3a. Approach

This project proposes to measure bivalves from one sample per-month for all available months at two of the longest-term monitoring sites sampled by the IEP EMP (D4 and D28A). Site D4-L is located in the lower Sacramento River near Collinsville, close to the confluence of the Sacramento and San Joaquin Rivers, and has been consistently sampled monthly or near-monthly since October 1975. Site D28A-L is located in Old River, which is a portion of the lower San Joaquin River system, and been consistently sampled monthly or near-monthly since June 1977. Locations of the two long-term monitoring sites are shown in Figure 1.

Bivalves occurring in samples taken during the Small Scale Spatial Variability Study-(SSSVS), conducted in April and July, 2005, and discussed above, will also be measured. The SSSVS sampling locations include neighborhoods in San Pablo Bay, Carquinez Strait, Suisun Bay, the Lower Sacramento River, Old River, and the lower San Joaquin River, as shown in Figure 2. The distribution of samples within neighborhoods is shown in detail in Figure 3.

Computations of the biomass of invasive bivalve species found in each sample will be accomplished using species-specific length-to-weight equations that have been developed over many bivalve studies in the San Francisco Bay-Delta system. Length-to-weight equations have been developed through ashing (to measure ash-free dry weight) for invasive bivalve species in this system for the past two decades, and the equations derived from this length-to-weight analyses will be provided by Jan Thompson (USGS). Species-specific biomass values will be reported in gC m-2. For long-term records, time series of invasive bivalve biomass will be compiled for further analysis with existing abiotic (hydrographic, physico-chemical, and substrate) data as well as biotic (benthic assemblage, phytoplankton, and zooplankton) data. Species-specific invasive bivalve biomass values from the SSSVS samples will be used with spatial coordinates from the samples, ancillary physical habitat data (depth, sediment type, bathymetric setting, channel location), and biological data (benthic assemblage) to analyze trends in biomass over physical and biological gradients.

Size frequency and biomass data will be stored on the Bay Delta and Tributaries (BDAT) data server (http://bdat.ca.gov/), where it will be publicly available for download: Meta data and reports of the data analyses will be hosted on the IEP EMP website (http://www.iep.ca.gov/emp/), which is also open to the public.

3b. Methods Techniques and Equipment, Data Collection, Statistical Analyses, Quality Assurance and Separation of Tasks

Task 1- Project Management, Data Analysis and Reporting

The project manager will ensure that all listed products and deliverables are completed within the project timeline. Quarterly reports and a final report will be submitted to CALFED by the project manager. The quarterly reports will contain relevant information regarding the status of project tasks.

The final report will integrate the results of tasks 1 through 3 and present the project findings in a technical format. All administrative, contracting and budget maintenance tasks will be carried out under the auspices of the DWR.

Benthic macrofaunal biomass estimates: The analyses of biomass data will include identifying and describing large scale and small scale spatial patterns of biomass within the upper San Francisco Estuary. We will also characterize long term trends in biomass at the 2 EMP sites. Seasonal and inter annual trends in biomass will be reported by site and by species. Biomass trends will be related to environmental variables (e.g.

conductivity, freshwater flow rate, phytoplankton biomass, etc.), CVP and SWP operations, and invasive species chronologies. These analyses will build upon and greatly improve the results of an ongoing retrospective analysis of the EMP benthic monitoring data that was partially funded by the CALFED science program. This retrospective analysis objectives are: identifying recurring taxa assemblages within the benthic community at core EMP benthic monitoring sites; determining the predictable relationships between taxa assemblages and environmental conditions and/or species invasions; describing community function over the course of the historical sampling period using the results of taxa assemblage analyses and published records of species natural histories and functional characteristics. Importantly, benthic bivalve biomass estimates will greatly improve our ability to determine where and when benthic assemblages were capable of having significant effects on bio-geo-chemical cycling of nutrients and trace elements (e.g., where and when have filter-feeders have been abundant enough to limit food to other populations, and where and when changes in benthic assemblages might have affected trace element transport or patterns of predation for higher trophic levels). We will identify and describe spatial patterns of benthic biomass within the upper Estuary. Biomass patterns will be related to patterns of environmental variables (e.g. conductivity, temperature, bathymetry, flow rate, phytoplankton biomass, and sediment characteristics).

Information dissemination: Two methods will be used to disseminate the biomass data and species information acquired during this project. First, we will work with BDAT staff to make weight measurements and population notes data available for download in tabular form from the BDAT portal. Secondly, methodological information such as the *conversion* coefficients *used for each species* will be included *in the* benthic *program* element's metadata pages on the EMP web site.

All researchers place high value on regular peer-reviewed publication of results and sharing of information and ideas at conferences. This proposed program will prepare one or more scientific papers for peer-reviewed journals. One or more members of the team will also present their results annually at either the State of the Estuary or the CALFED Science conference. Lastly, the EMP website will display reports,. publications by project members, documents, and related links.

Task 2 - Biomass Measurement

Estimating biomass: Our method of estimating biomass will be as follows:

(1) Measure the shell length (longest axis) of each *Corbula amurensis* and *Corbicula fluminea* found in each sample. Measurements, to the nearest millimeter in shell length will be made using one of three methods a) measurement using ocular micrometer on a dissecting microscope; b) measurement using calibrated digital image analysis software, or c) measurement with hand-held Vernier calipers. While species have been archived separately in recent samples, some historic samples require species pre-sorting, before bivalves can be measured. For all samples, the number of bivalves found in the archived sample material will be compared to bivalve counts from the original samples analysis - to verify that all animals in the sample are accounted for in the measuring. Once clams are measured, the number of measurements is again checked against the number of clams in the sample. Measurements of objects of known size are used to calibrate bivalve measuring devices at least daily. When the digital image analyzer is used for measuring bivalves, calibration measurements are made each time the instrument is adjusted. Visual inspection of the data and the bivalve sample material are made before the data are recorded.

(2) Convert bivalve shell-length measurements to tissue dry weight using length-to weight conversion equations;

(3) Convert dry tissue weight to carbon equivalent (g C m-2);
(4) Sum species biomass values for each sample;
(5) Estimate error of biomass values.

Estimation error: Several factors may introduce error into these estimates and an error analysis of the data (Bevington and Robinson 1992) will include the following factors. First, the error associated with benthic sampling can be substantial due to the patchy nature of benthic communities. Some error can be expected to propagate from poorly archived samples with disintegrating shells, which are difficult to measure accurately though care will be taken to get the most representative measurements possible for each sample. Additional checks on the wet weight to dry weight conversions will be available for two of the bivalves *(Corbula. amurensis* and *Corbicula. fluminea)* which have been measured, and converted to dry weight by use of length to tissue weight regressions (unpublished data, Thompson USGS). There can be seasonal and regional patterns in length-to-weight relationships for bivalves. Where regional and seasonal differences in length to tissue weight regressions are known, regressions sensitive to the regional bias will be used.

Samples to be measured: We have selected samples from two sources which will yield complementary information on changes in invasive bivalve biomass. Samples with high temporal resolution are drawn from 2 EMP long-term benthic monitoring stations (D4 and D28A). One sample from each (mostly monthly) sampling event from 1975 - Sept 2006 will be measured. Samples with high spatial resolution are drawn from the SSSVS, a special study conducted in spring and summer, 2005, which collected a total of 360 samples.

Task 3 - Data Storage and Management

The EMP currently maintains a relational database to store and manage its benthic element's data. This database contains the entire EMP benthic macro invertebrate monitoring dataset from 1975 to the present. It also stores sediment data acquired in conjunction with the benthic sampling. Data from special studies such as the SSSVS are now also stored in this database. Metadata are available from the EMP web site *(http://iep.water.ca.gov/emp/)*. Once data have been reviewed for accuracy (and published in the case of special studies), they are exported electronically to the IEP Bay-Delta & Tributaries Project (BDAT) servers and are publicly available through the BDAT data portal *(http://baydelta.ca.gov)*. We will modify the structure of the EMP Benthic database to allow for the storage of the bivalve measurements and biomass estimates acquired during this project, and work with BDAT staff to make weight measurements and population notes data available for download in tabular form from the BDAT portal.

4. Feasibility

4a. Project Feasibility

The proposed project is a continuation of research efforts that have been successfully conducted by the collaborators in the past. The sample material has already been collected, which is a major cost savings as no new samples need to be collected. No permits are needed. All laboratory space and equipment have been secured (at no additional cost). The methods that are proposed to be used for measuring bivalve samples, compiling size frequency distributions, and estimating biomass have been successfully used by contributing authors (Jan Thompson) in previous studies. The staff has already been trained. Salaries for several of the collaborators will be covered by current agency budgets and these salaries are not budgeted within this project.

4c. Project Completability

The project team consists of individuals in institutions, agencies and companies uniquely qualified for this research. This project combines the experience and expertise of staff and researchers at DWR and USGS. Researchers at USGS have gained an increasing amount of knowledge of processes and interactions in the benthic community of the San Francisco Estuary. The DWR has conducted research and monitored the San Francisco Estuary since 1975, providing major insight into the effects of water project operations, introduction of invasive species and other natural stressors on the San Francisco Estuary ecosystem. Personnel on this team have been involved in long-term monitoring of the delta and the estuary by DWR and USGS. Curricula vitae for key staff have been entered into the CALFED PSP website

4c. Project Management, Coordination and Cost Sharing

This project will be a collaborative effort between the California Department of Water Resources (DWR) and the United States Geological Survey (USGS).

Task 1 (Project Management, Data Analysis and Reporting) data analysis, data reporting and publication production will be conducted by K. Gehrts (DWR), H. Peterson (USGS) and Dr. M. Vayssieres (DWR). Dr. J. Thompson (USGS) will provide support. Project management and coordination will. be through DWR under the direction of Dr. D. Messer.

Task 2 (Biomass Measurement) will be conducted by K. Gehrts, and one Scientific Aid (DWR): Dr. J. Thompson (USGS) will provide methodology and support. As mentioned in the budget justification, staff salaries are the only major expense because lab space and equipment have already been secured with DWR and USGS. Due to the time necessary to sort, identify, count and measure DWR has agreed to pay the salary of the lead environmental scientist, K. Gehrts.

Task 3 (Data Storage and Management) will be conducted by Dr. M. Vayssieres, K. Gehrts and one Scientific Aide (DWR).

EXHIBIT A: ATTACHMENT 4
TASK TABLE

Task #	Task Title	Start Month	End Month	Personnel Involved	Description	Task Budget
1	Project Management, Data Analysis and Reporting	1	24	Messer, Dean Gehrts, Karen Riordan, Dan	Data analysis, data reporting and publication production will be conducted by K. Gehrts (DWR), H. Peterson (USGS). Dr. J. Thompson (USGS) will provide support. Project management and coordination will be through DWR under the direction of Dr. D. Messer.	$177,821.99
2	Biomass Measurement	1	22	Brown, Tiffany Canepa, Analisa Thomspon, Jan	Biomass Measurement will be conducted by K. Gehrts, and one Scientific Aid (DWR). Dr. J. Thompson (USGS) will provide methodology and support. As mentioned in the budget justification, staff salaries are the only major expense because lab space and equipment have already been secured with DWR and USGS. Due to the time necessary to sort, identify, count and measure DWR has agreed to pay the salary of the lead environmental scientist, K. Gehrts.	$42,000.01
3	Data Storage and Management	1	24	none	Task eliminated due to loss of staff.	$0.00

Total Budget=$219,822