Sea Grant California

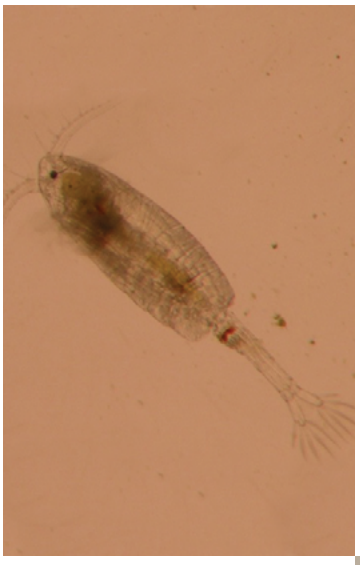
Detecting changes at the base of the pelagic food web in the San Francisco Estuary

Julien Modéran, former Delta Science Fellow

BACKGROUND

Since about 2004, populations of delta smelt, longfin smelt, juvenile striped bass, and threadfin shad have dropped significantly in the Sacramento-San Joaquin Delta for no obvious or as yet substantiated reason.

Food shortages at the base of the food web, however, are among the factors theorized to be contributing to the pelagic organism decline.



PROJECT

This project examines historical zooplankton samples, as well as new field data, to explore trends and variability in zooplankton diets since the 1970s and their implications for the pelagic food web at large. The theory is that there has been a shift in the base of the food web from nutritious, large phytoplankton species to less-nutritious bacteria-degraded vascular plant debris.

Such a shift, if it can be detected (analyses are ongoing), would mean less food for the larger zooplankton species that are the dietary staples of larval fishes. It would also be consistent with other observations that strongly suggest the estuary is food-limited. These observations include a drop in the total amount of phytoplankton in the estuary's low-salinity zone and a drop in the biomass from larger phytoplankton species.

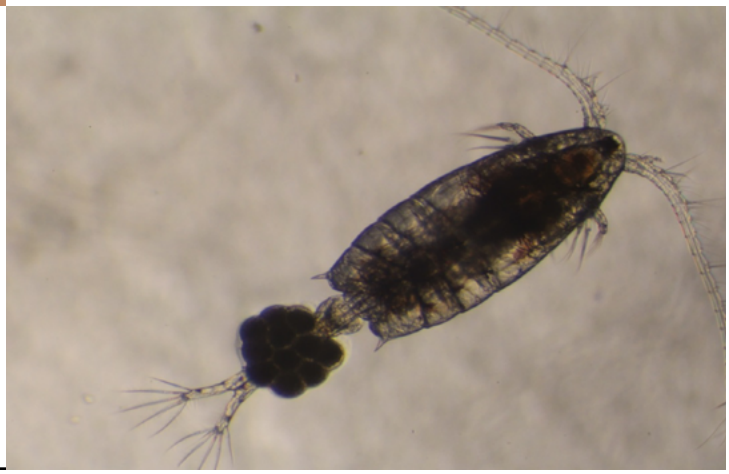
These changes – less food and smaller bites – have been attributed, at least partially, to a proliferation of invasive Asian clams (*Potamocorbula amurensis*) that feed on larger phytoplankton, as well as to elevated ammonium levels, which other researchers have shown can restructure phytoplankton communities.

To explore these ideas, this project focuses on three main objectives:

1) To collect new field data along the estuary's salinity gradient from San Pablo Bay to the San Joaquin and Sacramento rivers to document present-day seasonal variations in zooplankton diets and their link to environmental factors, such as salinity and turbidity.

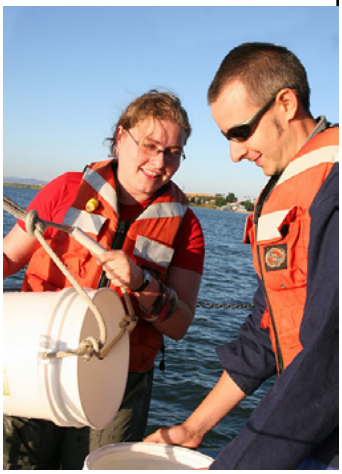
2) To verify the ability to perform meaningful stable isotope analyses on formalin-preserved zooplankton samples, collected in the San Francisco Estuary from 1976 to 2010 through the Interagency Ecology Program (IEP). This was achieved by comparing stable isotope compositions of frozen vs. formalin-preserved zooplankton samples for eight different species. Freezing is the preferred method for storing samples for isotope analyses.

3) To use stable isotope methods to document diets and trophic levels of historical zooplankton samples from a freshwater station in the San Joaquin River and a low-salinity-zone station, where phytoplankton, zooplankton and pelagic fish declines have been most pronounced.



The zooplankton species *Pseudodiaptomus forbesi*, *above*, is found in San Francisco Estuary's low-salinty zone and is an important food source for some fishes. *PHOTO: W. Kimmerer Lab*

Pseudodiaptomus marinus zooplankton, *right*, is a key prey species found in the estuary. *PHOTO: W. Kimmerer Lab*



Delta Science Fellow Julien Modéran (right) and graduate student Karen Kayfetz collect water samples from the San Francisco Estuary. *PHOTO: T. Ignoffo*

RESULTS

Formalin was shown to have only minor effects on carbon isotopes (for all eight species analyzed) and nitrogen isotopes (for six of the eight species), and these minor effects occurred rapidly, remained relatively constant over time and were thus easily corrected. The main result of this project, to date, has been in validating the ability to perform meaningful isotopic analyses on the IEP's historical zooplankton database.

At the freshwater station, zooplankton diets were observed to be highly variable at short time scales. Scientists observed unusual spikes in heavy nitrogen (15N) that could not be attributed to natural processes and have since been linked to low river flows and high nitrogen loads. Heavy nitrogen is a marker of bacterial processes and can be used to track nitrogen from fertilizers and treated wastewater into the food web.

"The heavy nitrogen spikes are probably from treated waste-water discharges into the river," Modéran said. "This is not necessarily a problem in itself, but it does highlight major human-induced disturbances at the base of the food web. These might propagate to higher level organisms."

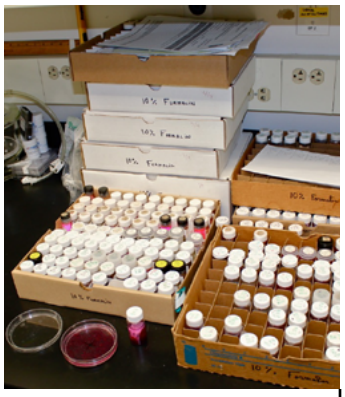
Analyses of the low-salinity zone archival record are ongoing. Besides looking for a shift in what zooplankton have been eating since the 1970s, scientists hope to use heavy nitrogen isotope signatures to document the scale of human impacts to the food web via nitrogen loading. They will also be looking closely at whether the large numbers of clams that appeared in the estuary in the late 1980s have left a mark in the archival zooplankton record, which spans the bivalves' pre-arrival and establishment as an invader.

Analyses of the new field data are also ongoing; however, preliminary results show that most zooplankton species do not graze on Microcystis species and other blue-green algae, which have become problematic "bloom" species in the upper estuary and freshwater systems. This means that zooplankton could starve in a phytoplankton-rich soup.

"Toxic cyanobacteria may play a significant role in the food limitation that most zooplankton species face," Modéran said.

MANAGEMENT APPLICATIONS

Results from this project will help to identify the environmental factors that control the base of the food web and may help managers identify components of the food web that should be the focus of management and restoration efforts.



Researchers analyze historical zooplankton samples (shown in the vials above) to look for clues about fish declines. *PHOTO: J. Modéran*

PRESENTATIONS & POSTERS

Modéran, J., R. Stewart, & W. Kimmerer. (2013) Stable isotope analysis of historical zooplankton samples to document food web and biogeochemical changes in the San Francisco Estuary-Delta. Invited presentation – Interagency Ecological Program Workshop, Folsom, Calif.

Modéran, J., R. Stewart, & W. Kimmerer. (2013) Stable isotope analysis of historical zooplankton samples to document food web and biogeochemical changes in the urbanized San Francisco Estuary. ASLO 2013 Aquatic Science Meeting, New Orleans, La.

Modéran, J., R. Stewart, & W. Kimmerer. (2012) Evidence of food web and biogeochemical changes in the San Francisco Estuary as indicated by stable isotope analysis of historical zooplankton samples. 7th Bay-Delta Science Conference, Sacramento, Calif.

Modéran, J., R. Stewart, & W. Kimmerer. (2012) Stable isotope analysis of historical zooplankton samples document food web and biogeochemical changes in the San Francisco Estuary: effect of preservation methods and preliminary results. California Estuarine Research Society meeting, Long Beach, Calif.

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