

Lake Champlain: Our Future is Now

Lake Champlain Research Conference

January 8th-9th, 2018

Davis Center, University of Vermont

Burlington, VT  
[www.lcbp.org/lcrc](http://www.lcbp.org/lcrc)

**ABSTRACTS**



**Day 1: January 8th, 2018**

8:30-4:30 PM: Registration

8:00-10 AM: Coffee, Breakfast, and Networking

9:30 AM: Welcome

*Silver Maple Room*

10:30 AM – 12 PM: Concurrent sessions

10:30 AM – 12 PM: Concurrent Session A: Fish, Wildlife, and Habitat

Moderator: J. Ellen Marsden

* 10:30-10:45 AM: Vermont Dam Screening Tool

*Shayne Jaquith, The Nature Conservancy*

***Abstract.*** River corridors and their floodplains are highly productive ecosystems and provide a range of ecosystem services such as flood mitigation and water quality maintenance. Simultaneously, river corridors are among the most heavily managed ecosystems. Because of extensive management, a great percentage of floodplains have been hydrologically disconnected from the rivers they border, greatly reducing the flood mitigation and water quality benefits they would optimally provide.

Within the context of climate-change driven increases in flood frequency and magnitude along with increasing nutrient loading of surface waters, resource managers have started to look to the hydrologic and vegetative restoration of floodplains as a means or mitigating flood risk and water pollution. Although such restoration activities are increasingly popular, the impact they have on downstream flood stages and water quality remains imprecisely understood and is rarely quantified. There is a need to quantify how these floodplain restoration activities may mitigate flooding and improve water quality so that limited restoration resources can be most effectively utilized to address these challenges.

To address these research needs, we developed a hydraulic model to simulate the influence of floodplain re-vegetation and increasing floodplain connectivity on stream power, water depth and channel velocity at 5yr and 100yr flow return periods for two catchments located within the Lake Champlain basin. Further, we combined a multi-objective spatial optimization approach with the hydraulic model to target investments in floodplain re-vegetation and reconnection that maximize avoided damages from flooding and minimize the cost of intervention. Our preliminary modeling results show decreases in flow velocity associated with these restoration activities and reveal optimal locations for mitigation of flooding impacts within our study basins. Under all optimal scenarios, we find that the benefits of interventions exceed the costs. However, marginal benefits decrease as investment increases.

* 10:45-11:00 AM: Role of drainage and barriers in the genetic structuring of a tessellated darter metapopulation

*Peter Euclide, University of Vermont*

***Abstract.*** Although genetic structuring of populations is easily identified, the causes of the structure can be difficult to determine. Habitat fragmentation in aquatic systems has often been identified as a major source of increased population structure and decreased genetic diversity in fish, including benthic resident species such as darters. However, these findings are not replicated across natural and manmade barriers and generally focus on endangered or threatened populations in which the genetic structure is likely already compromised due to small population size. To evaluate factors involved in structuring a healthy darter metapopulation, we genotyped 504 tessellated darters from 18 sites in three different river drainages and one large lake (Lake Champlain). Sites were all in the same watershed but separated from one another by one or more of three different types of barriers: dams and natural fall lines in rivers, and causeways in the lake. We found that although diversity and allele frequency varied largely by drainage, within-drainage variation was minimal even across multiple barriers. No single barrier type appeared to be a stronger barrier than any other. Our results indicate that healthy populations of darters may naturally be structured by drainage, but likely allow sufficient downstream dispersal across barriers to retain drainage-wide panmixia.

* 11:00-11:15 AM: Water quality blueprint – nature-based solutions for clean water in Lake Champlain

*Dan Farrell, The Nature Conservancy*

***Abstract.*** Natural systems are increasingly considered to be cost-effective solutions to water quality problems, providing multiple ecological co-benefits. The Water Quality Blueprint is a publicly accessible online tool designed to help watershed managers and conservation practitioners make use of natural and restorable areas to achieve water quality and conservation goals in the Vermont portion of the Lake Champlain Basin. It includes two independent prioritizations of floodplains and other areas associated with rivers, lakes and wetlands: a map layer that highlights natural assets that would benefit from protection and restoration (Conservation Value) and a map layer that highlights locations that are impaired, at risk of impairment or that may attenuate sources of pollution (Water Quality Impact Value). These prioritizations are raster-based, weighted combinations of multiple component datasets that represent important habitats, natural processes, and impairments. The component datasets, as well as other supporting datasets, are included in the web-map to help users understand patterns related to ecology, pollution, restoration potential, and fluvial processes at the site, watershed, and basin scales. The results of the Water Quality Blueprint have been incorporated into the Clean Water Roadmap for Vermont, an online tool designed to support the VTDEC's efforts to reduce phosphorous pollution in the Lake Champlain Basin.

* 11:15-11:30 AM: Diet analysis of wild and stocked juvenile lake trout in Lake Champlain: Looking for clues that explain recruitment

*J. Ellen Marsden and Madeline Schumacher, University of Vermont*

***Abstract.*** Lake trout disappeared from Lake Champlain by 1900, and have been stocked as age-0 and yearlings since 1972; until recently, however, little to no natural recruitment has occurred. Stocked fish, identified by fin clips, are assessed annually in fall at spawning sites; no regular sampling for juveniles is conducted. In 2015 we began focused bottom trawling for juvenile lake trout, and found 23% of age-0 to age-3 were wild (i.e., progeny of stocked fish). The proportion increased to 33% in 2016, and 50% in 2017, with increasing numbers of young-of-the-year lake trout each year. Our goal is to understand what factors are involved in this sudden successful recruitment of wild lake trout. Potential prey of age-0 lake trout may have become more available, or competition with stocked lake trout may have altered. We analyzed diet and condition factor of 622 wild lake trout and 870 stocked lake trout between 50 and 400 mm total length collected in May to November 2015-2017. Stocked fish were, on average, the size of wild fish one year older. Average Fulton’s condition factor was slightly higher overall for stocked fish (0.90) than wild fish (0.83), and higher in spring and fall than mid-summer. Mysis comprised 90-100% of the diet (by number) of age-0 wild lake trout, 90% of the diet of wild spring yearlings, and 45-54% of the diet in summer and fall of age-1 fish. In contrast, only 15-60% of the diet of age-0 stocked fish, seasonally, was Mysis. By age 1, the diet of stocked fish was very similar to that of the wild age-2 lake trout, consisting of small smelt, sculpin, alewife, and Mysis. The low diet overlap of age-0 wild and stocked fish suggests competition is not likely to be a limiting factor; instead, recruitment may depend on availability and abundance of Mysis. Mysis populations declined dramatically in the 1990s and have not apparently recovered. Changes in distribution, local abundance, or spatial overlap of Mysis with age-0 lake trout may potentially explain increased survival of young lake trout beginning in 2015.

* 11:30 AM-11:45 AM: Does elevated water temperature in causeway openings differentially affect movement of coldwater and coolwater fish in Lake Champlain?

*Jessica Griffin and J. Ellen Marsden, University of Vermont*

***Abstract.*** Causeways in Lake Champlain divide the lake into distinct basins. Although the causeways have openings which allow water to flow through them, the extent that fish pass through the openings is unknown. If the openings restrict fish movement, fish may become isolated or unable to reach spawning grounds. Conditions in the causeway openings, especially temperature, may affect passage through causeway openings. Coldwater and coolwater fish, such as lake trout and walleye, have different optimal temperature ranges – 10-15 °C for lake trout, and 18-22 °C for walleye – and tend to avoid the warm waters of the epilimnion. Thus, water temperature in the shallow openings of Lake Champlain’s causeways may restrict their movement in summer. We hypothesized that the frequency of movement through causeway openings by lake trout and walleye would be negatively correlated with temperature, and that lake trout movement would be limited to a greater extent than walleye movement because lake trout have a lower optimum temperature range. We tracked the movements of these two species in Lake Champlain using acoustic telemetry. A total of 93 lake trout and 27 walleye were captured in 2013-2016, surgically implanted with 3-year acoustic tags, and their movements were monitored using passive receivers placed throughout the lake. Temperature data at causeways were collected with HOBO temperature loggers placed year-round at six causeway openings. Preliminary results support our hypothesis: frequency of transitions through causeways for both species decreased during the summer months and was highest during the winter months. Additionally, lake trout crossed causeways less often during the warmer months than walleye. These results suggest that the warm water in causeway openings may act as a seasonal barrier to fish passage, possibly interrupting feeding and spawning movements and contributing to the 60-year decline of walleye in Lake Champlain. However, we also need to consider that the shallow water in the area of causeways may have historically limited lake trout and walleye movements prior to construction of the causeways.

* 11:45 AM-12:00 PM: Extended Discussion

10:30 AM – 12 PM: Concurrent Session B: Preventing algal blooms in the Missisquoi Bay of Lake Champlain: Interdisciplinary approach to identifying opportunities for improving agro-ecological programming

Moderator: Jean-Francois Bissonnette, Université du Québec en Outaouais

* 10:30-10:45 AM: Evaluating the state of knowledge diffusion in agrienvironment in the context of intensive agriculture in Southern Quebec

*Jean-Francois Bissonnette and Jerome Dupras, Université du Québec en Outaouais*

***Abstract.*** Southern Quebec’s agricultural sector is faced with an important number of environmental issues related to soil quality, water management, along with forest cover and biodiversity conservation. To try and reduce environmental impacts of intensive agriculture, authorities have developed advisory service programs in agrienvironment to improve knowledge diffusion on agro-ecological practices and access to services in this field. Agronomists acting as agrienvironmental advisors play an important role in this process given the personalised services they are able to provide to farmers. Advisors are often called upon to create a bond of trust with farmers, while they manage to bring together farmers with different service providers and give access to funding programs and specific agrienvironment schemes. However, according to recent studies, despite some promising initiatives, the changes in public fund allocation for advisory service programs and sustained economic pressure on the farming sector has somewhat limited the scope of agrienvironment knowledge diffusion. As such, this project aims to document the current state of knowledge diffusion related to agrienvironmental practices by focusing more specifically on the experience and perspectives of advisors who provide support to farmers.   
  
To do so, the research project has two main objectives: 1) to analyse the institutional and organisational context in which advises in agrienvironment are provided by a range of actors, the purpose being to record modes of collaboration between stakeholders from numerous sectors located at different administrative levels involved in advisory services; and 2) to evaluate the agricultural sector’s response to environmental regulations beneficial to improving environmental quality in relation with access to advisory services. Data is derived mainly from program documentation and semi-structured interviews with agrienvironment advisors from local non-profit agrienvironment clubs and private-sector agrienvironment service providers. This study seeks to assess the scope and limitations of agrienvironment advices to improve environmental quality and especially water quality in regions of intensive agriculture in Southern Quebec, with a special emphasis on Montérégie and the Missisquoi Bay watershed area.

* 10:45-11:00 AM: The effect of cyanobacteria on water quality and recreation: A study of willingness to pay in southern Quebec

*Chloe L’Ecuyer-Sauvegeau, Université du Québec en Outaouais*

***Abstract.*** Cyanobacteria or blue-green algae are naturally found in waterbodies. However, when nutrients, largely coming from agricultural production and municipal releases, are present above a certain level in the water, it increases harmful algal bloom phenomena and toxins can be released (Wolf and Klaiber 2017). Toxins released by cyanobacteria can cause health problems and have an effect on recreational activities, tourism, and on the well-being of residents due to the odours emitted, and their visual and ecological impacts (Bejranonda et al. 1999, Ho and Michalak 2015, Wolf and Klaiber 2017). In 2015, 99 lakes were impacted by the presence of one or more algal bloom over the summer in Quebec (MDDELCC 2016). Due to the magnifying impact of climate change on algal blooms (Wolf and Klaiber 2017), their occurrence is likely to increase in the coming years and become a societal concern because of their environmental and economic impacts (Andersson 2009; Steffenson 2008). This is a particular concern in the Missisquoi Bay where the issue is already important (Chouinard 2015). In this context, it is urgent to find ways to reduce the anthropogenic release of nutrients in watersheds and apply solutions to this end. Some of these solutions are already known, but they remain costly and complex to administer, especially given the fact that the issue cannot be resolved within local administrative boundaries (Emond 2015). This research looks at the willingness to pay (WTP) of recreational water users to finance solutions that would reduce nutrient loads at the watershed level and thus enhance water quality. The data collection was administered to over 200 people and performed in person using a 20-minutes long questionnaire. In order to obtain each respondent’s WTP to improve water quality through an increase in municipal taxes, a choice modelling approach was used. This method also enables the identification of characteristics (visual aspect, activities that were safe to perform in the waterbodies, odour, ecosystem health and cost) that are the most important to users and it outlines the trade-offs made by respondents when choosing a scenario (Bateman et al. 2002). A preliminary analysis showed that some respondents had concerns about the ability of governments to resolve the problem. In addition, the majority of respondents had very little knowledge about the ways in which they contribute to the phenomenon, and a lot of them were mixing up water-related issues. This qualitative information combined with the WTP of recreational water users could be used by planners and decision makers to target solutions to reduce nutrient loads coming from different sources in watersheds.

* 11:00-11:15 AM: The economic characteristics of watershed goods and services: a novel institutional approach

*Vijay Kolinjivadi, Université du Québec en Outaouais*

***Abstract.*** Understanding linkages between human well-being and ecological stewardship at the land-water nexus is needed in order to develop effective, equitable, and resilient institutions to govern watershed resources. In 2011, The Food and Agricultural Organization of the United Nations identified specific policy and institutional support recommendations for visioning a ‘new generation of watershed management programmes’. These recommendations emphasize the role of innovative financing, increased social deliberation of policy choices and highlight socio-economic development within watershed management frameworks. They also recognize the role of incentive-based approaches such as ‘payments for ecosystem services’ (PES) as playing an integral role in overcoming shortcomings of the integrated and adaptive water resource management framework (IWRM). In this presentation, we respond to questions assessing the potential of PES in actualizing IWRM, including how economic characteristics of ecosystem services inform the set of institutions required for effective and long-term watershed governance, and ways in which human well-being is dependent on the resiliency of ecosystem services. In response, we propose a conceptual framework that identifies the potential of PES in managing watershed services as well as the institutional level for which PES should be applied in realizing IWRM. We argue that PES plays a useful role for IWRM if attention is drawn to: (a) nested governance arrangements reflecting horizontal coordination across space according to the economic characteristics of watershed goods and services as well as hierarchical legitimacy between higher and lower levels of governance; (b) ‘payments’ that are socially negotiated rather than designed according to oversimplified efficiency claims for watershed services and (c) ‘payments’ that are well placed to overcome the individual, social and physical constraints associated with watershed goods and services so that capabilities or the ‘freedom to do and be’ (e.g. Sen, 2010) can be enhanced. We also emphasize that PES collective agreements provide the opportunity to improve well-being through enhanced capability sets for individuals. Specifically, we argue that management of watershed goods and services requires governance at nested scales to further link ecological integrity of the resource base with the welfare-enhancing values that characterize an improved capability set for stakeholders. We conclude by illustrating the impossibility of effectuating sheer market-based trades for regulating, cultural and supporting ecosystem services in watershed settings due to their inherent non-rival characteristics. We also emphasize how nested governance arrangements serve to better visualize IWRM as providing a bundle of watershed goods and services to beneficiaries at both local and global scales.

* 11:15-11:30 AM: Institutional analysis of the regulatory and voluntary agri-environmental measures in Quebec and their implications for the design of Payments for Ecosystem Services (PES)

*Alejandra Zaga Mendez, Université du Québec en Outaouais*

***Abstract.*** Agri-environmental programs have gained considerable attention in the Canadian province of Quebec in recent years. Initiatives to encourage the implementation of sound agri-environmental practices that improve water quality through the implementation of riverbank buffer zones are being encouraged through sanction-based regulations, provincially funded subsidies such as Prime Vert, and more private pilot initiatives such as the Alternative Land Use Services (ALUS). This latter initiative introduces for the first time a payment for ecosystem service (PES) arrangement to the Quebec agricultural policy landscape.

In this work, we consider that the institutional design of new PES arrangements requires closer attention to the institutional, historical and political aspects of previous regulations and programs aimed to encourage the adoption of sound agri-environmental practices in Quebec and the improvement of the quality of targeted ecosystem services.

Moreover, agri-environmental governance relies on a variety of policy instruments and depends on a combination of community-based institutional arrangements, market tools and governmental command and control. Thus, this research proposes closer engagement with the institutional complexity of how agri-environmental governance develops in practice.

The aim of this paper is to identify the synergies and gaps between the regulatory and the voluntary approaches presented in the current agri-institutional governance framework in Quebec, by comparing the language of regulations (i.e. Agricultural Operations Regulations) to the language of incentive-based programs (i.e. Prime Vert), and suggesting institutional considerations for the design of future PES initiatives within agricultural policy. This content and institutional analysis will characterize the current institutional language of incentives and compare it to the characteristics of sanctions in terms of effectiveness and deficiencies.

The results of this research identifies salient institutional opportunities and constraints for future incentive-based mechanisms such as PES for agri-environmental management in Quebec, which still lack a theoretical grounding to justify their application. This research pays special attention to the analysis of the normative role of institutions and their dynamics in order to go beyond a focus on legally binding rules and command and control policies towards more diverse and hybrid institutional frameworks.

* 11:30-11:45 AM: Developing agro-environmental scenarios for multiple ecosystem services – a co-benefits approach

*Sylvia Wood and Caroline Simard, Université du Québec en Outaouais*

***Research Background***. Agricultural practices in southern Quebec have intensified over the past decades with impacts for biodiversity and water quality, especially in the Lake Champlain basin. Current public and private programs to encourage the uptake of mitigating agro-environmental practices in Quebec have met with limited success controlling nutrient pollution to date. In addition to low adoption, these programs fail to integrate the role of landscape heterogeneity and farming heterogeneity practices when designing program-roll out and incentive structures, potentially impacting program effectiveness.

***Questions***. How does targeting agro-environmental practices to landscape context potentially increase the effectiveness of water quality services? How does consideration of environmental co-benefits change the targeting approach?

***Methods.*** We will use spatially explicit ecosystem service-modelling tools, MESH and RIOS, to rapidly assess multiple ecosystem services provision across the Baie Missisquoi basin and target agro-environmental practices across the landscape based on published efficiencies and costs. We compare two scenarios i) interventions optimized for water quality and ii) interventions optimized for multiple ecosystem services.

***Results & Conclusions***. Preliminary results suggest that targeting agro-environmental practices based on landscape context can improve the delivery of water quality ecosystem services over ad hoc adoption patterns. Furthermore, when we consider the environmental co-benefits, certain practices become more highly selected despite their weaker efficiencies for water quality protection (e.g. riparian buffers). These initial findings suggest that public and private programs may be able to increase their cost-effectiveness by prioritizing hotspots across the landscape, however decision-makers will need to consider which sets of environmental goals they hope to achieve through promotion of agro-environmental practices.

* 11:45 AM-12 PM: Do windbreaks and managed riparian habitat maintain robust wildlife communities in fragmented ecosystems?

*Matthieu Beaumont and Jérome Dupras Université du Québec en Outaouais*

***Abstract.*** Urgent change towards sustainable agricultural intensification implies landscape design management to implement actions supporting robust wildlife communities and enhancing ecosystems services. Ecological network initiatives are privileged to maintained functional connectivity and preserve components of diversity. In my Phd research, I am exploring the potential of landscape linear elements such as windbreaks and managed riparian habitats to limit the erosion of connectivity in Monterégie fragmented agroecosystem (Québec). More specifically, I am estimating the contribution of these elements to reduce the resistance to movements in the landscape matrix. Landscape must be seen as a hierarchical mosaic matrix of contiguous and extensive cover types where animal movements are affected by the motivation of individuals to inhabit habitat patches. Species distribution patterns can then be used to estimate the levels of connectivity in a fragmented landscape. In low resistance matrix landscapes, diversity within habitat patches and similitude between habitat patches should be greater than in high resistance matrix landscapes. In this project, I am using the earlier Québec breeding birds survey (point count data) to evaluate the effect of linear elements on forest bird communities’ composition. I want to show how confounding effects such as habitat amount, fragmentation per se and matrix quality must be control to perform adequate biodiversity analyses. These analyses generate parameters that can be further integrated into a variety of connectivity management scenarios that incorporate empirical resistance values.

10:30 AM – 12 PM Concurrent Session C: Informing and building resilience to extreme events using an integrated modeling approach in the Lake Champlain Basin

Moderator: Elizabeth Doran, University of Vermont

* 10:30-10:45 AM: Exploring and defining resilience in Vermont: Town and regional disaster preparedness and planning

*Clare Ginger, University of Vermont, and Richard Kujawa, Saint Michael’s College*

***Abstract.***In 2011, the state of Vermont experienced flooding in the Lake Champlain Basin in the spring, and also from Tropical Storm Irene in late summer. In the wake of these events, the Vermont State Legislature passed Act 138 in 2012 and Act 16 in 2013. The former directed the Secretary of Administration to create a Flood Resilient Communities Program (10 V.S.A, § 1428(c)). The latter specified municipal-level actions to “encourage flood resilient communities” (43 V.S.A. § 4302(c)(14)). In 2013, the Lake Champlain Basin Program issued a report focused on flood resilience in the Lake Champlain Basin and the Upper Richelieu River. This report made policy and management recommendations to promote flood resilience (http://www.lcbp.org/wp-content/uploads/2013/04/FloodReport2013\_en.pdf accessed 10/27/2017).  
  
The United Nations Habitat Program defines resilience generally as “the ability of human settlements to withstand and to recover quickly from any plausible hazards” (https://unhabitat.org/urban-themes/resilience/ accessed 10/27/2017). In this presentation, we explore how the concept of flood resilience is defined more specifically through municipal planning and management in Vermont. We describe how municipal actions are assessed with the state-level Emergency Relief and Assistance Fund (ERAF) mechanism. Using an exploratory index calculated from ERAF compliance measures, we assess whether ERAF scores correlate with several factors including the relative impacts of Tropical Storm Irene. We also explore how Vermont’s Flood Resilience Checklist and the Vermont Economic Resiliency Initiative provide more detailed definitions of ‘resilience,’ and integrate both process and outcomes dimensions of the term. Finally, we consider the roles of regional planning commissions and the State of Vermont in supporting municipal level actions to increase flood resilience. We draw primarily on data from municipal records, regional planning commission websites, and databases compiled by the State of Vermont. We incorporate insights from informational interviews with regional and state-level authorities.  
  
We conclude with reflections on the challenges of implementing measures for resilience across scales of governance. We propose next steps to more fully understand how we can define and implement concepts of flood resilience in the Lake Champlain Basin and in Vermont more generally.

* 10:45-11:00 AM: The drones are coming

*Jarlath O’Neil-Dunne, University of Vermont*

***Abstract.*** For years we have used remotely sensed data to help us more effectively manage natural resources in the Lake Champlain Basin. But let’s face it, the data never had a high enough spatial resolution, it was not acquired at the appropriate time, and was simply too expensive. Drones are changing that, providing us with new ways to map, monitor, and measure resources within the Lake Champlain Basin. This presentation will go beyond the hype, using real-world examples to dive into the capabilities and limitations of drones, along with providing insight into best practices for using drones to support everything from disaster response to geospatial applications to natural resource management.

* 11:00-11:15 AM: Modeling the impact of extreme events on the water quality in Lake Champlain

*Bill Gibson, University of Vermont*

* 11:15-11:30 AM: Modeling water quality governance networks on the Missisquoi River Watershed

*Patrick Bitterman, University of Vermont*

***Abstract.*** The ability of a social-ecological system (SES) to manage its resilience to extreme events is dependent on the efficacy of governance actors across many scales, jurisdictions, and problem domains. The Lake Champlain Basin (LCB) SES can be characterized as a complex adaptive system — comprised of interacting actors, processes, and structural components that operate at various spatial and temporal scales. In the LCB, social and environmental processes (e.g., stormwater management, agricultural intensification, precipitation fluctuations) are adversely affecting water quality, creating impaired rivers and streams, and producing harmful algal blooms. While governments at the federal, state, and local scales play critical roles in addressing water quality issues in the LCB, non-governmental organizations and businesses also have key roles in managing water quality. Further, the Vermont Clean Water Act has empowered nascent watershed-scale groups to plan, implement, and manage interventions to improve water quality as well. Collectively, these organizations and institutions form a network of water governance, the shape of which can affect the ability of the SES to plan for and react to, extreme events. At the University of Vermont, researchers in the National Science Foundation-funded Basin Resilience to Extreme Events (BREE) program are working to build a series of integrated, coupled models to better understand how governance, hydrology, economics, and land use interact to affect water quality, ecological function, and human well-being in the LCB. This paper presents an adaptive agent-based model of the multi-scale, multiplex governance network in the Missisquoi Watershed, located within the LCB. Using this model, we explore how network structure, institutional rules, and resource allocations across three action arenas alter incentives for land managers and affect water quality in the LCB. Our results suggest that water quality and SES resilience are reduced as a result of spatiotemporal misalignment between policy objectives, expectations, and biophysical processes.

* 11:30-11:45 AM: Digging into adaptive capacity: On farm monitoring of indicators of soil health

*Sarah Coleman, University of Vermont*

***Abstract.*** “Soil health” receives ongoing attention as a critical element in being able to sustain agricultural production and avoid continued environmental degradation. But a challenge is that soil health encompasses a diverse and complex set of indicators and it cannot easily be prescribed to individual farm operations. Its achievement requires knowledge and a long-term commitment to a holistic and adaptive approach combining practices over time. This research addresses the question, “to what extent do agricultural producers assess indicators of soil health, and use feedback to inform decisions about farm management?” A second phase of a 2013 farmer survey in Lamoille and Missisquoi watersheds in Vermont was conducted in 2016. The importance of soil health information and its use in farmer management decision-making is being examined in the context of production systems, farmer attributes, and adoption of best management practices (BMPs) using the 2016 survey data. This research seeks to understand biophysical feedback reflecting soil health information as an adaptive management tool, its role in informing decisions, and its relationship to BMP adoption at the farm level. With soil health objectives at the root of so many agriculture and environmental initiatives, this research and future inquiry that digs into adaptive capacity and the different contexts for soil health management, can provide valuable context that can help inform technical assistance and policy network approaches.

* 11:45 AM-12 PM: Unpacking intention: Using agent based models to predict adoption of best management practices in the Missisquoi River Watershed

*Elizabeth M.B. Doran, University of Vermont*

**Abstract.** Addressing the challenge of excessive nutrient loading in Lake Champlain, and particularly the shallow bays, will require action across the lake’s watershed – a pastoral landscape where people have chosen to live and work. Many actions, or Best Management Practices (BMPs), intended to limit the release of nutrients from property to surface waters will be taken at the household, farm or business scale with individuals responding to both internal and external forces shaping and influencing their decisions. Agent based models (ABMs) have become a popular tool for analyzing these distributed, or bottom up, decision dynamics in complex social-ecological systems (SESs). When coupled with hydrological models and models of the lake itself, we can begin to understand the impact of these distributed decisions downstream. In this presentation, expect to become familiar with the decision models driving BMP adoption by the Farmer Agents in the VT EPSCoR ALL ABM. Preliminary results of the downstream impacts on the Lake will also be shared.

10:30 AM – 12 PM Concurrent Session D: Tile Drains and Nutrients

Moderator: Marli Rupe, Vermont Department of Environmental Conservation

* 10:30-10:45 AM: Edge-of-field nitrogen and phosphorus export in tile-drained field managed as corn for silage

*Eric Young, Stephen Kramer, and Laura Klaiber, Miner Institute*

***Abstract.*** Agricultural subsurface tile drainage is an important practice for farms with poorly drained soils and can substantially increase crop yields. While tile drains can facilitate the loss of nitrate-nitrogen, impacts on phosphorus (P) transport are less clear. We initiated a USDA-NRCS funded edge-of-field (EoF) water quality monitoring study in the fall of 2014 to compare nutrient export in surface runoff and tile drainage from two adjacent corn fields. The site is located in the Lake Champlain Basin of Clinton County, NY. Runoff monitoring has occurred year-round since late 29 October 2015. Soluble reactive P (SRP), total P (TP), ammonium-N, nitrate-N, total N (TN) and total suspended solids (TSS) in runoff are estimated by multiplying event mean concentrations by runoff volume. Two years of baseline runoff monitoring indicate that tile drain flow accounts for the majority of runoff flows leaving the fields. Tile drains run nearly continuously during the year, with the exception of very dry periods in summer and/or under extreme cold in the winter. Loading data and flow-weighted mean concentrations indicate that tile drains are the primary pathway for both TN and nitrate-N loss from fields. However, total P, SRP, TSS, and ammonium-N runoff losses were dominated by surface runoff. Total P exported in surface runoff was >10-fold greater in surface runoff compared to tile drainage, while surface runoff SRP export was 5.5 to 16.5-fold higher than tile drainage. Results suggest that surface runoff is the main pathway for both TP and SRP (i.e., bioavailable P) loss from fields, whereas tile drainage is the main pathway for N loss. With respect to agronomic efficiency, only a very small fraction of applied N and P in fertilizer/manure were recovered in runoff flows. Results highlight the importance of field hydrology and its impact on both P and N transport pathways.

* 10:45-11:00 AM: Four-component hydrograph separation model to predict phosphorus and tracers export from a Pike River subwatershed

*Aubert Michaud, R&D Institute for the Agri-Environment, Joann Whalen, McGill University, and Simon-Claude Poirier*

**Abstract.** Although surface runoff is associated to the dominant portion of annual phosphorus (P) loadings within the Pike River’s watershed, tile drain flow has also been linked to substantial P exports from clayey or sandy topsoils overlying marine or lacustrine clays. Field drainage monitoring experiments reported that between 53-80% of total drained water occurred through tile drain flow, which accounted up to 40% of the annual TP loss from fields. A study was carried out to further describe the hydrological pathways of P involved. Water electrolyte tracers and electrical conductivity (EC) were used to link the to P composition of surface and subsurface tile-drain water from 10 sampled fields to the water quality monitored at the Ewing’s subwatershed outlet (32.2 km2), located downstream of Pike’s watershed. A four-component hydrologic model was derived, separating the surface runoff, subsurface-tile-drain flow (matrix and preferential flow) and groundwater resurgence components, representative of the global mixing composition at the watershed outlet. The stream discharge was separated based on a mass balance equation using the EC as a simple method to differentiate the surface from the subsurface/tile drain contribution during peak flow. Within the subsurface/tile drain contribution, the preferential flow was discriminated from the matrix flow based on a computed EC-discharge relationship developed from water quality observations of tile drain and surface runoff monitored at the upstream agricultural field outlets. The four-component model was then used to predict P instantaneous load during distinct Fall and Spring seasons. Most f the total P (TP) loads exported at the watershed outlet (46-67%) originated from surface water runoff that occurred during peak flow. Subsurface tile-drained water accounted for 27-29% TP loads, of which 75-88% was linked to preferential pathway, as opposed to the matricial slower flow path. Groundwater resurgence accounted to for 4-9% TP. Streambank erosion was defined as a potential source ranging between 0-21% of the total exported TP and a significant source of PP (26-41%). TSS were linked to in-stream sorption of approximately 30% of the dissolved reactive phosphorus (DRP) exported from the fields. The separation of hydrograph peaks showed to be a reliable and simple method to differentiate sources of P in agricultural St. Lawrence Lowlands streams.

* 11:00-11:15 AM: Evaluating the impacts of agricultural tile drain systems to water quality in St. Albans Bay, Vermont, and the performance of a reactive media filter

*Dave Braun, Stone Environmental, Inc.*

***Abstract.*** Subsurface tile drainage is an essential water management practice on many agricultural fields in the Lake Champlain Basin, allowing timely equipment access, reduced soil compaction, and increased crop yields in fields otherwise too wet to efficiently farm. The combined effects of drawing down the water table and providing rapid conveyance of subsurface water to an outlet can enhance infiltration and groundwater transmission, reducing surface runoff. However, once dismissed as negligible, phosphorus (P) levels in subsurface tile drain flow are now recognized as potentially significant.  
  
Across the Lake Champlain Basin, little is known about the extent of tile drainage systems, and the potential impacts of tile drainage systems on water quality have not been assessed with adequate rigor. Stone Environmental is performing an intensive study in the Jewett Brook watershed in St. Albans, Vermont to address certain knowledge gaps. The objectives of this study are to quantify: 1) the degree of association between agronomic variables and P concentrations and loads in tile drain flow, and 2) the proportion of all P exported from the watershed that is contributed by tile drains.  
  
Twelve tile drains were selected for monitoring on commercial dairy farms in the Jewett Brook watershed, considering cropping system, soil type, and the construction and layout of the tile drain system. Construction of monitoring stations near the drain outlets was completed in April 2017. Flow rate is continuously monitored and composite water samples are processed weekly for total P, total dissolved P, and total nitrogen analysis.  
  
Results to date demonstrate extremely high variability in P concentrations among the sites and with time. Total P concentrations have ranged from 11 to greater than 4,000 µg/L. P concentrations in tile drain flow appear to reflect both soil P concentrations and the effects of recent nutrient additions. Patterns in these data will be explored and preliminary findings regarding the significance of tile drain nutrient loading will be presented.  
  
To mitigate P transport from tile drainage systems to receiving waters, USDA NRCS and others are exploring designs for reactive media filters constructed at tile drain outlets and in farm ditches to which tile drains discharge. There is a significant need for the development of standardized approaches to reduce tile drain P contributions. Stone designed, installed, and monitored two such media filters in 2016 on a farm in Franklin, Vermont, in collaboration with the Friends of Northern Lake Champlain. Concentrations and loads of total and dissolved P, total nitrogen, and total suspended solids were determined at the inflow and at the outflows of each filter over a one-year period. Drinking water treatment residuals removed 69% of total P overall, slightly higher than the 54% removed by the filter containing crushed limestone. The filters clogged prematurely due to higher than anticipated sediment loads.

* 11:15-11:30 AM: Impact of a winter rye cover crop on edge-of-field nutrient losses in corn silage production

*Keegan Griffith and Eric Young, Miner Institute*

***Abstract.*** Cover crops have the potential to reduce environmental impacts of corn production. The objective of this study was to quantify differences in nutrient loading between corn plots with or without a winter rye cover crop (Secale cerale). Four field plots (30 x 46 m) in Chazy, NY with edge-of-field monitoring were used for the study. Two plots were randomly assigned a rye cover crop treatment and were planted with a grain drill at a rate of 112 kg ha-1 after corn silage harvest in 2015 and 2016. Continuous water flow was monitored from each hydrologic pathway during runoff events. Soluble reactive P (SRP), total P (TP), nitrate-N, total N (TN), and total suspended solids (TSS) were measured and multiplied by runoff volume to estimate nutrient export. In general, rye plots had lower nutrient loss compared to control plots. Cumulative loads for nitrate-N and TN were 1.0 and 1.1 fold greater for control plots, respectively (31.4 vs. 29.8kg nitrate-N ha-1 and 37.8 vs. 43.0 kg TN ha-1). Cumulative TP and SRP loads were 3.1 and 3.0-fold greater from control plots, respectively compared to rye plots (1.1 vs. 2.4 kg TP ha-1 and 2.0 vs. 4.0 kg SRP ha-1). Total and SRP loads in surface runoff were 3.0-fold greater for control plots, respectively compared to rye plots (0.72 vs. 2.25 kg TP ha-1 and 0.63 vs. 1.89 kg SRP ha-1). TSS load in surface runoff was 2.1-fold greater for control plots, respectively compared to rye plots (0.8 vs. 0.2 kg ha-1). The impact of rye on tile drainage water quality was less clear. Results suggest that a winter rye cover crop was effective at reducing TP and SRP loading from surface water runoff as compared to corn silage left fallow after harvest.

* 11:30-11:45 AM: End of pipe filter prototypes for agricultural tile drains

*Tara Kulkarni, Norwich University*

***Abstract.*** Lake Carmi, located in Franklin County, Vermont, has a high phosphorus concentration ranging from 0.16 mg/L to 0.65 mg/L. The Total Maximum Daily Load (TMDL) limits all water entering the lake to 0.1 mg/L. The lake has experienced severe algal blooms, impacting water quality, aesthetics, and limiting the residents’ use of the lake and its recreational offerings. The Norwich University Environmental Engineering Research team has investigated several in-lake ecological solutions, including floating treatment wetlands, for phosphorus reduction as well as designed agricultural tile drain filters, using novel media to control the flow of external phosphorus into the lake. This presentation will focus on the various filter prototypes under investigation for end of pipe treatment at Lake Carmi. The presentation will include a discussion of results from the materials tested in filter development, including pervious concrete, gypsum, and WTRs. The phosphorus removal mechanisms using these novel media, will also be covered as well as the removal percentages and flow rates achieved for different combinations of materials tested. The initial results indicate that WTRs proved to be the best medium for phosphorus removal, with a 98% reduction of influent phosphorus concentrations, but with a slow flow rate of 0.000567 ft3/s. It was determined that a layer of WTRs placed in between two layers of pervious concrete would be a better filter design since it would retain some of the removal efficiency of the WTRs (about 55% in lab testing and 58% in the field) while increasing the flow to about 0.00283 ft3/s, an order of magnitude improvement. Work is still ongoing, however, this kind of end of pipe treatment has several advantages in phosphorus mitigation, as it allows for widespread application in any farm with an agricultural tile drain, as well as for wastewater treatment plant outfalls and other high phosphorus rich sources where the effluent is piped out, ensuring broad impact.

* 11:45 AM-12 PM: Phosphorus flows and legacy accumulation in Vermont from 1925-2012: Implications for nutrient management policy

*Michael Wironen and Jon Erickson, University of Vermont*

***Abstract.*** Phosphorus (P) is a scarce but critical input for agriculture, yet its overuse can lead to water quality degradation and eutrophication. Most P applied as fertilizer and manure binds to soils, accumulating over time, constituting a legacy source that has important implications for managing nutrient pollution of water bodies. To investigate how the flows and balance of P evolved over a period of rapidly changing technology, agricultural practices, and land cover, we modeled P flows in Vermont’s dairy-dominated agricultural system at county- and state-levels from 1925 to 2012. Over this time period, agricultural soils accumulated at least 1,000 tonnes of P annually, accruing a legacy P stock of more than 230,000 tonnes. The peak surplus of 4,439 tonnes occurred in 1950, declining to 1,493 tonnes per annum in 2012. The rate of legacy P accumulation at the state-level ranged from < 1 kg ha-1 to > 16 kg ha-1, depending on year and measurement method. The rate exceeded 5 kg ha-1 from 1959 onward for all years and methods. The decline in total P surplus reflects a reduction in P imports, with an 82% decline in fertilizer use being partly offset by an increase in animal feed imports, the largest source of P entering VT’s agricultural system since 1982. Despite declining inputs, milk output doubled over the same time period, a sign of increased P use efficiency. Simultaneously, animal unit density increased by > 250%, enabled by rising feed imports. While feed is imported and milk exported, manure remains in VT; hence, VT agricultural soils continue to accrue legacy P at rates > 5 kg ha-1, undermining efforts to reduce P runoff and achieve water quality targets. We discuss the governance and policy implications, including opportunities to revise nutrient management planning regulations to improve whole-farm nutrient accountability, which can help address the persistent P imbalance and the growing importance of animal feed as a P source.

12 PM-1 PM Lunch

1-2:30 PM Concurrent sessions

1-2:30 PM: Concurrent Session E: Nutrient and algal dynamics in the Lake’s shallow eutrophic embayments: drivers of inter- and intra-annual variability

Moderator: Andrew Schroth and Wilton G. Burns, University of Vermont

* 1:00-:1:15 PM: A comparison of FlowCam and microscopy methods for phytoplankton community assessment in Lake Champlain

*Allison Hrycik, University of Vermont; Angela Shambaugh, Vermont Department of Environmental Conservation; and Jason Stockwell, University of Vermont*

***Abstract.*** FlowCam is a particle analysis system, and its relatively recent application to phytoplankton permits rapid identification and biovolume measurements through automated imaging and analysis. However, direct comparisons of estimates from FlowCam and standard microscopy methods using diverse phytoplankton assemblages have been limited. We processed over 100 samples collected bi-weekly from heterogeneous regions of Lake Champlain from May to October 2015. Habitats ranged from shallow, eutrophic bays to the deep, mesotrophic main lake, and the phytoplankton assemblages included cyanobacteria, chlorophytes, diatoms, chrysophytes, dinoflagellates, and cryptophytes. We measured cell densities and dimensions with both an inverted microscope and a FlowCam, and compared taxa biovolumes and community metrics such as genera richness and diversity. FlowCam calculates higher biovolume estimates than microscopy, however, it is possible to calculate a conversion factors between the two methods to better synchronize results. Results from this study inform the use of FlowCam for diverse phytoplankton communities in other freshwater systems.

* 1:15-1:30 PM: Changes in the cyanobacteria community of Lake Champlain as revealed by the Cyanobacteria Monitoring Program

*Angela Shambaugh, Vermont Department of Environmental Conservation*

***Abstract.***Lake Champlain is a large complex lake, reflecting a wide range of water quality conditions across its 125 mile length. Cyanobacteria blooms have been a common occurrence in some areas of the lake for decades while others rarely experience bloom events. Since 2003, the Lake Champlain Cyanobacteria Monitoring Project has been tracking cyanobacteria density and composition around the lake. At the 15 open water locations associated with the Champlain Long-term Water Quality and Biological Monitoring Project, 3m tows utilizing a 63 µm plankton net were used to capture surface conditions. Several shoreline locations in the central and northern areas of Champlain have been evaluated using grab samples. Through these data, changes in the cyanobacteria community have been observed over the life of the project – the colonial cyanobacterium Woronichinia spp. has become less abundant in the main lake, and several new taxa (Limnothrix spp. and Scytonema crispum) now are present. On Missisquoi Bay, unidentified environmental conditions resulted in an almost complete disappearance of cyanobacteria during summer 2007 and a significant decrease in median cell density that has persisted to the present. We’ll discuss water quality and environmental changes that may have influenced cyanobacteria community dynamics throughout Lake Champlain over the last 16 years.

* 1:30-1:45 PM: The eutrophication of St. Albans Bay, VT: A paleolimnological assessment

*Andrea Lini, Matthew Kraft, and Suzanne Levine, University of Vermont*

***Abstract.*** Changes in land use and human population growth in the Lake Champlain basin since 1760 have had significant impacts on the trophic status of the lake. Due to the lake's large size, multiple basins and complex mixing patterns, however, the timing and intensity of eutrophication have varied between lake regions. To assess the progression of cultural eutrophication, sediment cores were collected from widely spaced sites and analyzed for a suite of paleolimnological indicators of productivity, nutrient conditions, and algal community structure. All analyses suggest that the sub-basins of Lake Champlain are naturally oligotrophic and that despite substantial deforestation, and agricultural and commercial activity on and around the lake, productivity and nutrient accumulation rates changed little prior to late 19th century. C/N ratios and C stable isotopes point to a progressive increase in the contribution of algal organic matter to the sediment. This is especially evident for the post-1950 records.  
  
Here we focus on the detailed, multi-core record of St. Albans Bay, where we collected four new gravity cores in Fall of 2016. These are in addition to previous cores retrieved from the bay in 2006. St. Albans Bay is currently one of the most eutrophic regions of Lake Champlain, and the new cores allow us to investigate the impact that continued cultural eutrophication has had on this shallow bay during the past decade. Previous data indicate that eutrophication of St. Albans Bay was concurrent with sewer installation and expansion in early 20th century, and again with urban development in the 1960–70s. The steady increase in algal organic matter deposition documented in the newly collected sediment cores suggests that, thus far, management practices implemented to ameliorate the conditions of the bay have had little to no effect.

* 1:45-2:00 PM: Bloom or no bloom: the dynamics of toxic cyanobacterial communities in Missisquoi Bay, Quebec

*Nathalie Fortin, Natural Research Council Canada*

***Abstract.*** The National Research Council Canada (NRC) has been monitoring and characterizing cyanobacterial blooms in Missisquoi Bay, Quebec since 2006. For the past two years our research activities have intensified as part of the Genomics Research and Development Initiative (GRDI) and the Genome Canada project “Algal Blooms, Treatment, Risk Assessment, Prediction and Prevention through Genomics (ATRAPP).”

We are using new sequencing technologies that are powerful molecular approaches to survey microbial diversity and investigate cyanobacterial dynamics. With these methods we were able to observe that the extensive flood event during the spring of 2011 was concomitant with the predominance of the genus Dolichospermum for the first time since 2008. High-throughput sequencing of 16S rRNA gene amplicons showed that shifts in dominance occurred primarily between the genera Microcystis and Dolichospermum since 2006. The results demonstrated that drastic shifts in populations favouring Microcystis appeared to be associated with intense rainfall events and the subsequent spike of nutrients such as phosphorus and total and dissolved nitrogen. A significant correlation between rainfall and the opportunistic pathogen E. coli was also identified in our tributary stations.

During intense rainfall episodes nutrients can originate from a variety of sources such as sewage overflow, surface runoff and tile drain effluents. The resulting high concentrations and types of nutrients can promote the growth of toxin-producing cyanobacteria. Redundancy analysis (RDA) revealed that toxic cyanobacterial blooms can be explained primarily by total nitrogen and phosphorus concentrations, and to a lesser extent by dissolved phosphorus.   
Knowledge of the bloom promoting factors in Lake Champlain combined with the identification of external sources of nutrients can contribute to the design of corrective measures and strategies for the abatement of toxic cyanobacterial blooms. Our results suggest that manure and fertilizer application prior to intense rainfall or prolonged periods of rain should be restricted and preferably avoided in the spring and throughout the year.

*Contributors: N. Fortin, N. Tromas, J. Shapiro, C.W. Greer*

* 2:00-2:15 PM: The potential contribution of streambanks to phosphorus loads in the Lake Champlain Basin, with a focus on the Missisquoi River

*Don Ross, Vanesa Perillo, and Beverley Wemple, University of Vermont*

***Abstract.*** Erosion of streambank soils has been identified as a major source of sediment to Lake Champlain, especially in the Missisquoi River watershed. The phosphorus (P) in this sediment contributes to P loads and may contribute to continued harmful algal blooms. We sampled streambank soils and adjacent land-uses in numerous tributaries of the Lake and measured total P, bioavailable P and the degree of P saturation. Land-use, land-cover included active dairy farms, abandoned agriculture, forests, wetlands and suburban development. In the Missisquoi River watershed, soils in actively managed silage corn and hay crops, and wetlands, were elevated in total P relative to the regional average (600 mg/kg). The total P of the corresponding streambanks of each land-use was statistically significantly lower. Forest soils and nearby streambanks were relatively low in total P. Bioavailable P (estimated with soil test P) was very low in forests, wetlands, and all the streambanks of the different land uses, but elevated in the active agricultural fields. The degree of P saturation averaged 36% in the corn fields, but was less than 21% in all of the streambanks. Little legacy effect from abandoned agriculture was observed, likely because P additions were not historically high. The combination of relatively low soil P and low saturation suggests that the streambank soils have little potential for short-term release of P if eroded into the adjacent streams. However, depending on buffer widths and stream channel behavior, continued erosion could easily lead to deposition of high-P sediment from the active agricultural land-use.

* 2:15-2:30 PM: Similar and contrasting drivers of nutrient and cyanobacteria dynamics in two adjacent shallow, eutrophic bays in Lake Champlain

*Wilton G. Burns, Jason Stockwell, Toby Smith, Bridger Banco, and Andrew Schroth, University of Vermont*

1:00-2:15 PM: Concurrent Session F: Stormwater treatment technologies – balancing volume and phosphorus reduction

Moderator: Becky Tharp, Watershed Consulting Associates

* 1:00-:1:15 PM: Lessons from 5+ years of stormwater bioretention research in Vermont

*Stephanie Hurley, University of Vermont*

***Abstract.***This presentation describes design, maintenance, and monitoring of a dozen bioretention cells at three sites in Vermont stemming from multiple research projects taking place over the past 5+ years. The specific bioretention cells are located on the University of Vermont campus, Burlington, VT; the Miller Farm Research Center, South Burlington, VT; and a suburban shopping plaza parking lot in Waitsfield, VT. I will share lessons learned about design features-- including soil media and amendments, native vegetation, and internal hydrology-- and the ways in which they influence water quality and hydrology of the bioretention systems. I will discuss specific issues pertaining to maintaining healthy and attractive vegetation in high-visibility settings, and in the context of variable precipitation patterns (saturation, drought) and intensive winter maintenance regimes (freeze-thaw, plowing, salt and sand application).

* 1:15-1:30 PM: Case Study: Bioretention installation at Giorgetti Arena, Rutland, and Harwood High School, Duxbury – design considerations, public partnership, aesthetic improvement and educational outreach in the name of improving water quality

*Andres Torizzo, Watershed Consulting Associates, LLC*

***Abstract.*** During the summer of 2017, two bioretention practices were installed at public institutions in two different Vermont communities.   
  
The first, at Giorgetti Arena in Rutland, a publicly owned sports facility in Rutland City, made use of an existing green space at the entrance to the parking lot to treat the majority of the arena's roof and parking lot using a design that mimics a natural stream bed and surrounding floodplain. The bioretention design also allows for the eventual incorporation of a bike path that will curve around the outer edge of the practice, providing users of the path with an opportunity to see stormwater management in action. This design process heavily involved the City of Rutland and the local Natural Resources Conservation District, illustrating how effective public involvement can lead to meaningful implementation.   
  
The second bioretention practice was installed at Harwood Union School in Duxbury as part of a campus-wide stormwater master plan grant obtained by the Friends of the Mad River. In collaboration with school stakeholders, in particular the science teachers for the 7th and 8th grade, the bioretention was designed to facilitate science curriculum focused on water quality in the Mad River watershed. The practice treats rooftop runoff via roof drains using a unique piping system that makes use of the hydraulic head generated by the roof's elevation vis-a-vis the bioretention to force water up out of the roof drain pipe (which is sub-surface) via a vertical standpipe and on to the bioretention's soil surface where it infiltrates back in to groundwater, versus being conveyed directly to a small tributary via stormwater pipes. The design also incorporates a suspended wooden walkway with integrated seating and a teaching platform to allow it to function as an outdoor classroom. Monitoring wells were also installed to allow students to obtain water samples for analysis for nutrients or other parameters.   
  
Presentation attendees will learn about the design process and how to facilitate final implementation through effective public partnerships.

* 1:30-1:45 PM: Visualizing Green Stormwater Infrastructure (GSI) to understand maintenance capacities of Vermont towns and aesthetic preferences of Vermont municipal officials

*Holly Greenleaf, University of Vermont*

***Abstract.*** We know that green stormwater infrastructure (GSI) can help integrate developed landscapes into more natural hydrologic patterns, but how can we integrate the planning and maintenance of GSI into our communities in more successful place-based and people-based ways? It is evident that maintenance and public perception are hurdles to overcome for successful GSI. Our research explores the maintenance capacities of Vermont municipalities and the role that landscape visualizations may play in helping to communicate ideas and elicit responses surrounding the planning, implementation, and maintenance of GSI. The long-term goal of the research is to base GSI planning and design decisions on the capacities of Vermont towns to maintain the systems and the visual and functional preferences of Vermonters. We included questions in an online survey conducted by the Vermont National Science Foundation Established Program to Stimulate Competitive Research (NSF-EPSCoR) Basin Resilience to Extreme Events (BREE) Team and administered by the Castleton Polling Institute. The survey went out to municipal officials in all Vermont municipalities in June 2017 and is the first of two surveys on stormwater management.   
  
Our first research question is to identify the current maintenance capacities of Vermont towns, including practices and access to equipment, that are required to maintain most GSI projects. Maintenance practices ranged from standard landscaping tasks to more specialized GSI management requirements. Our second research question is to gauge respondents’ aesthetic preferences and perceived maintainability, based on landscape visualizations of conventional stormwater management and GSI options. Landscape visualizations, including photo-simulations (Adobe Photoshop) and conceptual diagrams (Google SketchUp), were created to depict conventional drainage infrastructure and three different types of vegetated bioretention cells for a typical downtown street right-of-way in Vermont (background based on average population density). Respondents were asked to rate visual appeal and ability for their town to maintain the system. The final dataset is almost completed, and a preliminary dataset from the beginning of October 2017 included 215 respondents (23% of sample frame) from 138 Vermont municipalities (55% of all Vermont municipalities), and represented all of Vermont’s counties, 57% of land area, and 60% of Vermont’s population.   
  
We plan to have data figures to present at the Lake Champlain Research Conference to contribute to the knowledge of our capacity as a state to maintain GSI and the perceptions of our municipal officials for visual appeal and ability for their town to maintain conventional and green infrastructure systems. We hope this research can contribute to making GSI adapted to our towns and preferences of Vermonters to create green streets and resilient rights-of-way that are place-based, people-based, and valued.

* 1:45-2:00 PM: Floating treatment wetlands for stormwater pond performance enhancement – implications for application in northern climates

*Becky Tharp, Watershed Consulting Associates*

* 2:00-2:15 PM: Applying Bayesian Belief Network to understand public perception of green stormwater infrastructures in Vermont

*Qing Ren, University of Vermont*

***Abstract.*** Decisions of adopting best management practices made on residential properties play an important role in reduction of nutrient loading from non-point sources into Lake Champlain and other waterbodies in Vermont. In this study, we use Bayesian belief network (BBN) to analyze a 2015 survey dataset about adoption of six types of green infrastructures (GSIs) in Vermont’s residential areas. Learning BBNs from physical probabilities of the variables provides a visually explicit approach to reveal the message delivered by the dataset. Using both unsupervised and supervised machine learning algorithms, we are able to generate networks that connect the variables of interest and conduct inference to look into the probabilistic associations between the variables. Unsupervised learning reveals the underlying structures of the dataset without presumptions. Supervised learning provides insights for how each factor (e.g. demographics, risk perception, and attribution of responsibilities) influence individuals’ pro-environmental behaviors. We also compare the effectiveness of BBN approach and logistic regression in predicting the pro-environmental behaviors (adoption of GSIs).  
  
The results show that influencing factors for current adoption vary by different types of GSI. Respondents who own their residents (also in older age groups) are more likely to have adopted roof diversion. If runoff is a problem in neighborhood, respondents are more likely to have adopted rain gardens and/or tree boxes. County is a relatively important factor for current adoption of roof diversion, rain garden, and permeable pavement. The preference of each county varies. Younger respondents (<40) are more likely to have adopted rain gardens. Income is an important factor for infiltration trenches and permeable pavement. Generally speaking, higher income groups are more likely to adopt these infrastructures. Respondents who live in multifamily houses are more likely to have adopted constructed wetlands. Owners of larger properties with lower built proportion are more likely to adopt infiltration trenches and permeable pavement. In addition, Stormwater issues such as runoff, flooding in neighborhood, flooding on property, and lawn erosion are related. High probability of one issue also increases the probability of the other issues. Runoff issues are more likely to be considered as the governments’ (town, state, and federal agencies) responsibility, whereas lawn erosion is more likely to be considered as the residents’ own responsibility.   
  
When using the same set of variables to predict pro-environmental behaviors (adoption of GSI), BBN approach produces more accurate prediction compared to logistic regression.

* 2:15-2:30 PM: Extended Discussion

1:00-2:30 PM: Concurrent Session G: Floodplain Connectivity and Geomorphic Significance

Moderator: Mike Kline, Vermont Department of Environmental Conservation

* 1:00-:1:15 PM: Natural functioning floodplains in Vermont: Assessing their loss, value, and restoration

*Mike Kline, Vermont Agency of Natural Resources*

***Abstract.***Field-level stream geomorphic assessments have been completed for over 2,200 miles of river and stream in Vermont since 2004. Three-quarters of Vermont Rivers are moderately to severely incised (Kline and Cahoon, JAWRA, 2010). While channel down-cutting results from natural fluvial processes, the VT ANR has documented human alterations of river channels, floodplains, and watersheds that have occurred since European settlement, exacerbating incision and the loss of floodplain function. Frequently inundated floodplains reduce downstream flooding and fluvial erosion hazards, protect water quality by storing sediment and nutrient, and help create/maintain complex aquatic and riparian habitats (Loos and Shader, 2016; Opperman et al., 2017). These ecosystem services are of great interest to Vermont as it endeavors to secure the health, safety and general welfare of its citizens. The Vermont Rivers Program is working with both researchers and practitioners to document these services in Vermont and expand on both our theoretical and practical knowledge of restoring natural-functioning floodplains, including the environmental and social challenges that may govern our progress.

* 1:15-1:30 PM: Restoring floodplains in Vermont

*Roy Schiff, Milone & MacBroom*

*Abstract.* Connected floodplains reduce flood levels, limit erosion potential, store fine sediment, and take up nutrients. This talk will highlight Vermont case studies to return important functions of floodplains that ultimately improve water quality and protect Vermont communities. Restored floodplains have been shown to reduce potential flood damages and save millions of dollars in recovery funds.

* 1:30-1:45 PM: Geomorphic and hydrologic controls of Japanese knotweed, an invasive exotic plant species: Lessons learned from the Western U.S.

*Rebecca Diehl, University of Montana*

***Abstract.*** Japanese knotweed, a non-native exotic plant species, is pervasive along many stream banks and lake margins throughout the Lake Champlain Basin. Because of its ecology and morphology, knotweed alters native flora and fauna and influences the stability of landforms and mobility of sediment. As a result, knotweed is believed to have a negative impact on riparian habitat, reducing flood resiliency, and contributing to sediment and nutrient loading to Lake Champlain. Manual or chemical removal efforts have had limited success. To better manage invasive plant species, I propose that we need a better understanding of the physical controls on plant establishment and success.   
  
In the Western US, the non-native plant Tamarisk has, over the last century, expanded its range to become one of the most common plants growing along many riparian corridors. Recent research has demonstrated that distinct hydrologic and geomorphic controls exist on its presence and density. As a result, river managers may anticipate the expansion (or contraction) of Tamarisk with a change in environmental conditions.   
  
In this presentation, I highlight lessons-learned about Tamarisk that may be applicable to Japanese Knotweed. Because non-native species are often less competitive than native species when physical processes are intact, I hypothesize that degraded rivers will have more numerous, and denser, infestations of knotweed than those with a dynamic geomorphology. In particular, I explore the role of floodplain connectivity and knotweed presence. Depending on the physical controls on knotweed establishment and success, floodplain restoration or preservation may help to prevent, or reduce, knotweed expansion in the Lake Champlain Basin.

* 1:45-2:00 PM: Restoring river-floodplain connectivity and floodplain vegetative communities for flood risk and water pollution management

*Shayne Jaquith, The Nature Conservancy*

***Abstract.*** River corridors and their floodplains are highly productive ecosystems and provide a range of ecosystem services such as flood mitigation and water quality maintenance. Simultaneously, river corridors are among the most heavily managed ecosystems. Because of extensive management, a great percentage of floodplains have been hydrologically disconnected from the rivers they border, greatly reducing the flood mitigation and water quality benefits they would optimally provide.  
  
Within the context of climate-change driven increases in flood frequency and magnitude along with increasing nutrient loading of surface waters, resource managers have started to look to the hydrologic and vegetative restoration of floodplains as a means or mitigating flood risk and water pollution. Although such restoration activities are increasingly popular, the impact they have on downstream flood stages and water quality remains imprecisely understood and is rarely quantified. There is a need to quantify how these floodplain restoration activities may mitigate flooding and improve water quality so that limited restoration resources can be most effectively utilized to address these challenges.  
  
To address these research needs, we developed a hydraulic model to simulate the influence of floodplain re-vegetation and increasing floodplain connectivity on stream power, water depth and channel velocity at 5yr and 100yr flow return periods for two catchments located within the Lake Champlain basin. Further, we combined a multi-objective spatial optimization approach with the hydraulic model to target investments in floodplain re-vegetation and reconnection that maximize avoided damages from flooding and minimize the cost of intervention. Our preliminary modeling results show decreases in flow velocity associated with these restoration activities and reveal optimal locations for mitigation of flooding impacts within our study basins. Under all optimal scenarios, we find that the benefits of interventions exceed the costs. However, marginal benefits decrease as investment increases.

*Contributors: Nitin Singh, Jesse Gourevitch, Beverley Wemple, Arne Bomblies and Taylor Ricketts*

* 2:00-2:15 PM: Using unmanned aircraft system (UAS) to monitor bank erosion along river corridors

*Scott Hamshaw, University of Vermont*

***Abstract.*** Excessive streambank erosion is a significant source of fine sediments and associated nutrients in many river systems within the Lake Champlain basin. Geomorphic change detection using high-resolution topographic data is a useful method for monitoring the extent of bank erosion along river corridors. Advances in unmanned aircraft system (UAS) and structure from motion (SfM) photogrammetry techniques have provided a powerful new tool for capturing high resolution topographic data. To evaluate the effectiveness of UAS-based photogrammetry for monitoring bank erosion, a fixed-wing UAS was deployed to survey 20 km of river corridors in central Vermont multiple times over a two-year period (2015-2017). Evaluation of the UAS-based topographic data was performed by comparison of streambank cross-section data to ground survey data at seven streambank monitoring sites. Mean error between UAS and ground survey as low as 11 cm were achieved in early spring conditions. Digital elevation models (DEMs) and DEMs of difference were utilized to quantify the volumetric change along selected portions of the survey area where notable erosion occurred. Longer term estimates of change were also made by comparison of UAS surveys to previously collected airborne lidar surveys. Results showed that UAS was capable of collecting high quality topographic data at fine resolutions even along vegetated river corridors provided that the survey timing and conditions were optimal. UAS survey data compared well to existing airborne lidar surveys and allowed robust quantification of significant geomorphic changes along rivers. The ability to monitor geomorphic change and quantity bank erosion using a flexible and efficient survey method such as UAS will help to inform watershed management plans and monitor progress in reducing sediment loading due to bank erosion.

* 2:15-2:30 PM: Extended discussion

2:15-2:45 PM Coffee Break

2:45-4:15 PM Concurrent Sessions

2:45-4:15 PM: Concurrent Session H: Nutrient loading in the Lake Champlain Basin across time and space: insights from long term monitoring and targeted short-term studies on the impacts of climate and land use change

Moderator: Andrew Schroth and Erin Seybold, University of Vermont

* 2:45-3:00 PM: Emerging *in-situ* sensor technologies provide insight into the ecological function of three Vermont streams

*William Bowden, Ryan Sleeper, Andrew Schroth, and Matthew C.H. Vaughan, University of Vermont*

***Abstract.*** Stoichiometric constraints imply that the cycling of carbon and other essential nutrients are closely coupled in space and time in stream ecosystems. Rates of cycling and their driving processes are affected by numerous environmental variables (e.g., temperature and light) and may be modified by land use/land cover. In this study, we used a combination of in-situ sensor technologies and novel modeling techniques to estimate rates of ecosystem metabolism and nitrate uptake in three Vermont streams spanning the forested, agricultural, and urban land cover spectrum. For gross ecosystem production (GEP) and ecosystem respiration (ER), we found statistically significant between-site differences and within-site seasonal dynamics, which followed patterns in light and nutrient availability. We observed seasonal patterns in the metabolic sub-parameters alpha (rate of production at low light levels) and Pmax (maximum rate of production at high light levels) that may reflect community-scale algal succession or adaption to changing environmental conditions. We utilized a novel modelling technique to calculate nitrate uptake based on diurnal fluctuations in dissolved nitrate concentrations measured continuously by in-situ spectrophotometers. This approach vastly increased the number of nitrate uptake estimates we obtained compared to traditional field experiments (e.g., nitrate or nitrogen-15 isotope addition experiments). Nitrate uptake rates were strongly correlated with rates of GEP, especially in the most productive stream. However, based on stoichiometric considerations, the rates of nitrate uptake were as much as ten times higher than expected based on the rates of GEP. This suggests that processes beyond biological uptake by primary producers in these streams may contribute significantly to diurnal fluctuations in nitrate concentration. The results of this study suggest that emerging in-situ sensor technologies can be used to measure important metrics of stream ecosystem function that are responsive to land use/land cover differences.

* 3:00-3:15 PM: Yields and trends in flux of total suspended solids, phosphorus, and nitrogen from tributaries to Lake Champlain, 1991 through 2014

*Laura Medalie, United States Geological Survey*

***Abstract.*** Average daily yields and trends in flux of total and dissolved phosphorus, total nitrogen (TN), and total suspended solids (TSS) from 18 streamgaging and water-quality monitoring stations on tributaries to Lake Champlain were calculated by the U.S. Geological Survey (USGS) using the Weighted Regressions on Time, Discharge, and Season model. The trend periods is 1991 (1993 for TN and TSS) through 2014, although noteworthy patterns within the full period are discussed.  
  
Strong upward trends in flux of TSS were seen for the Winooski, Poultney, and Missisquoi Rivers and Lewis Creek. Trends in the Winooski and Missisquoi Rivers were decreasing until about 2004. An upward trend in flux in the Pike River began to decrease after its peak in 2006. The Winooski and Missisquoi Rivers had decreasing trends in flux of TSS until about 2003, when they began to increase. Overall, 3 tributaries had downward trends in flux of TSS, 11 had upward trends, and the remaining 4 tributaries had no trends.  
  
Trend results and time-series patterns for total phosphorus (TP) were similar to those for TSS. From 1991-2014, 10 tributaries had upward trends in flux of TP, 5 had downward trends, and 3 had no trends. When depicted together as yields, the downward trend in the LaPlatte River stands out, as do trends in the Missisquoi, Winooski, and Poultney Rivers and in Little Otter and Lewis Creeks, which all began to trend upward between 2000 and 2005. Of all tributaries, TP yields were highest in the Pike River for most of the period. Also noteworthy is the decrease in TP flux in Otter Creek over the study period. Trend results were similar for dissolved phosphorus as for TP, except that the Little Chazy River had a strong decreasing trend in flux beginning in 2000 and the Pike River trend remained steadily decreasing throughout the period.   
  
From 1993 through 2014, 10 tributaries had downward trends in flux of TN, 4 had upward trends, and 4 had no trends. The Pike River was unique by having the largest yields of all the tributaries, but also a strong decrease from about 2002 onward. The next largest yields were in the Little Otter Creek and the Missisquoi River; otherwise, no distinguishing patterns in TN flux were observed among tributaries.

* 3:15-3:30 PM: Identification of patterns in hysteresis in suspended sediment-discharge relationships to infer watershed sediment dynamics

*Scott Hamshaw, University of Vermont*

***Abstract.*** Studying the hysteretic relationships embedded in high-frequency suspended sediment concentration and river discharge data over individual storm events provides insight into the drivers and sources of riverine sediment during events. However, existing research remains limited to analyses using simple visual classifications (linear, clockwise, counter-clockwise, and figure-eight patterns) or the collapse of these patterns to a hysteretic index. In this study, we leverage three-years of high-frequency suspended sediment, discharge, and meteorological monitoring from within the Mad River watershed to demonstrate a new machine learning based approach to classifying storm events based on the type of hysteresis observed. The main stem of the Mad River and five of its tributaries were monitored between 2013 and 2015 providing 600 unique events to analyze. Fourteen different types of hysteresis were identified within the data set. Events were classified automatically by training a restricted Boltzmann machine (RBM), a type of artificial neural network, on images of the suspended sediment-discharge plots. The probabilistic RBM classification network predicted the correct or next most similar class 71% of the time.   
  
The expanded classification system allowed for new insight into drivers of hysteresis types including spatial scale, antecedent conditions, hydrology and rainfall. Additionally, differences in the type and frequency of hysteresis type were observed between sites and between seasons. This provided insight into differences in timing and source proximity of sediment loading between subwatersheds. With increased availability of high-frequency suspended sediment data, the hysteretic classification approach presented here can be used to inform watershed management efforts to identify sediment sources and reduce fine sediment export.

* 3:30-3:45 PM: Effects of land use on the timing and magnitude of carbon and nitrogen fluxes: an analysis of high-frequency sensor measurements from forested, agricultural, and urban watersheds in the Lake Champlain Basin

*Erin Seybold & Andrew Schroth, University of Vermont*

***Abstract.*** Land use/land cover change has been shown to have significant impacts on nutrient loading to aquatic systems, leading to increased nitrogen and phosphorous fluxes from terrestrial ecosystems to streams and rivers. This elevated nutrient loading can have downstream water quality impacts, and has been linked to eutrophication and harmful algal blooms like those observed in the Lake Champlain basin. While it is clear that changes in land use/land cover are associated with changes in aquatic ecosystem function, a mechanistic understanding of how nutrient fluxes from distinct land cover classes respond to hydrologic events on event and seasonal scales remains unknown. Recent advances in the availability of high-frequency water quality sensors provide an opportunity to assess these relationships at a high temporal resolution.   
  
We deployed a network of in-situ spectrophotometers in three sub-watersheds of the Lake Champlain Basin with contrasting land uses: forested, agricultural, and urban. Our study sought to assess how land cover affected the timing and magnitude of fluxes of carbon (C) and nitrogen (N) from watersheds with distinct land uses, and to determine how sensitive these fluxes were to inter-annual climate variability.

We found systematic differences in the timing of C and N fluxes across these different land use classes as well as the total magnitude of C and N exported from these different landscapes. We also found strong inter-annual variability in carbon and nitrogen fluxes in response to inter-annual variability in precipitation and discharge, suggesting a high degree of hydrologic control over nutrient loading. These findings emphasize the potential for climate change, and in particular precipitation variability, to drive strong variation in the magnitude of downstream nutrient flux to receiving lakes and estuaries. Our study emphasizes the pervasive influence of land cover and its effects on water quality in the Lake Champlain watershed, and also highlights the strong signature of anthropogenic land use choices on regional C and N cycling.

* 3:45-4:00 PM: Use of Bayesian regression models to discern spatial patterns in sediment and nutrient export to Lake Champlain

*Kristen Underwood, University of Vermont*

***Abstract.*** Given the variable biogeochemical, physical, and hydrological processes driving riverine sediment and nutrient export from catchments, the water science and management communities need data-driven methods to identify regions prone to production and transport of sediments and nutrients under variable hydro-meteorological conditions. We have outlined a methodological approach that applies advanced statistics to better understand spatial variability in sediment and solute transport within the Lake Champlain basin (LCB). We used Bayesian analysis to segment linear regression models of concentration vs. discharge for total suspended solids (TSS) and particulate and dissolved phosphorus (PP, DP) using longterm monitoring data from eighteen LCB watersheds. Our method leveraged information from Bayesian inference to estimate regression model parameters, and identify threshold position to avoid potential bias associated with manual threshold selection. The identified threshold positions demonstrated a considerable range below and above the median discharge – which has been used previously as the default breakpoint in segmented regression models to discern differences between pre- and post-threshold export regimes. The Bayesian approach identified different functional stages of TSS, PP and DP export, in that a probability distribution on pre- and post-threshold regression slopes from a segmented regression model could be interpreted to discern between “reactive” and “hydrologically-driven” stages of constituent export. We extended the term “reactive” export regime to include the array of biologically-, chemically- and physically-mediated processes that are responsible for the uptake or release of constituents from advective transport. A nonparametric clustering method then partitioned the watersheds into clusters of PP and DP export regimes using watershed characteristics, as well as the Bayesian regression intercepts and slopes. Two clusters of high-flux basins were defined, one where PP flux was predominantly episodic and hydrologically-driven; and another in which the sediment and nutrient sourcing and mobilization were more bimodal, resulting from both hydrologic processes at post-threshold discharges and reactive processes (e.g., nutrient cycling or lateral/vertical exchanges of fine sediment) at pre-threshold discharges. Two high-flux clusters of DP exhibited a bimodal concentration-discharge response, but appeared driven by differing land use. Our novel framework shows promise as a tool with broad management application that provides insights into landscape drivers of riverine solute and sediment export.

* 4:00-4:15 PM: Using *in situ* UV-visible spectrophotometer sensors to predict phosphorus species concentrations in Lake Champlain tributaries

*Matthew C.H. Vaughan, William Bowden, Andrew Vermilyea, Jamie Shanley, Beverley Wemple, and Andrew Schroth, University of Vermont*

***Abstract.*** Accurate riverine phosphorus concentration measurements and load estimates are critical to meeting water quality targets in the Lake Champlain Basin. Currently, total phosphorus load estimates rely on proxy variables such as turbidity and discharge, and little is known about important phosphorus fraction dynamics for dissolved and soluble reactive phosphorus that are more readily available forms for cyanobacteria uptake. Optical water quality sensors can make rapid sub-hourly measurements and have been shown to reduce uncertainty in load estimates and reveal high-frequency storm dynamics for solutes such as nitrate and dissolved organic carbon. We tested the utility of in situ UV-Visible spectrophotometers to predict total, dissolved, and soluble reactive phosphorus concentrations in streams draining agricultural, urban, and forested land use / land covers in the Lake Champlain Basin. We present the first statistically robust validation technique applied to optical water quality sensors in order to emulate how the sensors may perform in predicting unknown phosphorus species concentrations. Models to predict dissolved and soluble reactive phosphorus explained a greater portion of the variance than any other known proxy variable technique, and results varied by land use / land cover. Total phosphorus predictions from UV-Visible spectra were most accurate when data from all sites were combined, and the amount of variance explained was similar to results of others that rely on discharge and turbidity. This monitoring approach is unique in its ability to predict not only total phosphorus concentrations with reasonable accuracy, but also concurrent dissolved phosphorus fraction concentrations in addition to concurrent nitrate and dissolved organic carbon concentrations, and turbidity. This technology may be particularly useful for researchers or managers that aim to quantify and monitor the chemical partitioning of phosphorus species at a high-frequency. While these next-generation sensors are currently expensive, this technology is evolving rapidly. In the foreseeable future this type of instrumentation may extend our ability to monitor critical nutrients at times and places that would be difficult to sample in any other way. However, these instruments present new challenges for maintenance, calibration, and data management. We will discuss these benefits and challenges.

2:45-4:15 PM: Concurrent Session I: International Joint Commission’s Flood Study

Moderators: Robert Flynn and Keith Robinson, United States Geological Survey

* 2:45-3:00 PM: IJC Lake Champlain-Richelieu River Study Session Introduction

*Keith Robinson, United States Geological Survey and Jean-Fran***ç***ois Cantin, Environment and Climate Change Canada*

***Introduction.*** The International Joint Commission (IJC) has had a long history of flood activities in the Lake Champlain – Richelieu River basin going back to the 1930s. This new and active study will be completed over the next 5 years, being completed at the end of 2021.  
  
The major objectives of this study include:  
1. Evaluating the causes and impacts of past floods, especially the event of 201l.  
2. Assessing the possibilities offered by the floodplain best management practices.  
3. Evaluating possible adaptation strategies to the expected future variability in Water quantity.  
4. Developing and making recommendations for implementing, as appropriate, an operational, real-time flood forecasting and flood inundation mapping system for the Lake Champlain-Richelieu River watershed.  
5. Conducting an in-depth study of current social and political perception on structural and other mitigation measures to support and confirm the desirability of potential structural mitigation solutions.  
6. Performing a quantitative and qualitative assessment of potential flood management and mitigation measures (non-structural and/or moderate structural works) and their impacts on important resources of the system: the wetland and fauna, recreational, domestic, industrial and municipal uses of water, shoreline and floodplain built environment and agriculture.  
7. Developing resource response models that include basic indicators for water resources response to water levels fluctuations, with special attention on the data inventory and identification of thresholds. Climatic projections, wind wave and ice models, additional new data for the evolution of watershed physiographic characteristics over time and a complete digital terrain model should also be produced to allow the planning, evaluation and ranking of potential flood mitigation solutions, using a shared-vision approach.

* 3:00-3:15 PM: Do we have the science to reduce the severity of impacts due to flooding on the Lake Champlain-Richelieu River Basin? The International Joint Commission Mandate

*Michael Laitta and Pierre-Yves Caux, International Joint Commission*

***Abstract.*** The Lake Champlain and Richelieu River flood of 2011 caused significant damage to basin infrastructure and dramatically affected many residents. A flood of this magnitude is thought to have a recurrence interval of 500 years; however, in addition there were a number compounding factors (significant snow pack, rain, ice) that exacerbated its severity. The International Joint Commission was given the mandate to investigate these compounding factors and propose mitigation and management solutions to address flooding in the system over the course of a five year Study. To conduct the Study, the Commission has established a Study Board comprising members from both Canada and the United States who are authorities in all aspects of the Study. Alongside the Study Board, a Public Advisory Group has been struck to liaise with all stakeholders in the basin and ensure all opinions are considered. The Commission has also created an Independent Review Group to ensure scientific rigor and impartiality of Study results. Guided by previous Commission studies, this multimillion dollar Study will provide a state of the art flood forecasting system, accurate hydrologic and hydraulic descriptions and models of the watershed. This combination of key elements is essential to a flood forecasting prediction tool for flood mitigation. This tool will be made available (on line) as a computer application to assist decision-makers, emergency preparedness crews and the public to be responsive and more resilient to unfavourable flood forecasts. The tool will also be used to explore potential soft to moderate control measures or infrastructure in the basin to mitigate floods. Various measures will be explored and may include increasing the storage or retention capacity of Lake Champlain to controlling the Richelieu River flow at the St-Jean sur Richelieu shoals during high flows in the spring. A binational governance structure will be proposed to continuously support, review and improve the tool over the long-term. Jurisdictional policies and best management practices regarding existing flooding mitigation and management measures will be also be reviewed. Because of the diverse views from multiple stakeholders, the Study Board will gage the viability and acceptability of proposed measures through socioeconomic and political analyses and extensive engagement with the public. By 2021, the Commission will issue to the Canadian and U.S. governments its final report with recommendations.

* 3:15-3:30 PM: LCRR Social, Political and Economic Advisory Group

*Curt Gervich, SUNY Plattsburgh*

***Abstract.*** The Social, Political and Economic Advisory Group (SPE AG) is responsible for the execution of an in-depth study of current social and political perception on structural and other flood mitigation measures to support and confirm the desirability of potential mitigation measures, including consultations with the publics, stakeholders and decision-makers of relevant political jurisdictions and in collaboration with the Public Advisory Group (PAG). Initially, this group will be responsible to address the social dimension of causes and impacts of flooding in the LCRR basin, and adaptations to future climates once hydrological water supplies and associated water levels under selected climate change scenarios will be available. This advisory group will be active throughout the Study. The group will also assist the Study on assessments of economic aspects related to the impacts of flooding, and benefit/costs analysis related to the potential flood management and mitigation measures.   
  
In addressing Socio-political considerations, the SPE AG will seek the input of elected officials and decision-makers to obtain their perspective on the proposed flood mitigation measures. Mechanisms/structures and processes to obtain this information will be decided by the TWG in consultation with other study leadership and the IJC.

* 3:30-3:45 PM: LCRR Flood Management and Mitigation Measures Technical Working Group

*Bill Werick*

***Abstract.*** The Flood Management and Mitigation Measures Technical Work Group (FMMM TWG) is primarily responsible for the design and assessment of the possible flood management and mitigation measures (non-structural and moderate structural) and to work throughout the study to plan, evaluate and rank the potential candidate measures for flood management and mitigation.   
  
Working with other TWGs, project developers, etc. the FMMM TWG will interact with the various groups to evaluate the utility of the broader set of metrics /PIs and finalize the suite of metrics/PIs that that will be used to analyze the proposed mitigation measures. The evaluation will assess the sensitivity of the various metrics/PIs against changing water levels and help assess whether they will provide meaningful results for prioritizing/ranking of options.  
  
The FMMM TWG will develop a Collaborative Decision Support Toll (CDST) to evaluate and rank the potential candidate measures for flood management and mitigation. That is, develop computer models that evaluate the various mitigation measures (non-structural and structural). The models will factor in social (including human health, peoples’ livelihoods, property, the communities in addition to other factors), political, economic and environmental perspectives. An active engagement process with local, state/regional and national decision makers and stakeholders will be integral to this effort.

* 3:45-4:00 PM: LCRR Hydrology, Hydraulics and Mapping Technical Working Group

*Jesse Feyen, National Oceanic and Atmospheric Administration*

***Abstract.*** The Hydrology, Hydraulics and Mapping Technical Work Group (HMM TWG) is responsible for the execution of the hydrological models, identification of data needs for these models (historical, near-future and climatic weather scenarios), the hydraulic models, real-time floodplain mapping and the operation of a real-time flood forecasting and flood mapping system. Once calibrated, the models will serve in analysis mode as the basis to test the various flood management and mitigation measures that will be developed by the Flood Management and Mitigation Measures TWG. The HMM TWG will be active throughout the Study. Because of the complexities of the work associated with this TWG, sub groups, or committees may be formed to address specific topics that may need additional expertise.   
  
The HHM team will assemble all components of a predictive flood forecasting and real-time flood plain mapping system that uses ensemble predictive meteorology-hydrology and hydrodynamic models. Also, a 2D and a 3D hydrodynamic model for flood prediction on Lake Champlain in conjunction with a 2D hydrodynamic model for the entire Richelieu River which will be driven by hydrologic predictions and meteorological forecast models. A wind wave model will be implemented for the lake to be used in this predictive system. The predictive system will combine U.S. and Canadian meteorology and three hydrological models (ECCC, NCRR and MDDELCC) that will be transferred to a single U.S.-Canada hydrodynamic model to map expected flooding extent. An ensemble approach for predicting lake and river levels and flooding potential will provide probabilistic forecast guidance that will be used to select flood maps which reflect forecast conditions. This system will assimilate recent observations to produce reliable solutions. The HHM team will use an approach that involves, in a first step, the rapid implementation and use of current forecasting tools & early development of new tools. These would be used as soon as the spring 2018. These tools will evolve and will be updated as soon as new products become available in order to learn from potential public outreach and real-time use. HHM will test this flood forecasting system and make recommendations on future operational implementation.   
  
The 3D modeling proposed for Lake Champlain will use NOAA's enterprise forecasting model system and could, eventually, help address many of the questions the public had on addressing water quality and sedimentation concerns for the Lake should future other studies address these concerns.

* 4:00-4:15 PM: LCRR Resource Response Technical Working Group

*Perry Thomas, Vermont Agency of Natural Resources, and Glenn Benoy, International Joint Commission*

***Abstract.*** The Resource Response Technical Work Group (RR TWG) is primarily responsible for developing and calibrating a set of Performance Indicators (PIs) for use in assessing impacts of proposed flood management and mitigation measures on wetland and fauna, recreational, domestic, industrial and municipal uses, shoreline and floodplain built environment and agriculture. The RR TWG will begin their work by coordinating a review of the causes and impacts of past floods, especially the spring event of 2011. Contextual narratives will be incorporated into this review to foreshadow the use of PIs. The RR TWG anticipates including case studies of agricultural impacts, structural damages (stage-damage curves), environmental consequences, and recreational use changes as well as descriptions of community responses to 2011 flooding.   
  
The RR TWG will work closely with the Social, Political and Economic Analyses Group TWG and Flood Mitigation Measures TWG to identify an initial set of PIs and use an iterative process to review and select additional PIs most suited to the range of measures to be considered. PIs will address water uses, the shoreline and built environment, agriculture, and the natural environment and will be used as input to resource response models. Indicators will be calibrated and responses forecasted based on historical flood events, including the event of 2011, using existing data to the extent possible.   
  
The RR TWG envisions using an Integrated Resource Response Model, based on Integrated Ecosystem Response Models used in other transboundary studies on impacts of water level changes, to provide PI values for incorporation in a collaborative decision support tool. In addition, the RR TWG plans an assessment of cumulative impacts of anthropogenic modifications to the system. Over the decades, the system has undergone substantial change due to successive anthropogenic modifications. These modifications range from the establishment of eel cribs and rail and road transportation piers to widening of piles and the Chambly Canal, among others. The RR TWG will quantify the relative impacts of these alterations, thereby enabling a common understanding of what anthropogenic factors have led to the current hydraulic regime. This analysis may lead to quantification of anthropogenic impacts on wetlands and other resources.

2:45-4:15 PM: Concurrent Session J: Cultural Heritage

Moderators: Jim Brangan, *Lake Champlain Basin Program*

* 2:45-3:00 PM: A synthetic overview of paleobotanical and paleofaunal remains from the Champlain Basin Native American archeological sites

*Jess Robinson, State of Vermont Division of Historic Preservation*

**Abstract.** Using archived publications, field records, and archaeological collections curated at the Vermont Archaeology Heritage Center, the authors have recently completed a database of all identified paleobotanical (plant) and paleofaunal (animal) remains recovered from radiocarbon-dated contexts in Vermont Native American archaeological sites. These data cumulatively span approximately 9,000 years. While analysis of this data set is ongoing, the authors will present some initial insights gleaned from the data and note trends and discontinuities in plant, animal, and firewood use through time.

* 3:00-3:15 PM: The shipwrecks of Lake Champlain Underwater Historic Preserve

*Jenny Craig, Lake Champlain Maritime Museum*

***Abstract.***The Lake Champlain Underwater Historic Preserve was started under Art Cohn of the Lake Champlain Maritime Museum’s Maritime Research Institute in 1985. It expanded over 32 years to include ten shipwrecks: Phoenix, Horse Ferry, O.J. Walker, General Butler, A.R. Noyes, Sloop Island Canal Boat, Diamond Island Stone Boat, Water Witch, Champlain II and US Lavallee. This presentation will provide video footage with oral description of the shipwrecks sites.

* 3:15-3:30 PM: In Champlain’s wake: the small boat traditions of Lake Champlain

*Douglas Brooks, Henry Sheldon Museum of Vermont History*

***Abstract.***While the naval and commercial histories of Lake Champlain have been well-studied, no significant research has been done on the traditions of boats and boatbuilding in our region. Yet the Lake Champlain Basin: the lake and its tributaries, were home to a variety of small craft, many of which seem to have been built by their owners. The uses of small craft on the Lake were as rich and varied as the types, from native canoes, sailing ferries for transportation across the lake, pleasure boats, fishing boats, and trapping boats. In 2014 the Henry Sheldon Museum of Vermont History in Middlebury initiated an ambitious research project which seeks to document the variety of our region's small boat traditions. Entitled "In Champlain's Wake; The Small Boat Traditions of Lake Champlain," the project has partnered with schools and universities to study and document various regional boat types through oral histories, photographs, measured drawings, publications, and the construction of replicas. In this talk I will provide an overview of our work to date as well as show historic photographs which showcase the compelling variety of boats from our region. I will have on hand copies of our publications as well as a collection of CAD drawings of historic boats. These drawings represent the very first comprehensive documentation of small craft of the region.

* 3:30-3:45 PM: The Gleaner of St. Albans: Canals, commerce, and connections on 19th Century Lake Champlain

*Alex Lehning, Saint Albans Museum*

***Abstract.*** 2017 marks the beginning the bicentennial period for the New York State Canal system. In 1823, newly elected Vermont governor Cornelius Van Ness exclaimed “A new era has indeed burst upon us, when we can hear of the arrival of vessels at the city of New York, from the Northern extremity of Vermont.” That same year, the “Gleaner” - a sailing canal boat - was constructed in St. Albans Bay. This “Barque of the Mountains” was celebrated along the waterways during her maiden voyage - the first on the Champlain Canal - and through Troy, Albany, and eventually New York City. It was captained by William Burton and carried wheat and potash. The 60-ton “Gleaner” is the first known example of this vessel type which was unique and specific to Lake Champlain, and was so revered that a second boat with the same name was commissioned in 1883. St. Albans Bay, known for a time as Port Washington, competed with Burlington as a working waterfront, and several steamboats were later constructed by the same owners as a result of this initial success. This presentation will explore the maritime history and archaeology of the “Gleaner” - which is approaching its own 200th anniversary in 2023 - as well as the revolutionary social and economic impact of her expedition and of St. Albans Bay on early to-mid 19th century Vermont and Lake Champlain.

* 3:45-4:00 PM: Boats, travel, and trains: the Kent-Delord House and Lake Champlain teens telling history

*Don Wickman, Kent-Delord House Museum*

***Abstract.*** Since the Kent-Delord House Museum’s inception in 1928 many of the stories delivered to the general public center on Henry Delord and his role in the War of 1812 and the financial distress he suffered in its aftermath. There is much more to the story of all the home’s residents and the theme used in the grant awarded through the Champlain Valley National Heritage Partnership exemplifies several of the tales that can be told. The title was “Boats, Travel & Trains: The Kent-Delord House and Lake Champlain.” And it fit directly into the theme of “Lake Champlain: Corridor Commerce.”  
  
The grant focused on three topics: where William Bailey and Henry Delord purchased the products sold in their ‘Red Store’ during 1812-1813; the Delord Family Travels and the story of the Plattsburgh & Montreal Railroad which opened in 1852. All had direct links to the Lake Champlain Valley.  
  
What was the most stimulating part of the grant was the role played by teenagers. Three high school students researched, composed exhibit copy, designed and assembled exhibit panels and authored brochures explaining their work. The museum director guided the process. The students learned about primary sources, image selection and the techniques of exhibit design.  
  
The end result were exhibit panels dedicated to each topic that were on display during the 2017 season and will continue being available for 2018.  
  
The students gained experience that they can utilize in future studies.  
  
The work plan also included with partnering with various organizations on both side of the lake.  
  
In the end, the museum expanded their education mission while teaching high school students on museum techniques, research, and composition skills.

* 4:00-4:15 PM: Preserving *Spitfire*: A legacy of 1776

*Art Cohn, Lake Champlain Maritime Museum*

4:15-4:30 PM Coffee Break

4:30-5:30 PM Panel Discussion: Congressional Delegation Staffers

5:30-7:00 PM: Poster session (see p. 11 for full list of posters), dinner, and social, sponsored by   
the Lake Champlain Research Consortium

*Note*: Poster session will run from 5:30-6:30, and dinner and drinks will be served from 5:30-7:00PM.

7:00-8:30 PM Keynote address by Dan Egan, author of *The Death and Life of the Great Lakes*

**Day 2: Tuesday, January 9th, 2018**

8:30 AM-12:00 PM: Registration

8:30-9:30 AM: Coffee, breakfast, and networking

9:30-10:30 AM: Keynote address by Larry Greenberg, Karlstad University: Conservation of landlocked Atlantic salmon in a regulated river: Taking a holistic approach

10:30-11:00 AM: Coffee break

11:00 AM-12:15 PM: Concurrent Sessions

11:00-12:15 PM: Concurrent Session K: Salmon Restoration, Part I

Moderator: William Ardren

* 11:00-11:15 AM: Evaluating performance of landlocked Atlantic salmon stocked in Lake Champlain from feral and domestic brood sources

*Brian Chipman, Vermont Fish and Wildlife Department*

***Abstract.*** The Vermont Fish and Wildlife Department stocks Sebago strain landlocked Atlantic salmon (Salmo salar) in Lake Champlain, reared from eggs collected from a domestic broodstock, as well as from feral broodstock that return from Lake Champlain in fall spawning runs. Benefits of a domestic broodstock include a more reliable egg source, reduced risk of disease, and managed genetic diversity, but domestication may also result in loss of fitness in the wild. Use of feral fish as a brood source may provide reduced fish culture costs and unknown fitness benefits in the wild, but may also require increased staffing costs for egg collection, and increased risk of disease introduction to the fish culture facility. The purpose of this study is to compare the post-stocking performance of Sebago strain landlocked Atlantic salmon smolts produced from feral and domestic brood sources. Smolts from the feral and domestic broodlines were reared at the Ed Weed Fish Culture Station, Grand Isle, Vermont and marked prior to stocking with fin clips specific to each brood source. Target numbers of 39,000 smolts each from feral and domestic parents were stocked annually from 2012 through 2016, in the Lamoille River, Missisquoi River, and at five sites throughout northern Lake Champlain. An average of 40,752 (51%) feral-origin smolts and 39,218 (49%) domestic-origin smolts were stocked annually over the 5-year period. Returns of the two experimental groups to spawning runs (identified by fin clip) were evaluated annually during routine fall salmonid assessment surveys from 2012 through 2017. Returns to the fishery were evaluated by creel surveys of the Main Lake basin in 2015 and the Inland Sea (Northeast Arm) in 2016. Feral-origin salmon clearly outperformed domestic-origin salmon in fall salmonid assessment samples. The ratio of fall feral:domestic returns steadily increased from 1.44:1 in 2012 (n=39) to 3.83:1 (n=304) in 2016. One angler-caught domestic-origin salmon was examined during in the 2015 Main Lake creel survey, while 22 domestic-origin salmon and 20 feral-origin salmon were examined during the 2016 Inland Sea creel survey. Creel survey results suggest there is little difference in returns of the two salmon groups to the lake open water fishery. However, the tendency for greater tributary returns of feral-origin salmon may improve fall tributary fishing opportunities, as well as enhance spawner abundance and potential for natural reproduction in suitable spawning habitat.

* 11:15-11:30 AM: Atlantic salmon restoration in Lake Ontario – what have we learned so far?

*Margaret Murphy, Integrated Aquatic Sciences, LLC*

***Abstract.*** Research on Atlantic Salmon in Lake Ontario has gained momentum in the past decade; however, continued research is necessary to more fully understand habitat needs, where restoration would enhance production potential, and determine how a changing climate and human activities may impact the long-term success of this effort. Improving coordination and collaboration of studies on Lake Champlain and Lake Ontario to better document successes and failures during all life stages would be beneficial for the larger effort of restoring Atlantic Salmon to these two Great Lakes (Lake Champlain being the unofficial sixth Great Lake). Our overall vision for New York over the next 5 to 10 years includes assessing survival and growth of juveniles, mean age at smolting, and adult spawning success among strains to evaluate future potential for Lake Ontario. Previous research efforts in Lake Ontario tributaries have included strain comparisons, overwinter survival and growth, and bioenergetics modeling. Atlantic salmon fry of four strains (two sea-run and two landlocked) were stocked for four years in five central New York streams to assess survival and growth rates. Comparisons among monthly survival and specific growth rates at all stream sites and years resulted in no obvious trends; survival ranged from 0 to 81% and growth rates were between 0.02 to 0.04 g/g/d. There were no significant differences in growth or survival observed between sea-run versus landlocked strains. Based on laboratory and field assessments, Atlantic salmon specific growth rate was greatest at approximately 18C during the summer months. Overwinter growth of young-of-the-year Atlantic salmon was studied during two winters in central New York streams. We hypothesized that longer and colder winters would negatively influence the growth of young-of-the-year Atlantic salmon. Based on experiments conducted during two winters we observed negative growth rates during both winters, but with significantly greater weight loss during the warmer winter. Growth rates were also significantly different between months, with more weight loss in December and January and less weight loss or positive growth by the end of the winters (March). Based on the observations in this study, lower threshold temperatures for feeding activity may be even lower than previously reported, possibly near 0C. We have gained a better understanding, but it is critical to continue and expand the studies to smolts and adults, as well as potential effects related to climate change and changing stream and lake dynamics.

* 11:30-11:45 AM: Ardren: Minor shifts towards more natural conditions in captivity improve long-term survival and reduce dispersal in reintroduced salmon populations

*William Ardren, U.S. Fish and Wildlife Service, Andrew Harbicht and Dylan Fraser, Concordia University*

***Abstract.*** Successful reintroduction of migratory species requires an understanding of the impacts of captive rearing on development, long-term survival and dispersal post release, particularly for species with metapopulation structure. Among captive-bred salmonids, accelerating growth rates using elevated water temperatures is commonly done to increase size-at-release and post-release survival, but can disrupt juvenile developmental processes (olfactory imprinting), increasing dispersal rates and posing a genetic risk to nearby, locally-adapted conspecifics. We tested whether more natural developmental conditions (seasonal temperatures, earlier release dates) reduced dispersal without reducing survival (adult recaptures and spawning returns) among landlocked Atlantic salmon. Three cohorts of fry (age 0+) and yearling (age 1+) were produced under two thermal conditions (seasonal brook water and above-seasonal groundwater) and release times (early or normal) to supplement two tributaries. The resulting adults were monitored over four years and identified using DNA parentage-based tagging. Among yearling releases, straying rates were reduced 6.3-fold by seasonal brook water, while earlier release dates halved straying to normal rates. Survival for yearling releases was consistently higher than that of fry, but to varying degrees. Among yearling releases, seasonal brook water improved adult recaptures and spawning returns by 4.4-fold and 5.1-fold respectively, while earlier release dates had no overall effect on adult recaptures, but halved spawning returns. These simple, cost effective changes take ecology and key developmental windows/requirements into account and reduce dispersal while improving lifetime survival. Adopting such practices may aid with population reintroduction and the re-establishment or maintenance of metapopulation structure in species with complex life histories.

* 11:45 AM-12:00 PM: The evolutionary consequences of staying in freshwater: Seawater performance, physiology and endocrinology of landlocked and anadromous salmon

*Stephen McCormick, United States Geologic Survey*

***Abstract.*** Landlocked populations of anadromous fish have evolved frequently in some species, but the effects of this altered life history on traits associated with survival in seawater have not been well established. Landlocked Atlantic salmon usually maintain migration from streams to lakes, similar in timing to the seaward migration of anadromous strains. Thus, there is relaxed selection on traits associated with ocean entry but not on other life history changes such as downstream migration and imprinting. In this study anadromous and landlocked Atlantic salmon were reared under identical conditions after fertilization and examined for differences in seawater performance and its underlying physiological and endocrine control during the time of spring downstream migration. We found that salinity tolerance as judged by plasma chloride after direct transfer to 35 ppt increased in both strains in spring but was highest for the anadromous strain. Survival and growth in the first two weeks of seawater exposure was also greater for the anadromous strain. Gill Na+/K+-ATPase (NKA) activity and plasma cortisol, ACTH and growth hormone levels were greater in the anadromous strain, whereas plasma thyroid hormone levels were similar in the two strains. The anadromous strain had higher levels of pituitary ACTH (POMC) mRNA and brain levels of CRH and Urotensin II mRNA at the peak of smolt development. The results provide evidence that the stimulation of the hypothalamic-pituitary adrenal axis leads to increased salinity tolerance during smolt development, and that these traits are decreased in landlocked Atlantic salmon.

* 12:00-12:15 PM: Dispersal, habitat use and density-dependent growth of Atlantic salmon (*Salmo salar)* juveniles: insights from stocking fry in the Boquet River, New York

*James Grant, Eric Brunsdon, and Dylan Fraser, Concordia University*

***Abstract.*** Large-scale reintroduction programs for landlocked Atlantic salmon are ongoing in Lakes Champlain and Ontario. The success of such programs is often constrained by a lack of suitable habitat or a knowledge of habitat requirements. How individuals disperse from redds or stocking sites is also essential for the fitness of young individuals and shape the distribution, growth and persistence of populations. We quantified these processes during the release of 170,000 unfed Atlantic salmon fry into 14 reaches of the Boquet River in May 2014. By manipulating the density of released salmon fry, we evaluated the effects of clumped- (releasing all the fish at one location) and dispersed-stocking (releasing the fish evenly over a complete reach) treatments on juvenile habitat use, dispersal, growth and survival. During their first summer of life, salmon used habitats much as described in the literature for wild anadromous populations. Across 14 river reaches, clump-stocked YOY density decreased and growth rate increased with distance downstream, whereas dispersed-stocked YOY densities and growth were relatively constant. Overall, density, growth and survival did not differ between these two stocking treatments, likely due to the greater-than-expected mobility of fish in clumped-stocking reaches: YOY dispersed up to 1600-m, with 41% moving over 200-m downstream. As predicted from previous work, growth rate of individual fish was density-dependent, following a negative power curve. The survival of stocked fish was low and only weakly related to habitat quality. However, the best predictor of survival success at a reach level was the amount of habitat available immediately after stocking. Our results provide insights into how the growth and survival of released individuals are affected by habitat quality, dispersal, density and stocking method.

11:00-12:15 PM: Concurrent Session L: Cyanobacteria

Moderator: Angela Shambaugh, Vermont Department of Environmental Conservation

* 11:00-11:15 AM: Seasonal drivers of phosphorus partitioning at the sediment-water interface of two shallow eutrophic Vermont lakes

*Meagan Leduc, University of Vermont*

***Abstract.*** In shallow lake systems, phosphorus (P) availability to water column algal populations is often controlled by the release (internal loading) or sequestration of P in lake sediment. This study aims to provide novel insight into feedbacks between watershed-lake physical configurations, seasonal variability in weather and biological productivity, and the chemical partitioning of P in lake sediment. To accomplish this, time series sediment geochemical extractions with concurrent water column physical and biogeochemical monitoring will be analyzed to examine the relationship between water column dynamics and P partitioning of near-surface sediments in two shallow, intensively-monitored eutrophic systems. Each system experiences internal loading of P that produces severe recurring cyanobacteria blooms, but previous work suggests that their different physical configuration (bathymetry, surface area, watershed-lake area) impacts the composition and behavior of P in their respective sediment and water columns. As such, this work will test hypotheses around how the chemistry of concurrent sediment P pools evolves across the seasons in three systems that 1) suffer from the same pollution problem, 2) are exposed to the same weather, but 3) differ fundamentally in their physical configuration. Ultimately, this will improve our conceptual model of the physical, chemical, and biological drivers of internal loading or sequestration of sediment P pools across time and space in shallow freshwater systems, with widespread applicability to understanding the global water quality issue of eutrophication.

* 11:15-11:30 AM: Developing a long-term indicator of cyanobacteria bloom frequency for Lake Champlain

*Bridget O’Brien, Vermont Department of Health*

* 11:30-11:45 AM: Cyanotoxins and public health

*Sarah Vose, Vermont Department of Health*

***Abstract.*** This presentation by the Vermont Department of Health will review the current guidelines regarding cyanobacteria and cyanotoxins, including microcystin, anatoxin, and cylindrospermopsin. A review of the state of the science for BMAA will also be included.   
  
The Health Department encourages all Vermonters to be vigilant regarding cyanobacteria. Conditions can change quickly on Vermont’s lakes, so Vermonters must be prepared to evaluate conditions and avoid cyanobacteria. The Health Department analyzes recreational water samples for microcystin, anatoxin, and cylindrospermopsin. Recreational values have been derived to guide beach closures and prevent exposure. To date, beaches close due to the visual indicator of cyanobacteria rather than residual toxin levels that remain after a bloom dissipates. The Health Department analyzes raw and finished surface water from the 22 public water systems on Lake Champlain for cyanotoxins. Drinking water values have been developed to guide a public health response to cyanotoxins in drinking water.

* 11:45 AM-12:00 PM: Barriers to change: factors influencing a community’s response to harmful algal blooms

*Diana Hackenburg, University of Vermont*

***Abstract.*** Cyanobacteria blooms on Lake Champlain threaten the human health and economic vitality of Vermont’s lakeshore communities. Despite decades of efforts to improve water quality, the blooms continue with the potential to be exacerbated by climate change. What factors have prevented communities in Vermont from addressing this environmental issue? This study focuses on the community response of St. Albans, Vermont to ongoing cyanobacteria blooms in St. Albans Bay. Observations of and interviews with stakeholders will be combined with a media content analysis to identify what and how information has been communicated about the issue, past efforts, and potential barriers to action. Key issues to be explored include the role of scientific information, framing, social identity, and collaboration in citizen involvement. Results from this historical analysis will influence the design of a survey and focus groups being carried out as part of a transdisciplinary study of the links between harmful algal blooms, human well-being, and community action.

* 12:00-12:15 PM: Extended Discussion

11:00-12:15 PM: Concurrent Session M: Toxins and Contaminants in the Lake Champlain Ecosystem

Moderator: James Pagano

* 11:00-11:15 AM: Toxic in the waters of the Lake Champlain Basin, a preliminary assessment of the risks to aquatic biota from organic compounds in our rivers and lakes

*Nat Shambaugh*

***Abstract.*** Prior to 2016, information on organic contaminants in the surface waters of the Lake Champlain Basin was widely dispersed and had not been systematically evaluated. In 2016 a database was compiled which showed that 160 potentially toxic anthropogenic organic contaminants have been found at quantifiable levels in the surface waters of the Lake Champlain Basin since 2000. Sources of contaminants include urban runoff, Wastewater Treatment Facility effluent, as well as rural and agricultural non-point runoff. This data, combined with aquatic toxicity data from the EPA ECOTOX database and other sources has been used to undertake a preliminary risk assessment of toxics in our waters. Examples of organic contaminants found in our waters at possibly toxic levels include: synthetic estrogens in WWTF effluent, polycyclic aromatic hydrocarbons (PAHs) in urban runoff, and neonicotinoid insecticides in agricultural tile drain discharge.  
  
A summary will be presented of existing contaminant data along with which compounds appear to exceed acute aquatic toxicity levels of concern. Data gaps and future research needs will be discussed.

* 11:15-11:30 AM: Pharmaceutical contaminants in the Lake Champlain Basin

*Christine Vatovec, University of Vermont*

***Abstract.*** Pharmaceuticals are receiving increasing attention as chemicals of emerging concern in the aquatic environment. The purpose of this presentation is to share the most recent data on pharmaceuticals in the Lake Champlain basin, along with current gaps in knowledge. METHODS: This research employs multidisciplinary mixed methods including wastewater sampling to detect pharmaceuticals entering the lake, social science surveys to examine consumer behaviors as sources of pharmaceutical pollution, and interviews to provide insight on clinical prescribing and dispensing practices. RESULTS: We share results from five interrelated studies: 1) we have detected 51 pharmaceuticals entering the lake via wastewater effluent, 2) a survey of UVM students (n = 358) indicates that leftover drugs pose future disposal concerns, 3) a survey of Burlington residents (n = 161) indicates that flushing is not a major source of pharmaceutical pollution, 4) a survey of Vermont residents (n = 421) indicates that both human and veterinary medications are sources of pollution in the lake, 5) interviews with clinicians suggest that the political economy of pharmaceutical prescribing and dispensing is a key point of intervention for minimizing pollution. CONCLUSIONS: Pharmaceuticals pose potential risks to the health of the Lake Champlain watershed. Further research is needed to better understand the ecological effects of these contaminants.

* 11:30-11:45 AM: Lake George, New York: Two recent case studies of inefficient community wastewater treatment technology and the consequences to ground water contamination with plant nutrients and other contaminants

*Jim Sutherland*

***Abstract.*** During 2013-2014, operations staff at the Village of Lake George Wastewater Treatment Plant (VLG WWTP) noted elevated nitrate-nitrogen (NO3-N) levels in data from ground water wells sampled bi-monthly for New York State Department of Environmental Conservation SPDES permit plant operating requirements. Levels consistently were exceeding the permit threshold of 10 mg N·L-1 and plant operating reports for prior years did not indicate a problem. Further investigation revealed that WWTP reports had been falsified to reflect plant operation within SPDES permit requirements.   
  
Also during the past decade, water quality issues have occurred in Bolton Bay (Town of Bolton) on the west side of Lake George, particularly in the littoral zone and shoreline areas, rendering the area unusable for recreational purposes due to nuisance algal growth. Two tributaries flow into Bolton Bay, one north, the other south, of the impacted area, and both tributaries receive drainage from the Bolton WWTP.  
  
Both WWTPs in the Lake George basin were constructed during the twentieth century on upland slopes of natural delta sand deposits created by outwash from receding glaciers in order to utilize the sand as an infiltration area for treated wastewater effluent.

Studies conducted on both WWTPs included sampling ground water wells, seepage streams, and local tributaries. The VLG WWTP study was conducted for 17 months with biweekly sampling; the Bolton WWTP study occurred over 13 months with biweekly sampling from May through October and monthly sampling during the winter.  
  
The studies showed that wastewater treatment is not effective in either plant and that high concentrations of nutrients and other contaminants are discharged to sand recharge beds not capable of providing a final effluent polish. The discharged effluent then enters the ground water and eventually emerges down-gradient as seepage streams that enter tributaries flowing into Lake George.  
  
Loading of nitrate-nitrogen and chloride to West Brook from the VLG WWTP since the mid-1970s was estimated to be 154 tons and 3,164 tons, respectively. Calculations performed for the Bolton WWTP revealed that 97.5 tons of nitrate-nitrogen and 379 lbs of soluble reactive phosphorus were discharged to Bolton Bay during a 47-year period.  
  
Scenarios similar to the situation described herein for the two Lake George basin WWTPs may be prevalent in other areas, like the Lake Champlain Basin, where local wastewater treatment plants discharge treated effluent to sand recharge beds (from glacial outwash) that then enters the local ground water up-gradient from the lake.

* 11:45 AM-12:00 PM: Heavy metal contaminants of soil and water associated with illegal garbage burn piles, West Haven, Vermont

*Helen Mango, Castleton University*

***Abstract.*** The Nature Conservancy owns and manages the Helen W. Buckner Memorial Preserve in West Haven, Vermont, bounded on the south by the Poultney River and on the west by the South Bay of Lake Champlain. Illegally dumped and burned garbage piles have existed for years along the access road that runs along the river. Analysis of ash and soil samples from different burn piles over several years shows elevated levels of many contaminants, including arsenic, copper, lead, zinc, chromium and cobalt, often exceeding background levels by orders of magnitude. Burned materials include household trash, construction debris, and commercial waste (including electronics). The area is seasonally flooded, resulting in both erosion and deposition. Periodically, old burn piles get washed away, and contaminated soil gets covered by new sediment. One burn pile has been sampled three times over four years; Pb concentrations have varied between 1270 and >5000 ppm, Cu between 424 and >10,000 ppm, Zn between 7900 and 12,500 ppm, Cr between 261 and 1230 ppm, Mn between 1260 and 2170 ppm, and As between 147 and 460 ppm. Background levels (taken from a presumed uncontaminated site 1 km from the burn piles) are well within the normal range for soils (e.g. sample contains 16 ppm Pb, 11 ppm Cu, 60 ppm Zn, 2.8 ppm As, 67 ppm Cr). Geochemical analysis from vertical and horizontal core sampling along a transect from one burn pile to the river suggests that contaminants have migrated downward into the underlying soil, as well as laterally towards the river. Different relative concentrations of individual metals from one core to another may be the result of differential solubility and transport mechanisms. Contaminants ultimately end up in the river, which flows into Lake Champlain less than 2 km downstream. As a result of these findings, in 2015 the Vermont Department of Environmental Conservation hired a consulting company to assess and remediate the site. Four cubic yards of contaminated soil was removed, and the site was repurposed into an official boat launch with parking area. (This allows the Department of Fish and Wildlife to patrol the area, rather than relying on the very limited resources available to the West Haven sheriff.) However, recent sampling, including the excavation of an 82-cm deep hole in the vicinity of one of the longer-lasting burn piles, suggests that contamination may still exist at depth. In addition, signs of recent burn piles indicate that potential contamination of soil and water continues.

* 12:00-12:15 PM: Microplastic pollution and biomagnification in Lake Champlain

*Danielle Garneau, SUNY Plattsburgh*

***Abstract.*** Microplastic pollution in freshwater ecosystems is an emerging topic. Primary microplastics are designed to be small (e.g., microbeads, pre-production nurdles) and secondary microplastics result from photo and mechanical degradation. The origin of microplastics is marine debris and personal care products, whose small size evades wastewater treatment plant processing. Many organisms mistake microplastics for food and the particulates biomagnify up the food chain. There is growing concern that microplastic particulate has potential to adsorb chemicals and pathogenic bacteria, leaching plasticizers up the food chain. We quantify and characterize microplastics derived from 24-hr samplings of wastewater treatment plant (WWTP) post-treatment effluent, as well as long-term monitoring (LTM) zooplankton samples in the Lake Champlain watershed. We quantified whether these particulate were biomagnify within lake organisms. Using wet peroxide oxidation we digested post-treatment WWTP effluent (Plattsburgh and Ticonderoga NY; St. Albans and Burlington, VT) in the Lake Champlain basin during 2015-16.   
  
Across all sites, the dominant microplastics were characterized as fragments and fibers. Of samples processed, the fragment:fiber percentages have varied by plant, specifically Plattsburgh (51:23%), Ticonderoga (44:40%), St. Albans (67:8%), and Burlington (69:18%). Over 1000 microplastics were identified from a 24-hr sampling session, showing the potential of WWTP to be a significant source. Simultaneously, a total of 2265 LTM samples collected between 2010-2015 were processed. Pre-production rubber pellets (nurdles) were observed in samples from 2012-2015, twice as many were found in 2012-13 as compared to 2014-15 and microplastics were noted. Concern for the biomagnification of microplastics culminated in a trophic study. All organisms (n=411) representing invertebrates (n=257), 14 fish species (n=139), and double-crested cormorants (n=15) were processed in a manner similar to WWTP samples. Microplastic biomagnification was noted and abundance varied across species. Average microplastic abundance in invertebrates, fish, and cormorants was 0.05, 1.91, and 22.93, respectively and the majority were fibers that are dominated by polyester, rayon, and cellulose. This research represents the first of its kind to quantify and map the microplastic pollution problem in Lake Champlain. Results from this study will inform wastewater treatment plant operators, land owners, Fish and Wildlife managers, lake stewards, and governmental officials of the threats microplastics pose to aquatic organisms.

11:00-12:15 PM: Concurrent Session N: Geology, Land Use, and Land Cover

Moderator: Kris Stepenuck

* 11:00-11:15 AM: Transport dynamics of Missisquoi Bay, Lake Champlain, Vermont

*Patricia Manley and Thomas Manley, Middlebury College; Jean-Phillippe Juteau, Maritime Way Scientific Ltd.*

***Abstract.*** Missisquoi Bay, located in both Canadian and US waters in the northeast portion of Lake Champlain (NY-Vermont), is a uniformly shallow bay with a mean depth of slightly less than 3 m. Changes in land-use practices since the 19th century such as intensification of agriculture, increased animal husbandry, and rapid urbanization has increased the loadings of nitrogen and phosphorus causing eutrophication and seasonal oxygen depletion. Since monitoring began in 1992, Missisquoi Bay has displayed the greatest mean total phosphorus concentrations and chlorophyll-ɑ concentrations in Lake Champlain. A 3-year monitoring program (VT EPSCoR RACC program) from 2012-14 utilized an array of ADCPs, water level gauges, vertical temperature strings, and meteorological sensors to monitor the bay’s hydrodynamics. From these data, four basic modes of circulation were found to exist. The first was defined as “wintertime sluggish” wherein water velocities were vertically uniform and on the margin of detectability by the ADCPs. The second “spring melt” mode was when all three river inputs were maximized with high-volume flows. The third and fourth modes were documented when stratified conditions could exist (May-November) and subsequently were divided up into those times when the water column was well mixed (mode 3 - “well-mixed summer”) and when stratified conditions led to highly dynamic 2-layer flow (mode 4 - “two-layer summer”). As a result, the circulation patterns within the bay are in constant flux due not only to the presence of any one of the four modes but, just as importantly, wind forcing. To understand sediment transport in the bay with regards to these modes of circulation, two sediment studies, Sediment Trend Analysis® (STA) and acoustic sediment characterization software (SwathWay) were done. Using grain size determination from grab samples in a 500 m grid, STA was performed to identify the patterns of net sediment transport and dynamic behavior (e.g., deposition, erosion, and dynamic equilibrium). SwathWay (Maritime Way Scientific, Ltd.) defined 12 distinct acoustic backscatterance signatures (classes or regions) from 3-years of Multibeam sonar data collected over a majority of the bay. Combining hydrodynamics, sediment grain size and density, STA results and acoustic zonations, a pattern has evolved which addresses the flow regime that is most representative of sediment transport and deposition.

* 11:15-11:30 AM: Climate change and intraseasonal variability in Lake Champlain: application of the SUNY Plattsburgh data buoy and long-term monitoring data

*Eric Leibensperger and Mark Malchoff, SUNY Plattsburgh*

***Abstract.*** The climate of the Lake Champlain Basin is changing, but the rate of warming and some fundamental characteristics of Lake Champlain remain uncertain. We present work stemming from the deployment of a data buoy in Lake Champlain, which collected surface weather and water temperatures (surface to 50m) June-October 2016 and 2017. We further leverage long-term monitoring data to relate lake warming to atmospheric conditions.   
  
Observed trends in August and summer mean near-surface water temperature (~0.9°C/decade) have risen beyond the uncertainties of synoptic and interannual variability, and is strongly related to atmospheric conditions. We use these observed relationships to predict surface water warming of ~1.9°C and ~4.8°C by 2050 and 2090, respectively. However, significant uncertainty surrounds the impact of changes in wind mixing and loss of lake ice in the future.  
  
The buoy data present opportunities to examine thermal fluctuations across multiple, short time scales (i.e. inter-annual, seasonal, monthly, or weekly) and relate to wind forcing events. We compared July through August temperature-at-depth, and wind forcing data across two consecutive summers (2016 and 2017). Mean daily temperatures at a depth of 19 meters varied as much as 11°C in 48 hours in 2017, and 10°C in 24 hours in 2016. Daily average southerly wind speeds above 7.5 m/s were positively correlated (Pearson’s R=0.87) with temperatures at 19 meters lagged 6hrs relative to wind data. The impact of wind forcing was further examined via principal component analysis of the lake’s thermal structure. The analysis reveals a primary mode associated with wind mixing that is related to wind speeds, allowing prediction and reanalysis of observed data.   
  
Despite their importance to the ecology, water quality, and management of Lake Champlain, the NY/VT long-term monitoring program cannot provide meaningful guidance regarding changes in mixed layer depths or temperatures within the metalimnion because of large variability associated with internal waves and mixing. It is recommended that high-frequency sampling of the thermal structure be continued and expanded.

* 11:30-11:45 AM: High-resolution land cover for the Lake Champlain Basin

*Jarlath O’Neil-Dunne, University of Vermont*

***Abstract.*** New collections of high-resolution remotely sensed data, such as imagery and LiDAR, are giving us an unprecedented way to map, measure, and monitor our changing landscapes. This presentation will discuss how terabytes of remotely sensed data for the Lake Champlain Basin are being turned into the most detailed and accurate land cover product ever generated - 900 times more detailed than the best available existing land cover! Learn the ins and outs of the methodology used to derive the Basin high-resolution land cover along with some of the ways in which it can be used to help improve the health of the Basin.

* 11:45 AM-12:00 PM: Exploring lawn care practices of homeowners across the Lake Champlain Basin to promote behavior changes, and ultimately reduce stormwater runoff

*Kris Stepenuck, University of Vermont, UVM Extension, and Lake Champlain Sea Grant Program*

***Abstract.*** Lake Champlain’s water quality is greatly influenced by human uses of the land due to a very high land-to-water ratio, of about 18:1, in the watershed. However, this large land to water ratio results in there being a significant disconnect between people’s understanding of their land uses and the influence of those land uses on water quality in Lake Champlain. Even those who live nearer to the lake often do not always realize the actions they take on their property can significantly influence transport of stormwater, nutrients, sediments and other pollutants to tributary streams and Lake Champlain. Research studies have shown that, on average, acre for acre, runoff from developed lands in the Lake Champlain Basin contributes up to four times more phosphorus than agricultural lands and seven times more than forests. Further, Vermont Department of Environmental Conservation has found traces of lawn care chemicals in surface waters in the watershed.  
  
To contribute towards an “all in” approach to water quality improvement and protection, and to reduce the amount of stormwater runoff entering tributaries and Lake Champlain, a team of partners from numerous agencies and organizations initiated a Healthy Soils project in fall 2015. Using a technique called Community-based Social Marketing, the team identified key lawn care practices that homeowners in the Lake Champlain Watershed might carry out that would promote development of healthy soils, which in turn, will increase stormwater infiltration and reduce runoff from lawns. The team surveyed homeowners across the Lake Champlain Watershed to identify motivations and barriers to implementing selected lawn care practices. More than 1000 people from 56 towns in Vermont and New York responded to the survey. This presentation will share results of the survey that characterized current lawn care practices in urban, suburban and rural communities, as well as motivations and barriers to specific lawn care practices. In addition, the presentation will share results of focus groups that helped to inform an outreach campaign and a supporting research effort, both of which are currently underway in communities in the Lake Champlain Watershed.   
  
*Contributors: Karen Bates, Kimberly Coleman, Kerri Crowningshield, Lori Fisher, Colleen Hickey, Linda Patterson, Pat Sagai, Jolene Wallace*

* 12:00-12:15 PM: Lake George Septic Initiative Program

*Chris Navitsky, The FUND for Lake George*

***Abstract.*** Antiquated and failing onsite wastewater treatment systems (OWTS) contribute excessive nutrients to local groundwater and surface waters resulting in negative impacts to water quality by decreasing water clarity and increasing algal growth potentially resulting in blooms containing toxins. This is a difficult problem to identify due to varying subsurface conditions and lack of inspection requirements.   
  
The Lake George Septic Initiative Program is developing an innovative tool that creates three data sets based on GIS-based site suitability analysis, biomonitoring using algal analysis with metrics application and a detailed inventory review of systems that are merged generating a prioritization map to focus resources for system upgrades. Site suitability analysis components include depth to groundwater, depth to bedrock, soil hydraulic conductivity, setback to water bodies and slope information and are analyzed through a weighting system. Biomonitoring is through near shore algal samples collected in less than 10 feet of water from all available substrate and determine water quality impacts through application of confirmed metrics, primarily focusing on algae known to be present in areas that contain organic pollution from human waste. The third data set is compiled through a detail inventory of septic systems by reviewing municipal files and owner survey with importance on the system’s age, components, maintenance, permitting and inspection. These three data sets are then analyzed through a joins and relate process to create a map to assess parcels that may be impacting water quality which can then be prioritized for system replacement and improved management. This data can be coupled with outreach and education to inform stakeholders through public meetings, technical conferences and social media to impart a better understanding of the relationship between septic systems and water quality.

12:15-1:15 PM: Lunch

1:15-2:30 PM Concurrent Session O: Salmon Restoration, Part II

Moderator: William Ardren

* 1:15-1:30 PM: Homing and imprinting cues for landlocked Atlantic salmon (*Salmo salar*)

*David Minkoff, Boston University*

***Abstract.*** Indigenous populations of Atlantic salmon (Salmo salar) in Lake Champlain were extirpated by 1838, the result of excessive harvest and habitat changes caused by dams and stream sedimentation. Restoration efforts from 1973-present, including annual stocking from hatcheries, have established a population sufficient to support a recreational fishing industry, however the number of wild spawning (river-run) salmon remains low. Current management plans emphasize the need to restore self-sustaining populations, however the reasons for the dearth of river-run salmon remain uncertain. Our research focuses on the timing and mechanisms of S. salar imprinting and homing, with potential implications for hatchery protocols for rearing salmon targeted for restoration. The focus of our studies includes:  
  
1. Investigation of the relative concentrations and temporal stability of Dissolved, Free Amino Acids (DFAA) in salmon stream sites in Vermont, New York and Maine during known period of downstream (Spring) and spawning (Autumn) migrations to determine if DFAAs can be candidate odors for imprinting on natal stream chemistry.  
  
2. Developing a weekly time-series of relative concentrations of thyroxine (T4) hormone during different stages of development to establish the time windows of thyroxin surges in Atlantic salmon that may correspond with odor imprinting periods hypothesized to occur both in parr-smolt and hatchling-emergence stages of development.

* 1:30-1:45 PM: Dam removal on the Boquet river and its effect on Atlantic salmon (*Salmo salar*)

*Jessamine Trueman, Concordia University*

***Abstract*.** Dams have caused the extirpation of many freshwater fish species across North America by degrading available habitat and preventing upstream or downstream migration. The Willsboro dam was removed from the mouth of the Bouquet River in New York in August 2015. However, the nearby cascades remain mostly impassable for spawning Atlantic salmon. In Autumn 2016, adult salmon were moved above the cascades and spawned in the upper reaches of the Bouquet. Habitat use by spawning Atlantic salmon were investigated above and below the cascades in 2016, and below the dam in 2014 to test whether spawning habitat was limited and of poor quality below the dam and abundant and of high quality above the dam. Redd data for mean water velocity, substrate and depth were compared to habitat availability at each site. Data were collected from microhabitat surveys conducted below the dam site before and after removal, above the dam site after removal. Habitat use below the dam site differed significantly between 2016 and 2014 and all variables were closer to literature values in 2016. Variance in habitat use was higher in sites below the dam than above, and salmon only showed preference for specific habitat types in areas above the dam site. Overall, our data suggests that a) dam removal has resulted in an improvement in spawning habitat downstream, b) spawning habitat is limited below the dam, resulting in salmon spawning in a wide variety of habitat, and c) fish moved above the dam have access to an abundance of high quality spawning habitat.

* 1:45-2:00 PM: Understanding effect: consequences of delayed movement for both upstream and downstream passage of Atlantic salmon at barriers

*Theodore Castro-Santos, United States Geological Survey*

***Abstract.***  Fish passage is about more than simply passing fish.  The goal is to provide connectivity between habitats, and delays incurred during passage can have long-term consequences for individual fitness as well as key processes at the population level.  In a pair of studies performed in tributaries to Lake Champlain we quantified passage performance of landlocked Atlantic salmon, both during a downstream smolt migration and  an upstream spawning migration.  In both cases the barriers were passable, but overall passage was reduced by the extended delays incurred by salmon as they tried to pass.  By quantifying the effort expended attempting to pass these barriers we gain insights into biological and environmental factors that limit motivation, and how these combine with structural features to govern passage success.

* 2:00-2:15 PM: The influence of thiamine deficiency on the behavior of larval landlocked Atlantic salmon

*Nicole Hill, Ashlee Prevost, Dylan John Fraser, Concordia University; William Ardren, U.S. Fish and Wildlife Service; James W.A. Grant, Concordia University*

***Abstract***. While the Atlantic salmon reintroduction program in Lake Champlain is showing promise with increasing numbers of adults returning to tributaries to spawn, a lack of recruitment is still limiting recolonization success. The consumption of alewife, a non-native forage fish in the lake, has resulted in the development of a maternally transferred thiamine deficiency which can cause up to 100% mortality in larvae (Early Mortality Syndrome, EMS). Despite the devastating effects of EMS, little quantitative work has explored its influence on behavior. Eggs from 17 returning lake females of varying thiamine levels were fertilized and divided into two treatment groups, one which received a thiamine bath after fertilization and one that did not. Individuals from each treatment, in addition to a control group of sea run larvae, were observed for differences in behavior at two developmental stages prior to first feeding: sac fry and button up. Preliminary results suggest that activity levels at the sac fry stage are low across all groups, and that behavior differs more between families than between treatments. These results indicate that thiamine deficiency does not strongly influence individuals at this developmental stage. While we are still analyzing data from the button up stage, the results will have important implications for the Lake Champlain restoration plan. Behavioral differences between treatments would suggest sub-lethal effects which may influence fitness in a natural setting; limiting recruitment beyond the initial mortality experienced by low thiamine individuals. Furthermore, differences between families would suggest that certain genotypes are more robust in response to thiamine deficiency. If this is the case, restoration efforts will likely need to focus on these genotypes in order to increase recruitment success in Lake Champlain.

* 2:15-2:30 PM: Extended discussion

1:15-2:30 PM Concurrent Session P: Invasive Species

Moderator: Timothy Mihuc

* 1:15-1:30 PM: Long-term zooplankton community patterns in Lake Champlain, USA: The role of invasive species in restructuring lake food webs

*Timothy Mihuc, SUNY Plattsburgh*

***Abstract.*** Freshwater lakes provide ideal habitat for invasive species that may deteriorate ecological integrity by altering food web dynamics. Long-term records (1992-present) for water quality parameters, native Mysids as well as native zooplankton (Rotifers, Cladocera, and Copepods) in Lake Champlain illustrate the impact of invasive species on the pelagic food web. Zooplankton exhibited major shifts from 1992-present, including a decline in rotifer abundance in the mid-1990s, following invasion of zebra mussels (Dreissena polymorpha) into Lake Champlain. More recent community shifts can be attributed to invasion of the Alewife (Alosa pseudoharengus) and Spiny Waterflea (Bythotrephes longimanus). These shifts represent a major change in community structure with implications for the Lake’s food web dynamics. The primary driver of change in Lake Champlain’s plankton over the past two decades appears to be species invasions rather than patterns in water quality or trophic status. Food web analysis using HEA (hybrid evolutionary algorithm) models suggests zebra mussel direct impacts on Rotifers, via predation, with potential indirect effects on Cladocera, Copepods, and Mysids. Impacts of Alewife and Spiny waterflea invasion in the mid-2000s and 2014, respectively, occurred on selected larger bodied Cladocera and Copepod taxa. Post- invasion patterns in Lake Champlain’s pelagic plankton communities illustrate the threat that invasive species pose to the integrity of freshwater ecosystems.

* 1:30-1:45 PM: A comparison of zooplankton diel vertical migration in Lake Champlain before and after the invasion of *Bythotrephes*

*Mark LaMay, Lake Champlain Research Institute*

***Abstract.*** Zooplankton diel vertical migration (DVM) was analyzed in Lake Champlain to assess the potential impacts of the invasive Bythotrephes longimanus (spiny water flea) on the native zooplankton assemblage. DVM is the daily migration of aquatic animals up and down the water column in response to various biotic and abiotic triggers, with most zooplankton typically residing in lower strata during the day then moving to the surface waters at night. Bythotrephes is a predacious cladoceran that has significantly impacted zooplankton communities in other invaded systems, including the Great Lakes. Discrete day and night sampling occurred monthly from June to September each year from 2013, the year before Bythotrephes appeared in Lake Champlain, through 2016. Triplicate vertical tows were conducted using 153-µm- and 250-µm-mesh closing nets at discrete 5-m increments to assess zooplankton vertical structure at one 50 meter site southeast of Valcour Island. Temperature profiles were recorded using a Manta 2 multi-depth probe and light transparency was estimated using a LI-COR PAR meter in addition to a Secchi disc. While zooplankton DVM has been extensively studied in other systems, few have sampled such a deep site at such a fine scale and doing so continuously before, during and after Bythotrephes invasion is novel. Results suggest differences in zooplankton vertical structure between the pre-invasion year and post-invasion years of Bythotrephes, particularly in the case of Daphnia retrocurva, traditionally the most common Daphnia species in the lake and a preferred prey item of Bythotrphes. While D. retrocurva displayed no significant migration patterns in 2013, there was a pronounced difference in day and night mean depths as soon as one year after the appearance of Bythotrephes; this may suggest that Bythotrephes are driving some species into deeper strata. These data indicate that in addition to direct predatory impacts Bythotrephes has on zooplankton populations, it may also indirectly affect both individual and population growth rates by restricting prey species to the cold, less productive hypolimnion.

* 1:45-2:00 PM: Adirondack Lake Mapping Project: Using sonar to collect data on Lake Characteristics

*Erin Vennie-Volrath, The Nature Conservancy*

***Abstract.*** Advances in electronic equipment allows for the rapid collection of high resolution sonar data which can be post processed using cloud-based computing to map lake depth, bottom substrate hardness, and vegetation. The technology is intriguing and its use as a tool to help inform aquatic invasive species early detection and management programs in the Adirondacks is currently being evaluated by the Adirondack Park Invasive Plant Program (APIPP) and the Adirondack Park Agency (APA). A pilot study was conducted this past summer to assess its potential. If the review of the technology indicates that a program is indeed going to be a wise investment, then a citizen scientist based mapping program may be initiated for the region. This presentation will provide a summary of the pilot study results and a discussion on the limitations and potential uses.

* 2:00-2:15 PM: Leveraging partnerships to advance the Adirondack Aquatic Invasive Species (AIS) Prevention Program: a voluntary boat inspection and decontamination program in the Northeast

*Eric Holmlund, Paul Smith’s College Adirondack Watershed Institute, and Meg Modley, Lake Champlain Basin Program*

**Abstract.** The Adirondack region of northern New York boasts over 3,000 lakes and ponds across a 6+ million-acre landscape. Abundant recreational boating opportunities, emphasized by their close proximity to major points of AIS entry into North America, have resulted in the introduction and spread of at least 11 species into the region. Survey data compiled since 2002 indicates that at least two thirds of the lakes and ponds in the region are still free of AIS. Since 2015, a collaboration of state agencies, local government officials, environmental organizations, lake associations, and invasive species programs have used historic AIS distribution and vector data to design and implement a landscape-scale AIS spread prevention program. The first program of its kind in the Northeast, The Adirondack AIS Prevention Program provides voluntary boat inspection and decontamination services at priority road and waterway locations while advancing strategic communications and awareness building initiatives. To date the program has inspected over 105,000 trailered vessels and intercepted 2,903 AIS on boats either attempting to launch into or being retrieved from Adirondack waters. The Program’s success in leveraging partnerships amongst a diverse set of stakeholders provides a model for future collaborative invasive species prevention efforts. This session will provide a summary of the Program and strategy to promote consensus amongst stakeholders to combat the spread of AIS in the Adirondacks.

* 2:15-2:30 PM Extended Discussion

1:15-2:30 PM Concurrent Session Q: Road Salt

* 1:15-1:30 PM: Base cation loss from road salting with implications for acid deposition recovery

*Daniel Kelting and Corey Laxson,* Paul Smith's College

**Abstract.** Road salt (NaCl) and acid deposition co-occur across much of the Adirondack Park (AP), where the effects of acid deposition have been widely studied and the effects of road salt have not. Road salt delivers 3,560 Mmolc of Na to AP roads each year, which has significant potential to displace soil base cations and exacerbate ecosystem recovery from acidification. With this, our objective was to estimate the effect of road salt on soil base cation export for the AP. We used a simple steady state model based on estimated runoff and cation concentrations from lakes in watersheds with (n=84) and without (n=68) paved roads to estimate watershed export of Ca, Mg, K, and Na. Road salting resulted in significantly higher export for all cations, with 28, 15, 2, and 83 mmolc/m2/yr more Ca, Mg, K and Na released, respectively, compared to watersheds without paved roads. Mineral weathering rates are insufficient to replace these lost cations and thus watershed recovery from acidification will be slower in the presence of road salt. Road salt should be included as a co-occurring stressor and accounted for when assessing the impacts of pollutants on ecosystem health, not only in the AP but wherever road salt is applied.

* 1:30-1:45 PM: Road salt induced meromixis of Mirror Lake (Lake Placid, NY)

*Brendan Wiltse, Ausable River Association; Corey Laxson,* Paul Smith's College*; Elizabeth Yerger*

***Abstract.*** Regional salinization of waters within the Lake Champlain Basin is an important research topic. The specific impacts of that salinization on the chemical, physical, and biological components of aquatic ecosystems are still not completely understood. Mirror Lake, located in the Village of Lake Placid, is one of the most urban lakes in the Adirondack Park. The lake receives direct stormwater runoff from the Village through a network of over 25 stormwater outfalls. This stormwater delivers high loads of road salt directly to the lake. The objective of this research was to understand the impact of road salt on Mirror Lake. Specifically, we sought to understand an apparent lack of spring turnover observed in 2015 and 2017. We studied the lake on a bi-weekly to monthly basis for two and a half years to understand the spatial and temporal variation in chloride concentrations within the water column of the lake. Additionally, we sampled the stormwater outfalls around the lake on two occasion in early 2016 to understand the spatial distribution of salt contributions to the lake. Our results show surface water chloride concentrations ranging from 36 to 54 mg/L, while bottom water concentrations range from 48 to 123 mg/L. The median concentration of chloride in Adirondack lakes not impacted by road is 0.24 mg/L, putting Mirror Lake’s concentrations 150- to 513-times higher than comparable unimpacted lakes. Elevated bottom water chloride concentrations appear at the same time as winter and spring runoff events. In 2015 and 2017 these elevated concentrations persisted throughout the summer until fall turnover. The persistently elevated chloride concentrations during these two years indicate that the lake did not completely mix in the spring. Calculations of Schmidt Stability for immediately after ice out in 2016 and 2017 showed elevated chloride concentrations increased the energy needed to mix the lake by a factor of three in 2016 and a factor of 75 in 2017. This implies that salt induced density differences contributed to the lack of spring turnover in 2017. To the best of our knowledge, this is the first documented case of salt induced inhibition of spring turnover in the Adirondacks. The disruption of this critical physical process has the potential to impact internal nutrient cycling and habitat availability for cold water species.

* 1:45-2:00 PM: Monitoring for chloride concentration using automated equipment

*Dana Allen, Watershed Consulting Associates, LLC*

***Abstract.*** Chloride associated with deicing activities is an emerging contaminant of concern in the Lake Champlain Basin. As communities, watershed groups, and regulatory agencies begin to grapple with how to comply with and enforce regulations, the need for simple, effective monitoring strategies is increasing. This presentation will explore the use of an automated water quality sonde measuring specific conductance in-stream and how that data can be used to determine chloride concentration for a given water body at a given time. Data trends by season and by weather event will be examined using data collected in a stream in the greater Burlington area over a nearly two-year monitoring period. Exploration of these data trends will help guide monitoring efforts by informing stakeholders conducting the monitoring when deploying equipment will be most effective to determine regulatory compliance. Sample site setup will be discussed, as will data digestion and reduction to achieve effective, easy to understand graphs and materials to analyze in-stream chloride levels.

* 2:00-2:15 PM: Salt export to the Ausable River from the Village of Lake Placid

*Corey Laxson, Elizabeth Yerger, and Dan Kelting, Paul Smith’s College*

***Abstract.*** Widespread use of road deicers has resulted in significant salinization of many of the lakes and rivers in the Adirondack portion of the Champlain basin. Several studies have examined salinization at the regional level in the Adirondacks; however, no study has quantified the contribution that a relatively small urbanized area makes to the salt load of a major tributary of Lake Champlain. This study examines the contribution the village of Lake Placid makes to the road salt load of the Ausable River. The Village and its immediate environs comprise one of the most urbanized areas within the Adirondack Park, and being positioned in the headwaters of the Ausable River, land use practices in this location can have major impacts on the Champlain Basin. A combination of in-stream stage and conductivity recorders, as well as discharge measurements and routine chemical analysis were used to quantify hourly chloride export from two stations on the Chubb River (tributary of the Ausable) over the course of 19 months. The Upper Chubb is upstream of Lake Placid and has a very low density of salted roads, thus it is representative of the least impacted condition. The Lower Chubb station is downstream of the village near the confluence of the Ausable River, and is impacted by a high concentration of impervious surfaces and a substantial amount of road runoff. We found that the village of Lake Placid alters the chemistry of the Chubb River by significantly increasing the concentration of dissolved ions. The total chloride load of the Chubb increased as it passed through the village by a factor 100 on average, and by a factor of nearly 200 on occasion. When corrected for watershed area, Lake Placid is responsible for increasing the chloride export into the Ausable River by a factor of 22 on average, and by a factor of 50 on occasion. Overall, our estimates of the export coefficient are conservative, as ice damage to our sensors interfered with our ability to completely quantify salt export during the spring of 2017. Our preliminary work illustrates the magnitude of impact urban environments have on water quality, even in seemingly pristine areas like the Adirondacks. This type of high resolution data improves our understanding of the movement of road salt through the environment and provides a baseline for gauging the efficacy of forthcoming changes to winter road management planned in Lake Placid.

* 2:15-2:30 PM Winter Maintenance Best Practices: Identifying and Lowering Private Contractors' Barriers to Adoption

*Holden Sparacino, University of Vermont*

***Abstract.*** Winter road maintenance keeps roads free of snow and ice, but also negatively impacts water quality, poses risks to aquatic life, and may increase health risks for private well owners. As environmental concerns have grown and materials costs have risen, many municipalities have adopted preventative measures (best management practices) to reduce salt use, lower environmental impacts, save money, and provide a similar level of service. However, it is largely unknown if private contractors who maintain private roadways, commercial parking lots and sidewalks have adopted these practices, and what their motivations and barriers are to doing so. In this talk, an ongoing mixed-methods study in the Lake Champlain Basin will be discussed that seeks to identify the current practices of private contractors, and use findings to identify barriers to best management practice adoption and develop outreach and learning opportunities for contractors. Ultimately the study and outreach aims to increase private contractors’ awareness of environmental and economic outcomes of best management practices, and lower barriers to adopting these behaviors.

1:15-2:30 PM Concurrent Session R: Lake Champlain Unfiltered

Moderator: Eric Howe

2:30-3:30 PM: Optional networking and ad hoc meeting time

Poster Session: January 8th, 5:30-6:30 PM

**Monitoring for Chloride Using Automated Equipment & Estimating Watershed Scale Source-Specific Chloride Application Reductions**

*Dana Allen, Watershed Consulting Associates*

***Abstract.*** Chloride associated with deicing activities is an emerging contaminant of concern in the Lake Champlain Basin. As communities, watershed groups, and regulatory agencies begin to grapple with how to comply with and enforce regulations, the need for simple, effective monitoring strategies is increasing. This presentation will explore the use of an automated water quality sonde measuring specific conductance in-stream and how that data can be used to determine chloride concentration for a given water body at a given time. Data trends by season and by weather event will be examined using data collected in a stream in the greater Burlington area over a nearly two-year monitoring period. Exploration of these data trends will help guide monitoring efforts by informing stakeholders conducting the monitoring when deploying equipment will be most effective to determine regulatory compliance. Sample site setup will be discussed, as will data digestion and reduction to achieve effective, easy to understand graphs and materials to analyze in-stream chloride levels.

**Characterization of Microplastic Polymers Biomagnifying up the Lake Champlain Food Web**

*Erin Ashline and Danielle Garneau, SUNY Plattsburgh*

***Abstract.*** Microplastics are small particles of plastic considered to be <5mm and are characterized by color, type (e.g., fragment, pellet, fiber, foam, film), and density. These synthetic particulate can adsorb contaminants (e.g., heavy metals, hydrocarbons, hormone disruptors, and pathogenic bacteria) and bioaccumulate within organisms impacting their survival and reproduction. Fourier transform infrared (FT-IR) is a spectroscopy technique widely used to analyze polymer profiles of particulate at a chemical level. Both FT-IR and Raman spectroscopy use spectral absorption bands to confirm the identity of a pure compound, as well as impurities. The goal of this study was to assess the polymer composition of microplastics ingested by aquatic organisms from Lake Champlain. Organisms were obtained from fishing tournaments, dissected, digested using wet peroxide oxidation to eliminate organic material, dried in drying ovens, and later characterized by type and size. Preliminary results suggest fibers are the most prominent particle type in organisms (N = 482). Among these fibers, the most common plastic polymer was polyester [PET] (14.5%), followed by cellulose [20u ave particle size] (11.1%), alpha-cellulose [99.5% pure] (11.0%), and rayon (8.5%). Fragments were the second most prominent particle type (N = 168) and were commonly polyester [PET] (52%), followed by vinal (9%), polypropylene, isotactic (4%), and rayon (4%). Pellets (N = 14) were primarily vinylidene chlorine [200ppm mhdq] (14.2%) and polyethylene, chlorinated 36% chlorine (14.2%), followed by both vinal (7%), and cellulose nitrate (7%). Films (N = 11) were primarily rayon (27%), poly [methylmethacrylate] (27%), followed by poly [1,4-cyclohexanedimethylene terephthalate] (18%), and polypropylene, isotactic (9%). The least common polymer type found were foams (N = 10) comprised of polyethylene, chlorosulfonated (50%), polyethylene, chlorinated 36% chlorine (40%), and alzon [casein] (10%). Overall, polyester [PET] was more abundant as compared to other plastics and derives from synthetic clothing and food and beverage packaging. PET is a non-reactive material that is resistant to many chemical and biological reactions, thus persists in the environment with the potential to be mistaken for food among aquatic organisms. Educating the public and manufacturers using plastic as to the problem and their contribution may be the first step in reducing microplastic contamination in aquatic environments.

**The Role of Overwintering Zooplankton on Winter Freshwater Food Webs**

*Ben Block, University of Vermont*

***Abstract.*** Winter limnology is a relatively uncharted territory. Only 2% of the literature on freshwater systems includes under-ice lake processes, of which a fraction of those discuss zooplankton. Yet, zooplankton are the major conduits of energy from primary producers to higher trophic levels. Zooplankton are commonly observed in resting stages during winter, which have been attributed to low photoperiods, cold temperatures, and (our perception of) low food availability. However, zooplankton are also able to overwinter in an active life stage. Overwintering zooplankton can subsist on different food sources than in summer, and can also forgo consumption by subsisting on fat stores, similar to many mammals during hibernation. I predict that overwintering may become more common in the subsequent decades. Drastic changes may occur to zooplankton phenology as a consequence of increasingly warmer winters and less frequent ice cover. Warmer winters may cause zooplankton, which normally enter a resting stage, to remain active during the winter. These overwintering zooplankton may have a competitive advantage over those emerging from resting eggs after ice-out by being present for the beginning of the spring algal bloom. Additionally, warmer winters may cause predator-prey decoupling by exhausting food resources earlier in the year. As warming progresses, winter could become an evolutionary driver for changes in zooplankton life cycles as well as food web dynamics. I propose to study the winter ecology of zooplankton using a three-pronged approach of field observations, laboratory experiments, and a global sampling effort through a Global Lake Ecological Observatory Network (GLEON) working group. I will focus on three hypotheses: (1) eutrophic lakes will contain more diverse and abundant overwintering zooplankton communities than oligotrophic lakes, (2) zooplankton will actively forage in winter if sufficient resources are present, but will switch to lipid stores if prey densities are too low to elicit active feeding, and (3) zooplankton which overwinter will have a competitive advantage over species which use a resting stage by being present for the spring algal bloom. Through these studies, I hope to elucidate the role of actively overwintering zooplankton on the winter food web and how winter assemblages influence summer assemblages.

**Exploring Aerosolized Cyanobacteria as a Potential Environmental Risk Factor for Amyotrophic Lateral Sclerosis (ALS)**

*Tanya Butt and Dominic Facciponte, Dartmouth-Hitchcock Medical Center*

***Abstract. Background.*** Chronic environmental exposure to cyanobacterial (CB) toxins may be an environmental risk factor for the neuronal degeneration leading to ALS. Our previous studies have correlated areas of high ALS incidence in Northern New England to waterbodies with frequent blooms of CB. To determine if the aerosolization of CB is a potential route of human exposure to cyanotoxins, the assessment of aerosol from waterbodies and the identification of CB in the human respiratory tract are important steps. ***Question.*** Is the natural aerosolization of cyanobacteria a potential route of human exposure to cyanotoxins? ***Methods.*** Samples of aerosolized CB were collected using standard limnology techniques at Lake Sunapee during June-August 2016. Samples were collected in 6-hour intervals using an aerosol collector with a fiber filter containing a pore size of 0.6 micrometers. A microcystin (MC) enzyme-linked immunosorbent assay (ELISA) kit was used to measure total MCs extracted from filters and mixed water surface samples. Concentrated water samples were collected using a plankton net; phycocyanin and chlorophyll (Chl-a) concentrations in the concentrated samples were measured with a Beagle fluorometer. Seventeen non-ALS participants undergoing diagnostic bronchoscopy from Dartmouth-Hitchcock Medical Center consented to donate right upper lobe bronchoalveolar lavage (BALF) and/or nasal swab (NS) specimens. BALF samples were processed using standard cytocentrifuge methods and aliquots were reserved for nested 16s rDNA polymerase chain reaction (PCR). BALF and NS slides were analyzed using fluorescence microscopy (FM) to identify CB cells expressing phycocyanobilin pigments. “Fiji” software was used to analyze images for CB using a macro developed to measure fluorescent particles with ≥95% circularity for area and feret diameter. Purified CB was used as a positive control and analyzed following the same protocol as BALF and NS samples. ***Results.*** A significant difference was found between the MC concentration of the filters and MC concentration of the water samples (p=.037). The average ratio of MC concentration on the filter to the MC concentration from the water sample was 0.436 (SD=0.161). 70.5% of BALF samples tested positive for CB using PCR. 91.6% of the PCR-positive BALF samples had CB detectable by FM, compared to only 20% of the PCR-negative samples. We found no significant differences between both feret diameter and area of NS CB cells (Mean=2.85µm, SD=0.760µm; Mean=4.48µm, SD=2.91µm) versus control CB cells (Mean=3.19µm2, SD=0.767µm2; Mean=5.82µm2, SD=2.71µm2); p= 0.486, p= 0.245. ***Conclusions.*** These data suggest that humans may inhale aerosolized CB which can be harbored in the nostrils and, in some cases, the lungs. This is consistent with the hypothesis that aerosol may be a significant route of CB transmission.

**The Transport of Fecal Coliform and *E. coli* bacteria via surface and subsurface runoff from artificially drained fields in the Champlain Basin**

*Casey Corrigan, Laura Klaiber, and Steve Kramer, Miner Institute*

***Abstract.*** The transport of Fecal Coliform bacteria and E. coli through tile drains and surface flow are being monitored for a paired field study in the temperate climate of the Champlain Basin in upstate New York. Bacteria are required to bring about soil health, but the addition of animal manure to fields can bring about potentially dangerous pathogenic bacteria such as E. coli O157:H7. The higher the concentration of fecal coliform bacteria and E. coli bacteria species in effluent, the more likely that pathogenic fecal bacteria will be present. Tile drains and surface runoff generally flow into surface water sources, and if bacteria persist, they can present a risk for water usage and recreation downstream. Results of monitoring Fecal Coliform and E.coli bacteria from January 9th to present indicate that surface flow had consistently higher concentrations of both bacteria types than subsurface flow, except for in one case where snow melt was the primary source of water and there was little to no rain impact on the soil itself to entrap soil and bacteria in the water. Loadings of both bacteria were variable when comparing surface to subsurface flows since loading is a function of flow and concentration. Since tile drains generally transport more total water compared to surface runoff during events, the ratio between surface and subsurface flow volumes varied based on antecedent soil moisture, rain intensity and volume, and season. Results suggest that fecal bacteria do exist in runoff from agricultural fields fertilized with manure, and steps need to be taken to minimize loading from these systems and to ensure the safety of downstream water use by testing for harmful bacteria.

**Shipwreck Tugboat US Lavallee**

*Jenny Craig, Lake Champlain Maritime Museum*

***Abstract.*** The US Lavallee is a shipwreck in the Vermont State portion of the Lake Champlain Underwater Historic Preserve. It joined in 2017 as the 10th addition to the Preserve. This presentation will include a description of the site and the reason for including it in the Preserve.

**Using the ERA5 Reanalysis Dataset to Identify Extreme Flooding Events in the Northeastern United States**

*Caitlin Crossett, Arne Bomblies, Lesley-Ann Dupigny-Giroux, and Alan Betts, Vermont EPSCoR*

***Abstract.*** This study evaluates the utility of the ERA5 dataset in assessing extreme flooding events in the Northeastern United States. The ERA5 is a new global climate reanalysis dataset from ECMWF that spans 2010-01-01 through 2016-12-31, with the years back to 1979 currently in production. The ERA5 dataset has a spatial resolution of 31 km, and an hourly temporal resolution. Data included in this study is over the region from 37.5°N to 50°N, and 82.5°W to 65°W, encompassing the Northeast US. We first quantify precipitation spin-up as the model equilibrates to the initial conditions: spin-up of precipitation is about 20% in the first 12 hours. In addition, this study explores the ability to simulate floods in the Lake Champlain Basin using extreme precipitation and other variables from ERA5. Emphasis in the case study will be given to verifying the spatial and temporal distribution of precipitation over the duration of an event, as well as a discussion of the land-atmosphere interactions and their role in the intensity of the flood.

**Analysis of Large Precipitation Events for Burlington, VT from 1900 to 2016**

*Harris Eidelman, Vermont EPSCoR*

***Abstract.*** The Global Historical Climatology Network (GHCN) has suggested that extreme precipitation events in the Northeastern US have increased significantly since the late 1950s. In our study, we examined hourly and daily precipitation records from the National Climate Data Center for the Burlington, Vermont weather station to determine the frequency and intensity of large precipitation events from 1900 to 2016. In addition, we evaluated the occurrence of winter storm events and compared their frequency and intensity between two time periods: 1900 to 1950 and 1951 to 2016. Between the two time periods the total annual precipitation increased by 12.1%, the number of large events increased by 15.6%, and the percentage of annual precipitation from large events increased by 5.4%. Each season showed an increase in total precipitation, the number of large events, and the percentage of precipitation from large events compared to the climate norms for the two time periods. However, evaluation of the number of winter storms suggested a slight decrease between the two time periods. In general, the trends from the Burlington, Vermont data support the trends articulated by the GHCN. Exploring the difference between what constitutes an extreme event vs. a large event needs to be more clearly developed.

**Water Quality Blueprint - Nature-Based Solutions for Clean Water in Lake Champlain**

*Dan Farrell, The Nature Conservancy*

***Abstract.*** Natural systems are increasingly considered to be cost-effective solutions to water quality problems, providing multiple ecological co-benefits. The Water Quality Blueprint is a publicly accessible online tool designed to help watershed managers and conservation practitioners make use of natural and restorable areas to achieve water quality and conservation goals in the Vermont portion of the Lake Champlain Basin. It includes two independent prioritizations of floodplains and other areas associated with rivers, lakes and wetlands: a map layer that highlights natural assets that would benefit from protection and restoration (Conservation Value) and a map layer that highlights locations that are impaired, at risk of impairment or that may attenuate sources of pollution (Water Quality Impact Value). These prioritizations are raster-based, weighted combinations of multiple component datasets that represent important habitats, natural processes, and impairments. The component datasets, as well as other supporting datasets, are included in the web-map to help users understand patterns related to ecology, pollution, restoration potential, a nd fluvial processes at the site, watershed, and basin scales. The results of the Water Quality Blueprint have been incorporated into the Clean Water Roadmap for Vermont, an online tool designed to support the VTDEC's efforts to reduce phosphorous pollution in the Lake Champlain Basin.

**LCRR Hydrology, Hydraulics and Mapping Technical Work Group**

*Jesse Feyen, National Oceanic and Atmospheric Administration*

***Abstract.*** The Hydrology, Hydraulics and Mapping Technical Work Group (HMM TWG) is responsible for the execution of the hydrological models, identification of data needs for these models (historical, near-future and climatic weather scenarios), the hydraulic models, real-time floodplain mapping and the operation of a real-time flood forecasting and flood mapping system. Once calibrated, the models will serve in analysis mode as the basis to test the various flood management and mitigation measures that will be developed by the Flood Management and Mitigation Measures TWG. The HMM TWG will be active throughout the Study. Because of the complexities of the work associated with this TWG, sub groups, or committees may be formed to address specific topics that may need additional expertise.   
  
The HHM team will assemble all components of a predictive flood forecasting and real-time flood plain mapping system that uses ensemble predictive meteorology-hydrology and hydrodynamic models. Also, a 2D and a 3D hydrodynamic model for flood prediction on Lake Champlain in conjunction with a 2D hydrodynamic model for the entire Richelieu River which will be driven by hydrologic predictions and meteorological forecast models. A wind wave model will be implemented for the lake to be used in this predictive system. The predictive system will combine U.S. and Canadian meteorology and three hydrological models (ECCC, NCRR and MDDELCC) that will be transferred to a single U.S.-Canada hydrodynamic model to map expected flooding extent. An ensemble approach for predicting lake and river levels and flooding potential will provide probabilistic forecast guidance that will be used to select flood maps which reflect forecast conditions. This system will assimilate recent observations to produce reliable solutions. The HHM team will use an approach that involves, in a first step, the rapid implementation and use of current forecasting tools & early development of new tools. These would be used as soon as the spring 2018. These tools will evolve and will be updated as soon as new products become available in order to learn from potential public outreach and real-time use. HHM will test this flood forecasting system and make recommendations on future operational implementation.   
  
The 3D modeling proposed for Lake Champlain will use NOAA's enterprise forecasting model system and could, eventually, help address many of the questions the public had on addressing water quality and sedimentation concerns for the Lake should future other studies address these concerns.

**Cyanobacteria Monitoring in Lake Champlain**

*Lori Fisher, Lake Champlain Committee*

***Abstract.*** Spurred on by two dog deaths in 1999 linked to cyanobacteria and an increased frequency of blooms at several Lake Champlain locations, a bi-state NGO and state agencies got together to establish what has evolved into one of the most comprehensive cyanobacteria monitoring programs in the country. The regional program is a partnership between state environmental, health and recreation agencies, a watershed-based nonprofit, municipalities and citizens. The Lake Champlain Committee (LCC) recruits, trains and supports a cadre of volunteer monitors who weekly assess and report on conditions at over 100 sites on Lake Champlain and inland lakes during a 15-week monitoring season. Monitors are encouraged to report daily during bloom periods. Monitors' visual assessments are further substantiated by quantitative testing at select sites chosen for their propensity for blooms and high recreational use. The VT Health Department hosts a cyanobacteria tracker map where reports are accessible to anyone with internet access, conducts toxin analyses and leads the public health response. The VT Dept. of Environmental Conservation (VT DEC) provides phytoplankton analysis, monitoring of drinking water facilities, and project oversight, and the Lake Champlain Basin Program provides funding for the majority of the monitoring efforts. All partners collaborate on outreach to educate citizens about how to recognize, report and avoid blooms. LCC sends three separate weekly reports on conditions tailored for monitors, interested citizens and the media to help engage the community around this issue and encourage actions to reduce future blooms. Now entering its 15th year, this program continues to train new volunteers and provides a long-term database of cyanobacteria conditions on Lake Champlain.

**Visual display of complex, multidimensional spatial data from acoustic telemetry**

*Jessica Griffin and J. Ellen Marsden, University of Vermont*

***Abstract.*** Spatial data are valuable for studies ranging from behavior of individual organisms to landscape-level patterns of species’ movements. Modern tracking technologies, such as acoustic telemetry in aquatic systems, produce high-frequency, geographically extensive data that can be overwhelming to analyze and interpret; for example, acoustic telemetry of a single fish can yield over 250,000 data points per individual per year. Concise, multidimensional presentation of these data is a powerful tool to summarize information and reveal patterns in behavior. We use acoustic telemetry data from lake trout and walleye in Lake Champlain to demonstrate visual interpretation of large datasets. We tracked 93 lake trout and 27 walleye, implanted with V13 VEMCO acoustic tags, for three years using an array of 27 passive receivers deployed throughout Lake Champlain. The database consisted of single detections with a timestamp, fish id, and receiver location; data on fish length and, for a subset of individuals, sex were co-variates. Using R, we created multi-panel graphs to display patterns of movement for each species using number of detections (marker size) of individual fish (along the x-axis) at each receiver location (latitude, on the y-axis) by tagging location (marker color) in each year (panel rows) and season (panels columns). The composite of graphs provides a comprehensive representation of lake-wide movements and periods of relatively stationary behavior, with comparisons and contrasts among individual fish. For example, spawning sites are immediately identifiable from the ‘contagious’ positioning of most fish at a single location in the spawning season; while most fish showed similar patterns of behavior among years (i.e., site fidelity), straying between sites by certain individuals is also clearly apparent. This visualization method can be applied to any high-frequency data that track individual locations and movement of organisms.

**Spatial and Temporal Distribution and Abundance Microplastics in Lake Champlain Long-Term Monitoring Samples**  
*Susan-Marie Nadeau Hagar, Lindsey E. Austin, and Danielle Garneau, SUNY Plattsburgh*

***Abstract***. Microplastics are particles less than 5mm in size, characterized as fibers, fragments, beads, foams, and pellets. Microplastics (MP) arise from four main processes: environmental degradation (UV exposure, mechanical and/or biological), direct release by means of wastewater treatment processing, unintentional loss of raw materials, and discharge of macerated wastes. Microplastics are potentially toxic to aquatic biota and the presence of microplastics in freshwater ecosystems is largely under-researched. The goal of our research was to examine the spatial and temporal distribution of microplastics and pre-production particulate (nurdles) from long-term monitoring (LTM) zooplankton samples within Lake Champlain collected between 1992-2016. Nurdles were counted in full from samples, whereas microplastics (e.g., fragments, fibers) were subsampled due to size. Fourier Transform Infrared Spectroscopy (FTIR) characterized nurdles as polyisoprene rubber ribbon. Within the LTM samples (n = 2265), nurdles (n = 3455) and microplastics (n = 249), predominantly fibers, were identified. The greatest microplastic abundance was noted in 2015 (n = 73 microplastics, n = 494 samples). Nurdles were found only in samples that had been collected 2012-2016, with the greatest nurdle abundance noted in 2012 (n = 1,169 nurdles, n = 412 samples) and at varying depths. Nurdle abundance declined since the 2012 peak and in 2015 was greatly reduced (n = 531 nurdles, n = 494 samples). Spatial distribution maps suggest the complexity of the story with high abundances at deep central locations, as well as shallow isolated bays. The high influx of nurdles in 2012 may be related to the 2011 Lake Champlain flood; however more research will need to be conducted to tease apart timing and potential nurdle point-sources (e.g., train tracks, industrial/urban centers).

**Estimating Abundance of Spawning Lake Sturgeon in the Winooski River, VT Using Dual-Frequency Identification Sonar (DIDSON)**

*Lisa Izzo, Vermont Cooperative Fish and Wildlife Research Unit, Donna Parrish, University of Vermont, Gayle Zydlewski, University of Maine, and Chet Mackenzie, Vermont Fish and Wildlife Department*

***Abstract.*** Historically Lake Champlain supported a small commercial fishery for lake sturgeon, Acipenser fulvescens, but declining harvest in the 1940s led to the closure of the fishery in 1967 and the listing of the species as endangered in Vermont in 1972. In the late 1990s and early 2000s, spawning was confirmed in three of the four historic spawning tributaries to the lake, but information on the abundance of any life stage of lake sturgeon in Lake Champlain is currently lacking. Sampling conditions and low numbers of spawners have made gillnet-based mark-recapture surveys challenging in spawning tributaries. To avoid the need to handle pre-spawn fish, the goal of this study is to develop a hydroacoustic sampling protocol to estimate the abundance of spawning adult lake sturgeon. In 2017, a fixed-location dual-frequency identification sonar (DIDSON) was deployed downstream of the lake sturgeon spawning site in the Winooski River, VT from May 10 to June 21 to identify and count upstream migrating lake sturgeon. The information was paired with an array of five stationary acoustic receivers that monitored the movements of tagged adult lake sturgeon (n=10, tagged in 2015 and 2016) in the Winooski River during the 2017 spawning season. Counts of lake sturgeon targets from DIDSON footage indicated a peak in the spawning run in mid-May, but upstream movement of lake sturgeon continued into mid-June. While four tagged lake sturgeon made a single run upstream to spawn, telemetry data indicate that six tagged sturgeon made multiple movements upstream during the spawning run, potentially inflating sturgeon counts made with the DIDSON. To estimate overall spawning abundance, counts from the DIDSON will be combined with acoustic telemetry data to account for repeat movement past the DIDSON throughout the spawning season. Results of this work, which will continue through 2019, will provide managers with an estimate of spawning adult abundance and methods for future assessments to track progress towards recovery.

**Vermont Dam Screening Tool**

*Shayne Jaquith, The Nature Conservancy*

***Abstract.*** The fragmentation of river habitats through dams and poorly designed culverts is one of the primary threats to aquatic species in the United States (Martin, E. H. and C. D. Apse. 2011.). Dams cause impacts on water quality, aquatic habitat, the ability of fish to move freely upstream and downstream, and the downstream transport of sediment (Vermont ANR/American Rivers, 2009). The Northeastern U.S. (the New England and Mid-Atlantic states) has the highest density of dams and road crossings in the country, with an average of 7 dams and 106 road-stream crossings per 100 miles of river (Martin, E. H. and C. D. Apse. 2011.). Vermont has over 1000 dams, many of which currently provide no beneficial function, resources for removal of those dams are extremely limited.  
  
Removing dams is a difficult and expensive endeavor. To many working in the field of aquatic resource management it is apparent that given likely future constraints on availability of funds and staffing, it will be critical to be more strategic about investments in connectivity restoration projects (Martin, E. H. and C. D. Apse. 2011.). In order to enable more strategic dam removal investments in Vermont, the Vermont chapter of The Nature Conservancy developed the Vermont Dam Screening Tool (VTDST).  
  
The Vermont Dam Screening Tool (VTDST) is an online tool presented in a spatial analysis interface (web map) available to anybody with an internet connection. The VTDST uses 17 metrics to rank the relative ecological impact of dams in the Vermont portion of the Lake Champlain basin. Dams are then sorted into five tiers, from very high to very low ecological impact, based on their rank. The Dam Screening Tool is currently being used for a joint dam removal initiative of The Nature Conservancy and the Vermont Natural Resources Council. Our hope is that the tool will be used by anybody interested in the ecological impact of Lake Champlain Basin dams.

**Development of a Lake Champlain Anglers' Temperature Database**

*Joseph Judge, SUNY Plattsburgh Research Foundation*

***Abstract.*** Lake Champlain temperature data has been collected since at least 1969. Robust temperature data sets became available with the inception of the Lake Champlain Long-Term Water Quality and Biological Monitoring Program in 1992. The Program collects samples on a weekly to biweekly timeframe, with some parameters measured solely at the surface. However, water temperatures vary on shorter timescales, responding to surface temperature changes, wind-driven mixing, internal waves (seiche), and other variables.   
  
Much of this variability is under-sampled with current observations. To address this problem, a research data buoy was placed near Valcour Island in 2016, and has been used to gather long-term, high-frequency subsurface observations and meteorological data on the Main Lake. Thermal profile data has been transmitted (in near-real-time) from the buoy via satellite to researchers at SUNY Plattsburgh, and in-turn provided to various stakeholders online.  
  
Though the research was designed to assess climate change impacts, the archival aspect of the data proved valuable to salmonine anglers who target thermal structure using downriggers and digital transmitting thermometers (e.g. Fish Hawk™ x4D and TD devices). To build upon this researcher-angler relationship, we sought to improve spatial thermal profile resolution by capturing and uploading “citizen science” data for areas of the lake not sampled by the buoy. The Lake Champlain Anglers' Temperature Database (lcatᴰᴮ) is an easy to use, widely accessible database for Lake Champlain citizen science observations. The site is built to work on both desktop and mobile. Each measurement in the database requires a latitude, longitude, and time, with users being able add their own sensors to record data from. The site currently supports (and focuses on) temperature and depth sensors.  
  
Visualization tools include the ability to create maps and 2-D plots using multiple data sets (3-D plotting capability planned). Sets of data can be created by specifying time periods, coordinate ranges, etc. Apps are planned for both iOS and Android which will provide offline functionality, as well as allow for more hardware-oriented features. Users are also able to mass export data, and for the more technical, an API is available, allowing data to be programmatically retrieved, soon allowing mass amounts of data to be imported. Our goal is to foster the ongoing collection of thermal profile data among the angling community. The resulting data should improve spatial and temporal thermal profile resolution for researchers and managers, while simultaneously allowing anglers to upload and share useful fishing information.

**Water Quality Impacts of a Wood Chip Bioreactor Treatment System Receiving Silage Bunker Runoff in the Lake Champlain Watershed**

*Deborah Kraft, University of Vermont*

***Abstract.*** Excess nutrients in surface waters, such as nitrogen and phosphorus, are damaging to aquatic ecosystems and can lead to habitat degradation and loss of biodiversity. Silage runoff is an often overlooked form of point source pollution from dairy farms that is high in nutrients and BOD. Current storage and treatment methods for silage runoff are ineffective or prohibitively expensive. Research has shown promising results for treating certain types of farm runoff with vegetative treatment areas (VTAs) and constructed wetlands, but these methods have not been effective in treating silage runoff. Wood chip bioreactors are an emerging type of treatment technology that aim to address the limitations of both VTAs and constructed wetlands. They are designed to enable nitrate removal by facilitating denitrification through the provision of an anaerobic, carbon rich environment. A wood chip bioreactor treatment system, consisting of 3 pre-treatment tanks and two wood chip bioreactors with varying retention times, was constructed at the Miller Research Farm in Burlington, Vermont. Runoff from an adjacent silage bunker was directed into the system. The pre-treatment tanks include two settling tanks and one aeration tank, designed to allow sedimentation of organic matter and to convert varying forms of nitrogen into nitrate before the runoff reaches the wood chip bioreactors. Automatic water samplers were located at 4 different points within the system to test the efficacy of each treatment step. The samplers were programmed for periodic flow-based sampling and were intended to representatively capture entire storm events. Runoff samples were analyzed for TN, NO3, NH3, TP, SRP and BOD using a Lachat FIA instrument and DO probe. Preliminary data suggest that the treatment system assists in reducing BOD and removing certain nutrient forms from the silage bunker runoff.

**Quantifying Phosphorus Content in Riparian Buffers of Different Land Use**

*Brittany Lancellotti, University of Vermont*

***Abstract.*** Excess phosphorus (P) loading to freshwater systems can lead to eutrophication, resulting in a loss of ecosystem services. Lake Champlain has historically exhibited negative effects of eutrophication due to P overloading from non-point sources. Reducing P inputs to the Lake is critical, as lake-related tourism contributes nearly 4 billion dollars to the economies of Vermont, New York and Quebec each year. Riparian buffers help protect adjacent water bodies from runoff by sequestering sediment and excess nutrients. To better understand how P retention in riparian buffers is influenced by soil saturation and adjacent land use, we explored differences in P content between riparian buffers located in forested and agricultural watersheds. Within each land use type, we focused on two paired riparian buffers with contrasting soil saturation levels (one wet transect and one dry transect). At each of the four sites, soil pits were dug along a transect perpendicular to the streambank and were placed strategically to capture convergent and divergent landscape positions. Soil samples were collected from each horizon within 0-45cm of the soil profile. We measured soil test P, soluble P, degree of phosphorus saturation (DPS), and trace elements in each soil sample.  
  
No significant differences in soil test P content were detected among the four riparian transects. In contrast, soluble P content varied significantly between the agricultural (median = 0.46 mg P/kg soil) and forested (median = 0.30 mg P/kg soil) transects. Degree of P saturation also differed significantly between the agricultural (median = 1.7%) and forested (median = 9.0%) transects. Linear regression analysis indicated that in the agricultural soils DPS levels greater than 20% may result in desorption of soluble P, subsequently generating P runoff. Our results suggest DPS and soluble P may be better indicators of potential P runoff than soil test P. Accurately quantifying P in riparian soils is necessary to evaluate their potential to store and transform nutrients that have potentially harmful consequences for Lake Champlain.

**Observed and projected temperature change in Lake Champlain**

*Eric Leibensperger and Vasu Govani, SUNY Plattsburgh*

***Abstract.*** We examine observations at Site 19 (Main Lake) in Lake Champlain to assess recent and future climate change within the lake. We use water temperature data extracted from the Long-Term Water Quality and Biological Monitoring Project (LTMP) archive and relate them to a Lake Champlain Basin air temperature record compiled from 7 observational sites within version 3.3 of the Global Historical Climatology Network. We detect changes in observed conditions and project future changes using data from the North American Coordinated Regional Downscaling Experiment (NACORDEX).  
  
Using regression models, we derive the sensitivity of water temperatures to air temperatures and project future warming using simulated changes in air temperature from the regional climate models.

**Sedimentary Pockmarks in Missisquoi Bay**

*Patricia Manley, Thomas Manley, and Eli Orland, Middlebury College*

***Abstract.*** Previous bathymetric surveys of Lake Champlain based on lead-line and single-beam echo sounder measurements were only capable of defining bottom structure on scales of 10-100s of meters. The use of CHIRP seismic profiling and more recently multibeam sonar technology over has provided a wealth of central lake information related to large subaqueous landslides (Gosh, 2001; Rosales-Underbrink, 2015; Silverhart, 2016), furrows (Leucke, 1995; Manley et al., 1999), large sediment drifts and waves (Hayo, 2002; Weeks, 2012; Manley et al., 2011) as well as pockmarks (North, 1997; Gutierrez, 2001; Manley et al., 2004). As part of the VT EPSCoR RACC program, Missisquoi Bay was mapped by multibeam from the 2013-2015 using a uniform 33% coverage pattern in depths greater than 12 ft. Results showed the bay to be a shallow bowl-shaped structure with the presence of a few shoals as well as numerous pockmarks concentrated around the outer perimeter of the Missisquoi River delta with decreasing numbers as distance away from the delta increased. An initial estimate of the total number of pockmarks in the multibeam data set was put at 1800 however; a more rigorous analysis on ~20% of the data set suggests a range between 7000-9000. Considering that the multibeam data only covered 1/3 of the bay, this initial range could be expanded to 21,000 – 27,000 individual pockmarks. Our initial observation at these features shows them to be better defined and deeper near the north-south central axis of the Missisquoi River delta. A vast majority of these features show no specific orientation however there are some that show preferential linear alignment suggesting fault control. Preliminary statistics show that these range in size from 2-4 m in diameter with depths varying between very shallow (0.25 m) up to at least 1 m. Whether or not these features are created from biogenic release of methane, fish nesting, groundwater or dewatering of sediment is still in question.

**Missisquoi Bay circulation dynamics and 3D hydrodynamic modeling of the restricted arm of Lake Champlain; a question of water quality and causeways**

*Tom Manley, Middlebury College; Zachery Perzan, Stanford University; Liv Herdman and Tina Chen, Middlebury College*

***Abstract.*** Missisquoi Bay is a uniformly shallow bay with a mean depth of slightly less than 4 m. With a surface area of 78 km², it is the 3rd-largest physical feature of the lake with the Main Lake (683 km²) and Northeast Arm (269 km²) being the first two major sectors. Three rivers that discharge into Missisquoi Bay (the Missisquoi, Pike and Rock) have drainage areas totaling 2900 km² that are primarily located in agricultural settings. In the mid-1800s, a large rock-filled causeway was built across 1200 m wide southwest channel which provided the only access to Lake Champlain. Only ~200 m of the original channel was left open for water movement. As farming practices continue to develop within the drainage basins, so did the amount of phosphorus accumulation and unsightly/unhealthy algal blooms of blue-green algae. Even though numerical modeling of the bay showed that there would be no significant improvement in water quality even if the entire causeway was removed, the narrow channel was opened up by an additional 100 m by the state of Vermont in an effort to balance the public outcries of highly eutrophic conditions as well as the rock-filled causeway becoming a breeding site for an endangered species. This model was verified against a single ADCP record of ~6 weeks and a few surface drifter tracks during that time period. During a 3-year monitoring program, arrays of ADCPs, water level gauges, vertical temperature strings and meteorological sensors were used to monitor the bay’s hydrodynamics. From this program, four basic modes of circulation were found to exist. The first is defined as “wintertime sluggish” wherein water velocities are vertically uniform and on the margin of detectability by the ADCP. The second mode is “spring melt” where all three river inputs were maximized with high-volume flows. The third and fourth modes were confined when stratified conditions could exist (May-November) but were divided up into those times when the water column was well mixed (mode 3 - “well-mixed summer”) and when stratified conditions led to highly dynamic 2-layer flow (mode 4 - “two-layer summer”). All of the four modes exhibited unique circulation dynamics that if modeled correctly, would provide greater insight to the chemical, biological and sedimentological transports within the bay as well as creating a more informed public and management with regards to phosphorus dynamics related to the causeway. Presently, we are in the process of verifying a fully 3D hydrodynamic model for the Restricted Arm that will shed further light on the issues of causeway removals and water quality from Missisquoi Bay to Malletts Bay.

**Global analysis of rotifer guild ratio in relation to Daphnia abundance across 51 lakes**

*Kevin Melman, University of Vermont*

***Abstract.*** Zooplankton community structure is influenced by many forces, including food quality and quantity. Competition for food plays an important role in determining which species will dominate in a system at a given time. The size-efficiency hypothesis predicts that larger organisms will outcompete smaller organisms vying for similar food items. Among freshwater zooplankton, Daphnia are large, efficient, herbivorous filter feeders that often outcompete smaller herbivorous zooplankton, such as some rotifers. Numerous studies have found that while Daphnia abundance tends to negatively relate to microphagous (i.e., herbivorous) rotifer abundance, predatory rotifer populations remain relatively uninfluenced because they target different food sources. The rotifer guild ratio (GR’) describes the proportion of predatory to microphagous rotifer biomass in lakes. Previous work suggests that as the percent biomass of cladocerans increases in a system, GR’ increases as predatory rotifer biomass increases relative to microphagous rotifer biomass, likely because Daphnia outcompete microphagous rotifers. Our hypothesis is that in more eutrophic systems, pelagic primary productivity is high enough to dampen competition between Daphnia and microphagous rotifers, and thus we expect competitive influence of Daphnia on rotifer community structure to decrease as lake productivity increases. We compiled rotifer and zooplankton data from 51 lakes and reservoirs of varying trophic state across 14 countries, and tested our hypothesis. Preliminary results indicate that GR’ in highly productive systems tends towards greater dominance of microphagous rotifers in the presence of Daphnia, suggesting that highly productive systems dampen the competitive influence of Daphnia on GR’, and therefore, rotifer community structure in general. Data on aquatic community structure in relation to trophic state is important to better understand the ecology of our world, in which many lakes are eutrophying and shifting community baselines.

**A Survey of Microplastics in Wastewater Treatment Plant Effluent in the Lake Champlain Basin**

*Melissa Moriarty and Danielle Garneau, SUNY Plattsburgh*

***Abstract.*** Microplastic pollution researchers are beginning to quantify, characterize, and collaborate on finding solutions to this emerging pollution problem. Recent studies have documented consumer care products and laundering of synthetic garments as major sources of microplastics. Most current wastewater treatment plant (WWTP) technologies are unable to capture and remove particulate <5mm in size, thus over time biomagnification poses a threat to aquatic organisms. In 2015, we began surveying and have currently processed WWTP post-treatment effluent samples from the city of Plattsburgh, NY (N = 55) and in 2016 brought online three other plants in the Lake Champlain watershed, specifically St Albans, VT (N = 43), Ticonderoga, NY (N = 31), and Burlington, VT (N = 6). Twenty-four hour post-treatment effluent samples were collected and digested using wet peroxide oxidation methods. All samples were characterized based on microplastic type (e.g., fragment, fiber, pellet, film, foam) and color. The most common microplastic type varied by WWTP and was dominated by fibers in Plattsburgh (42%) and Ticonderoga (39%), and foams and fragments in St. Albans (44%) and Burlington (57%), respectively. Estimated output of microplastic particles per day are: Plattsburgh (n = 12,770), St. Albans (n = 30,164), Burlington (n = 16,843), and Ticonderoga (n = 8,432). Differences likely reflect plant characteristics, for example Plattsburgh and Burlington serve a similar sized population and have a similar capacity, the difference in particle abundances may be due to differences in infrastructure updates. St. Albans and Ticonderoga serve similar population sizes; however St. Albans has tertiary treatment and Ticonderoga is in the process of upgrading clarifiers. Microplastics may not appear to be a significant issue when considering output in a sieve after a 24 hour sampling session, but when the abundance is scaled up by plant flow rate and sheer number of treatment plants discharging into Lake Champlain, the microplastic issue compounds. These particulate have the potential to adsorb harmful chemicals residing in the water and pose risk to aquatic organisms and human health. By documenting wastewater treatment plants as a source of microplastics, we can share these findings with wastewater treatment plant operators, lake stewards, government officials, and work towards solutions both up and downstream.

**Examining the PO4 gradient at the sediment water interface of Vermont stormwater ponds**

*Harrison Myers, University of Vermont; Rebecca Tharp, Watershed Consulting Associates; and Eric Roy, University of Vermont*

***Abstract.*** Phosphorus (P) in urban and agricultural runoff is known to cause eutrophication in freshwater ecosystems (Azevedo, et al., 2014), which degrades the economic, environmental, and social value of the ecosystem. The purpose of my research project was to examine the biogeochemical cycling of P within stormwater ponds (SWPs), particularly at the sediment-water interface (SWI). SWPs are the most widely used stormwater management practice in Vermont (VTDEC, 2016), so understanding the movement of P within these ponds is critical to minimizing the detrimental impacts of eutrophication on Lake Champlain. My investigation was part of the doctoral dissertation research of Becky Tharp, that sought to make design recommendations for future stormwater pond designs based on an analysis of pond design, water quality, sediment properties, and biological analysis. I focused on the SWI with the goal of connecting the gap between water and sediment data collected in the larger study. Examining the SWI created a more robust picture of P cycling within SWPs because the SWI is one of the most dynamic regions for P cycling in a SWP. Nutrient gradients can occur at the SWI due to relatively low nutrient concentrations in the pond inflow, and relatively high concentrations within the sediments of SWPs due to accumulation over time. The gradient of P from the sediment to the water can drive internal loading of P at the SWI (Roy et al., 2012). The vertical gradient of soluble reactive P (SRP) at the SWI was measured using dialysis porewater samples (“peepers”; Urban et al., 1997). Peepers were deployed in three SWPs, and a clear SRP gradient was observed in two out of the three SWPs. A positive correlation was observed between the vertical SWI SRP gradient and organic matter content and percent sand in the pond sediment. Organic matter content drives down dissolved oxygen (DO) at the SWI, and has been shown to increase porosity in flooded sediments (Avnimelech, et al., 2001), creating a less restrictive path for the flux of SRP. A higher percent sand also causes increased porosity. Additionally, sediments made up of smaller particles are more likely to be suspended in water, increasing turbidity and decreasing the amount of sunlight reaching submerged aquatic vegetation (SAV). Decreased sunlight for SAV in turn decreases overall biomass and therefore the amount of organic matter in pond sediments.

**Protecting Water Quality Through Low Impact Development Certification**

*Chris Navitsky, The FUND for Lake George*

***Abstract.*** According to the USEPA, stormwater is "the Nation's largest source water quality problem" and one that impacts each of our watersheds. The State of Lake Champlain Report states that phosphorus remains a problem and much work remains to reduce nutrients washing off of the landscape. This is amplified by increasing development cutting, clearing and covering natural features that would otherwise capture, absorb, infiltrate and treat stormwater. To reduce these impacts, the Lake George Waterkeeper created a systematic approach of Low Imapct Development standards to promote improved development practices with the end goal of utilizing ecosystem services for water quality protection that have been assembled into the LID (Low Impact Development) Certification System.

**Resource use, behavior, and ecology of Mysis in Lake Champlain**

*Brian O’Malley and Jason Stockwell, University of Vermont*

***Abstract.*** Many populations of migratory animals exhibit behavioral variability at the individual level. In Lake Champlain, the opossum shrimp Mysis diluviana, undergoes extensive diel vertical migration (DVM), linking offshore benthic and pelagic communities. The general model of Mysis DVM assumes individuals are benthic by day and pelagic by night. Previous benthic investigations, however, have also reported some Mysis remain benthic at night (non-migrants). Non-migrants may or may not feed on benthic resources at night, potentially creating potential for a sub-population solely dependent on benthic rather than pelagic resources. We examined Mysis diel habitat use at two deep sites (60 and 100m) in Lake Champlain to quantify Mysis resource use in the water column and on the lake bottom over 24-hour periods during April-October. Preliminary analysis indicates Mysis gut contents were rarely empty when collected on the lake bottom, regardless of time of day, suggesting non-migrant mysids may continue to feed on benthic resources when foregoing DVM. In total, our results highlight the importance of considering benthic habitat when depicting implications of Mysis migration behavior on their trophic role and availability as prey to fishes in Lake Champlain’s food web.

**Understanding the biogeochemical role of soil microbial communities in Northern VT agricultural riparian zones connected to Lake Champlain waterways**

*Kunal Palawat and Colleen Yancey, University of Vermont*

***Abstract.*** Riparian buffers are integral to managing nutrient flows and fluxes across water systems. They are especially important in controlling nutrient cycling during extreme weather events, which are predicted to increase with climate change. One consequence of extreme events is increased eutrophication and algal blooms which have negatively affected the health of Lake Champlain in recent years. Soils are an important component of riparian buffers and their role in biogeochemical cycling during extreme events is not fully understood. Specifically, the influence of soil microbial communities on nutrient flows and fluxes has not been thoroughly studied. We investigated the response of riparian buffer soil microbes under average and extreme rainfall conditions with a soil incubation study. We collected intact soil cores from wetland and dry locations within a riparian zone of Hungerford Brook in Swanton, VT, in order to compare how soils with different soil moisture regimes respond to extreme events. We simulated slow and fast rainfall conditions and measured the responses of the soils over seven days. Slow wetting was based on average rainfall rates in Swanton, VT while fast wetting was based on the heaviest rainfall period Swanton experienced during Hurricane Irene in 2013. We measured microbial biomass and extracellular enzymatic activity to assess how microbial populations are affected by the treatments. To better understand how microbial responses impact nutrient fluxes, we analyzed greenhouse gas fluxes using a photo-acoustic gas analyzer and we collected leachate for nitrate and ammonium analysis. Our data provides novel insights on the complexities of the characteristics of an agricultural riparian zone in Northern Vermont to better inform the VT-EPSCoR Integrated Assessment Model.

**Algal biomonitoring within littoral zone of lakes as part of water quality monitoring efforts**

*Corrina Parnapy, Winooski Natural Resources Conservation District*

***Abstract.*** Sources of organic pollution are contributing excessive nutrients to local groundwater and surface waters resulting in impacts to water quality, decreased water clarity and increased algal blooms potentially containing toxins. By utilizing an innovative tool that incorporates monitoring and research using algal analysis and application of metrics, prioritization of targeted shoreline properties within the Lake Champlain Basin for project implementation that are indicating organic pollution sources has taken place to then inform the public and policy makers.   
  
Algae, the base of the aquatic food web are utilized world-wide in monitoring efforts to determine changes in water quality. Forms of algae can be used to pinpoint organic pollution, chloride, heavy metals and excessive nutrients. While traditional water quality sampling is impacted by wave action and dilution, only showing a snapshot in time, algae can show the whole story. Biomonitoring algal collection is focused on nearshore areas in less than 10 feet of water when algae are observed during shoreline observations and areas of concern are identified. All available substrates (rocks, docks, logs, sand, mud, macrophytes and water column) are scrapped or suctioned to collect a multi-habitat sample focusing on a small area according to known regional and federal protocols. Algal samples are brought back to the lab; identified and counted. Known and confirmed metrics are used to determine water quality impact. Special attention is made to forms of algae that are known to be present in areas that contain organic pollution, specifically from human waste. The data collected has been utilized by concerned citizens and regulatory officials to make informed decisions and implement projects and practice changes to improve water quality.  
  
Within the Lake Champlain Basin, algal biomonitoring is being used as part of an innovative tool to identify failing and under functioning septic systems. It has focused citizen involvement and resulted in the creation of a wastewater management district, replacement of systems and the subsequent preliminary data indicating an improvement in water quality.

**EPSCoR soil monitoring network as classroom: preliminary data on the biogeochemistry of soils and streams**

*Julia Perdrial, Erin Seybold, Brittany Lancellotti, B. Anderson, C.Beisel, A. Collings, A. Couderc, A. Liebenson, N. May, T. Quesnell, M. Reilly, and S. Ryan, University of Vermont*

***Abstract.*** The sites of the cutting-edge soil sensor network in the Hungerford Brook and Wade Brook watersheds were used to teach an Environmental Geochemistry lab course with the dual goal to 1) enable students to complete a concise research project independently and 2) provide seed data for the overarching EPSCoR Basin Resilience to Extreme Events (BREE) effort. Overarching questions of the BREE soil monitoring network are related to the effectiveness of the riparian areas attenuating nutrients during extreme events. For the lab project students chose from a list of research questions that are related to the links between soils and streams. Students performed literature searches, developed hypotheses, collected samples in the field, collected data on various instruments, analyzed data, synthesized their findings to test specific hypothesis and contributed to the writing of this abstract. Fife separate projects were conducted where specific hypotheses on concentration and distribution of total nitrogen, dissolved organic carbon and metals (in soils and streams) as well as mineralogy (soil) were tested. Preliminary results indicate significant differences in carbon and nitrogen concentrations and carbon quality between forest and agricultural stream water. Water extractable soil carbon varied with soil wetness, landscape position (hillslope vs. riparian) and sites (forest vs. agricultural setting). Clay lenses in the agricultural wetland contain a large fraction of non-swelling clay (Illite) and show similarities to a locally sourced chlorite-bearing schist. The forested wetland did not exhibit such a clay layer, however, this wetland was tested for carbon and metal concentrations of inflow and effluent waters. Because all samples were taken during a major rainstorm (the first since weeks), these samples are considered event samples. For example, during this rain storm, dissolved carbon in the wetland effluent water was approximately 10 times higher than that of the inflow water.

**Aesthetics, Environment and Economics: Permitting Parameters and Development Response in the Visual Environment of Lake Champlain Shorelands**

*David Raphael, University of Vermont*

***Abstract.*** In a period in which property owners, municipalities, and the states of Vermont, New York and the province of Quebec are addressing climate change, lake water quality, and the ongoing impacts of development in the Lake Champlain Watershed there has been limited research and review of the intersection of ecological systems, economics and aesthetics within lakeshore communities. Where there are sensitive ecological systems that are most often equally sensitive aesthetic and scenic resources that are considered important for their role in retaining cultural heritage values, attracting tourism, and the enjoyment of recreational activities. The proposed poster will examine aesthetic resources, environmental quality and the individual and political processes and economic determinants that affect the look, feel and function of our treasured lakeshore environment.  
  
The key topics, questions and findings to be synopsized in the poster presentation are as follow:

1) A study of Vermont lakeshore town plans and zoning ordinances in Addison and Chittenden Counties as they relate to shoreline scenic resource management yields inconsistencies and issues with regional connectivity and specificity as to how to manage and protect these resources;   
  
2) The advent in Vermont of the Shoreland Protection Act has provided preventative and regulatory parameters for development and change along Vermont’s lakeshores that often supersede local provisions, but the Act lacks and educational and prescriptive guidance for design and management of shoreland environments;   
  
3) The monitoring of lakeshore development in sample towns over the last two decades has revealed extensive clearing of native vegetation, the increase of development footprints for residential construction, and substantive increases in impervious cover. This is due to typical “business as usual” approaches that do not incorporate effective aesthetic and ecological design methodologies that have proven effective in balancing retention and mitigation techniques; and  
  
4) A challenge is emerging with regard to the restoration of aesthetic and ecological resources of the more extensively developed areas.   
  
The poster will include a brief review in graphic form of some established and newly emerging ecological design principles (vegetative management and green infrastructure), visual management techniques (view retention, site planning and building design) and the cost/benefit balancing approaches that have been utilized in the effort to restore desired lakeshore visual qualities in concert with the retention or restoration of natural resource elements that are effective tools in the effort to improve water quality, habitat integrity and enhance scenic resources in the public realm.

**Observations and recommendations from implementing large-scale boat inspection and decontamination across the Adirondacks**

*Jeffrey Sann, Adirondack Watershed Institute*

***Abstract.*** For three consecutive years (2015-2017) The Adirondack Watershed Institute (AWI) has partnered with New York State Department of Environmental Conservation (NYSDEC), The Lake Champlain Basin Program, and other partners, to develop, staff and manage the Adirondack Park Invasive Species Spread Prevention Program. This program extends the reach of AWI by funding boat launch steward locations and high-pressure hot water decontamination stations which were strategically placed to maximize region wide spread prevention. For the 2017 season, decontamination sites were selected and placed under the guidance of NYSDEC fisheries staff with intent to minimize the spread of small-bodied invasive animals such as the invasive zooplankton Spiny water-flea (Bythotrephes longimanus). Previously, decontamination sites were classified into one of three site types based on location (boat launch, roadside, and intersection.) Under the new approach several sites would be placed along Lake Champlain’s western shore at NYSDEC boat launches as well as other boat launch locations on specified waterways.   
  
In all 20 decontamination locations were staffed and managed by AWISP and partners yielding 26,623 inspections and 3,697 organisms removed. 1,303 of the organisms removed were confirmed AIS and 2,792 vessels underwent the decontamination process. 9.5% of boats encountered at these locations were transporting an organism of some kind (native or exotic) and 3.8% of boats were transporting confirmed AIS. Close proximity of decontamination units to boat launching sites has continued to encourage boater use. 2017 saw the greatest number of boat launch located decontamination sites since this program was introduced. Several other variables may impact overall use of vessel decontamination sites such as user familiarity with the decontamination process, staff engagement or personality, and number of seasons each station has been operational. Correct installation and use of highway right-of-way signage has proven to be important when operating in roadside locations. Locating, designing and constructing decontamination sites requires coordination among several partner agencies to ensure compliance with environmental regulation and safety of the public or program staff. Repeatedly, compromise among stakeholders was necessary to find a viable solution. Multiple or single permits and liability insurance are often required to execute one or more vessel decontamination sites on public or private lands. Efficient communication and local support are instrumental to the successful implementation of boat wash stations.

**Microplastic Biomagnification in Invertebrates, Fish, and Cormorants in Lake Champlain**

*James Stewart, Joshua Walrath, and Danielle Garneau, SUNY Plattsburgh*

***Abstract.*** Microplastics are plastic particles that are <5 mm in diameter. They are categorized as either primary, which are pellets commonly found in personal care products, or secondary microplastics, which are degraded macroplastics. Microplastics enter into waterbodies by passing through wastewater treatment plants, as marine debris, via mechanical and photo-degradation of macroplastic, and release of pre-production raw materials. Microplastics are known to adsorb smaller pollutants, such as heavy metals copper and zinc, and organic toxins and can potentially biomagnify up the food web. Microplastics have also been shown to function as vectors for long distance transport of pathogenic marine bacteria. When ingested by fish, particulates often result in satiation and can become embedded within the digestive tract and leach into deep tissues, posing a potential concern for environmental and human health. The goal of this research was to convey that microplastics are biomagnifying within invertebrates, fish, and Phalacrocorax auritus (Double-crested Cormorants) resident to Lake Champlain. We did so by quantifying and characterizing (e.g., fragment, fiber, film, foam, pellet) plastic particulate. Wet peroxide oxidation digests were performed on digestive tracts of 436 lake organisms, specifically invertebrates (n = 258), 14 species of fish (n = 163), and Phalacrocorax auritus (Double-crested Cormorants) (n = 15). Our research indicated that fibers were the most abundant particulate in all organisms (n = 889), followed by fragments (n = 133), films (n = 66), foam (n = 17), and pellets (n = 13). The fish species Yellow Perch (Perca flavescens) contained the greatest average microplastic abundance (n = 23), followed by Lake Trout (Salvelinus hamaycush) (n = 19.82), and Bowfin (Amia calva) (n = 16). The mean number of microplastics found in individual fish (n = 95), where analysis was performed in specific organs, revealed the greatest average microplastics abundanec in the esophagus (n = 8.71), followed by the stomach (n = 6.83), and intestines (n = 4.90). Microplastics were size separated and preliminary results show particulate ranged from ≥ 1mm (n = 298), to ≥ 355µm (n = 371), and to ≥ 125µm (n = 458). These findings illustrate biomagnification in Lake Champlain organisms, as invertebrates, fish, and Double-crested Cormorants contained on average 0.05, 4.67, and 22.93 microplastic particles. Results from this research serve to inform residents of the Lake Champlain watershed, anglers, non-profit lake organizations, as well as public health and government officials of the risks microplastics pose to aquatic biota and ultimately humans.

**Effect of photochemical transformation on dissolved organic carbon concentration and bioavailability from various land use/cover in the Lake Champlain Basin**

*Andrew Vermilyea, Ashley Sanders, and Ernesto Vazquez, Castleton University*

***Abstract.*** The transformation of freshwater dissolved organic carbon (DOC) can have important implications for water quality, aquatic ecosystem health, and our climate. DOC is an important nutrient for heterotrophic microorganisms near the base of the aquatic food chain and the extent of conversion of DOC to CO2 is a critical piece of the global carbon cycle. Photochemical pathways have the potential to transform recalcitrant DOC into more labile forms that can then be converted to smaller DOC molecules and eventually be completely mineralized to CO2. This may lead to a DOC pool with different bioavailability depending on the structural composition of the original DOC pool and the mechanistic pathways undergone during transformation. This study aimed to measure the changes in DOC concentration and bioavailability due solely to photochemical processes in three watersheds of northern Vermont, USA that have varied land cover, land use (LCLU) attributes. Our hypothesis was that photochemical transformations will lead to (1) an overall loss of DOC due to mineralization to CO2 and (2) a relative increase in the bioavailable fraction of DOC. Additionally, the influence of LCLU and base flow versus storm flow on both mineralization rates and changes in DOC bioavailability was investigated.  
  
Irradiation of filtered samples in quartz vessels under sunlight led to small changes in DOC concentration over time, but significant changes in DOC bioavailability. In general, fluorescence excitation-emission matrices (EEMs) showed a shift from an initially more humic-like DOC pool, to a more protein-like (bioavailable) DOC pool. Specific UV index (SUVA) along with bioavailable DOC (BDOC) incubations were also used to characterize DOC and its bioavailability. There were only small differences in the DOC transformation that took place among sites, possibly due to only small differences in the initial bioavailability and fluorescent properties between water samples. Photochemical transformation appears to play an important role in the transformation of a more recalcitrant (humic) pool of DOC into a more bioavailable DOC pool that can then be utilized by aquatic heterotrophs and ultimately be converted to CO2.

**Mapping Brook Trout occupancy using environmental-DNA**

*Brendan Wiltse and Carrianne Pershyn, Ausable River Association; Lee Ann Sporn, Paul Smith’s College*

***Abstract.*** Brook Trout (Salvelinus fontinalis) have been identified by New York State Department of Conservation (NYS DEC) as a species of greatest conservation need, and the Adirondack Park is considered one of their last population strongholds in the northeastern US. Habitat fragmentation from road-stream crossings and competition from non-native salmonids are listed in the top four threats to Brook Trout in the Northeast by the Eastern Brook Trout Join Venture. Efforts have been made to model Brook Trout occupancy across their native range. Validating those models using traditional fish surveying techniques is both costly, time consuming, and often not done at a high spatial resolution. We piloted a project in the 1,571 hectare Otis Brook watershed in Jay, NY using environmental DNA (eDNA) to determine Brook Trout occupancy. Sites were spaced one stream kilometer apart throughout the watershed, as well as additional sites added above each road-stream crossing, resulting in 26 sample sites. Each site was sampled in June, August, and October to assess seasonal changes in Brook Trout occupancy. Brook Trout were detected at all sites within the watershed were previous electrofishing surveys had detected them, and at additional sites where electrofishing had failed to detect them. We observed a seasonal contraction of the spatial distribution of the eDNA signal during August. We hypothesize this is due to increased water temperatures in the lower reaches and reduced stream flow in the upper reaches. Ongoing work is being done to assess the distribution of Brown Trout and Rainbow Trout within this system using the same samples. We propose that eDNA is a more time efficient and less invasive method for detecting Brook Trout occupancy in Lake Champlain Basin streams. These methods offer the potential to map the distribution of fish species at fine spatial scales and aid in the prioritization of the replacement of culverts that serve as barriers to aquatic organism passage.