough
2	Sycamore Slough
3	Mandeville Point
4	Liberty I
5	Twichell I
6	Decker I
7	Blacklock
8	Grizzly I
9	First Mallard Branch
10	Suisun Slough

Figure 3. Station locations for the study.

Outreach
We propose to present information at two scientific settings (conference and workshop) at the end of the grant to inform stakeholders and regulatory agencies of our results and recommendations.

4. Deliverables
This project will provide quarterly reports, a final report, and a manuscript ready for submittal to a peer reviewed publication. Scientific talks will be given at two conferences and or workshops.

5. Feasibility
This project requires no permits, access permissions, or not contingent on other programs. The fish and clam transplants have been conducted by others in previous projects and methods have been developed and are have an excellent chance of being completed in the time frame proposed (3 years).

6. Relevance to the CALFED ERP

The following Priorities listed in the PSP:

Restoration Projects that Restore or Enhance Aquatic Habitat in the Sacramento-San Joaquin Delta and Suisun Marsh and Bay

> *To meet immediate and long-term goals for restoration of floodplain and intertidal/subtidal environment, there is a need for projects that provide the following:*
>
> *1. Floodplain restoration to optimize salmon rearing and splittail spawning and rearing functions.*
> *2. Intertidal restoration to estuarine productivity, provide spawning and rearing habitat for native fishes using the Delta, and which accommodate long-term habitat changes resulting from climate change.*
> *3. Restore geomorphic processes and riparian vegetation and assess aquatic invertebrate production and the resulting effects on fish survival and growth.*

All the potential aquatic restoration projects will require a permit from the CVRWQCB. The CVRWQCB will probably be somewhat reluctant to grant the permit unless the applicant can provide information that proves they will not have significant methyl mercury discharge. Currently there is not enough scientific evidence for applicants to use to justify no discharge of methyl mercury.This permit process, along with the requirement that the applicant may need to do extensive research, could hold up restoration projects for many years. This project should provide invaluable information to applicants regarding MeHg exports from wetlands.

Projects using Constructed Facilities to Control Mercury or other Mine Drainage in the Bay-Delta or Dissolved Oxygen and Other Water Quality Problems in the Lower San Joaquin River and South Delta

> *To meet water quality goals and standards in the Delta for mercury and dissolved oxygen and to reduce mobilization of mercury into the foodweb or into the Delta there is a need for projects that implement and evaluate best management practices for reducing loads of these constituents to the Delta.*

This project will help evaluate the magnitude of the fish mercury bioaccumulation problem in the Delta. It will identify wetlands that export the least amount of methyl mercury along with their landscape attributes which could aid in the design of newly created wetlands proposed as part of BDCP (65,000 acres).

7. Expected quantitative result (project summary)

The length of Delta water ways in meters affected by methyl mercury contamination will be determined.

8. Other products and results: Results could be used to inform the DRERIP Mercury Model.

9. Qualifications

Kenneth Coale, Wes Heim (Moss Landing Marine Labs) and Mark Stephenson (Department of Fish and Game) have managed 10 mercury related projects over the past 10 years. Almost all of the projects involved mercury studies in the Central Valley. Three of the projects involved multi-investigator teams from different universities and agencies. Mark Stephenson, will manage the project from DFG with a subcontract from SJSUF. He will manage the grant from DFG and interact with the project's PI Dr. Kenneth Coale to insure the work on the project gets done. He will make sure the deliverables are on time, the work is completed on time, and the work is of the highest quality. He will approve all purchases on the grant.

The mercury analytical chemist staff at Moss Landing Marine Labs consists of one lead chemist (Wes Heim) and two mercury chemists, all of whom have extensive experience in analyzing mercury and methyl mercury in water, tissue, and sediments. The lab's analytical results consistently exceed quality assurance and quality control requirements.

Mark Stephenson is the Director of Marine Pollution Studies for the Department of Fish and Game and Moss Landing Marine Labs. Recent environmental water quality projects in which he has been principal investigator include: California State Mussel Watch, Coastal Fish Contaminants, the Bay Protection and Toxic Cleanup Program and the California State Surface Water Ambient Monitoring Program. Kenneth Coale is the director of Moss Landing Marine Labs. Wes Heim is a Research Associate at Moss Landing Marine Labs. Mark Stephenson, Kenneth Coale, and Wes Heim were the principal investigators of the CALFED mercury programs "Assessment of Ecological and Human Health Impacts of Mercury in the Bay-Delta Watershed and "Transport, Cycling and Fate of mercury and monomethylmercury in the San Francisco Delta and Tributaries—An integrated mass balance assessment approach. Study designs, data collection, and final reports for each 3.8 million (Federal and State funding) projects were completed according to the grant agreements and received positive reviews from an independent scientific panel. Currently they are investigators in studies involving mercury loadings from rice fields and managed wetlands in the Yolo Bypass Wildlife Area, mercury and low dissolved oxygen in Suisun Marsh, development of biological accumulation factors for mercury in California lakes and harbors, Central Valley Regional Water Quality Control Board's Methyl Mercury TMDL, and the State Water Resources Control Board's Biological Oversight Group of the State Ambient Water Assessment Program.

List of Projects:
ERP-99-B06: An Assessment of Ecological and Human Health Impacts of Mercury in the Bay-Delta Watershed — completed as contracted

ERP-02-C06-a and ERP-02-C06-b: Transport, Cycling, and Fate of Mercury and Monomethyl Mercury in the San Francisco Delta and tributaries—An Integrated Mass Balance Assessment Approach — completed as contracted

10. Literature Cited

Ackerman, J. T., C. A. Eagles-Smith, J. Y. Takekawa, S. A. Demers, T. L. Adelsbach, J. D. Bluso, A. K. Miles, N. Warnock, T. H. Suchanek, S. E. Schwarzbach (2007). Mercury concentrations and space use of pre-breeding American avocets and black-necked stilts in San Francisco Bay. *Science of the Total Environment.* 384: 452–466.

BDCP, 2010. http://bdcpweb.com/Libraries/Whats_in_Plan/draft_BDCPreport_11292010_ClickableLinks7.pdf

Churchill, R. 2000. Contributions of mercury to California's environment from mercury and gold mining activities—insights from the historical record. *In*: Assessing and managing mercury from historic and current mining activities. A symposium held Nov 28-30 in San Francisco, CA.

Davis, J, B. Greenfield,., G. Ichikawa, M. Stephenson,. 2008. Mercury in sports fish from the Sacramento-San Joaquin Delta region, California. US. Science and the Total Environment. 391: 66-75.

Foe, C. 2003 http://mercury.mlml.calstate.edu/reports/2003-reports/

Gill, G. 2008. Task 5.1 Monomethylmercury Photo-degredation Studies1 http://mercury.mlml.calstate.edu/wp-content/uploads/2008/10/09_task5_1_final.pdf

Hurley, J.P., J.M. Benoit, C.L. Babiarz, M.M. Shafer, A.W. Andren, J.R. Sullivan, R. Hammond, and D.A. Webb. 1995. Influences of watershed characteristics on mercury levels in Wisconsin rivers, *Environmental Science and Technology*. 29: 1867-1875.

Krabbenhoft, D.P., J.G. Wiener, W.G. Brumbaugh, M.L. Olson, J.F. DeWild, and T.J. Sabin. 1999. A national pilot study of mercury contamination of aquatic ecosystems along multiple gradients, in *U.S. Geological Survey Toxic Substances Hydrology Program--Proceedings of the Technical Meeting, Vol. 2, Contamination of Hydrologic Systems and Related Ecosystems*, Morganwalp, D.W. and Buxton, H.T., Eds., U.S. Geological Survey Water-Resources Investigations Report 99-4018B, 1999, 147-160.

Rudd, J.W. 1995. Sources of methyl mercury to freshwater ecosystems: a review. 1995. *Water, Air and Soil Pollution.* 80: 697-713.

St. Louis, V.L., J.W.M. Rudd, C.A., Kelly, K.G. Beaty, N.S. Bloom, and R.J. Flett. (1994). Importance of wetlands as sources of methylmercury to boreal forest ecosystems. Can. J. Fish. Aquat. Sci. 51:1065.

St. Louis, V.L., J.W.M. Rudd, C.A. Kelly, K.G. Beaty, R.J. Flett, and N.T. Roulet. 1996. Production and loss of methylmercury and loss of total mercury from boreal forest catchments containing different types of wetlands, *Environmental Science and Technology*. 30: 2719-2729.

U.S. EPA. 2001. Water Quality Criterion for the Protection of Human Health: Methylmercury. Office of Water. EPA-823-F-01-001

Wiener, J.G., C.C. Gilmour, and D. P. Krabbenhoft.2004. Mercury Strategy for the Bay-Delta Ecosystem: A Unifying Framework for Science, Adaptive Management, and Ecological Restoration. Final Report to CALFED ecosystem restoration program.

Section 7: Project Budget 3 Year Budget

Budget			
Minimizing the Impact of Mercury from BDCP Restoration Activities			
			Totals
PERSONAL SERVICES			
Staff Level	**Number of Hours**	**Hourly Rate***	
Project Assistant (1)	900	31.33	97,113
Project Assistant (2)	1,546.88	49.72	76,911
Project Assistant (3)	1,546.88	49.72	76,911
Project Assistant (4)	149.97	20.41	3,061
Subtotal			
Staff Benefits @ 36.2%, 37.2%, 38.2%			94,599
TOTAL PERSONAL SERVICES			**348,595**
OPERATING EXPENSES			
Description			
Subcontractor Costs			30,000
Materials			38,627
Photographic Supplies			0
Printing and Duplicating			0
Office Supplies			0
General Expense			0
Travel and Per Diem			60,000
Training			0
Add/delete line items above for work to be performed by the contractor			
Total Operating Expenses			128,627
EQUIPMENT			0
SUBTOTAL			477,222
OVERHEAD @ % (Less Equipment)			122,778
GRAND TOTAL			**600,000**

*hourly rate is the average over the 3 years; rates may differ by 15%.
Funds not used in a fiscal year will roll-over and be available that next fiscal year through the life of the contract.

2. Budget Justification

No unusual cost items are requested.

Project staff will estimate the area affected by habitat restoration and creation of wetlands by determining increases of methyl mercury (MeHg) in tissue. The project team will transplant fish and clams to 10 wetland areas, calculate area affected by increases in MeHg in Fish and Clams, correlate area affected by wetland parameters such as volume of wetland, amount of water exchanged, concentration difference between wetland and adjacent waterways, and size of watershed around wetland, vegetation of wetland and type of sediments within wetland, and will recommend to BDCP ways to mitigate the methyl mercury bioaccumulation problem

Mark Stephenson, CA Department of Fish and Game will assist with project management.

3. Administrative Overhead

The SJSU Research Foundation has the Department of Health and Human Services as its cognizant federal agency that reviews, closely evaluates, and approves all indirect cost items included in the negotiated rate. The federally negotiated rate of 26% for off campus research is applied against direct costs, and only on the first $25,000 of subcontracts.