CALFED Progress Report
California Sea Grant College Program

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TypeQuestionnaire_2B Final Questionnaire

Preparer Information

PrepName_1A Gretchen Rollwagen Bollens
PrepEmail_1B rollboll@vancouver.wsu.edu
PrepPhone_1C 360-546-9115

Project Information

ProjectNo_2C R/SF-5 **StartDate_3a** Aug1, 03 **EndDate_3b** July 31, 06
ProjectTitle_4 Protistan Microzooplankton in the Suisun Bay Food Web: Source or Sink?

CALFed Fellow contact information

FelTitle_5A Dr. **FelLast_5B** Rollwagen Bollens **FelFirst_5C** Gretchen **FelInit_5D**
FelInstitution_5E Washington State University Vancouver
FelDepartment_5F School of Biological Sciences
FelStreetAddr_5G 14204 NE Salmon Creek Ave
FelCity_5H Vancouver **FelState_5I** WA **FelZip_5J** 98686
FelPhone_5K 360-546-9115 **FelFax_5L** 360-546-9064
FelEmail_5M rollboll@vancouver.wsu.edu
FelPositionTitle_5N Assistant Research Professor

Research Mentor (for additional please see #8)

RMTitle_6A Dr **RMLastName_6B** Bollens **RMFirstName_6C** Stephen **RMInit_6D** M
RMInstitution_6E Washington State University Vancouver
RMDepartment_6F School of Biological Sciences
RMStreetAddr_6G 14204 NE Salmon Creek Ave
RMCity_6H Vancouver **RMState_6I** WA **RMZip_6J** 98686
RMPhone_6K 360-546-9116 **RMFax_6L** 360-546-9064
RMEmail_6M bollens@vancouver.wsu.edu
RMPositionTitle_6N Professor and Director, Science Programs

Community Mentor (for additional please see #9)

CMTitle_7A Dr **CMLastName_7B** Mueller-Solger **CMFirstName_7C** Anke **CMInit_7D**
CMInstitution_7E Department of Water Resources
CMDepartment_7F Division of Environmental Services
CMStreetAddr_7G 3251 S. St. Rm C-25
CMCity_7H Sacramento **CMState_7I** CA **CMZip_7J** 95816-7017
CMPhone_7K 916-227-2194 **CMFax_7L**
CMEmail_7M amueller@water.ca.gov
CMPositionTitle_7N Staff Environmental Scientist

Additional Research Mentors and Community Mentors

Additional Research Mentors_8

Additional Community Mentors_9

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

ProjectObjectives_10

Our primary goal in this project was to quantify the role of protistan microzooplankton in the planktonic food web in the upper saline reaches of the SFE-D and to provide insights into the structure, function and limits on productivity of the lower planktonic food web. We addressed this goal by examining the abundance and taxonomic composition of the protistan plankton at two contrasting sites, the Suisun Bay channel and the Grizzly Bay shoals, on an approximately monthly basis over 2004 and 2005. In addition to monitoring the protist community, we also experimentally assessed the trophic role of microzooplankton in the Suisun Bay channel over the same time period.

Summary of progress in meeting each of these goals and objectives

ProgressSummary_11

Consumption of microzooplankton by metazoan predators may serve to trophically complement phytoplankton biomass. In the laboratory, when mesozooplankton are fed low quality algae they are at times unable to grow well unless heterotrophic protists are a trophic intermediate (Klein Breteler et al. 1999). For instance, egg production rates and hatching success are often higher when *Acartia* sp. are fed dinoflagellates rather than some algae (Tang and Taal 2005). Phytoplankton in the SFE-D may often be of high quality, however phytoplankton is very low in abundance throughout most of the year except during brief spring blooms (Cloern 1996). Thus consuming microzooplankton may serve to augment a diet of algae, resulting in microzooplankton acting as a "source" of production to the planktonic food web. Indeed, recent results from the Delta indicate that detritus, despite being the dominant form of organic matter in the freshwater-tidal regions of the SFE-D, is not a significant energy source to the metazoan food web (Sobczak et al. 2005), thus reinforcing the need to complement phytoplankton production in order to support the lower pelagic food web.

Conversely, the addition of a trophic step between phytoplankton and mesozooplankton can mean lower trophic efficiency of the food web, which could result in microzooplankton serving as a "sink" for production in the food web. However, experimental and field evidence demonstrates that many heterotrophic planktonic protists, particularly small oligotrich ciliates such as we found in Suisun Bay (e.g. *Strombidium*, *Strombilidium*), effectively and consistently consume bacterioplankton (Artolozaga et al. 2002, Sherr et al. 1989). Therefore, microzooplankton could be re-packaging and contributing bacterial carbon into the classic metazoan food web, which could counterbalance losses from reduced trophic efficiency.

In summary, our results, in combination with those of Gifford et al. (2007), suggest that microzooplankton are providing an additional prey resource to copepods and cladocerans in Suisun Bay, especially when algal biomass is low, and microzooplankton are consuming a substantial amount of phytoplankton production. Thus microzooplankton likely act as a source to higher trophic levels in the pelagic food web. Moreover, it is clear that there are strong trophic links between phytoplankton, microzooplankton, and mesozooplankton in Suisun Bay, and that these links need to be taken into account when quantifying the pathways for materials and energy that support higher trophic levels, including at-risk fish species such as

Delta smelt

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

Notably, the microplankton community during the November 2004 dilution experiment was dominated by the mixotrophic ciliate *Myrionecta rubra*, and the abundance of other heterotrophic ciliates and dinoflagellates was extremely low. Possibly the dilution process removed these large, chlorophyll-rich ciliates such that the most dilute treatments no longer had the contribution of *M. rubra* to overall phytoplankton apparent growth, leading to higher apparent growth in the undiluted treatment during November 2004.

Overall, these dilution experiment results demonstrate microzooplankton in Suisan Bay to have a significant role in consuming algal production during periods of both high and low chlorophyll concentration. And a substantial proportion of phytoplankton carbon may be moving through the microzooplankton community, as evidenced by grazing impacts as high 55% of phytoplankton standing stock per day.

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

Nevertheless, the three valid experiments conducted in Suisun Bay by Murrell and Hollibaugh (1998) each resulted in microzooplankton grazing rates that exceeded phytoplankton growth rates, and the grazing rates measured in May 1994 (Table 2 in Murrell and Hollibaugh 1998) were very similar to our results in April 2005. Particularly in the context of recent caveats described above on how protist trophic diversity may influence dilution experiment results, we have a somewhat different interpretation of the results in Murrell and Hollibaugh (1998). Namely, we believe they complement our own experiments and serve to reinforce the argument that microzooplankton grazing is important in Suisun Bay.

The trophic importance of microzooplankton in Suisun Bay is further supported by the experimental observation that heterotrophic protists were the dominant component of mesozooplankton predator diets in Suisun Bay in 2004-2005, regardless of season, predator species or size (Gifford et al. 2007). Clearance and ingestion rates of copepods (*Acartia* sp., *Oithona davisae*, *Limnoithona tetraspina*) and cladocerans (*Daphnia* sp.) feeding on natural assemblages of planktonic prey were highest for ciliates in seven experiments conducted over 18 months (March 2004 to August 2005), demonstrating a strong preference by mesozooplankton for protistan microzooplankton over diatoms and other autotrophic cells (Gifford et al. 2007). These ingestion rates are comparable to previous studies in estuaries (e.g. reviewed in Calbet and Saiz

2005, Ohman and Runge 1994), including San Pablo Bay, slightly downstream of Suisun Bay in the SFE-D

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

Publications

Gifford SM, Rollwagen-Bollens G, Bollens SM (2007) Mesozooplankton omnivory in the upper San Francisco Estuary. Mar Ecol Prog Ser 348: 33-46

Rollwagen-Bollens G, Gifford SM, Bollens SM. (Submitted) The role of protistan microzooplankton in the upper San Francisco Estuary planktonic food web: Source or sink?. Submitted to *Estuaries and Coasts*.

Presentations

Rollwagen Bollens G, Gifford SM, Slaughter AM, Bollens SM. "Protist diversity and trophic role in a large temperate estuary." 4th Bienniel CALFED Science Conference. Sacramento, CA. October 2006.

Rollwagen Bollens G., Gifford SM, Bollens SM. "Protist diversity and trophic role in a large temperate estuary." Gordon Research Conference on Marine Microbes. Biddeford, ME. July 2006.

Rollwagen Bollens G, Gifford SM, Slaughter AM, Bollens SM. "Protists in a Temperate Estuary: Diversity, Grazing and Consumption by Metazoans." Joint Ocean Sciences Meeting of the American Society of Limnology and Oceanography and the American Geophysical Union. Honolulu, HI. February 2006.

Rollwagen Bollens G, Gifford SM, Slaughter AM, Bollens SM. "Protists in a Temperate Estuary: Diversity, Grazing and Consumption by Metazoans." Pacific Estuarine Research Society Annual Meeting. Friday Harbor, WA. February 2006.

Gifford, S.M., Rollwagen Bollens, G., Bollens, S.M., Slaughter, A.M., Mesozooplankton predation on the protists of Suisun Bay (Northern San Francisco Estuary). Estuarine Research Federation 18th Biennial Conference, Norfolk, VA. October 2005.

Rollwagen Bollens, G., Gifford, S.M., Slaughter, A.M. Bollens, S.M. Microzooplankton in the northern San Francisco Estuary: Important food resources but minimal phytoplankton grazers. ASLO Aquatic Sciences Meeting, Salt Lake City, UT. February 2005.

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

Romberg Tiburon Center for Environmental Studies, San Francisco State University (research vessel and laboratory space)
Washington State University Vancouver (research space and support)

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

I was selected to participate in the DIALOG VI Symposium, co-sponsored by the American Society for Oceanography & Limnology (ASLO) and the Estuarine Research Federation (ERF). Dauphin Island Marine Laboratory, Mobile, AL. November 2004.

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

Keywords_17

microzooplankton, dilution experiments, Suisun Bay, mesozooplankton, grazing, feeding experiments

PATENTS: List any patents associated with your project.

Patents_18

Does not apply.

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

Additions_19