Stratification Influences Nitrogen Removal in a Eutrophic Reservoir: Potential Implications for Dam Management

Bridget Deemer and John Harrison, Washington State University-Vancouver

In recent decades anthropogenic activities have led to increased nitrogen (N) inputs to freshwater systems and associated increases in harmful algal blooms, fish kills, and other negative ecosystem impacts. In Washington State, 664 lakes and reservoirs and 748 total freshwater entities do not meet the Clean Water Act 303(d) standard, which means that beneficial uses of these waters, such as for drinking, habitat, swimming, fishing, and industrial use, are impaired by pollutants. With the application of N fertilizers projected to more than double in the next 50 years, a better understanding of nutrient cycling in freshwater systems is critical to informing water management strategies.

While the microbially mediated conversion of biologically available N to non-reactive atmospheric N is considered the primary N-removal pathway in aquatic systems, its temporal dynamics are poorly understood. Lacamas Lake, a small reservoir draining to the Columbia River, was sampled monthly from June 2007 to September 2008 and a sediment incubation experiment was also conducted. Membrane inlet mass spectrometry was used to quantify concentrations of N_2, the gaseous byproduct of microbial N removal, throughout the water column.

Summertime accumulation of N_2 below the thermocline of the reservoir indicates that microbial transformations in this zone are responsible for removing all the NO_3-N present during mixed conditions. We estimate that summertime nitrogen removal rates average 134 umol N m^{-2} h^{-1} and that late spring rates may be much higher, with a low end average from our study indicating 448 umol N m^{-2} h^{-1} during this time. These estimates fall well within the range of N removal estimates made in other reservoir systems. Our sediment incubation experiment found that nitrate was a significant factor limiting sediment N removal during the stratified season. Sampling conducted during a fall dam spill operation also indicated that small and large spills may have the capacity to destabilize the thermocline, thus mixing oxidized N downward toward an environment conducive to N removal. These results have important implications for how we understand the controls on N removal in lentic systems. Future research should investigate whether summertime dam spills could be an effective management strategy for reducing the downstream flow of biologically available N.

Bridget Deemer

Bridget Deemer is currently working on an M.S. degree in Environmental Science with the watershed biogeochemistry group at Washington State University-Vancouver. Most of her research is conducted at Lacamas Lake in Camas, Washington, and she is studying how this local reservoir can act both as a bio-filter to remove nutrient pollution and as a source of greenhouse gases. Bridget received her B.A. in Environmental Studies from Vassar College in 2004. Her previous experiences include leading marine ecology walks for a small non-profit aquarium, studying water quality in forested and deforested tropical streams, and interning with national resource agencies including the U.S. Forest Service, National Park Service, and U.S. Fish and Wildlife Service. She received the Robert Lane Fellowship in Environmental Science in 2008 and 2009, the WSUV Research Showcase Outstanding Poster Award in 2009, and has received a National Science Foundation GK-12 Fellowship for 2009-2010.