



Investigating the Role of Nitrogen Fixation and Denitrification in a Highly Eutrophic Southern California Estuary

Dr. Peggy Fong
Ecology and Evolutionary Biology
University of California, Los Angeles

This project expands our knowledge of nitrogen cycling and processing in highly eutrophic estuaries of southern California. Field surveys show rates of nitrogen fixation are spatially and seasonally variable and could depend on both abiotic and biotic factors, especially nitrate levels in the water column.

Our research takes place in the Upper Newport Bay Ecological Reserve, a protected estuary in Newport Beach, California. Estuaries are critically important habitat to many species of plants, birds and fish, including several endangered and threatened species. They also perform ecosystem services such as protecting the coastline from erosion and filtering nutrient rich water that enters the system as runoff. This is especially important as urban development continues, though few functional coastal marshes remain in southern California. The remaining estuaries are threatened by eutrophication that results from excessive nitrogen loading from developed watersheds.

Our objective is to investigate the microbial processes of nitrogen fixation and denitrification that occur in the sediments of the estuary. Since these processes can add or remove nitrogen, they have the ability to affect nutrients in the water and sediments and therefore can affect the presence of plants and algae in the estuary.

Surveys of the estuary took place in March 2005, Sep. 2005, Feb. 2006, and Sep. 2006 and included sampling the intertidal mudflat along 5 locations in each of two tidal creeks. During each survey sediment was taken for nitrogen fixation and denitrification measurements. Samples were also taken to determine other characteristics of the sediments, such as sediment type and nutrient content, organic material present, and water nutrients. This will allow us to determine any

correlations between the nitrogen processing rates and ecosystem characteristics.

All survey sites exhibited some nitrogen fixation activity, though it is clear that there is a great deal of spatial and temporal variability within the estuary. For most sites, activity was low relative to estuaries on the east coast of the United States. Though some sites exhibited higher nitrogen fixation rates, there does not appear to be a spatial or seasonal pattern. This indicates fixation is not simply related to seasonal or long-term site characteristics, and is more likely to be controlled by shorter-term sediment, water and biotic controls. Rates are hypothesized to be higher in areas of decreased nitrogen supply from the water and surrounding sediments. Denitrification rates are not yet available, though they are expected to be



A student stands knee-deep in mud to collect algae for an experiment.

highest in areas with higher nitrate concentrations and higher organic material content.

Three field experiments were also performed. In July 2005 we executed a nutrient experiment to test the response of sediment nitrogen fixation and denitrification rates after exposure to nutrient enriched water treatments. This simulates estuary conditions as nutrient loading into the system continues to increase. Nitrogen fixation rates were significantly lower when overlying water contained higher nitrate concentrations, while the addition of phosphorus had no effect. Denitrification is expected to show increased rates with the addition of nitrate.

In July – August 2005 we performed a sediment transplant experiment to investigate how microbial nitrogen processing rates are affected by differences in sediment types. All sediment types showed an increase in nitrogen fixation rates when transplanted to a location where each received the same tidal flushing and exposure to water nutrients. Initial analysis indicated that this change coincided with a decrease in available water nitrate, and does not depend on sediment type. Denitrification is expected to decrease in these conditions.

In June – July 2006, a 40-day long field experiment investigated how the presence and density of green macroalgal mats, often a product of nutrient enrichment, affect nitrogen fixation and denitrification rates and other sediment and water characteristics beneath the algal mats. Initial results indicate that the presence of macroalgae did not affect nitrogen fixation rates, though fixation rates did change significantly over the course of the experiment. Further analysis will determine if the changes correlate with other abiotic characteristics. We predict the presence of macroalgae will affect denitrification.

This research contributes to our basic understanding of how nitrogen cycles through Upper Newport Bay Estuary and will provide insight into other southern California estuary systems. It is important to understand these processes, as few estuaries remain and they

may function differently than east coast estuaries, which are much different in structure and climate. Understanding nitrogen cycling in these systems could allow policy makers to make more informed decisions regarding the regulation of nutrient inputs into these systems. Processes that add and remove nitrogen from estuarine ecosystems are especially important as nutrient loading and subsequent eutrophication will only increase in the future.

Selected Professional Presentations

Kane, Tonya and P. Fong. Sediment nitrogen fixation in Upper Newport Bay Estuary, southern California. California Estuarine Research Society Annual Meeting. Bodega, CA, March 2007.

Kane, Tonya and P. Fong. Quantifying rates and mechanisms controlling sediment nitrogen fixation and denitrification in a eutrophic estuary. Estuarine Research Federation Meeting. Providence, RI, November 2007.

Collaborative Efforts

Determination of nitrogen fixation and denitrification rates requires a Gas Chromatograph to measure gas concentrations obtained during assays. Dr. Doug Capone at the University of Southern California has allowed us to use his equipment for these measurements. He and members of his lab have been very helpful in teaching us the techniques to measure these characteristics.

This work has also fostered collaboration with the Southern California Coastal Water Research Project (SCCWRP). A proposal has been funded by the San Diego Regional Water Quality Control Board to incorporate some of the questions we have been asking in Upper Newport Bay Estuary to a more integrative project in San Diego Lagoon.

For further information please contact:

Peggy Fong
pfong@biology.ucla.edu
(310) 825-5444
www.eeb.ucla.edu/faculty