Report as of FY2006 for 2006ME86B: "Does food-web structure mediate landscape-scale responses of Maine lakes to nutrient enrichment?"

Publications

Project 2006ME86B has resulted in no reported publications as of FY2006.

Report Follows

RESEARCH:

Objectives:

The traditional focus of lake rehabilitation efforts has been on controlling the sources of nutrients that eventually lead to chronic algal blooms, anoxic hypolimnia and degraded water clarity. This 'bottom-up' approach is obviously necessary for improving or maintaining lake water quality. However, an increasing body of evidence suggests that 'top-down' controls play a major role in how nutrient loading is expressed in enriched lakes (Carpenter et al. 1995; Gliwicz 2002; Stemberger and Miller 2003). From this perspective, the relative dominance of the fish assemblage by planktivores (zooplankton-eating fish) over piscivores (fish-eating fish), influences algal biomass and water clarity. Lakes with intense planktivory tend to have smaller cladocerans, which are less efficient grazers of algae. Under this scenario, algal populations are released from control by grazing leading to reduced water clarity (Carpenter et al. 1995). The size structure of the cladoceran community, and especially *Daphnia* species, has been posited as one of the key indicators of the resilience of lakes to eutrophication (Carpenter et al. 1995). Over the past century, fish introductions through official and illegal means as well as dispersal through hydrologic corridors, have dramatically altered the structure of aquatic communities in the Northeast US (Whittier and Kincaid 1999). By altering food web structure and the associated energy transfers between trophic levels, introduced fish may further reduce the resilience of lakes to nutrient enrichment and make traditional lake rehabilitation approaches less effective. The landscape-scale implications of these fish community changes and, in particular, their interaction with other anthropogenic stressors have important implications for biodiversity, sustainability, and management of aquatic ecosystems.

Our research has the overarching goal of determining if top-down effects of resident fishes mediate the response of lake food webs, particularly cladoceran size structure, to eutrophication at the landscape scale. We ask whether heterogeneity in cladoceran size structure across a gradient of lake nutrient status is related to the intensity of planktivory and, whether that relationship differs among lakes in predictable ways.

Our specific objectives are:

1) To create a hierarchical model that defines the landscape features and lake characteristics (both physical and chemical) that influence lake trophic state variables in order to isolate the influence of cladoceran size structure.
2) Assess the role of top-down processes on lake responses to nutrient enrichment by examining the influence of cladoceran size structure (measured as body size indicators and species ratios) on water clarity – nutrient relationships in Maine lakes and how that is influenced by the assemblage of fish species in the lake.
3) Develop, test and evaluate outreach materials (websites, presentations) that inform lake users of these processes and relationships.

Methods:

We are using an extensive dataset and archived zooplankton samples collected by the Maine Department of Environmental Protection (MDEP) as part of the Baseline Monitoring Program. The MDEP collected zooplankton samples, nutrient and trophic status data, and water chemistry from a widely dispersed set of ~500 lakes between 1996 and present. We have assembled associated hydrogeomorphic data on lake and catchment morphometry, hydrologic position, geology and elevation as well as data on human disturbance such as land cover near the lake, road density, and population density and ecoregion. These features define the hydrogeomorphic framework for classifying lakes. Within each lake class, we will select lakes that represent trophic gradients in total phosphorus and humic color. Mean body length for each cladoceran will be determined for a total of ~200 individuals using a dissecting scope equipped with a digital camera. Lengths are then determined from these images using ImageJ software (http://rsb.info.nih.gov/ij/) and collated by genus. We will do the body size analyses in summer 2007. From these data, we will calculate body size metrics such as the indices developed by Stemberger and Miller (2003) and the ratio between the abundances of *Daphnia* and *Bosmina* (Kitchell and Kitchell 1980). These indices will be related to trophic status measures, such as TP, Secchi transparency and chlorophyll a, within hydrogeomorphic classes. Statewide data on fish assemblages are limited to presence/absence data collected by the Maine Department of Inland Fisheries and Wildlife over the past 50-100 years. From these assemblage data we will develop an index of fish planktivory. For example, lakes with planktivores such as white perch or alewife have potential to develop abundant populations that have strong effects on cladoceran community size structure.

Importance:

Results of our proposed research will have two immediate benefits, an improved understanding of how food web structure interacts with nutrient enrichment on the landscape scale, and application of these results in the development of new and novel tools and indices for lake assessment and management. Our partnership between academic and state management institutions will further be utilized to develop and test outreach materials to educate the public on the importance of preventing fish introductions that alter lake foodweb structure.

References:

Carpenter, S.R., *et al.* 1995. *Environmental Science and Technology* 29: 784-786.
Gliwicz, Z.M. 2002. *Freshwater Bio.* 47:2296-2312.
Kitchell, J.A. and J.F. Kitchell. 1980. *Limnol. Oceanogr.* 25:389-403.
Stemberger, R.S and E.K Miller. 2003. *Can. J. Fish.Aquat. Sci.* 60: 1477-1468.
Whittier, T.R. and T.M. Kincaid. 1999. *Trans. Am Fish. Soc.* 128:769-783.

STUDENT SUPPORT:

This research supports Elizabeth Whitmore, an M.Sc. candidate in Ecology and Environmental Sciences at the University of Maine. She began her program last August and is on target to finish her thesis by June 2008.