The influence of lake productivity on methane production and ebullition from temperate and arctic lake sediments

Megan C. Wimsatt; Advisor: Dr. Ruth K. Varner
UNH Department of Earth Science: Geochemical Systems Specialization M.S. Program
NH Space Grant Consortium UNH Research Fellowship Final Report
September 14, 2023

This past spring, I was honored to be offered a summer research fellowship from the NH Space Grant Consortium to support my project investigating the influence of lake productivity on methane production and ebullition from temperate and arctic lake sediments. Lake productivity is a measure of algal growth and nutrient inputs. I hypothesized that increased lake productivity would increase methane production and emission from lake sediments in temperate and arctic lakes due to the increased organic matter availability and lack of oxygen caused by increased algal growth. This relationship is critical to understand as average surface temperatures continue to rise. Lake productivity has and continues to increase, which may have consequences for human health and further warming by increased methane emissions to the atmosphere.

To determine the influence of lake productivity on methane production and emission, 9 temperate lakes from New Hampshire, USA and 3 arctic lakes from Abisko, Sweden were studied. NH lakes were chosen based on their proximity to residence, their trophic class assessments by the NH Department of Environmental Services (NHDES), their size, and membership in the NHDES Volunteer Lake Assessment Program (VLAP). Three lakes were chosen for each of the 3 lake trophic classes (oligotrophic – low productivity, mesotrophic – medium productivity, and eutrophic – high productivity). Only 3 lakes (similar size to chosen NH lakes) were selected in Sweden because prior research data and observations suggested the presence of the oligotrophic class but not others. Fieldwork in NH was conducted in June and fieldwork for Sweden was conducted in July. At each lake, 3 bubble traps were deployed within 5-10m of each other and in 1.5-4m of water depth to capture the shallow, littoral (near shore with high light availability) zone being careful to avoid stream/river inlets and development. Having 3 replicates at each lake and 3 replicate lakes for each trophic class provided a data safety net in the event of damaged/lost traps. Post deployment, one gas sample was collected from each trap each week for a total of 3 weeks to account for variance in emission due to environmental conditions. During each lake visit, water samples were collected for analyses of chloride, pH, conductivity, turbidity, and chlorophyll-a (produced by algae). Dissolved oxygen and temperature were measured in the water column at each trap each visit. The water quality data will provide a larger picture of what might be influencing methane emissions in each lake. Lastly, the top 0-10cm of surface sediments were collected using a gravity core from each lake to be analyzed for methane production rates via incubations, organic carbon, nitrogen, and sand/silt/clay content.

In NH, I worked with volunteers from the NHDES VLAP to gain assistance with boat access. This was a challenging aspect of this project as it required a high level of organizational and communication skills to schedule visits to 9 lakes each week and be flexible with inclement weather. The time needed for early communication with the volunteers and preparing the equipment I needed was underestimated and in short supply. However, with generous support and assistance from my lab teammates and advisor, I was able to stay on track. During the second week of lake visits, I found numerous traps had broken and/or sunk, possibly due to storms or faulty design/construction, leaving some gaps in the data. As many traps as possible were retrieved, fixed, and redeployed. In Sweden, the same issue occurred with some of the bubble traps, and other challenges included sharing equipment and vehicles. This project taught me to be patient, adaptable, and to thank those that helped me along the way.

Fieldwork has concluded and the fall semester is about to begin. I currently only have fragments of the water quality data and gas concentrations from the bubble traps, making it difficult to draw conclusions at this time. However, it appears that chlorophyll-a increased with trophic class designation of increasing lake productivity (oligotrophic to eutrophic), while the volume of ebullitive gas decreased. With the acquisition of the remaining data this fall, it is expected that ebullitive methane concentrations and methane production rates with increase with productivity, suggesting that higher trophic classes may have lower ebullitive fluxes of methane with higher concentrations. The results from this work will help us further understand the relationship between eutrophication and methane ebullition from lakes across different eco-regions.

I plan to present my findings at the American Geophysical Union Fall Meeting this December in San Francisco in a poster session and defend my master's thesis spring of 2024. These are both excellent opportunities to share my project outcomes with the wider scientific community and enhance my networking. I have begun my search for a full-time position post-graduation where I can demonstrate my strengths and develop my weaknesses. There is still uncertainty as to the type of position I am seeking, but I gain a better understanding of my career interests with each academic and research experience, such as this fellowship. I would like to thank the NH Space Grant Consortium for their generous financial support of this project and for their dedication to helping students gain research experiences that enhance our understanding of this world, and beyond.