TRoUBLE? Trends Of Rising And Unexpected Bloom Levels In The Estuary

submitted to Science Program 2006

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lead investigators:
Cloern, James
Labiosa, Rochelle
Lucas, Lisa
Ralph, Cheng
Thompson, Janet
Jassby, Alan

Project Information And Executive Summary

TRoUBLE? Trends Of Rising And Unexpected Bloom Levels In The Estuary

This is proposal #0022 for the Science Program 2006 solicitation.

Frequently asked questions and answers for this PSP are now available.

The submission deadline for this proposal has passed. Proposals may not be changed.

Instructions

Please complete the Project Information and Executive Summary Form prior to proceeding to the other forms contained on this website and required to be completed as part of your PSP application submittal. Information provided on this form will automatically support subsequent forms to be completed as part of the Science PSP submission process. Information provided on this form will appear in the Contacts and Project Staff, Task and Budget Summary, and Conflict of Interest forms.

Proposal Title: **TRoUBLE? Trends of Rising and Unexpected Bloom Levels in the Estuary**

This field is limited to 255 characters. All proposal titles must be entered in title case. No abbreviations or acronyms will be accepted.

Applicant Information

Applicant Organization Name: **United States Geological Survey**

Please provide the name of the organization submitting the application as follows: Davis, California University of; Fish and Game, California Department of; California Waterfowl Association, etc.

Applicant Organization Type:
federal agency

eligibility

Below, please provide contact information for the representative of the applicant organization who is authorized to enter into a contractual agreement with the State of California and who has overall responsibility for the operation, management, and reporting requirements of the applicant organization. (This should be the same individual who signs the signature page.)

Salutation: **Dr.**
First Name: **James**
Last Name: **Cloern**
Street Address: **345 Middlefield Rd.**
City: **Menlo Park**
State or Province: **CA**
Zip Code or Mailing Code: **94025**
Telephone: **650 329 4594**
E-mail Address: **jecloern@usgs.gov**

Below, please provide contact information for the primary point of contact for the implementation of the proposal. This person should be the same individual who is serving as the project Lead Investigator/Project Director.

Salutation: **Dr.**
First Name: **James**
Last Name: **Cloern**
Telephone: **650 329 4594**
E-mail Address: **jecloern@usgs.gov**

Proposal Information

Total Amount Requested: $299,422

The figure represented above is provided by the total amount requested on your completed Task and Budget Summary Form. The applicant must ensure the amount indicated above is correct and equal to the total amount requested in the budget document uploaded via the Budget and Justification Form for this project.

Select one primary and up to three secondary topic areas that best apply to this proposal:

Trends and Patterns of Populations and System Response to a Changing Environment (Primary)

Habitat Availability and Response to Change

Aquatic Invasive (Exotic) Species

Select up to five keywords to describe this project.
− ***agriculture***
− ***agricultural economics***
− ***agricultural engineering***
− ***agronomy***
− ***agro−ecology***
− ***benthic invertebrates***
− ***benthos***
− ***biochemistry***
X ***biological indicators***
− ***birds***
− ***channels and sloughs***
X ***climate change***
− ***conservation or agricultural easements***
− ***conservation program management***
− ***database management***
− ***ecotoxicology***
− ***economics***
− ***engineering***
− ***erosion control***
− ***environmental education***
− ***evapotranspiration***
− ***fish biology***
− delta smelt
− salmon and steelhead
− other species
− otoliths
− tagging
− ***fish management and facilities***
− ***flooded islands***
− ***floodplains and bypasses***
− ***forestry***
− ***genetics***
− ***geochemistry***
− ***geographic information systems (GIS)***
− ***geology***
− ***geomorphology***
− ***groundwater***
− ***human health***
− ***hydrodynamics***
− ***hydrology***
− ***insects***
− ***integrated pest management***
− ***integrated resource planning***
− ***invasive species / non−native species / exotic species***
− ***irrigation systems***
X ***land use laws and regulations***
− ***land use management***
− ***land use planning and policy***
− ***levees***
− ***mammals***
− ***microbiology / bacteriology***
− conceptual
− quantitative
− ***oceanography***
− ***performance measures***
X ***phytoplankton***

− ***plants***
− terrestrial
− aquatic
− wetland
− ***remote sensing / imaging***
− ***reptiles***
− ***reservoirs and lakes***
− ***restoration***
− ***riparian zone***
− ***rivers and streams***
− ***sediment***
− ***soil science***
− ***statistics***
− ***subsidence***
− ***sustainable agriculture***
− ***trophic dynamics and food webs***
− ***water operations (diversions, pumps, intakes, exports, barriers, gates, etc.)***
X ***water quality***
− other
− temperature
− contaminants
− nutrients, organic carbon, and oxygen depleting substances
− salinity
− sediment and turbidity
− ***water supply***
− ***watershed assessment***
− ***watershed management***
− ***wetlands***
− ***zooplankton***

Provide the geographic coordinates that best describe the center point of your project. (Note: If your project has more than one site, provide a center point that best captures the central location.)

Example:	Latitude:	38.575; must be between 30 and 45
	Longitude:	−121.488; must be between −120 and −130

Help for finding a geographic location.

Latitude: **37.825**
Longitude: **−122.372**

Provide the number miles radius from the center point provided above, to demonstrate the radius of the entire project.
30

Provide a description of the physical location of your project. Describe the area using information such as water bodies, river miles and road intersections.

The geographic focus is San Francisco Bay and its connections to its urban watersheds, inflows from the Delta, and exchanges with the coastal Pacific Ocean.

Successful applicants are responsible for complying with all applicable laws and regulations for their projects, including the National Environmental Policy Action (NEPA) and the California Environmental Quality Act (CEQA). Projects funded through this PSP that tier off the CALFED Programmatic EIS/EIR must incorporate applicable mitigation strategies described in the CALFED Programmatic Record of Decision to avoid or minimize the project's adverse environmental impacts. Applicants are encouraged to review the Programmatic EIS/EIR and incorporate the applicable mitigation strategies from Appendix A of these documents for their projects.

If you anticipate your project will require compliance of this nature (ie applications for permits, other environmental documentation), provide below a list of these items, as well as the status of those applications or processes, if applicable. If you believe your project will not require these regulatory actions, please provide one or two lines of text outlining why your proposed project will not be subject to these processes. Further guidance is available in The Guide to Regulatory Compliance for Implementing CALFED Activities.

The project will not require these regulatory actions because it is purely model based.

Is this proposal an application for next phase funding of an ongoing project funded by CALFED Science Program?
X No. **−** Yes.

If yes, identify the ongoing project:

Project Title:
CALFED Contract Management Organization:
Amount Funded:
Date Awarded:
Lead Organization:
Project Number:

Have primary staff and/or subcontractors of the project team (those persons listed on the Contacts and Project Staff form) received funding from CALFED for a project *not* listed above?
− No. **X** Yes.

If yes, list the projects below: (only list up to the five most recent projects)

Project Title: **CASCaDE: Computational Assessment of Scenarios of Change in the Delta Ecosystem**
CALFED Contract Management Organization: **CALFED Science Program**
Amount Funded: **$1,662,870**
Date Awarded: **March 2006**
Lead Organization: **USGS**
Project Number: **84**

Project Title: **Assessment of the Sacramento−San Joaquin River Delta as Habitat for Production of the Food Resources that Support Fish Recruitment**
CALFED Contract Management Organization: **USBR**
Amount Funded: **1,440,649**
Date Awarded: **April 1998**
Lead Organization: **USGS**
Project Number: **Contract Number 1425−989−AA−20−16240**

Project Title: **Transport, Transformation and Effects of Se and C in the Delta: Implications for ERP**
CALFED Contract Management Organization: **Ecosystem Restoratio Program**
Amount Funded: **3,361,160**
Date Awarded: **October 2001**
Lead Organization: **USGS**
Project Number:

Project Title:
CALFED Contract Management Organization:
Amount Funded:
Date Awarded:
Lead Organization:
Project Number:

Project Title:
CALFED Contract Management Organization:
Amount Funded:
Date Awarded:
Lead Organization:
Project Number:

Has the Lead Investigator, the applicant organization, or other primary staff or subcontractors of your project team ever submitted a proposal for this effort or a similar effort to any CALFED PSP?
X No. **−** Yes.

If yes, list the submission below: (only list up to the five most recent projects)

Project Title:
CALFED Program:
Date of PSP:

Project Title:

CALFED Program:
Date of PSP:

Project Title:
CALFED Program:
Date of PSP:

Project Title:
CALFED Program:
Date of PSP:

Project Title:
CALFED Program:
Date of PSP:

Note: Additional information on this or prior applications submitted −− or proposals funded −− may be required of applicants.

List people you feel are qualified to serve as scientific and/or technical reviewers for this proposal and are not associated with your organization or CALFED.

Full Name	Organization	Telephone	E−Mail	Expertise
Lawrence W. Harding	University of Maryland Center for Environmental Science, Horn Point Laboratory	410.221.8247	larry@hpl.umces.edu	phytoplankton
Mark J. Brush	Virginia Institute of Marine Science	804 684 7402	brush@vims.edu	modeling, quantitative
Nicole Goebel	Ocean Sciences Department, University of California−Santa Cruz	831.459.5152	ngoebel@pmc.ucsc.edu	phytoplankton
Richard L. Wetzel	Virginia Institute of Marine Science	804 684 7381	dick@vims.edu	modeling, quantitative

Provide additional comments, information, etc. here:

Executive Summary

Provide a brief but complete summary description of the proposed project; its geographic location; project objective; project type, approach to implement the proposal; expected outcomes; and adaptive management approach and relationship to the Science Program goals. The Executive Summary should be a concise, informative, stand−alone description of the proposed project and be no longer than one page in length. Please note, this information will be made public on our website shortly after the closing date of this PSP.

The San Francisco Bay−Delta is an exceedingly complex ecosystem whose biological communities are in nonsteady state manifested as high interannual variability and significant trends of population change over recent decades. Trends of declining pelagic biota in the Delta and Suisun Bay have accelerated in recent years to alarm politicians, resource agencies and the public. The underlying causes of pelagic organism decline remain elusive to scientists in spite of multiple decades of biological monitoring, reflecting the complexity of an ecosystem whose dynamics are driven by multiple sources of variability. Habitat quality in the estuary is strongly influenced by river inputs of water and substances it carries from runoff in the watersheds, atmospheric forcing as winds and heat influx influence mixing, and connectivity to ocean−derived tides and upstream salt transport. Interacting with these natural processes are myriad human activities that manipulate hydrology and introduce toxic contaminants, nutrients, and exotic species. Pelagic population dynamics are responses to variability in all these drivers of biological variability, but we have not identified which drivers are most important or how the individual drivers interact to cause population fluctuations or trends. Slow progress is a reflection of the magnitude of the scientific challenge and the scarcity of tools available to unravel complex ecosystem dynamics. Here, we propose to develop the first 3D hydrodynamic and pelagic ecosystem model of San Francisco Bay, and use simulations to identify the underlying causes of altered phytoplankton dynamics that has occurred over the past decade. While pelagic biomass has declined in low salinity regions of the estuary, phytoplankton biomass has increased significantly since the mid 1990's in San Pablo, Central and South San Francisco Bay. This increase is manifested as altered

seasonality and heightened year−round phytoplankton biomass, leading to a near−doubling of primary production over the past decade. Other symptoms of pelagic change include the unprecedented occurrence of dinoflagellate red tides, appearances of new species of toxic algae, and events of unusually low bottom water oxygen. These changes might be signs that San Francisco Bay's historic resistance to the harmful consequences of nutrient enrichment might be changing. Potential implications include habitat degradation in marine regions of the estuary utilized by species of concern as a migration route or rearing habitat. The goal of this project is to use simulations to identify the drivers of recent ecological changes in San Francisco Bay, to understand interactions among those drivers, and to build a foundation for anticipating trajectories of future change as the Bay ecosystem continues to evolve in directions that may have important implications for water and habitat quality, sustainability of key species, and regulation of nutrient loadings to the estuary. Numerical simulation experiments will test four plausible mechanisms of phytoplankton biomass increase: increasing water transparency as sediment inputs to the estuary gradually decline over time; reduced predation as bivalves have disappeared in recent years; increased inputs of marine phytoplankton during this past decade of strong upwelling; or, interactions among these processes. This project meets objectives listed in the CALFED PSP to apply models to analyze and synthesize existing data. It is directly relevant to Priority Topics #3 (Trends and Patterns of Populations and System Response to a Changing Environment) and #4 (Habitat Availability and Response to Change). Cost of this research project will be shared, approximately equally, between the CALFED Science Program and USGS.

Contacts And Project Staff

This is proposal #0022 for the Science Program 2006 solicitation.

Frequently asked questions and answers for this PSP are now available.

The submission deadline for this proposal has passed. Proposals may not be changed.

INSTRUCTIONS

Use this form to provide titles, affiliations, qualifications, and descrptions of roles of the primary and secondary project staff. Include any consultants, subcontractors and/or vendors. The Lead Investigator or Project Director, as identified in the Project Information and Executive Summary Form, is required to upload a PDF version of their resume. To complete the qualification field of this form, please provide a bulleted list of relevant project/field experience and any publications/reports that support your participation in the proposed project.

Information provided on this form will automatically support subsequent forms to be completed as part of the Science Program PSP submission process. Please note tht information you enter in this form will appear in the Task and Budget Summary and Conflict of Interest forms.

Information on subcontractor services must be provided even if the specific service provider has not yet been selected. If the specific subcontractor has not been identified or selected, please list TBD (to be determined) in the last name field and the anticipated service type in the title field (example: Fish Biologist).

Please provide this information before continuing to the Tasks and Deliverables Form.

Applicant

United States Geological Survey
Dr. James Cloern
345 Middlefield Rd.
Menlo Park CA 94025
650 329 4594
jecloern@usgs.gov

Lead Investigator/Project Director

Salutation: **Dr.**
Last Name: **Cloern**
First Name: **James**
Title: **Research Physical Scientist**
Organization: **U.S. Geological Survey**
Responsibilities: **Project direction, administration**
Resume:

You have already uploaded a PDF file for this question. Review the file to verify that appears correctly.

Mailing Address: **USGS MS496, 345 Middlefield Rd.**
City: **Menlo Park**
State: **CA**
Zip: **94025**
Telephone: **650 329 4594**
E−Mail: **jecloern@usgs.gov**

All Other Personnel

Salutation: **Dr.**
Last Name: **Labiosa**
First Name: **Rochelle**
Title: **Postdoctoral Associate**
Organization: **US Geological Survey**
Position:

Co-PI
Responsibilities: **Model development, calibration/verification, simulations, interpretations, and publication of results.**
Qualifications:

EDUCATION

August 2006 (expected) Ph.D. Geophysics (Biological Oceanography) Stanford University, Stanford, C.A. Dissertation: A highly productive oligotrophic region? What drives phytoplankton blooms in the Gulf of Aqaba, Red Sea.

M.S. Geophysics Stanford University, Stanford, C.A.

B.A. (High Honors) Earth Sciences and B.A. Science in Society Program FELLOWSHIPS, HONORS, AND AWARDS • Currently on fellowship award through the Geophysics Department, Stanford University • Achievement Rewards for College Scientists (ARCS) Fellow (2004–2005) • Stanford University School of Earth Sciences Research Review Best Poster Presentation Award (2005) • Sigma Xi grant in aid of education for support of field research (2003–2004) Stanford School of Earth Sciences Shell grant awards for travel to conferences (2002, 2003, 2004, 2006) • Stanford School of Earth Sciences McGee Grant award for field research (2001, 2004) • National Aeronautics and Space Administration (NASA) Earth Systems Science Fellow (2001–2004) • Stanford School of Earth Sciences Kirby Fellow (2000–2001) • "On the spot" award, U.S. Environmental Protection Agency (2000) • Director's appreciation award, U.S. Environmental Protection Agency (1998) • High Honors in Earth and Environmental Sciences, Wesleyan University (1995) • Ford Foundation Grant in Aid of Undergraduate Research (1994)

PROFESSIONAL EXPERIENCE Research and Teaching Assistant, Stanford University, Stanford, C.A.

Student Appointee, United States Geological Survey, Menlo Park, C.A.

Environmental Protection Specialist, GS 11, United States Environmental Protection Agency, Washington, D.C.

Agroforestry Extensionist, United States Peace Corps, Paraguari, Paraguay

PUBLICATIONS

Mackey, K.R.M., R.G. Labiosa, M. Calhoun, J. Street, A.F. Post, and A. Paytan. Phosphorus availability, phytoplankton community dynamics, and taxon-specific phosphorus status in the Gulf of Aqaba, Red Sea (submitted to Limnology and Oceanography).

Labiosa, R.G., J. Street, D. Iluz, A. Genin, A. Post, and A. Paytan. Abrupt succession of phytoplankton taxa in the Gulf of Aqaba, Red Sea: the role of light and nutrients (in prep. for submission to Limnology and Oceanography).

Labiosa, R.G., A. Genin, S. Monismith, K.R. Arrigo. Geostrophic flow in an inverse estuarine system, the Gulf of Aqaba, Red Sea (in prep. for submission to Journal of Geophysical Research)

Labiosa, R.G., C.J. Tu, D. Bhaya, K.R. Arrigo, A.R. Grossman, J. Shrager. 2006. Examination of diel changes in global transcript accumulation in Synechocystis. Journal of Phycology. 42(3):622–636.

Cloern, J.E., Schraga, T.S., Lopez, C.B., Knowles, N., Labiosa, R.G., and Dugdale, R., 2005, Climate anomalies generate an exceptional dinoflagellate bloom in San Francisco Bay. Geophysical Research Letters. 32(14) L14608.

Labiosa, R.G., K.R. Arrigo, A. Genin, S.G. Monismith, G. Van Dijken. 2003. The interplay between upwelling and deep convective mixing in the Gulf of Aqaba, Red Sea: evidence from SeaWiFS and MODIS. Limnology and Oceanography. 48(6):2355–2368.

Cloern, J.E., Schraga, T.S., Lopez, C.B., and Labiosa, R., 2003. Lessons from monitoring water quality in San Francisco Bay. 2003 Pulse of the Estuary, San Francisco Estuary Institute, p. 15–20.

List relevant project/field experience and publications/reports.

Salutation: **Dr.**
Last Name: **Lucas**
First Name: **Lisa**
Title: **Research Engineer**
Organization: **US Geological Survey**
Position:
Co-PI
Responsibilities: **Advice/consultation in model development, calibration/verification, design of simulation experiments, interpretations of results and writing final reports.**
Qualifications:

Education

Stanford University, Palo Alto, California Ph.D. in Civil and Environmental Engineering, Environmental Fluid Mechanics Program (1997)

Stanford University, Palo Alto, California M.S. in Civil Engineering, Environmental Fluid Mechanics Program (1992)

University of Notre Dame, South Bend, Indiana B.S. in Civil Engineering (1989), Graduated with Honors

Research and Professional Experience

ECOHYDRODYNAMICIST/RESEARCH ENGINEER, U.S. Geological Survey, Menlo Park, CA (April 2000-Present)

ASSOCIATE EDITOR, Estuaries, An International Journal of Coastal Science Published by the Estuarine Research Federation (October 2005-Present)

CONSULTING ASSISTANT PROFESSOR, Stanford University, Dept. of Civil and Environmental Engineering, Stanford, CA (October 2002-Present)

NRC POSTDOCTORAL RESEARCH ASSOCIATE, U.S. Geological Survey, Menlo Park, CA (May 1998-April 2000)

VISITING SCIENTIST, Stanford University, Dept. of Civil and Environmental Engineering, Stanford, CA (September 1997-October 2002)

HYDROLOGIST, U.S. Geological Survey, Menlo Park, CA (July 1997-April 1998) Highlights

• Selected as Lecturer for U.S.G.S. Water Resources Discipline Research Lecture Series (2005) • Recipient of Estuarine Research Federation Cronin Early Career Award (September 2003) • Elected Secretary of the Estuarine Research Federation (September 2003) • U.S. Dept. of Interior Star Award (December 2004) • U.S. Dept. of Interior Star Award (November 2001) • U.S. Dept. of Interior Star Award (June 2001) • U.S. Dept. of Interior Star Award (September 2000) • NRC Postdoctoral Fellowship (1998-2000) • U.S. Department of Agriculture Postdoctoral Fellowship (1998, declined) • Josephine de Karman Fellowship (1995) • Stanford Fellowship for Masters Study (1991-1992) • McCarthy Scholarship (1988) and Sidney-Kelsey Outstanding Scholar Award (1989), for top Notre Dame Civil Engineering Junior and Senior, respectively • Graduated from Notre Dame with Honors, Notre Dame Scholar

Technical Publications

Lucas, L. V., D. M. Sereno, J. R. Burau, T. S. Schraga, C. B. Lopez, M. T. Stacey, K. V. Parchevsky, V. P. Parchevsky. 2006. Intra-daily variability of water quality in a shallow tidal lagoon: mechanisms and implications. Estuaries and Coasts, in press.

Lopez, C. B., J. E. Cloern, T. S. Schraga, A. J. Little, L. V. Lucas, J. K. Thompson, and J. R. Burau. 2006. Ecological values of shallow-water habitats: implications for restoration of disturbed ecosystems. Ecosystems 9: 422-440.

May, C., J. R. Koseff, L. V. Lucas, J. E. Cloern, and D. H. Schoellhamer. 2003. Effects of spatial and temporal variability of turbidity on phytoplankton blooms. Marine Ecology Progress Series 254: 111-128.

Lucas, L.V., J.E. Cloern, J.K. Thompson, and N. E. Monsen. 2002. Functional variability of habitats in the Sacramento-San Joaquin Delta: restoration implications. Ecological Applications 12(5): 1528-1547.

Lucas, L.V., T. Schraga, C.B. Lopez, J.R. Burau, and A.D. Jassby. 2002. Pulsey, Patchy Water Quality in

the Delta: Implications for Meaningful Monitoring. Newsletter, Interagency Ecological Program for the Sacramento–San Joaquin Estuary 15(3): 21–27.

Lucas, L.V. and J.E. Cloern. 2002. Effects of tidal shallowing and deepening on phytoplankton production dynamics: a modeling study. Estuaries 25(4A): 497–507.

Monsen, N. E., J. E. Cloern, L. V. Lucas, and S. G. Monismith. 2002. A comment on the use of flushing time, residence time and age as transport time scales. Limnology and Oceanography 47(5): 1545–1553.

Lucas, L.V., J.R. Koseff, J.E. Cloern, S.G. Monismith, and J.K. Thompson. 1999. Processes Governing Phytoplankton Blooms in Estuaries. I: The Local Production–Loss Balance. Marine Ecology Progress Series 187: 1–15.

Lucas, L.V., J.R. Koseff, S.G. Monismith, J.E. Cloern, and J.K. Thompson. 1999. Processes Governing Phytoplankton Blooms in Estuaries. II: The Role of Horizontal Transport. Marine Ecology Progress Series 187: 17–30.

Lucas, L.V., J.E. Cloern, J.R. Koseff, S.G. Monismith, and J.K. Thompson. 1998. Does the Sverdrup Critical Depth Model Explain Bloom Dynamics in Estuaries? Journal of Marine Research 56: 375–415.

Lucas, L.V. 1997. A Numerical Investigation of Coupled Hydrodynamics and Phytoplankton Dynamics in Shallow Estuaries. Ph.D. Dissertation, Stanford University.

Cloern, J.E., C. Grenz, and L.V. Lucas. 1995. An empirical model of the phytoplankton chlorophyll/carbon ratio –– the conversion factor between productivity and growth rate. Limnology and Oceanography 40(7): 1313–1321.

Vidergar, L.L., J.R. Koseff , and S.G. Monismith. 1993. Numerical models of phytoplankton dynamics for shallow estuaries, in: Hydraulic Engineering '93, ed. H.W. Shen, S.T. Su, and F. Wen. ASCE, 1025–1030.

List relevant project/field experience and publications/reports.

Salutation: **Dr.**
Last Name: **Ralph**
First Name: **Cheng**
Title: **Senior Research Scientist**
Organization: **US Geological Survey (Retired)**
Position:
Co–PI
Responsibilities: **Advice/consultation in applying the model UNTRIM to San Francisco Bay and incorporating phytoplankton dynamics into this model.**
Qualifications:

Ralph T. Cheng Project Chief, Senior Research Hydrologist Water Resources Discipline U. S. Geological Survey 345 Middlefield Rd, MS–496 Menlo Park, CA 9402

PRESENT TITLES AND POSITION: Project Chief, Water Resources Division, U. S. Geological Survey Senior Research Scientist (Since April 1992) Consulting Professor, Civil Engineering Department, Stanford University (1989–) Guest Professor, Physical Oceanography Department, Qingdao Ocean University (1995–

EDUCATION: University of California at Berkeley, Ph.D. 1967, Mechanical Engineering. University of California at Berkeley, M. S. 1964, Mechanical Engineering. National Taiwan University, B. S. 196l Mechanical Engineering.

PROFESSIONAL SOCIETIES: American Geophysical Union Estuarine Research Federation San Francisco Bay and Estuarine Association American Society of Oceanography and Limnology

AWARDS AND HONORS: 1988 National Science Foundation award to Co–sponsor the 1988 Inter. Conf. on Physics of Shallow Estuaries and Bays. 1989 Special Achievement Award, WRD, USGS. 1989 Superior Service Award, Department of the Interior. 1994 The USGS 1994 Federal Engineer of the Year Award, the National Society of Professional Engineers. 1996 Hugo B. Fischer, The Bay and Delta Modeling Forum. 1996 Meritorious Service Award, Department of the Interior. 1999 Legacy Award, California State Lands Commission.

PROFESSIONAL EXPERIENCE: Member of Hydro-21 Committee, Defining Hydrologic Instrumentation for the 21-st Century, Oct 1997 to present. Research and Technical Advisor to Water Science Centers including projects of San Diego Bay, Calif. Upper Klammath Lake, Oregon, Hood Canal, Washington, Devil's Lake, North Dakota, and Glacier Bay, Alaska. Responsible for hydrodynamic investigations of the impacts from introducing an Aquatic Transfer Facility (ATF) in San Pablo Bay. ATF is a proposed structure to be constructed in San Pablo Bay by the U. S. Army Corps of Engineers to temporarily store dredged sediments before transferring the sediments on shore for wetland restoration. The anticipated results will determine the feasibility of this approach. Project Chief, NRP, WRD, USGS, June of 1976 to present: Responsible for overall hydrodynamic studies of San Francisco Bay. This project is a segment in the interdisciplinary San Francisco Bay research programs in NRP, WRD. Research activities include both field data collection and mathematical modeling, and comprehensive integration and interpretation of field data and modeling results. Assistant and Associate Professor, Mechanical Engineering Department, State University of New York at Buffalo, 1967-1974. Organizing Committee on the International Conference on the Physics of Estuaries and Coastal Seas, (Member, 1986, 1990, Chairman, 1988, advisory Board, 1992, 1994, 1996, 1998, 2000, 2002) Vice Chairman and Chairman, Technical Committee on Computational Hydraulics, American Society of Civil Engineers, 1981-1984. Organizing Committee for the International Conference on Estuarine and Coastal Modeling Co-editors for the Proceedings, 1989, 1991, 1993, 1995 (Co-chairman), 1997, 1999, 2001, 2003, 2005.

Selected Publications:

Feng, R.T., Cheng, R.T., and Xi, P., 1986b, Tide-induced Lagrangian residual current and residual transport, Part I: Residual current, Water Resources Research, Vol. 22, No. 12, p. 1623-1634.

Feng, R.T., Cheng, R.T., and Xi, P., 1986, Tide-induced Lagrangian residual current and residual transport, Part II: Residual transport with applications in South San Francisco Bay, California, Resources Research, Vol. 22, No. 12, p. 1635-1646.

Cheng, R. T., 1990, Residual Currents and Long-term transport, (Ed), Coastal and Estuarine Studies, Vol. 38, Springer-Verlag, 554 pp.

Casulli, V. and R. T. Cheng, 1992, Semi-implicit finite difference methods for three-dimensional shallow water flow, Inter. J. for Numer. Methods in Fluids, Vol. 15, p. 629-648.

McDonald, E. T., and R. T. Cheng, 1997, A Numerical Model of Sediment Transport Applied to San Francisco Bay, California, in Marine Environmental Engineering, Vol. 4, p. 1-41.

Cheng, Ralph T. and R. E. Smith, 1998, A Nowcast Model for Tides and Tidal Currents in San Francisco Bay, California, Ocean Community Conf. '98, Marine Technology Society, Baltimore, Nov. 15-19, p. 537-543.

Wang, P. F., Cheng, R. T., Richter, Kenneth, Gross, E. S., and Gartner, J. W., 1998, Modeling Tidal Hydrodynamics of San Diego Bay, California, J. of Am. Water Resources Association, Vol. 34, No. 5, p. 1123-1140.

Cheng, R. T., C. H. Ling, J. W. Gartner, and P. F. Wang, 1999, Estimates of Bottom Roughness Length and Bottom Shear Stress in South San Francisco Bay, California; Journal of Geophysical Research, v. 104, no. C4, p. 7715-7728.

Cheng, R. T. and Casulli, V., 2002, Evaluation of the UnTRIM model for 3-D tidal circulation, the proceedings of the 7-th Inter. Conf. on Estuarine and Coastal Modeling, St. Petersburg, FL, November 2001.

Costa, J. E., Cheng, R. T., Haeni, F. P., and Melcher, N. B., 2002, Looking to the Future: Non-Contact Methods for Measuring Streamflow, Proceedings, ASCE 2002 Hydraulic Measurements and Experimental Methods Conference, Estes Park, CO 7/28/02-8/1/02.

Cheng, R. T. and V. Casulli, 2004, Modeling a three-dimensional river plume over continental shelf using a 3D unstructured grid model, the proceedings of the 8-th Inter. Conf. on Estuarine and Coastal Modeling, Monterey, CA, November 2003, p. 1027-1043.

Cheng, R.T., J. E. Costa, R. R. Mason, W. J. Plant, J. W. Gartner, K. R. Spicer, F. P. Haeni, N. B. Melcher, 2004, Continuous non-contact river discharge measurements, Proc. of the 9-th Inter. Symposium on River Sedimentation, October 2004, Yichang, China, p. 2535-2542.

Cheng, R. T., J. W. Gartner, and T. M. Wood, 2005, Modeling and model validation of wind-driven circulation in Upper Klamath Lake, Oregon, World Water and Environmental Resources Congress 2005, Anchorage, Alaska.

List relevant project/field experience and publications/reports.

Salutation: **Dr.**
Last Name: **Thompson**
First Name: **Janet**
Title: **Research Biologist**
Organization: **U.S. Geological Survey**
Position:
Co-PI
Responsibilities: **Incorporation of bivalve data and processes into the biological model.**
Qualifications:

CURRICULUM VITA Janet Kay Thompson U.S. Geological Survey Water Resources Division 345 Middlefield Road MS 496 Menlo Park, California 94025

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 • 1982-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 • 1971: Teaching Assistant, 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: Aquatic Nuisance Species Digest (1999-present) Postdoctorates: Dr. Laurent Chauvaud, Dr. Rene Takesue

Relevant Publications:

Carlton, J.T., Thompson, J.K., Schemel, L.E., Nichols, F.H., 1990. Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam Potamocorbula amurensis. I. Introduction and dispersal, Marine Ecology Progress Series, 66, pp. 81-94.

Nichols, F.H., Thompson, J.K., Schemel, L.E., 1990. Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam Potamocorbula amurensis. II. Displacement of a former community, Marine Ecology Progress Series, 66, pp. 95-101

Monismith, Stephen G., Koseff, J. R., Thompson Janet K., O'Riordan, Catherine A., and Nepf, Heidi M. 1990. A study of Model Bivalve Siphon Currents: Limnology &Oceanography v. 35, no. 3, p. 680-696

Cole, B.E., J.K. Thompson, and J.E. Cloern. 1992. Measurement of filtration rates by infaunal bivalves in a recirculating flume. Marine Biology, 113: 219-225.

Lucas, L.V., J.E. Cloern, J.R. Koseff, S.G. Monismith, and J.K. Thompson. 1998. Does the Sverdrup critical depth model explain bloom dynamics in estuaries? Journal of Marine Research, 56:375-415

Lucas, L.V., J.E. Cloern, J.R. Koseff, S.G. Monismith, and J.K. Thompson. 1999. Processes governing phytoplankton blooms in estuaries. Part I: The local production-loss balance. Marine Ecology Progress Series v. 187, pp. 1-15 Lucas, L.V., J.E. Cloern, J.R. Koseff, S.G. Monismith, and J.K. Thompson.

1999. Processes governing phytoplankton blooms in estuaries. Part II: The role of horizontal transport. Marine Ecology Progress Series v. 187, pp. 17-30

Thompson, J. K., 1999. The effect of infaunal bivalve grazing on phytoplankton bloom development in South San Francisco Bay, PhD Thesis, Stanford University, Dept. of Civil and Environmental Engineering, Stanford, CA: 419p.

Lucas, L.V., J. E. Cloern, J.K. Thompson, and N.E. Monsen. 2002. Functional variability of shallow tidal habitats in the Sacramento-San Joaquin Delta: restoration implications. Ecological Applications 12(5): 1528-1547.

Crimaldi, J.P. J.K. Thompson, J.H. Rosman, R. J. Lowe, J. R. Koseff. 2002. Hydrodynamics of larval settlement: The influence of turbulent stress events at potential recruitment sites. Limnology and Oceanography. 47(4):1137-1151

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

Chauvaud, L., J. K. Thompson, J. E. Cloern, and G. Thouzeau. 2003. Clams as CO2 generators: The Potamocorbula amurensis example in San Francisco Bay. Limnology and Oceanography 48(6):2086-2092

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

Thompson, J.K, J. Koseff, S. Monismith, L. Lucas. Shallow water processes govern system-wide bloom dynamics: II. A field Study. Submitted to J. Marine Systems.

Lucas, L., J. Koseff, S. Monismith, J. Thompson. Shallow water processes govern system-wide bloom dynamics: II. A modeling study. Submitted to J. Marine Systems.

List relevant project/field experience and publications/reports.

Salutation: **Dr.**
Last Name: **Jassby**
First Name: **Alan**
Title: **Research Professor**
Organization: **Department of Environmental Science and Policy, University of California-Davis**
Position:
Co-PI
Responsibilities: **experimental design, analyses of simulation results**
Qualifications:

Alan Douglas Jassby Dept. Environmental Science &Policy telephone: +1 (530) 752-7865 University of California adjassby@ucdavis.edu Davis, California 95616 U.S.A.

Education Ph.D. in Ecology, 1973, Univ. of California, Davis B.S. in Mathematics, 1969, Massachusetts Institute of Technology.

Positions Held 1990-present, Research Ecologist, Dept. Environmental Science &Policy, Univ. of California, Davis. 1986-1989, Postgraduate Research Associate, Dept. Environmental Science &Policy, Univ. of California, Davis. 1980-1985, Director, Research and Development, Earthrise Farms, Calipatria, Calif. 1975-1979, Staff Scientist, Lawrence Berkeley Laboratory, Univ. of California, Berkeley. 1973-1975, Research Scientist, Marine Ecology Laboratory, Bedford Institute of Oceanography, Dartmouth, Nova Scotia.

Areas of Expertise Limnology; estuarine ecology; water quality; lake and reservoir restoration and management; water and public health; long-term monitoring and data analysis.

Professional Societies American Society of Limnology and Oceanography; California Estuarine Research Society; Estuarine Research Federation; Societas Internationalis Limnologiae.

Recent Appointments and Awards Hugo B. Fischer Award, 1995, California Water &Environmental Modeling Forum (awarded for contributions to solution of California environmental problems using modeling or quantitative analysis). http://cwemf.org/FischerAwardWinners.htm Consulting Professor, Department of Civil &Environmental Engineering, Stanford University, 1995–present. http://www.stanford.edu/group/efml/ Academic Federation Professional Development Award, 1999, University of California, Davis (for community development work in Myanmar). Associate Editor, San Francisco Estuary and Watershed Science Journal, 2003–present. http://repositories.cdlib.org/jmie/sfews/ Research Oceanographer, U.S. Geological Survey (occasional appointments, under an Intergovernmental Personnel Agreement).

Peer Review Service Publication referee and/or editorial consultant: American Association for the Advancement of Science; Aquatic Ecosystem Health and Management; Aquatic Toxicology; Archiv für Hydrobiologie; Canadian Journal of Fisheries and Aquatic Sciences; CRC Press; Ecology; Estuaries; Estuarine, Coastal and Shelf Science; Hydrobiologia; Internationale Vereinigung fuer Theoretische und Angewandte Limnologie Verhandlungen; Journal of Coastal Research; Limnology and Oceanography (received citation as L outstanding reviewer: L Bulletin 14[2], 2005); Marine Environmental Research; Marine Ecology Progress Series; Organic Geochemistry; Physiologia Plantarum; Water Resources Bulletin. Grants: California Bay–Delta Authority; Environmental Protection Agency; National Park Service; National Science Foundation; Sea Grant; U.S. Civilian Research and Development Foundation. Recent program review panels: Interagency Ecological Program, San Francisco Bay–Delta Environmental Monitoring Program, March–April 2002 (the semi–decadal review process of the main water quality program for the estuary). California Bay–Delta Authority, San Joaquin River Dissolved Oxygen TMDL Studies, May–June 2002 (this program is investigating the causes of an oxygen sag in the ship channel that serves as a barrier to Chinook salmon migration). San Joaquin River Group Authority, Water Quality Monitoring Plan for the East San Joaquin Water Quality Framework, 2005 (a consortium of farms and animal husbandry operations for management of runoff to San Joaquin River).

Selected Recent Publications (peer–reviewed only)

Jassby AD, Powell TM. 1990. Detecting changes in ecological time series. Ecology 71(6):2044–2052.

Jassby AD, Powell TM, Goldman CR. 1990. Interannual fluctuations in primary production: Direct physical effects and the trophic cascade at Castle Lake, California (USA). Limnology and Oceanography 35(5):1021–1038.

Jassby AD, Goldman CR, Powell TM. 1992. Trend, seasonality, cycle and irregular fluctuations in primary productivity at Lake Tahoe (California–Nevada USA). Hydrobiologia 246(3):195–203.

Goldman CR, Jassby AD, Hackley SH. 1993. Decadal, interannual, and seasonal variability in enrichment bioassays at Lake Tahoe, California–Nevada, USA. Canadian Journal of Fisheries and Aquatic Sciences 50(7):1489–1496.

Jassby AD, Cloern JE, Powell TM. 1993. Organic carbon sources and sinks in San Francisco Bay: Variability induced by river flow. Marine Ecology Progress Series 95(1–2):39–54.

Jassby AD, Reuter JE, Axler RP, Goldman CR, Hackley SH. 1994. Atmospheric deposition of nitrogen and phosphorus in the annual nutrient load of Lake Tahoe (California–Nevada). Water Resources Research 30(7):2207–2216. Jassby AD, Powell TM. 1994. Hydrodynamic influences on interannual chlorophyll variability in an estuary: Upper San Francisco Bay–Delta (California, USA). Estuarine Coastal and Shelf Science 39(6):595–618.

Cloern JE, Jassby AD. 1995. Year–to–year fluctuation of the spring phytoplankton bloom in South San Francisco Bay: an example of ecological variability at the land–sea interface. In: Steele JH, Powell TM, editors. Ecological time series. New York, NY: Chapman and Hall. p 139–149.

Jassby AD, Kimmerer WJ, Monismith SG, Armor C, Cloern JE, Powell TM, Schubel JR, Vendlinski TJ. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecological Applications 5(1):272–289.

Jassby AD, Koseff JR, Monismith SG. 1996. Processes underlying phytoplankton variability in San Francisco Bay. In: Hollibaugh JT, editor. San Francisco Bay; the ecosystem. San Francisco, CA: Pacific Division, American Association for the Advancement of Science. p 325–349.

Jassby AD, Cole BE, Cloern JE. 1997. The design of sampling transects for characterizing water quality in estuaries. Estuarine Coastal and Shelf Science 45(3):285–302.

Jassby AD. 1998. Interannual variability at three inland water sites: Implications for sentinel ecosystems. Ecological Applications 8(2):277–287. Jassby AD, Goldman CR, Reuter JE, Richards RC. 1999. Origins and scale dependence of temporal variability in the transparency of Lake Tahoe, California–Nevada. Limnology and Oceanography 44(2):282–294.

Jassby AD, Cloern JE. 2000. Organic matter sources and rehabilitation of the Sacramento–San Joaquin Delta (California, USA). Aquatic Conservation: Marine and Freshwater Ecosystems 10(5):323–352.

Jassby AD, Cloern JE, Cole BE. 2002. Annual primary production: patterns and mechanisms of change in a nutrient–rich tidal ecosystem. Limnology and Oceanography 47(3):698–712.

Müller–Solger AB, Jassby AD, Müller–Navarra D. 2002. Nutritional quality of food resources for zooplankton (Daphnia) in a tidal freshwater system (Sacramento–San Joaquin River Delta, USA). Limnology and Oceanography 47(5):1468–1476.

Sobczak WV, Cloern JE, Jassby AD, Müller–Solger AB. 2002. Bioavailability of organic matter in a highly disturbed estuary: The role of detrital and algal resources. Proceedings of the National Academy of Sciences 99(12):8101–8105.

Jassby AD, Reuter JE, Goldman CR. 2003. Determining long–term water quality change in the presence of climate variability: Lake Tahoe (USA). Canadian Journal of Fisheries and Aquatic Sciences 60:1452–1461.

Jassby AD, Cloern JE, Müller–Solger AB. 2003. Phytoplankton fuels Delta food web. California Agriculture 57(4):104–109.

Nickel DK, Brett MT, Jassby AD. 2004. Factors regulating Shasta Lake (California) cold water accumulaton, a resource for endangered salmon conservation. Water Resources Research 40:W05204, doi:10.1029/2003WR002669.

Jassby AD. 2005. Phytoplankton regulation in a eutrophic tidal river (San Joaquin River, California). San Francisco Estuary and Watershed Science 3(1 [March 2005]):Article 3. http://repositories.cdlib.org/jmie/sfews/vol3/iss1/art3.

Jassby AD, Van Nieuwenhuyse EE. 2005. Low dissolved oxygen in an estuarine channel (San Joaquin River, California): mechanisms and models based on long–term time series. San Francisco Estuary and Watershed Science 3(2 [September 2005]):Article 2. http://repositories.cdlib.org/jmie/sfews/vol3/iss2/art2/.

Sobczak WV, Cloern JE, Jassby AD, Cole BE, Schraga TS, Arnsburg A. 2005. Detritus fuels ecosystem metabolism but not metazoan foodwebs in San Francisco Estuary's freshwater Delta. Estuaries 28(1):124–137.

Swift TJ, Perez–Losada J, Schladow GS, Reuter JE, Jassby AD, Goldman CR. 2006. Water clarity modeling in Lake Tahoe: Linking suspended matter characteristics to Secchi depth. Aquatic Sciences 68:1–15.

List relevant project/field experience and publications/reports.

Conflict Of Interest

This is proposal #0022 for the Science Program 2006 solicitation.

Frequently asked questions and answers for this PSP are now available.

The submission deadline for this proposal has passed. Proposals may not be changed.

Instructions

To assist Science Program staff in managing potential conflicts of interest as part of the review and selection process, we are requesting applicants to provide information on who will directly benefit if your proposal is funded. Please provide the names of individuals who fall in the following categories and are not listed in the Personnel Form:

- Persons listed in the proposal, who wrote the proposal, will be performing the tasks listed in the proposal, or who will benefit financially if the proposal is funded; and/or
- Subcontractors listed in the proposal, who will perform tasks listed in the proposal, or will benefit financially if the proposal is funded.

Applicant
Submittor
Lead Investigator/Project Director
Primary Staff
Secondary Staff
Subcontractor

Provide the list of names and organizations of all individuals not listed in the proposal who helped with proposal development along with any comments.

Last Name	First Name	Organization	Role

Task And Budget Summary

This is proposal #0022 for the Science Program 2006 solicitation.

Frequently asked questions and answers for this PSP are now available.

The submission deadline for this proposal has passed. Proposals may not be changed.

Instructions

Use the table below to delineate the tasks needed to carry out your proposal. Tasks in this form should support the narrative description of your project in your proposal document and the informa tion provided in your detailed budget spreadsheet. Each task and subtask must have a number, title, timeline, list of personnel or subcontractors providing services, and associated budget figure.

When creating subtasks, ensure that each activity is counted only once. Please note, the initial task of your table (Task 1) must present all project management/administrative activities supporting your overall proposal.

For proposals involving multiple agencies or organizations (including subcontractors), the table must clearly state the tasks and subtasks performed by each entity.

Task #	Task Title	Start Month	End Month	Personnel Involved	Description	Task Budget
1	Project Management	1	36	Cloern, James Labiosa, Rochelle	Overall study design; budget management and reporting; progress reports to CALFED; progress briefings as requested; monitoring of progress to assure timely completion of all tasks.	11,677
2	Ecological Model	1	20	Cloern, James Labiosa, Rochelle Lucas, Lisa Thompson, Janet Jassby, Alan	Build and verify performance of the equation and parameter sets used to describe coupled dynamics of nutrients (DIN), 3 phytoplankton components, and zooplankton biomass. Compile data for model parameterizations and simulation calibration/validation. Begin with a zero dimensional model using STELLA, then proceed to a high resolution 1D vertical model. Validate the 1D ecological model against annual measurements of DIN, phytoplankton and zooplankton biomass at selected locations within North, Central and South San Francisco Bays.	59,726
3	3D Hydrodynamic Model	1	20	Labiosa, Rochelle Lucas, Lisa Ralph, Cheng	Learn the UTRIMM model application and build a high resolution computational grid to compute currents,mixing, salinity, temperature, and stratification in San Francisco Bay. Compile data for driving boundary conditions. Validate the hydrodynamic and scalar transport model against seasonal measurements of water elevation, current speed and direction, vertical salinity and temperature distributions at sites of continuous measurements with moored instruments. Conduct sensitivity tests to measure responses of the hydrodynamic and scalar transport model to fluctuations in forcings as coastal upwelling, river flow, wind stress, and surface heating. Construct a coarse-resolution physical model that captures the underlying estuary-wide physical dynamics of the fine-resolution model. Compare outputs of the fine- and coarse-resolution models.	95,232
4	Coupled Physical-Ecological	20	36	Cloern,	Merge the ecological model and coarse-resolution 3D hydrodynamic model.	132,787

	Model			**James Labiosa, Rochelle Lucas, Lisa Ralph, Cheng Thompson, Janet Jassby, Alan**	**Compile estuary-wide data sets for boundary conditions and prescribed quantities including seasonal/spatial distributions of bivalve biomass and grazing. Calibrate the model and validate its performance against time series of currents, salinity, water temperature, phytoplankton biomass, DIN concentration, and zooplankton biomass from moored instruments and hydrographic/biological surveys. Conduct simulation experiments to quantify the estuary-wide consequences of (a) reduced sediment inputs to North Bay, (b) decreased bivavle biomass in South Bay, (c) heightened upwelling intensity and import of coastal phytoplankton biomass, and (d) all three processes operating simultaneously. Run simulations for periods of a decade to reveal the long term evolution of responses as changing phytoplankton seasonal dynamics and biomass. Compare model simulation results with observed patterns of changing phytoplankton dynamics over the past decade. Project future changes under prescribed scenarios of persistent disruption of bivalve recruitment and further reductions in sediment input. Synhtesize and publish results in peer reviewed journal articles and outlets for the public and resource managers.**	

total budget=$299,422

Detailed Budget Upload And Justification

This is proposal #0022 for the Science Program 2006 solicitation.

Frequently asked questions and answers for this PSP are now available.

The submission deadline for this proposal has passed. Proposals may not be changed.

Using the budget provided via this link as a guide, please complete a budget for your proposal in the software of your choice (e.g. Excel). This document must be in a format and software that can be converted to PDF prior to uploading on the web system.

It is incumbant upon the applicant to fully explain/justify the significant costs represented in the attached budget. This information can be provided either in a text document and uploaded below, or included in your proposal text in a clearly defined budget justification section. If it is not abundantly clear to reviewers what project costs are commensurate with which efforts and benefits, the proposal may receive a poor review and denied funding.

Costs for each task described in the Task and Budget Summary Form and each staff or subcontractor described on the Contacts and Project Staff Form, must be included in your budget. The budget for Task One should represent project management activities, including but not limited to cost verification, environmental compliance, data handling, report preparation, project oversight, and public outreach. The total amount of your budget must equal the total amount represented on your Task and Budget Summary Form and the total budget amount represented on your Project Information and Executive Summary Form.

In a separate text document to be uploaded below, identify any cost share and other matching funds available to support your proposed project. If you identify cost share or matching funds, you must also describe them in the text of your proposal (see explanation of "cost share and other matching funds" in Section Two of the solicitation document).

CBDA may request additional information pertaining to the items, rates and justification of the information presented in your budget. Applications without completed budgets will not be considered for funding.

Uploading The Completed Budget Template

First, convert your completed Budget to a PDF file. Then, use the browse function to locate the PDF version of your document, select the document and click on the upload prompt below.

You have already uploaded this document. View it to verify that it appears as you expect. You may replace it by uploading another document

Uploading The Completed Budget Justification

First, convert your completed Justification text to a PDF file. Then, use the browse function to locate the PDF version of your document, select the document and click on the upload prompt below.

You have already uploaded this document. View it to verify that it appears as you expect. You may replace it by uploading another document

Uploading The Description Of Cost Share/Matching Funds

First, convert your completed Description of Cost Share/Matching Funds text file to a PDF file. Then, use the browse function to locate the PDF version of your document, select the document and click on the upload prompt below.

You have already uploaded this document. View it to verify that it appears as you expect. You may replace it by uploading another document

Schedule Of Deliverables

This is proposal #0022 for the Science Program 2006 solicitation.

Frequently asked questions and answers for this PSP are now available.

The submission deadline for this proposal has passed. Proposals may not be changed.

Use the table below to delineate the key deliverables and the time necessary to complete them (in months from the date the project's grant agreement is executed). Each Science Program 2006 PSP grant recipient must provide the required minimum deliverables for each project. The required minimum deliverables for each funded proposal are as follows:

- Semi−annual report(s)
- Final Report
- One page project summary for public audience at beginning of project
- One page project summary for public audience upon project completion
- Project closure summary report or copy of draft manuscript
- Presentation at CALFED Science Conference
- Presentations at other events at request of CALFED Science Program staff
- Copy of all published material resulting from the grant

Deliverable	Description	Delivered By: # (In Months From Project Start Date)
Semi−annual report	progress report on first 6 months of research	7
Semi−annual report	progress report on second 6 months of research	13
Semi−annual report	progress report on third 6 months of research	19
Semi−annual report	progress report on fourth 6 months of research	25
Semi−annual report	progress report on fifth 6 months of research	31
Final Report	all manuscripts prepared for publication in peer reviewed scientific journals or other outlests such as the IEP Newsletter or Estuaries Newsletter of the Estuary Project. These products will be bundled with an overview highlighting major findings and their management significance, serving as a closure summary report.	36
One page project summary for public audience	One page project summary for public audience at beginning of project	2
One page project summary for public audience upon project completion	One page project summary for public audience upon project completion	36
Presentation at CALFED Science Conference	Presentation at the 2008 CALFED Science Conference	18
Presentation at CALFED Science Conference	Presentation at 2009 CALFED Science Conference or State of the Estuary Conference	35
Presentations at other events at request of CALFED Science Program staff	Progress reports and project briefings can be provided once annually or as requested by CALFED staff	36
Copy of all published material resulting from the grant	Copy of all published material resulting from the grant	36

If you are unable to provide a Schedule of Deliverables as outlined above, please provide your justification of non−compliance in the text box provided below. The Science Program reserves the right to determine a proposal non−eligible based on an applicants inability to provide the materials requested above.

Letters Of Support Form

This is proposal #0022 for the Science Program 2006 solicitation.

Frequently asked questions and answers for this PSP are now available.

The submission deadline for this proposal has passed. Proposals may not be changed.

Letters Of Support

Should you wish to provide letters of support for your proposed project, you must do so through use of this web form. Letters of support will be provided to independent, panel and public reviewers for reference as part of the overall review process. It is not mandatory to provide letters of support. Failure to do so will in no way affect the review or final determination of your application.

Submission Of These Materials.

To submit Letters of Support, you must do so as .PDF files. To upload these materials, use the browse function to locate the appropriate .PDF version of the documents, select the documents and click on the upload prompt below.

Please ensure your PDF file contains all letters you would like to submit. Individual files (or letters) will not be accepted by the system. The system is designed to receive one single file. Submittal of these documents are not mandatory for your application to be considered under the 2006 Science Program PSP. Failure to submit letters does not impact your ability to compile your proposal along with the supporting forms required for final submission and consideration under the Science Program 2006 PSP.

Letters Of Support	*Please upload a PDF version of your letters of support. To upload a document, use the "Browse" button to select the PDF file containing the document.*

TRoUBLE? Trends of Rising and Unexplained Bloom Levels in the Estuary

Project Purpose

San Francisco Bay has experienced large biological changes in the past decade that are ecologically significant, but unexplained. The purpose of this project is to develop a model of coupled estuarine hydrodynamics and pelagic ecological dynamics to systematically explore a set of plausible mechanisms. The goal is to use simulations to identify the drivers of recent ecological changes in San Francisco Bay, to understand interactions among those drivers, and to build a foundation for anticipating trajectories of future change as the Bay ecosystem continues to evolve in directions that may have important implications for water and habitat quality and sustainability of key species.

The largest living component of San Francisco Bay is the phytoplankton, a suspension of microscopic algae that provides the most important source of energy to fuel production in food webs through photosynthesis. Although San Francisco Bay receives large inputs of detritus from river inflow, that pool of organic matter is largely refractory or respired by microbes and contributes little to animal production in the Bay and Delta (Sobczak et al. 2002). Mussels, clams, polychaete worms, amphipods, copepods, cormorants, canvasback ducks, pelicans, sturgeon, herring, anchovies, Delta smelt, salmon and harbor seals resident in the Bay-Delta ultimately derive most of their nutrition (both energy and dietary components) from phytoplankton.

San Francisco Bay is highly enriched in nitrogen (N) and phosphorus (P) as a result of inputs from its local urban watershed and the agricultural watersheds of its large tributary rivers (Smith and Hollibaugh 2006). Although nutrient enrichment has promoted excessive growth of phytoplankton, leading to hypoxia/anoxia, harmful algal blooms, and other modes of habitat degradation in many coastal ecosystems, these manifestations of nutrient enrichment have not developed in San Francisco Bay (Cloern 2001). In fact, multiple lines of evidence indicate that low phytoplankton biomass and primary production limit the carrying capacity of the Bay-Delta ecosystem to support fish and their forage organisms, in spite of its nutrient enrichment.

The Bay's low productivity has been attributed to several inherent attributes, including light limitation of photosynthesis by high concentrations of suspended sediments (Cloern 1999) and strong grazing pressure from benthic bivalves that consume phytoplankton cells as fast as they are produced (Cloern 1982). Phytoplankton primary production decreased a remarkable five-fold in Suisun Bay following introduction of the Asian clam *Corbula amurensis* (Alpine and Cloern 1992). Primary production in the Delta (only 75 g C m^{-2} y^{-1}; Jassby et al. 2002) is lower than primary production in the ultra-oligotrophic Lake Tahoe, and this low primary production is a constraint on the capacity of Suisun Bay and the Delta to sustain populations of upper trophic level organisms (Cloern 2006) and is considered a contributing factor to recent declines of pelagic organisms there (http://science.calwater.ca.gov/pod/pod_index.shtml).

San Francisco Bay's condition as a high nutrient-low productivity ecosystem is changing, based on sustained observations of chlorophyll *a* (Chl*a*) as an indicator of phytoplankton biomass. The USGS began measurements of Chl*a* in 1978, and for over two decades these measurements revealed a recurrent annual pattern of low phytoplankton biomass except during spring, when blooms developed and persisted for periods of weeks in San Pablo and South Bay (Cloern 1996).

Fig. 1 Sampling stations where USGS measures phytoplankton biomass (Chla) and other water-quality constituents. The Sacramento-San Joaquin Delta (inset), a network of tidal freshwater channels and shallow lakes, is the transition region between the Sacramento-San Joaquin Rivers and the estuary of San Francisco Bay.

Results from the USGS observational program indicate that this annual pattern began to change some time in the late 1990's, and the change is manifested as (1) larger spring blooms, (2) steadily increasing baseline (annual minimum) Chl*a*, and (3) occurrences of secondary blooms during autumn and winter.

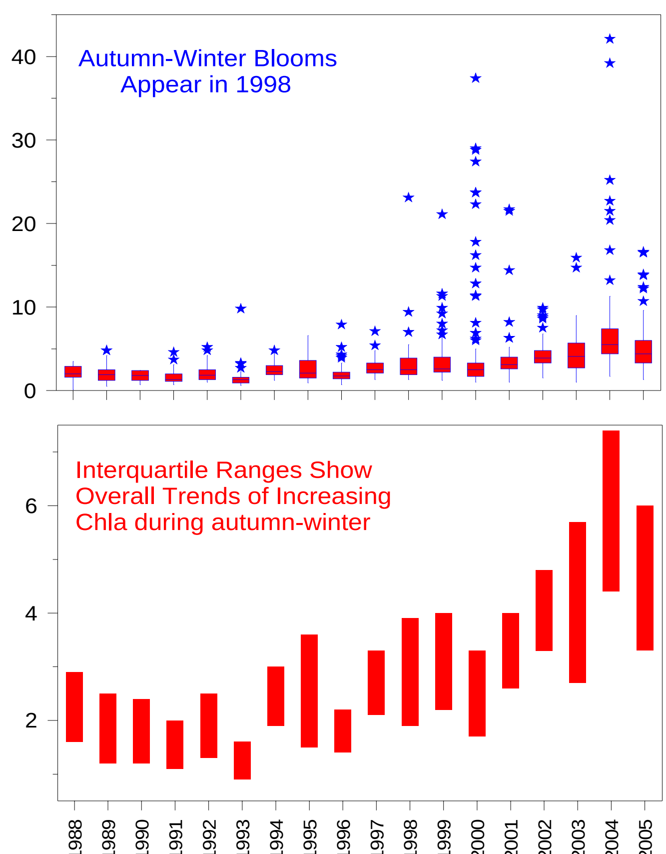


*Fig. 2. Annual distributions of Chla (mg m^{-3}) measured along the transect from San Pablo Bay through South Bay (Fig. 1) for the months August-December of years 1988 through 2005. Horizontal blue lines are medians, red boxes are interquartile ranges (IQR spans the 25th to 75th percentile). Blue stars are outliers (> [75th percentile + 1.5*IQR]), events of unusually high Chla. These autumn-winter bloom began in 1998 and have occurred regularly since.*

Expanded graph of the 1988-2005 series of Chla interquartile ranges shown above, highlighting the overall trends of increasing phytoplankton biomass that began in the 1990's. These trends are statistically significant in San Pablo, Central, and South Bay.

Analyses with the Seasonal Kendall tau test reveal that all three trend types are positive, and most are statistically significant at all sampling stations within San Pablo, Central, and South Bay (Cloern et al. 2006). These records are compelling evidence that algal biomass in the marine domains of San Francisco Bay is increasing, and that seasonal phytoplankton dynamics are changing as secondary blooms develop during seasons other than spring. These changes are ecologically important. Estimates of annual phytoplankton primary production (following Jassby et al. 2002) indicate that San Francisco Bay is becoming a high productivity ecosystem as a consequence of increasing phytoplankton biomass.

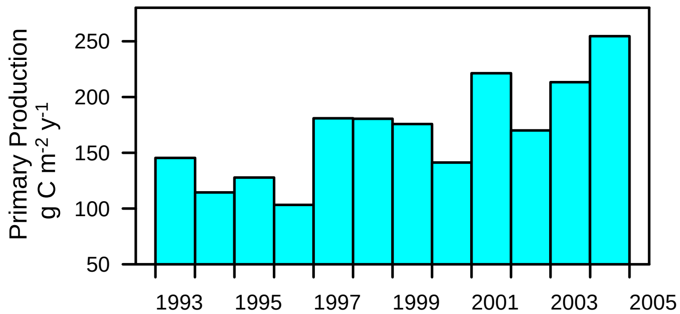


Fig. 3. Mean estimated primary production for the years 2001-2004 was 215 g C m^{-2} compared to 120 g C m^{-2} for the years 1993-1996.This series is based on measures of Chla and turbidity in San Pablo, Central, and South San Francisco Bay (stations 11-36, Fig. 1).

These trends may be early warning signs that San Francisco Bay's resistance to the harmful consequences of nutrient enrichment could be changing. We documented an unprecedented red tide during September 2004 (Cloern et al. 2005), the first occurrence of a large bloom by a dinoflagellate species that has caused fish kills and closure of shellfish aquaculture in other bays. The 2006 spring bloom was unprecedented in magnitude and duration, and we observed occurrences of new phytoplankton species in 2005 and 2006 (e.g. *Aureococcus* sp., *Karenia mikimotoi*) that are toxic to shellfish and their consumers. In May 2006 we observed unusually low concentrations of dissolved oxygen (< 60% saturation) in bottom waters extending from San Pablo Bay through South Bay.

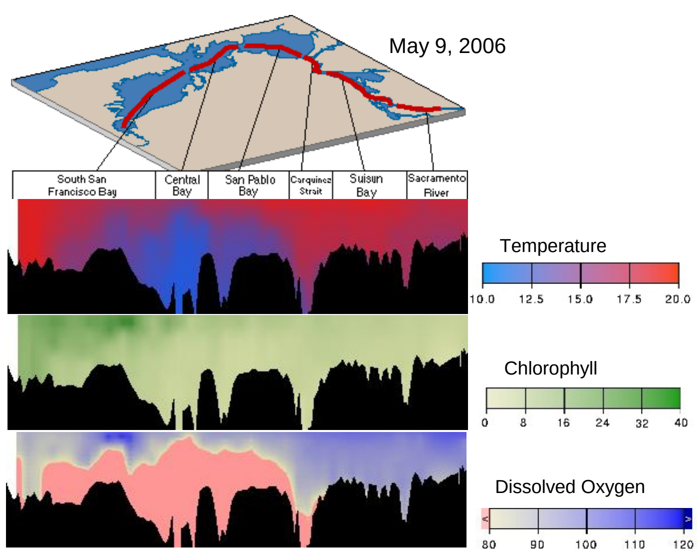


Fig. 4. Color contour plots showing the vertical and longitudinal distributions of temperature, Chla, and dissolved oxygen (as % saturation) along the sampling transect from the lower South San Francisco Bay to the Sacramento River on May 9, 2006. The pink depicts low dissolved oxygen extending over large regions of the Bay. Data are available online: http://sfbay.wr.usgs.gov/access/wqdata

Observational data are insufficient to determine whether these changes are directly related to multiple fish kills during spring 2006 (http://cbs5.com/pets/local_story_186225658.html), but the occurrences of new species of toxic algae and unusually low dissolved oxygen suggest that toxic blooms or excess algal production may have degraded water quality in regions of the Bay during this recent year of high precipitation and runoff. Will these recent events and trends continue to expand, and will San Francisco Bay progress toward a coastal ecosystem impaired by overproduction of algal biomass in response to high N and P loadings as observed in many other estuaries?

The objective of this project is to build and apply a numerical model as a tool to synthesize available data to answer the first order question: What processes are causing changes in phytoplankton seasonal dynamics and biomass in San Francisco Bay? Identification of the underlying mechanisms is an essential step for assessing trajectories of how water quality might evolve in the next decade. Phytoplankton dynamics are complex responses to multiple processes, including those operating at the estuary's atmospheric, oceanic and watershed boundaries as well as processes within the estuary. We take a global view of the question, and will explore four hypotheses that recent trends of phytoplankton increase in San Francisco Bay are the result of:

1. increased phytoplankton growth rates as a result of reduced sediment inputs and increasing water transparency
2. decreased phytoplankton mortality rates as a result of recent declines in the abundance of bivalve suspension feeders
3. increased oceanic inputs of phytoplankton biomass as a result of anomalously strong upwelling and phytoplankton production in the California Current
4. interactions among two or all of these processes.

Background and Conceptual Model

Phytoplankton biomass builds as algal cells divide, is lost to sedimentation and grazing by zooplankton and benthic suspension feeders, and it is transported by water currents and mixing.

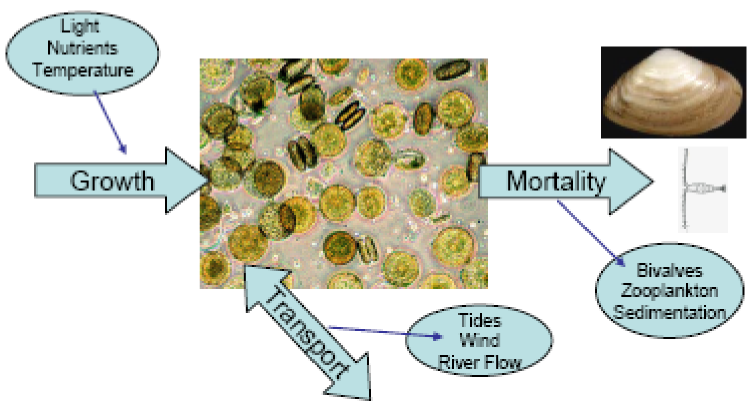


Fig. 5. Simple conceptual model of phytoplankton population dynamics, driven by processes of cell growth, mortality, and transport.

Changes in any or all of these processes can change seasonal dynamics of phytoplankton biomass, and all of these processes can be included in numerical models such that each can be altered, systematically, to explore phytoplankton responses. The problem requires a systematic approach because the forces driving variability of each process have changed in San Francisco Bay during the recent era of Chla increase.

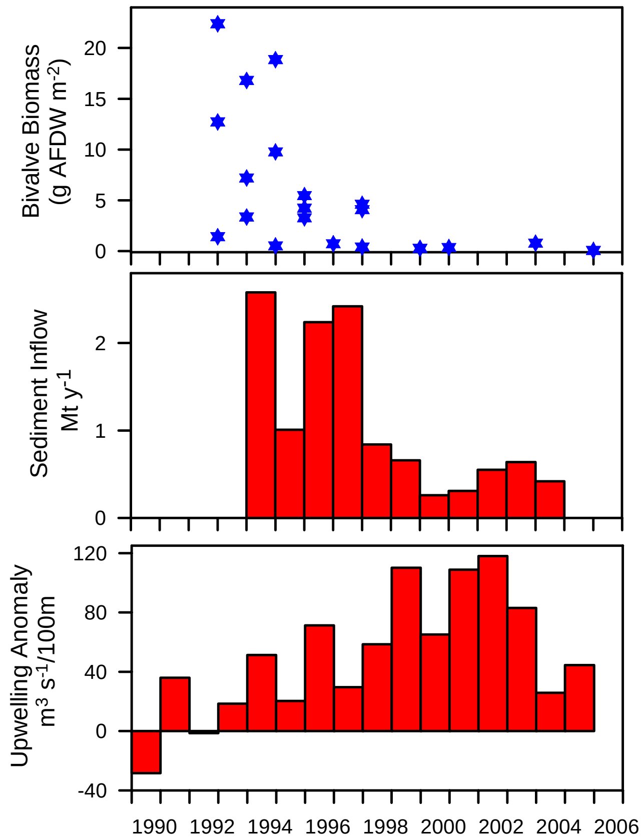


Fig. 6. Annual series of three forcings that regulate phytoplankton dynamics in San Francisco Bay.

Seasonal biomass of bivalves in lower South Bay (data from J.K. Thompson)

Annual inflow of sediments from the Delta to San Francisco Bay (McKee et al. 2006).

Upwelling index at 39 N, as the annual deviation from the long term mean for months April-October (NOAA, www.pfeg.noaa.gov/products/PFEL/)

Fig. 6 (upper panel) shows that mean biomass of bivalve suspension feeders across a network of sampling sites in the lower South Bay dropped substantially after 1999, implying that reduced benthic grazing is a mechanism of phytoplankton increase (Hypothesis 1).

Sediment supply from the Sacramento River has been reduced by construction of dams on all large tributaries, and sediment inflow measurements show significant declines over the past decade (middle panel). Continuous measurements from moored sensors in San Pablo Bay show that mean annual suspended sediment concentration (SSC) was 82 mg/L for water years 1993-1998 but only 40 mg/L for water years 1999-2004 (Dave Schoellhamer, personal communication). This change is consistent with the longer term record showing a 50% reduction of SSC in the Delta over the period 1975-1995 (Jassby et al. 2002). Reduced sediment yield from the Central Valley is apparently causing a gradual clearing of Bay-Delta waters as far seaward as San Pablo Bay. Turbidity of San Francisco Bay is primarily a result of light scattering and absorption by suspended sediments, so these trends of declining sediment concentrations motivate Hypothesis 2 – light limitation of phytoplankton growth is gradually diminishing and growth rates are gradually increasing.

The past decade has been a period of consistently strong coastal upwelling (Fig. 6, bottom panel), and this trend motivates Hypothesis 3 – the coastal Pacific Ocean has been an unusually large source of marine phytoplankton as a consequence of high primary production in the California Current. This hypothesis is consistent with observations that secondary blooms in the Bay are dominated by coastal species, such as the diatom *Thalassiosira punctigera* and dinoflagellate *Akashiwo sanguinea*. Red tides of *Akashiwo* developed in the Bay after they occurred offshore and in Monterey during August 2004, and satellite imagery (e.g. Fig. 8) confirms that Ch*la* in the nearshore coastal ocean is higher than inside San Francisco Bay during periods of sustained upwelling (Cloern et al. 2005). Estuarine scientists are just beginning to explore and understand ocean-estuary connectivity, and import of upwelling-generated phytoplankton biomass appears to be an important mechanism in estuaries adjacent to the California Current (Roegner and Shanks 2001).

Estuaries are highly complex ecosystems because of their connectivity to atmospheric, oceanic and hydrologic drivers of environmental variability. Increasing phytoplankton biomass in San Francisco Bay is likely a result of multiple processes, with the influence of each having a distinct spatial distribution. Suspended sediment concentrations are decreasing in the Delta and North Bay but not in the Central Bay or South Bay. Conversely, bivalves have declined recently in South Bay but not North Bay. The influence of variability in the coastal ocean is expected to be strongest in the Central Bay region of rapid bay-ocean exchange. Numerical models provide a tool for unraveling complex problems of multiple, spatially distributed processes. The four guiding hypotheses will be tested with numerical experiments in which phytoplankton dynamics are computed within the entire estuary over decadal simulations as individual, spatially localized processes are varied. The approach will provide quantitative determination of how, for example, trends of increasing water clarity in the North Bay or decreased bivalve grazing in the South Bay can propagate to induce Bay-wide variability in phytoplankton biomass and primary production.

Approach

This work will produce the first 3D pelagic ecosystem model of San Francisco Bay that includes dynamic coupling between nutrient, phytoplankton and zooplankton dynamics within a tidal-scale hydrodynamic model. Such biological-physical models have proven to be powerful tools for determining the underlying causes of phytoplankton bloom magnitudes and timing in many regions of the world (e.g., Arrigo et al. 2003; Hood et al. 1999, 2003,2004). Coupled hydrodynamic-plankton models have been used extensively to pose and test mechanisms of bloom dynamics in San Francisco Bay (e.g. Cloern 1991, Lucas et al. 1998, Lucas et al. 1999), but these models have not included dynamics of nutrient cycling or zooplankton population growth and they have not exploited recent development of an unstructured 3D hydrodynamic model.

Experimental Design

We propose to use numerical models to test the four hypothesized mechanisms of phytoplankton increase in San Francisco Bay:

(1) Increased transparency of water due to decreased suspended sediment concentrations in the North Bay.

-*Light limitation is a primary constraint on phytoplankton growth rate in San Francisco Bay (Cloern 1999). We will model light attenuation in the water column as a* *function of simulated phytoplankton biomass and measured suspended sediment concentrations from moored sensors at fixed locations (Fig. 7) and ship-based sampling (Fig. 1). A specific objective will be to determine if small, sustained trends of increasing water clarity in North Bay, shown below, can generate estuary-wide trends of increasing phytoplankton biomass and the occurrence of autumn-winter blooms that propagate into Central and South San Francisco Bay.*

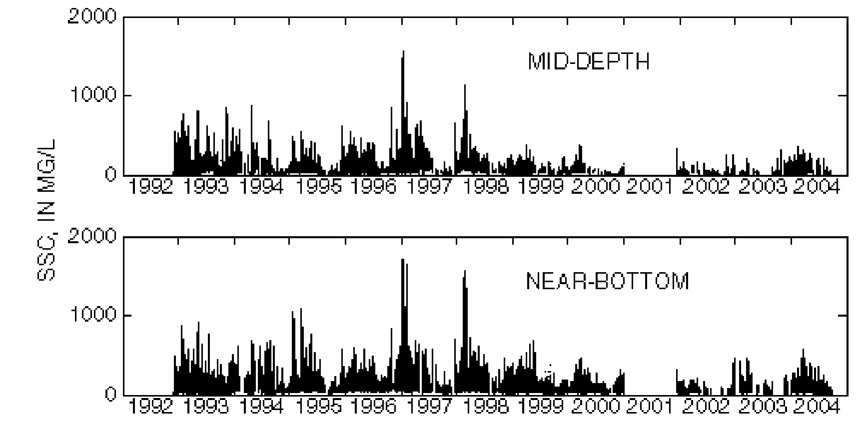


Fig. 7. Continuous measurements of SSC from optical backscatter sensors moored in San Pablo Bay. Measurements are recorded every 15 min. http://sfbay.wr.usgs.gov/sediment/cont_monitoring/background.html)

(2) A decrease in benthic grazing caused by declining abundance of bivalve suspension feeders such as the mussel *Musculista senhousia* and clams *Corbula amurensis*, *Tapes japonica* and *Mya arenaria*.

- *We will test this hypothesis by first running the model with high benthic grazing rates based on seasonal distributions of bivalves sampled across shallow and deep habitats of San Francisco Bay during 1987 and 1988 (Schemel et al. 1990). Then, simulations will compare Baywide phytoplankton dynamics after reducing benthic grazing rates based on the decreased bivalve abundance measured in lower South Bay after 1999 (Fig. 6). A specific objective will be to determine if local-scale reductions of benthic grazing loss can induce estuary-wide responses as multi-year trends of increasing phytoplankton biomass and the occurrence of autumn-winter blooms.*

(3) Import of high chlorophyll water originating at the external ocean boundary, which may be a result of increased upwelling over the last decade.

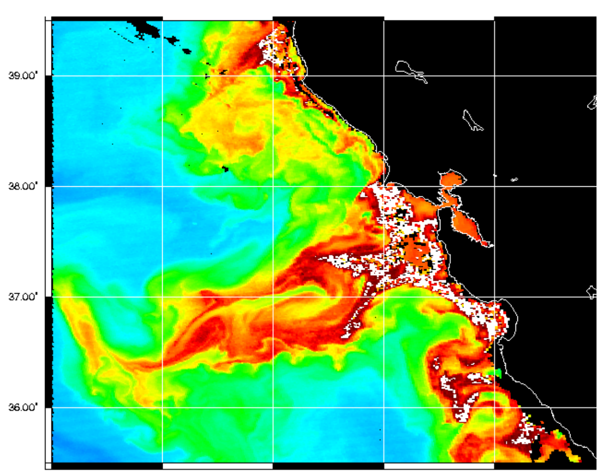


Fig. 8. SeaWifs-derived image of surface Chla, indicating high phytoplankton biomass (red) produced in the coastal ocean by wind-driven upwelling.

-We will compare the model with boundary forcing under both strong (high chlorophyll, low temperature) and weak (low chlorophyll, high temperature) upwelling conditions and corresponding wind forcing. A specific objective is to determine the magnitude of Chla flux into San Francisco Bay across a range of upwelling intensity and duration, and to determine the spatial extent of bloom development within San Francisco bay triggered by seeding from the coastal ocean.

(4) Observed trends of phytoplankton biomass in San Francisco Bay cannot be explained by one mechanism, but are consistent with interactions of multiple mechanisms.

- *We will run sensitivity tests with all processes at work in the model: benthic grazing, water clarity, and upwelling strength, to determine what combinations of these processes could result in the observed patterns phytoplankton increase.*

The modeling approach (Table 1) will consist of three tasks: (1) creation of a 2-box (channel and shoal) biological (NPZ) model representing sites throughout the Bay to test the parameterizations and systems of equations for incorporation into the 3D model; (2) validation of scalar transport (temperature and salinity) within a fine-resolution 3D hydrodynamic model of San Francisco Bay under climatological forcing for the spring and autumn seasons; and (3) coupling of the biological model to the 3D physical model, and subsequently driving model runs with interannual data to explore the relative contributions of benthic grazing, coastal upwelling, and light availability on phytoplankton dynamics in San Francisco Bay.

Table 1: Model configuration and testing

MODEL TYPE & DOMAIN	SOURCE	FORCING	TIME PERIOD	PURPOSE
2-box (channel & shoal) NPZ model	STELLA	Solar irradiance, temperature, N loading	One year, daily variability in forcings	Identify parameterizations and equation sets to describe annual NPZ dynamics in coupled shallow-channel domains of SF Bay
3D fine resolution: Full SF Bay	UTRIM	Heat and Salt Flux; ocean tides; wind speed and direction	Long-term (30-year) Average Spring and Autumn runs	Validate simulations of scalar transport with measured temperature and salinity fields, current speeds/directions
3D coarse resolution pelagic model: Full SF Bay	UTRIM	Heat and Salt Flux; ocean tides; wind speed and direction; interannually varying	Decadal, comparing baseline with altered benthic grazing, SSC, and upwelling	Test four hypotheses of mechanisms causing phytoplankton increase in San Francisco Bay since the 1990's

Our four hypotheses will be tested in turn, using the coarse-resolution 3D biological-physical coupled model. To do this, we will first spin-up the 3D model using climatological forcing for the pre-extended Autumn bloom time period (1980-1995). After convergence, the model will be forced interannually using boundary and surface forcing for individual years from 1995-2005. However, in the first interannual simulation, the water transparency, boundary forcing of Chla, and bivalve grazing rates will not be altered. Instead, this run will depict “business as usual”. In this way, we can determine if surface forcing alone, aside from boundary forcing, water transparency, and benthic grazing, is responsible for the altered pattern in Chla. Next, we will run the model with interannual forcing to conduct the following set of simulations over the period 1995-2005: (1) with interannually varying Chla at the boundary, (2) with interannually varying water transparency, (3) interannually varying bivalve biomass, and (4) with all three of these variables changing together. In addition, we will do some sensitivity testing, for example, running the simulations for a shortened time period (1-2 years) with extremely high and low (1/10 and 10X) Chla at the boundary, high and low water transparency, and high and low bivalve biomass. The specific details of each model will be discussed in the following sections.

Ecological Model Description

An ecological submodel will be developed from a 2-box NPZ (Nitrogen-Phytoplankton-Zooplankton) model created to describe pelagic dynamics in the Sacramento-San Joaquin River Delta (Cloern 2006). This ecological model will be developed using STELLA software to represent the coupled channel and shoal regions of Suisun Bay, San Pablo Bay, and South Bay (see Fig. 1). This structure is based on field studies (e.g. Cloern et al. 1985) and simulation experiments (e.g. Lucas et al. 1999) demonstrating that shallow domains of the estuary are important sources of phytoplankton biomass, and lateral transport of this biomass sustains secondary production of consumers in the deep channel domains. This simple box model will be used to test the range of parameterizations and metabolic configurations for diatoms (the dominant phytoplankton component; Cloern and Dufford 2005), mesozooplankton (i.e. copepods), dissolved inorganic nitrogen, and bivalve grazing rate. The STELLA box model allows for diffusive exchange between the channel and shoal boxes, and the biological model will be used to prescribe phytoplankton growth as a function of temperature, light, and nutrient concentration, with loss of phytoplankton through mortality, exudation and grazing.

The net source minus sink for the state variables (Q) will be defined (in units mg N m^{-3} d^{-1}) as:

$$Q_P = (\mu_P - x_P - e_P)P - g_{ZP}Z - g_{BP}B \quad (1)$$

$$Q_Z = (\gamma g_{zp} - x_Z - e_Z)Z - p_Z Z \quad (2)$$

$$Q_{DIN} = (1-\beta)\{(-\mu_P + x_P + e_P)P + [(1-\gamma)g_{ZP} + x_Z + e_Z)]Z + (1-\gamma)g_{BZ}B\} + r_d D + NS \quad (3)$$

where *P*, *Z* and *B* are phytoplankton, zooplankton and bivalve biomass, *D* is detritus, and *DIN* refers to dissolved inorganic nitrogen (ammonium + nitrate) concentration.

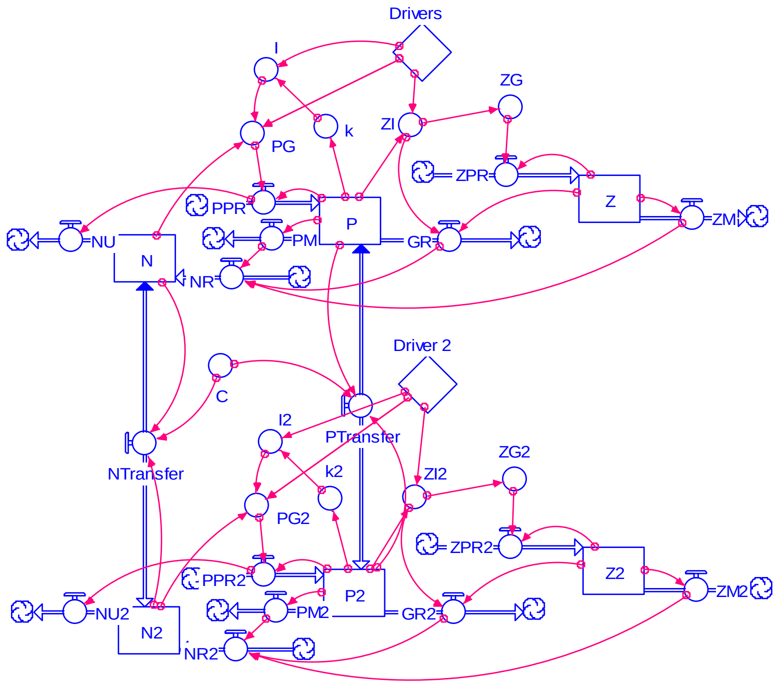


Fig. 9. Schematic diagram of a pelagic model where the transport of N, P and Z between a shallow (upper boxes) and deep habitat (lower boxes) is treated as a turbulent diffusive process (from Cloern 2006). Drivers are daily solar radiation, water temperature, light attenuation coefficient, and nutrient input.

In Eq. 1, the rate of change in phytoplankton biomass (*P*) will be a function of the balance of growth (μ), death (*x*), exudation (*e*), and grazing (*g*) losses to zooplankton and bivalves. Growth rates will be calculated as a function of light, nutrients, and temperature, following the approach of Cloern (2006). Phytoplankton mortality ranges from 0.03 to 0.075 d^{-1} (e.g., Doney et al. 1995, Berges and Falkowski 1998), and exudation will increase with decreasing nutrient concentration as described by Ohlendieck et al. (2000).

The rate of change in zooplankton biomass (Eq. 2) is determined by the product of grazing rate and assimilation efficiency (γ), the rates of death (*x*), excretion (*e*), and predation (*p*). Grazing rates for zooplankton will be a function of phytoplankton concentration, while benthic grazing will be a function of bivalve biomass and size distribution, including corrections for a concentration boundary layer that depletes phytoplankton biomass near the bed (as described in Thompson 2005). The assimilation efficiency will range from 0.5 to 0.75 d^{-1} (Fasham 1993; Doney et al. 1996). Rates of zooplankton grazing have been reported to range from 0.5-3 d^{-1} in highly productive regions (e.g., Murrell and Hollibaugh, 1998; Mallin and Paerl, 1994). Zooplankton mortality is density dependent (Ohman and Hirsche 2001) and ranges from 0.03-0.18 d^{-1}. The initial parameter set will follow those derived by Cloern (2006), and sensitivity tests will encompass the range of variability in each parameter.

The rate of change of DIN concentration (Eq. 3) will be determined by rates of phytoplankton uptake, remineralization of detritus, and external supply *NS*. The soluble percentage of phytoplankton exudation, zooplankton excretion and unassimilated grazing will enter the DIN pool directly, while concentrations will also be influenced by remineralization of detritus and external loadings at the river and ocean boundaries. At the bottom boundary, there will be a no flux condition for all passive tracers with the exception of the upward flux of DIN from the sediments and the downward benthic flux of grazed phytoplankton. The insoluble fraction (β) of algal exudation is assumed lost to the detrital pool as are unassimilated grazing and dead phytoplankton and zooplankton.The remineralized flux of nutrients at the sediment boundary will be calculated as a function of phytodetritus and DIN using the empirical equations of Grenz et al. (2000) derived from measurements using sediment cores. Spatial distributions of bivalve abundance will be derived from Schemel et al. (1990), Thompson (1999), and unpublished datasets (J. Thompson, pers. comm.).

Daily measures of solar radiation are available for a number of spatial locations around San Francisco Bay (http://wwwcimis.water.ca.gov/cimis/data.jsp). Light attenuation in the water column will be a function of suspended sediment, detritus, and phytoplankton concentrations. The phytoplankton contributions to the light attenuation will be derived from the biological model, while sediment and detritus (which covaries with sediment; Wienke and Cloern 1987) will be specified from continuous measurements at fixed locations (e.g. Fig. 7) and ship-based measurements of spatial variability.

For the 3D version of the ecosystem model, all state variables will be treated as passive tracers. Following Blumberg and Mellor (1983), the equation for any passive tracer is

$$\frac{\partial}{\partial t}\zeta + \frac{\partial}{\partial x}(u\zeta) + \frac{\partial}{\partial y}(v\zeta) + \frac{\partial}{\partial z}(w\zeta) - \frac{\partial}{\partial z}\left(K_z \frac{\partial \zeta}{\partial z}\right) - F_\zeta = Q_\zeta \quad (4)$$

where ζ is the tracer concentration, *u* and *v* are the horizontal velocities, and *w* is the vertical velocity. The turbulent mixing coefficient *Kz* is calculated using the level 2.5 Mellor-Yamada turbulent kinetic energy closure scheme (Cheng and Casulli 2002) and is used to determine vertical mixing of tracers. The horizontal mixing of tracers is represented by F_ζ and is given by Cheng and Casulli (2002).

The 2-box NPZ model will be calibrated with data collected by USGS in 1980, the only full year in which Chla and primary productivity (Cloern et al. 1985), DIN, light attenuation coefficient, SSC, water temperature and salinity (Ota et al. 1989), and zooplankton biomass (Ambler et al. 1985) were measured across channel and shoal transects in South Bay, San Pablo Bay, and Suisun Bay. The calibrated NPZ model will then be validated with measurements of DIN, Chla and SSC made across a network of subtidal sites in South Bay from 1993-1996 (Thompson 1999).

Physical Model Description

Modeling efforts will focus on solving for meteorologically and tidally forced flows in San Francisco Bay. This requires simultaneously computing flows driven by tides, winds, and temperature and salinity gradients. The physical model will be the z-coordinate Unstructured Tidal Residual Intertidal Mudflat model (UTRIM 2.00.4), the most current version of the TRIM model described in Cheng et al. (1993) and Casulli and Cheng (1994), which has been applied to scalar transports within San Francisco Bay during numerous investigations (e.g., Cheng et al. 1993; Gross et al. 1999a, 1999b). UTRIM allows for wetting and drying of cells, and captures the major currents throughout the San Francisco Bay, in the channel and shoals. UTRIM also has subroutines to handle open boundary and surface forcing conditions. The hydrodynamic model will be configured to compute flows in a domain that includes the whole San

Francisco Bay (from Suisun Bay to the South Bay), extending to the Farallone Islands outside of the Bay.

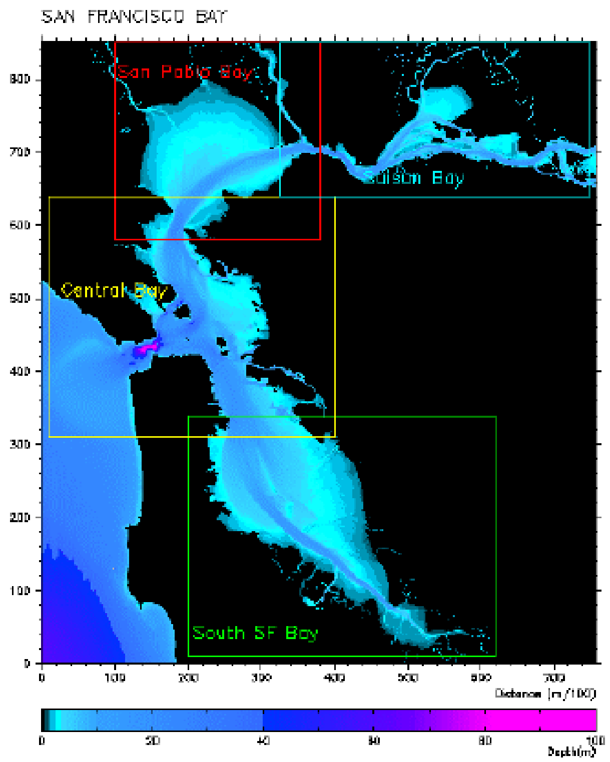


Fig. 10. Spatial domain of the 3D UTRIM model to be applied to San Francisco Bay, from the eastern boundary at the confluence of the Sacramento and San Joaquin Rivers and extending into the adjacent coastal ocean. Bathymetry is indexed as color intensity, showing the deep channels bounded by broad lateral shallows in South, San Pablo and Suisun Bays.

We anticipate using a grid that has ~100 m resolution in the horizontal, although the UTRIM grid is unstructured, allowing higher resolution in regions with complex flow such as Suisun Bay (up to 25 m), and decreasing outside the Bay (~1000 m). Layer thickness in the surface (the layers comprising the shoals) will be approximately 0.5 m, while deeper layers will be coarser, 1 m resolution (10 levels maximum). Bathymetry data have been gridded for the San Francisco Bay (Cheng et al. 1993), and we will begin our study using a relatively fine grid to compute the seasonal climatologically-driven current flows in the San Francisco Bay, comparing hydrodynamics during the dry autumn and wet spring.

Biological-Physical Coupled Model Runs at Coarse Resolution

Once the biological and physical models have been developed and validated separately, we will couple the biological model to the physical model using the UTRIM scalar transport scheme (outlined in Eq. 4). Since our intent is to run the model to examine gradual decadal changes in boundary forcing, it will be necessary to decrease the horizontal (and potentially the vertical) resolution of the physical model in order to conserve computational time. Therefore, we will test several coarse-resolution grids to determine the minimum resolution that preserves the major flow features observed in the fine resolution model. Once the coarse resolution grid is chosen, we will use initialization data from 1980 (“pre-extended bloom signal” time period), including temperature, salinity, zooplankton, nutrient, phytoplankton, and sediment concentrations, and bivalve abundance. The model physics will first be spun up until convergence using the climatological “pre-extended bloom” signal forcing (1980-1995; see “Surface Forcing” below), and then it will be forced with interannually-varying winds, heat flux, and salinity variations for the period from 1995-2005 when Chla has increased in the estuary.

For each set of runs over the 1995-2005 period, we will test the model from weak-to-strong upwelling conditions, strong-to-weak benthic grazing conditions, and low-to-high average light conditions in the water column (separately and together), in order to determine which agent may be responsible for the unprecedented increase in phytoplankton bloom strength and frequency observed over the past decade. These simulations will be compared to the initial "business as usual" interannual model run, where the Chla seeding at the boundary, water transparency, and benthic biomass are kept at climatological levels.

Initial and Boundary Conditions

Initialization data are available from a survey of all biological state variables conducted in 1980 (pre-extended bloom period), and we will use this spatially distributed dataset to prescribe initial winter conditions (Fig. 11 below) for the STELLA 2-box model and the coarse-resolution 3D model. For the STELLA 2-box model, we will also specify time-variable temperature, salinity, surface irradiance, and sediment concentration from semi-monthly spatial surveys along deep channels and parallel shallow water transects.

Initial conditions for the high resolution 3D model simulations (Spring and Autumn) will be climatological (30-year mean) conditions, with the data averaged over all years of the USGS and mooring datasets (temperature, salinity, density, water flow). For the interannual runs, the initial conditions will be climatological conditions for 1980-1995 (again, mean conditions for that whole time period). Biological state variables will be initialized as in the STELLA simulations.

For salinity and temperature, the open boundary will be configured with a layer in which computed flows are relaxed (nudged) to specified climatology (see e.g., Haidvogel and Beckmann 1999). NOAA buoy data are available for meteorology (wind speed, direction, air temperature) and sea surface temperature (http://www.ndbc.noaa.gov/station_history.php?station=46026). To model tides, the tidal variation in the free surface at the open boundary will be specified using harmonic constants from NOAA (http://tidesandcurrents.noaa.gov/). We will use all available data to specify Chla, nutrients, temperature and salinity in the coastal ocean using existing measurements from the surface (satellite), and profiles from cruises and moorings (further south at Monterey Bay) to bootstrap a multi-year (1995-present) daily dataset. Phytoplankton and nutrients at the boundary will also be constrained by in situ data, where available from bi-monthly cruises by the Point Reyes Bird Observatory (B.L Saenz, pers. comm.). We will use the surface SST and upwelling state as a predictor for Chla and nutrients when satellite-based Chla data are not available (some time periods prior to 1997; thereafter when cloud cover or turbidity interferes with recovery). To do this, we will generate a statistical model that predicts Chla and nutrients at the boundary from SST and/or upwelling state, using NOAA's Upwelling Index (http://www.pfeg.noaa.gov/products/PFEL/modeled/indices/upwelling/) at 39 N. In addition, we will use these methods to create a climatological dataset at the boundary for the years 1980-1995.

A variety of satellite data products are available to provide validation of boundary conditions. Sea surface temperature from the AVHRR (1985-2006) and/or MODIS

(2000-present) satellite sensors will be used to help assess the temperature inputs. SeaWiFS (1997-present) and MODIS imagery will be used to initialize the phytoplankton boundary fields. In addition, MODIS sensors provide 250 m resolution turbidity data within the Bay and in the coastal ocean. Satellite SST can be used to determine upwelling strength at the boundary for all years of interest. All imagery will be processed through Level 3, as we have in the past (Cloern et al. 2005), using the SeaDAS software package developed at NASA/GSFC. The imagery will then be mapped to a common projection for ease of comparison. Daily gridded maps will be produced and temporally averaged over appropriate time scales (~3 day averages) to minimize the amount of missing data that inevitably results from cloud or turbidity contamination or satellite/HRPT transmission and collection problems.

Surface Forcing

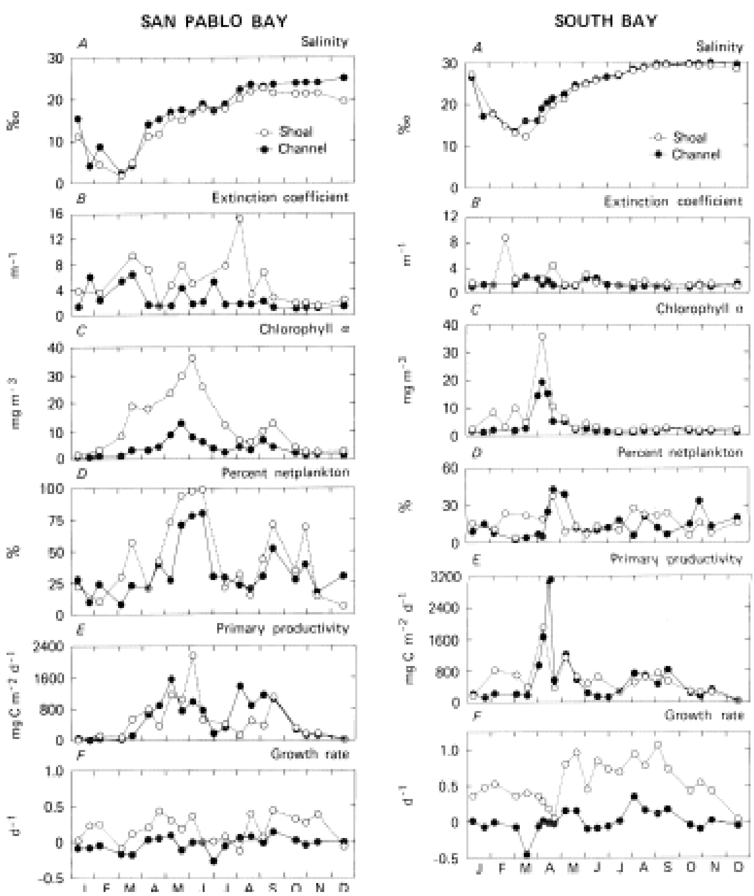
The seasonal surface forcing fields for the high resolution model will be obtained from the daily mean products from the National Centers for Environmental Prediction/National Center for Atmospheric Research Reanalysis Project (Kalnay et al. 1996) for the period 1979-present provided by the NOAA-CIRES Climate Diagnostics Center. The daily average values also will be used to create a long-term (1979-present) daily surface forcing data set that will be used to investigate event-scale processes. In addition to the NCEP climatologies, 10 m wind speed, wind direction, and other atmospheric data will be collected from monitoring stations throughout the Bay, including the San Francisco (SFO) and Oakland (OAK) airports, in order to incorporate diel atmospheric forcing into the model. Long term, multi-decadal data from these monitoring stations will be used to force the biological-physical coupled model. A climatology will be created for the “pre-extended bloom time period”, 1980-1995, and interannual variability in forcing conditions will be imposed starting in 1995. Wind stress will be calculated using standard stability-dependent bulk exchange coefficients (e.g. drag coefficient). The temperature field will be forced by computed air-sea heat fluxes using winds and observed atmospheric temperature fields. Salinities will be controlled by the interplay between tidal entrainment of high salinity waters from the coastal ocean (derived from upwelling and tidal forcing) and freshwater fluxes from runoff to the North Bay and South Bay (derived from USGS stream gage data).

Validation

The fidelity of our results will be assessed through comparison with archival CTD data collected by the USGS, and surface current and other mooring data available from San Francisco State University (http://norcalcurrents.org/COCMP/SFBay.html, http://sfbeams.sfsu.edu/). The validation of modeled phytoplankton, zooplankton, and nutrient concentrations will be done in comparison with the archive of data available from the USGS monthly cruises, including the extensive data set collected in 1980 that includes measurements of zooplankton abundance and biomass.

First, with the STELLA 2-box model, we will conduct sensitivity tests (min, max, mean and order of magnitude changes) in each parameter to determine how sensitive the dynamics of the model state variables (DIN, Chla, zooplankton biomass) are to the parameterizations. We will compare the output of the 2-box model for the year of simulation (mean for 1980-1995) and calibrate the model to fit the USGS monitoring data for that modeled timeframe. As we will initialize the model in winter, the model will be used to simulate the spring bloom, summer, and the following autumn/winter.

For the 3D coupled model, we will conduct model calibration (adjustment of parameters based on sensitivity testing) against the subset of the USGS dataset corresponding to the time period prior to the extended-bloom period (1980-1995), while model validation will be performed by statistically comparing the simulated spatial extent, timing and magnitude of the phytoplankton, DIN, and zooplankton dynamics interannually (1995-present) against each corresponding year from the USGS monitoring data.



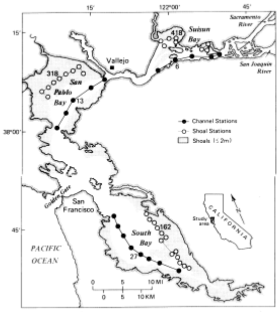


Fig. 11. Series of semi-monthly sampling along transects in the deep channels and lateral shallow domains of San Pablo Bay (left) and South Bay (center) during 1980. Map above shows locations of sampling sites. Series are means along channel and shoal transects of salinity, light extinction coefficient, Chla, percent of Chla in the netplankton fraction, primary productivity, and computed phytoplankton growth rate.

Feasibility

Numerical modeling is an appropriate approach for teasing apart the contributions of individual drivers of biological variability in complex ecosystems. The outputs of numerical models gain credibility as they are grounded in observational data and built from conceptual models that have emerged from long term study. We propose a 3-task research project (Table 2), beginning with construction of a simple pelagic model to describe nutrient-phytoplankton-zooplankton dynamics in linked compartments representing the high-productivity shallow and low-productivity channel domains of San

Francisco Bay. This biological model will be calibrated using NPZ dynamics measured along and across Suisun, San Pablo and South Bay during a complete annual cycle. The 2-box model is computationally fast, so we can carry out quasi-Monte Carlo analyses to determine the sensitivity of the biological model to its parameterizations without running the full 3D version of the model. Given the existence of a STELLA-based NPZ model and ready access to all data required for driving and calibrating the model, this task can be completed within one year.

Table 2. Timeline showing the progression of 3 research tasks over three years and the sharing of costs between USGS and CALFED.

Task	Subtask	Yr 1	Yr 2	Yr 3
		USGS	USGS CALFED	CALFED
1. Project mgt.				
2. NPZ Model	set up model equations			
	test parameterizations			
	gather boundary forcing and initial data			
	couple to coarse-resolution UTRIM 3D model			
3. Fine Resolution	create boundary forcing datasets			
3D Model	initialize and run model			
	validate seasonal runs (Spring & Autumn)			
4. Coarse Resolution	set up coarse resolution grid			
3D Model	check results of fine vs. coarse grids			
	interannual runs 3D bio-phy model			
	test hypotheses; synthesize-publish results			

The second task involves application of an existing fine-resolution 3D hydrodynamic model to San Francisco Bay, and verifying the accuracy of its transport computations with measured distributions of salinity and temperature during the hydrologic extremes of high river discharge variability during spring and stable freshwater inflow during autumn. This task can be completed in year 2 because UTRIM has already been gridded for the bathymetry of San Francisco Bay. Its transport computations have not yet been validated against measured data, and this task will be greatly facilitated by guidance from Dr. Ralph Cheng, a co-creator of the TRIM series of models having long history of application to modeling tidal currents in the Bay system.

The final task will begin with construction of a coarse-resolution version of UTRIM that is computationally efficient but captures the main patterns and rates of transport within San Francisco Bay as forced by oceanic tides, wind, and density gradients driven by surface heating and freshwater inflow. Finally, the equations and parameters of the NPZ model will be added to the coarse resolution model to allow decadal simulations of phytoplankton biomass under prescribed scenarios of change to test the four guiding hypotheses. This task will begin in year 2 and will be completed by the middle of year 3. The final 6 months of the project will be devoted to synthesis/analysis and publication/presentation of results.

This project is ambitious, but we are confident that the timeline outlined in Table 2 can be met. This project will be the fulltime responsibility of Rochelle Labiosa, whose expertise includes research applications of coupled hydrodynamic and pelagic models. Her research will be conducted in close collaboration with a team of oceanographers and engineers (see below) who assisted in the design of this study, bring expertise in critical areas of pelagic-benthic ecology and estuarine hydrodynamics, and have a long history of collaborative work using numerical models to analyze their observational data collected in San Francisco Bay.

Relevance to the CALFED Science Program and 2006 PSP

CALFED's Science Program has been Delta-centric because of critical functions provided in the Delta as habitat for key species and routing of water for delivery to consumers. This proposal is built from a broader geographic perspective that the Delta is one component of a large ecosystem comprising its tributary rivers, their watersheds and airsheds, San Francisco Bay, and the coastal Pacific Ocean. Tides originating in the Pacific propagate into the Delta, driving transport of salt, plankton and other constituents from downstream. Runoff produced in the watersheds transits the Delta and carries fresh water, sediments, nutrients, and contaminants to influence water and habitat quality of San Francisco Bay. Multiple species of fish and invertebrates, such as Delta smelt, sturgeon, salmonids, shad, and Crangon shrimp spend critical stages of their life histories in the Delta, the Bay, and the Pacific Ocean. Sustainability of the estuary's biological diversity is therefore dependent upon connectivity between all these habitats and the functions they provide, necessitating a broad ecosystems perspective.

This proposal addresses scientific questions that emerge from this broad perspective and are relevant to two Priority Research Topics identified in the PSP:

- **Topic 3: Trends and Patterns of Populations and System Response to a Changing Environment**
- **Topic 4: Habitat Availability and Response to Change**

Primary goals are to discover: (1) how changing inputs of sediments and nutrients from the Delta and local watersheds influence phytoplankton dynamics and water quality in San Francisco Bay; and (2) how the transformation of Delta-derived nutrients into phytoplankton biomass is influenced by processes of connectivity between the Bay and coastal ocean. Answers to these questions are essential for assessing the probability that water quality of San Francisco Bay will deteriorate in response to enrichment from watershed-derived nutrients (Topic 3), and the risk level of future habitat degradation (hypoxia, harmful blooms) for key species that use the estuary as a migration route or rearing habitat (Topic 4).

Recent trends of increasing phytoplankton biomass in San Francisco Bay are significant. We cannot forecast future trajectories of these trends, or anticipate the need for remedial actions, without first understanding the underlying causes. This project specifically addresses two informational needs identified in the PSP:

- *To better understand, through use and synthesis of existing information, present and future dynamics of populations of key species … to anticipated environmental changes which may be a function of natural or human caused phenomena*

- *Long-term Delta planning requires a better understanding of the effects of anticipated … and unanticipated changes … on habitats and communities of key species and the potential for remedial action*

This project was also designed to meet three general needs highlighted in the PSP: **Interdisciplinary Projects; Analysis, integration and synthesis of existing information**; and **Models.** The CALFED Science Program PSP reflects a growing concern about the need for tools to understand dynamics of pelagic organisms. This project will create the first 3D numerical model that couples hydrodynamic transport processes with nutrient-plankton-benthos dynamics in the Bay-Delta system. The problem is inherently multidisciplinary, requiring quantitative descriptions of the interactions between small- and large-scale hydrodynamics, multiple processes of pelagic-benthic coupling, sediment inputs as a constraint on phytoplankton growth, and drivers of pelagic dynamics originating in the atmosphere, watersheds, coastal ocean and within the estuary. The models will be grounded in the rich observational data sets collected in San Francisco Bay and Delta, and the simulation experiments are designed to analyze and synthesize existing information to identify mechanisms of phytoplankton increase in the estuary.

This project is proposed as a research project to be jointly funded by the CALFED Science Program and the U.S. Geological Survey, so it meets the cost-sharing objective identified in the PSP. Total project cost over three years is $569,724 of which USGS will contribute $270,302 (details of cost sharing are provided in the online budget forms).

Qualifications

This research project requires knowledge of estuarine pelagic/benthic ecology and hydrodynamics, and expertise in the development and application of coupled hydrodynamic-ecological models to synthesize observational data. Rochelle Labiosa acquired appropriate expertise in physical-biological modeling during her doctoral dissertation research at Stanford University. She brings additional expertise in the analysis of satellite multispectral data required to create boundary conditions of coastal Chla. This project is conceived as a three-year postdoctoral study to be conducted by Dr. Labiosa under the mentorship of James Cloern and in close collaboration with Lisa Lucas, Ralph Cheng, Janet Thompson and Alan Jassby. Dr. Cloern has directed a program of ecosystem science focused in San Francisco Bay and the Delta for three decades, with emphasis on plankton ecology and water quality. Dr. Cheng is the resident expert in the measurement and modeling of tides and currents in San Francisco Bay, and Dr. Thompson is the resident expert on benthic invertebrate ecology, both conducting research in San Francisco Bay for over three decades. Dr. Lucas has applied her expertise in environmental engineering and computational fluid mechanics to solve ecological problems in the Delta and San Francisco Bay with a variety of numerical models. Dr. Jassby has expertise in the application of multivariate statistical techniques and time series analyses to identify patterns in long ecological series and their underlying causes, with nearly two decades of experience working on data sets collected in the Delta and San Francisco Bay.

This team has a proven record of delivering results from studies supported by the CALFED Science Program. In addition to dozens of presentations (including a keynote talk in 2003) at CALFED Science Meetings, State of the Estuary Conferences and IEP

Annual Meetings (including a dedicated session on Delta hydrodynamics in 2006), we have published results in the IEP Newsletter, the CALFED *Science in Action* Series, the San Francisco Estuary Project's *Estuary* newsletter, and the following peer-reviewed scientific journal articles that acknowledge CALFED support:

Jassby, A.D. and J.E. Cloern. 2000. Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). *Aquatic Conservation: Marine and Freshwater Ecosystems* 10: 323-352.

Cloern, J.E., E.A. Canuel, D. Harris. 2002. Stable carbon and nitrogen isotope composition of aquatic and terrestrial plants of the San Francisco Bay estuarine system. *Limnology and Oceanography* 47: 713-729.

Jassby, A.D., J.E. Cloern, B.E. Cole. 2002. Annual primary production: patterns and mechanisms of change in a nutrient-rich tidal ecosystem. *Limnology and Oceanography* 47: 698-712.

Lucas, L.V., J.E. Cloern, J.K. Thompson, N.E. Monsen. 2002. Functional variability of habitats within the Sacramento-San Joaquin Delta: restoration implications. *Ecological Applications* 12: 1528-1547.

Müller-Solger AB, Jassby AD, Müller-Navarra D. 2002. Nutritional quality of food resources for zooplankton (Daphnia) in a tidal freshwater system (Sacramento-San Joaquin River Delta, USA). *Limnology and Oceanography* 47(5):1468-1476.

Sobczak, W.S., Cloern, J.E., Jassby, A.D and Mueller-Solger, A. 2002. Bioavailability of organic matter in a highly disturbed estuary. The role of detrital and algal resources. *Proceedings of the National Academy of Sciences* 99: 8101-8105.

Monsen, N.E., Cloern, J.E., Lucas, L.V., and Monismith, S.G. 2002. A comment on the use of flushing rate, residence time and age as transport time scales. *Limnology and Oceanography* 47: 1545-1553.

Jassby, A.D., J.E. Cloern, A. Mueller-Solger. 2003. Phytoplankton fuels the food web in Delta waterways. *California Agriculture* 57:104-109.

Sobczak, W.V., J.E. Cloern, A.D. Jassby, B.E. Cole, T.S. Schraga, and A. Arnsberg. 2005. Detritus fuels ecosystem metabolism but not metazoan food webs in San Francisco Estuary's freshwater Delta. *Estuaries* 28(1):122-135.

Lopez, C.B., J.E. Cloern, T.S. Schraga, A.J. Little, L.V. Lucas, J.K. Thompson and J.R. Burau. 2006. Ecological values of shallow-water habitats: implications for restoration of a highly disturbed ecosystem. *Ecosystems* 9:422-440.

Cloern, J.E. 2006. Habitat Connectivity and Ecosystem Productivity: Implications from a Simple Model. *The American Naturalist* (in press)

Lucas, L. V., D. M. Sereno, J. R. Burau, T. S. Schraga, C. B. Lopez, M. T. Stacey, K. V. Parchevsky, V. P. Parchevsky. 2006. Intra-daily variability of water quality in a shallow tidal lagoon: mechanisms and implications. *Estuaries and Coasts* (in press).

Literature Cited

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 37:946-955.

Ambler, J.W., Cloern, J.E., and Hutchinson, A., 1985. Seasonal cycles of zooplankton from San Francisco Bay: Hydrobiologia, v. 129, page 177-197.

Arrigo, K.R., D.L. Worthen, and D.H. Robinson. 2003. A coupled ocean-ecosystem model of the Ross Sea. Part 2: Iron regulation of phytoplankton taxonomic variability and primary production. Journal of Geophysical Research 108: C7, 3231, 10.1029/2001JC000856.

Berges, J., and P. Falkowski. 1998. Physiological stress and cell death in marine phytoplankton: Induction of proteases in response to nitrogen or light limitation. Limnology and Oceanography 43: 129-135.

Blumberg, A. F. and G. L. Mellor. 1983. Diagnostic and prognostic numerical circulation studies of the South Atlantic Bight. Journal of Geophysical Research. 88: 4579-4592.

Casulli V., and Cheng R. 1994. "Solutions of Primitive Equation for Three-dimensional Tidal Circulation". Journal of waterway port coastal and ocean engineering, 1994, p. 396-406.

Cheng, R.T., Casulli, V., and Gartner, J.W., 1993. Tidal residual intertidal mudflat (TRIM) model and its applications to San Francisco Bay, California. Estuarine, Coastal and Shelf Science, 36, 235-280.

Casulli, V. and R.A. Walters. 2000. An unstructured grid, three-dimensional model based on the shallow water equations. Inter. J. for Numer. Methods in Fluids 32, 331–348.

Cheng, R. T. and V. Casulli, 2002, Evaluation of the UnTRIM model for 3-D tidal circulation,Proceedings of the 7-th International Conference on Estuarine and Coastal Modeling, St.Petersburg, FL. p. 628-642.

Cloern, J.E., 1982. Does the benthos control phytoplankton biomass in South San Francisco Bay (USA)? Marine Ecology-Progress Series 9:191-202.

Cloern, J.E., Cole, B.E., Wong, R.L.J., and Alpine, A.E., 1985. Temporal dynamics of estuarine phytoplankton: A case study of San Francisco Bay: Hydrobiologia, v. 129, page 153-176.

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

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 34:127-168

Cloern, J.E. 1999. The Relative Importance of Light and Nutrient Limitation of Phytoplankton Growth: A Simple Index of Coastal Ecosystem Sensitivity to Nutrient Enrichment: Aquatic Ecology 33:3-15.

Cloern, J.E. 2001. Our evolving conceptual model of the coastal eutrophication problem. Marine Ecology Progress Series 211:223-253.

Cloern, J.E., R. Dufford. 2005. Phytoplankton community ecology: principles applied in San Francisco Bay. Marine Ecology Progress Series, 285:11-28.

Cloern, J.E., T.S. Schraga, C.B. Lopez, N. Knowles, R.G. Labiosa, and R. Dugdale. 2005. Climate anomalies generate an exceptional dinoflagellate bloom in San Francisco Bay. Geophysical Research Letters 32, LI4608.

Cloern, J.E. 2006. Habitat Connectivity and Ecosystem Productivity: Implications from a Simple Model. The American Naturalist (in press).

Cloern, J.E., A.D. Jassby, T.S. Schraga and K.L. Dallas. 2006. What is causing the phytoplankton increase in San Francisco Bay? 2006 Pulse of the Estuary (available online in September 2006: http://www.sfei.org/rmp/pulse/2006/index.html)

Doney S.C., Glover D.M., Najjar R.G. 1996. A new coupled, one- dimensional biological-physical model for the upper ocean: applications to the JGOFS Bermuda Atlantic Time-series Study (BATS) site. Deep-Sea Res II 43:591–624.

Fasham, M. J.R. 1993. Modelling the marine biota, in The Global Carbon Cycle, M. Heimann (Ed), Berlin: Springer-Verlag 457–504.

Gregg, W., and K. Carder. 1990. A simple spectral solar irradiance model for cloudless maritime atmospheres. Limnology and Oceanography 35:1657-1675.

Grenz, C., J.E. Cloern, S.W. Hager, and B.E. Cole. 2000. Dynamics of nutrient cycling and related benthic nutrient and oxygen fluxes during a spring phytoplankton bloom in South San Francisco Bay (USA). Marine Ecology Progress Series 197:67-80.

Gross, E.S., J.R. Koseff and S.G. Monismith. 1999a. Evaluation of advective transport schemes for simulation of salinity in a shallow estuary," ASCE Journal of Hydraulic Engineering, 125(1):32-46.

Gross, E.S., J.R. Koseff and S.G. Monismith. 1999b. Salinity simulations of San Francisco Bay," ASCE Journal of Hydraulic Engineering, 125(11):1199-1209.

Haidvogel, D. B. and A. Beckmann. 1999. Numerical Ocean Circulation Modeling. Imperial College Press, London, 318 pp.

Hood, R.R., H.V. Wang, J.E. Purcell, E.D. Houde, and L.W. Harding. 1999. Modeling Particles and pelagic organisms in Chesapeake Bay: Convergent features control plankton distributions. Journal of Geophysical Research 104: 1223-1243.

Hood, R.R., K.E. Kohler, J.P. McCreary, and S.L. Smith. 2003. A four-dimensional validation of a coupled physical-biological model of the Arabian Sea. Deep-Sea Research, 2nd Special Issue on the U.S. JGOFS Synthesis and Modeling Project, 50: 2917-2945.

Hood, R.R., V.J. Coles and D.G. Capone. 2004. Modeling the distribution of Trichodesmium and nitrogen fixation in the Atlantic Ocean. Journal of Geophysical Research 10: 10.1029/2002JC001753.

Jassby, A.D., J.E. Cloern, B.E. Cole. 2002. Annual primary production: patterns and mechanisms of change in a nutrient-rich tidal ecosystem. Limnology and Oceanography 47:698-712.

Kalnay, E., M. Kanamitsu, R. Kistler, W Collins, D. Deaven, L. Gandin, M. Iredell, S. Saha, G. White, J. Woollen, Y. Zhu, M. Chelliah, 1996. The NCEP/NCAR 40-year reanalysis project. Bulletin of the American Meteorological Society 77:3, 437-471.

Lucas, L, J.E. Cloern, J.R. Koseff, S.G. Monismith, and J.K. Thompson, 1998, Does the Sverdrup Critical Depth Model explain bloom dynamics in estuaries? Journal of Marine Research, v. 56: 1-41.

Lucas, L.V., Koseff, J.R., Cloern, J.E., Monismith, S.G., and Thompson, J.K., 1999, Processes governing phytoplankton blooms in estuaries—Part I, The local production-loss balance: Marine Ecology Progress Series, v. 187, p. 1-16.

Mallin, M.A. and H.W. Paerl. 1994. Planktonic Trophic Transfer in an Estuary: Seasonal, Diel and Community Structure Effects. Ecology 75(8):2168-2184.

McKee, J.J., N.K. Ganju and D.H. Schoellhamer. 2006. Estimates of suspended sediment entering San Francisco Bay from the Sacramento and San Joaquin Delta, San Francisco Bay, California. Journal of Hydrology 323:335-352.

Murrell, M.C. and J.T. Hollibaugh. 1998. Microzooplankton Grazing in Northern San Francisco Bay by the Dilution Method. Aquatic Microbial Ecology 15:53-63.

Ohlendieck U., Stuhr A., Siegmund H. 2000. Nitrogen fixation by diazotrophic cyanobacteria in the Baltic Sea and transfer of the newly fixed nitrogen to picoplankton organisms. Journal of Marine Systems. 25: 213-219.

Ohman, M.D. and H.J. Hirsche. 2001. Density-dependent mortality in an oceanic copepod population. Nature 412:638-641.

Ota, A.Y., L.E. Schemel and S.W. Hager. 1989. Physical and chemical properties of San Francisco Bay, California, 1980. U.S. Geological Survey Open-File Report 89-421.

Roegner, G.C. and A.L. Shanks. 2001. Import of coastally-derived chlorophyll *a* to South Slough, Oregon. Estuaries 24:244-256.

Schemel, L.E., A.Y Ota, J.G. Harmon, J.M. Shay and R.M. Adorador. Benthic macrofauna and ancillary data for San Francisco Bay, California, January to November 1988. U.S. Geological Survey Open File Report 89-596.

Smith, S.V. and J.T. Hollibaugh. 2006. Water, salt, and nutrient exchanges in San Francisco Bay. Limnology and Oceanography 51:504-517.

Sobczak, W.S., Cloern, J.E., Jassby, A.D and Mueller-Solger, A. 2002. Bioavailability of organic matter in a highly disturbed estuary. The role of detrital and algal resources. Proceedings of the National Academy of Sciences 99: 8101-8105.

Thompson, J. K., 1999. The effect of infaunal bivalve grazing on phytoplankton bloom development in South San Francisco Bay, PhD Thesis, Stanford University, Dept. of Civil and Environmental Engineering, Stanford, CA: 419p.

Thompson, J.K., 2005, One estuary, one invasion, two responses--Phytoplankton and benthic community dynamics determine the effect of an estuarine invasive suspension-feeder, in Dame, R.F., and Olenin, S., eds., The comparative roles of suspension-feeders in ecosystems: the Netherlands, Springer Press, p. 291-316.

Wienke, S.M., and Cloern, J.E., 1987. The phytoplankton component of seston in San Francisco Bay: Netherlands Journal of Sea Research, v. 21, page 25-33.

BIOGRAPHICAL SKETCH - JAMES E. CLOERN

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

2005	Chercheur Associe, Centre National de la Recherche Scientifique, Brest, France
2005	Instructor, Ecole Doctorale, Universite de Bretagne Occidentale, Brest, France
1999-present	Senior Research Scientist (ST3104), U.S. Geological Survey
1976-1999	Research Scientist, U.S. Geological Survey, Menlo Park, CA
1997-1998	Lecturer, University of California-Santa Cruz, Department of Earth Sciences
1997-present	Consulting Professor, Stanford University, Department of Civil Engineering
1993	Distinguished Visiting Scientist, National Institute of Water and Atmospheric Research, Hamilton, New Zealand
1993-1994	Directeur de Recherche, Universite d'Aix-Marseille II, France
1974-1976	Teaching Assistant, Washington State University.
1972-1973	Teaching Assistant, University of Wisconsin-Milwaukee

RESEARCH INTERESTS

Ecology and biogeochemistry of aquatic ecosystems, focused around a long term (29-year) investigation of San Francisco Bay that has included study of: primary production, algal and zooplankton community dynamics, plankton diversity, net ecosystem metabolism, carbon budgets, resource limitation of algal growth, grazing by benthic suspension feeders, disturbance by introduced species, impacts of climatic/hydrologic variability, mechanisms and biogeochemical significance of algal blooms, benthic and pelagic nutrient regeneration, stable isotopes and lipid biomarkers to characterize sources of organic matter, coastal eutrophication, and ecosystem variability at time scales from hours to decades and spatial scales from thin layers to watersheds.

Awards

USGS Star Award for Performance Excellence, 2006
Golden Screen Award, National Association of Government Communicators, for the documentary "Delta Revival: Restoration of a California Ecosystem", 2003
U.S. Department of Interior Distinguished Service Award, 2000
U.S. Federal Senior Scientist ST3104, 1999
USGS Shoemaker Communications Award, 1998
Fulbright Research Scholar, 1993-94 (Centre d'Oceanologie de Marseille)
NATO Collaborative Research Grant Award, 1993
U.S. Department of Interior Meritorious Service Award, 1991

Scientific/Technical Advisory Committees (examples):

Florida Bay Science Oversight Panel, 1996-1998
USGS, Strategic Change Team, Reston, VA 1999
National Science Foundation, Panelist, Cooperative Activities in Environmental Research between the National Science Foundation and the European Commission, 2003

Heinz Center, Reviewer, State of the Nation's Ecosystems, 2002-2003
USEPA STAR Grant Program, Environmental Indicators in the Estuarine Environment, Scientific Advisory Committee, 2004
NOAA, Coastal Ocean Research, Panelist, Ecological Forecasting, 2004
USGS, Tampa Bay Studies Program, Science Advisory Committee, 2004-
USEPA, National Nutrient Criteria Program, Experts Workgroup, 2005-
Network of Excellence EUR-OCEANS (www.eur-oceans.org), proposal evaluator 2005

Scientific Societies:

Editorial Board, *Limnology and Oceanography*, 1989-1992
Associate Editor, *Estuaries*, 1989-1994
Associate Editor, *Oceanologica Acta*, 1999-2004
Estuarine Research Federation, Program Chair, Biennial Meeting, 1991, San Francisco
American Society of Limnology and Oceanography, Steering Committee Aquatic Sciences Meeting, Santa Fe NM 1997
Estuarine Research Federation, Steering Committee, ERF Initiative in Biocomplexity: Estuarine Responses to Climate Change and Variability, 2001
Limnology and Oceanography, Outstanding Reviewer, 2004
American Society of Limnology and Oceanography, Session Organizer, ASLO/TOS Ocean Research Conference, Honolulu, HI 2004
Limnology and Oceanography, Associate Editor, 2004-2005
Estuarine Research Federation, Selection Committee, Odum Lifetime Achievement Award, 2005
8th International Conference on Shellfish Restoration, Scientific Program Committee and Session Chair, Brest, France, 2005
Estuarine Research Federation, 2007 Program Advisory Council

Selected Recent Publications (available at: http://water.usgs.gov/nrp/proj.bib/cloern.html)

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. The design of sampling transects for characterizing water quality in estuaries: Estuarine, Coastal and Shelf Science, v. 45: 285-302.

Caffrey, J.M., C. Grenz, and J.E. Cloern, 1998. Changes in production and respiration during a spring phytoplankton bloom in San Francisco Bay, California: implications for net ecosystem metabolism. Marine Ecology Progress Series 172:1-12.

Cloern, J.E. 1999. The Relative Importance of Light and Nutrient Limitation of Phytoplankton Growth: A Simple Index of Coastal Ecosystem Sensitivity to Nutrient Enrichment: Aquatic Ecology 33: 3-15.

Grenz C., Cloern J.E., Hager S.W., Cole B.E. 2000. Dynamics of nutrient cycling and related benthic nutrient and oxygen fluxes during a spring phytoplankton bloom in South San Francisco Bay (USA). Marine Ecology Progress Series 197: 67-80

Howarth, R., D. Anderson, J. Cloern, C. Hopkinson, B. LaPointe, T. Malone, N. Marcus, K. McGlathery, and A. Sharpley. 2000. Nutrient Pollution of Coastal Rivers, Bays, and Seas. Issues in Ecology 7:1-15.

Cloern, J.E. 2001. Our evolving conceptual model of the coastal eutrophication problem. Marine Ecology Progress Series 211: 223-253.

Cloern, J.E., E.A. Canuel, D. Harris. 2002. Stable carbon and nitrogen isotope composition of aquatic and terrestrial plants of the San Francisco Bay estuarine system. Limnology and Oceanography 47: 713-729.

Jassby, A.D., J.E. Cloern, B.E. Cole. 2002. Annual primary production: patterns and mechanisms of change in a nutrient-rich tidal ecosystem. Limnology and Oceanography 47: 698-712.

Lucas, L.V., J.E. Cloern, J.K. Thompson, N.E. Monsen. 2002. Functional variability of habitats within the Sacramento-San Joaquin Delta: restoration implications . Ecological Applications 12: 1528-1547.

Sobczak, W.S., Cloern, J.E., Jassby, A.D and Mueller-Solger, A. 2002. Bioavailability of organic matter in a highly disturbed estuary. The role of detrital and algal resources. Proceedings of the National Academy of Sciences 99: 8101-8105.

Monsen, N.E., Cloern, J.E., Lucas, L.V., and Monismith, S.G. 2002. A comment on the use of flushing rate, residence time and age as transport time scales. Limnology and Oceanography 47: 1545-1553.

Chauvaud, L., Thompson, J.K., Cloern, J.E. and Thouzeau, G. 2003. Clams as CO_2 generators: The *Potamocorbula amurensis* example in San Francisco Bay. Limnology and Oceanography 48: 2086-2092.

Cloern, J.E., R. Dufford. 2005. Phytoplankton community ecology: principles applied in San Francisco Bay. Marine Ecology Progress Series, 285:11-28.

Cloern, J.E., T.S. Schraga, C.B. Lopez, N. Knowles, R.G. Labiosa, and R. Dugdale. 2005. Climate anomalies generate an exceptional dinoflagellate bloom in San Francisco Bay. Geophysical Research Letters 32, LI4608.

Bachman, R.W., J.E. Cloern, R.E. Hecky and D.W. Schindler (editors). 2006. Eutrophication of Freshwater and Marine Ecosystems. Limnology and Oceanography, Special Issue 51: 351-800.

Lopez, C.B., J.E. Cloern, T.S. Schraga, A.J. Little, L.V. Lucas, J.K. Thompson and J.R. Burau. 2006. Ecological values of shallow-water habitats: implications for restoration of a highly disturbed ecosystem. Ecosystems 9:422-440.

Cloern, J.E. 2006. Habitat Connectivity and Ecosystem Productivity: Implications from a Simple Model. The American Naturalist (in press)

Proposal Number: 0022
Proposal Name: *TROUBLE? Trends of Rising and Unexplained Bloom Levels in the Estuary*

Detailed Budget Breakdown by Task and by Fiscal Year

Applicant Name: James E. Cloern

		Year 1			**Year 2**			**Year 3**		
BUDGET FOR TASK ONE (Administrative)	**TOTAL AMOUNT TASK 1 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
James Cloern	$ -	$ -	40	$ -	$ -	40	$ -	$ -	40	$ -
Rochelle Labiosa	$ 5,920.00	$ -	80	$ -	$ 36.00	80	$ 2,880.00	$ 38.00	80	$ 3,040.00
Lisa Lucas	$ -	$ -	0	$ -	$ -	0	$ -	$ -	0	$ -
Ralph Cheng	$ -	$ -	0	$ -	$ -	0	$ -	$ -	0	$ -
Alan Jassby	$ -	$ -	0	$ -	$ 62.00	0	$ -	$ 65.00	0	$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ 5,920.00**			**$ -**			**$ 2,880.00**			**$ 3,040.00**
[1/] Benefits as percent of salary	29%			$0.00			$820.80			$866.40
Personnel Total (salary + benefits)	**$7,607.20**			**$0.00**			**$3,700.80**			**$3,906.40**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses:	$ -						$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[5/]Overhead Percentage (Applied to Personnel & Other Costs)	54%			$ -			$ 1,979.93			$ 2,089.92
Total Costs for Task One	**$ 11,677.05**			**$ -**			**$ 5,680.73**			**$ 5,996.32**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes.
No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

Proposal Number: 0022
Proposal Name: *TROUBLE? Trends of Rising and Unexplained Bloom Levels in the Estuary*

Detailed Budget Breakdown by Task and by Fiscal Year

Applicant Name: James E. Cloern

		Year 1			Year 2			Year 3		
BUDGET FOR TASK TWO	**TOTAL AMOUNT TASK 2 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
James Cloern	$ -	$ -	40	$ -	$ -	40	$ -	$ -	40	$ -
Rochelle Labiosa	$ 25,200.00	$ -	1000	$ -	$ 36.00	700	$ 25,200.00	$ 38.00		$ -
Lisa Lucas	$ -	$ -	80	$ -	$ -		$ -	$ -		$ -
Ralph Cheng	$ -	$ 72.00	0	$ -	$ 75.00	0	$ -	$ 78.00	0	$ -
Alan Jassby	$ 5,080.00	$ -	0	$ -	$ 62.00	40	$ 2,480.00	$ 65.00	40	$ 2,600.00
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ 30,280.00**			**$ -**			**$ 27,680.00**			**$ 2,600.00**
1/ Benefits as percent of salary	29%			$0.00			$7,888.80			$741.00
Personnel Total (salary + benefits)	**$38,909.80**			**$0.00**			**$35,568.80**			**$3,341.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
5/ Overhead Percentage (Applied to Personnel & Other Costs)	54%			$ -			$ 19,029.31			$ 1,787.44
Total Costs for Task Two	**$ 59,726.54**			**$ -**			**$ 54,598.11**			**$ 5,128.44**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes. No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK THREE	**TOTAL AMOUNT TASK 3 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
James Cloern	$ -	$ -	0	$ -	$ -	0	$ -	$ -	0	$ -
Rochelle Labiosa	$ 25,200.00	$ -	1000	$ -	$ 36.00	700	$ 25,200.00	$ 38.00		$ -
Lisa Lucas	$ -	$ -		$ -	$ -	80	$ -	$ -		$ -

Ralph Cheng	$ 14,520.00	$ 72.00	160	$ 11,520.00	$ 75.00	40	$ 3,000.00	$ 78.00	0	$ -
Alan Jassby	$ -	$ -	0	$ -	$ 62.00	0	$ -	$ 65.00	0	$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ 39,720.00**			**$ 11,520.00**			**$ 28,200.00**			**$ -**
1/ Benefits as percent of salary	29%			$3,283.20			$8,037.00			$0.00
Personnel Total (salary + benefits)	**$51,040.20**			**$14,803.20**			**$36,237.00**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: PC ($3000), JANET software ($2200), FORTRAN compiler ($800), License for UTRIM2004 ($5000)	$ 11,000.00			$ 11,000.00			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ 11,000.00**			**$ 11,000.00**			**$ -**			**$ -**
5/ Overhead Percentage (Applied to Personnel & Other Costs)	54%			$ 13,804.71			$ 19,386.80			$ -
Total Costs for Task Three	**$ 95,231.71**			**$ 39,607.91**			**$ 55,623.80**			**$ -**

1/ Indicate your rate, and change formula in column immediately to the right of this cell

2/ Travel expenses and per diem must be at rates specified by the Department of Personnel Administration. The contractor is required to maintain travel receipts and records for auditing purposes. No travel out of the state of California shall be reimbursed unless prior written authorization is obtained from the State.

3/ Please provide a list and cost of major equipment ($5,000 or more) to be purchased, and complete "Equipment Detail" Worksheet

4/ Please list each subcontractor and amounts (if subcontractor not selected yet, use function like "ditch construction subcontractor")

5/ Indicate rate in column immediately to the right of this cell; and provide a description of what expenses are covered by overhead. If overhead is > 15% must provide justification

		Year 1			Year 2			Year 3		
BUDGET FOR TASK FOUR	**TOTAL AMOUNT TASK 4 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
James Cloern	$ -	$ -	40	$ -	$ -	40	$ -	$ -	40	$ -
Rochelle Labiosa	$ 59,120.00	$ -		$ -	$ 36.00	80	$ 2,880.00	$ 38.00	1480	$ 56,240.00
Lisa Lucas	$ -	$ -		$ -	$ -		$ -	$ -	80	$ -
Ralph Cheng	$ 3,120.00	$ 72.00	0	$ -	$ 75.00	0	$ -	$ 78.00	40	$ 3,120.00
Alan Jassby	$ 5,080.00	$ -	0	$ -	$ 62.00	40	$ 2,480.00	$ 65.00	40	$ 2,600.00
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -
	$ -	$ -		$ -	$ -		$ -	$ -		$ -

Detailed Budget Breakdown by Task and by Fiscal Year

	$ -	$ -		$ -	$ -		$ -	$ -		$ -
Personnel Subtotal	**$ 67,320.00**			**$ -**			**$ 5,360.00**			**$ 61,960.00**
[1/] Benefits as percent of salary	29%			$0.00			$1,527.60			$17,658.60
Personnel Total (salary + benefits)	**$86,506.20**			**$0.00**			**$6,887.60**			**$79,618.60**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
Operating Expenses: (ex: seed, plant materials, irrigation supplies, software, office supplies, etc)	$ -			$ -			$ -			$ -
2/ Travel and Per Diem	$ -			$ -			$ -			$ -
3/ Equipment	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
4/ Sub-Contractor	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
[5/]Overhead Percentage (Applied to Personnel & Other Costs)	54%			$ -			$ 3,684.87			$ 42,595.95
Total Costs for Task Four	**$ 132,787.02**			**$ -**			**$ 10,572.47**			**$ 122,214.55**

Total Project Budget Summary by Task and by Fiscal Year

Note: This budget summary **automatically links** to the costs and totals on the **"Budget Detail"** worksheet. **DO NOT CHANGE FORMULAS OR ENTER NUMBERS INTO ANY CELLS EXCEPT THE SHADED CELLS** for "Cost Share" and "Other Matching Funds"

BUDGET SUMMARY	**Total Amount for Year 1**	**Total Amount for Year 2**	**Total Amount for Year 3**	**Total Amount for All Years**
Total Costs for Task One	$ -	$ 5,680.73	$ 5,996.32	$ 11,677.05
Total Costs for Task Two	$ -	$ 54,598.11	$ 5,128.44	$ 59,726.54
Total Costs for Task Three	$ 39,607.91	$ 55,623.80	$ -	$ 95,231.71
Total Costs for Task Four	$ -	$ 10,572.47	$ 122,214.55	$ 132,787.02
Total Costs for Task Five	$ -	$ -	$ -	$ -
Total Costs for Task Six	$ -	$ -	$ -	$ -
Total Costs for Task Seven	$ -	$ -	$ -	$ -
Total Costs for Task Eight	$ -	$ -	$ -	$ -
Total Costs for Task Nine	$ -	$ -	$ -	$ -
Total Costs for Task Ten	$ -	$ -	$ -	$ -
Total Costs for Task Eleven	$ -	$ -	$ -	$ -
Total Costs for Task Twelve	$ -	$ -	$ -	$ -
Total Costs for Task Thirteen	$ -	$ -	$ -	$ -
Total Costs for Task Fourteen	$ -	$ -	$ -	$ -
Total Costs for Task Fifteen	$ -	$ -	$ -	$ -
Total Costs for Project Tasks	$ 39,607.91	$ 126,475.10	$ 133,339.31	$ 299,422.32
1/Cost Share	$ 160,021.47	$ 50,815.40	$ 59,464.70	$ 270,301.56
2/ Other Matching Funds	$ -	$ -	$ -	$ -

1/ *Cost share funds* are specifically dedicated to your project and can include private and other State and Federal grants. Any funds listed in this line must be further described in the text of your proposal (see Chapter 3, Section D, of the PSP document)

2/ *Other matching funds* include other funds invested consistent with your project in your project area for which the ERP grant applicant is not eligible. Any funds listed in this line must be further described in the text of your proposal (see Chapter 3, Section D, of the PSP document)

Budget Justification
CALFED Proposal # 0022
TROUBLE? Trends of Rising and Unexplained Bloom Levels in the Estuary
Applicant: James E. Cloern

This proposal describes a study to build and apply models to identify the underlying causes of recent trends of phytoplankton increase in San Francisco Bay, and to anticipate future changes in algal biomass and production.

The project is conceived as a three-year study to be conducted by Rochelle Labiosa as a postdoctoral associate at USGS, under the mentorship of James Cloern and in collaboration with Ralph Cheng (USGS retired), Janet Thompson (USGS), Lisa Lucas (USGS), and Alan Jassby (UC Davis). The funding request of this proposal is $299,422. The total estimated cost of the study is $569,724 of which $270,302 will be contributed by USGS as labor costs and overhead for the contributions of Cloern, Thompson, Lucas, and 18 months salary for Labiosa.

The bulk of the request to CALFED will pay for an additional 18 months of Rochelle Labiosa's time. A small ($11,000 net) request is made to purchase a fast PC dedicated to the project, software (FORTRAN compiler and JANET software for grid construction of the UNTRIM model), and license for the 2004 version of UNTRIM ($5000). Additional requests are included for four weeks labor of Alan Jassby ($10,160), and six weeks labor of Ralph Cheng ($17,640) who will collaborate on this project after retirement from USGS. Dr. Cheng was a developer of UNTRIM, and he will mentor Rochelle Labiosa in application of the model to San Francisco Bay, validation of computed currents and salinity, incorporation of biological processes into the scalar transport routines, and in synthesizing/publishing results. Dr. Jassby will provide guidance in the design of simulation experiments and interpretation/publication of their results.

The scientific problem under consideration here is complex and beyond the scope of a standard 1- or 2-year postdoctoral research project. The project comprises a series of labor intensive tasks dedicated to data compilation, experimental design, model construction and validation, processing of remote sensing data, creative analyses of simulation results, and presentation of results for decision makers and environmental scientists. We are requesting support from CALFED to support half of this study such that each of these tasks can be completed with the rigor required to produce reliable models and useful simulations for understanding the changing San Francisco Bay ecosystem and its potential future trajectories.

USGS Cost Share   Proposal Number: 0022   Applicant: James E. Cloern

BUDGET FOR TASK ONE	TOTAL AMOUNT TASK 1 All Years	Year 1 Amount per hour	Year 1 Number of Hours	Year 1 Total Amount for Year 1	Year 2 Amount per hour	Year 2 Number of Hours	Year 2 Total Amount for Year 2	Year 3 Amount per hour	Year 3 Number of Hours	Year 3 Total Amount for Year 3
Personnel										
James Cloern	$ 8,856.40	$ 71.63	40	$ 2,865.20	$ 73.78	40	$ 2,951.20	$ 76.00	40	$ 3,040.00
Rochelle Labiosa	$ 2,741.60	$ 34.27	80	$ 2,741.60	$ 36.00	0	$ -	$ 38.00	0	$ -
Personnel Subtotal	**$ 11,598.00**			**$ 5,606.80**			**$ 2,951.20**			**$ 3,040.00**
[1/] Benefits as percent of salary	29%			$1,625.97			$855.85			$881.60
Personnel Total (salary + benefits)	**$14,961.42**			**$7,232.77**			**$3,807.05**			**$3,921.60**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
Overhead Percentage	54%			$ 3,869.53			$ 2,036.77			$ 2,098.06
Other Costs Total (subtotal + overhead)	**$ 8,004.36**			**$ 3,869.53**			**$ 2,036.77**			**$ 2,098.06**
Total Costs for Task One	**$ 22,965.78**			**$ 11,102.31**			**$ 5,843.82**			**$ 6,019.66**

BUDGET FOR TASK TWO	TOTAL AMOUNT TASK 2 All Years	Year 1 Amount per hour	Year 1 Number of Hours	Year 1 Total Amount for Year 1	Year 2 Amount per hour	Year 2 Number of Hours	Year 2 Total Amount for Year 2	Year 3 Amount per hour	Year 3 Number of Hours	Year 3 Total Amount for Year 3
Personnel										
James Cloern	$ 2,865.20	$ 71.63	40	$ 2,865.20	$ 73.78	0	$ -	$ 76.00	0	$ -
Rochelle Labiosa	$ 52,990.00	$ 34.27	1000	$ 34,270.00	$ 36.00	520	$ 18,720.00	$ 38.00	0	$ -
Lisa Lucas	$ 3,800.80	$ 47.51	80	$ 3,800.80	$ 49.89	0	$ -	$ 52.38	0	$ -
Janet Thompson	$ 3,800.80	$ 47.51	80	$ 3,800.80	$ 49.89	0	$ -	$ 52.38	0	$ -
Personnel Subtotal	**$ 59,656.00**			**$ 40,936.00**			**$ 18,720.00**			**$ -**
[1/] Benefits as percent of salary	29%			$11,871.44			$5,428.80			$0.00
Personnel Total (salary + benefits)	**$76,956.24**			**$52,807.44**			**$24,148.80**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
Overhead Percentage	54%			$ 28,251.98			$ 12,919.61			$ -
Other Costs Total (subtotal + overhead)	**$ 41,171.59**			**$ 28,251.98**			**$ 12,919.61**			**$ -**
Total Costs for Task Two	**$ 118,127.83**			**$ 81,059.42**			**$ 37,068.41**			**$ -**

		Year 1			Year 2			Year 3		
BUDGET FOR TASK THREE	**TOTAL AMOUNT TASK 3 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
Rochelle Labiosa	$ 34,270.00	$ 34.27	1000	$ 34,270.00	$ 36.00	0	$ -	$ 38.00	0	$ -
Lisa Lucas	$ 3,991.20	$ 47.51	0	$ -	$ 49.89	80	$ 3,991.20	$ 52.38	0	$ -
Personnel Subtotal	**$ 38,261.20**			**$ 34,270.00**			**$ 3,991.20**			**$ -**
[1/] Benefits as percent of salary	29%			$9,938.30			$1,157.45			$0.00
Personnel Total (salary + benefits)	**$49,356.95**			**$44,208.30**			**$5,148.65**			**$0.00**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
Overhead Percentage	54%			$ 23,651.44			$ 2,754.53			$ -
Other Costs Total (subtotal + overhead)	**$ 26,405.97**			**$ 23,651.44**			**$ 2,754.53**			**$ -**
Total Costs for Task Three	**$ 75,762.92**			**$ 67,859.74**			**$ 7,903.17**			**$ -**
		Year 1			**Year 2**			**Year 3**		
BUDGET FOR TASK FOUR	**TOTAL AMOUNT TASK 4 All Years**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 1**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 2**	**Amount per hour**	**Number of Hours**	**Total Amount for Year 3**
Personnel										
James Cloern	$ 3,040.00	$ 71.63	0	$ -	$ 73.78	0	$ -	$ 76.00	40	$ 3,040.00
Rochelle Labiosa	$ 19,760.00	$ 34.27	0	$ -	$ 36.00	0	$ -	$ 38.00	520	$ 19,760.00
Lisa Lucas	$ 4,190.40	$ 47.51	0	$ -	$ 49.89	0	$ -	$ 52.38	80	$ 4,190.40
Janet Thompson	$ 4,190.40	$ 47.51	0	$ -	$ 49.89	0		$ 52.38	80	$ 4,190.40
Personnel Subtotal	**$ 26,990.40**			**$ -**			**$ -**			**$ 26,990.40**
[1/] Benefits as percent of salary	29%			$0.00			$0.00			$7,827.22
Personnel Total (salary + benefits)	**$34,817.62**			**$0.00**			**$0.00**			**$34,817.62**
Other Costs	**Total All Years**			**Total Year 1**			**Total Year 2**			**Total Year 3**
	$ -			$ -			$ -			$ -
Other Costs Subtotal	**$ -**			**$ -**			**$ -**			**$ -**
Overhead Percentage	54%			$ -			$ -			$ 18,627.42
Other Costs Total (subtotal + overhead)	**$ 18,627.42**			**$ -**			**$ -**			**$ 18,627.42**
Total Costs for Task Four	**$ 53,445.04**			**$ -**			**$ -**			**$ 53,445.04**
total costs for all tasks	$ 270,301.56			$ 160,021.47			$ 50,815.40			$ 59,464.70

Signature

The applicant for this proposal must submit this form by printing it, signing below, and faxing it to +1 877-408-9310. Send exactly one form per transmission.

Failure to sign and submit this form will result in the application not being considered for funding. The individual submitting this proposal will receive e-mail confirmation as soon as this signature page has been processed.

The individual signing below declares that:

- all representations in this proposal are truthful;
- the individual signing the form is authorized to submit the application on behalf of the applicant (if applicant is an entity or organization);
- the applicant has read and understood the conflict of interest and confidentiality discussion under the Confidentiality and Conflict of Interest Section in the main body of the PSP and waives any and all rights to privacy and confidentiality of the proposal on behalf of the applicant, to the extent provided in this PSP; and
- the applicant has read and understood all attachments of this PSP.

Proposal Title:	TRoUBLE? Trends of Rising and Unexpected Bloom Levels in the Estuary
Proposal Number:	2006.01-0022
Applicant Organization:	United States Geological Survey
Applicant Contact:	Dr. James Cloern

Applicant Signature Jim C Cl **Date** 8-16-06