



**CALFED Progress Report**  
**California Sea Grant College Program**

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 TypeQuestionnaire\_2B Interim Report

**Preparer Information**

PrepName\_1A Monika Winder  
 PrepEmail\_1B mwinder@ucdavis.edu  
 PrepPhone\_1C 530 754 9354

**Project Information**

ProjectNo\_2C R/SF-36 StartDate\_3a 10/1/2008 EndDate\_3b 8/31/2011  
 ProjectTitle\_4 Plankton Dynamics in the Sacramento-San Joaquin Delta: Long-term Trends and Trophic Interactions

**CALFed Fellow contact information**

FelTitle\_5A Dr. FelLast\_5B Winder FelFirst\_5C Monika FelInit\_5D \_\_\_\_\_  
 FelInstitution\_5E University of California, Davis  
 FelDepartment\_5F John Muir Institute of the Environment  
 FelStreetAddr\_5G One Shields Ave.  
 FelCity\_5H Davis FelState\_5I CA FelZip\_5J 95616  
 FelPhone\_5K 530 754 9354 FelFax\_5L 530 754 9364  
 FelEmail\_5M mwinder@ucdavis.edu  
 FelPositionTitle\_5N Postdoc

**Research Mentor (for additional please see #8)**

RMTitle\_6A Dr. RMLastName\_6B Schladow RMFirstName\_6C Geoff RMInit\_6D \_\_\_\_\_  
 RMIInstitution\_6E University of California, Davis  
 RMDepartment\_6F Tahoe Environmental Research Center  
 RMStreetAddr\_6G One Shields Ave.  
 RMCity\_6H Davis RMState\_6I CA RMZip\_6J 95616  
 RMPhone\_6K (530) 752 3942 RMFax\_6L \_\_\_\_\_  
 RMEmail\_6M gschladow@ucdavis.edu  
 RMPositionTitle\_6N Professor

**Community Mentor (for additional please see #9)**

CMTitle\_7A Dr. CMLastName\_7B Jassby CMFirstName\_7C Allen CMInit\_7D D  
 CMInstitution\_7E University of California, Davis  
 CMDepartment\_7F Department of Environmental Science and Policy  
 CMStreetAddr\_7G One Shields Ave.  
 CMCity\_7H Davis CMState\_7I CA CMZip\_7J 95616  
 CMPPhone\_7K \_\_\_\_\_ CMFax\_7L \_\_\_\_\_  
 CMEmail\_7M adjassby@ucdavis.edu  
 CMPositionTitle\_7N Research Ecologist

**Additional Research Mentors and Community Mentors**

**Additional Research Mentors\_8**

Dr. James Cloern  
USGS  
Menlo Park, CA  
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**Additional Community Mentors\_9**

Dr. Wim Kimmerer  
Romberg Tiburon Center  
Dr. Anke Mueller-Solger  
CALFED  
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**Project Objectives: Please type your responses, and answer the questions in a style appropriate for laymen.**

**ProjectObjectives\_10**

Primary consumers (zooplankton) are a critical trophic link for energy transfer to upper trophic levels and a key food source for threatened and endangered fish species in the Delta. Yet long-term trends and patterns for zooplankton and mechanisms that regulate their abundances remain largely unstudied despite the fact that the importance of food availability for fish has been recognized as one potential major component for the observed fish declines and a taxonomically-rich historical plankton data set exists. The proposed research aimed to identify spatial and temporal plankton variability and biotic interactions by quantitatively analyzing the long-term database from the Delta, which has a 33-year record related to the planktonic food web along with complementary environmental data.

The proposed project addresses the following objectives:

- (1) Identification of long-term spatial and temporal patterns in zooplankton
- (2) Identifying long-term interactions between primary producers and zooplankton
- (3) Identification of biotic interactions in the plankton community

We proposed that through integrating plankton variability into the management and restoration plan for the Delta, the dynamics of the ecosystem can be viewed from a new perspective.

**Summary of progress in meeting each of these goals and objectives**

**ProgressSummary\_11**

Objective 1: Identification of long-term spatial and temporal patterns in zooplankton  
Results of this project were published in a paper in *Estuaries and Coasts* (see below)

Objective 2: Identifying long-term interactions between primary producers and zooplankton  
During the work process of Objective 1 it became clear that most of species interactions in the SF Delta are strongly driven by species invasions. Therefore I changed the focus of this task and investigated in more detail the timing and environmental conditions that facilitated establishment of invasive species. This study was published in *Ecology Letters* (see below).

Objective 3: Identification of biotic interactions in the plankton community  
The focus of this objective was changed because the long-term phytoplankton data set revealed limitation of its usage at the species level because the precision of the species values is overall low and small sized cells have not been counted. However, we will investigate biotic interactions in more details using biochemical markers. This study provided some preliminary results, which we will follow up in another project funded by the Delta Science Program.

In addition, I completed other projects while receiving the Sea Grant stipend:

- Integration of the long-term chlorophyll SF Delta dataset with a global dataset on chlorophyll time series to extract phenologies of phytoplankton biomass. See paper in *Proc. Roy. Soc. B*.

- Collaborative NCEAS work that investigated large-scale climate oscillations with an abrupt shift at several trophic levels in the SF Bay. See paper in *Geophysical Research Letters*.

- A comment on the use of CUSUM-transformed variables to investigate environmental effects on species dynamics. See paper in *Limnology and Oceanography*.

**PROJECT MODIFICATIONS:** Please explain any substantial modifications in research plans, including new directions pursued. Describe major problems encountered, especially problems with experimental protocols and how they were resolved. Describe any ancillary research topics developed.

**Modifications\_12**

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**BENEFITS AND APPLICATIONS:** Suggest the relevance of these new findings to management. Describe any accomplishment, that is significant effects your project has had on resource management or user group behavior. CALFED is looking for "management cue" (see <http://science.calwater.ca.gov/pdf/soemgmtcues.pdf>).

**BenefitsApplic\_13**

To our knowledge this is the first project that describes long-term zooplankton trajectories in terms of carbon available for higher trophic levels. Consequently, these findings will be of importance to understand to what extent change in food supply for fish affected the long-term and more recent declines of many pelagic fish species.

While the long-term decline of diverse fisheries in the Delta coincided with reduced primary and secondary production, our analysis showed that the sudden drop of many pelagic fishes around 2000 was not accompanied by an equivalent decrease in quantity of zooplankton carbon. Substantial zooplankton and mysids declines occurred in the mid to late 1980s, and biomass of both taxonomic groups remained at a consistent low level from 1995–2001 to 2002–2008. This suggests that changing prey quantity was not a dominant factor contributing to the recent fish declines. However, it is expected that a combined effect of low food supply and changing prey conditions, resulting from zooplankton taxonomic shifts enhanced food limitations for higher trophic levels.

Another study highlights that freshwater inflow to the Delta affect species interactions in a way that facilitated the establishment of invasive species. This study documented that hydrological modifications exacerbated the effects of droughts that modified biotic interaction and increased benthic grazing pressure.

**PUBLICATIONS:** List any publications, presentations, or posters that have resulted from this funded research. Give as many details as possible, including status of paper (e.g., in review; in press), journal name, conference location and date of presentation. Please note (as outlined in the conditions of the award) that each fellow is required to submit an abstract for an oral or poster presentation at each State of the Estuary conference and CALFED Science Conference during the duration of the fellowship.

**Publications\_14**

Presentations at scientific meetings:

Winder M. Synergies between climate anomalies and hydrological modifications facilitate estuarine biotic invasions: European Geosciences Union (EGU), Vienna, Austria 2011.

Winder M. Climate extremes promote the proliferation of invasive species. Life in warming waters: Aquashift Conference, Kiel, Germany 2010.

Winder M. Shifts in zooplankton community structure: implications for food-web processes in the San Francisco Estuary. Bay-Delta Science Conference, Sacramento 2010.

Winder M. Shifts in zooplankton community structure: implications for food-web processes in the San Francisco Estuary. Climate change impacts on estuarine and coastal ecosystems: a zooplankton perspective. Boulogne sur Mer, France, June 2010.

Winder M, Jassby AD. Shifts in zooplankton community structure: implications for food-web processes in the San Francisco Estuary. ASLO, Santa Fe, USA, June 2010.

Publications

Winder M, Jassby AD, R Mac Nally (2011) Synergies between climate anomalies and hydrological modifications facilitate biotic invasions. Ecology Letters.

Cloern J, Jassby AD, Carstensen J, Bennet WA, Kimmer W, Mac Nally R, Schoellhamer DH, Winder M (in print) Perils of correlating CUSUM-transformed variables to infer ecological relationships (Breton et al. 2006, Glibert 2010). Limnology and Oceanography.

Cloern JE, DiLorenzo M, Hieb K, Largier J, Jacobson T, Jassby AD, Meiring W, Peterson B, Powell Z, Sanso B, Stacey M, Winder M (2011) Biological communities in San Francisco Bay track North Pacific Climate patterns. Geophysical Research Letters.

Winder M, Jassby AD (2011) Shifts in zooplankton community structure: Implications for food-web processes in the upper San Francisco Estuary. Estuaries and Coasts. 34: 675-690. Recommended by Faculty of 1000 Biology

Winder M, Cloern JE (2010) The annual cycles of phytoplankton biomass. Philosophical Transactions of the Royal Society B. 365: 3215-3226. Recommended by Faculty of 1000 Biology

**COOPERATING ORGANIZATIONS:** List those agencies and/or persons who provided financial, technical or other assistance to your project since inception. Describe the nature of their collaboration.

**CoopOrganiz\_15**

State Water Contractors: provided 3-month bridge funding

**AWARDS:** List any special awards or honors that you, or mentor or members of the research team, have received during the duration of this project.

**Awards\_16**

**KEYWORDS:** List keywords that will be useful in indexing your project.

**Keywords\_17**

Zooplankton; Estuaries; Long-term ecological research; Invasion; Trophic interactions; Sacramento-San Joaquin River Delta; San Francisco Estuary

**PATENTS:** List any patents associated with your project.

**Patents\_18**

Additions: Additional information can be added here. Please begin the text with the number of the question you are adding to.

Additions\_19

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