Vermont Water Resources and Lakes Studies Center

Annual Program Report
June 18, 2019 – June 17, 2020

The Vermont Water Resources and Lake Studies Center (Vermont Water Center) facilitates water resources related research and supports faculty and students at Vermont colleges and universities. Research priorities are identified through collaboration with the United States Geological Survey (USGS), the State of Vermont Department of Environmental Conservation, Lake Champlain Sea Grant, Lake Champlain Basin Program, and other programs in the state. By regularly working with state, regional, and national partners, the Vermont Water Center links scientific research with decision making in water resource management and policy development. The Director of the Water Center is also the director of Lake Champlain Sea Grant (LCSG) and both programs share the same advisory board, which leverages the strengths of each program. In 2019, the Director of the Water Center was also a member of the Steering Committee of Lake Champlain Basin Program (LCBP) and regularly brought information from Center-funded projects to the attention of LCBP committees. Their activity on these committees also helps to inform the directions of the Water Center and has led to a number of productive partnerships. Following is a list with links to descriptions of projects supported by the Vermont Water Center in 2019 and related activities and publications.

Identifying drivers of change in denitrification capacity of riparian soils during the spring snowmelt/runoff period

Investigators Carol Adair and Brittany Lancelloti

Introduction

Movement of nutrients during the dynamic spring snowmelt period has been linked to harmful algal blooms in Lake Champlain and other water bodies. Normally, riparian areas reduce nutrient loading to adjacent water bodies; however, soil denitrification exhibits high spatial and temporal variability.

Methods

To better understand how the denitrification capacity of riparian soils changes, we measured actual denitrification rates (ADR) and key drivers of denitrification in one upland and one wetland spot along one forested and one agricultural soil transect during eight sampling events throughout spring snowmelt. Employing existing high frequency soil sensors to monitor changes in soil conditions, we collected soil samples for inorganic N and organic C analysis and downstream molecular analysis and performed quantitative polymerase chain reaction (qPCR) to quantify functional genes for nitrification, denitrification, and the bacterial community. We also performed a metagenomic analysis on all soil samples to identify and quantify many different functional genes, which will enable study of the microbial community composition of each sample and pinpoint the abundance of a wide variety of genes that impact soil biogeochemical cycling.

Results

Initial results indicate that the agricultural site had an increased magnitude of actual denitrification rates compared to the forested site. At both sites, functional denitrification genes were significantly more abundant than nitrification genes. The metagenomic analysis produced a unique and robust dataset that will be used to describe how soil microbial communities change according to land use and landscape position during spring snowmelt.

Products

Lancelloti, B. 2019. Spring snowmelt: a ‘hot moment’ for denitrification in riparian areas? Poster presented by Brittany Lancellotti at the American Geophysical Union’s Fall 2019 Meeting in Francisco, CA. Abstract: https://agu.confex.com/agu/fm19/meetingapp.cgi/Paper/613320

Lancelloti B. 2020. “Identifying drivers of change in the denitrification capacity of riparian soils during the spring snowmelt/runoff period.” PhD diss., University of Vermont.

Lancelloti B. March 31, 2021. What’s going on down there? How does Vermont’s spring snowmelt period affect the soil ecosystem? “Presentation at the Teen Science Café network, 2021.” https://teensciencecafe.org/about/

Lancelloti B. November 2020. What does a soil scientist do? “Presentation and Q&A to two classes at Northfield Middle School in Northfield, VT, 2020.”

Lancelloti, B. Adair, E. Perdrial, J. February 24, 2021. Drivers of change in denitrification capacity of riparian soils during the spring snowmelt. Lake Champlain Sea Grant Research Seminar Series.

Response of phytoplankton communities to recovery from acidification in Vermont lakes

Investigators Ana "Mindy" Morales-Williams and Sydney Diamond

Introduction

In northeastern United States, surface waters of aquatic ecosystems have been heavily impacted due to acid rain deposition and climate change processes. With emissions control plans in place in North America and Europe, there has been observation of recovery.

Methods

In this project, researchers analyzed long-term monitoring and meteorological data for Vermont's 12 acid-impaired lakes. To assess the biological response to these processes, we collected monthly phytoplankton samples in four focus ponds (Beaver, Big Mud, Bourn, Haystack) representing a gradient of DOC concentration during ice-free seasons of 2018 and 2019. We also reconstructed paleo-chemistry and diatom community composition in Beaver Pond from approximately 1836 to the present.

Results

We found that phytoplankton community composition varied seasonally within and between lakes but was generally dominated by chrysophytes and dinoflagellates except for Big Mud Pond, which was dominated by filamentous green algae. We found low concentrations of potentially bloom-forming cyanobacteria at all sites and we did not observe bloom events during the study period. Paleo analyses for Beaver Pond indicate that the largest shift in in diatom community composition has occurred over the last 30 years, but that modern assemblages are significantly different than pre-acidification. Together, our modern and paleolimnological analyses indicate that sensitive, high-elevation ecosystems are rapidly changing in response to multiple pressures. Funding for assessment of the risk of shifts to a cyanobacteria-dominated state has been secured.

Products

Diamond, S. (2021). "Assessing chemical and biological recovery from acid rain deposition in montane vermont lakes" PhD diss., University of Vermont; ProQuest Dissertations & Theses A&I. (2524210441). Retrieved from https://login.ezproxy.uvm.edu/login?url=https://www.proquest.com/dissertations-theses/assessing-chemical-biological-recovery-acid-rain/docview/2524210441/se-2?accountid=14679

Diamond S. 2020. A look into the past: understanding how shifts in diatom communities are indicative of recovery from acidification. Lake Champlain Sea Grant: Zoom a Scientist.

Diamond S, Harvey RA, Morales-Williams A. 2019. Response and Recovery from Acidification in Vermont Lakes: Assessing the Sensitivity of Acid Impaired Lakes to Cyanobacteria Blooms. "Presentation to North American Lake Management Society, 2019."

Diamond S, Harvey R, Heathcote A, Lini A, Morales-Williams A. 2019. Browning or Greening? Diatom Community Changes in an Acid Impaired Lake. "Presentation at the Association for the Science of Limnology and Oceanography, San Juan, PR., 2019."

Impact of storms on lake phytoplankton community dynamics

Investigator Jason Stockwell

Introduction

Although climate change is expected to cause more intense and frequent extreme weather events, we only have a basic understanding of how these events might alter freshwater phytoplankton communities. Storms can have strong impacts on thermal stratification and mixing dynamics of lakes, which in turn may influence niche availability and phytoplankton succession, and thus taxonomic and functional diversity of freshwater phytoplankton communities. A working group ("Storm-Blitz") was organized within the Global Lake Ecological Observatory Network (GLEON) in 2013 to address questions about the impacts of storms on phytoplankton community through sharing of long-term datasets and high-frequency data in lakes across the globe.

Methods

Our limited knowledge on storm impacts on phytoplankton communities is related to difficulties in i) disentangling storm-related impacts from the influences of environmental factors, especially those involved in seasonal dynamics, ii) identifying general rules across lakes due to individual characteristics of lakes and watersheds. To overcome these two difficulties, the group proposed multi-variate comparative approaches and developed a R-package to assist the use of heterogeneous phytoplankton datasets for inter-lake comparisons. Based on analysis of the aggregated long-term data sets, the group demonstrated that long-term series can be efficiently used to answer questions related to storm impacts on lake physical and biological characteristics such as water temperature and phytoplankton communities.

Results

In its 2020 paper "Storm impacts on phytoplankton community dynamics in lakes," the group identified how storms interact with lake and watershed attributes and their antecedent conditions to generate changes in lake physical and chemical environments. Related datasets and computed derived data are accessible through the FEMC archive/portal system. Those data will be used to carry on testing hypotheses and further analysis.

Products

Stockwell JD, Anneville O, Patil VP (2020) Global Evaluation of the Impacts of Storms on freshwater Habitat and Structure of phytoplankton Assemblages (GEISHA). Available online at: https://www.uvm.edu/femc/data/archive/project/geisha-stormblitzfr

Stockwell JD, Doubek JP, Adrian R, Anneville O, Carey CC, Carvalho L, et al. 2020. Storm impacts on phytoplankton community dynamics in lakes. *Global Change Biology* 26:2756-2784. https://doi.org/10.1111/gcb.15033

Stockwell JD. September 30, 2020. Storm Impacts on Phytoplankton Community Dynamics in Lakes. "Presentation at the Lake Champlain Sea Grant Research Seminar Series, 2020." Available at: https://www.uvm.edu/seagrant/storm-impacts-phytoplankton-community-dynamics-lakes

Influence of changing lake temperatures on early life stages of freshwater whitefishes at local to global scales: modeling and experimental approaches

Investigators Jason Stockwell and Taylor Stewart

Introduction

Water temperature in lakes is increasing due to climate change, but we do not understand how managed resources will adapt (or not) to such changes. Freshwater whitefishes, *Salmonidae Coregoninae*, are of great socio-economic value but critically sensitive to the effects of increased water temperatures because they are cold, stenothermic fishes. The evolutionary responses of many species are predicted to be inadequate to counter the speed and magnitude of climate change, leaving species vulnerable to decline and extinction. Shifts in physiology or reproductive phenology of populations living close to their physiological limits will be required if species are to persist as water temperatures continue to increase across the globe.

Methods

We used a cross-lake, cross-continent, cross-species approach to experimentally evaluate the response of coregonine embryos to changing incubation thermal regimes. Our experiments demonstrated both similar and contrasting reaction norms to temperature for life-history and morphological traits in conspecific and congeneric coregonines. Additionally, the field sampling support from this project enabled an additional laboratory experiment to be conducted examining the effect of light on embryo incubations for freshwater whitefish.

Results

Propelled by this research, a degree-day model to evaluate latitudinal differences in, and potential impacts of, changing thermal habitat on the relationship between spawning and hatching dates is now under development. Knowing how populations have adapted historically to environmental variability will help us understand the range of possible responses to climate change and assist managers to conserve coregonines.

Products

Stewart, T.R., Mäkinen, M., Goulon, C. 2021. Influence of warming temperatures on coregonine embryogenesis within and among species. *Hydrobiologia* **848,** 4363–4385. https://doi.org/10.1007/s10750-021-04648-0

Stewart TR, Mäkinen M, Brun C, Goulon C, Guillard J, Lasne E, Karjalainen J, Stockwell JD. 2020. Influence of changing lake temperatures on coregonine embryogenesis at local to global scales. 14th International Coregonid Symposium (WebCoregonid2020). June 2020.

Administration and Information Transfer

Investigators William "Breck" Bowden (Director) and Julianna White

The Vermont Water Resources and Lake Studies Center facilitates water resources-related research and supports faculty and students at Vermont colleges and universities. Water resources management research, including physical, biological, chemical, social science, and engineering were solicited in the 2019-2020 RFP. Four research projects, including two graduate student projects from University of Vermont and two faculty projects from University of Vermont were selected, based on reviews by external peers and the advisory board. Five undergraduate students, three graduate students, and three post doctorate scholars were funded through 104b and matching funds from these projects. The Water Center supports administration of projects; financial and technical reporting; linkages among researchers, stakeholders, and decision-makers; and communication of results. This supported sites such as the VT Water Center website and related programs and resources for public education and use.

Vermont Water Center publications resulting from support in previous years

Euclide, PT, Marsden JE. 2018. Role of drainage and barriers in the genetic structuring of a tessellated darter metapopulation. Conservation Genetics 19:1378–92 https://doi.org/10.1007/s10592-018-1107-2

Giddings LA, Chlipala G, Driscoll H, Bhave K ,Kunstman K, Green S, Morillo K, Peterson H, Maienschein-Cline M. 2020. Seasonal Ely Rock Copper Mine Superfund Site Shotgun Metagenomic and Metatranscriptomic Data Analysis. *Data Brief*. 32, 106282. https://doi.org/10.1016/j.dib.2020.106282

Giddings LA, Chlipala G, Kunstman K, Green S, Morillo K, Bhave K, Peterson H, Driscoll H, Maienschein-Cline M. 2020. Characterization of an Acid Rock Drainage Microbiome and Transcriptome at the Ely Copper Mine Superfund Site. *PLoS ONE*. 15 (8), e0237599. https://doi.org/10.1371/journal.pone.0237599

Hammond Wagner CR, Greenhalgh S, Niles M, Zia A, Bowden WB. 2020. Evaluating water quality regulation as a driver of farmer behavior: a social-ecological systems approach. *Ecology and Society* 25(4):35. https://doi.org/10.5751/ES-12034-250435

Hamshaw SD, Engel T, Rizzo DM, O'Neil-Dunne J, Dewoolkar, MM. 2019. Application of unmanned aircraft system (UAS) for monitoring bank erosion along river corridors. Geomatics, Natural Hazards and Risk. 10:1285-1305. https://doi.org/10.1080/19475705.2019.1571533

Millarhouse A, Vatovec C, Niles M, Ivakhiv A. 2020. What's in your body of water? Reducing the psychological distance of pharmaceutical pollution through metaphoric framing in risk communication. *Environmental Management*. 65: 630–641. https://doi.org/10.1007/s00267-020-01275-8

Perillo VL, Ross DS, Wemple BC, Balling C, Lemieux LE. 2019. Stream corridor soil phosphorus availability in a forested–agricultural mixed land use watershed. *Journal of Environmental Quality*, 48(1), 185–192. https://doi.org/10.2134/jeq2018.05.0186