Project Summary

Overview: Nitrogen (N) pollution of aquatic ecosystems is an important and increasing concern worldwide. Lakes and reservoirs are important sites for N transformation and removal, but our ability to manage N in these systems is hampered by our limited understanding of the interaction between hydrological processes and biogeochemical cycling. We propose novel interdisciplinary work, combining approaches from fluid dynamics and biogeochemistry, to improve understanding of N and other chemical dynamics within reservoirs. More specifically, we propose to refine and apply a novel, interdisciplinary approach to address the following research question: **how do physical and biological factors interact to create hot spots and hot moments for N_2 and N_2O fluxes from sediments to the water column?** In the process, we will collect extensive turbulence-resolving measurements within the boundary layer, likely enhancing our understanding of fluid dynamics in this important region of elevated mixing. Numerous chemical measurements will shed light on processing of N in lake waters and sediments. The interplay between physics and chemistry will be highlighted by contrasting N transformation processes in three very different eutrophic reservoirs: one characterized by strong seasonal stratification with energetic internal waves and an annual punctuated surface water release, another characterized by weak diurnal stratification with relatively steady downriver flows and minimal water level fluctuation, and a third characterized by summer stratification and sustained hypolimnion drawdown. We will train several graduate and undergraduate students, and communicate our findings and methods to the broader scientific community, reservoir operators, water managers, and policy-makers.

Intellectual Merit: The proposed research is original and potentially transformative in that it combines state of the art physical and biogeochemical techniques in a new and potentially powerful way to improve fundamental understanding of an essential nutrient transformation with critical societal importance. Approximately one third of all reactive N entering freshwaters is trapped or removed via denitrification in lakes and reservoirs, and N removal (denitrification) is especially rapid in reservoirs. Nevertheless, the mechanisms controlling N removal in reservoirs remain relatively poorly understood. Much of this gap in understanding is due to the fact that microbial N removal is challenging to measure and spatio-temporally variable. The proposed work addresses these challenges by combining hydrodynamic and biogeochemical approaches in the application of a new "flux gradient" method that can both quantify spatio-temporal variability of *in situ* N removal rates and relate them to hydrologic processes. ***This contribution is significant because it is expected to improve our ability to measure, explain, predict, and (potentially) control N removal (and hence downstream N transport) in reservoir systems and watersheds more broadly.*** The method we will refine, apply, and disseminate will be broadly applicable to understand sediment-water column fluxes of many materials (not just N). This project will also enhance understanding of the role that humans play in controlling downstream nutrient transport.

Broader Impacts: The proposed research is designed not only to fundamentally advance the fields of ecosystem ecology, hydrology, and biogeochemistry, but also to provide management-relevant results that help address pressing societal concerns. We propose to create tools and approaches with potentially far-ranging applicability: researchers may be able apply these tools to understand interactions between physical mixing and biological processing of nutrients in other aquatic systems, while managers may be able to more wisely manage water resources and associated ecosystems. To help other researchers and managers apply the flux-gradient technique, we will create a website explaining the approach and providing detail on important practical and methodological considerations. This project will also have a significant educational impact. We anticipate that at least 2 PhD students and 3 undergraduates will receive direct support under this grant. Many more students will benefit from the incorporation of this work into a module called "Dams and Reservoirs" used in at least two upper-division undergraduate/graduate courses, "Water in the Environment" and "Watershed Biogeochemistry" taught by Henderson and Harrison, respectively. Finally, this work will support the planning and execution of a special session on "*Enhancing Reservoir Management for the Environment*" at the Joint Aquatic Sciences Meeting planned for Spring 2014, in which water reservoir managers are expected to participate.