



**Project Objectives: Please type your responses, and answer the questions in a style appropriate for laymen.**

**ProjectObjectives\_10**

The two primary objectives for this multi-year project were to determine:

1) whether and how nutrients affect competitive interactions between native and invasive invertebrate species (snails) in benthic marine habitats; and 2) what effects invasive species (snails) have on benthic communities at the onset of their invasion and after they become established.

The impetus for the project was to consider more broadly both how a basal resource (nutrients) could affect higher trophic levels, and to assess how one pollution source (nutrients) might interact with another (invasive species as biological pollution). The project was focused on assessing the threshold where nutrients went from resource to pollutant. The 3 focal species were: 1) an invasive snail species that has been in San Francisco Bay for many decades (*Ilyanassa obsoleta*), 2) an invasive snail that has arrived within the last decade (*Batillaria attramentaria*)-and one endemic, the only native mud snail in San Francisco Bay (*Cerithidea californica*).

The main hypotheses were that: 1) enhanced nutrient input would alter the composition of benthic microalgae, which would in turn affect competitive dynamics between the grazing snail species *Ilyanassa* and *Cerithidea*; and 2) the *Batillaria* population would affect the habitat it was invading.

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

**ProgressSummary\_11**

During the report period (spring 2010-spring 2011), the nutrient experiments had already been completed and samples and data were being analyzed. We used the 2010 field season to collect critical data on the rapidly expanding *Batillaria* populations in San Francisco Bay and Bodega Harbor, and we conducted habitat samples to assess the snails initial impacts on sediment characteristics, such as carbon: nitrogen ratios, organic matter and benthic chlorophyll a.

**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**

No major modifications were made during this period. We did apply for and secure an additional grant to focus on *Batillaria* eradication in Bodega Harbor. As project lead, I oversaw this fieldwork but it was conducted mostly by a technician as I was focused on analyzing the data from our field experiments.

We also pursued two new directions during the last reporting period:

- 1) behavior responses to sediment characteristics (do snails respond differently to different sediment types with different microalgal communities?), and
- 2) is crab predation pressure different for the two main species (*Ilyanassa* and *Cerithidea*)?

We carried out these two studies in order to broaden the scope of our work and help us understand the natural history of these two snail species in San Francisco Bay.

**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**

There are two important applied results that have come out of our research to date. First, nutrients do appear to affect both grazer growth and mortality, and the effect is enhanced in certain habitats. Interestingly, the 2003 Management Cues document, to which we have been referred for considering the applied aspects of our research, does not mention nutrients in San Francisco Bay. Traditionally, SF Bay has been considered to be light-, not nutrient-limited (Cloern 2001). However, our results which are focused on the benthic intertidal mudflats and salt marshes suggest that in fact thresholds have not been achieved, and therefore Bay species may be susceptible to nutrient enrichment. Thus, reducing nutrient enrichment is an important management objective that should be considered along with other forms of pollution in the Bay.

The second major result with management implications is that the new invasive species, *Batillaria attramentaria*, may facilitate its own invasion by rapidly achieving extremely high densities and altering the habitat to increase the standing biomass of benthic microalgae. While our study was not designed to explicitly test this hypothesis or to determine the mechanism, the pattern is there in our results, and should be noted. If this species achieves a certain density threshold in the North Bay (the only place where it currently exists), it could trigger a positive feedback loop that would make it even more difficult to control or eradicate.

**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**

Nutrient loading & benthic native-invasive species dynamics. Weiskel, H. W., C. N. Janousek, and E. D. Grosholz. Sixth Biennial Bay-Delta Science Conference. Sacramento, CA 27-29 September 2010.

Seventy-sixth Annual American Malacological Society/Western Society of Malacologists Meeting

27 June 2010: Demographics and eradication of two new invasive populations of *Batillaria attramentaria* in California.

**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**

- 1) San Francisco State University Romberg Tiburon Center staff and faculty (Director, Dr. Toby Garfield).
- 2) UC Davis professors (in particular Dr. Peter Green, as he allowed us the use of his High Performance Liquid Chromotography instrument for more than a year, and Susan Williams, who allowed use of her spectrophotometer).
- 3) US Geological Survey office in Menlo Park (in particular, Drs. Jan Thompson, Jim Cloern and Carol Kendall have been very helpful).
- 4) CA Department of Fish & Game.
- 5) City of San Leandro Public Works Office.

**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**

We did not receive any other funding for this project specifically during this reporting period. We did apply for and receive a rapid response CA Sea Grant award (\$9,991) to investigate eradication prospects for *Batillaria attramentaria*. My mentor (Dr. Grosholz) was the lead PI for that grant.

Dr. Grosholz also received two unrelated research grants during this reporting period:

- 1) California Ocean Science Trust. "Invaders for Sale: A Vector Analysis of Commercial Aquaculture and the Aquarium and Aquascape Trades." \$201,178.

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

**Keywords\_17**

Founder population, resource ecology, native-invasive dynamics, nutrients, diatoms, cyanobacteria, *Ilyanassa obsoleta*, *Batillaria attramentaria*, *Cerithidea californica*, mudflat, marsh, stable isotopes, HPLC, positive feedback.

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

**Patents\_18**

None to date.

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

**Additions\_19**

Question 13: Reference:

Cloern, J. E. 2001. Our evolving conceptual model of the coastal eutrophication problem. Marine Ecology Progress Series 210: 223-253.

Question 16: Awards: