South Bay Salt Pond
Restoration Project
Restoring the Wild Heart of the South Bay

Restoration Funding Application
Cover Sheet

APPLICANT INFORMATION

Name of Organization(s) Requesting Funding: United States Geological Survey

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Federal Employee Identification Number: ____________________

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PROJECT INFORMATION

RFP Study Topic # 5, 6

Project Title Benthic invertebrate community assessment as a phytoplankton consumer and fish and bird prey source before and after the start of the restoration

Funding Request per year $114,789 (Y1) & $62,048(Y2) Number of years: 2

Confirmed in-kind or matching contributions: $ 161,700

Source of in-kind or matching contributions: USGS

Purpose and Objectives: Compare the benthic community before and after the restoration began to determine if it has changed in ways that can account for recent trend changes in phytoplankton biomass and could change prey availability for fish and birds. Establish a pre- and post- restoration benthic community data set that will be made available to the public.

Proposed starting date: May 2009 Estimated completion date: April 2011

Signature : Janet K. Thompson Date: 5 Dec 08
Principal Investigator

Signature : Ean Warren Date: 12/5/08
Grant Administrator

Abstract

We propose to examine the effects of the South Bay Salt Pond Restoration Project on the water quality, ecology and physical habitat of the South Bay by using previously collected, spatially-intensive benthic samples collected during three seasons in each of three years prior to the restoration project (1993-1995) and after the restoration activities started (2006-2008). The benthic community is important as a consumer of phytoplankton and as a prey item for fish, birds, and invertebrates. The benthic community structure and therefore its function may be altered as a result of changes in the physical (substrate, depth) or chemical (salinity, oxygen) habitat. Changes to the benthic community that alters the relative dominance of filter feeders can have far reaching effects; decrease in the benthic filter feeders in 1999-2004 resulted in an increase in phytoplankton biomass throughout the period. While this finding is not yet alarming, the Bay is a high nutrient system that could, with appropriate reductions in grazing and turbidity become eutrophic. As prey items for fish and birds, changes in the physical habitat through redistribution of sediment from the intertidal flats into the ponds could change both the availability of the benthic community and the species present for predation.

Background and justification

The effects of the South Bay Salt Pond Restoration Project on the water quality, ecology, and physical habitat of the South Bay are unknown and have been highlighted as priority research topics in the RFP for 2008. We propose to address the following topics using two sets of existing benthic invertebrate samples that were collected from the South Bay prior to and since the restoration project began: (1) Will the restoration adversely affect water quality and productivity in the Bay (Topic#5, Q1); (2) Will an increased tidal prism affect water quality in the Bay (Topic#5, Q3); (3) Will the habitat value and carrying capacity of the Bay for foraging migratory and resident birds be maintained or improved relative to current conditions (Topic#6, Q2).

The primary goal of the proposed study is to first describe how water quality and physical habitat have structured the benthic invertebrate community in the South Bay in the past, based on past work (Nichols and Thompson 1985a, 1985b, Nichols and Pamatmat 1988, Lee et al. 2003) and the more recent 1993-1995 samples. It should be noted that most of the earlier work occurred prior to the invasion of several important exotic species including *Corbula amurensis* and so some of the conclusions are no longer relevant. We will then determine if the benthic community has been sufficiently altered since the onset of the restoration project to change the benthos' grazing impact on phytoplankton and the availability of benthic prey for birds and fish. We believe this project is feasible and advisable because the samples are already available and, as described below, we have observed recent post-restoration trends: phytoplankton biomass is increasing and bivalve biomass, a valuable food supply for birds and fish, is declining. Despite the demonstrated importance of the benthic community in this and other estuaries, there is no routine monitoring of the benthic community in the South Bay such as is done in the Northern Bay by the California Department of Water Resources (http://www.baydelta.water.ca.gov/emp/index.html). The proposed work will make samples that have collected usable, and available to the scientific community and help guide future research in the system.

South bay is a system dependent on phytoplankton as the base to the food web (Jassby et al 1993). Despite abundant nutrients, South Bay has limited phytoplankton production due to poor light conditions and high grazing losses. Thus the system only rarely experiences anoxia that is usually associated with high nutrient systems (Cloern 2001). Our conceptual model for phytoplankton growth in South Bay includes a delicate balance between light availability, grazing losses (primarily in the shallow water) and physical mixing of the water column (Lucas et al 2009). This balance has maintained the phytoplankton in South Bay at low biomass levels relative to other high nutrient urban estuaries (Cloern 2001). Increases in light availability, decreases in benthic grazing rates, or a reduction in mixing can and have resulted in unusually high phytoplankton biomass on some occasions. Two such occasions occurred in 1993 and 1998 (Figure 1) when periods of increased light availability, caused by density stratification of the water column, increased the phytoplankton growth rate (Thompson et al 2008, Cloern 1996). Other periods of elevated chlorophyll *a* concentrations were seen in summer and fall 1994 (Thompson et al 2008) and in 1999-2004 (Cloern et al 2007) resulting from a sharp reduction in benthic grazers (dominated by bivalves in this system).

In contrast to these episodic fluctuations in bivalve biomass, a fall reduction in bivalves in the shallow water each year allows the spring phytoplankton bloom to develop in the South Bay (Figure 2). Each fall, predation by migratory and resident birds (Thompson et al 2008), fish, and invertebrates (Cloern et al 2007) decimates the shallow water bivalve communities in South and San Pablo Bays (Poulton et al 2002, 2004, Richman and Lovvorn 2004). This elimination of bivalve grazing in the shallow water allows the phytoplankton to grow if light and mixing are not limiting (Thompson et al. 2008). Bivalves in the shallow water are thus essentially an annual species with larvae settling each spring followed by rapid growth which allows them to become a controlling factor on the phytoplankton by late spring and summer. However, as shown by increases in phytoplankton biomass in South Bay during the strong upwelling events in 1999-2004, the relationship between benthic grazers and phytoplankton is not always so tidy. We found that juvenile demersal fish and invertebrates that rear in the bay thrive during strong upwelling years and that this higher abundance of predators was sufficient to limit bivalve populations throughout the year. The result of the reduced grazing pressure on the phytoplankton was an increasing trend in phytoplankton biomass and the development of fall blooms (Figures 1, 3, Cloern et al 2007). As shown by this example, understanding the ecological dynamics of South Bay is not always straightforward. This is a cautionary story, as it is important that we not misinterpret changes such as was seen in 1999-2004 as salt pond restoration effects.

Changes in the benthic community structure occur normally. Benthic species distributions are dependent on the physical habitat (substrate and depth), physiological limits (ie salinity in this system, Lee et al 2003), and predators (Cloern et al 2007). Therefore seasonal and interannual differences in freshwater flow result in both seasonal and episodic patterns in species abundance and community composition (Nichols and Thompson 1985a, 1985b). Episodic events such as invasive species introductions can have lasting effects on the benthic community whereas other events such as wastewater treatment plan malfunctions are likely to have shorter term effects. Contaminants can also restrict the success of some species (Hornberger et al 2000). It should be noted that even when changes in species composition occur within a community, the functional form of the community may remain the same, eg. the community is still dominated by a filter feeders. In these instances the effect of a change in the benthic community on the phytoplankton growth rate may be large or minimal depending not only on the type of feeding mode but also on the relative feeding rate of the new species.

The importance of benthic invertebrates as prey is sometimes undervalued but they are considered a sufficiently significant prey resource for many fish species managed by Fisheries Management Plans under the Magnuson Stevens Fishery Conservation and Management Act that they are considered a component of essential fish habitat. Our conceptual model for maintaining appropriate benthic prey for fish and bird species is based on knowing what prey characteristics and habitat of the prey are important for the predator. The effect of species swaps within benthic communities may be very significant to predators. For example, a surface dwelling bivalve like *Corbula amurensis* has a soft shell, is highly caloric, and easy to capture and has been shown to be valuable prey in the Bay (Richman and Lovvorn 2004). A deep burrowing tube-dwelling worm such as *Sabaco elongatus* that is common in South Bay (Lee et al 2003) is unlikely to be fed upon by either fish or birds. For this reason our analysis of the benthic community data will include abundance, grazing rate where appropriate, and functional ecology (feeding and reproductive mode, habitat, motility, and structures such as tubes and shells which may impede predation) of each species.

In summary, we feel it is important to look for changes in the benthic community within the context of the restoration project for two reasons. First, it appears that the balance between physical and biological factors that determine the net phytoplankton growth rate and thus phytoplankton biomass, a primary water quality indicator, are vulnerable to change due to the restoration actions. In particular, increasing the tidal prism and thereby changing circulation patterns and salinity distribution in time and space may change the makeup of the benthic community due to the physiological tolerances of individual species to salinity. Second, the possible redistribution of sediment into the ponds, resulting in an altered bathymetric profile and a reduction of intertidal mudflat surface area could change the balance between grazing, mixing, and light that is responsible for limiting phytoplankton production. This same action may limit the available habitat for some species and may reduce the area of habitat that is available for specific predators on the benthos. Changes in the circulation and physical habitat may also affect the success and composition of the benthic community larvae that repopulate the shallow water each spring. One disturbing outcome of the physical/chemical habitat and circulation changes would be the invasion (not necessarily an exotic species phenomenon) of a dominant filter feeder that can limit net phytoplankton growth but is unpalatable to predators and therefore is present throughout the year. Although the most common concern is that the South Bay not become eutrophic, it would also be devastating to the food web if phytoplankton blooms were eliminated; such an occurrence in North Bay is believed to have contributed to the decline of key fish species in that system (Sommer et al 2007).

We also believe that we need to focus on changes in phytoplankton biomass and benthic grazers because the increasing trend in the phytoplankton biomass observed in 1999-2004 that was attributed to a reduction in grazers (Cloern et al. 2007) has returned. The predators on the benthos that resulted from upwelling events have now declined to normal levels (Figure 3), but the phytoplankton biomass is again increasing and the fall blooms are quite significant (Figure 1). A gross examination of the benthic samples from the recent period reveals that the filter-feeding bivalves were present in 2006 but not in 2007 and 2008.

Hypotheses and Tests:

The hypotheses to be tested by this study and a brief description of the conceptual model that led us to each hypothesis follows:

H_0: The pre-restoration benthic community can be described relative to the known hydrologic conditions and predators present during the period.

H_0: There has been a change in the benthic community structure since the initiation of the restoration project that can not be associated with known stressors. (predators, hydrologic events, invasive species)

Conceptual Model: Benthic species distributions are dependent on the physical habitat (substrate and depth), physiological limits (ie salinity), and predators (Cloern et al 2007). Episodic events such as invasive species introductions can have lasting effects on the benthic community.

H_0: Functional changes in the benthic community have resulted in decreased grazing pressure on the phytoplankton resulting in increased phytoplankton bloom frequency and duration.

Conceptual Model: Phytoplankton biomass accumulation (bloom) is a function of light, nutrients, mixing and transport rates, and losses to grazers A change in any of these factors can limit phytoplankton biomass growth.

H_0: Changes in the benthic community structure have changed the food available to their predators either through changes in biomass, availability, or palatability

Conceptual model: Benthic organisms are a good food source when the energy needed to find and remove the prey from the sediment is less than the energy assimilated from the prey. Near-surface dwelling, large animals such as bivalves are considered good food for demersal fish, diving ducks, and shore birds. The balance between energy consumed and assimilated is related to the predators caloric cost of retrieving prey from specific depths in the sediment relative to the calories consumed and then lost due to processing body covering, tubes and other protective structures. Palatability is also an important determinant of a prey species value.

Relationship to Ongoing Research

The USGS (Dr. J. Cloern) has monitored the water quality of South Bay since the 1970's on weekly to monthly cruises (http://sfbay.wr.usgs.gov/access/wqdata/index.html). These data will be invaluable in our assessment of water quality conditions and phytoplankton biomass during our study period. The USGS has also been monitoring the benthic community composition of a mudflat station near Palo Alto since 1974 (Dr. J. Thompson) and those data will be compared with our results. Kathy Heib, California Department of Fish and Game, has been a collaborator for many years and we expect to incorporate her knowledge of the fish and invertebrate monitoring data to establish the likely predators on the benthos during these periods. We are closely associated with Dr. J. Takekawa through the USGS Priority

Ecosystem Science Program and expect our results to be useful in his future endeavors to model the carrying capacity of the system for bird species.

Study Objectives

Our primary objective is to compare the benthic community near the restoration sites in the South Bay before and since the restoration commenced to determine if the benthic community differs in ways that (1) can account for recent trend changes in phytoplankton biomass (ultimately primary production) and (2) could change prey availability for fish and birds. Our secondary objective is to establish a pre- and post- restoration benthic community data set that will be made available to the scientific community to evaluate other post-restoration benthic community data.

Study Area

The study (Figure 4) is inclusive of the area from the San Mateo Bridge (SMB) into the mouth of Coyote Creek and stations are located in both the subtidal and deep intertidal areas. As shown in Figure 4b, the 22 stations that will be analyzed are a subset of a larger study. The stations adjacent to and south of the Dumbarton Bridge (DB) are near the Alviso complex and the benthic community at these stations has had the longest exposure to the restoration process (Figure 4b, area A). The stations north of the San Mateo Bridge are nearest the Eden Landing restoration site (Figure 4b, area B) and have been included for two reasons. First, Jaffe and Foxgrover (2008) report that loss of intertidal area is most likely to occur north of DB so the eastern shoal due to its size is most likely to be impacted by the redistribution of sediment. Second, this shallow area is of the critical importance in the formation of phytoplankton blooms in this system. Over a 5 year study we consistently saw phytoplankton blooms start on the eastern mudflats between the SMB and DB. Blooms are initiated and grow rapidly in this area due to the isolation of the water on this shoal from the deep channel water where the phytoplankton grow poorly, if at all (Thompson et al 2008). A few channel stations are included as the bivalves in the channel are the source of recruits following the fall predation on the bivalves. Thus to fully understand the benthic community changes through the seasons we need benthic community data from all depths.

Approach

Our approach is simple. We will analyze benthic community species composition and the functional composition of the community before and after the restoration. We have chosen 2- three year periods for the study which encompass a range of hydrologic and salinity conditions (Figure 3). The advantages in using these samples is their timeliness (before and after restoration), the fact that they have already been collected so the cost of collection is excluded, and the reduction in coast of processing the early samples that have had the bivalves removed and measured. These samples have been collected as part of a field and modeling study that examined the mechanisms of phytoplankton bloom development in south bay (Thompson et al, 2008, Lucas et al. 2009). We did two types of sampling. Replicate monthly samples were collected from 1991-1996 at 5-15 stations. We also collected the spatially intensive samples shown in Figure 4b to insure that our monthly station data were representative of the broader spatial benthic community in the bay. We found that the subset is reasonably representative of the larger sampling effort and feel that it will supply the resolution needed for the questions posed here. Collection dates for the spatial samples s were set to match the phytoplankton bloom period in spring, the low bloom period in mid-summer, and the fall bloom period (Thompson et al. 2008). The timing of the sampling was verified by the monthly time series data. The timing of the sampling is also appropriate for assessment of the benthic prey that are available from spring through fall of each year. Figure 5 shows the evolution of bivalve grazing rate (a function of biomass) at these locations during the three years (1993-1995) that we are proposing to analyze. Analyses of these samples includes sorting the samples (only the bivalves were removed), identifying and enumerating the remaining non-bivalve species from the samples.

Samples were collected with a $0.05m^2$ weighted van Veen grab that was hand deployed in all but the deep water stations. Samples were sieved through a 0.5mm screen, preserved in 10% buffered formalin, and transferred to 70% ethyl alcohol with Rose Bengal dye. Samples will be sorted and well known species enumerated at the USGS. We have a quality assurance procedure of double sorting/identifying a percentage of the samples depending on the difficulty of the sample and the number of organisms in the sample. More difficult taxonomic groups will be contracted out to taxonomic consultants with a request that all but the rare species be identified and enumerated to the lowest taxon possible. The contractor will be asked to supply a taxonomic voucher collection.

Large bivalves will be measured for conversion to biomass and grazing rate in the recent samples (2005 -2008) to allow for comparison with the pre-restoration data. Grazing rates of other dominant filter feeding species will be estimated using published pumping rates for the species if possible or for the closest taxon available.

Data will be reported as species lists with abundance data and functional ecology notes (feeding mode, body position in/on the substrate and external structures/protection, reproduction mode). Community structure will be discussed as a function of hydrologic conditions (temperature and salinity as reported by USGS: http://sfbay.wr.usgs.gov/access/wqdata/index.html) and demersal fish and invertebrate predators (California Department of Fish and Game Bay Study Database: ftp://ftp.delta.dfg.ca.gov/Bay%20Studies/).

Multivariate analyses will be done with the PRIMER statistical package to delineate differences in community structure (ANOSIM) as a function of species and as a function of functional groups between the data sets. If the communities are found to differ, SIMPER will be used to identify the species or functional group that are contributing most to the difference in community structure. This detailed analysis will determine if the functional groups have changed or if there has been an interchange of species with similar ecological functions.

Grazing rates in the 2005-2008 data will be compared against the benthic grazing threshold ($\geq 0.5\ m^3 m^{-2} d^{-1}$) for phytoplankton growth that was derived in Thompson et al (2008). Grazing rates for hydrodynamically separate areas (eastern shoal north of SMB, shoals south of DB, channel south of DB, channels north of DB) will be derived by pooling the areal data and statistically comparing the data from the different dates with ANOVA.

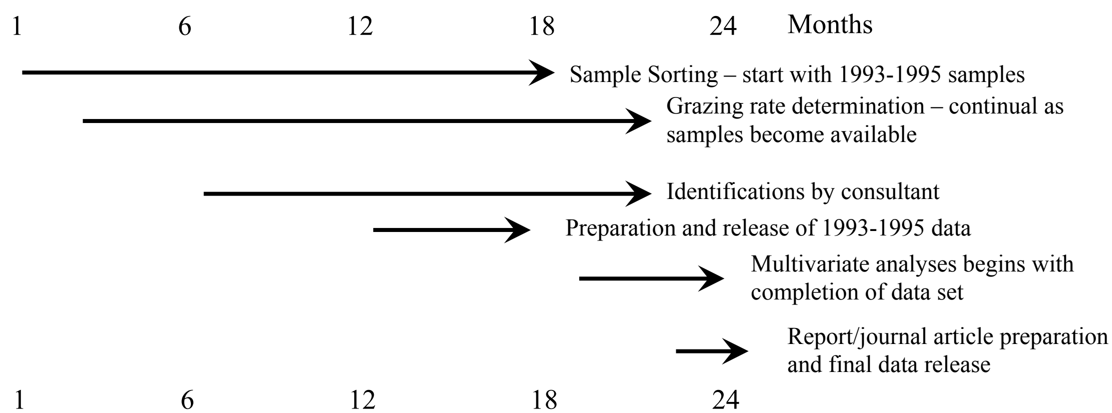
Data Archiving Procedures

The data (species name, abundance, functional ecology notes for each station and date) will be made available in EXCEL spreadsheet format. We have found this format to be most user friendly in our prior data releases because EXCEL is directly importable into ACCESS for those users who wish to use a database program. Data will be released electronically through a USGS web interface and will be available to the SBSPRP for inclusion on their web site if they wish.

Work Schedule

Sorting will begin immediately and samples will be delivered to the taxonomic consultant as they become available. We plan to process the 1993-1995 samples first and post them on the web for immediate use by the scientific community. The work will take 2 years to complete.

Our timelines are as follows:



Expected Products

We expect there will be significant findings in this study and that the results will be worthy of journal publication. If not, a data report with the statistical findings and a discussion of the findings will be released through the USGS and made available in electronic format.

We will give a presentation of the data at the South Bay Science Symposium and be available for discussions with all researchers who might find the data useful.

Connection to Other Studies and "Matching" Funding

The primary costs in this study are for a technician to sort samples and for a contractor to identify and enumerate the more difficult taxonomic groups. Dr. Thompson's project at the USGS is currently continuing the sampling that is reported in this study as part of the Priority Ecosystem Study of the South Bay Salt Pond Restoration. Unfortunately the funding that is requested here to analyze the earlier samples is not available in the PES program. The costs of the field work and all laboratory equipment have been and will be paid for by the USGS Core Research Funding and the Toxics Program. The salary dollars needed by Dr. Thompson to manage the project and for F. Parchaso and J. Thompson to analyze the data and write the report will be covered by the USGS. A small amount salary has been included for F. Parchaso to supervise and train the technicians.

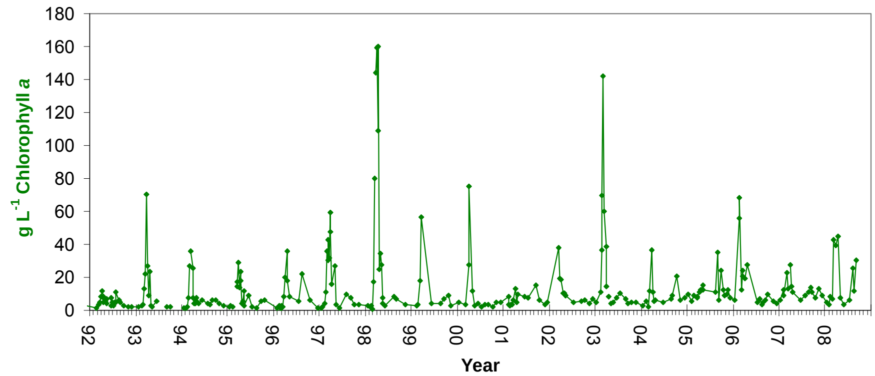


Figure 1. Phytoplankton biomass (as represented by chlorophyll a concentration) from USGS station 36 (at label A on Figure 4b). Data acquired from http://sfbay.wr.usgs.gov/access/wqdata/index.html.

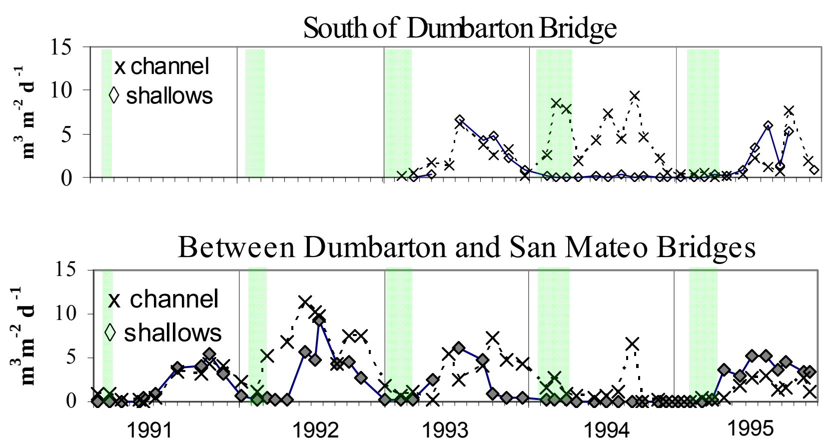


Figure 2. Time series of benthic grazing rate of the bivalves at stations south of Dumbarton Bridge and between the Dumbarton and San Mateo Bridges. Channel and shallow water stations are shown separately. Note the reduction to near zero each winter in the shallow water following the fall migratory bird period. The green panels represent the period when chlorophyll *a* concentration exceeded 10 µg L^{-1} and we considered the phytoplankton to be building biomass (blooming). Data from Thompson (1999).

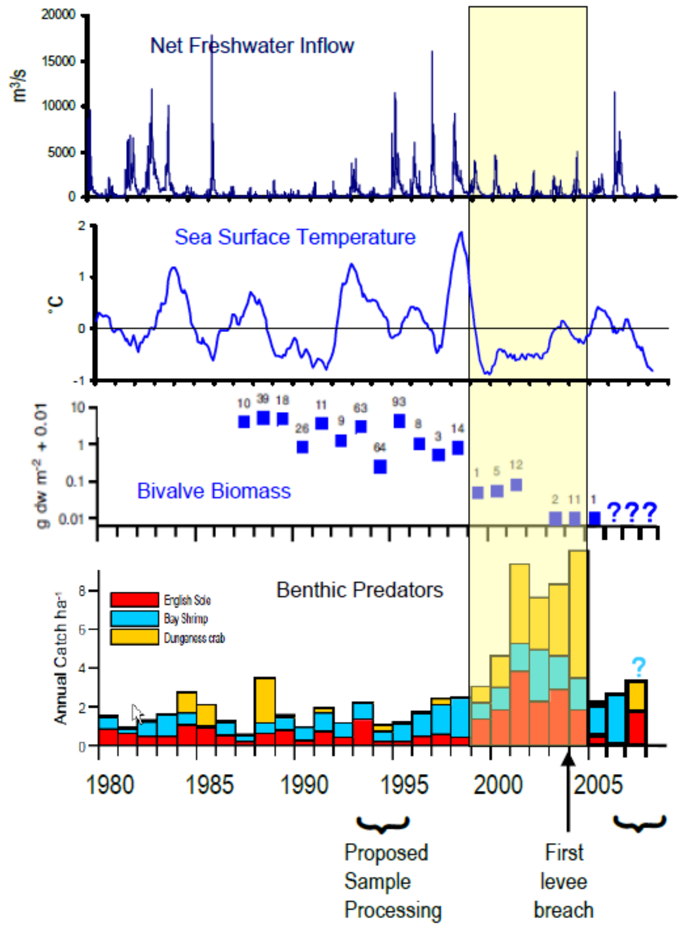


Figure 3. Edited figure from Cloern et al (2007) showing freshwater inflow into North Bay; sea surface temperature near the Farallon Islands which is used as an indicator of upwelling; average annual bivalve biomass (note log scale); and annual catch of the major juvenile fish and invertebrate predators on the bivalves. Arrow shows the onset of the Salt Pond restoration actions and brackets show the period of proposed sample analyses. Highlighted area is the time period reported in Cloern et al (2007).

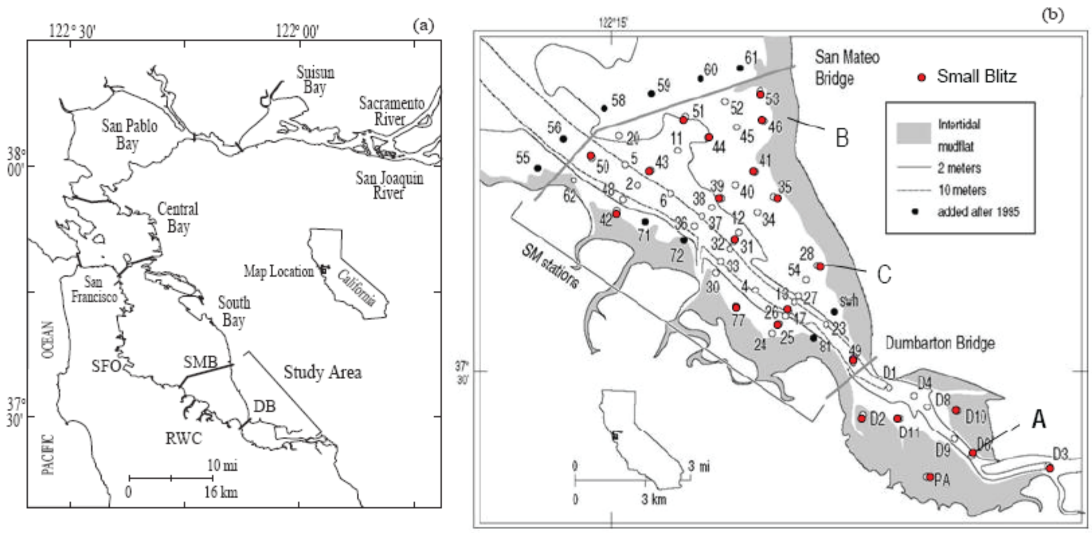


Figure 4. Study site in context of San Francisco Bay. Sampling locations shown in red. The samples at the remaining stations are not part of this proposal.

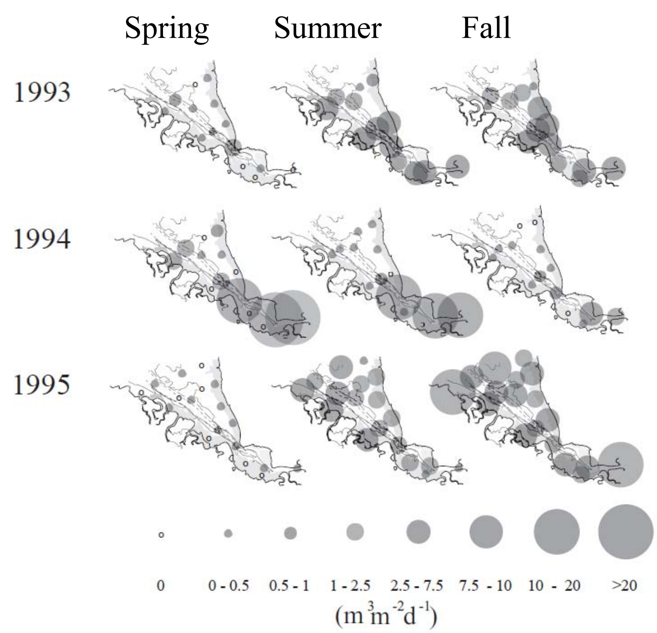


Figure 5. Excerpt of figure 6 from Thompson et al (2008) showing progression of bivalve grazing rate for 3 years through the seasons a decade prior to the restoration project actions. These are the years we propose to analyze. 1993 was a hydrologically wet year, 1994 was a critically dry year and 1995 had a 100 year flood event.

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CURRICULUM VITA

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Education

- Stanford University, Stanford, California, Ph.D. Civil and Environmental Engineering
- California State University, San Francisco, California, M.A. Marine Biology
- Lewis and Clark College, Portland, Oregon, B.S. Biology

Experience

- 1972-present: Research Scientist, U.S. Geological Survey Menlo Park, California:
- 1972: Teaching Assistant, Oregon Institute of Marine Biology, University of Oregon; Lewis and Clark College

Research Interest:

Ecology and physical dynamics of aquatic systems based on long term (30 year) investigations of the San Francisco Bay and freshwater Delta that has included studies of the following: the coupling between, and interdependence of benthic and pelagic communities; biogeochemical processes related to benthic organism accumulation of natural and anthropogenic elements; the physical dynamics of organic and inorganic particle transfer to the bed; the study of benthic community dynamics in response to natural and anthropogenic stress; and the response of aquatic ecosystems to non-indigenous species.

Highlights:

U.S. Department of the Interior, Superior Service Award, 2003

Science Advisory Committees: California Bay/Delta Food Chain Committee-1999-present: California Sea Grant Committee on Exotic Species 1996-present; Interagency Ecological Program Review of Long-term Fish Monitoring Program; CALFED Exotic Species Program 2000-present

Editorial Board: San Francisco Estuary and Watershed Science (2008-present) Aquatic Nuisance Species Digest (1999-present)

USGS, National Research Program. Project Chief: Environmental Influences on Estuarine Benthic Community Dynamics

Postdoctorates: Dr. Laurent Chauvaud, Dr. Rene Takesue

Relevant Publications:

Thompson, JK. 2005. One estuary, one invasion, two responses: phytoplankton and benthic community dynamics determine the effect of an estuarine invasive suspension feeder. *In:* The comparative Roles of Suspension Feeders in Ecosystems, S. Olenin and R. Dame Editors, p. 291-316

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CURRICULUM VITA
Francis Parchaso
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Education
- San Francisco State University, San Francisco, California, M.S. Marine Biology
- San Francisco State University, San Francisco, California, B.A. Marine Biology

Experience
- 1989-present: Research Scientist, U.S. Geological Survey Menlo Park, California:

In charge of all field and laboratory operations for the Environmental Influences on Estuarine Benthic Community Dynamics Project (USGS, J. Thompson, Project Director).

- 1988-89: Biologist, Entrix, Walnut Creek, CA
- 1986-88: Teaching Assistant, San Francisco State University
- 1983-84: Field Biologist, California Fish & Game, Monterey, CA

Research Interest:
Ecology of aquatic systems and physiology of benthic invertebrates. Special studies on exotic species and how they have adapted to their new environment. Invertebrate eco-physiology and reproduction of bivalves in San Francisco Bay: including physiological and reproductive responses to physical dynamics.

Relevant Publications:
Parchaso, F. and J.K. Thompson, 2002, The influence of hydrologic processes on reproduction of the introduced bivalve *Potamocorbula amurensis* in Northern San Francisco Bay, California, *Pacific Science*, 56(3):329-345

Brown, C.L., F. Parchaso, J.K. Thompson, S.N. Luoma. 2003. Assessing toxicant effects in a complex estuary: A case study of effects of silver on reproduction in the bivalve, *Potamocorbula amurensis,* in San Francisco Bay. *Human and Ecological Risk Assessment*. 9(1):95-119

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Topping, B.R., Kuwabara, J.S., Parchaso, F., Hager, S.W., Arnsberg, A.J., Murphy, F., 2001, Benthic Flux of Dissolved Nickel in the Water Column of South San Francisco Bay: U.S. Geological Survey Open-File Report 01-089, 50 p.

Budget

Explanation of OH
The USGS WRD Branch of Regional Research has a 55.12% overhead rate that is set at the federal office. Neither I nor my supervisors have any control over this rate. In partial compensation for the rate, I have donated all laboratory costs and my time and F. Parchaso's time for the analyses and write up of this project.

South Bay Salt Pond Restoration Project
Selected Monitoring and Applied Studies
Project Budget Worksheet*

Timeframe: May 2009- April 2011**

Budget Categories	Total Project Budget		Total Grant Request		Total Proposed From Other Sources *(please specify the source, if known)*	Description	Source
	Year 1	**Year 2**	**Year 1**	**Year 2**			
Labor- Technician	45000	15000	45000	15000	63,700	Thompson	USGS
Labor- Parchaso	4000		4000		57,000	Parchaso	USGS
Consultant fees/ Contractual Services	25000	25000	25000	25000			
Travel	0	0	0	0	1000		USGS
Project specific equipment, supplies/materials	0	0	0	0	40000	includes prior collection & processing	USGS
Overhead (not to exceed 10%)	40789	22048	40789	22048			
Other:________________ *(please specify)*							
TOTAL	**$114,789**	**$62,048**	**$114,789**	**$62,048**	**$161,700**		
				$176,837 RFP	**$161,700** USGS		

Date Created: 5 December 2008

Potential Reviewers:

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Assessments, permits, certifications: None

Animal Care and Use certification - NA