Report as of FY2006 for 2006CA176B: "Investigating the role of nitrogen fixation and denitrification in ameliorating deteriorating water quality in a highly eutrophic southern Californian estuary"

Publications

Project 2006CA176B has resulted in no reported publications as of FY2006.

Report Follows

RESEARCH PROGRAM:

Estuaries are highly productive ecosystems that support many endangered and commercially important species. In most estuaries, nitrogen limits primary productivity. However, if present in excess, nitrogen can lead to eutrophic conditions, which can adversely affect water and habitat quality. Southern California's estuaries have highly developed watersheds, often resulting in high loads of nitrogen from anthropogenic sources and eutrophication. Our overall goal is to understand the role of two biogeochemical processes, nitrogen fixation and denitrification, that affect processing of nitrogen in estuaries and to investigate their response to increased nitrogen loads from the watershed. Ultimately, we aim to aid in protecting these important aquatic ecosystems by understanding the constraints and controls that function to balance these two processes and how these processes, especially denitrification, may act to ameliorate the negative effects of eutrophication.

Nitrogen fixation transforms elemental nitrogen (N_2) into ammonium ions (NH_4^+) that can be used by primary producers, and therefore is considered a "new" source of nitrogen. Denitrification transforms nitrate (NO_3^-) into atmospheric nitrous oxide (N_2O) or nitrogen (N_2), and is therefore a loss of nitrogen from aquatic ecosystems. As these processes either contribute or remove nitrogen from the system, they have the potential to affect water quality and ecosystem health. However, little is known about nutrient dynamics in southern California estuarine environments, and only one study addresses these microbial nitrogen transformations.

We measured spatial and temporal variability of nitrogen fixation and denitrification and investigated relationships to abiotic/biotic factors in a eutrophic southern California estuary through four field surveys and three experiments in Upper Newport Bay Ecological Reserve, a large estuary in Orange County, California. This combined approach allows us to understand the factors that control these important processes in the nitrogen cycle that potentially may limit eutrophication. All field and laboratory work for this project has been completed, with the exception of running gas samples for denitrification measurements. Analysis and interpretation of data is in progress.

Field surveys of the estuary encompassed both the wet and dry seasons and took place in March 2005, Sept 2005, Feb 2006, and Sept 2006. We sampled the intertidal mudflat along 5 locations in each of two tidal creeks spanning the spatial gradient of the estuary. During each survey sediment was taken for nitrogen fixation and denitrification measurements, via acetylene reduction and acetylene block techniques, respectively. Samples were also taken to determine other characteristics of the sediments, including sediment type and nutrient content, organic material present, benthic chlorophyll content, and water nutrients. This will allow us to determine any correlations between the nitrogen processing rates and ecosystem characteristics.

It is clear from the surveys that there is a great deal of spatial and temporal variability in nitrogen fixation rates within the estuary (Figure 1). Overall, with notable exceptions, fixation rates were low relative to those found in other, less eutrophic estuaries. It is clear that patterns of fixation are not simply explained by seasonal or long-tern site characteristics. We expect to see that nitrogen fixation rates will correlate with shorter-term sediment, water, and biotic factors. Rates are hypothesized to be higher in areas of decreased nitrogen supply from the water and surrounding sediments, as well as in areas with high organic material. Denitrification rates are not yet available, though they are expected to be highest in areas with higher nitrate concentrations and in more oxygen depleted conditions.

In July 2005 we executed a nutrient experiment in the laboratory using sediment cores from the field to test the response of nitrogen fixation and denitrification rates after exposure to

nutrient enriched water treatments, including enhanced nitrate and phosphorus levels. Replicate sediment cores were exposed to one of four seawater treatments (NO_3^- and PO_4^{3-}, NO_3^- only, PO_4^{3-}only, and ambient). This simulates estuary conditions as nutrient loading into the system continues to increase. Preliminary results of the nutrient experiment suggest nitrogen fixation rates were lower in the presence of increased nitrate and not affected by the addition of phosphorus.

In July – August 2005 we performed a sediment transplant experiment to investigate how sediment characteristics that co-vary with eutrophication affect nitrogen fixation and denitrification rates using a common garden design. Large sediment cores from three areas of the estuary with contrasting sediment types were relocated and left to acclimate to the environmental conditions at this new location (i.e. same tidal flushing and exposure to water nutrients). Initial (Day 0) and final (Day 25) measurements of fixation and denitrification rates and a suite of abiotic characteristics (see field survey) were measured. Preliminary analysis of data shows an increase in fixation rates for all cores transplanted from sites with smaller sediment grain size, which suggests an effect of sediment type.

In June – July 2006, a 40-day long field experiment studied the effects of the prolific green macroalgal mats that dominate upper Newport Bay. We investigated how the presence and density of these mats, often a product of nutrient enrichment, affect nitrogen fixation and denitrification rates and other sediment and water characteristics beneath the algal mats. We used a caging experiment to investigate the effect of high, low and zero density macroalgal treatments on the benthos after 10, 25 and 40 days exposure. We expect presence of macroalgae will decease oxygen and increase nutrient flux to the sediment, especially as decomposition begins. This could decrease fixation and increase denitrification rates over time.

This research will determine: spatial and temporal patterns of nitrogen fixation and denitrification rates, correlations of biotic/abiotic factors with rates, and quantitative relationships between factors and rates. It will contribute to our basic understanding of how nitrogen cycles through Upper Newport Bay Estuary and will provide insight into southern California estuary systems and other unique Mediterranean and heavily impacted ecosystems. It is imperative to understand these processes in California estuaries, since approximately 90% of estuarine and salt marsh systems have already been lost along California's coast. The remaining estuaries are critical habitat and our work will aid in ensuring survival of this vital remaining habitat. Understanding nitrogen cycling in these systems could allow policy makers to make more informed decisions regarding the regulation of nutrient inputs into these systems. These processes that add and remove nitrogen from estuarine ecosystems are especially important as nutrient loading and subsequent eutrophication will only increase in the future.

INFORMATION TRANSFER PROGRAM:

Initial results of nitrogen fixation rates for the field surveys was presented at the California Estuarine Research Society (CAERS) Annual Meeting in Bodega, California in March 2007, and at the UCLA Ecology and Evolutionary Biology Annual Research Symposium in May 2007. Additionally, one undergraduate student involved in the project presented portions of the data which he assisted on at the UCLA Undergraduate Science Poster Day in 2007.

An abstract has been submitted to present the nutrient and algae experiment data at the Estuarine Research Federation Bi-Annual Meeting in Providence, Rhode Island in November of 2007. Portions of this research will also be presented at the Western Society of Naturalists Annual

Meeting in November 2007. As data analysis is being completed, we expect a minimum of four manuscripts will be prepared for publication.

This project has also fostered new collaborations. As determination of nitrogen fixation and denitrification rates requires a Gas Chromatograph in order 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 laboratory have been very helpful in teaching us the techniques to measure these characteristics. In addition, we have begun a collaboration with the Southern California Coastal Water Research Project (SCCWRP) to incorporate some of the questions we have been asking in Upper Newport Bay Estuary to a more integrative project in San Diego Lagoon.

STUDENT SUPPORT:

This project has been the main funding source for one PhD student (Tonya Kane). Several additional PhD students contributed to the research and many undergraduates have assisted on this project, as volunteers, for educational credit, and/or for financial support.

	Total Project Funding		Supplemental Awards	Total
	Federal Funding	State Funding		
Undergrad.	23	23	$5,000	23
Masters	1	1	None	1
PhD.	6	6	$2,000	6
Post-Doc.	None	None	None	None
Total				

NOTABLE ACHIEVEMENTS AND AWARDS:

A poster presentation by Tonya Kane, the PhD student this project supports, at the UCLA Ecology and Evolutionary Biology Annual Research Symposium in May 2007 earned a second place award.

PUBLICATIONS FROM PRIOR PROJECTS:

n/a

PUBLICATIONS AND CITATION FORMAT:

All publications from this project are in progress.

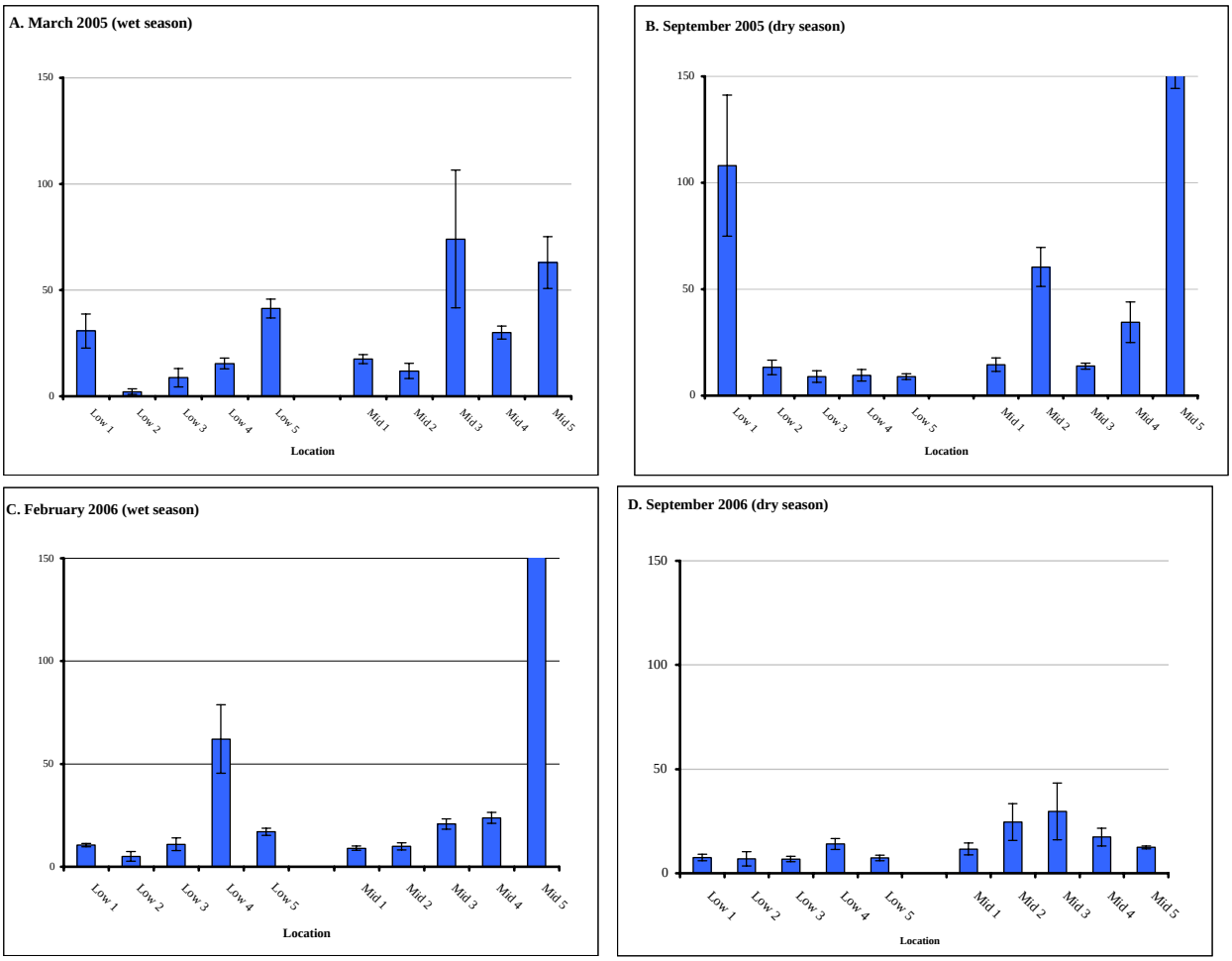

Figure 1. Mean nitrogen fixation rates (nmol N fixed m-2 hr-1) at each location for field surveys over two years. (For September 2005, Mid 5 extends to 180 $\pm$ 36. For February 2006, Mid 5 extends to 378 $\pm$ 101)