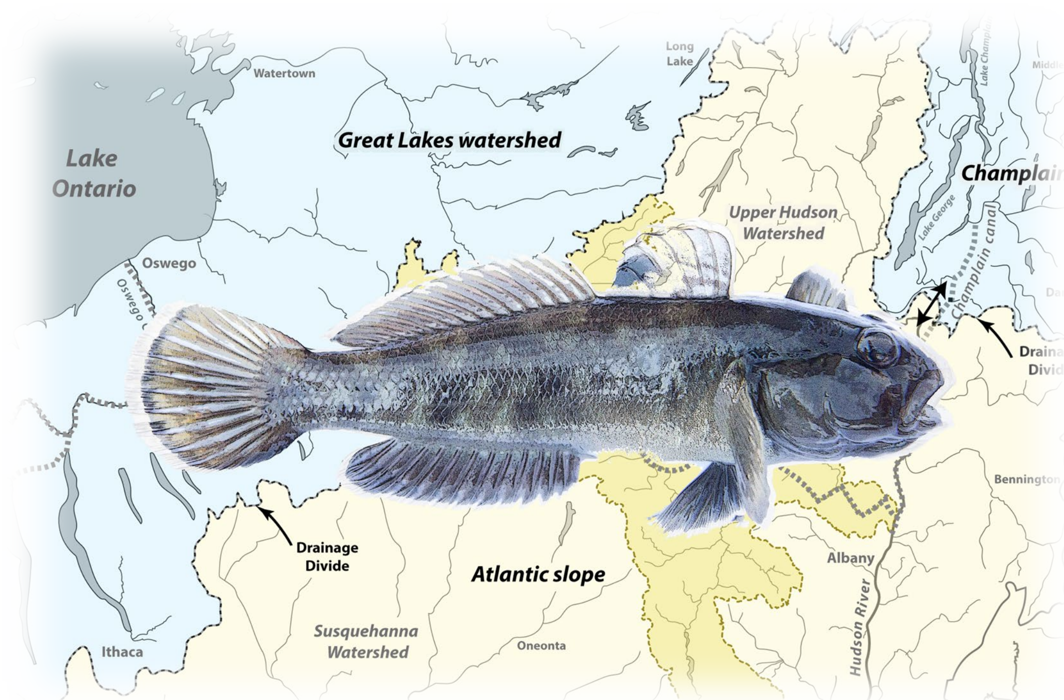
Mohawk Watershed Symposium 2023



Abstracts and Program

College Park Hall, Union College

Schenectady NY

17 March 2023

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Edited by

John I. Garver, Jacqueline A. Smith, and Carolyn M. Rodak

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On the Cover

Round Goby *(Neogobius melanostomus) is a fish that has recently invaded the Mohawk Watershed using the Erie Canal to enter from the Great Lakes. The Round Goby is a benthic predator that threatens the fishery in the Mohawk and Hudson Rivers. This European fish first invaded the Great Lakes by hitchhiking in ballast water of freighters arriving from Europe. The species migrated from west to east across the Mohawk River, and entered the Hudson River by 2021. It has since expanded its range and threatens Lake Champlain.*

The invasive pathway and timing of advancement has been well documented by researchers at the USGS and the NYS DEC. These fish are known to be a vector of Viral Hemorrhagic Septicemia Virus (VHSV), which can be lethal to some other fish. Invasion of the Round Goby represents a turning point in the history of the Mohawk Watershed, and at this point we need to be proactive in addressing invasive species and to fully evaluate how the Erie Canal acts as an invasive superhighway.

The discovery of these fish in 2021 in the Hudson River has alarmed many, and rightly so. John Waldman, Professor of Biology at Queens College, warned about the detrimental effect these fish may have on the fishery in the lower Hudson, including on Atlantic Sturgeon. In July 2021 he noted: "...this little fish has the potential to become an ecological game changer and another example why prevention of invasives is the only good cure."

Photo: Peter van der Sluijs, reproduced here under Creative Commons license. Background map modified from Garver, 2021 (Stop the invasion: barriers needed between the Mohawk and the Great Lakes in *Notes from a Watershed*).

Preface to the 2023 Mohawk Watershed Symposium

The 13th Mohawk Watershed Symposium has been delayed by two years due to the pandemic, but we are excited to finally get back together and concentrate on the issues that affect the Mohawk River Watershed. Over the years the Symposium has taken on an important role in unifying and galvanizing stakeholders. Since the last meeting in 2019, the Mohawk River Basin Program has updated and released the 2021-2026 Mohawk River Basin Action Agenda, which is a critical guiding document for the Mohawk River Watershed. The program mission is conserving, preserving, and restoring the environmental quality of the Mohawk River while helping to manage the Watershed's resources for a sustainable future.

Mitigation of ice jamming on the lower Mohawk River behind the Vischer Ferry dam was targeted by the Reimagine the Canals task force. Since 2020, the Canal Corporation and New York Power Authority (NYPA) have initiated ice-breaking procedures to lessen the impact of ice-jamming with an overall goal of reducing the flood hazard in the Historic Stockade of Schenectady. There, and elsewhere in the basin, communities are implementing flood mitigation projects that include riparian restoration, channel restoration, and building resilience into a system where the hydrology appears to be changing rapidly.

Water quality remains a central issue and a large number of stakeholders are involved in this effort. For a healthy and vibrant ecosystem, along with the ecosystem services that the River provides, we need clean water. The health of our waters can be assessed from hundreds of measurements taken across the Watershed by dedicated stakeholders. New and important state and federal programs will provide local municipalities with the funding to address infrastructure problems that affect water quality. The New York State Department of Environmental Conservation (NYS DEC) is in the process of developing a watershed-wide Total Daily Maximum Load (TMDL) for phosphorus pollution, which is a major step in addressing water quality in the Watershed.

Invasive species are having an impact on biodiversity, recreation, and water quality. The uncontrolled spread of Water Chestnut (*Trapa natans*), that spread from its original introduction in Collins Pond in Scotia, has affected boating and marina access in the lower Mohawk River. The Round Goby (*Neogobius melanostomus*), which was a stowaway in ballast water in Great Lakes freighters, successfully navigated the Erie Canal and entered the Mohawk several years ago, and made it to the Hudson in 2021. It now threatens Lake Champlain. This small benthic predator has the potential to alter our fishery because it preys on the eggs of other fish and carries disease. We need proactive solutions to invasive species control, especially for those unassisted invaders using the Erie Canal from the Great Lakes. As we are reminded by the NYS DEC: *"Prevention is the most effective method for dealing with invasive species. If they are never introduced, they never become established."*

Stewardship and education are a critical piece of effective watershed management. Stakeholder meetings like the Mohawk Watershed Symposium and local water advocates play a key role in identifying problems, educating the public, and effecting change where it is most needed. Youth education programs centered on water quality and ecosystem health ensure that all our waterways pass into the hands of a next generation of active, engaged, and knowledgeable stewards.

The meeting this year features 30 presentations that cover a wide range of topics. We were delighted to see so many familiar names and we welcome those new to the Mohawk Watershed Symposium.

Enjoy the day.

John I. Garver, Union College

Jacqueline A. Smith, Union College

Carolyn M. Rodak, SUNY Polytechnic Institute

MWS 2023 Co-chairs

Major Financial Support for MWS 2023

Major Financial support for MWS 2023 was provided by the **New York State Department of Environmental Conservation though the Mohawk River Basin Program**.

The Mohawk River Basin Program (MRBP) is a multi-disciplinary environmental management program focused on conserving, preserving and restoring the environmental, economic, and cultural elements of the Mohawk River Watershed. Through facilitation of partnerships among local, state and federal governments, the MRBP works to achieve the goals outlined in the Mohawk River Basin Action Agenda (2012-2016). The MRBP sees the continuation of the Union College Mohawk Watershed Symposium as an ideal platform for communication among stakeholders at all levels.

The MRBP partners with organizations such as the **New York State Water Resources Institute (WRI)**, a government mandated institution located **at Cornell University**, whose mission is to improve the management of water resources. This year, through the cooperative relationship between the MRBP and Cornell University (WRI), funding was offered to help support and sponsor the Symposium.

Riverkeeper's mission is to protect the environmental, recreational and commercial integrity of the Hudson River and its tributaries. Visit the webpage to learn more: Riverkeeper.org.

2023 Mohawk Watershed Symposium - Exhibitors

	Capital-Region Partnership for Regional Invasive Species Management (PRISM) Covering the counties of Albany, Columbia, Montgomery, Rensselaer, Schenectady and portions of Fulton, Greene, Herkimer, Saratoga, Warren, and Washington, the Mission of the Capital Mohawk PRISM is to: *"Detect, prevent, and control invasive species through direct action and education to protect biodiversity, the natural environment, economy and quality of life."*
	Cornell University – The NYS Water Resources Institute (WRI) Through the Federal Water Resources Research Act of 1984, WRI was established under state law in 1987 to address water resource quality and management through research, outreach and education, grant and funding opportunities, and building relationships with state agencies, professional organizations and citizen stakeholder groups.
	Hudson River Watershed Alliance The Hudson River Watershed Alliance's mission is to unite and empower communities to protect our shared waters. The Alliance works across the Hudson River watershed to support watershed groups, help communities work together on water issues, and communicate as a collective voice, empowering effective stewardship to ensure the availability of clean, abundant water today and into the future.
	Mohawk Towpath Byway The Mohawk Towpath Byway, an official New York State Byway created through State legislation in July 2003, is a series of local, county and state highways that follow the historic route of the Erie Canal between Schenectady and Waterford/Cohoes in upstate New York. As one travels the Byway you unlock the story of the Mohawk River, the Erie Canal, the waterway west and the part these communities played in the westward expansion of the country and the Industrial Revolution.
	Mohawk River Basin Program DEC's Mohawk River Basin Program (MRBP) works to promote the integrated and coordinated management of the many environmental resources of the Mohawk River and its unique watershed. As a partnership-based initiative, the MRBP fosters collaborative decision-making based on an understanding of the entire ecosystem, recognizing that the complex issues within the region cannot be fully resolved by managing certain sectors, species, or pollutants on an individual basis.

2023 Mohawk Watershed Symposium - Exhibitors

	National Oceanic and Atmospheric Administration (NOAA) NOAA is an agency that enriches life through science. NOAA’s mission to better understand our natural world and help protect its precious resources extends beyond national borders to monitor global weather and climate, and work with partners around the world. NOAA holds key leadership roles in shaping international ocean, fisheries, climate, space and weather policies.
	Riverkeeper A member of the Mohawk River Basin Program's steering committee, Riverkeeper is a non-profit organization formed in 1966 and devoted to protecting the Hudson River and its tributaries. Riverkeeper's work in the Mohawk River watershed began in 2014, when Capt. John Lipscomb extended his Hudson River patrols into the Mohawk and continues with water quality monitoring in partnership with SUNY Cobleskill and SUNY Polytechnic. riverkeeper.org
	Schoharie River Center – Environmental Study Teams Established in 1999, the Schoharie River Center (SRC) is a not-for-profit organization dedicated to educational and cultural programming about the Schoharie Creek and surrounding communities. As part of their programming, SRC operates and sponsors Environmental Study Team (EST) programs designed to engage middle and high school age youth to study, monitor and improve the water quality of local streams, rivers and lakes. While learning about their environment, EST members go hiking, swimming, biking, cross-country skiing, snowshoeing, canoeing, kayaking and sailing, and in the spring can learn how to make maple syrup in the Center’s maple syrup sugar shack.
	United States Geological Survey (USGS) As the Nation's largest water, earth, and biological science and civilian mapping agency, USGS collects, monitors, analyzes, and provides science about natural resource conditions, issues, and problems. USGS’ diverse expertise enables them to carry out large-scale, multidisciplinary investigations and provide impartial scientific information to resource managers, planners, and others. In partnership with the Mohawk River Basin Program, USGS has taken the lead on projects such as Ice Jam Monitoring, Sediment Monitoring, Fish Assemblages of the Mohawk, and assisting with outreach and education efforts

Mohawk Watershed Symposium - 2023
17 March 2023, College Park Hall, Union College, Schenectady NY

Oral session (College Park) - Registration and badges required. No photography

7:45 AM	8:10 AM	***Registration, Coffee - College Park***
8:10 AM	8:15 AM	**Introductory Remarks** *Carolyn Rodak, MWS Co-chair, SUNY Polytechnic Institute, Utica, NY*
8:15 AM	8:30 AM	**Pervious concrete offers a potential solution to contaminated runoff threatening surface water quality** *Ashraf Ghaly, Engineering Department, Union College, Schenectady, NY*
8:30 AM	8:45 AM	**Steele Creek Restoration and Flood Mitigation Project** *Mark Carabetta, SLR Consulting, New Paltz, NY*
8:45 AM	9:00 AM	**Incorporating ice jam flooding into regulatory Base Flood Elevations at the Historic Schenectady Stockade** *James Woidt, Streamworks PLLC, Scarborough, ME*
9:00 AM	9:15 AM	**Using the Riparian Opportunities Assessment to identify riparian restoration or protection sites for flood mitigation** *Kristen Hychka, NYS Water Resources Institute, Cornell University, Ithaca, NY*
9:15 AM	9:40 AM	**Sauquoit Creek Channel & Floodplain Restoration Program: Community Resiliency to Flooding using Mitigation and Adaptation** *Margaret Reilly, Sauquoit Creek Channel & Floodplain Restoration Program, Program Manager, Ramboll, Utica, NY*
9:40 AM	10:25 AM	***COFFEE and POSTERS (see next page for listing)***
10:25 AM	10:50 AM	**Toward a more swimmable Mohawk: Trends in water quality based on an eight-year fecal indicator bacteria (FIB) monitoring partnership** *Neil A. Law, SUNY Cobleskill, Cobleskill, NY*
10:50 AM	11:05 AM	**Fecal indicator bacteria and microbial source tracking in the Mohawk River watershed: Observations from a case study in Utica and Rome, NY** *Carolyn Rodak, MWS Co-chair, SUNY Polytechnic Institute*
11:05 AM	11:20 AM	**Extreme precipitation and sewage overflows are driving an emerging health crisis: a case study from Schenectady, NY** *John Garver, MWS Co-chair, Geosciences Department, Union College, Schenectady, NY*
11:20 AM	11:45 AM	**Characterization of disinfection by-product formation potential in Mohawk River source waters to support TMDL implementation** *Andrea Conine, Mohawk River Basin Program, Bureau of Water Resource Management, Division of Water, NYSDEC*
11:45 AM	1:10 PM	***LUNCH and POSTERS - Lunch at College Park Hall***
1:10 PM	1:35 PM	**Mitigation approaches to water chestnut (Trapa natans) on the Mohawk River** *Hannah Coppola, Aquatic Invasive Species Program Manager, Capital Region PRISM, Ballston Spa, NY*
1:35 PM	1:50 PM	**Predicted effects of passage efficiency and additive mortality sources of blueback herring relative to use of novel habitat in the Mohawk River and Erie Canal** *Dan Stich, State University of New York College at Oneonta, Oneonta, NY*
1:50 PM	2:15 PM	**Invasive Round Goby in the Mohawk and Hudson Rivers: What's the Latest?** *Scott George, USGS, New York Water Science Center, Troy, NY*
2:15 PM	2:40 PM	**Coevolution between round gobies and VHSV in the St. Lawrence River signals added risk for the Mohawk River** *Anna Haws, State University of New York College of Environmental Science and Forestry, Syracuse, NY*
2:40 PM	3:25 PM	***COFFEE and POSTERS (see next page for listing)***
3:25 PM	3:50 PM	**Blocking invasive species in the New York State canal system: The barriers to barriers** *Stuart F. Gruskin, Chief Conservation and External Affairs Officer, The Nature Conservancy New York, New York, NY*
3:50 PM	4:15 PM	**Fish, Drink, Swim: The Mohawk in the 50th Year of the Clean Water Act** *Tracy Brown and Dan Shapley, Riverkeeper, Ossining, NY*
4:15 PM	4:25 PM	**Break and Introduction of Congressman Tonko**
4:25 PM	4:55 PM	**Congressman Paul Tonko, NY 20th District**
4:55 PM	5:00 PM	**Concluding Remarks** *John Garver, MWS Co-chair, Geosciences Department, Union College, Schenectady, NY*

*The lead or presenting author(s) is(are) listed here; for complete author listings and affiliations please refer to the abstract.

5:00 PM	7:00 PM	***Symposium Reception in College Park Hall Lobby, 5:00 - 7:00 PM***

Poster session (all day)

P1	**MyCoast NY: A Statewide Tool for Engaging Communities and Documenting Flood Events** *Kristen Hychka, NYS Water Resources Institute, Cornell University, Ithaca, NY*
P2	**Recreational Boating in the Mohawk Watershed** *Daniel Miller, US Coast Guard Auxiliary, Sacandaga-Mohawk Flotilla, Glenville, NY*
P3	**The swinging environmental pendulum: how policies and attitudes shift with changes in the US administration** *Ashraf Ghaly, Engineering Department, Union College, Schenectady, NY*
P4	**Investigating the dynamics of organic matter in the Hudson River across spatial, temporal, and hydrologic regimes** *Alex Collins, Department of Earth and Environmental Science, Rensselaer Polytechnic Institute, Troy, NY*
P5	**Characterization of Stream Turbidity in the Catskills, New York: Insights into Environmental Controls** *Christine Swanson, Environmental Science, Policy, and Engineering Program, Union College, Schenectady, NY*
P6	**Microplastic analysis of high-flow and low-flow streams located in Rensselaer County** *Inara Ilse, Columbia High School, East Greenbush, NY*
P7	**Troubled tributary: Continued water quality analysis using fecal indicator bacteria of the North Chuctanunda Creek in Amsterdam, NY** *David E. Barkevich, SUNY Cobleskill, Cobleskill, NY*
P8	**iMapInvasives: the official invasive species database for New York State** *Mitchell O'Neill, New York Natural Heritage Program, Albany, NY*
P9	**Comparing Fish Communities in Restored and Unrestored Streams** *Alexander Javitz, Department of Fisheries, Wildlife and Environmental Science, SUNY Cobleskill, Cobleskill, NY*
P10	**Blueback Herring in the Hudson-Mohawk watershed: anadromy run amok?** *Karin Limburg, SUNY College of Environmental Science and Forestry, Syracuse, NY*
P11	**Identifying nitrogen inputs to the Mohawk River and tributaries** *Brieann Lohmann, Department of Biology, Utica University, Utica, NY*
P12	**The invisible biology of freshwater: Urban and rural land use is reflected in the microbial communities of the Mohawk River and nearby freshwater systems** *Julian Damashek, Department of Biology, Utica University, Utica, NY*
P13	**Regional salinization in the lower Mohawk River: effects on urban streams, the Great Flats Aquifer, and raw water for municipal use** *John Garver, MWS Co-chair, Geosciences Department, Union College, Schenectady, NY*
P14	**Changes in temperature and precipitation patterns in the Mohawk Watershed: implications for flooding, water quality, and ecosystem health** *Ian Plummer, Department of Atmospheric and Environmental Sciences, University at Albany, Albany NY*

*The lead or presenting author(s) is(are) listed here; for complete author listings and affiliations please refer to the abstract.

5:00 PM	7:00 PM	***Symposium Reception in College Park Hall Lobby, 5:00 - 7:00 PM***

Congressman Paul Tonko
NY 20th Congressional District

Congressman Paul D. Tonko is an eighth-term member of the U.S. House of Representatives, representing New York's 20th Congressional District in the Capital Region, including most of the lower part of the Mohawk Watershed. Tonko is currently the Ranking Member of the Energy and Commerce Subcommittee on Environment, Manufacturing, & Critical Minerals. In addition to serving on the Energy and Commerce Subcommittee on Energy, Climate, and Grid Security, and Subcommittee on Oversight & Investigations, he is also a member of the Committee on Science, Space, and Technology.

In 2021, Congressman Tonk introduced the NY-NJ Watershed Protection Act. Representative Tonko has long advocated for watershed protection and economic development along our historic and iconic waterways - including the Mohawk River. Early versions of the bill were first introduced as the Hudson-Mohawk River Basin Act of 2012, and that bill was modified and reintroduced to the US House as the Hudson-Mohawk River Basin Act in December 2016 and then in December 2018. The NY-NJ Watershed Protection Act submitted in 2021 grew from these earlier efforts,

Part of his early focus in the Watershed was on his *Mighty Waters* task force. In July 2010, he hosted the first Mighty Waters Conference at the Schenectady County Community College. This conference focused on promoting sustainable and responsible waterfront development projects to improve the quality of life in communities along the Hudson and Mohawk Rivers and Erie Canal]. In early 2011 the Mighty Waters effort had developed a mission statement, which read: *"The mission of the Mighty Waters Task Force is to help create a climate of investment, recovery and public awareness for the waterways and communities of the upper Hudson and Mohawk Rivers, Erie Canal and related waterways by mobilizing federal resources that encourage policy reform, economic development, public access and enjoyment and effective environmental and cultural resource management."*

Congressman Tonko has long been a champion for clean energy and the environment. Prior to serving in Congress, he was the president and CEO of the New York State Energy Research and Development Authority. Before that, he served in the New York State Assembly for 25 years, serving for 15 years as Chairman of the Committee on Energy. Tonko graduated from Clarkson University with a degree in mechanical and industrial engineering and is a former engineer for the New York State Public Service Commission.

We welcome Congressman Tonko back to the Mohawk Watershed Symposium.

Mohawk River Basin Action Agenda

**CONSERVING, PRESERVING, AND RESTORING
THE MOHAWK RIVER WATERSHED**

2021–2026

Special thanks to

Katherine M. Czajkowski

**Mohawk Watershed Coordinator
NYSDEC Mohawk River Basin Program
Division of Water**

Troubled Tributary: Continued water quality analysis using fecal indicator bacteria of the North Chuctanunda Creek in Amsterdam, NY

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Seasonal sampling of North Chuctanunda Creek (a tributary of the Mohawk River) as it flows through Amsterdam, New York, performed by SUNY Cobleskill since 2016, has identified increased levels of fecal indicator bacteria (FIB) as a cause for concern. The concentration of FIB can indicate the presence of reduced water quality and may indicate the presence of pathogens. The FIB levels when compared to the beach action values (BAV) and geometric mean thresholds (GM) set by the EPA suggest that contamination of the water body above that BAV level indicates that human interaction with that water is more likely to lead to illness.

Results from sampling through 2017 have been presented previously at this venue. A more extensive review of data from 2016 to 2022 along the lower section of North Chuctanunda Creek will be presented. The North Chuctanunda Creek at locations in Amsterdam's Shuttleworth Park and beside Forest Avenue has been sampled consistently since 2017 from May to October for *Enterococci* and *E. coli*, both established FIB. The data presented will include details of BAV and GM levels in dry vs. wet weather as well as annual trends at both locations.

At both locations, the frequency of the BAV exceedances and elevated GMs represent causes for concern. Where these sites are sampled, the North Chuctanunda Creek flows through area of mixed land use with commercial and residential stretches. As such, the source of contamination may be homes utilizing private septic services which are nutrient-loading the creek via the groundwater, with the process being accelerated during precipitation events. Alternatively, sources of contamination may include failing septic systems near the creek, leaking sewer lines, or run-off, which may be impacted by pet or wildlife waste in the area. In 2016, a known sewer leak just upstream of one of the sites was discovered in the City of Amsterdam, for example.

One reason to consider water quality in the North Chuctanunda is the recent emphasis by localities along the creek to view it as natural resource for the community. Currently the City of Amsterdam is moving forward with plans to improve public access to North Chuctanunda Creek for hiking, fishing and general use. This includes a planned improvement and extension of the walking trail that parallels the creek from Amsterdam's new Flat Rock Park to the Village of Hagaman. Therefore, water quality might become an increasing issue of concern within this watershed, especially for those who might fish, paddle or otherwise engage in recreation along or in the North Chuctanunda Creek.

Fish, Drink, Swim: The Mohawk in the 50th year of the Clean Water Act

Tracy Brown
Dan Shapley

Riverkeeper, Ossining, NY

The Mohawk River is a major source of drinking water, a destination for recreation on its own and as part of the Erie Canal, a source of ecological wealth, and the Hudson River's largest tributary. Climate change and unique risks from the river and valley's use as industrial transportation corridors present significant threats to the river's water quality and ecology. Meeting these challenges will require building on historically high levels of state and federal investments and passing the NY/NJ Watershed Protection Act.

Fish

The invasive Round goby entered the canal system from the Great Lakes in 2013 and by 2021 had traversed the Erie Canal and Mohawk River to reach the Hudson River, where it is now established. Future threats, most notably jumping carp, must be prevented from using the same pathway with engineered solution that prevents multi-taxa from being transferred by water or boat from one watershed to another. Work should begin now to implement the 2019 recommendation of a Reimagine the Canal task force to create a "watershed divide" near Rome, as implementation will inevitably take years. In the eastern portion of the river, conversely, options for promoting fish passage, particularly for American eel, should be implemented through changes to hydroelectric dam and lock infrastructure and/or operations. Invasive species threaten native fish species in the Mohawk River and the Hudson River.

Drink

Industrial rail lines hug the shores of much of the Mohawk River. The recent East Palestine, Ohio, disaster is a reminder that too many improvements have been stalled or rolled back. In addition, spill prevention and response planning must be updated to include realistic scenarios for a derailment and spill into the Mohawk River. This should be urgent, given that more than 100,000 people rely on the Mohawk River as a source of drinking water. Emerging risks to drinking water – from road salt to PFAS – must also be addressed through treatment and drinking water source protection.

Swim

The Mohawk River Watershed includes at least 41 municipally owned wastewater treatment plants, and another 27 publicly owned sewer systems that collect waste from neighboring communities. Five communities have 57 combined sewer overflows that discharge to the Mohawk River or its tributaries. From 2017 to 2022, $250.3 million was invested in sewer system studies, repairs or upgrades with state and federal assistance in the Mohawk River Watershed, based on publicly reported state grant and loan announcements. The need for future investments remains great. As of 2022, communities in the Mohawk River Watershed had identified 52 wastewater projects totaling $349.1 million for which they are seeking state and federal funding assistance. Water quality data gathered since 2015 by Riverkeeper, SUNY Cobleskill, SUNY Polytechnic Institute, and Union College support the need for these investments. There are currently no formal swimming locations on the Mohawk River.

Steele Creek Restoration and Flood Mitigation Project

Mark Carabetta, PWS, CFM
Matthew Trueheart

SLR Consulting, 231 Main Street, Suite 102, New Paltz, New York

The Steele Creek Restoration and Flood Mitigation Project in the village of Ilion, New York, was a multifaceted project with many complex components. The primary purpose was to mitigate chronic flooding problems along Steele Creek, a tributary to the Mohawk River, which had been reported for over a century and escalated as the village grew and development increasingly encroached on the creek's floodplain. Following severe flooding in June 2013, SLR evaluated and identified scenarios for reducing flooding along Steele Creek, as well as 12 other tributaries to the Mohawk River in Herkimer, Oneida, and Montgomery Counties. SLR then developed detailed engineering design plans for construction of the Steele Creek Restoration and Flood Mitigation Project.

Project design components included the removal of the Remington Arms dam (reportedly constructed in 1917; however historical documents show that a dam had been present at the site since at least the 1850s to provide water to Remington's factory); removal of accumulated sediments behind the dam to restore the channel bed; demolition and removal of flood prone homes along the creek; removal of flood prone roadways; widening of the Steele Creek channel; creation of floodplain; replacement of a hydraulically undersized bridge and retrofitting of a second bridge; installation of in-stream habitat features; water, wastewater, natural gas, and electrical utility relocations; and, construction of a sanitary sewer pump station to replace a gravity sewer line that had passed under Steele Creek.

The stable channel analytical method was employed to determine equilibrium channel geometry to establish longitudinal slope, channel bottom width and target roughness based on user-input bedload sediment gradation, channel side slopes, and reference conditions. Peak design flows were increased, per guidance from New York State Department of Transportation, and used during hydraulic analysis to account for climate change and the effect of extreme weather events. SLR applied for and received all required regulatory permits, assisted the village with bidding of the project, and provided construction administration for the duration of the project, which was constructed during the 2020 and 2021 construction seasons.

The project substantially reduced flood risk in the village, with hydraulic modeling indicating that more than 100 homes were removed from Steele Creek's 100-year floodplain, and has been viewed very favorably by the local community. The channel was very uniform and lacked aquatic diversity and in-stream habitat features prior to construction. Riffles, rock vanes, pools, and boulder clusters were added to the channel to provide grade control, roughness, and in-stream habitat. The streambanks and floodplain were planted with native riparian species. With the removal of the dam, passage of fish and other aquatic organisms was restored. The Steele Creek Restoration and Flood Mitigation Project won the 2023 Diamond Engineering Excellence Award, Water Resources Category, from the American Council of Engineering Companies of New York.

Investigating the dynamics of organic matter in the Hudson River across spatial, temporal, and hydrologic regimes

Alex Collins
Sasha Wagner

Department of Earth and Environmental Science, Rensselaer Polytechnic Institute, Troy, NY

The Hudson River Confluence at Troy, New York is fed by its two main tributaries: the Mohawk River and the Upper Hudson River (Figure 1a). Hydrologic inputs from these tributaries are roughly equivalent to the water exported at the confluence and constitute 67% of the total water exported from the Hudson River to the coastal ocean (Howarth et al. 1991; Swaney et al. 1996).

The Upper Hudson and Mohawk River catchments exhibit different land cover, geology, and geomorphology. The Upper Hudson River is sourced from headwaters in the Adirondack Mountains and its basin is primarily mountainous and forested with few settlements. Conversely, the Mohawk River is sourced from Delta Lake and its basin is primarily characterized by agricultural and urban flatlands. Seasonal trends in discharge appear to be consistent in both the Mohawk River and Upper Hudson River tributaries. Winter and spring months generally have higher flows from frequent rainfall and snowmelt events, whereas the summer and early fall generally have less precipitation and therefore lower discharge on average. However, climate change is driving the increased frequency and magnitude of storm events and triggering earlier onset of snowmelt observed in the northeastern US (Figure 1b; Huang et al. 2017).

Dissolved organic matter (DOM) is one of the most important biogeochemical components of riverine systems because it is a vector for nutrient cycling and elemental exchange between terrestrial and oceanic reservoirs (Battin et al. 2008; Ensign et al. 2006). DOM constitutes a significant global carbon store because it is comprised of roughly 50% dissolved organic carbon (DOC) by mass (Mineau et al. 2016; Soares et al. 2019). DOM is also a significant vector for the mobilization of N and P from land to water, enhancing primary productivity in aquatic environments (Hedin et al 1995). DOM is ubiquitous in all ecosystems, contributes to carbon balances, is an important source of energy, biomass, and nutrient transfers from terrestrial to aquatic ecosystems (Neff 2001). Total dissolved nitrogen (TDN) includes both inorganic nitrogen species and dissolved organic nitrogen. Bioavailable nitrogen is a limiting nutrient, meaning that an overabundance within the ecosystem can lead to eutrophication or harmful algal blooms (Paerl 1997).

The timing and magnitude of TDN and DOC export depend on a complex interplay of hydrology, land cover, and seasonal processes. Therefore, with climate change altering both seasonal duration and hydrological regimes in the northeast USA, constraining changes in nutrient export across a spectrum of catchment land cover is essential to understand local affects to water quality and the environment (Huang et al 2017; Laufkotter et al. 2017; Reed et al. 2015). The mobilization of these nutrients directly impacts water quality and terrestrial environments through relative enrichments and depletion of essential nutrients, such as eutrophication or soil nutrient loss (Howarth et al. 2000; EPA NEPIS report 1973).

To constrain DOC and TDN export dynamics across hydrologic and seasonal regimes, we collected grab samples biweekly, targeting both hydrological events and lower flow periods for one year (March 2021 to May 2022) at three local sites representing the Mohawk River, the Upper Hudson River, and their confluence (Figure 1). These three sampling sites were chosen based on their proximity to continuous USGS stream gauges, location above major dams, ease of accessibility, and the absence of nearby point source outflows. DOC concentrations displayed strong seasonal and hydrologic trends, with higher concentrations observed in the summer and fall and with increased discharge (Figure 2a and 2b). TDN concentrations varied seasonally and between watersheds, with higher concentrations observed in winter months and in the Upper Hudson (Figure 2c and 2d). Taken together, these results indicate that climate change driven increases in discharge and duration of summer and fall months will result in net increases in export of DOC into the Hudson River, affecting water quality in systems connected to the Hudson downstream of these inputs.

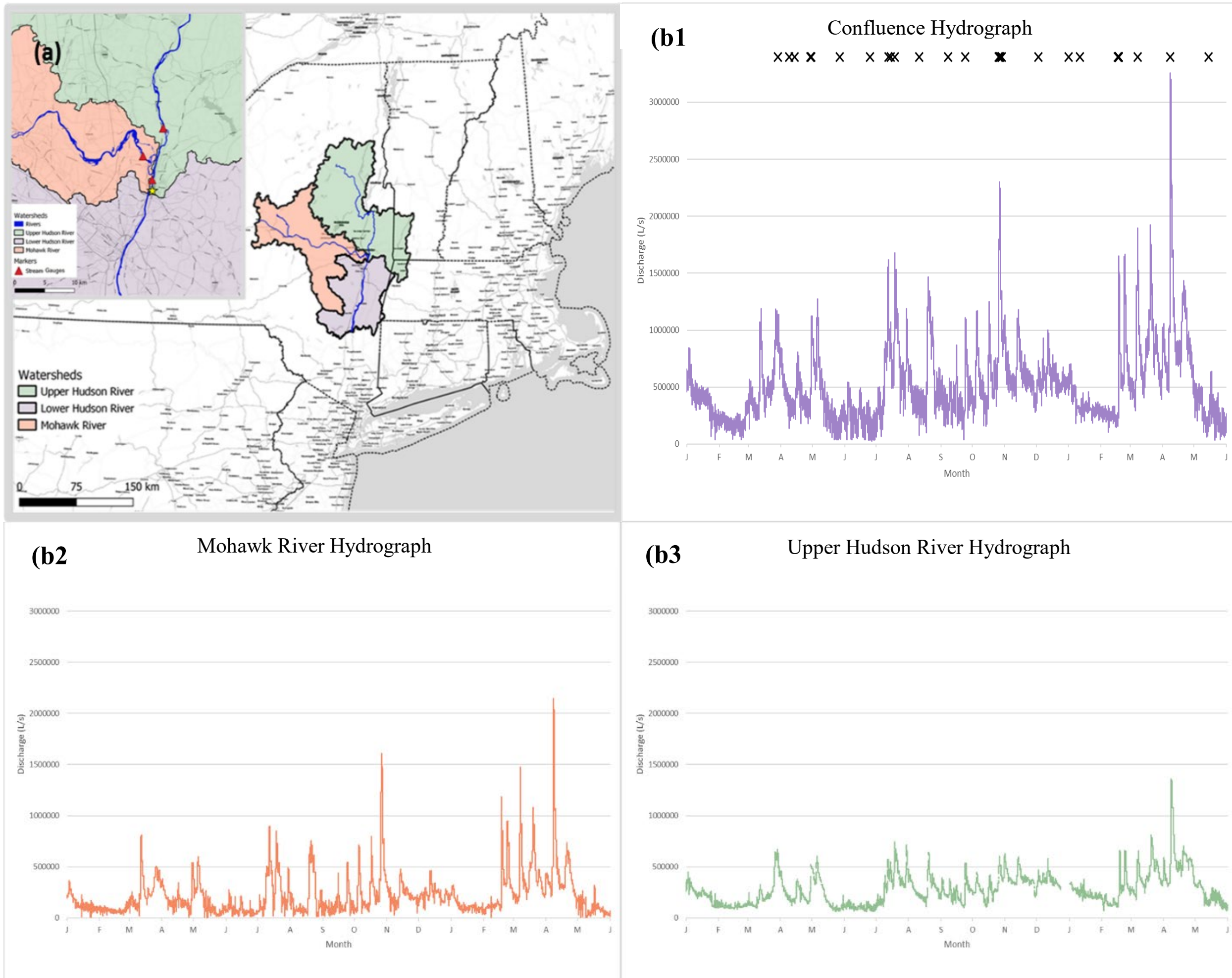

Figure 1: a) Map of the Hudson River Confluence in Troy, NY showing the Mohawk (orange, left) Upper Hudson (green, top) and post-confluence Hudson River (purple, bottom) watersheds. Smaller map included on top left shows a zoomed in image, with the yellow star representing Rensselaer Polytechnic Institute, and the red triangles representing USGS stream gauges from which discharge data is collected. **b)** Hydrographs of the Confluence **(b1)**, the Mohawk River **(b2)**, and Upper Hudson River **(b3)** over the sampling period represented in this abstract. Sampling events are indicated with Xs in the Confluence hydrograph, with samples targeting discharge events and base flow samples.

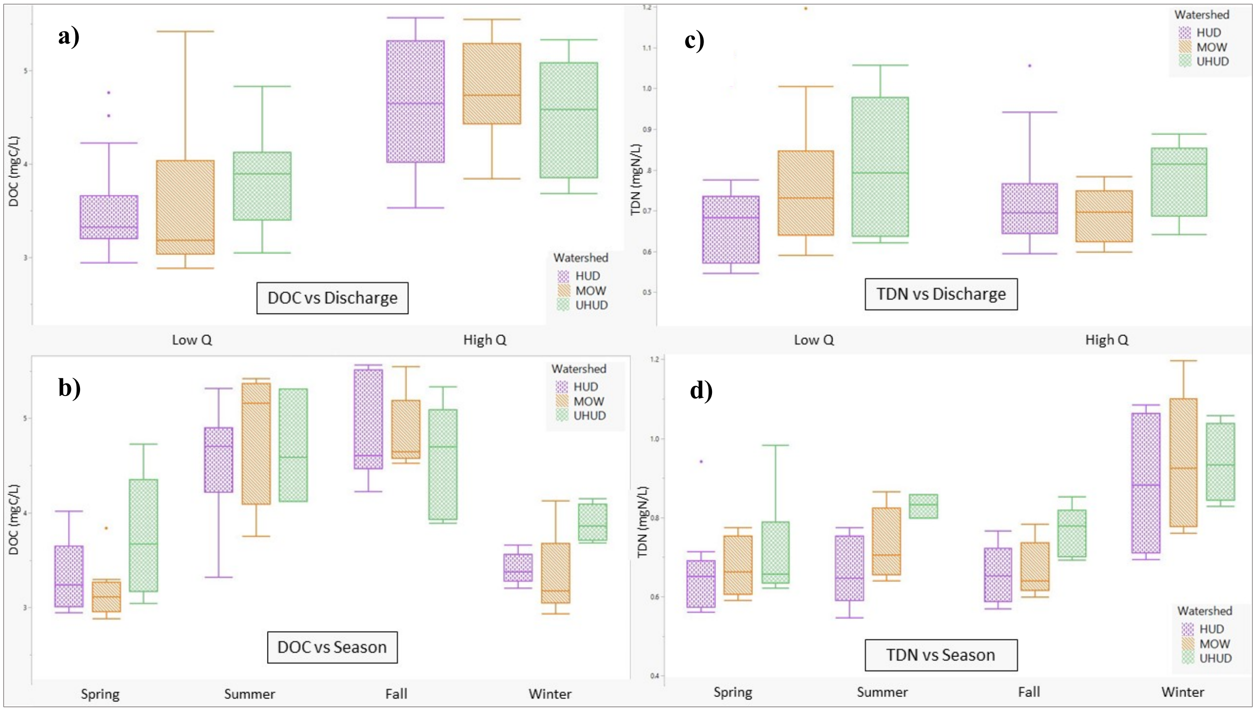

Figure 2: a) DOC concentration plotted against discharge for each watershed. **b)** DOC concentration plotted against season for each watershed. **c)** TDN concentration plotted against discharge for each watershed. **d)** TDN concentration plotted against season for each watershed.

References:

Battin, T. J., Kaplan, L. A., Findlay, S., Hopkinson, C. S., Marti, E., Packman, A. I., Newbold, J. D., & Sabater, F. (2008). Biophysical controls on organic carbon fluxes in fluvial networks. *Nature Geoscience*, *1*(2), Article 2. https://doi.org/10.1038/ngeo101

Document Display | NEPIS | US EPA. (n.d.). Retrieved February 2, 2023, from https://nepis.epa.gov

Ensign, S. H., & Doyle, M. W. (2006). Nutrient spiraling in streams and river networks. *Journal of Geophysical Research: Biogeosciences*, *111*(G4). https://doi.org/10.1029/2005JG000114

Hedin, L. O., Armesto, J. J., & Johnson, A. H. (1995). Patterns of Nutrient Loss from Unpolluted, Old-Growth Temperate Forests: Evaluation of Biogeochemical Theory. *Ecology*, *76*(2), 493–509. https://doi.org/10.2307/1941208

Howarth, F. G. (1991). Environmental Impacts of Classical Biological Control. *Annual Review of Entomology*, *36*(1), 485–509. https://doi.org/10.1146/annurev.en.36.010191.002413

Howarth, R. W., Swaney, D. P., Butler, T. J., & Marino, R. (2000). Rapid Communication: Climatic Control on Eutrophication of the Hudson River Estuary. *Ecosystems*, *3*(2), 210–215. https://doi.org/10.1007/s100210000020

Huang, H., Winter, J. M., Osterberg, E. C., Horton, R. M., & Beckage, B. (2017). Total and Extreme Precipitation Changes over the Northeastern United States. *Journal of Hydrometeorology*, *18*(6), 1783–1798. https://doi.org/10.1175/JHM-D-16-0195.1

Laufkötter, C., John, J. G., Stock, C. A., & Dunne, J. P. (2017). Temperature and oxygen dependence of the remineralization of organic matter. *Global Biogeochemical Cycles*, *31*(7), 1038–1050. https://doi.org/10.1002/2017GB005643

Mineau, M. M., Wollheim, W. M., Buffam, I., Findlay, S. E. G., Hall Jr., R. O., Hotchkiss, E. R., Koenig, L. E., McDowell, W. H., & Parr, T. B. (2016). Dissolved organic carbon uptake in streams: A review and assessment of reach-scale measurements. *Journal of Geophysical Research: Biogeosciences*, *121*(8), 2019–2029. https://doi.org/10.1002/2015JG003204

Neff, J. C., Finlay, J. C., Zimov, S. A., Davydov, S. P., Carrasco, J. J., Schuur, E. a. G., & Davydova, A. I. (2006). Seasonal changes in the age and structure of dissolved organic carbon in Siberian rivers and streams. *Geophysical Research Letters*, *33*(23). https://doi.org/10.1029/2006GL028222

Paerl, H. W., & Fulton, R. S. (2006). Ecology of Harmful Cyanobacteria. In E. Granéli & J. T. Turner (Eds.), *Ecology of Harmful Algae* (pp. 95–109). Springer. https://doi.org/10.1007/978-3-540-32210-8_8

Soares, A. R. A., Lapierre, J.-F., Selvam, B. P., Lindström, G., & Berggren, M. (2019). Controls on Dissolved Organic Carbon Bioreactivity in River Systems. *Scientific Reports*, *9*(1), Article 1. https://doi.org/10.1038/s41598-019-50552-y

Swaney, D. P., Sherman, D., & Howarth, R. W. (1996). Modeling water, sediment and organic carbon discharges in the Hudson-Mohawk basin: Coupling to terrestrial sources. *Estuaries*, *19*(4), 833–847. https://doi.org/10.2307/1352301

An introduction to the Mohawk Watershed phosphorus Total Maximum Daily Load (TMDL)

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Phosphorus is a naturally occurring nutrient that is essential to life, however at high concentrations it can become a threat to freshwater ecosystems. Excess phosphorus enters waterbodies through nonpoint sources such as runoff from the land and through point sources such as wastewater treatment effluent. High concentrations of phosphorus can be associated with sediment and other natural organic material which can increase costs and effort needed to effectively treat drinking water. Dissolved forms of phosphorus can also increase algal and plant growth which impacts recreational and aesthetic value of waterbodies.

The United States Environmental Protection Agency requires states to develop a Total Maximum Daily Load (TMDL) plan when a waterbody exceeds the state's water quality standard for a pollutant. A TMDL establishes a target load of a pollutant that the waterbody can assimilate without exceeding the water quality standard. The TMDL load target is made up of point source loads (wasteload allocation), nonpoint source loads (load allocation), and a margin of safety.

Three drinking water segments at the mouth of the Mohawk River are currently assessed as stressed for phosphorus. Collins Lake and Mariaville Lake, both within the Mohawk Watershed, are listed as impaired for phosphorus on the most recent 303 (d) list. As such, New York State Department of Environmental Conservation is in the process of developing a watershed-wide TMDL to restore those waterbodies and protect other waterbodies from further degradation from phosphorus pollution. This presentation will outline the process that has led to the development of the draft phosphorus TMDL for the Mohawk Watershed including data collection and watershed characterization, modeling to estimate current loading rates and loading capacity, modeling of potential implementation scenarios, and implementation strategies.

Mitigation approaches to water chestnut (*Trapa natans*) on the Mohawk River

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Trapa natans (water chestnut) is a growing issue concerning both ecologic and economic values of the Mohawk River. The Mohawk serves as the largest tributary to the Hudson River, with a surface area of 3,460-square-miles (NYSDEC). As a Tier 4 and widespread invasive species in New York State, *T. natans* reduces habitat and impacts recreation, transportation and property values. The expansive volume of *T. natans* in the Mohawk River requires a partnered response with strategic management. Current monitoring surveys have delineated approximately 850 acres of *T. natans*. Identifying highly affected ecologic and economic areas will assist in the creation of management plans.

T. natans is best identified by its triangular floating leaves forming a rosette. Long stems that reach the sediment have feathery leaves beneath the water's surface. Nut-like seeds with four barbs are produced on the underside of the rosette, which annually fall to the sediment. Seed dormancy can last from 4 months to 12 years, requiring long-term management (Schultz, 2019). Mechanical and manual methods have been shown to be effective on this species prior to seed drop. Mechanical methods are costly but necessary for management of monoculture populations. While harvesters have the ability to collect *T. natans* biomass in deeper segments of the Mohawk River, satellite populations and those close to the shoreline require alternative management. Smaller invasive aquatic plant machinery such as but not limited to, Weedoo Workboats and Eco Harvesters effectively bridge this gap, in combination with manual removals. Manual efforts are effective for removal of *T. natans* unable to be reached with mechanical methods. Hand pulling of *T. natans* is restricted by factors including the size of infestation, likelihood of eradication, and location; with that stated, populations can be controlled or eliminated locally with long term active management practices.

The Capital Region Partnership for Regional Invasive Species Management (CR-PRISM) assists on a limited basis in *T. natans* manual removal efforts based on a Water Chestnut Prioritization model. Through partnerships such as the Mohawk River Water Chestnut Working Group, and documenting removal efforts through the Water Chestnut Action Sites Program, the first steps towards decreasing populations of *T. natans* in the Mohawk River become feasible.

References

NYS Dept. of Environmental Conservation (n.d.). *Mohawk River Watershed*. www.dec.ny.gov. Retrieved February 2nd 2023. Available from https://www.dec.ny.gov/lands/48041.html.

Schultz, S. (2019). *Water Chestnut (Trapa natans): Best Management Practices* (p.1). New York Invasive Species Research Institute.

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The invisible biology of freshwater: Urban and rural land use is reflected in the microbial communities of the Mohawk River and nearby freshwater systems

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Given widespread use of the Mohawk River and its tributaries for drinking water and recreation, it is critical to monitor and understand the drivers of many water quality parameters throughout the river and its watershed. Recent research along the Mohawk has greatly advanced understanding of microplastics, nutrients, and human pathogens, facilitating outcomes such as public water quality alerts. However, little is known about the overall microbial communities of this river, its tributaries, or nearby freshwater ecosystems. Aquatic microbial communities not only host pathogens, which can be dangerous to humans upon contact, but are also responsible for carbon cycling, nutrient processing, greenhouse gas emissions, degradation of pollutants, and transfer of antibiotic resistance, among other ecosystems processes. Here, we present compiled data on microbial community diversity (16S rRNA gene amplicons) in a wide range of freshwater samples from the Mohawk River near Utica, the Mohawk River near Amsterdam, selected tributary creeks, and numerous lakes in the Syracuse/Utica area. These samples represent a wide variety of freshwater ecosystems with varying levels of agricultural or urban inputs from their watersheds.

Our primary analysis characterized levels of fecal contamination from sewage, cattle, dogs, and other animals based on microbial community diversity. Many Mohawk River communities indicated probable fecal contamination from sewage and from cattle or other ruminants along the entire sampled stretch of the river. Notably, both sewage and ruminant fecal contamination were present upstream of Utica and near Amsterdam. Communities from Cayuga Lake and Onondaga Lake also reflected contamination from sewage, while those from Green Lake and the North Chuctanunda Creek had strong signals of dog fecal contamination. We also analyzed sequence data from the presence of microbial clades involved in important biogeochemical processes, particularly nitrogen cycling (nitrifiers) and primary production (cyanobacteria). These data demonstrate the usefulness of microbial community profiling for assessing sources of contamination to the water, and for understanding the drivers of important ecological processes such as nutrient and carbon cycling.

Regional salinization in the lower Mohawk River: effects on urban streams, the Great Flats Aquifer, and raw water for municipal use

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New York State leads the nation in use of road salt for deicing roads in the winter and our watersheds are paying the price. Road salt, which is the mineral halite (NaCl - sodium chloride), is probably the most widely dispersed contaminant in the Mohawk Watershed. It is liberally applied as a deicer in the winter on roads and highways, but the fate of that salt in the watershed is a major concern. In an evaluation of salinization in the Northeast (NE US), Kaushal and colleagues suggest that salinization in urban and suburban settings is *"one of the most significant threats to the integrity of freshwater ecosystems in the northeastern United States"* (Kaushal et al., 2005), and then coined the term *Freshwater salinization syndrome* or FSS (Kaushal et al., 2018). Recently Kaushal and colleagues pointed out that salinization can drive the release and mobilization of a diverse set of "chemical cocktails" that can be problematic for freshwater resources (Kaushal et al., 2022). Salinization and the impairment of fresh water is a particular concern for those areas with significant urbanized areas with a high degree of imperviousness (pink and purple areas on Fig 1).

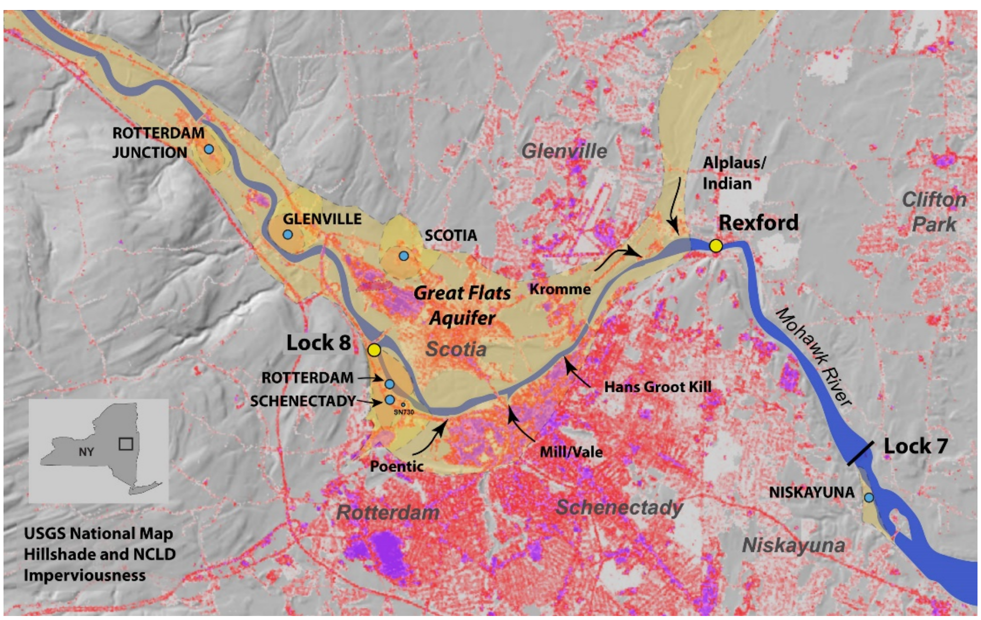

Figure 1: Map showing key features in the Schenectady area with imperviousness. Overlain in yellow is the general area of the Great Flats Aquifer, a regionally important aquifer for municipal water use that is composed primarily of Quaternary sands and gravels. The locations of municipal wells and principal local tributaries are also shown.

Although there are a number of known pathways for NaCl to enter the environment, by far the most significant is through the application of road salt as a deicer in the winter, although we are also concerned about storage facilities for salt (Garver, 2020). Since the early 1950s, chloride levels in the Mohawk River have increased by over 300% and this increase is year round, not just in the winter (see Garver, 2020). Some streams and rivers, especially those in urban settings, have high sodium and chloride levels in the mid-winter (January and February) when salt is dissolved and directly runs off into surface water. A remarkable amount of salt enters groundwater and is slowly released with baseflow over the rest of the year, and in some cases salt storage facilities can be the source of contaminant plumes in regional aquifers.

Here we are interested in evaluating salt pathways in the Mohawk Watershed. We have determined conductivity (EC and SPC - see below) and concentrations of most dissolved ions in urban streams in Schenectady and then evaluated how these solute loads may affect the Mohawk River. Elevated levels of dissolved sodium and chloride are stressors on aquatic life and drinking water resources. Drinking water resources are an important consideration here because the Town of Colonie (Latham water district) and the Village of Cohoes use raw water from the Mohawk River for their municipal drinking water. We also evaluate Na+ and Cl- in annual municipal drinking water reports from communities that use the Great Flats Aquifer, which has hydraulic connection to the Mohawk River (e.g., Allen and Weller, 1980).

Background. Dissolved ions in surface waters primarily include the cations sodium (Na+), potassium (K+), magnesium (Mg^{2+}), and calcium (Ca^{2+}); the anions chloride (Cl-), sulfate (SO_4^{2-}), fluoride (F-), nitrate (NO_3-), and phosphate (PO_3-); and carbonate species (HCO_3- , CO_3^{2-}). Salinity is a measure of the mass of dissolved cations and anions in water. For surface waters in the Mohawk watershed these dissolved ions are the sum of the mass fraction of the major cations (Na+, K+, Mg^{2+}, Ca^{2+},), major anions (Cl-, SO_4^{2-}), and carbonate species (HCO_3- , CO_3^{2-}).

Salinity is a function of charged ions, and thus electrical conductivity (EC) can be used to measure concentration of ions. EC is a measure of water's ability to conduct electrical flow, expressed in $\mu S\ cm^{-1}$ but in almost all applications it is corrected to 25°C because temperature affects conductivity, and it is then reported as specific conductance (SPC) (Duggan and Arnott, 2022). When normal rock salt (halite or NaCl) is used for deicing, the dominant ions are obviously sodium (Na+) and chloride (Cl-).

These ions have a variety of natural environmental and anthropogenic sources and sinks. In the Mohawk River, the major ions tend to be dominated by bicarbonate, calcium, chloride, and sodium, however the variability over a year is primarily attributed to changes in sodium and chloride. In the urban creeks that we have investigated, the major ions are chloride, sodium, and calcium, and high concentrations are especially apparent in the winter months, but chloride appears to dominate year round. We have focused our efforts on the Hans Groot Kill (Schenectady) and the Indian Kill (Glenville); both watersheds have relatively high road densities and aging infrastructure.

Methods. For electrical conductivity we use conductivity data from HRECOS, which maintains sites on the Mohawk River at Lock E8 (upriver from Schenectady) and Rexford (downriver from Schenectady). Electrical conductivity and temperature measurements from the Hans Groot Kill (urban stream in Schenectady) for 2022 were made every ten minutes with an in-stream HOBO Conductivity Logger (U24-001) that measures conductivity and temperature; from these data we calculate specific conductance (SPC) at 25°C. We evaluated sodium and chloride values reported in annual Water Quality (WQ) reports by municipalities that draw from the Great Flats Aquifer including Glenville, Scotia, Rotterdam, Rotterdam Junction, and Niskayuna (Schenectady has not reported Cl- since 2002, and was excluded). We also evaluated annual WQ reports from Cohoes and Colonie (Latham Water District), two municipalities that draw water directly from the Mohawk River. Here we review results for: (1) a local urban stream; (2) the Mohawk River; and (3) municipal water.

1) Hans Groot Kill: Conductivity in an urban stream. In the plot below (Figure 2) we show SPC for the Hans Groot Kill (HGK) in Schenectady and the SPC for the Mohawk River at Rexford (from HRECOS) for the winter (DJF) and early spring (MA) of 2021-22. Several things are apparent from this comparison. First, this small urban stream (HGK) has SPC values that are at least an order of magnitude higher than the Mohawk River. Second, it is apparent that SPC changes that occur in the Mohawk are related to contributions of salt-rich meltwater from tributaries such as the HGK. Third, the SPC for the HGK shows a distinctive winter pattern, with short periods of intensely salty water, and then after mid-March the pattern is again distinctive due to near-constant baseflow values of ~1500 to 1000 µS/cm that are interrupted by dramatically-lower values during precipitation events.

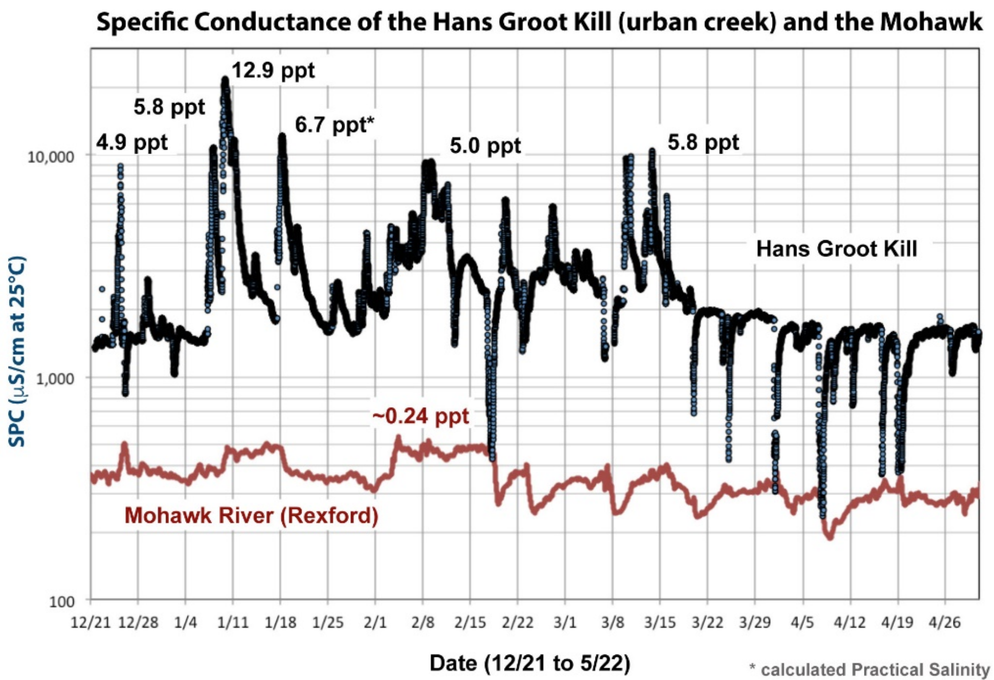

Figure 2: Specific Conductance of the Hans Groot Kill, a small urban creek in Schenectady (top), and the Mohawk River at Rexford (just downstream from the HGK-Mohawk confluence; bottom) for the winter and early spring of 2021-22. Peak salinity values are calculated practical salinity.

In the winter, the urban stream signal is dominated by runoff from melt events where road salt from urban streets enters the HGK (Figure 2), and this is partly because the HGK has been integrated into the stormwater handling system for the City of Schenectady. For peak salinity events, practical salinity has been calculated, and is shown above (maximum in this interval is 12.9 parts per thousand – ppt). Normal seawater is about 35-36 ppt, and thus in the winter the HGK is so salty that it has salinity values (calculated practical salinity) that are over 1/3 the salinity of typical seawater (12.9 ppt equals 12,900 ppm). The other intriguing component of this plot is the dramatic change that occurs in the early spring.

Sodium and chloride in surface waters. Most elevated SPC levels can be linked directly to Na+ and Cl- ions, which are mostly derived from road salt. Ion chromatography allows determination of solute loads in the Mohawk River and adjacent urban streams (Table 1). Because Na+ and Cl- co-vary nearly perfectly, we are confident that these ions are from halite, specifically road salt.

Table 1. Calcium, sodium, and chloride ion concentrations in surface water, Fall 2021.

	Mohawk (mixed)	Alplaus (rural)	Alplaus (semi-urban)	Indian (suburban)	Hans Groot (urban)
Calcium (ppm)	36.6	41.4	41.0	52.9	78.2
Sodium (ppm)	17.1	22.2	29.6	66.1	113.8
Chloride (ppm)	23.7	31.3	43.2	96.6	151.5
(Na+Cl):Ca	1.1	1.3	1.7	2.7	3.2
Samples (n)	29	19	16	25	15

Notes: Analyses are based on individual samples; averages are calculated from all individual sample values. Alplaus Kill is rural upstream from the Indian Kill, and then suburban or semi-rural, and the data clearly show this upstream vs. downstream difference. The samples for the Mohawk River were collected at four locations between Lock 8 and the Rexford Bridge (all in the Schenectady Pool). Samples were collected between 9/16/21 and 11/4/21 (SON).

Through an analysis of SPC and Cl- from USGS-monitored streams in the Mid-Atlantic and New England, Moore et al. (2019) demonstrate that elevated chloride concentrations are directly related to the use of deicing salts in the winter. In addition, streams in areas with high impervious surface cover (i.e., urban areas) exceed the EPA criterion for acute chloride toxicity in surface waters more frequently than do streams in more rural areas (Moore et al., 2019). According to the EPA, chronic chloride toxicity occurs at levels at or greater than 230 mg/l (4-day average) and acute chloride toxicity occurs at 860 mg/l (1-hr average); by these criteria, the HGK experiences acute toxicity for most of the winter, and chronic toxicity for the rest of the year.

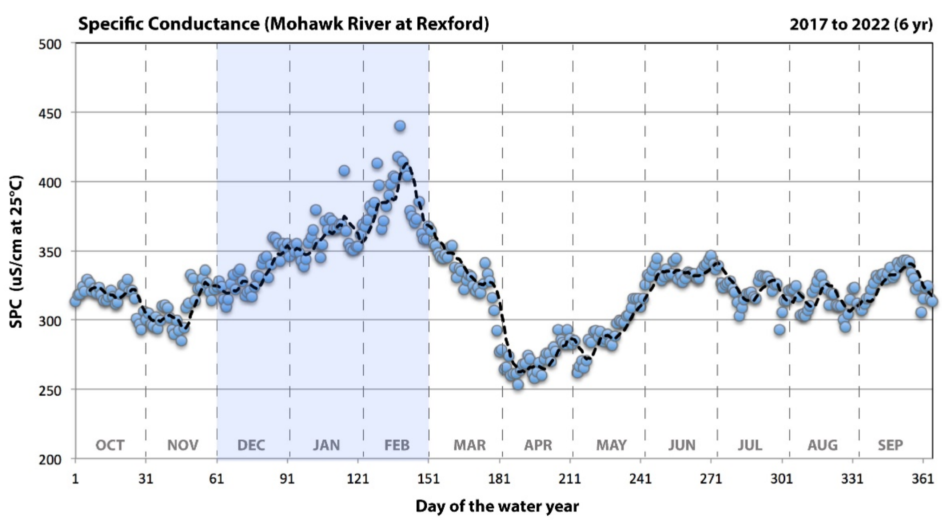

Figure 3: Specific conductance (SPC) measured in the Schenectady Pool at the Rexford HRECOS site, upstream from Vischer Ferry Dam but downstream from Schenectady. The highest values occur in February and the lowest in early April. January and February have some days with extraordinarily high values, presumably due to an influx of meltwater with high concentrations of road salt. Black dashed line is a seven-day moving average. Winter (DJF) shaded.

2) Mohawk: Specific conductance (SPC) in the Schenectady Pool. To determine annual variability of SPC in the Mohawk River (Figure 3), we used the Hudson River Environmental Conditions Observing System (HRECOS) data for 2017 to 2022, which are collected every 15 minutes, and thus constitute a large data set (~210k observations). We are primarily interested in using these data to give a synoptic view of SPC over a typical year, with particular focus on the winter months (DJF). We determined the mean daily SPC for each day of the year (DOY) since inception of this node of the HRECOS system (2017 to the present). We then averaged each DOY value (generally six years, but some DOY have missing values), and the results are shown below (plotted as DOY of the water year, which starts on 1 October).

When we look at specific winter values of SPC for the Mohawk (Figure 3) and adjacent urban streams we see that urban streams deliver pulses of salty water associated with thawing of roadways and winter rain events (here "meltwater") that have been treated with road salt. The lowest SPC values on this part of the Mohawk are in April, which coincides with peak annual discharge on the Mohawk, and thus the winter salts appear to have maximum dilution. Summer (JJA) and fall (SON) have moderate values.

3) Salinization of drinking water. Increasing chloride levels in the Mohawk River are undoubtedly a challenge for communities that use river water as raw water for municipal needs (Colonie and Cohoes). Additionally, regional salinization has almost certainly impaired hydrologically-connected aquifers tapped for municipal use (Rotterdam Junction, Glenville, Scotia, Schenectady, Rotterdam, and Niskayuna). High chloride (Cl-) concentrations in surface waters are problematic for communities that rely on contaminated surface waters for municipal water because it is difficult to remediate. Chloride is highly soluble and is difficult to remove by natural physicochemical processes: it does not volatilize, precipitate, or absorb onto mineral surfaces (Lax et al., 2017). Thus if chloride concentrations increase in the river, it also increases in the municipal water supply derived from river water.

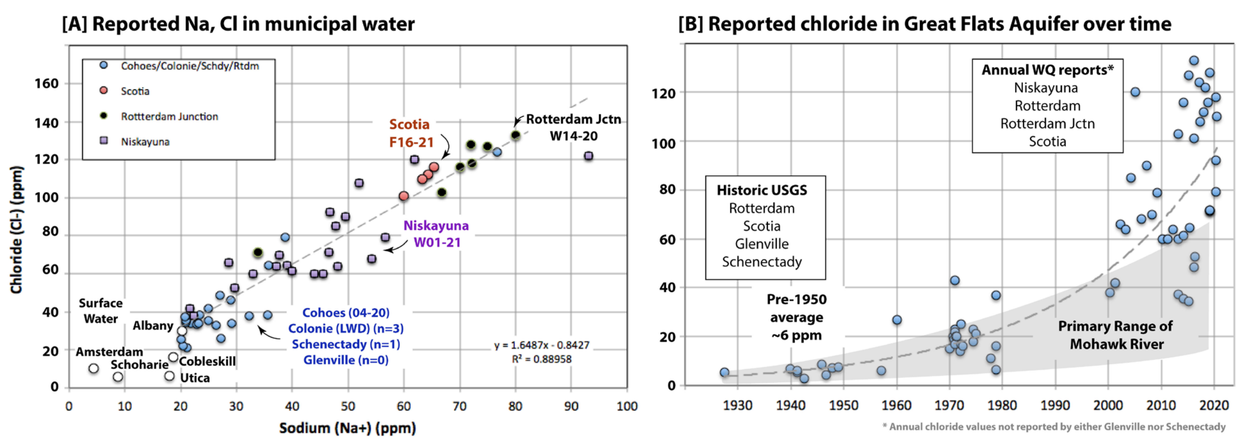

Figure 4. The occurrence of sodium and chloride in municipal drinking water sources in the lower Mohawk Watershed. [A] The relationship between Na+ and Cl- in reported municipal water (from annual water quality reports, which have variable reporting and completeness). For comparison are a single year from Albany, Amsterdam, Utica, Schoharie, and Cobleskill, all of which have surface water reservoirs. [B] Change in chloride as documented by the USGS or as reported by local municipalities that draw water from the Great Flats Aquifer (data source indicated on plot - the range of the Mohawk River is from USGS data, see analysis in Garver, 2020). The last two decades of high chloride values may indicate groundwater contamination.

The salinization of our watersheds has a profound impact on ecosystem services and we should be seeking solutions to this chronic and widespread problem that affects regional water quality. A major issue is the impairment of drinking water. Local municipalities that use the Mohawk River as a raw water source and those that use connected aquifers report relatively high and increasing sodium and chloride levels in their water. The reported WQ values strongly suggest that the Great Fats Aquifer is contaminated with road salt. Elevated sodium can be problemmatic for individuals on a severely restricted sodium diet. High chloride levels can cause corrosion in water distribution systems that can lead to elevated lead (Pb) and copper (Cu) in tap water (Stets et al., 2018). In 2022 the Village of Scotia reported several homes with elevated lead (Pb) levels, and initiated a corrosion-control study. Without addressing the core problem of salt storage and overuse in deicing, our drinking water sources may experience continued degradation.

References

Allen, R.V. and Waller, R.M., 1981. Considerations for monitoring water quality of the Schenectady aquifer, Schenectady County, New York (No. 80-103). US Geological Survey,.

Garver, JI. 2020, Road Salt: Heavy salt application on roads is damaging the Watershed, In *Notes from a Watershed* (Newsletter). Mohawk.substack.com

Godwin, K.S., Hafner, S.D. and Buff, M.F., 2003. Long-term trends in sodium and chloride in the Mohawk River, New York: the effect of fifty years of road-salt application. Environmental pollution, 124(2), pp.273-281.

Kaushal, S.S., Groffman, P.M., Likens, G.E., Belt, K.T., Stack, W.P., Kelly, V.R., Band, L.E. and Fisher, G.T., 2005. Increased salinization of fresh water in the northeastern United States. Proceedings of the National Academy of Sciences, 102(38), pp.13517-13520.

Kaushal, S.S., Likens, G.E., Pace, M.L., Utz, R.M., Haq, S., Gorman, J. and Grese, M., 2018. Freshwater salinization syndrome on a continental scale. Proceedings of the National Academy of Sciences, 115(4), pp.E574-E583.

Kaushal, S.S., Reimer, J.E., Mayer, P.M., Shatkay, R.R., Maas, C.M., Nguyen, W.D., Boger, W.L., Yaculak, A.M., Doody, T.R., Pennino, M.J. and Bailey, N.W., 2022. Freshwater salinization syndrome alters retention and release of chemical cocktails along flowpaths: From stormwater management to urban streams. Freshwater Science, 41(3), pp.420-441.

Kelly, V.R., Findlay, S.E., Hamilton, S.K., Lovett, G.M. and Weathers, K.C., 2019. Seasonal and long-term dynamics in stream water sodium chloride concentrations and the effectiveness of road salt best management practices. Water, Air, & Soil Pollution, 230(1), pp.1-9.

Lax, S.M., Peterson, E.W. and Van der Hoven, S.J., 2017. Stream chloride concentrations as a function of land use: a comparison of an agricultural watershed to an urban agricultural watershed. Environmental Earth Sciences, 76(20), pp.1-12.

Moore, J., Fanelli, R.M. and Sekellick, A.J., 2019. High-frequency data reveal deicing salts drive elevated specific conductance and chloride along with pervasive and frequent exceedances of the US Environmental Protection Agency aquatic life criteria for chloride in urban streams. Environmental science & technology, 54(2), pp.778-789.

Stets, E.G., Lee, C.J., Lytle, D.A. and Schock, M.R., 2018. Increasing chloride in rivers of the conterminous US and linkages to potential corrosivity and lead action level exceedances in drinking water. Science of the Total Environment, 613, pp.1498-1509.

Extreme precipitation and sewage overflows are driving an emerging health crisis: a case study from Schenectady, NY

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Increases in annual precipitation and extreme rainfall events in the Northeast are overwhelming aging stormwater and sanitary sewers systems, which is leading to a public health crisis. The increases in precipitation and extreme events in the Northeast are most pronounced in the last two decades. Since 1895, nine of the top 15 annual precipitation totals in Albany NY have occurred since 2000 (22 yr), and all (15/15) have occurred since 1972. Studies have shown that there has been a ~50% increase in intense or extreme precipitation in the Northeast in the past 20 years (Huang et al., 2017) and much of that increase has been in summer months (see Plummer and Garver, this issue). Moreover, a significant number of events are related to extratropical storms (Howarth et al., 2019).

The Quantitative Precipitation Forecasting (QPF) at the National Weather Service (NWS) is partly focussed on rainfall probability estimates in the context of annual exceedance probability based on a long record (70-100 yr) of stations in the NE, and these estimates assume stationarity in the record. Stationarity in a time series implies that the mean and variance do not change over time, but this may well be incorrect for precipitation in the Mohawk watershed, including extreme precipitation. If recent findings of increases in extreme events in the Northeast are correct, then the assumption of stationarity in the rainfall record is incorrect and those exceedance probabilities *underestimate* the actual probability of extreme event frequency and magnitude. If the tempo and pace of extreme rainfall is increasing (i.e., non-linear), the record of rainfall events 50 or 100 years ago is not relevant to understanding where we are today, and, more importantly, where we may be in the next few decades. This observation has major implications for both wastewater and stormwater management.

FIB in the Hans Groot Kill. Our research group at Union has been monitoring and measuring Fecal Indicator Bacteria (FIB) in the Hans Groot Kill (HGK or "College Creek") since 2019 and those measurements continued through the spring of 2022. Between 2019 and 2020 we analyzed 255 samples from seven sites along the HGK for *Enterococcus*[1] (Willard-Bauer et al., 2020). *Enterococcus* has a chlorine resistance that makes it useful for forensic analysis in urban creeks with high levels of chloride, which is the case of the HGK where salinity can reach as high as 1/3 that of seawater. In fact the salinity in this urban creek is so high that we suspect that *Enterococcus* is the only reliable FIB indicator in this setting. Many bacteria are neutralized by chlorine, but a concern is that there are a number of pathogens that have a resistance to chlorine (ie. *cryptosporidium*, *giardia,* and others).

In 2019-20, we focussed on six sampling sites along the length of the HGK and one outfall (a pipe emptying into the HGK). The geometric means of *Enterococcus* range between 510 and 1002 MPN/100 ml for the six sites in the creek channel (Figure 1) and 2250 MPN/100 ml from the outfall; values increased upstream to the east edge of the GE Realty Plot.

In the fall of 2021 we focussed on our sentinel HGK site (HGK-2), located in Jackson's Gardens on the Union campus, and we sampled it 32 times from mid-September to late November; this was a particularly wet fall. The overall minimum geometric mean was 2954 mpn/100 ml, and 100% of the samples failed the EPA Beach Action Value (BAV). But as can be seen in the plot of the data (Figure 2), there appears

[1] *ASTM Method (#D6503-99) approved by the EPA that was done using dilutions with Enterolert in Quanti-tray/2000 with the IDEXX system. Incubation at 41°C for 24 hr.*

to be a discreet difference between high flow (sampled during or within recent rainfall), and low flow. This pattern may indicate spilling above a certain threshold from sanitary sewers to stormwater sewers, perhaps a relict from when Schenectady had Combined Sewer Overflows (CSOs).

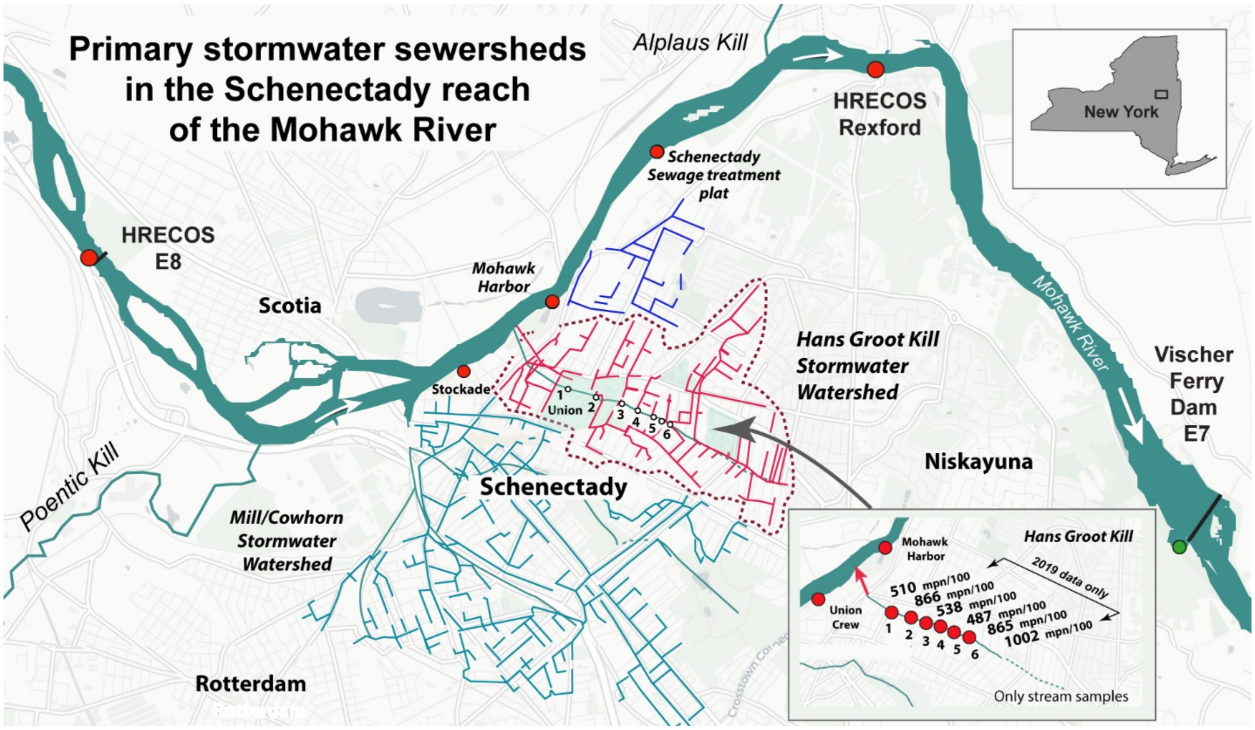

Figure 1: Map showing primary stormwater sewersheds in the Schenectady Pool on the Mohawk River. Of the urban streams that we have sampled, the Hans Groot Kill shows significant impairment. The HGK is contained in an underground stormwater drainage network except where it daylights on the grounds of Union College and to the east in the GE Realty Plot. Inset shows the geometric means of six sample sites of the HGK up to 2019 (and not shown is an outfall, near site 5 on this map). Data from Riverkeeper and partners show that the Mohawk Harbor site has the lowest water quality in this section of the Mohawk River (see Law et al., this volume, and Riverkeeper.org).

In the winter and spring of 2022 we continued sampling at HGK-2 on campus and analyzed the creek 16 additional times. Thus we have analyzed surface water for *Enterococcus* from the HGK 306 times over the last three years, and it has a failure rate of nearly 100%. This creek empties into the Mohawk just upstream from the Mohawk Harbor, one place with significant recreational contact with surface waters.

While recreational contact with the HGK does occur in a limited way, a concern is that the high pathogen levels indicate a broader problem with our wastewater infrastructure that may be also affecting drinking water. Problems may be related to infiltration-exfiltration between sanitary and stormwater sewers, especially during interruptions in service and low water pressure (see discussion in Garver, 2020). In the fall of 2020, ~30 students at Union College were sickened by gastroenteritis, and in several students the presence of *Giardiasis* was confirmed. A similar but larger outbreak occurred in the Fall of 2021, when 70-100 students were sickened with gastroenteritis; the epidemiology of this outbreak is unresolved. No specific pathogen has been identified, but the outbreak coincides with a sewage overflow on campus (see Garver, 2022).

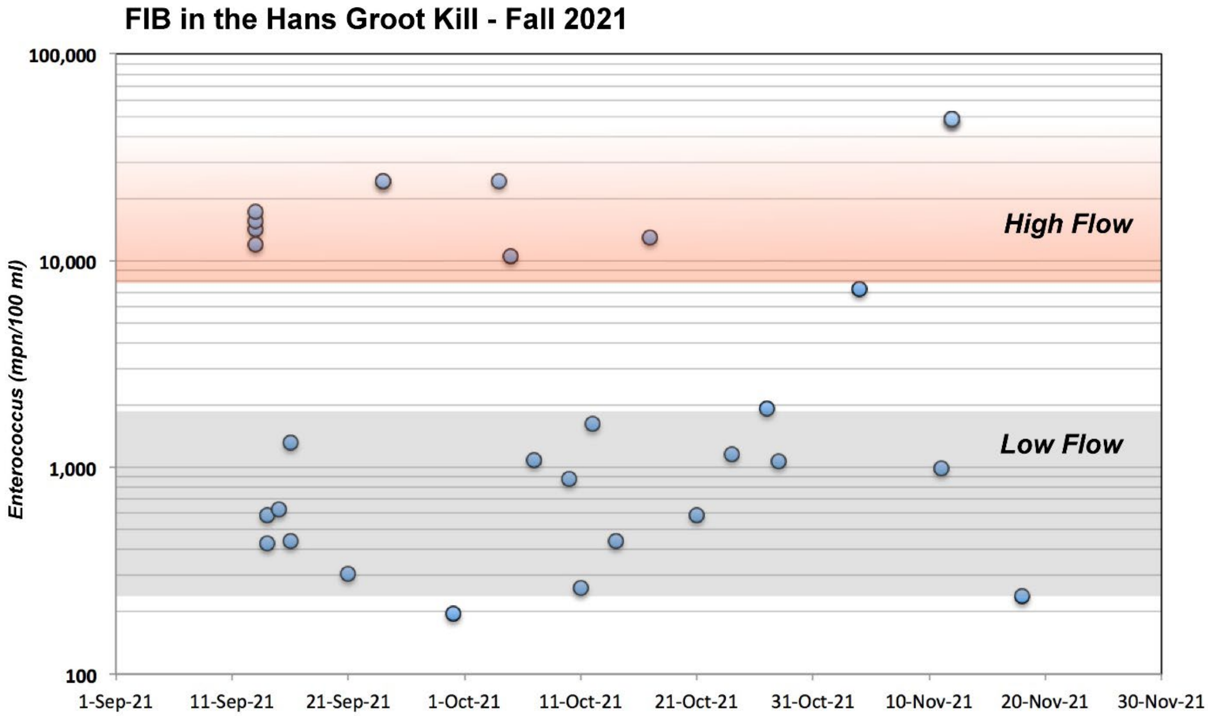

Figure 2: Measured FIB levels at the sentinel site (HGK-2) in Jackson's Garden on the Union College campus. A subtle but potentially important finding from these data is the apparent gap in contaminant levels between low-flow and high-flow samples. The gap may indicate that overwhelmed sanitary sewers reach a threshold, and then directly spill into stormwater sewers. This result may mean that the CSO to MS4 transition was not complete.

Extreme precipitation and sewage. A subtle but important emerging concern is how our wastewater systems handle extreme precipitation. Significant precipitation events overwhelm stormwater sewer systems, which may end up carrying direct or indirect sewage overflows. While the damage to our waterways from CSOs are relatively well recognized, a looming threat also exists from aged pipes that constantly and chronically leak and effectively act as CSOs during extreme events. Our work on the HGK shows that aging sanitary sewers directly impact water quality even where storm sewers are supposed to be separate from the sanitary system (Schenectady has a municipal separate stormwater sewer system or MS4).

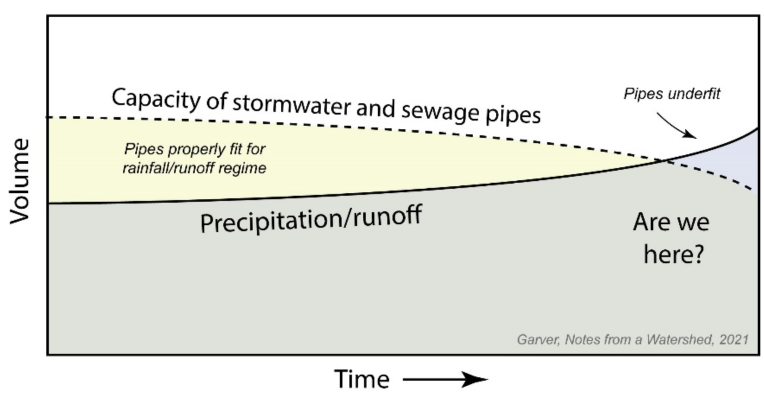

Figure 3: Cartoon showing the possible reduction in capacity of stormwater and sanitary sewer pipes due to age, and the increase in precipitation that may now have surpassed pipe capacity (from Garver, 2021).

The FIB in this impaired urban stream almost certainly reveals sewage exfiltration and direct leaks from aging sanitary sewers. Pathogen loads in stormwater during high-flow events are at least an of magnitude greater than acceptable criteria. This sewage ends up in our waterways, including the Mohawk River, where it diminishes water quality and increases nutrient availability that can drive Harmful Algal Blooms (HABs). This decline in water quality is a public health concern for those who come in conatct with this surface water and also for communities downriver that use the Mohawk River as a primary drinking water source (i.e. Colonie and Cohoes). Our aging infrastructure appears to be underfit to handle the increase in precipitation and extreme events, and thus without direct intervention we are facing a public health crisis due to rising levels of sewage in our waterways and possible cross contamination.

References cited

Garver, JI, 2020, "Giardia outbreak in the Mohawk Watershed: Thirty-two students at Union College diagnosed", in *Notes from a Watershed* at Mohawk.substack.com

Garver, JI, 2021 "Extreme Rainfall in the Northeast" in *Notes from a Watershed* at Mohawk.substack.com.

Garver, JI, 2022. Extreme precipitation and sewage overflows are an emerging health crisis: A case study from Schenectady NY. NY State floodplain and Stormwater Managers Assoc. & NY Water Env. Assoc. Ann. mtg. Schenectady NY, 2022.

Howarth, M.E., Thorncroft, C.D. and Bosart, L.F., 2019. Changes in extreme precipitation in the northeast United States: 1979–2014. *Journal of Hydrometeorology*, *20*(4), pp.673-689.

Huang, H., Winter, J.M., Osterberg, E.C., Horton, R.M. and Beckage, B., 2017. Total and extreme precipitation changes over the Northeastern United States. Journal of Hydrometeorology, 18(6), pp.1783-1798

Willard-Bauer, E., Smith, J.A., Garver, J.I., Goldman, D., Newcomer, B. 2020. *Enterococci* levels in the Hans Groot Kill and Mohawk River, Schenectady, NY. In: Garver, J.I., Smith, J.A., and Rodak, C. 2020, Proceedings of the 2020 Mohawk Watershed Symposium, Union College, Schenectady, NY, March 20, 2020, p. 63-68.

Wright, J., 2022. Sewage and pathogen contamination in urban streams in Schenectady in the lower Mohawk Watershed. Unpublished BSc Thesis, Geosciences, Union College, Schenectady NY, 63 p.

Invasive Round Goby in the Mohawk and Hudson Rivers: What's the latest?

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The Round Goby (*Neogobius melanostomus*) is an invasive benthic fish indigenous to the Ponto-Caspian region of Eurasia. It recently colonized the Great Lakes and has expanded eastward through the New York State Canal System over the past decade. The species was first documented in the Mohawk River watershed in 2014 and was found in the Hudson River in 2021. Round Goby can adversely affect aquatic ecosystems in many ways such as outcompeting native benthic fishes, consuming the eggs of nest-building species such as Smallmouth Bass (*Micropterus dolomieu*), and transferring contaminants to higher trophic levels (e.g., desirable gamefish). They can also carry the viral hemorrhagic septicemia (VHS) virus which has been linked to fish kills in New York and some evidence suggests Round Goby are an important vector in avian botulism outbreaks. However, the presence of Round Goby has also been linked to faster growth rate and larger maximum size of some predators such as Smallmouth Bass.

Comprehensive studies in the Mohawk River-Eastern Erie Canal system (2016-present), Hudson River estuary (2021-present), and upper Hudson River-Champlain Canal system (2022-present) have yielded valuable information about distribution, rates of expansion, and to a lesser extent, ecological impact of Round Goby (Figure 1). These studies have paired traditional sampling techniques such as benthic trawling, backpack electrofishing, and near-shore seining with the novel technique of environmental DNA (eDNA). Environmental DNA is a powerful, relatively new method that relies on the detection of DNA shed by organisms to make inferences about the distribution and even abundance of species.

Findings to date indicate the eastward expansion of Round Goby downstream through the Mohawk River and associated sections of the Eastern Erie Canal initially proceeded slowly between 2014 and 2019, but then appeared to accelerate during 2020 to 2021 once the species reached the eastern half of the river (George and others, 2021; U.S. Geological Survey, 2023). Current data suggest Round Goby populations are patchy but widespread throughout the Mohawk River. High densities were observed in 2022 near the mouth of the Mohawk River around Peebles Island and at the confluence of Schoharie Creek and the Mohawk River. In the Hudson River estuary, Round Goby were first captured in 2021 and current data indicate the species is present at least as far downstream as the Newburgh area but remains uncommon in this habitat type (U.S. Geological Survey, 2023). The establishment of Round Goby in the tidal Hudson River will result in numerous novel ecological interactions with important migratory and marine species such as American Eel (*Anguilla rostrata*), Striped Bass (*Morone saxatilis*), and Blue Crab (*Callinectes sapidus*), as well as sturgeon and herring species (Pendleton and others, 2022). These interactions are largely undocumented elsewhere in North America and will be important areas of future research. In the upper Hudson River-Champlain Canal system, Round Goby have been captured as far north as the Lock C1 dam near Waterford (George and others, 2022). Results from the Champlain Canal surveys are being used to inform operation of the New York State Canal System in accordance with the Interim Rapid Response Plan for Round Goby (NYPA and NYSDEC, 2022).

Together, these results suggest that since being found in the Hudson River in 2021, Round Goby have expanded downstream rapidly through at least 140 km of the Hudson River estuary but have only moved upstream approximately 5 km towards Lake Champlain. This finding is consistent with other studies indicating that rates of downstream expansion for Round Goby can be rapid and often exceed 20 km/year (Corkum and others, 2004; Merry and others, 2018) compared to rates of upstream expansion which are typically slower and have been observed at 0.5 to 4 km/year in other areas (Bronnenhuber and others, 2011; Kornis and others, 2012; Šlapanský and others, 2017).

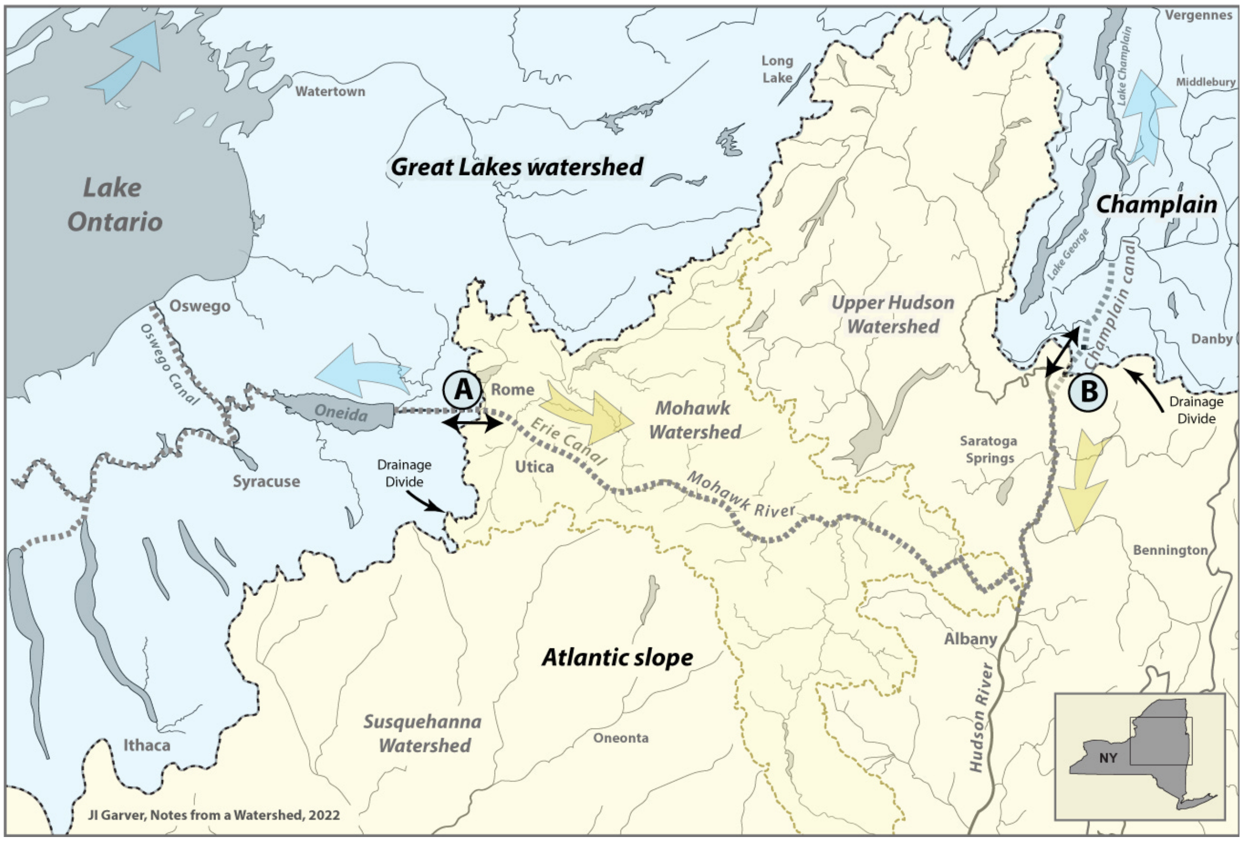

Figure 1: From Garver, J., (2022), *Aquatic pathway between the Mohawk and Lake Champlain. Notes from a Watershed - The Mohawk River*. Arrows indicate the general direction of natural flow of water in each watershed. "A" marks the watershed divide on the Erie Canal at Rome, and "B" marks the watershed divide on the Champlain Canal.

Continued research in 2023 will focus on assessing ecological impact and changes in distribution of Round Goby, testing for the VHS virus, and conducting salinity trials. Specific efforts will include conducting quantitative fish-community surveys on tributaries to the Mohawk River to determine the extent to which Round Goby have colonized this habitat type, using eDNA and seining in the Hudson River estuary to assess changes in abundance and distribution, and performing eDNA and traditional sampling in the upper Hudson River to determine if Round Goby have moved upstream of the Lock C1 dam on the Champlain Canal. The information gained from these concurrent efforts will help us better understand the invasion dynamics of Round Goby and can inform projections of potential expansion rates, habitat suitability, and ecological impacts in other uncolonized watersheds of the northeastern United States.

References

Bronnenhuber, J.E., Dufour, B.A., Higgs, D.M., and Heath, D.D., 2011, Dispersal strategies, secondary range expansion and invasion genetics of the nonindigenous round goby, *Neogobius melanostomus*, in Great Lakes tributaries: Molecular ecology, v. 20, no. 9, p. 1845-1859.

Corkum, L.D., Sapota, M.R., and Skora, K.E., 2004, The round goby, *Neogobius melanostomus,* a fish invader on both sides of the Atlantic Ocean: Biological invasions, v. 6, no. 2, p. 173-181.

Garver, J., 2022, Aquatic pathway between the Mohawk and Lake Champlain, Notes from a Watershed - The Mohawk River.

George, S.D., Baldigo, B.P., Rees, C.B., Bartron, M.L., and Winterhalter, D., 2021, Eastward Expansion of Round Goby in New York: Assessment of Detection Methods and Current Range: Transactions of the American Fisheries Society, v. 150, no. 2, p. 258-273.

George, S.D., Rees, C.B., Bartron, M.L., Atkins, L.M., and Baldigo, B.P., 2022, Environmental DNA data for Round Goby from the Champlain Canal (ver. 4.0, November 2022), U.S. Geological Survey data release. https://doi.org/10.5066/P9ZCMH8S.

Kornis, M., Mercado ‐ Silva, N., and Vander Zanden, M., 2012, Twenty years of invasion: a review of round goby *Neogobius melanostomus* biology, spread and ecological implications: Journal of Fish Biology, v. 80, no. 2, p. 235-285.

Merry, J.L., Fritts, M.W., Bloomfield, N.C., and Credico, J., 2018, Invasive Round Goby (*Neogobius melanostomus*) nearing the Mississippi River: The American Midland Naturalist, v. 180, no. 2, p. 290-297.

NYPA, and NYSDEC, 2022, Mitigating the spread of the invasive round goby: Interim rapid response plan for the Champlain Canal System in New York State, New York Power Authority, New York State Department of Environmental Conservation, p. 21.

Pendleton, R., Berdan, R., George, S., Kenney, G., and Sethi, S.A., 2022, Round Goby Captured in a North American estuary: Status and implications in the Hudson River: Journal of Fish and Wildlife Management, v. 13, no. 2, p. 524-533.

Šlapanský, L., Janáč, M., Kevin, R., Libor, M., and Pavel, J., 2017, Expansion of round gobies in a non-navigable river system: Limnologica, v. 67, p. 27-36.

U.S. Geological Survey, 2023, Specimen observation data for *Neogobius melanostomus* (Pallas, 1814), Nonindigenous Aquatic Species Database, https://nas.er.usgs.gov/queries/collectioninfo.aspx?SpeciesID=713.

Pervious concrete offers a potential solution to contaminated runoff threatening surface water quality

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Water quality in streams, lakes, and rivers is greatly impacted by the runoff that ultimately pours into these water bodies following a rainstorm. The top surfaces of roads and parking lots are oftentimes contaminated with oil drippings and other chemicals from cars, busses, and trucks that use these facilities. De-icing agents or salts used to prevent the skidding of vehicles trafficking roads and highways could also be a significant source of water contamination. All these contaminants are washed off pavement surfaces with rainstorms and become part of runoff that ends up in water bodies. This has the potential of compromising the quality of water and negatively impacting its chemical characteristics.

There is no full solution to this problem as preventing runoff from reaching water bodies is almost impossible. A partial and effective solution to this problem can be achieved if the quantity of contaminant-bearing runoff is reduced. The reduction in runoff volume can be achieved if a portion of the storm water is channeled down to the soil constituting the foundation supporting roads and parking lots where rain falls. This can be realized if the solid surfaces of asphalt or concrete used in paving roads and parking lots are replaced with a pervious material that allows the storm water to percolate through the pavement to the underlying soil, which has the potential to reduce, and could possibly eliminate, the runoff entirely.

Pervious concrete is a material made with the same ingredients conventional concrete is made of, namely coarse aggregates, sand, cement, and water, but it has an open-grade structure. This is similar to a honeycomb configuration where there are voids between the solid components of the matrix. In addition to reducing the volume of runoff of contaminated water, pervious concrete help rejuvenate underlying soil stratum, charge underground aquifers, accelerate the hydrological cycle, allow for the natural purification of contaminated water, reduce the dependency on drainage accessories and retention pools, and lessen the heat island effect that results from high concentration of areas paved with impervious surfaces. Furthermore, the pockets of air voids within pervious concrete structure provide a medium for aerobic bacteria to reside where it can naturally break down many of the pollutants carried off the surface by storm water, thus further degrading contaminants. This presentation will detail the benefits of pervious concrete, and the advantages that can be gained by improving water quality through the reduction of polluted runoff volume.

The swinging environmental pendulum: how policies and attitudes shift with changes in the US administration

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In the American system of government, the members of the House of Representatives are elected every two years, the members of the Senate are elected every six years, and the President is elected every four years. With every election cycle, and with every change in the parties holding power in the House, the Senate, and the White House, a shift in policies and attitudes toward the environment can be effortlessly noticed. In almost all situations, the declared goal of any change in policy is to preserve a cleaner and sustainable environment and to spur economic growth. In many instances, these two goals collide and decisions must be made as to which goal will get preference and take precedent over the other. A few recent examples of decisions that were made by certain administrations and were significantly altered or even reversed by succeeding ones are: the Paris climate agreement, Keystone XL pipeline, oil and gas drilling in federal land, logging in federal land, oil shale, gas flaring, outer continental shelf drilling, nuclear energy, oil exploration in the Arctic National Wildlife Refuge (ANWR), water quality standards, gas mileage standards, pollution and carbon emission standards, strip mining, coal mining, liquefied coal, carbon sequestration, solar and wind energy targets, and an assortment of rules regarding a variety of environmental regulations related to issues such as acid deposition, ozone depletion, hazardous waste, pesticides, bio fuels, noise levels, ocean dumping, and risk control. The above list is by no means exhaustive but it includes the majority of areas of interest to the American public. There are items in this list that touch people in their daily living such as the quality of air and water, two fundamentally basic ingredients of life.

The reasons for the change in a certain policy from one administration to another could be numerous and some of these reasons could be undoubtedly valid. It is counter-productive to attempt to examine why certain laws have been enacted the way they were written. It is much more important to debate environmental issues on the merit and pass laws with the policies that truly contribute to both a better environment and a stronger economic growth. It is also important to realize that when the pendulum of environmental regulations swings too far in one direction, this makes it very likely that it will be just a matter of time before it swings in the opposite direction. This presentation will offer a deep insight into several of the issues listed above and detail the pros and cons in an objective manner. It will make a serious effort to eliminate subjective bias that is usually associated with party affiliation to present a point of view that is as neutral and as ethical as possible. There is no guarantee that this approach will please everyone but it will certainly have the betterment of the environment and a sustainable future as its undisputed core value.

Blocking invasive species in the New York State canal system: The barriers to barriers

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Twenty years ago, recognizing the grave threat to New York State posed by invasive species, the legislature and the Governor passed a law creating an Invasive Species Task Force. The Task Force issued its final report in 2005, and made the following point about the New York canal system:

> "The New York State Canal System offers one example of how transportation networks can facilitate invasions. Since their beginnings in the early nineteenth century, the Erie and other canals connected aquatic ecosystems that had been isolated since the last glaciers more than 10,000 years ago. The locks that enabled the exchange of barges and goods across North America also enabled the exchange of species. The Great Lakes and Finger Lakes, the Hudson River and Mohawk River, and Lake Champlain all became one interconnected ecosystem."

The state Canal Corporation, which by law oversees the operation of the state canal system, participated in that Task Force. Despite the scientific and common-sense certainty that the canal system provides a pathway for the spread of aquatic invasive species (AIS), since that time no significant action has been taken to block AIS from moving along the canal system.

In 2019, the prospect of using barriers to prevent the further spread of AIS in the canal system arose when Governor Cuomo convened another task force, this time to consider the need to 'reimagine' the canal system. That initiative was prompted by the New York Power Authority (NYPA) – which is fiscally responsible for the canal system – realizing that a staggering amount of money was going into maintaining a system designed for purposes that no longer existed. Despite the near absolute loss of 'through navigation,' i.e., commercial traffic traveling the length of the system, the canal system was being maintained as if it were still the early 1900's, at an enormous cost. Accordingly, a group of experts from a variety of fields and organizations were asked to consider how the canal system could best serve the future and not the past. In theory, this was to be an objective review, without the historic political protectionism that deterred previous efforts aimed at most effectively using the canal infrastructure, consistent with modern times. One of the items on the Reimagine agenda was addressing the continuing spread of AIS via the canals.

To address that question, the Reimagine Task Force retained R2 Resource Consultants, a national expert in invasive species management. R2 convened scientists, NYS Department of Environmental Conservation (DEC) and Canal Corporation staff, academic institutions, and other stakeholders, to comprehensively look at the opportunities to deter the movement of invasives through the canal system. It its final report R2 concluded that the most effective alternative was "Watershed Divide" which would physically disconnect the watersheds that had been unnaturally connected by the canal system. Among other things, that option called for: (a) hydrologic separation (i.e., a barrier) at Rochester to protect the Finger Lakes and Oneida Canal from invasive species coming from the west; and (b) hydrologic separation at Rome to protect the Mohawk and Hudson River Estuaries from threats west of Rome.

At the same time R2 was performing its work for the Reimagine Task Force, another study involving invasive species was moving forward on the Champlain Canal portion of the system. There, the Army Corps of Engineers (ACOE) was dedicating its resources and expertise to select a feasible barrier to prevent AIS from moving between the Hudson River and Lake Champlain via the Champlain Canal. That study was pending for more than 15 years, and is, as might be expected from the ACOE, extremely comprehensive and detailed. A final report was issued in March 2022, and the ACOE concluded that the best solution is a "Physical Barrier Plan." The report found that a physical barrier was the most effective method to prevent the movement of AIS, as well as the most cost-effective solution, and would provide for continuing the most vessel traffic along the canal. That, of course, echoes R2's independent work on the other side of the canal system – in both cases, after comprehensively studying the options, the conclusion was reached that the connections people had built between naturally disconnected waterways should be removed, restoring the separation provided by nature. Participants in the ACOE study included (again) the Canal Corporation, DEC, the Lake Champlain Basin Program, Vermont Natural Resource Agency, and many others.

Once again, despite the completion of science-based, objective, and comprehensive studies, action to address the issue was not taken. External events created opportunity for change, however, when a non-native, destructive fish called the round goby was found in the Hudson River in the summer of 2021. The round goby is a small, aggressive fish that takes over habitat, eats the eggs and young of other fish, is a prolific breeder, can live in poor water quality, steals bait making it hard for anglers to catch other species, and has been linked to the spread of avian botulism. There is no known way of controlling the population once it has entered a waterway.

The round goby is thought to have been introduced via ballast water into the Great Lakes in the 1990s. It has steadily traveled via the canal across New York State, finally reaching the Hudson River where it was detected just south of the Troy Dam. DEC, NYPA and the Canal Corporation have admitted that "continued downstream expansion into the entire tidal length of the Hudson River is inevitable" which is bad news for the Hudson River and all the communities that rely upon it.

In fact, the round goby has been considered a threat to the Mohawk and Hudson Rivers, and Lake Champlain since it initially appeared in the Great Lakes. Incredibly, the movement of the round goby has been monitored for years as it crossed the state via the canal system, but despite clear warnings no action was taken by the Canal Corporation to prevent it from entering the Hudson River. Seeing an opportunity to prevent the further spread of this species and knowing that if history were a guide the Canal Corporation would not act on its own, prior to the start of the 2022 canal season The Nature Conservancy began a public information initiative to spread the word about the round goby threat to Lake Champlain. It was too late for the Hudson River, but not too late for Lake Champlain. In the absence of action, we would once again be looking backward at a lost opportunity to prevent irreversible harm to an important natural resource, as well as the economies of Lake Champlain communities.

The Conservancy reached out to government agencies, stakeholders, and public officials, suggesting that on an interim basis a lock on the Champlain Canal temporarily be closed to physically prevent the round goby from getting from the Hudson River to Lake Champlain. While that would inconvenience a very small number of boaters, pending a permanent plan it was the surest way to stop the movement of the round goby. It took a significant amount of effort to get the attention of public officials in New York and Vermont, elevate the issue in the media, and engage other stakeholders to weigh in. Eventually, in response to the public pressure, DEC, NYPA and the Canal Corporation adopted an "Interim Rapid Response Plan" which included, among other things, a commitment to alter canal operations including lock closure. Given the historic resistance of the Canal Corporation to modify canal operations to address the spread of AIS – including the obstacles the Conservancy encountered as it tried to address the threat to Lake Champlain -- this is a significant development. While this action is less prudent than a temporary lock closure, it is a positive step and sets a precedent for consideration of barriers.

Given the documented harm of AIS, and the undisputed use of the canal system as a "superhighway" by AIS, why has it taken so long to get just an acknowledgment that AIS barriers might be considered?

Based on my experience as a member of the Reimagine Task Force, as well as overseeing the initiative to address the round goby spreading into Lake Champlain, these are some of the key barriers to barriers:

- In connection with the Reimagine deliberations the Canal Corporation absolutely opposed any actions that would impact through navigation. They were considered 'off the table.' While the potential for barriers described in the Interim Response Plan is a step forward, an institutional mandate that subordinates everything to maintaining through navigation will make it difficult to objectively consider barrier-based solutions.

- It is often difficult for government to proactively address issues, and it is particularly hard where there are vocal constituencies that will be impacted. In this case, there is a passionate group of people dedicated to preserving the canal system 'as is' but no corresponding constituency advocating for the prevention of AIS spreading through the system. While there are plenty of organizations, academic institutions, and others working on the impacts of AIS, they do not have the same type of focused political presence.

- Related is that the argument for barriers is based on preventing a prospective threat, which opens the door for gross mischaracterization. Despite the overwhelming evidence of the need for barriers, including the two recent expert reports concluding barriers are the best option, the supporters of the status quo persist in asserting that calling for barriers is 'alarmist.'

- There has not been a comprehensive cost-benefit analysis, and that does not seem likely at this time. There is no question that barriers will have an impact on boating. Based on descriptions of canal usage provided during the Reimagine initiative, only a small number of boaters navigate the entire canal, and most boaters would not be impacted at all by the barriers proposed by R2. In the Interim Response Plan recent data for use of the Champlain Canal locks was provided, which on its face indicates that during the 2021 canal season the Champlain Canal saw limited monthly lock usage, which could lead to a conclusion that the cost, in terms of impact on canal users, would be low compared to the many benefits of preventing round goby from getting into Lake Champlain. That cost could further be mitigated by providing boat lift options as suggested by the ACOE. Any serious conversation about barriers would require disclosure and analysis of more data.

- Conflicting authorities between the Canal Corporation and DEC create a difficult dynamic. The Canal Corporation has the statutory authority to manage the canal and an obligation to continue canal operations, without consideration under its enabling statute to address invasive species. DEC has authority statewide to address invasive species, but no authority over canal management. That translates into a need for negotiated solutions spanning institutional interests, and those are difficult to achieve.

- The argument against barriers is fundamentally philosophical, and the argument for barriers is fact-based and harder to articulate. The opponents of barriers assert that the loss of through navigation, as it presently exists, will change the fundamental character of the canal, its historic purposes will be frustrated, its history will not be honored, and New York will accordingly lose something valuable. The counterargument relies on data about canal usage and invasive species movement; it requires an acknowledgment that canal operations need to change with the times; it requires objectively considering what the state is getting in return for an enormous annual investment in canal operations; and there is an aspect of taking something away from people who feel entitled to continue to maintain the status quo until the end of time.

The Canal Corporation and DEC recently announced that the Interim Rapid Response Plan will be continued through the upcoming canal season. This is heartening as it means that the issue is not being swept under the rug, and there is at least the possibility of action. Unfortunately, as of this writing the plan itself has not been updated, data with respect to 2022 canal usage has not been shared, and no information has been released with respect to the implementation of the "double draining" pilot. Yet hope springs eternal, and perhaps the first step to removing these barriers to barriers is identifying them and

Coevolution between round gobies and VHSV in the St. Lawrence River signals added risk for the Mohawk River

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Piscine novirhabdovirus, or Viral Hemorrhagic Septicemia Virus (VHSV), is a World Organization for Animal Health (OIE) reportable fish pathogen found across the northern hemisphere (OIE, 2019). A novel lineage, VHSV-IVb, was detected in the Great Lakes basin following sizable fish kills in the mid-2000's. Through IVb's history in the watershed, researchers have documented more than 30 fish species vulnerable to infection, high rates of genetic mutation, recurrent outbreaks, and expanding geographic range (Getchell et al., 2019). While this pathogen is extremely generalist in its capacity to infect many species, sensitivity to infection is highly variable between fishes (Kim & Faisal, 2010). Species that are susceptible to VHSV infection in the Mohawk River fish community are numerous (Table 1) (OIE, 2019). Factors that influence VHSV persistence following establishment are not well understood, therefore we are investigating the biotic and abiotic characteristics that facilitate viral amplification and genetic diversification in the upper St. Lawrence River (USLR) ecosystem where the virus has persisted for 20 years.

In the USLR, round goby (*Neogobius melanostomus*) is invasive and hypothesized as essential for the production, spread, and evolution of VHSV, due to their high susceptibility, high abundance, widespread distribution, and trophic significance for native predatory fishes. Still, other native fish hosts can maintain this virus, and further comparisons are needed to examine relative host competency among species. Round gobies are implicated in influencing VHSV's trajectory throughout North America as infected fish spread with their range expansion. One example of their combined advancing invasion front was observed through the Erie Canal, where the goby and pathogen entered into the New York Finger Lakes (Getchell et al., 2019). Thus, their movement and expansion in the Mohawk River threatens this and connected ecosystems with exposure to round goby and VHSV. The USLR has comparable biological and physical characteristics to the Mohawk in its fish community and large riverine structure. Our investigation of the epidemiological relationship between round gobies and VHSV in the USLR should be valuable to understanding the risk posed to ecosystems vulnerable to their introduction.

VHS infection can manifest in different forms which are associated with water temperature, host species, exposure dose, and previous infections of the host (OIE, 2019). Acute infection symptoms include internal or external hemorrhages on the fins, skin, or organs, bulged eyes, pale gills, darkening of skin, lethargy, and abnormal swimming, and can be isolated from a pooled organ (liver, kidney, spleen) sample (OIE, 2019). Acute outbreaks occur in the disease optimum temperature range from 9-12°C, with an upper limit for replication at 20°C (OIE, 2019). Chronic VHS infection is typically manifested in the nervous system and isolated from brain tissue, though most individuals present few to no external or internal signs of disease (Eckerlin et al., 2011; OIE, 2019). Many of the individual fish from which VHSV has been isolated have been asymptomatic, making rapid determination of infection status in the field impossible (Cornwell et al., 2015; OIE, 2019). Parallel testing of brain and pooled organ tissues by quantitative reverse transcriptase polymerase chain reaction (qRT-PCR) is the most reliable method to detect disease pathways and obtain values for viral titers (Hope et al., 2010).

We are using molecular techniques to compare round gobies to several native host species in their epidemiological characteristics (i.e., prevalence, viral titer, viral genomic sequence). We have surveyed VHSV in multiple fish species collected from nursery bays of the USLR over the last 5 years. Our data illustrates that round gobies experience significantly higher viral prevalence rates and titers relative to native hosts, exposing the central role this invasive species has in influencing the trajectory of VHSV persistence in the USLR.

Table 1: Fish species in the Mohawk River for which there is some evidence of susceptibility. Subset from OIE, 2019. ***Indicates species that were surveyed for VHSV in the USLR*

Order	Family	Common name	Latin name
Esociformes	*Esocidae*	Muskellunge	*Esox masquinongy*
		Northern pike	*Esox lucius*
Clupeiformes	*Clupeidae*	American gizzard shad	*Dorosoma cepedianum*
Perciformes	*Gobiidae*	Round goby**	*Neogobius melanostomus*
	Sciaenidae	Freshwater drum	*Aplodinotus grunniens*
	Percidae	Yellow perch**	*Perca flavescens*
		Walleye	*Sander vitreus*
	Centrarchidae	Largemouth bass	*Micropterus salmoides*
		Smallmouth bass	*Micropterus dolomieu*
		Bluegill**	*Lepomis macrochirus*
		Pumpkinseed**	*Lepomis gibbosus*
		Black crappie	*Pomoxis nigromaculatus*
		Rock bass**	*Ambloplites rupestris*
Siluriformes	*Ictaluridae*	Brown bullhead**	*Ictalurus nebulosus*
		Channel catfish	*Ictalurus punctatus*
Anguiliformes	*Anguilidae*	American eel	*Anguilla rostrata*
Cypriniformes	*Cyprinidae*	Fathead minnow	*Pimephales promelas*
		Bluntnose minnow	*Pimephales notatus*
		Emerald shiner	*Notropis atherinoides*
		Spottail shiner	*Notropis hudsonius*

Methods

From 2018-2022, fish were collected using a combination of trapnets and minnow traps set in multiple nursery bays of the Thousand Islands region throughout the month of May (Figure 1). These sites vary substantially in their biotic and abiotic characteristics and occur down the longitudinal gradient of the USLR. Collections were made while temperatures overlapped with the range of 9-15°C. Tissues were preserved for viral testing from round gobies in all five years, and expanded to include potential native reservoirs (i.e., yellow perch, rock bass, brown bullhead, and *Lepomis* sunfish) in 2020-2021. A total of 1,407 fish (2,814 tissues) were collected during these years. RT-qPCR was completed at the Cornell

Aquatic Animal Health Center at the College of Veterinary Medicine, and the genomic sequencing preparation is currently being conducted at the Cornell Environmental DNA and Genomics CORE Facility (Figure 2).

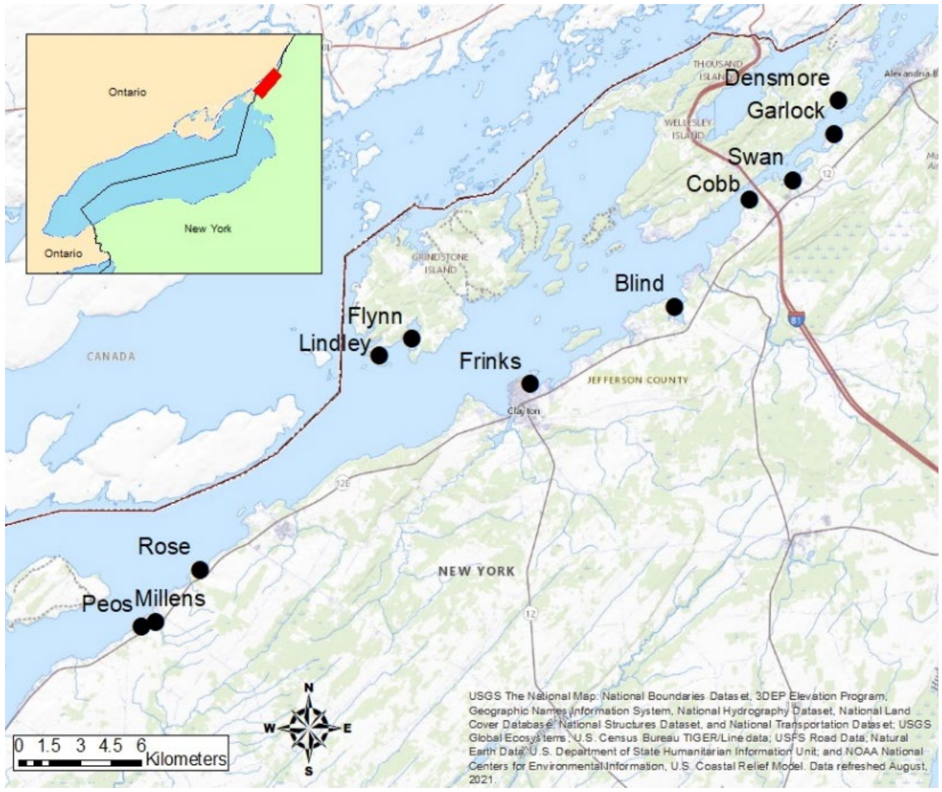

Figure 1: Map showing fish collection sites in the upper St. Lawrence River

Results

We found substantial amounts of VHSV in fish populations of each sampled nursery site in the USLR. Compared to any of the examined native host species, round gobies exhibited significantly higher rates of viral infection. The distributions of titers were not significantly different than native hosts, though round gobies did produce higher maximum viral concentrations in infected individuals (Figure 3).

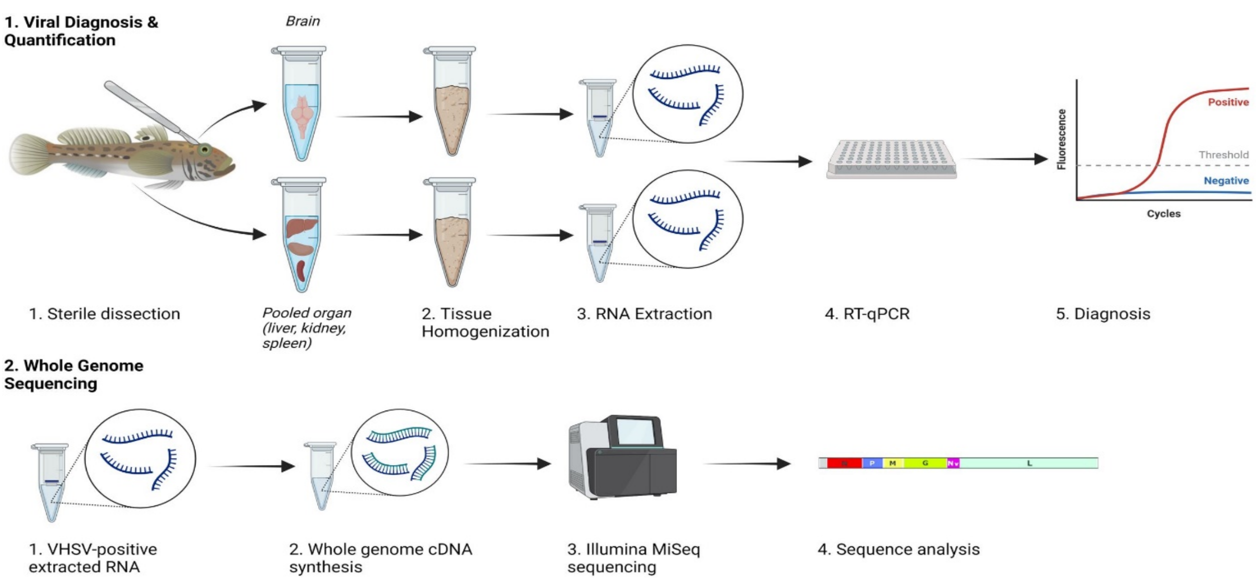

Figure 2: Diagram of molecular workflow for VHSV diagnosis, quantification, and genomic sequencing.

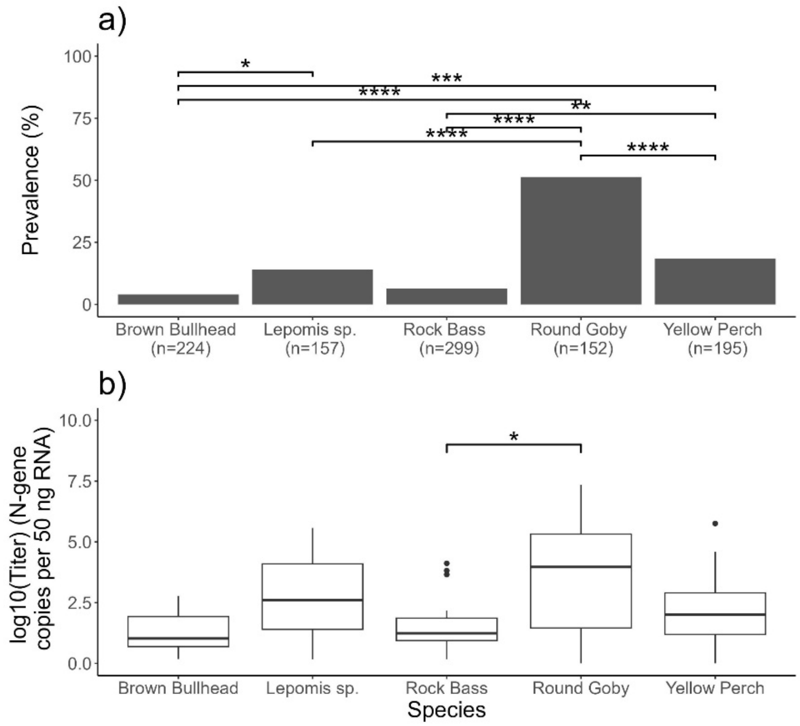

Figure 3: Host species differences in a) VHSV prevalence and b) viral titer in the fish community of the Upper St. Lawrence River

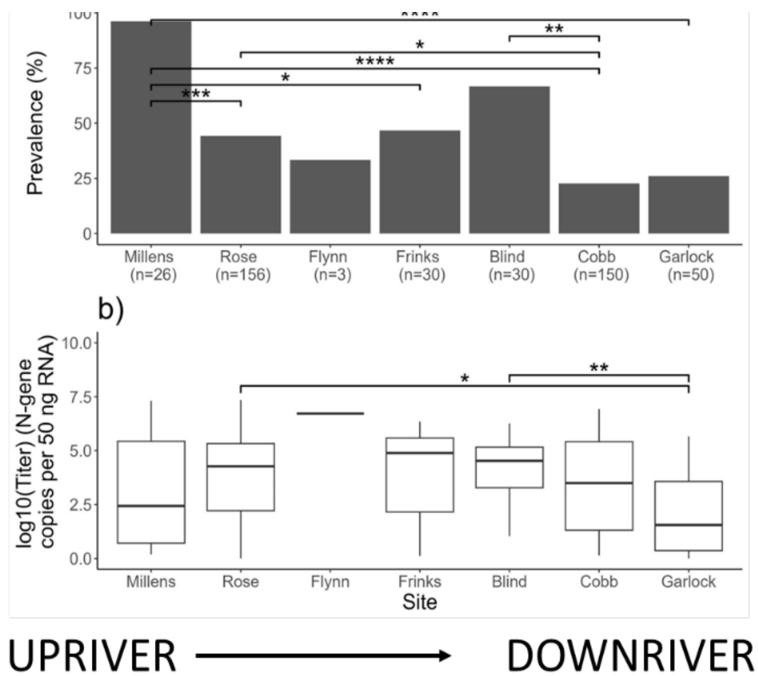

Figure 4: Spatial differences in a) VHSV prevalence and b) viral titer in round gobies from nursery bays of the Upper St. Lawrence River

Prevalence in round goby populations varied significantly between sites, with highest the infection rate reaching 96% at Millens Bay. Prevalence does not trend from upriver to downriver, instead presenting hotspots with high amounts of incidence. Viral titers in infected round gobies reached similarly high concentrations across all the sampled bays (Figure 4).

VHSV prevalence rates in round gobies of the USLR varied between years, with 2018 displaying the lowest rates of overall infection. However, 3/5 years presented over 50% infections in this species. Viral titers increased annually over the research period (Figure 5).

Conclusions

Our results demonstrate that the interaction of round gobies and VHSV is a significant additional consequence of their invasion. These fish are highly competent hosts that generate high quantities of the virus across habitats and sustain its production annually. Genomic analysis will further inform about how this species facilitates the pathogen's evolution in this persistent habitat. Stakeholders in the Mohawk and other at-risk watersheds need to consider the potential impacts of VHSV introduction via the round goby on their fish communities.

Acknowledgments

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We thank the staff, students, and technicians of the Thousand Islands Biological Station (2018-2022) who have aided in the collection of fish.

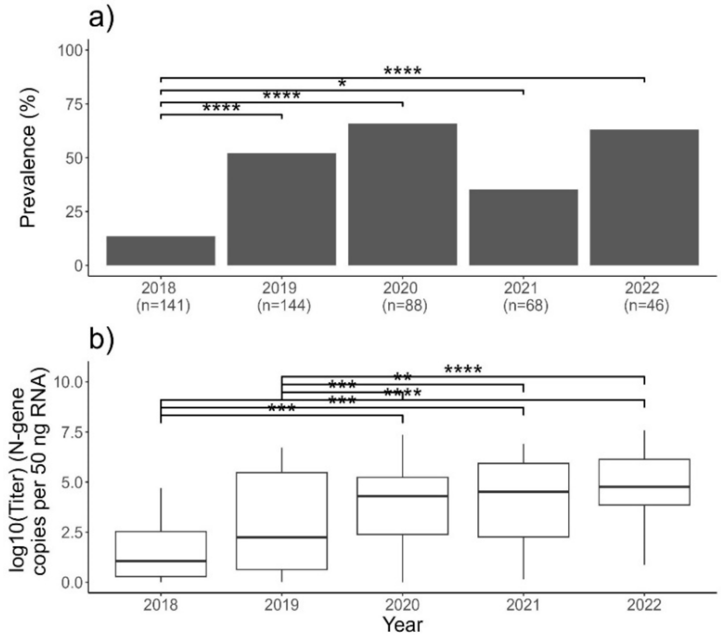

Figure 5: Temporal differences in a) VHSV prevalence and b) viral titer in nursery bays of the Upper St. Lawrence River

References

Cornwell, E. R., Anderson, G. B., Coleman, D., Getchell, R. G., Groocock, G. H., Warg, J. V., Cruz, A. M., Casey, J. W., Bain, M. B., & Bowser, P. R. (2015). Applying multi-scale occupancy models to infer host and site occupancy of an emerging viral fish pathogen in the Great Lakes. *Journal of Great Lakes Research*, *41*(2), 520–529. https://doi.org/10.1016/j.jglr.2015.01.002

Eckerlin, G. E., Farrell, J. M., Casey, R. N., Hope, K. M., Groocock, G. H., Bowser, P. R., & Casey, J. (2011). Temporal Variation in Prevalence of Viral Hemorrhagic Septicemia Virus Type IVb among Upper St. Lawrence River Smallmouth Bass. *Transactions of the American Fisheries Society*, *140*(3), 529–536. https://doi.org/10.1080/00028487.2011.581975

Getchell, R. G., First, E. J., Bogdanowicz, S. M., Andrés, J. A., Schulman, A. T., Kramer, J., Eckerlin, G. E., Farrell, J. M., & Marquis, H. (2019). Investigation of round goby viral haemorrhagic septicaemia outbreak in New York. *Journal of Fish Diseases*, jfd.13003. https://doi.org/10.1111/jfd.13003

Hope, K. M., Casey, R. N., Groocock, G. H., Getchell, R. G., Bowser, P. R., & Casey, J. W. (2010). Comparison of Quantitative RT-PCR with Cell Culture to Detect Viral Hemorrhagic Septicemia Virus (VHSV) IVb Infections in the Great Lakes. *Journal of Aquatic Animal Health*, *22*(1), 50–61. https://doi.org/10.1577/H09-028.1

Kim, R., & Faisal, M. (2010). Comparative susceptibility of representative Great Lakes fish species to the North American viral hemorrhagic septicemia virus Sublineage IVb. *Diseases of Aquatic Organisms*, *91*(1), 23–34. https://doi.org/10.3354/dao02217

OIE. (2019). VIRAL HAEMORRHAGIC SEPTICAEMIA. In *Manual of Diagnostic Tests for Aquatic Animals* (pp. 1–24). https://www.woah.org/fileadmin/Home/eng/Health_standards/aahm/current/chapitre_vhs.pdf

Using the Riparian Opportunities Assessment to identify riparian restoration or protection sites for flood mitigation

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Flooding is an increasingly urgent problem across the Northeast, and especially within New York State. Increases in intense precipitation events since the start of the twentieth century will likely increase even more into the end of this century (Easterling et al. 2017). In much of NYS, precipitation events with a 1% likelihood of occurrence in any year will likely double by the end of this century (DeGaetano & Castellano 2017). These projected increases in combination with increasing impervious surfaces and undersized infrastructure will result in more intense and frequent flooding in NYS.

One method of reducing the risks of some types of flooding events is through the protection and restoration of natural areas, like riparian zones. Restoring and protecting riparian zones can additionally provide a suite of benefits including reducing erosion, mitigating heat risk, and improved wildlife habitat.

The NYS Riparian Opportunity Assessment (ROA) (NY NHP 2018) is a mapping tool that targets sites for riparian restoration. It includes many metrics describing general ecosystem health and stress for watersheds across the state, along with "theme" scores that combine some of these metrics to address conservation efforts of interest, like stream temperature. Many metrics in the ROA can be used to evaluate areas for flood attenuation potential, but the tool currently does not yet explicitly use these to do so. Interviews with users have indicated a desire for the ROA to implement a flood metric that can help target watersheds with high opportunity for flood attenuation.

We developed new theme score for the ROA that describes flood attenuation opportunity. In addition, we performed a multivariate clustering analysis to target groups of watersheds with characteristics conducive to protection or restoration efforts. Finally, we performed a case study within the Mohawk River Basin to provide an example of how users can apply these results within their communities.

References

Easterling, D.R., K.E. Kunkel, J.R. Arnold, T. Knutson, A.N. LeGrande, L.R. Leung, R.S. Vose, D.E. Waliser, and M.F. Wehner, 2017: Precipitation change in the United States. In: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 207–230, doi:10.7930/J0H993CC.

DeGaetano, A. T., & Castellano, C. M. (2017). Future projections of extreme precipitation intensity-duration-frequency curves for climate adaptation planning in New York State. Climate Services, 5, 23-35.

NY NHP. (2018) Trees for Tribs Statewide Data Explorer. Trees for Tribs Statewide Data Explorer. https://lab.nynhp.org/trees_tribs_ny/data_explorer/

MyCoast NY: A statewide tool for engaging communities and documenting flood events

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As the frequency and intensity of floods increases across New York and managers are faced with the limitations of regulatory flood maps, community science offers an innovative way to engage residents and fill data gaps. MyCoast NY is a new community science webtool for collecting and analyzing photos of floods, hazardous weather impacts, and changing shorelines across New York's varied geography. Photos are placed on a map and linked to real-time environmental conditions from the closest weather station, tidal or lake, and river gauge data to help provide context. MyCoast NY functions as a phone app and a website supported by New York Sea Grant in partnership with the NYS Water Resources Institute as a 2-year pilot. The main goals are to build a database of flood photo reports by engaging residents and to understand how the photo reports can be utilized by floodplain managers, emergency managers, and planners to make more informed decisions. This presentation will provide background on MyCoast NY, how certain features have been customized for New York's varied coasts and waterbodies, and how to use the tool in your work.

Microplastic analysis of high-flow and low-flow streams located in Rensselaer County

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Introduction

Microplastics are a growing issue in modern society. As microplastics are being found in more remote areas, it is becoming even more important to record the amount of microplastics being dispersed into the local ecology. Plastic, after it has been discarded, breaks down into smaller pieces, creating microplastics. Microplastics found in streams have been shown to come from landfills and sewage pipes (Willard-Bauer et al., 2020; Silva et al., 2021). Streams and water sources are essential to microplastic transportation, and counting the microplastics in streams is a good way to see the microplastic abundance. A study done by Smith et al. (2020) showed that streams transport more microplastics during high-flow conditions than during low-flow conditions.

The purpose of this study was to collect samples from three streams in Rensselaer County to look for microplastics. The streams sampled were Quakenderry Creek, Mill Creek, and Moordener Kill. Samples were classified by stream characteristics and by low-flow, high-flow, and after-rain high-flow. The hypothesis was that there will be more microplastics in after-rain high-flow samples and that there will be more microplastics in streams with proximity to landfills or transfer stations.

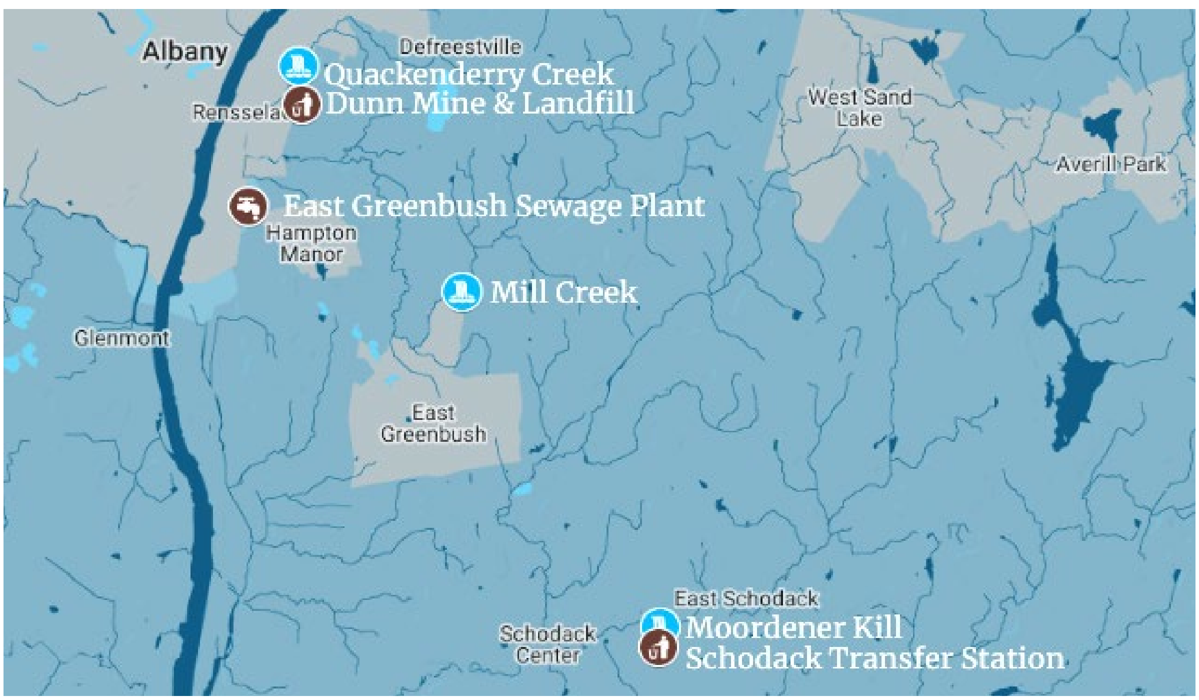

Figure 1: Sampling locations in Rensselaer Watershed and local landfill proximity. Streams were selected for accessibility and proximity to potential sources of microplastics. Quakenderry Creek is downstream of the Dunn Mine and in an urban area. Mill Creek was chosen because it is in a rural area and runs through many residential properties. Moordener Kill was chosen as it is downstream from the Schodaack Transfer station and it is more rural than both Quackenderry Creek and Mill Creek.

Sampling Procedure

A 3- meter neuston net with a 335-µm mesh was used to collect samples (Figure 2). The velocity of the stream was determined using a fishing bobber strung along a two-meter-long piece of fishing line. The bobber was timed six times in total, three times before sampling and three times after. It was placed a meter before where the net would be placed for sampling. A measuring tape was used to determine the stream's width and depth of water passing through the net. Each sample was collected for 30 minutes in the stream, with the exception of the after-rain high-flow sample for Quackenderry Creek, which was collected for 2 minutes and 15 seconds due to the amount of material passing into the net. Samples were washed from the net into a 16-ounce wide-mouth mason jar (Figure 3) using a backpack sprayer. Samples were dried outside under plastic bins (Figure 4).

Figure 2: Neuston net in Mill Creek

Figure 3: Jar of sample taken from Moordener Kill

Figure 4: To make the most of the time that samples could spend outside and to shield the jars from contamination, samples were dried underneath bins.

Laboratory Procedure

Samples were drained of water using filter paper, and once they were dry, they were sorted by particle size. Samples were sorted through a sieve with mesh sizes of 4,750 µm, 2,000 µm, 231 µm, and 63 µm (Figure 5). All microplastics counted in this study are larger than 63 µm. Sieved samples were placed in petri dishes to be stored and used to view under a stereoscope (Figure 6). All counting was done by the author.

Figure 5: Sieved samples in petri dishes.

Figure 6: View of petri dish in stereoscope, with three microplastic fibers in view.

Findings

As of writing this abstract, eight of the 10 samples have been counted; only the Quackenderry Creek and Mill Creek after-rain high-flow samples have yet to be counted. Microplastics have been found in all counted samples (Table 1). In general, microplastic fibers (Figure 6) have been the most abundant, followed by fragments. Total particle counts range from 3 in the Quackenderry low-flow sample to 40 in the Moordener Kill low-flow sample. Despite Moordener Kill having the highest microplastic particle count, Quackenderry Creek currently has the highest particle concentration at 2.61 particles/m^3 (Table 2).

Table 1: Current microplastic counts, highlighted streams have not been counted yet. Moordener Kill has the highest number of microplastic particles, at 40 total. The filter blank is from the sieve used to sort samples by particle size and contains seven microplastic fibers.

Date	Stream	fragments	foams	pellets/beads	films	fibers/lines	total particles
6/18/22	Mill Creek (L-F)	4			2	1	7
7/2/22	Mill Creek (H-F)	5				1	6
9/13/22	Mill Creek (H-F)						0
6/26/22	Moordener Kill (L-F)	9			1	30	40
7/5/22	Moordener Kill (H-F)	4		1		19	24
6/27/22	Moordener Kill (H-F)	5		1	2	13	21
6/29/22	Quackenderry Creek (L-F)	1	1		2	10	14
7/12/22	Quackenderry Creek (L-F)					3	3
7/28/22	Quackenderry Creek (H-F)				1	20	21
11/12/22	Quackenderry Creek (H-F)						0
	Filter Blank					7	7

Table 2: Current microplastic concentrations; highlighted streams have not been counted or calculated yet. Quackenderry Creek (H-F) has the highest particle concentration at 2.61 particles/m^3, and Mill Creek (H-F) has the lowest at 0.09 particles/m^3.

Date	Stream	total particles	Volume of water (m3)	Particle Concentration (particles/m3)
6/18/22	Mill Creek (L-F)	7	44.19	0.16
7/2/22	Mill Creek (H-F)	6	65.43	0.09
9/13/22	Mill Creek (H-F) (After Rain)	0	126.71	0.00
6/26/22	Moordener Kill (L-F)	40	53.94	0.74
7/5/22	Moordener Kill (H-F)	24	85.42	0.28
6/27/22	Moordener Kill (H-F) (After Rain)	21	108.90	0.19
6/29/22	Quackenderry Creek (L-F)	14	37.77	0.37
7/12/22	Quackenderry Creek (L-F)	3	12.52	0.24
7/28/22	Quackenderry Creek (H-F)	21	8.06	2.61
11/12/22	Quackenderry Creek (H-F) (After Rain)	0	31.25	0.00

Discussion and Preliminary Conclusions

Three creeks in Rensselaer New York were sampled for microplastics under both high flow and low flow conditions, and during rainstorms. To date, microplastic particles have been found in all counted samples; two samples have yet to be counted. From the data already collected, it seems likely that there will be more microplastics in the after-rain high-flow sample from Quackenderry Creek than in the Mill Creek after-rain high-flow sample, due to Quackenderry Creek's proximity to a landfill. The high particle counts and concentration in the Moordener Kill low-flow sample counter the original hypothesis that high-flow samples will have more particles and higher particle concentrations than low-flow samples. This finding suggests the Quackenderry Creek and Mill Creek after-rain high-flow samples may also have the same result.

References

Willard-Bauer, E., Smith, J. A., Garver, J. I., Goldman, D., & Newcomer, B. (2020). Enterococci levels in the Hans Groot Kill and Mohawk River, Schenectady, NY. In Garver, J.I., Smith, J.A., and Rodak, C., 2020, Proceedings of the 2020 Mohawk Watershed Symposium, Union College, Schenectady, NY, v. 12, p. 63-68.

Silva, A. L., Prata, J. C., Duarte, A. C., Soares, A. M., Barceló, D., & Rocha-Santos, T. (2021). Microplastics in landfill leachates: The need for reconnaissance studies and remediation technologies. Case Studies in Chemical and Environmental Engineering, 3, 100072.

Smith, J. A., Caruso, E., & Wright, N. (2020). Microplastic pollution in Mohawk River tributaries: likely sources and potential implications for the Mohawk Watershed. In Garver, J.I., Smith, J.A., and Rodak, C., 2020, Proceedings of the 2020 Mohawk Watershed Symposium, Union College, Schenectady, NY, v. 12, p. 53-58.

Comparing fish communities in restored and unrestored streams

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Since Hurricane Irene hit Schoharie County in 2011, millions of dollars have been spent on stream restoration efforts; however, many streams remain degraded. The goal of this study was to compare the fish communities to determine if restored streams exhibit higher diversity and abundance. To conduct this study we sampled three streams restored in 2015: Line Creek, Platterkill, and Little Schoharie Creek; and three unrestored creeks: Cobleskill Creek, Bear Kill, and Keyser Kill. The fish sampling was conducted by backpack electroshocking. Using the data from the fish populations, catch per hour of all fish, catch per hour of game fish, and Shannon Weaver Diversity Index values were calculated for each stream, and a t-test was used to explore for differences between restored and unrestored streams.

When comparing the average values from the restored streams and unrestored streams there was no significant difference between any of the variables we examined. This is mainly due to the high variation in fish populations at both restored and unrestored streams. While many benefits occur from stream restoration this study found that it does not lead to significant differences in fish diversity and abundance.

Toward a more swimmable Mohawk: Trends in water quality based on an eight-year fecal indicator bacteria (FIB) monitoring partnership

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Introduction

Making our waterways safe for swimming and fishing has been a national goal since the Clean Water Act of 1972. The Mohawk River, one of New York's most storied waterways, is a destination for recreation for those living within its watershed as well as tourists who visit the canal, and a source, or potential source, of drinking water for over 280,000 people who rely on the river directly (~102,000) or its associated Great Flats Aquifer. As the largest tributary to the Hudson River, the Mohawk also has important influences on the estuary.

Since 2015, SUNY Cobleskill, SUNY Polytechnic Institute, and Riverkeeper have monitored water quality at more than 40 sites in the Mohawk River and Barge Canal, and several of its tributaries. Measurements of Fecal Indicator Bacteria (FIB) are compared to Environmental Protection Agency (EPA) recreational water quality criteria, which are designed to ensure compliance with the Clean Water Act, and to protect public health for recreational users.

The results of the eight-year monitoring effort reveal several trends and patterns relevant to the public and to management of the river:

- While most sites sampled would fail to meet EPA-recommended safe-swimming criteria, there is significant variation in water quality along the length of the Mohawk and in its tributaries.
- Safe recreation is significantly affected by rainfall, with almost every site sampled showing higher concentrations of FIB measured within three days of cumulative rainfall of 0.25 inch or greater.
- Water quality can vary significantly on an interannual basis. *Enterococci* concentrations in the Mohawk watershed are variable and show a generally increasing trend from 2015-2022, while *E*. coli concentrations are variable but without any apparent trend from 2017-2022. It will be valuable to continue long-term monitoring that tracks changes over time with respect to climate change and its impacts on precipitation intensity and patterns, and ongoing wastewater infrastructure investments.

The FIB discussed in this work are *Enterococci*, and *E*. coli. Although FIB are not necessarily harmful, the presence of FIB in water samples is used to predict the likely presence of potentially harmful pathogens.[1-7] Where FIB are present in higher concentrations, other pollutants associated with their source may also be present, including nutrients and wastewater-associated micropollutants such as pharmaceuticals and microplastics. Among the potential sources are combined sewer overflows (CSOs), wastewater discharges without disinfection, sewer or septic system failures, wildlife and pet wastes, contaminated sediments, and surface water run-off, or agricultural run-off.[1-7]

In 2012, the US Environmental Protection Agency (EPA) published its "Recreational Water Quality Criteria," which states are to use to update water quality standards.[1] The recommended criteria include three measures, the Geometric Mean (GM), Statistical Threshold Value (STV) and Beach Action Value (BAV), each based on a concentration of *Enterococci* or *E*. coli in 100 mL of water (cfu/100 mL; cfu = colony forming units). The EPA's thresholds are set so as to prevent more than an estimated 32 or 36 illnesses per 1,000 bathers, based on epidemiological studies of beachgoers. No more than 10% of samples should exceed the STV. The BAV is a single-sample threshold that can be used to close beaches proactively if it is exceeded. The GM and the STV are meant to be used together, and exceedance of either criterion is considered a violation of EPA's recommended water quality criteria. Table 1 presents the GM, STV, and BAV for *Enterococci* and *E*. coli at both the 32 or 36 illness per 1000 bathers levels. Herein, the more stringent water quality threshold of 32 illness per 1000 bathers has been adopted for the water quality analyses presented.

Table 1. US EPA thresholds for *Enterococci* and *E*. coli[1]

	Estimated Illnesses per 1000 persons	Geometric Mean (GM)	Standard Threshold Value (STV)	Beach Action Value (BAV)
Enterococci	32	30	110	60
	36	35	130	70
E. coli	32	100	320	190
	36	126	410	235

Methods

Between May and October, during the recreational season on the waterway, over 40 sites are sampled in a single day each month along 121 miles of the Mohawk River from Delta Lake to the confluence of the Mohawk River with the Hudson River at Waterford, NY (Figure 2 and inset). This approach creates what is referred to as a "snapshot" of water quality along the entirety of the waterway.

Sampling sites were selected to test the river at monthly intervals, to test water at locations likely to be of interest to the public based on accessibility, to understand the relative quality and impact of larger tributaries, and to measure water quality both up- and downstream of likely sources of contamination, such as combined sewer overflows. For example, several samples are collected at Barge Canal locks that are part of the Mohawk River, where samplers routinely observe boating, picnicking, fishing, paddling, and persons walking, biking, or otherwise using the canal-side pathways, parks and park-like spaces. Other recreational activities are known to take place at some sites, including primary contact recreation like the practices and performances of the X-Squad Water Ski Show Team in Amsterdam.

Samples were tested for *Enterococci* bacteria, using EPA Standard Method 9230D, and for total coliform and *Escherichia* coli using EPA Standard Method 9223B. These methods involve IDEXX Quanti-Tray 2000 sample packs (49 large wells; 48 small wells) using Enterolert and Colilert (24 hour) systems. Water samples, preferably from moving water, were collected using sterile techniques in 250 mL or larger, sterilized, Nalgene bottles. Large and small well counts provide an MPN (Most Probable Number) value that represents the number of bacteria, or colony forming units/100 mL in the sample (cfu/100 mL). Sampling the entire 121 mile length (Delta Lake to the confluence with the Hudson River) has been achieved in as few as nine hours; the goal is 24-48 h. Sample hold time is six hours. Wet samples required at least 0.25 inches of cumulative precipitation (rain) prior to the time the sample was collected and over the preceding three days. Sampling protocols are consistent with Quality Assurance Project Plans developed by Riverkeeper and approved in 2014 by the New England Interstate Water Pollution Control Commission.

Results and Discussion

Since 2015, annual water quality monitoring campaigns using fecal indicator bacteria (FIB) that include *Enterococci* and, since 2017, *E*. coli, assess water quality in a "snap-shot" approach from May to October. Recreation on the waterway would be expected to be at its peak during these months.

Figure 1 shows the percentage of 2015-2022 single samples that were below, or exceeded the more protective (32 illnesses per 1,000 recreational users) US EPA's BAV for *Enterococci* and *E*. coli. For *Enterococci*, 57% of all of the single samples exceeded the BAV, versus 26% of the *E*. coli samples. The individual sampling sites show a range from 6% of samples meeting the BAV at one site to 95% meeting the BAV at another. For 28 out of 40 sites, half or more of the single samples recorded from 2015-2022 exceeded the BAV. For *E*. coli, the sampling sites range from 21% of samples meeting the BAV at a site to 100% meeting the BAV. For only 2 out of 40 sites, half or more of the single samples recorded were in excess of the US EPA BAV. The fact that the percentages differ is consistent with reported differences in survival in surface water between the two, which might also include factors such as the source concentrations of FIB, sunlight, and water temperature.[5-7]

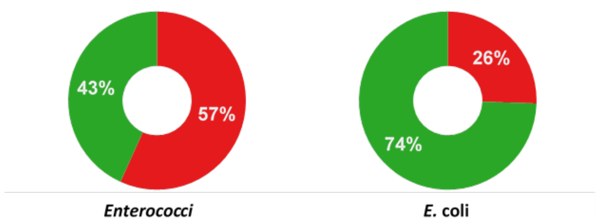

Figure 1: The two circle charts present the percentages of single samples collected from all sites that meet the US EPA BAV[1] green (left side of circle charts) or exceeded the BAV (red) from 2015-2022. US EPA single sample BAV for *Enterococci* is 60 cfu/100 mL; single sample BAV for *E.* coli equals 190 cfu/100 mL.

Figure 2 (left panel) presents the *Enterococci* data for the Mohawk River Watershed as geometric means (geomean) of all data gathered per site. Markers on each sampling site along the mainstem of the Mohawk River, the Barge Canal, and selected tributaries are shown, with the geomean value for the 2015-2022 data. The dots are colored to correspond to US EPA's recommended geomean criterion of 30 cfu/100 mL for *Enterococci*. Note that the values tend to be at higher levels within certain urban areas and decrease downstream. This upstream/downstream pattern for example is observed to different degrees in Utica, Herkimer, Amsterdam, and Schenectady. However, unlike the *Enterococci* data, the *E*. coli data show most of the sites achieving the geometric mean criterion.

The US EPA's 2012 Recreational Water Quality Criteria also recommend a statistical threshold value (STV) criterion to be used in addition to a geometric mean criterion.[1] This was encouraged because, "FIB are highly variable in ambient waters",[1] which is seen in this work. The STV approximates the 90th percentile of the water quality distribution. Therefore, when calculating the geomean, the EPA stated that no more than 10% of samples should exceed the STV. Viewed as STV, only one site near Rome, NY did not exceed 10% for STV for *Enterococci*. Out of 40 sites, 10 did not exceed the more protective (32 illnesses per 1,000 rates) STV for *E*. coli. However, the less protective (36 illnesses per 1,000 rate) resulted in fewer exceedances. In short, the state's selection of one of the four possible EPA-recommended criteria won't change pollution levels in the river, but it will profoundly influence our view of whether or not the river meets safe swimming criteria.

Overall, samples drawn on sampling dates deemed “wet” (>0.25 inches of rain, cumulatively, on the day of and in the three days preceding sampling) show higher FIB counts than samples from the same sites deemed “dry”, Figure 3. This agrees with the primary literature on other bodies of water that show higher bacterial counts when precipitation increases runoff into the waterbody, for example a 2020 USGS report on the Chattahoochee River in Georgia.[11] In 2022, for a segment of the region near Rome and Utica, NY, Rodak et al., reported that correlations between FIB counts and precipitation were observed. The correlations were stronger in more urban areas with greater potential for surface run-off, resuspension of sediment, and prevalence of CSOs.[4]

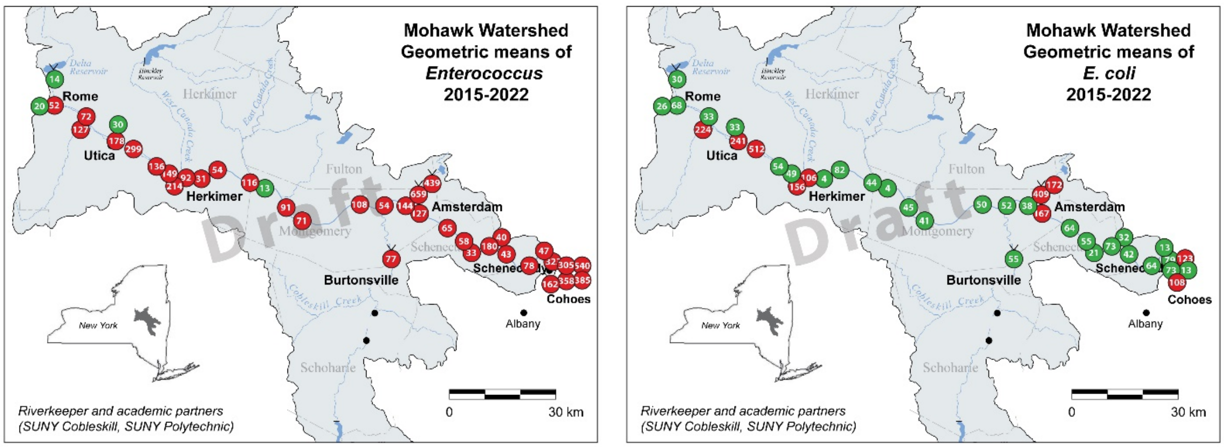

Figure 2: Each marker presents the geomean of the *Enterococci* data collected at that site from 2015-2022 within the Mohawk River Watershed, left panel. Using the US EPA geomean BAV for *Enterococci* of 30 cfu/100 mL, all but four sites exceeded the BAV. Note the pattern of increasing bacterial counts near some urbanized areas of the watershed, with bacterial counts decreasing downstream into less urbanized areas. In the right panel, each marker presents the geomean of the *E*. coli data collected at that site from 2017-2022 within the Mohawk River Watershed (US EPA geomean BAV for *E*. coli of 100 cfu/100 mL). The *E*. coli data show a similar pattern of increasing and decreasing bacterial counts to that of *Enterococci*. (Figure from Garver, 2022)

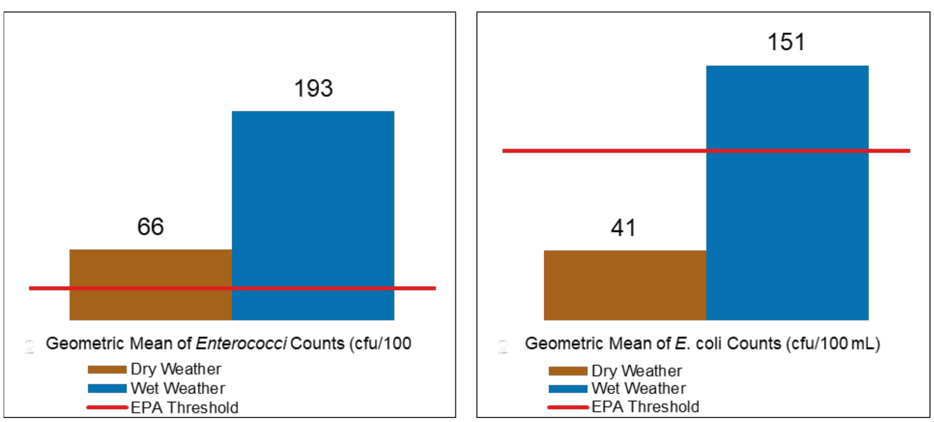

Figure 3. Dry weather versus wet weather geometric means for *Enterococci* and *E*. coli samples. The dry samples, brown (left hand column) and wet samples, blue (right hand column). Samples collected in wet weather show increased bacterial counts. The EPA threshold values are the BAV values of 30 cfu/100 mL for *Enterococci* and 100 cfu/100 mL for *E*. coli. Wet weather samples are defined as >0.25 inches of rain, cumulatively, on the day of and in the three days preceding sampling.

With respect to the longitudinal nature of this work, Figure 4 shows an overall *Enterococci* geomean collected at reference sites that have been consistently sampled each year. Year-to-year from 2015-2022 the trend is toward greater concentrations of *Enterococci*. However, Figure 5 shows that *E*. coli trends from the same sites have not demonstrated the same pattern. Open questions to consider include: 1) are there increased inputs due to infrastructure or land use pattern changes, and 2) how does this relate to wet versus dry conditions? 3) what conditions (persistence, differential sources) could explain divergent trends in *Enterococci* vs. *E*. coli? With respect to question 2, the Mohawk River Basin Action Agenda, Conserving, Preserving, and Restoring the Mohawk River Watershed 2021-2026, presents a plot (prepared by Professor John Garver) that shows that total Mohawk River flow at Cohoes, NY, has been increasing since the mid-1990s.[8,9] This observation of flow is consistent with climate change reports on rainfall trends[13] and recently reported research noting that extreme rainfall events have been increasing across the northeastern United States[14]. Analysis of these data is ongoing.

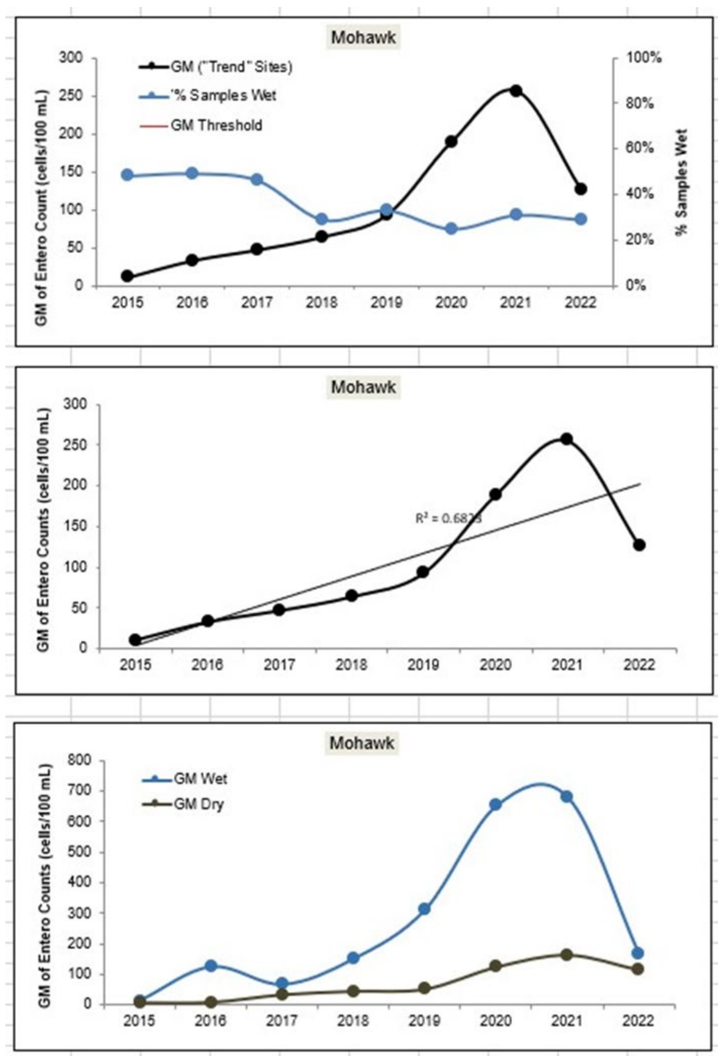

Figure 4. *Enterococci* interannual trends for 2015-2022. The top panel shows the overall trend in the annual geometric mean versus the percentage of wet samples. The bottom panel separates the samples by wet versus dry sampling conditions. Note that the general pattern of increase in the geometric means is observed for both dry and wet samples.

In light of these 2015-2022 data, among the changes that would be anticipated to have had positive impacts on water quality trends are state and federal grants and loans that helped communities in the Mohawk Watershed commit to over $250 million to wastewater system improvements. The Water Infrastructure Improvement Act, first enacted in 2015 and expanded in 2017 with the Clean Water Infrastructure Act and subsequent annual investments by NYS has been responsible for a large proportion of these investments, with 90% of total investment commitments supported in part by WIIA grants.[12,15]

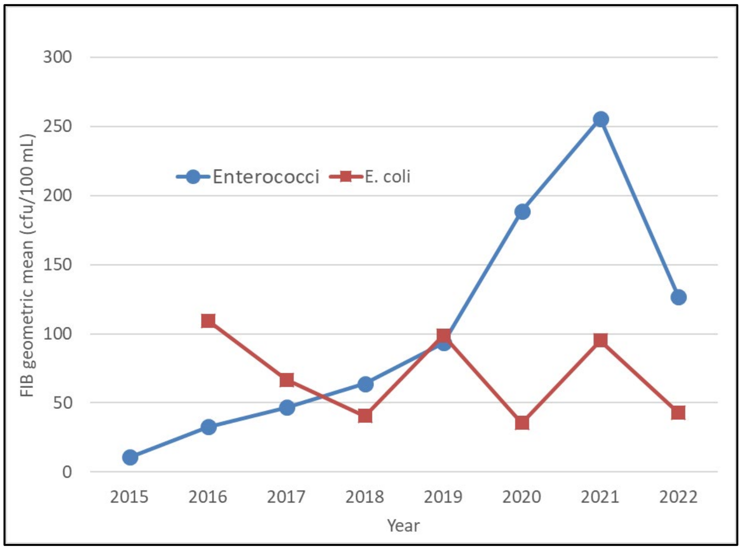

Figure 5. Interannual trends for *Enterococci* (blue line/dots; years 2015-2022) versus *E*. coli (red line/squares; years 2016-2022). The *Enterococci* data indicate an increasing trend, versus the *E*. coli data**.**

The Mohawk River Watershed includes at least 41 municipally owned wastewater treatment plants (WWTP), another 27 publicly owned sewer systems (POSS) that collect waste from neighboring communities for processing at these facilities. Of the 41 WWTPs, 28 have a current violation, according to US EPA's Environmental Compliance History Online (ECHO) data.[16] Of these, four have a significant non-compliance issue (as of January 2023). Four systems, in Utica, Little Falls, Amsterdam, Cohoes and Waterford, rely in part on combined sewer systems (CSS), and together, they have 57 combined sewer overflows (CSOs) that discharge to the Mohawk River or its tributaries. Of the communities with CSOs, each has a state-approved Long Term Control Plan (LTCP) designed to meet Clean Water Act Requirements for reducing, but not eliminating, overflows. Looking to the future, Mohawk River Watershed communities have identified $349.1 million in additional upgrades that are needed[17], at a time when federal and state funding is more available than any time in the last generation.

References

1) Recreational Water Quality Criteria (20212) US EPA, OFFICE OF WATER 820-F-12-058 (www.epa.gov/sites/default/files/2015-10/documents/rwqc2012.pdf, accessed January 22, 2023)

2) Boehm A.B. and Sassoubre L.M., (2014) Enterococci as Indicators of Environmental Fecal Contamination", in Enterococci: From Commensals to Leading Causes of Drug Resistant Infection [Internet], Gilmore M.S.; Clewell D.B.; Ike Y., et al., eds. (Boston: Massachusetts Eye and Ear Infirmary). Available from: https://www.ncbi.nlm.nih.gov/books/NBK190421/ (accessed February 6, 2023).

3) Buckalew, D.W.; Hartman, L.J.; Grimsley, G.A.; Martin, A.E.; Register, K.M. (2006) A long-term study comparing membrane filtration with Colilert® defined substrates in detecting fecal coliforms and *Escherichia* coli in natural waters. *J. Environ. Management*, 80: 191-197.

4) Lininger, K.J.; Ormanoski, M.; Rodak, C. M., (2022) Observations and Correlations from a 3-Year Study of Fecal Indicator Bacteria in the Mohawk River in Upstate NY. *Water,* 14: 2137-2145. https://doi.org/10.3390/w14132137

5) Byappanahalli, M.N.; Nevers, M.B.; Korajkic, A.; Staley, Z.R.; Harwood, V.J. (2012) Enterococci in the environment. Microbiology and Molecular Biology Reviews. 76: 685–706. https://doi.org/10.1128/MMBR.00023-12
6) Jang, J.; Hur, H.-G.; Sadowsky, M.J.; Byappanahalli, M.N.; Yan, T.; Ishii, S. (2017) Environmental Escherichia coli: ecology and public health implications—a review. *Journal of Applied Microbiology*, 123: 570-581. https://doi.org/10.1111/jam.13468
7) Liu, L.; Phanikumar, M.S.; Molloy, S.L.; Whitman, R.L.; Shively, D.A.; Nevers, M.B.; Schwab, D.J.L, and Rose, J.B.(2006) Modeling the Transport and Inactivation of *E. coli* and Enterococci in the Near-Shore Region of Lake Michigan". *Environ. Sci. Technol.* 40:5022–5028. https://doi.org/10.1021/es060438k
8) Mohawk River Basin Action Agenda, Conserving, Preserving, and Restoring the Mohawk River Watershed 2021-2026, (https://www.dec.ny.gov/docs/water_pdf/mohawkrbaa2021.pdf, accessed January 25, 2023)
9) Garver, J. (2023) personal communication, and as cited Reference 8.
10) Riverkeeper's (https://www.riverkeeper.org/) Water Quality Program data reporting website (Mohawk Watershed pages developed in collaboration with SUNY Cobleskill and grant to BLB, 2016) https://www.riverkeeper.org/water-quality/citizen-data/mohawk-river/ (accessed February, 2023).
11) Aulenbach, B.T.; McKee, A.M., 2020, Monitoring and real-time modeling of *Escherichia coli* bacteria for the Chattahoochee River, Chattahoochee River National Recreation Area, Georgia, 2000–2019: U.S. Geological Survey Open-File Report 2020–1048, https://doi.org/ 10.3133/ ofr20201048.
12) A Partially Treated Problem: Overflows from Combined Sewers, report from Office of the New York State Comptroller, Thomas P. DiNapoli, (2018) https://www.osc.state.ny.us/files/local-government/publications/pdf/combined-sewers.pdf (accessed February, 6, 2023)
13) Fourth National Climate Assessment (2018) https://nca2018.globalchange.gov/
14) Huang, H.; Patricola, C.M.; Winter, J.M; Osterberg, E.C; Mankin, J.S. (2021) Rise in Northeast US extreme precipitation caused by Atlantic variability and climate change. *Weather and Climate Extremes*. 33: Article 100351. https://doi.org/10.1016/j.wace.2021.100351
15) Environmental Facilities Corporation (New York State) https://efc.ny.gov/
16) US EPA Enforcement and Compliance History Online. https://echo.epa.gov/
17) NYS Environmental Facilities Corp.'s 2022 Final Annual Intended Use Plan for the Clean Water State Revolving Fund. https://efc.ny.gov/system/files/documents/2021/11/11172021_cwiup_web.pdf

Acknowledgments

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Blueback Herring in the Hudson-Mohawk watershed: anadromy run amok?

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The Hudson River is divided roughly into three geographic regions: the upper Hudson, sourced out of the Adirondack High Peaks region; the Mohawk River, which joins the Hudson approximately 255 km from the mouth; and the tidal estuary, which flows south from the Troy Dam (253 km from the sea) to its marine exit at New York City. Blueback Herring (BBH) use all regions for spawning and nursery habitat. The upper Hudson is poorly researched, but BBH are known to run regularly through the Mohawk's locks and canalways, at times having been found as far west as Lake Ontario. We used a combination of biogeochemical biomarkers to interpret how they spent their last year prior to being captured, as well as provenance. Our preliminary findings suggest that many BBH spent their final year of life in estuarine waters of varying salinity. Some fish had ambiguous biomarker signatures that may suggest yet a different final-year habitat, i.e., out-of-basin but not oceanic. We conclude that BBH in this system display highly flexible migration modes.

Evidence of "moderate" philopatry?

Capture River	Origin	2000	2003	2012	2013	2016	2017	2018	Row totals
Hudson	Hudson	5	9	0	15	0	17	0	46
Hudson	Mohawk	2	1	0	32	0	3	0	38
Total		7	10	0	47	0	20	0	84
	H:M	2.5	9		0.47		5.7		
Mohawk	Hudson	0	0	4	3	4	0	1	12
Mohawk	Mohawk	0	0	27	32	36	0	7	102
Total		0	0	31	35	40	0	8	114
	H:M			0.15	0.09	0.11		0.14	
Column Totals		7	10	31	82	40	20	8	198

Limburg, Ewell Hodkin & Wells, in prep.

Table 1: Natal origins of blueback herring in the Hudson-Mohawk watershed were determined by otolith chemistry ($^{87}Sr/^{86}Sr$ and bulk Sr:Ca ratios). H:M ratios show that fish tend to return to their natal rivers to spawn.

Looking into the "big blue box" – try to understand marine migrations of adult BBH in the final year before being captured on or en route to the spawning grounds

- Used a variety of biogeochemical tracers:
  - Strontium isotopic ratios to understand ***salinity*** of final year Otolith chemistry
  - Oxygen isotopic ratios to estimate ***temperature*** of final year Otolith chemistry
  - Stable isotopic ratios of C and N for ***diet histories*** Muscle tissue

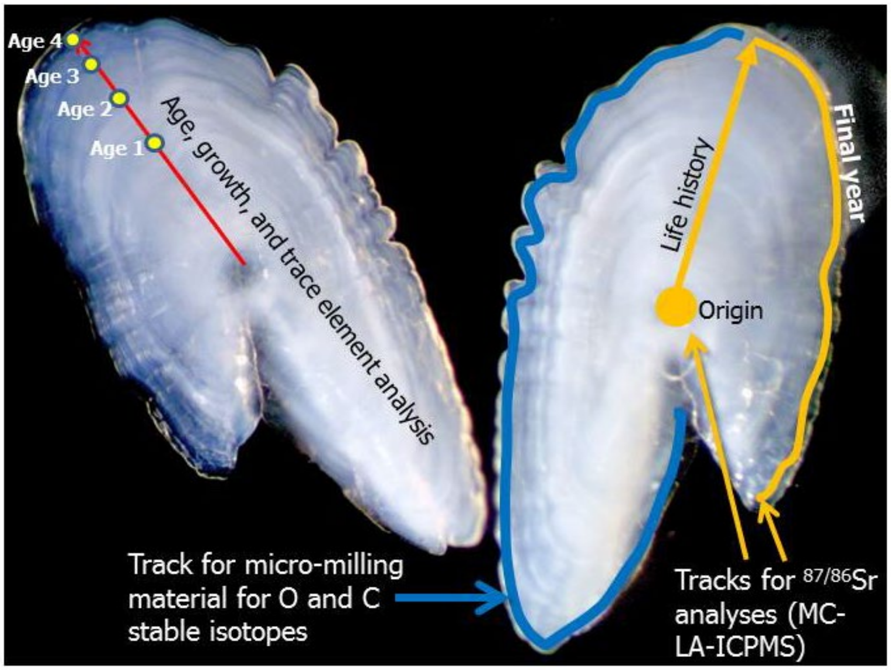

Figure 1: Otoliths of an adult blueback herring, showing how samples were processed for age determination and trace element analysis (left), and for isotopic studies (right).

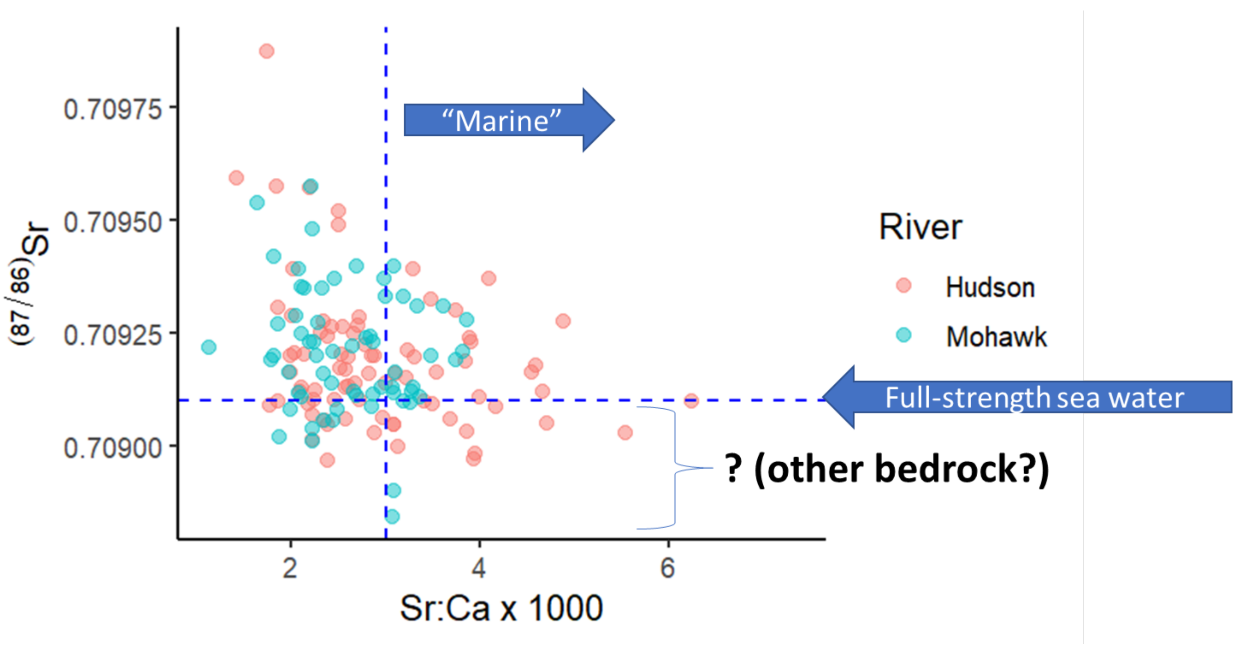

Figure 2: Results of otolith strontium isotope and bulk Sr:Ca analyses suggest that only a minority of adult blueback herring captured on (or en route to) spawning grounds could be classified as having spent their final year in the Atlantic Ocean. This was an unexpected result.

Identifying nitrogen inputs to the Mohawk River and tributaries in the greater Utica area

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As a vital part of amino acids, proteins, and pigments, nitrogen (N) is a crucial nutrient for freshwater ecosystems and their primary producers. Without enough N organisms would not be able to grow, but excess N can contribute to overgrowth of algae and aquatic plants, sometimes leading to harmful algal blooms (HABs) or hypoxia. HABs release toxins in the water, leading to negative impacts to resident aquatic organisms and making water unsafe for human consumption or recreation. Though N is typically not the growth-limiting nutrient in freshwater, some recent research indicates the form of N in freshwater systems can be an important determinant of HAB formation and toxicity. In particular, many HAB-forming cyanobacteria seem to prefer N present as ammonium or urea instead of nitrate. HABs are widely recognized as a growing concern throughout the US and much of the rest of the country, but relatively little is known about N cycling in the Mohawk River and nearby freshwater ecosystems. We present data on N concentrations in rivers, streams, and lakes around the local Utica area collected from 2019-2022, including the Mohawk River, some of its tributaries, and other nearby environments. Our particular foci include comparing concentrations of urea and ammonium to nitrate and nitrite, tracking nitrite as a possible marker of nitrification, and comparing overall inorganic N and urea concentrations to phosphate concentrations. These data will help us further understand nutrient sources and cycling in these waters, a key part of determining their susceptibility to HABs and in maintaining their overall water quality as a drinking water from these sources. We are currently connecting these nutrient data to fecal source tracking analyses to better determine the specific nutrient inputs such as agricultural runoff or sewage.

Recreational Boating in the Mohawk Watershed

Daniel Miller

US Coast Guard Auxiliary, Sacandaga Mohawk Flotilla, Glenville, NY

"The victim was not wearing a life jacket when found unresponsive in the water."

A recent accidental drowning highlights the need for education and awareness of boating safety. Using NYS Department of Motor Vehicles boat registration data and identification of boat launches and marinas, the poster seeks to identify areas where more boater education efforts may be directed.

iMapInvasives: the official invasive species database for New York State

Mitchell O'Neill

New York Natural Heritage Program, Albany, NY

Abstract

iMapInvasives is an online, collaborative, GIS-based database and mapping tool used for tracking invasive species in North America. iMapInvasives is used by natural resource professionals, community scientists, and members of the public to both submit and obtain information about invasive species. The platform enables real-time tracking of infestations and improves management decisions to protect native species and ecosystems. Powered by the international non-profit, NatureServe, iMapInvasives can be used anywhere in North America, and is actively used in several U.S. states and Canadian provinces.

In New York State, iMapInvasives serves as the official database for invasive species work, and it is administered by the New York Natural Heritage Program (NYNHP), a partnership between SUNY College of Environmental Science and Forestry and the NYS Department of Environmental Conservation. Key users include the Partnerships for Regional Invasive Species Management (PRISMs), State agencies (including the Department of Environmental Conservation, and the Office of Parks, Recreation, and Historic Preservation), various non-profits, community scientists, students, educators, researchers, and members of the public.

Key features include a filterable map interface with data summary tools, mobile reporting tools, customizable email alerts, and the ability to track survey efforts (including presence and not-detected data) as well as management efforts and their effectiveness over time.

References

iMapInvasives: NatureServe's online data system supporting strategic invasive species management. © [2023], NatureServe. Available at http://www.imapinvasives.org.

Changes in temperature and precipitation patterns in the Mohawk Watershed: implications for flooding, water quality, and ecosystem health

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Precipitation patterns in central and eastern NY are affected by several processes that vary over the course of a year, and these processes appear to be changing, which has major implications for the hydrology of the watershed. The western part of the Mohawk Watershed (i.e., West Canada Creek) is one part of the basin that is affected by lake-effect snowfall because it is downwind of Lake Ontario. Warmer temperatures have resulted in an increase in lake-effect snowfall because lake temperatures are warmer and there is more ice-free water (Burnett et al., 2003). Coastal systems that draw on moisture from the Atlantic have made significant impacts on the watershed, especially in the Schoharie valley, and some of these events have driven damaging flooding (i.e., Irene/Lee in 2011).

Therefore changes in watershed hydrology are complicated by several different processes that drive precipitation. Understanding these changes is important for watershed management for several reasons. Fundamentally, increases in precipitation may drive flooding, but the temporal pace of flooding may be changing. Precipitation also has indirect effects on water quality. Snowfall results in widespread use of deicers, mainly sodium chloride, which is driving regional salinization that affects aquatic ecosystems and drinking water supplies. It also seems clear that our sewage infrastructure is having trouble handling extreme precipitation events. Associated sewage overflows and leaking pipes drive sewage into rivers, impairing recreation and drinking water sources. Hence, we are interested in understanding how precipitation, including snowfall, is changing the Mohawk Watershed and the reasons behind those changes.

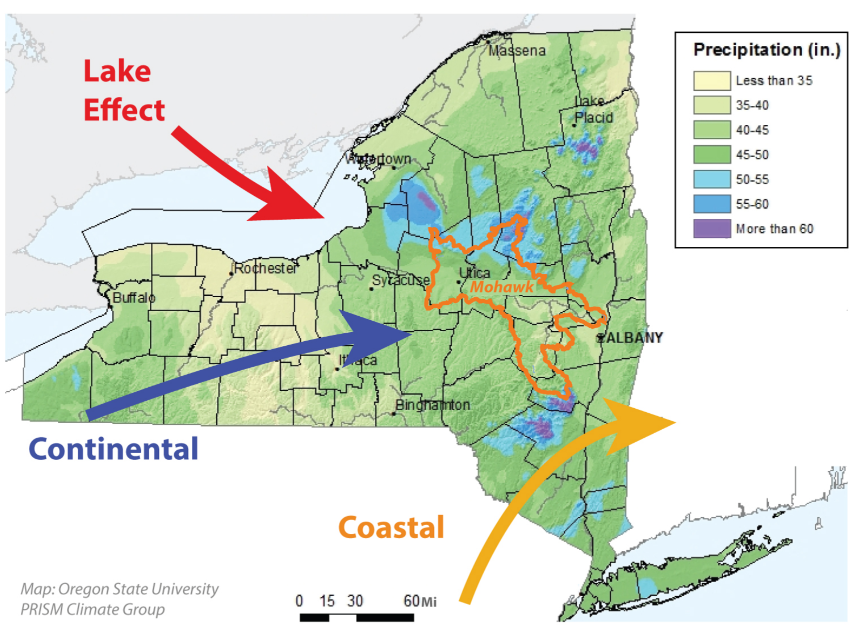


Figure 1: New York State, with the Mohawk Watershed outlined and prevalent sources and directions of moisture delivery indicated by arrows.

1. Precipitation and temperature in the Mohawk Watershed.

To evaluate changes in precipitation in the Mohawk Watershed, we evaluated nine stations in the NCEI GSOD database that are within or very close to the watershed. These sites are mostly records from individual airports, with data from Albany, Schenectady, Utica, Fort Plain, and Rome. Collectively these data sets extend back to 1945, with essentially continuous temperature and precipitation measurements. The benefit of using this many stations is that the precipitation gaps can be filled in by other stations to make an average for the whole basin. To assess changes in snowfall over the period of study we analyzed data from the Midwest Regional Climate Center at Perdue (https://mrcc.purdue.edu/).

Temperature. There is an increase in both annual and monthly temperature throughout the record. The whole basin has undergone a significant warming of mean annual temperatures by nearly 2°C since 1945. If the change continues in a linear way into the future, the last decade of this century (2090-2100) will have a mean temperature of 12.48°C (±0.8°C), which is an approximately 3°C increase from the present decade. Although this calculation does not account for any modes of natural variability, the mean temperature change is equivalent to what would be predicted under the RCP4.5 and RCP6.0 scenarios (Hayhoe et al., 2014).

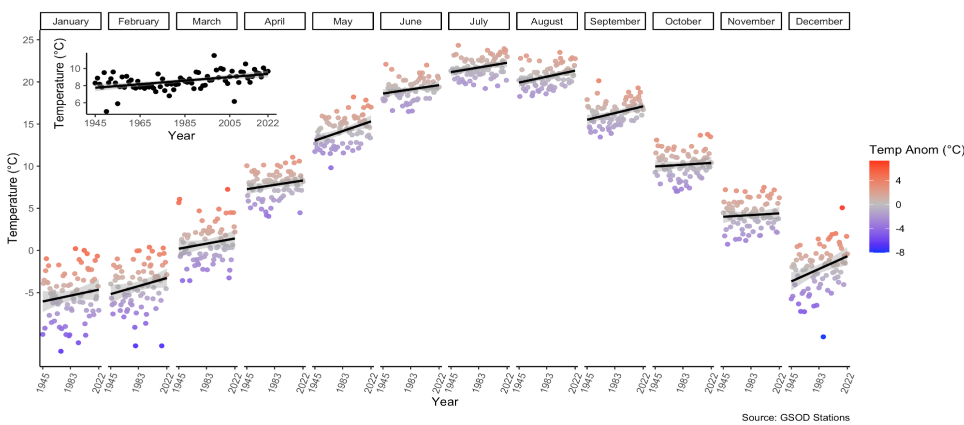
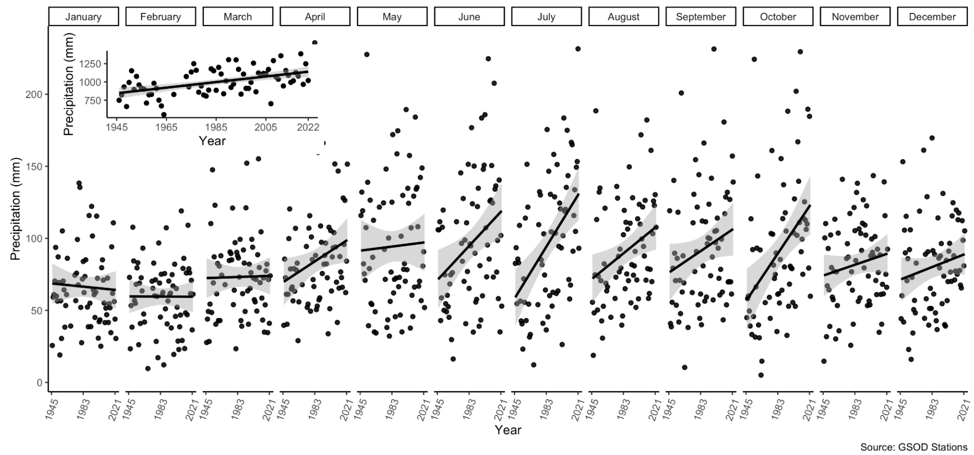


Table 1: Trends and P Values for monthly and annual temperature

	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Trend (°C/yr)	0.018	0.025	0.016	0.013	0.029	0.013	0.014	0.018	0.021	0.005	0.005	0.038	0.021
P Value	0.200	0.054	0.163	0.097	4.06E-04	0.027	0.014	0.003	0.002	0.502	0.53	0.002	1.76E-05

There are seasonal discrepancies in the rate and significance of warming. The greatest warming trends are in the winter (DJF). While the significance of this warming is low in January, warming is significant in February and December, and the rate of warming in December is the highest. Warming in May is significant and the second fastest rate of all months. June, July, August, and September are also seeing significant warming through the record. It is important to note that when calculated over the last 42 years, warming becomes more significant in all months.

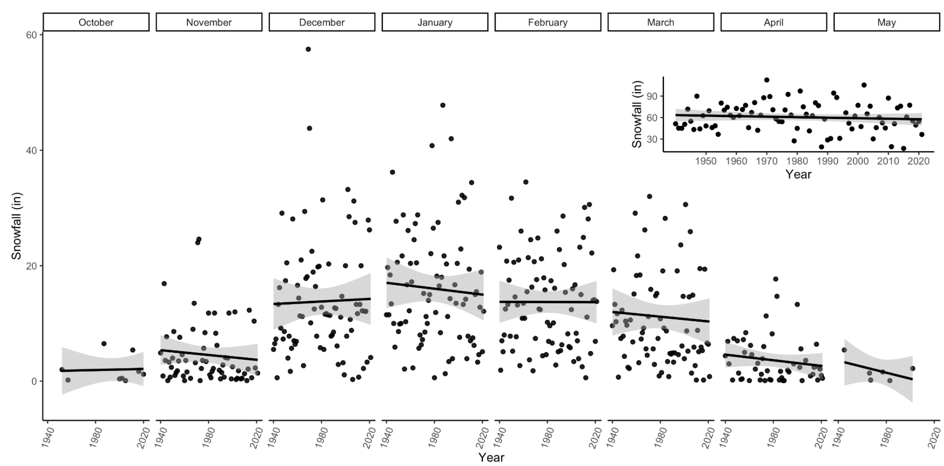
Precipitation. Annual precipitation across the watershed has undergone a statistically significant increase of 3.82 mm/year since 1945. Our analysis reveals key differences in seasonal precipitation trends. There does not appear to be a significant trend in precipitation in any of the winter months. There may be an increase in winter precipitation in the extreme western part of the basin (i.e., West Canada Creek), which is partly influenced by lake-effect from Lake Ontario (including the Tug Hill Plateau - see below). There appears to be little change in spring precipitation with the exception of April (increase). There are also significant increases in precipitation in June, July, August, and September. The increase in spring, summer, and autumn precipitation may well be driving flooding and water quality issues.



	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Trend (mm/yr)	-0.058	-0.003	0.021	0.381	0.075	0.625	0.947	0.471	0.394	0.868	0.198	0.229	3.832
P Value	0.702	0.981	0.891	0.037	0.751	0.007	3.66E-05	0.012	0.072	4.99E-04	0.214	0.177	1.65E-05

Table 2: Trends and P Values for monthly and annual precipitation

Albany snowfall. The annual snowfall record for Albany, which is in the far eastern edge of the Mohawk Watershed, has a slight negative trend. Our analysis indicates that trends in annual snowfall in Albany are relatively weak when compared to liquid precipitation. Thus, attributing meaningful trends to these data is difficult. November, April, and May show increases in precipitation but decreases in snowfall totals. These results would seem to be consistent with an increase in temperature driving more precipitation in autumn and spring, but the regime is shifting to more rain instead of snow. The lack of significant trend in precipitation and snowfall in the winter may be a result of the absence of a strong snowfall driver (i.e., lake-effect or coastal) in the watershed.



	October	November	December	January	February	March	April	May	Annual
Trend (in/yr)	0.004	-0.021	0.011	-0.1435	-0.001	-0.02	-0.024	-0.051	-0.072
P Value	0.899	0.472	0.819	0.591	0.984	0.639	0.308	0.299	0.443

Table 3: Trends and P Values for monthly and annual snowfall

2. Lake-effect snowfall

Previous work has showed a statistically significant increase for lake-effect snowfall and no trend in adjacent non-lake-effect settings across the Northeast (see Burnett et al (2003), and this pattern appears to have continued to the present. The increase in lake-effect snow in the latter part of the 20th century is believed to arise from warmer surface water in the Great Lakes and a decrease in ice cover. This change may be important for the upper part of the Mohawk Watershed (esp. West Canada Creek) that is affected by winter lake-effect snowfall.

NOAA/GLERL collect and maintain an ice cover database derived from satellite measurements of ice cover across the Great Lakes. The plots below show changes in ice cover (left) and changes in snowfall (right) in the winter. Over the last 49 years there have been significant negative trends in ice cover during January and February. The decrease in ice cover appears to be negatively correlated with the significantly increasing trends of lake-effect snow over the last 49 years. The increasing trend in snowfall in the winter months (DJF) supports the hypothesis from Burnett and colleagues (2003) that less ice cover and warmer lake temperatures during the winter results in more lake-effect snowfall. The autumn snowfall, which is less substantial than winter snowfall, is decreasing across lake-effect sites that we analyzed, and this could be due to rising surface temperatures.

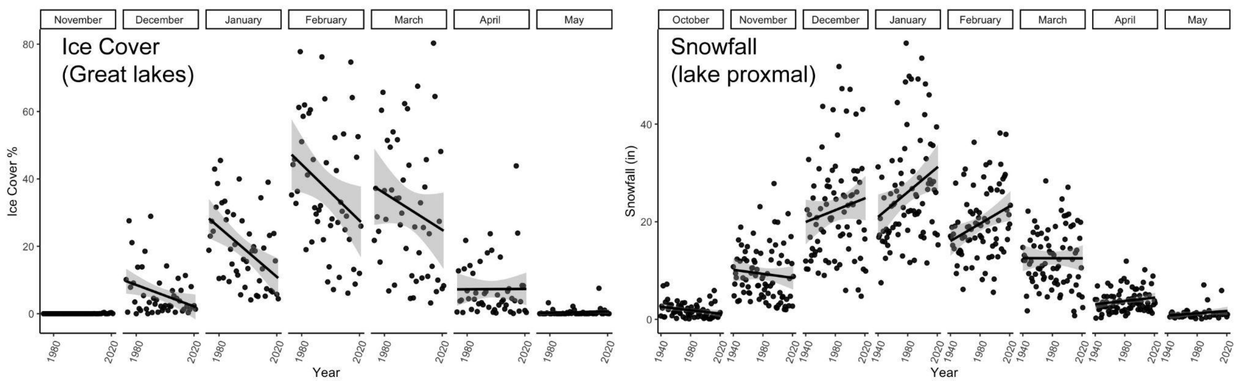


Table 4: Trends and P Values for monthly and annual ice cover (top) and lake effect snow (bottom)

	November	December	January	February	March	April	May	Annual
Trend (%/yr)	0.002	-0.159	-0.368	-0.417	-0.272	0.003	0.010	-0.171
P Value	8.48E-04	0.019	9.26E-04	0.031	0.185	0.971	0.398	0.036
Trend (in/yr)	-0.020	0.060	0.126	0.089	-4.29E-04	0.017	0.012	0.047
P Value	0.43	0.220	0.017	0.007	0.988	0.117	0.215	9.74E-04

3. Implications

There have been a number of studies on the impact of climate change, especially in the Northeast, on the temporal (when) and spatial (where) distribution of precipitation in NY and New England (Hayhoe et al., 2007; Frumhoff et al., 2008; Pourmokhtarian et al., 2016; Huang et al., 2017). This part of the Northeastern United States appears to be difficult to model for future climate change, and this difficulty is partly a function of the difference in the way in which storms track through NY (Huang et al., 2017). In the watershed it has long been recognized that we are seeing more precipitation and that that precipitation is not evenly distributed (Garver and Cockburn, 2011, 2012; Cockburn and Garver, 2015).

There are several key findings from these data. One is that winters are getting warmer and in most of the basin winter precipitation has not changed significantly. The exception is the upper part of the watershed (especially West Canada Creek) that drain parts of the western Adirondacks, as well as the Tug Hill Plateau, where snowfall may be increasing due to enhanced lake-effect snowfall driven by warmer temperatures and reduced ice cover. A full analysis of the change in Atlantic-driven precipitaion needs to be undertaken.

Precipitation in the watershed is increasing in the summer and early fall, which is partly related to coastal atmospheric systems; some of these have driven dramatic and spectacular floods (e.g., Irene). It is established that with a warming atmosphere, the mid- and high-latitudes are most likely to observe increases in annual precipitation through the 21st century. Hayhoe et al (2018) projected that the majority of the increase in annual precipitation across the Northeast will occur during winter and spring. The biggest change in precipitation appears to be in the summer and fall, and some of the extreme events in this part of the year are directly attributed to Altlantic-driven precipitation.

Flooding and water quality. The changes in precipitation may have two important implications for flooding in the watershed. One is that rain-driven flooding is becoming more frequent in the summer months, and another is that winter ice-jam flooding is becoming less frequent (see Garver, 2021a). The increase in precipitation in the summer, which coincides with the navigation and recreation season, is problematic because increased precipitation may drive sewage overflows and exfiltration from leaky, impaired, or aging pipes (Garver, 2021b). It appears that this effect may already have been recognized and enumerated in regional water quality studies using fecal indicator bacteria (see Law et al., this volume). Although snowfall amounts have remained nearly constant across the basin, warming winters mean that deicing (NaCl as road salt) may see a reduction. This potentially has important implications for the reduction of regional salinization of rivers and streams in the watershed, some of which are used as sources of drinking water (e.g., by Cohoes and Colonie) and those sources have shown an increase in chloride in the last few decades.

References

Adam H. Sparks, Tomislav Hengl and Andrew Nelson (2017). GSODR: Global Summary Daily Weather Data in R. The Journal of Open Source Software, 2(10). DOI: 10.21105/joss.00177.

Burnett, A.W., Kirby, M.E., Mullins, H.T. and Patterson, W.P., 2003. Increasing Great Lake–effect snowfall during the twentieth century: A regional response to global warming? *J. of Climate*, *16*(21), pp.3535-3542.

Cockburn, J.M. and Garver, J.I., 2015. Abrupt change in runoff on the north slope of the Catskill Mountains, NY, USA: Above average discharge in the last two decades. J. of Hydrology: Regional Studies, 3, pp.199-210.

Frumhoff, P.C., McCarthy, J.J., Melillo, J.M., Moser, S.C., Wuebbles, D.J., Wake, C. and Spanger-Siegfried, E., 2008. An integrated climate change assessment for the Northeast United States. Mitigation and adaptation strategies for global change, 13(5-6), pp.419-423.

Garver, J.I. and Cockburn, J.M.H., 2011, Changes in the Hydrology of the Mohawk Watershed and implications for watershed management. In Mohawk Watershed Symposium (pp. 16-21).

Garver, J.I. and Cockburn, J.M.H., 2012, Change in the Mohawk Watershed and vulnerability to Infrastructure. In Mohawk Watershed Symposium (pp. 12-16).

Garver, J.I. 2021a. River ice in a shrinking cryosphere: Warmer winters will reduce ice jams and change winter ecology. February 2021, *Notes from a watershed* (Mohawk.substack.com).

Garver, J.I.. 2021b. Extereme rainfall in the Northeast: its raining a lot and our wasetwater system is bursting at the seams. October 2021. *Notes from a watershed* (Mohawk.substack.com).

Hayhoe, K., D.J. Wuebbles, D.R. Easterling, D.W. Fahey, S. Doherty, J. Kossin, W. Sweet, R. Vose, and M. Wehner, 2018: Our Changing Climate. In Impacts, Risks, and Adaptation in the US: Fourth National Climate Assessment, v. II - U.S. Global Change Research Program, Washington, DC, pp. 72–144.

Hayhoe, K., and 10 others, 2007. Past and future changes in climate and hydrological indicators in the US Northeast. Climate Dynamics, 28(4), pp.381-407.

Huang, H., Winter, J.M., Osterberg, E.C., Horton, R.M. and Beckage, B., 2017. Total and extreme precipitation changes over the Northeastern United States. J. of Hydrometeorology, 18(6), pp.1783-1798

NOAA. Historical Ice Cover, Daily averages by lake: basinwide. Great Lakes Environmental Research Laboratory, https://www.glerl.noaa.gov/data/ice/#historical. Accessed 12/21/2022.

Perica, S., Pavlovic, S., St Laurent, M., Trypaluk, C., Unruh, D., Martin, D. and Wilhite, O., 2015. Precipitation-Frequency Atlas of the United States. Volume 10, Version 3.0. Northern States; Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont

Snowfall Climatology Toolbox, Midwestern Regional Climate Center, C2023r. December 2022. Retrieved from /mw_climate/snowfallClimatology/snowfallClimatology.html.

Sauquoit Creek Channel & Floodplain Restoration Program: Community resiliency to flooding using mitigation and adaptation

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Introduction

Since its inception in 2016, the Sauquoit Creek Channel & Floodplain Restoration Program has evolved into the largest program of its kind in New York State. This program is an on-going effort to determine and implement the improvements needed to alleviate historical flooding (Figure 1) along the Sauquoit Creek in the Town of Whitestown, Oneida County. Due to the success of this innovative program, it is being used as a model throughout the State on how communities can actively become more resilient to flooding due to climate change (Figure 2). It is an example for other municipalities in the Sauquoit Creek Basin as well as other nearby watersheds.

Figure 1: Flooding: 2019 Halloween Storm - Whitesboro, NY

Figure 2: Flooding at the CSX Bridge: 2019 Halloween Storm - Whitesboro, NY

Program Description

The Sauquoit Creek Channel & Floodplain Restoration Program is a global approach consisting of five major components:

- Mitigation (natural approach; construction of floodplain benches)
- Adaptation (residential property buy-out: NRCS EWPP -FEP Program)
- Infrastructure Improvements (bridges and culverts)
- Floodplain Management (smarter development)
- Debris Management (routine maintenance)

Collectively, the components of the Sauquoit Creek Channel & Floodplain Restoration provide the greatest flood stage benefit and/or reduction. It will also help to assist those affected by repetitive flooding and protect against future loss in the most effective manner.

Mitigation

The mitigation component involves the construction of several floodplain benches, areas of bank stabilization, channel widening and the creation of a public access trail along a 1-plus-mile corridor of the lower Sauquoit Creek in Whitestown and Whitesboro. The work will continue to stabilize the lower Sauquoit Creek while connecting it to its original floodplain. This helps create a reduction in flood stage during flooding events, lessening damage to repetitive flood loss homes and businesses. In October 2019, Mitigation Project 1 involving the construction of two floodplain benches (Figure 3) at Dunham Manor Park in Whitestown, was completed. This project was originally chosen because the Town owned the property (Figure 4).

Figure 3: Construction of Project 1.

Figure 4: Project 1 Flood bench.

The construction of Mitigation Project 2 (Figure 5) began in the summer of 2021 and was completed in August 2022. Mitigation Project 2 specifically includes the construction of a floodplain bench in the Village of Whitesboro south of the CSX Railroad Crossing with five additional 48" diameter culverts (Figure 6) being installed underneath the CSX Railbed with a return bench on the north side.

Figure 5: Project 2 – Return floodplain bench, Whitesboro, NY.

Figure 6: Project 2 – Culverts and floodplain bench, Whitesboro, NY.

Whitestown recently secured additional grant funding for Mitigation Project 3 which includes enhancing the floodplain bench on Project 2 and constructing an additional flood bench just downstream of Project 1. The Town has also secured a NYSDEC Community Forest Conservation Grant to acquire property required for Project 3 while conserving approximately 14 acres of forested land adjacent to Sauquoit Creek. There are also plans for Mitigation Project 4, which will conclude with the construction of additional flood mitigation measures. This project will complete the Town of Whitestown's original construction goal set in 2016 when it launched the mitigation component of the Sauquoit Creek Channel & Floodplain Restoration Program.

Mitigation Project Timeline

- 11 Floodplain Benches Proposed: Mid-2016 (Program Launch)
- Project 1:
  - Preliminary & Final Design: June 2016 - November 2018
  - Construction: March 2019 - October 2019
- Project 2:
  - Preliminary Design & Final Design: September 2018 - March 2021
  - Construction: June 2021 - August 2022
- Project 3:
  - Preliminary Design: June 2021 - present
  - Projected Construction Completion: December 2025

Adaptation

The adaptation component involves the potential buyout of repetitive flood loss residential properties in the Village of Whitesboro (Figure 7) using federal funding secured through the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). The purpose of the NRCS Emergency Watershed Protection Program – Floodplain Easement (EWPP-FPE) is to purchase floodplain easements on eligible lands and to restore the floodplain functions and values to natural conditions to the greatest extent practicable. Floodplain easements restore, protect, maintain, and enhance the functions of the floodplain along with reducing long-term federal disaster assistance while safeguarding lives and property. The buyout of a participating property owner's property is achieved by NRCS purchasing both a floodplain easement and the structures (house) within the easement area; and the Town of Whitestown, as project sponsor, purchasing the remaining fee title (land). The value of the property is based on the appraised fair market value as of the day before the 2019 Halloween Storm. At the end of the process, the Town of Whitestown becomes the property owner, subject to a floodplain easement held by the United States. The land within the floodplain easement must remain forever "green" in accordance with NRCS regulations.

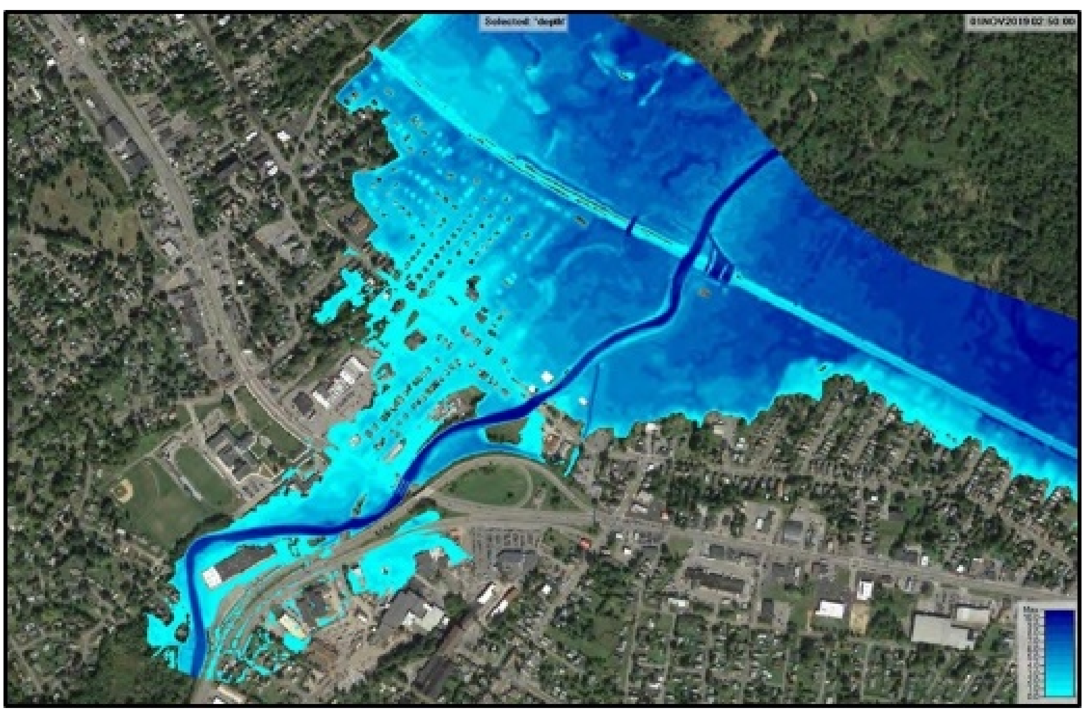

Figure 7: Peak Flow – 2019 Halloween Storm, Whitesboro, NY.

Infrastructure Improvements

The infrastructure improvements component involves the evaluation of future upsizing of several bridges and culverts in the Town of Whitestown along the lower Sauquoit Creek.

Floodplain Management

The floodplain management component involves the adoption of smarter, or "green," development practices in the Sauquoit Creek Watershed through municipal zoning and other controls.

Debris Management

The Debris Management component involves all municipalities in the Sauquoit Creek Watershed participating in the "Sauquoit Creek Stream Sediment and Debris Management Plan," which was developed by the engineering firm Ramboll Group, and formally adopted by the Sauquoit Creek Basin Intermunicipal Commission in August 2021. This plan includes actions designated for each municipality within the watershed that were developed to assist in making their communities more resilient to flooding.

Collaboration

The Sauquoit Creek Channel & Floodplain Restoration Program is an impressive, "all hands-on deck" approach, with collaboration among all involved stakeholders. Included in this effort between federal, state, county, and local governments, are the offices of the Governor, Senator, Congress, Oneida County Executive, Town of Whitestown, and Village of Whitesboro. Extensive collaboration and teamwork have taken place with New York State Department of Environmental Conservation, New York State Department of Transportation, New York State Office of General Services, New York State Environmental Facilities Corporation, Natural Resources Conservation Service, Federal Emergency Management Agency, Sauquoit Creek Basin Intermunicipal Commission, Town of Whitestown, Village of Whitesboro and Ramboll. While the Town of Whitestown is a catalyst, there is no way Whitestown could take on, implement, and fund a program of this magnitude on its own. They remain grateful for all the support and outstanding teamwork.

Cost and Funding

The Town of Whitestown has received over $9 million in funding for the design and construction of the mitigation projects constructed to date from either federal, state and/or county funding sources. There is over $3.5 million of secured funding for the design and construction of Mitigation Project 3 along with approximately $2 million allocated for the repairs of Project 1 due to damages incurred by the 2019 Halloween Storm. In addition to this funding is the monies that are secured for the NRCS buy-out program that are estimated at greater than $25 million. This investment is a testament to how dedicated all involved stakeholders are to this transformative and most critical program that is making the Town of Whitestown more resilient to the flooding caused by climate change.

References

Kandamby, A.H., Gannon, S.B., 2020, Sauquoit Creek Drainage Study, Findings of 2019 Halloween Storm – Hydraulic Modeling, Ramboll

Fecal indicator bacteria and microbial source tracking in the Mohawk River watershed: Observations from a case study in Utica and Rome, NY

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Background

The Mohawk River Basin Action Agenda highlights goals of improved water quality, recreation, and stewardship for the Mohawk River watershed (NYSDEC, 2021). To protect the public from recreational health risks, the USEPA proposes the use of fecal indicator bacteria (FIB) *E. coli* and *Enterococci* (USEPA, 2012). The presence of these FIB indicates the potential for fecal contamination of a waterbody. In the Mohawk River watershed, several studies have shown elevated FIB (Cockburn and Garver, 2018, Garver, *et* al., 2019, Garver *et* al. 2020, Lininger, *et* al., 2022). However, FIB are not specific to source type. Microbial source tracking (MST) can be used to identify the potential contaminant source type (e.g., human, canine, bovine). This information allows for improved understanding of the recreational risk and additional understanding of the mechanisms and sources of contamination. A parallel sampling campaign for FIB and MST was conducted on the Mohawk and select tributaries in Utica and Rome NY in 2019. Selected results are presented here.

Methods

Samples were collected from 10 sites in the Utica-Rome region of the Mohawk River watershed (Figure 1) over 20 days in the summer of 2019. Five of the sampling sites are located along the Mohawk River in the general area of Utica, two sites represent tributaries in the area (Sauquoit Creek and Oriskany Creek), and three sites are along the Mohawk River as it flows through Rome NY. The sample collection took approximately 2 hours, during which samples were kept on ice. Samples used for analysis of FIB were dropped off at the ELAP certified Onondaga County Water Environment Protection laboratory in Syracuse, NY. The samples for MST were transported to the SUNY Poly lab and immediately processed. Processing included: bacterial concentration through centrifugation, DNA extraction via Qiagen DNeasy PowerSoil Pro Kit, DNA quantification using DENVOIVS UV Spectrophotometry, and source tracking analysis via qRT-PCR for broad-range bacteria, human-specific bacteria (HF183), and bovine-specific bacteria (COWM3) TaqMan gene expression assays (Nadkarni, *et* al., 2002, Haugland, *et* al., 2010, Shanks *et* al., 2008).

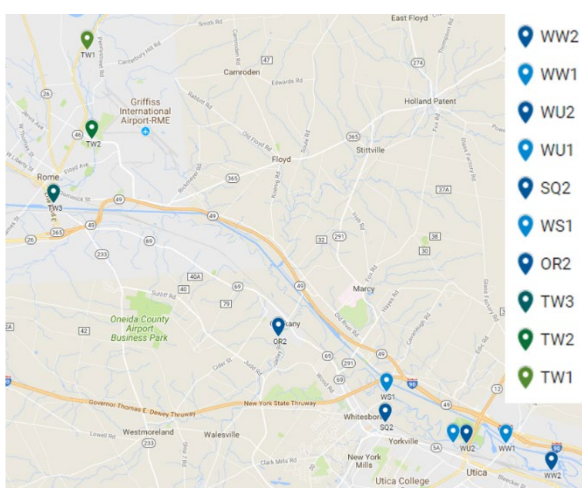

Figure 1: Location of 10 sites in the Utica-Rome region of the Mohawk River watershed.

Results and Discussion

The sampling campaign resulted in 19-20 samples per site for FIB analysis and 17-18 samples per site processed for MST. The following results and discussion focus on the use of FIB for assessing recreational risk and the co-occurrence of FIB and MST markers.

FIB Occurrence and recreational risk. In 2012, the USEPA defined recreational water quality criteria as follows for FIB for use in assessing risk from recreation in surface water bodies:

- Geometric Mean (GM)
  - E. coli < 100 CFU/100mL
  - Enterococci < 30 CFU/100mL
- Statistical Threshold Value (STV) – *90% of the samples should be below this value*
  - E. coli < 320 CFU/100mL
  - Enterococci <110 CFU/100mL
- Beach Action Value (BAV) – *single sample threshold value*
  - E. coli < 190 CFU/100mL
  - Enterococci < 60 CFU/100mL

Table 1 shows the evaluation of FIB with respect to the 2012 RWQC for each of the 10 sites. Sites which failed the GM or STV for each of the FIB are bolded in red. The sampling sites along the Mohawk in Rome NY demonstrated occasional recreational risks as indicated by BAV exceedances in 15-25% of the samples. All three of these sites in Rome also passed the GM and STV for E. coli. However, the upstream (TW1) and most downstream sample location (TW3) in Rome failed to pass the enterococci STV, with TW3 also failing the Enterococci GM. Values remain close to the RWQC thresholds, such that recreation at these sites may be appropriate.

All seven sampling sites in the Utica region, including sites along the Mohawk River and the tributaries of Sauquoit Creek and Oriskany Creek, failed the GM and STV for both FIB. In addition, the sites frequently violated the BAVs for both FIB with Sauquoit Creek violating the BAV in 85% and 95% of the samples for E. coli and Enterococci respectively. Although some sites show potential for future recreation, the sites in the Utica region are not currently appropriate for recreation based on the 2012 RWQC.

Table 1: FIB by site compared to the 2012 RWQC

n=20	Geometric Mean		% of Samples below STV		% of samples above BAV	
	E. coli	Enterococci	E. coli	Enterococci	E. coli	Enterococci
WW2	**439**	**144**	**40%**	**55%**	80%	60%
WW1	**254**	**60**	**60%**	**80%**	55%	35%
WU2	**186**	**69**	**75%**	**75%**	65%	40%
WU1*	**245**	**73**	**63%**	**89%**	63%	58%
SQ2	**588**	**238**	**25%**	**35%**	85%	95%
WS1	**180**	**46**	**75%**	**80%**	55%	35%
OR2	**144**	**57**	**75%**	**80%**	60%	45%
TW3	67	**43**	90%	**80%**	15%	25%
TW2	80	30	90%	90%	15%	15%
TW1	95	24	90%	**85%**	10%	15%
* WU1, n=19						

Occurrence of MST Markers. Within the study, the human marker was detected more frequently than the bovine marker, making up 84% of the samples where at least one marker was detected. In addition, the bovine marker showed up once (one day at one site) without the co-detection of the human marker. Therefore, the discussion which follows is representative of MST detection of primarily the HF183 human-source MST marker. Table 2 shows the percent of samples at each site which resulted in the detection of at least one MST marker. In general, detection of MST markers increased along the path of the water with no MST markers present at TW1 to the 65% detection rate at the most downstream site, WW2. Interestingly, only 33% of samples from Sauquoit Creek resulted in a detectable MST marker despite frequently failing to pass the single sample BAV, GM, or STV for both FIB. This suggests a significant source of FIB in the creek that is not human or bovine.

Table 2: Detection frequency for MST markers

Site	n	% samples with MST detection
WW2	17	**65%**
WW1	18	44%
WU2	18	56%
WU1	17	59%
SQ2	18	33%
WS1	18	39%
OR2	18	22%
TW3	18	17%
TW2	18	11%
TW1	17	**0%**

Co-occurrence of FIB and MST Markers. Table 3 provides a summary of the general co-occurrence of FIB above the BAV and the detection of a human or bovine source marker in the Utica-Rome region. Of the 61 samples where at least one of the MST markers was detected, 51 (83.7%) of these sites also had at least one FIB above the BAV. This suggests detection of a marker could indicate elevated FIB. However, FIB above the BAV does not necessarily result in the detection of a marker. Of the 107 samples which included at least one FIB above the BAV, only 47.7% of those samples included the detection of at least one MST marker. This suggests additional sources of FIB exist within the region.

Table 3: Regional Co-occurrence of FIB and MST Markers

Condition	Marker*	No marker	Total
Any FIB $\geq$ BAV	51	56	107
Both FIB < BAV	10	60	70
Total	61	116	177

*one or more MST marker detected.

Table 4 provides a summary of the co-occurrence of FIB and MST makers by site. A few noteworthy results have been highlighted in yellow. The most downstream site in Utica, WW2, is also just downstream of a combine sewer overflow (CSO). 47% of the samples collected from this location included detection of the MST markers and elevation of both FIB above their BAVs. In general, the five sites along the Mohawk were more likely to include a marker than not when at least one FIB was above the BAV. The three sites in Rome had very few MST detections, leaving the few elevated FIB conditions with little additional explanation regarding potential sources of fecal contamination. However, very few violations of the BAV occurred at these three sites. The tributaries presented a more complex picture with 50% of the samples at Sauquoit Creek resulting in both FIB above the BAV but with no detectable markers, supporting the hypothesis of a significant non-human or bovine source along the tributary. The Oriskany Creek data also support the hypothesis of a significant undetermined source of FIB as samples with at least one FIB above the BAV were more likely to result in no identified source than in a marker detection through the MST.

Table 4: Co-occurrence of FIB and MST Markers by site

Site	n	Both FIB ≥ BAV		Only E. coli ≥ BAV		Only Entero ≥ BAV		Both FIB < BAV	
		Marker	No marker	Marker	No marker	Marker	No marker	Marker	No marker
WW2	17	**47%**	6%	12%	12%	0%	0%	6%	18%
WW1	18	17%	11%	11%	17%	6%	0%	11%	28%
WU2	18	11%	6%	28%	17%	11%	11%	6%	11%
WU1	17	18%	12%	18%	12%	18%	6%	6%	12%
SQ2	18	33%	**50%**	0%	**0%**	0%	**11%**	0%	6%
WS1	18	11%	11%	17%	17%	6%	6%	6%	28%
OR2	18	11%	**17%**	6%	**28%**	0%	**17%**	6%	17%
TW3	18	6%	11%	0%	0%	0%	11%	11%	61%
TW2	18	6%	11%	0%	0%	0%	0%	6%	78%
TW1	17	0%	12%	0%	0%	0%	6%	0%	82%

Conclusions

During the summer of 2019, water quality samples were collected from the Mohawk River watershed in the Utica-Rome area and processed for FIB and MST. Sampling occurred on 20 days and at 10 different locations in the region including the Mohawk River in the Utica and Rome areas along with Sauquoit Creek and Oriskany Creek near their confluence with the Mohawk River. Overall, water quality sampling in 2019 demonstrated levels of FIB above the 2012 RWQC particularly for the seven sites in the Utica region. Microbial source tracking provided support for human sources in the Utica region, particularly along the Mohawk River which is supported by the presence of CSOs in the region. The two tributaries also violated the 2012 RWQC, but the MST for those sites was less conclusive, suggesting a significant non-human or bovine source of fecal contamination. Notably, for SQ2 and OR2, our pan-bacterial probe demonstrated bacterial presence (i.e., 1 to ≥ 10 pg of total DNA for 29% and 41% of sampling dates, respectively) suggesting a contribution from soil sources. Overall, the data suggest that portions of the Mohawk River in Rome could be used for recreation but the locations in the Utica-region are not currently appropriate for recreation, potentially due to human sources of fecal contamination.

Acknowledgements

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References

Cockburn J, and Garver J. (2018). Proceedings of the 2018 Mohawk Watershed Symposium, Union College, Schenectady, NY.

Garver J, Smith J, and Rodak C. (2020). Proceedings of the 2020 Mohawk Watershed Symposium, Union College, Schenectady, NY.

Garver J, and Smith J, and Rodak C. (2019). Proceedings of the 2019 Mohawk Watershed Symposium, Union College, Schenectady, NY.

Haugland RA, Varma M, Sivaganesan M, Kelty C, Peed L, Shanks OC. Evaluation of genetic markers from the 16S rRNA gene V2 region for use in quantitative detection of selected Bacteroidales species and human fecal waste by qPCR. Syst Appl Microbiol. 2010 Oct;33(6):348-57. doi: 10.1016/j.syapm.2010.06.001. Epub 2010 Jul 24. PMID: 20655680.

Lininger KJ, Ormanoski M, Rodak CM. Observations and Correlations from a 3-Year Study of Fecal Indicator Bacteria in the Mohawk River in Upstate NY. *Water*. 2022; 14(13):2137. https://doi.org/10.3390/w14132137

Nadkarni MA, Martin FE, Jacques NA, Hunter N. Determination of bacterial load by real-time PCR using a broad-range (universal) probe and primers set. Microbiology (Reading). 2002 Jan;148(Pt 1):257-266. doi: 10.1099/00221287-148-1-257. PMID: 11782518.

NYSDEC New York State Department of Environmental Conservation (2021). Mohawk River Basin Action Agenda: 2021-2026. https://www.dec.ny.gov/docs/water_pdf/mohawkrbaa2021.pdf

United States Environmental Protection Agency 2012 Recreational Water Quality Criteria. Office of water 820-F-12-058

Shanks OC, Atikovic E, Blackwood AD, Lu J, Noble RT, Domingo JS, Seifring S, Sivaganesan M, Haugland RA. Quantitative PCR for detection and enumeration of genetic markers of bovine fecal pollution. Appl Environ Microbiol. 2008 Feb;74(3):745-52. doi: 10.1128/AEM.01843-07. Epub 2007 Dec 7. PMID: 18065617; PMCID: PMC2227726.

Predicted effects of passage efficiency and additive mortality sources of blueback herring relative to use of novel habitat in the Mohawk River and Erie Canal

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Life-history simulation models were used to predict effects of historical habitat loss in the Hudson River and use of novel habitat the Mohawk River by Blueback Herring *Alosa aestivalis* alongside additive mortality sources such as mortality during upstream passage of navigational locks and marine bycatch. Access to historical habitat in the upper Hudson River increased population abundance relative to no access when upstream passage and downstream survival through dams was sufficiently high. Predicted abundance was reduced relative to a “no passage” scenario when either juvenile or adult downstream survival through dams was less than about 0.50. Access to novel spawning habitat in the Mohawk River and Erie Canal resulted in increased abundance of Blueback Herring when downstream survival of adults and juveniles was at least 0.80 per dam and both upstream passage and probability of using the Mohawk River were greater than about 0.25. Mortality during upstream passage of locks and marine bycatch had the potential to reduce Blueback Herring abundance below historic population abundance, even with access to novel habitat in the Mohawk River and Erie Canal when dam passage was not sufficiently high or the proportion of spawners using novel habitat was less than 0.25.

Characterization of stream turbidity in the Catskills, New York: Insights into environmental controls

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Introduction

The Catskills region is an important supplier of water to New York City (NYC), as the Catskill/Delaware Watersheds contribute to more than 90% of NYC's daily water needs (Watershed Agricultural Council, 2022) (Figure 1). Considering that the NYC Water Supply System (NYCWSS) is one of the largest unfiltered surface water supplies in the world (National Academies of Sciences, Engineering, and Medicine, 2020), it is imperative to ensure that high quality water is delivered to NYC for safe consumption.

Figure 1: Map of the New York City Water Supply System (NYCWSS) (NYC DEP, n.d.).

Stream turbidity is one parameter often examined in water quality investigations. Stream turbidity is a measure of the cloudiness of water due to the light scattering from fine suspended sediments in the water column (Davies-Colley and Smith, 2001). Measuring turbidity is important because in highly turbid waters, suspended sediments can permit the attachment of pollutants to these particles, which poses health concerns when this water is used for human consumption (Tessier, 1992). However, maintaining high quality water in the NYCWSS is nuanced due to the multiple sources and nature of turbidity in this region.

The nature of the sources of turbidity in the Catskills are largely caused by the steep topography of the region, which allows highly erodible sediments to generate turbidity. Additionally, during severe storm events, erosion can lead to excessive turbidity in the Ashokan Reservoir, which is especially problematic for communities along the Lower Esopus Creek who receive this turbid water from the reservoir (Riverkeeper, 2022). Therefore, understanding the turbidity conditions in the Catskills is necessary to guide present-day watershed management decisions and to provide key insights regarding the sustainability of the NYCWSS.

Previous studies have examined turbidity conditions in the Catskills, but, from our knowledge, this information has not been synthesized for the entire region. Thus, in this study, we synthesize over a decade's worth of existing turbidity data in the Catskills to better understand the drivers of turbidity in this study area. This work is motivated by the importance of understanding the turbidity conditions in the Catskills due to the direct implications on maintaining the water quality of the NYCWSS and protecting downstream communities.

Methods

Data Acquisition. I obtained daily average turbidity and streamflow data for 20 monitoring sites located in the Catskills from 2010 to 2022 (n = 88,255) by querying the National Water Information System (NWIS) web service (Figure 2, see Appendix). The turbidity data I obtained are classified as unfiltered, light source of monochrome near infra-red LED light at wavelength range of 780-900 nm, and a detection angle of 90 ± 2.5 degrees, reported in formazin nephelometric units (FNU). Three sites located near the Mohawk River were also obtained to compare to the Catskill sites. All data acquisition, analysis, and visualization was performed in the statistical programming language R. The dataRetrieval package in R was used to obtain these data.

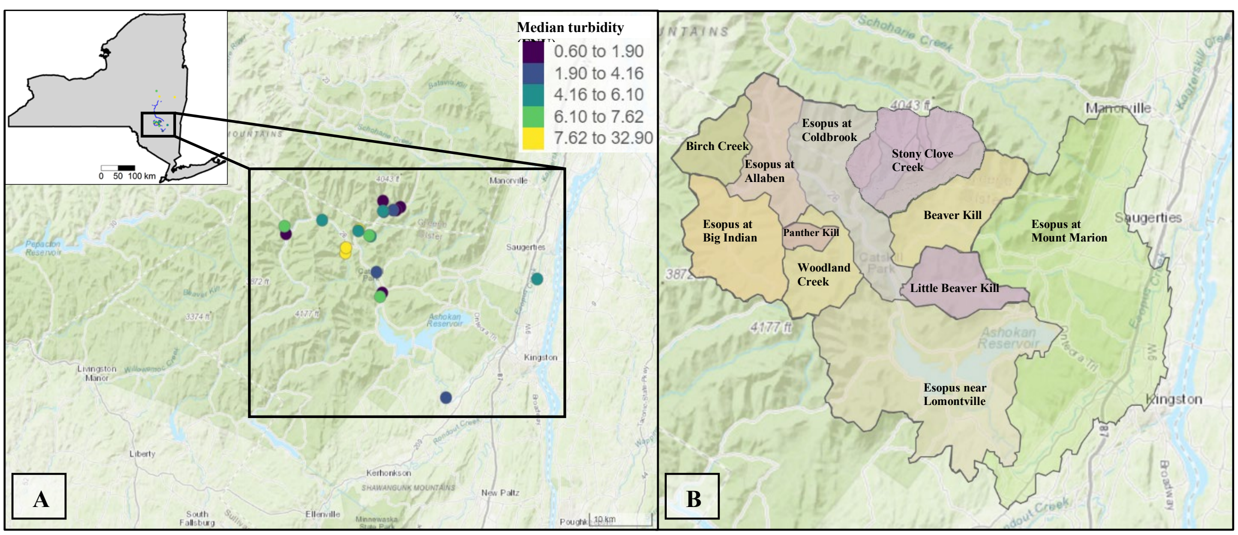

Figure 2: (A) Map of the median turbidity by monitoring site in the Catskills, and (B) map of the watershed study area for each monitoring station. The Esopus at Big Indian is the Esopus Creek Headwaters (Wang et al., 2021).

Data Quality Assurance. Before performing the data analysis, I prepared the data and identified data quality issues. I first examined the structure of the data set to obtain a sense of the data quantity for each variable. The rest of the data preparation required was to normalize both the streamflow and the turbidity data. Normalization of the turbidity, but especially the streamflow data, was necessary to allow for valid comparisons to be made across monitoring sites. To area normalize the streamflow data, for each monitoring site, I divided the streamflow data (cfs) by the drainage area (ft^2), which was then converted to units of in/month. The last key step of the data quality assurance was to examine the completeness of the records for both the streamflow and turbidity data by site. This step revealed a data quantity issue at one site in the Catskills, Panther Kill near Phoenicia, NY, as this site only has turbidity and streamflow data from 2021 to 2022 ($n_{turbidity} = 228$, $n_{streamflow} = 231$).

Results and Discussion

Data Analysis. I characterized turbidity in the Catskills by examining the spatial and temporal trends in turbidity across the 20 monitoring sites, and then related these results to the existing streamflow data.

Turbidity and Streamflow Characterization. Spatially, there is a statistical difference in mean turbidity across monitoring sites (ANOVA, $P < 0.05$); these results suggest that there are various mechanisms controlling turbidity in the Catskills, including differences in topography, land use, and extent of stream remediation efforts across sites. To understand the typical turbidity conditions in the Catskills, summarizing the data at each monitoring site reveals that the median turbidity values for sites in the Catskills range from 0.6 to 32.9 FNU, across all years of data (Figure 2). The stream with the highest median turbidity in the entire record was Stony Clove Creek at Chichester (01362370); this maximum median turbidity value of 81 FNU occurred in 2011. These results make sense because Stony Clove Creek at Chichester was modified to protect against flooding and turbidity during 2012 (the stream modification was completed in 2012) (Snow, 2012). After 2013, the median turbidity at this site decreased (the median turbidity at this site in 2013 was 18.65 FNU), which suggests that stream remediation likely played a role in regulating turbidity at this stream reach. Specific sites in addition to the Stony Clove Creek site at Chichester can also be pinpointed that have higher median turbidities: sites that lead into the Esopus Creek, including Panther Kill (01362297), Warner Creek (01362357), and Ox Clove (01362368), tended to have higher median turbidity (Figure 2). These results correspond to previous turbidity studies in the Catskills, where sites such as Stony Clove Creek were found to be chronic sources of suspended sediment to the Esopus Creek (McHale and Siemion, 2014).

Further examination of the spatial trends in turbidity reveals that the sites located in the Northeastern Catskills generally have lower median turbidity compared to the rest of the Catskills (Figure 2). This spatial trend may be explained by stream remediation efforts lowering turbidity at these sites over time, such as the Stony Clove sites. These results further suggest that the successful implementation of Sediment and Turbidity Reduction Projects (STRPs) in the Stony Clove Creek, which were designed to disconnect the stream channel from erosional connectivity with the glacial legacy sediment, were likely effective in lowering daily average turbidity (DEP, 2022).

In addition to spatial analysis, temporal trends in turbidity can be examined, such as after high magnitude storm events. A high magnitude flood occurred in December 2020, which likely was the cause of elevated turbidity across almost all monitoring sites in 2021 (Figure 3). Thus, grouping the data by site to examine annual trends allows for spatial and temporal trends to be more easily discerned.

Streamflow characterization was also conducted due to streamflow being an important factor affecting turbidity. Examination of specific sites in the Catskills with respect to normalized streamflow reveals that the top sites ranked by their mean normalized streamflow are the Esopus Creek at Coldbrook (01362500), Woodland Creek at Phoenicia (0136230002), Hollow Tree Brook at Lanesville (01362342), and Stony Clove Creek at Chichester (01362370). These results are expected because these sites are located in the eastern Catskills, or they are either located on the Esopus Creek or drain into the Esopus Creek (Figure 2). These results correspond to a USGS report by McHale and Siemion (2014), as previously discussed, where the Esopus Creek at Coldbrook was found to be chronically affected by an influx of suspended-sediments from Stony Clove Creek; streamflow, SSC, and turbidity were found to be stongly related at the Esopus at Coldbrook from their study as well, which corresponds to the results from this study.

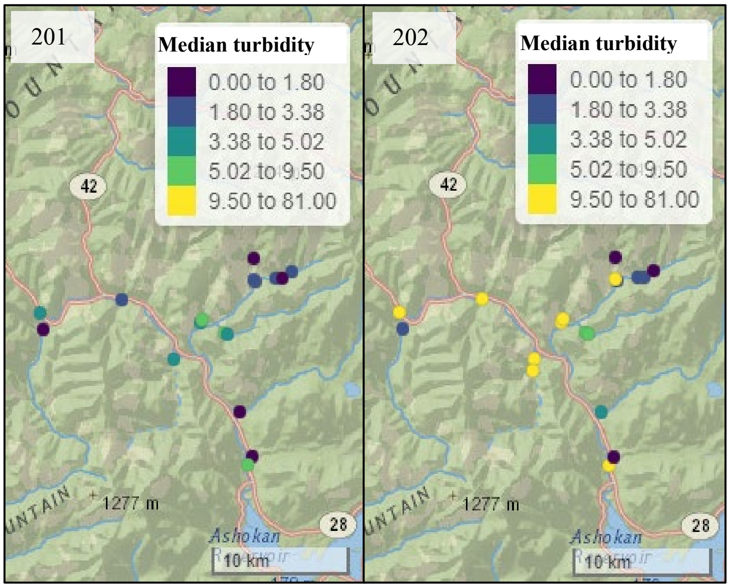

Figure 3: Comparison between median turbidity by site in the Catskills from 2017 and 2021.

Seasonality Analysis. Seasonality analysis based on the median turbidity indicates that turbidity peaks in January, March, and April across sites; these peaks are likely driven by earlier spring snowmelt events (Table 1). These results correspond to increasing trends in mean annual precipitation and streamflow in the Catskills from over the past 50 years (Burns et al., 2007).

Table 1: Summary statistics for the seasonal trends in turbidity across all monitoring sites. Data are from 2010 – 2022. Tn = Turbidity.

Month	Mean Tn (FNU)	Median Tn (FNU)	Minimum Tn (FNU)	Maximum Tn (FNU)	Standard deviation (FNU)	Count
1	15.35	5.6	0	394	30.21	4437
2	17.48	5.6	0	582	38.96	4037
3	17.84	5.9	0	866	41.84	4605
4	16.28	6.9	0	674	31.44	4768
5	8.96	4.4	0	1090	23.85	4985
6	8.32	3.6	0	1210	26.81	4763
7	8.79	3.3	0	776	24.78	4331
8	9.28	3.2	0	1010	31.80	4294
9	7.98	2.4	0	441	21.72	4151
10	10.55	2.8	0	916	35.84	4334
11	10.87	4.6	0	920	25.52	4414
12	13.75	4.6	0	1190	45.79	4649

Streamflow-Turbidity Relationship. Due to streamflow being an important factor affecting turbidity, it is necessary to examine the relationship between turbidity and streamflow both spatially and temporally. Examining this relationship at three spatially-distinct sites in the Catskills – Esopus Creek at Allaben (01362200), Esopus Creek at Coldbrook (01362500), and Little Beaver Kill (01362497) – reveals that the streamflow-turbidity relationship varies across sites (Figure 4).

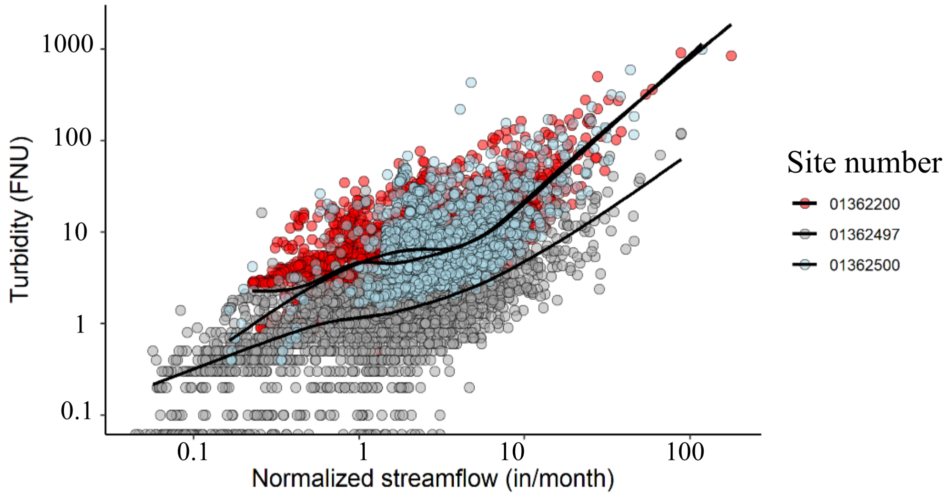

Figure 4: Streamflow-turbidity relationship for three sites in the Catskills. Smoothing method is LOESS.

For the same change in streamflow, the Little Beaver Kill has a smaller response in turbidity compared to the Esopus Creek sites (Figure 4). These results can be explained by the Esopus Creek having a larger drainage area than the Little Beaver Kill. Furthermore, the streamflow-turbidity relationship varies temporally, as shown at Stony Clove Creek at Chichester (01362370) (Figure 5). Thus, these results suggest that there are different mechanisms driving peaks in turbidity across seasons and years (temporally) and throughout the Catskills (spatially).

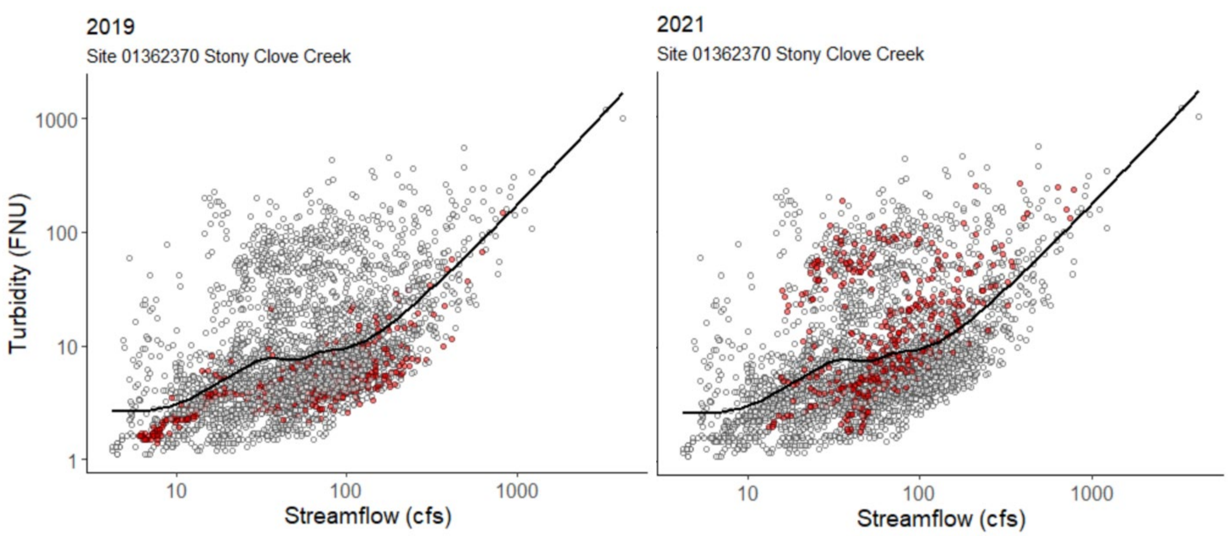

Figure 5: Differences in the streamflow-turbidity relationship between 2019 and 2021 at Stony Clove Creek at Chichester (01362370). The full record (2010 – 2022) is represented by grey circles, and data for each year (2019 and 2021, respectively) are colored in red. The LOESS fit to the full record is the solid black line. For the same streamflow, the average turbidity was generally higher in 2021 compared to 2019 at Stony Clove Creek. These results are likely due to the December 2020 flood.

Conclusions

This study presents a synthesis of the existing data on turbidity over the last decade in the Catskills, with specific attention to understanding the variability in turbidity across monitoring sites and the typical turbidity conditions in this region. Our results show that there is a statistical difference in mean turbidity across streams in the Catskills, suggesting there are multiple factors controlling turbidity, such as land use change and topography. Motivating the turbidity problem in the Catskills is that water coming from the Catskill/Delaware system, which supplies more than 90% of NYC's daily water supply, is not filtered prior to disinfection, making it imperative that high quality water is delivered to NYC for safe consumption. Maintaining the water quality of the NYCWSS, however, is nuanced due to the multiple sources of turbidity in the system, as well as the nature of the sources of turbidity in this region. Therefore, having a broader understanding of the turbidity conditions in the Catskills not only can guide present-day watershed management decisions, but also may provide key insights with respect to the sustainability of the NYCWSS.

Future work will involve obtaining additional data on factors affecting turbidity (land use, slope, climate), and then implementing a predictive model to identify the environmental controls most strongly related to the generation of turbidity in this region. Continuing this work will be crucial for determining which variables should be targeted when conducting stream remediation efforts at various monitoring sites in the Catskills.

References

Burns, D.A., Klaus, J., and McHale, M.R., 2007, Recent climate trends and implications for water resources in the Catskill Mountain region, New York, USA: Journal of Hydrology, v. 336, p. 155–170, doi:10.1016/J.JHYDROL.2006.12.019.

Davies-Colley, R.J., and Smith, D.G., 2001, Turbidity, Suspended Sediment, and Water Clarity: A Review: Journal of the American Water Resources Association, v. 37, p. 1085–1101.

DEP, 2022, Upper Esopus Creek Watershed Turbidity/Suspended-Sediment Monitoring Study: Mid-Term Report. Valhalla, NY.

McHale, M.R., and Siemion, J., 2014, Turbidity and Suspended Sediment in the Upper Esopus Creek Watershed, Ulster County, New York: p. 1–42.

National Academies of Sciences, Engineering, and Medicine, 2020, Review of the New York City Watershed Protection Program (2020): Washington, DC, The National Academies Press, 1–401 p., doi:10.17226/25851.

New York City Department of Environmental Protection, [n.d.], New York City water supply system: New York State Department of Environmental Conservation Web page, accessed August 5, 2022, at https://www.dec.ny.gov/lands/53884.html

Riverkeeper, Ashokan Reservoir: Stop the Mud, 9 Feb. 2022, https://www.riverkeeper.org/campaigns/safeguard/ashokan-reservoir-stop-the-mud/.

Snow, Violet. Work in Stony Clove Creek May Help with Flooding, Turbidity - Hudson Valley One. *Hudson Valley One - Independent News & Entertainment of the Hudson Valley*, 11 Aug. 2012, https://hudsonvalleyone.com/2012/08/11/work-in-stony-clove-creek-may-help-with-flooding-turbidity/.

Tessier, A., 1992, Environmental Particles: 425–453 p.

Wang, K., Davis, D., and Steinschneider, S., 2021, Evaluating suspended sediment and turbidity reduction projects in a glacially conditioned catchment through dynamic regression and fluvial process-based modelling:, doi:10.1002/hyp.14351.

Watershed Agricultural Council., 2022, Croton & Catskill/Delaware Watersheds. https://www.nycwatershed.org/about-us/overview/croton-catskilldelaware-watersheds/ (July 30, 2022).

Acknowledgements

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Appendix

Table 2: USGS monitoring stations analyzed in this study.

Stream name	USGS Station ID	Drainage area (mi^2)
ESOPUS CREEK BELOW LOST CLOVE RD AT BIG INDIAN NY	0136219503	29.60
BIRCH CREEK AT BIG INDIAN NY	013621955	12.50
ESOPUS CREEK AT ALLABEN NY	01362200	63.70
PANTHER KILL AT WOODLAND VALLEY RD NR PHOENICIA NY	01362297	3.53
WOODLAND CREEK ABOVE MOUTH AT PHOENICIA NY	0136230002	20.60
MYRTLE BROOK AT STATE HWY 214 AT EDGEWOOD NY	01362322	1.81
STONY CLOVE CREEK NEAR LANESVILLE NY	01362330	7.50
STONY CLOVE CREEK AT WRIGHT RD NEAR LANESVILLE NY	01362332	8.07
STONY CLOVE CR AT JANSSEN RD AT LANESVILLE NY	01362336	9.25
HOLLOW TREE BROOK AT LANESVILLE NY	01362342	1.95
HOLLOW TREE BROOK AT ST HWY 214 AT LANESVILLE NY	01362345	4.64
WARNER CREEK AT SILVER HOLLOW RD NR CHICHESTER NY	01362356	8.60
WARNER CREEK NEAR CHICHESTER NY	01362357	8.71
OX CLOVE NEAR MOUTH AT CHICHESTER NY	01362368	3.83
STONY CLOVE CREEK BLW OX CLOVE AT CHICHESTER NY	01362370	30.90
BEAVER KILL AT MOUNT TREMPER NY	01362487	25.00
LITTLE BEAVER KILL AT BEECHFORD NEAR MT TREMPER NY	01362497	16.50
ESOPUS CREEK AT COLDBROOK NY	01362500	192.00
ESOPUS CREEK NEAR LOMONTVILLE NY	01363556	279.00
ESOPUS CREEK AT MOUNT MARION NY	01364500	419.00

Incorporating ice jam flooding into regulatory Base Flood Elevations at the Historic Schenectady Stockade

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Introduction

Since 2005, the Stockade Historic District in the City of Schenectady, NY (Stockade) has been subject to six damage-causing flood events: a rain-on-snow event in April 2005, a continental storm in June 2006, Tropical Storm Irene in August 2011, Tropical Storm Lee in September 2011, and ice jams in March 2007 and February 2018. High water during these events damaged public infrastructure and private residences and necessitated the temporary closure of several City roads impacted by flooding. To mitigate future damages within the Stockade, the City of Schenectady applied for and received a grant from the Federal Emergency Management Agency (FEMA) to mitigate future flood damages within the Stockade. The work presented herein was prepared by the authors as part of a multi-disciplinary team working for and with the City of Schenectady on the Mitigation Measures to Reduce Flooding in the Historic Stockade project.

As part of the authors' role to support the project team and the City, the authors reviewed existing literature to identify potential data gaps in the understanding of existing flood risk within the Stockade. Upon synthesizing summaries of historical records and newspapers compiled by local and regional researchers, the authors identified that of the 54 identified flood events in the vicinity of the Stockade since 1646, at least 36 of these flood events were due to ice jams. While relatively recent Flood Insurance Rate Maps (FIRMs) were available from FEMA to define the fluvial ("free-flow") flood risk of the Mohawk River at the Stockade, the data underlying the FIRMs did not account for the flood risk resulting from ice jams (FEMA, 2014). As an accurate quantification of flood risk was critical to the receipt of continued FEMA grant funds and the proper design of the project, the authors undertook an effort to quantify the flood risk from ice jams and integrate that flood risk with the fluvial flood risk to develop a more complete understanding of flood risk in the Stockade.

Data Synthesis

To quantify the flood risk resulting from ice jams, the authors adopted a modified version of the "Annual-Event Series" direct analysis method provided in FEMA's (2018) *Guidance for Flood Risk Analysis and Mapping: Ice-Jam Analysis and Mapping*. This method entails the statistical analysis of past peak water surface elevations caused by ice jamming; it is the preferred method to quantify the flood risk from ice jams where sufficient data are available to conduct a statistical analysis.

Using statistical analysis of historic data to quantify existing flood risk is predicated on the assumption that historic data are representative of existing conditions. As such, the authors limited their analysis of historic ice jam data to the period after 1913 – the year that Vischer Ferry Dam was constructed and the period of time for which the authors assumed that conditions of the Mohawk River relevant to the formation and breakup of ice jams have remained relatively constant. However, the authors acknowledge that additional data may identify that a changing climate, changing morphology of the Mohawk River, or other factors may have a significant effect on the formation and breakup of ice jams.

To apply the Annual-Event Series direct analysis methodology, the authors developed a series of peak water surface elevations at the North Ferry Street gage (within the City's Riverside Park) by consolidating several dozen measurements and/or estimates of peak water surface elevations recorded for 19 distinct ice jams in the vicinity of the Stockade compiled by other authors. These data were validated by comparing independent estimates of water surface elevations at the same location for the same ice jam; generally, independent estimates matched within 1 foot. High water elevations for the 19 ice jam events were then adjusted to a common datum (North American Vertical Datum of 1988) and, where they were measured at a different location, translated to the North Ferry Street using a hydraulic model developed for the project. The hydraulic model was used to translate measured ice-jam induced water surface elevations to North Ferry Street by setting the water level in the hydraulic model to match the measured water surface elevation at the location it was measured and using the hydraulic model to model the upstream water surfaces at a discharge corresponding to the best-available estimate of peak discharge at the time of the ice jam from US Geological Survey stream gage records (USGS, 2019). The validity of using the hydraulic model in this way was confirmed by analyzing modeled and measured peak water surface elevations for ice jam events where multiple measurements were available; the difference between modeled and measured water surface elevations was 0.00 and 0.32 feet for the two ice jam events where such data were available. The estimates and measurements of high-water elevations, the source of the data, and the transform methodology used to convert these values to a common datum and location, are documented in Table 3 provided at the end of this abstract due to its length.

Development of Stage-Frequency Curves for Ice Jam Flooding

The FEMA (2018) Annual Event Series method dictates that peak stages be developed for the free flow season and ice jam season, therefore resulting in two data points for each year of record. The peak water surface elevations reported in Table 3 at the end of this abstract were used to develop a stage-frequency curve for the 19 recorded ice jam events assuming a systematic (continuous) record in accordance with the FEMA (2018) procedures and fitting a Log-Pearson III statistical distribution to the data. Due to the complex processes associated with their formation and break-up, US Army Corps of Engineers' Cold Regions Research and Engineering Laboratory (CRREL) practice is to not extrapolate statistical regressions beyond the ice jam flood of record to account for the fact that ice jams have a physical upper limit before they blow out. This upper limit was the historic 1914 flood when water surface elevations at North Ferry Street peaked at elevation 232.4 (Table 3). Table 1 provides the computed stage-frequency curve for ice jam-induced flooding assuming a systematic record with stages limited to the historic flood of record.

Table 1: Stage-Frequency Curve of Ice-Jam Induced Floods at the North Ferry Street Gage

Systematic ACE (RI) [a]	Conditioned ACE (RI) [b]	Water Surface Elevation (ft, NAVD88)
50 (2)	9 (11)	223.9
20 (5)	3.6 (28)	227.1
10 (10)	1.8 (56)	228.9
4 (25)	0.7 (139)	230.5
2 (50)	0.4 (279)	232.3
1 (100)	0.2 (558)	232.4 [c]
0.2 (500)	0.04 (2790)	232.4 [c]

Abbreviations: ACE = Annual Chance Exceedance; RI = Recurrence Interval
[a] Assuming a systematic record (i.e., 19 ice jams in 19 years)
[b] Conditioned probability = systematic probability x 19/106 to account for non ice-jam years
[c] Statistically-derived value limited to historic maximum

By assuming a systematic record, the authors note the probability of a stage occurring is overestimated as the systematic record assumption assumes that 19 ice jams occurred in 19 consecutive years. As these 19 ice jams occurred over 106 years, the authors applied a correction factor to "condition" the probabilities provided in Table 1 similar to that recommended in FEMA (2018) for the Annual Maximum Series method. The correction factor was equal to the number of records divided by the total period of record (19/106) and was multiplied with the probabilities from the systematic ice jam stage-frequency curve to develop a conditional ice jam stage-frequency curve reported in Table 1.

Development of Joint Stage-Frequency Curves

As ice jams are considered independent occurrences from fluvial flood risk (FEMA, 2018), an accurate representation of the flood risk at the Stockade combines both the independent flood risk from ice jams with the independent flood risk of fluvial flooding into a "joint probability". In other words, this joint probability accounts for the fact that if there is an X% chance that a certain flood elevation will occur in any given year as the result of an ice jam and a Y% chance that a certain flood elevation will occur in any given year as the result of fluvial flooding, the chance of that flood elevation occurring at least once in a year is greater than X% or Y% alone. The standard joint probability equation was used to calculate the joint probability stage-frequency curve at the North Ferry Street gage. The calculated joint probability is provided in Table 2 along with the comparison to the stage-frequency curve for fluvial flood risk alone.

Table 2: Fluvial and Joint Stage-Frequency Curve at the North Ferry Street Gage

ACE (RI)	Water Surface Elevation (ft, NAVD88)		
	Fluvial Flood Risk	Joint Probability	Difference
50 (2)	219.7	220.7	+ 1.0
20 (5)	223.0	223.9	+ 0.9
10 (10)	224.3	226.2	+ 1.9
4 (25)	227.1	228.4	+ 1.3
2 (50)	228.1	229.9	+ 1.8
1 (100)	229.6	231.4	+ 1.8
0.2 (500)	232.5	232.5	± 0.0

Abbreviations: ACE = Annual Chance Exceedance; RI = Recurrence Interval

Discussion

Reviewing Table 2, the inclusion of ice jams increases the stage-frequency curve from the fluvial flood risk alone at all frequencies but the 0.2-percent annual chance exceedance event (500-year flood). There is no increase in the 0.2-percent annual chance exceedance event as the water surface elevation from ice jams was assumed to not exceed the historic maximum water surface elevation from ice jams of 232.4 which is less than the calculated fluvial water surface elevation of 232.5. Considering the validity of the values provided in Table 2, the authors consider these results valid for the following reasons:

- The estimated 0.2-percent annual chance exceedance event of 232.4 is comparable to the flood of record in the systematic record. Considering historical records that suggest this flood was of unusual magnitude, these results appears reasonable.
- Within the systematic record, the 2-percent annual chance exceedance event elevation of 229.9 is comparable to that of Hurricane Irene and is a value that has been exceeded twice in the 106-year systematic record – which is expected for an event with a recurrence interval of 50 years.
- Similarly, the 10 percent ACE elevation of 226.2 has been matched or exceeded ten times in the 106-year record, which is expected.

Conclusion

As the historic source of flooding in the Stockade are ice jams which are not currently accounted for in FEMA's FIRMs, the authors performed a statistical analysis of historic high-water marks caused by ice jams to estimate the flood risk from ice jams alone. This ice-jam only flood risk was then combined with the fluvial flood risk to develop a joint-probability of flooding occurring as the result of either flooding source. The resulting calculations yielded that by including the flood risk from ice jams, the estimated magnitude of a 1 percent annual chance event (100-year flood) is approximately 1.8 feet higher than when only fluvial flood risk is considered. The results of these calculations were validated by a favorable comparison of the frequency of a certain flood stage occurring to historical occurrences of those flood stages occurring. Therefore, the authors consider the stage-frequency curve provided in Table 3 as the best-available quantification of existing flood risk in the Stockade.

References

Camp, Dresser, and McKee Environmental Engineers (CDM; 1976). Ice Jam Effects Hand Calculations.

Federal Emergency Management Agency (FEMA; 2014). Flood Insurance Study Number 36093CV000A. Schenectady County, New York (All Jurisdictions). January 8.

Federal Emergency Management Agency (FEMA; 2018). Guidance for Flood Risk Analysis and Mapping: Ice-Jam Analyses and Mapping. February

Garver, J.I. (2007). The 15 March 2007 Ice Jam on the Mohawk River (NY). Geology Department, Union College. Schenectady, NY.

Garver, J.I. (2014). "Insight from Ice Jams on the Lower Mohawk River, NY." 2014 Mohawk River Watershed Symposium. Union College, Schenectady, NY.

Garver, J.I. (2018). "Ice Jam flooding on the lower Mohawk River and the 2018 mid-winter ice jam event" 2018 Mohawk River Watershed Symposium. Union College, Schenectady, NY.

Gara, J.J. and Garver, J. (1998). A historical record of flooding on New York's Mohawk River based on stream gage records from Cohoes, NY. Geology Department, Union College. September. Schenectady, NY.

National Weather Service (NWS; 2019). Advanced Hydrologic Prediction Service, <https://water.weather.gov/ahps2/crests.php?wfo=aly&gage=schn6&crest_type=historic> (Accessed February 2019).

Lederer, J.R. and Garver, J.I. (2008). Ice Jams inferred from tree scars made during the 1996 mid-winter flood on the Mohawk River (New York). Geology Department, Union College. March. Schenectady, NY.

Scheller, M., Luey, K., Garver, J.I. (2008). Major Floods on the Mohawk River (NY): 1832-2000. Geology Department, Union College. March. Schenectady, NY.

United States Army Corps of Engineers (USACE; 2019). Ice Jam Database Application, <https://icejam.sec.usace.army.mil/ords/f?p=101:16:2760824826016> (Accessed February 2019).

US Geological Survey (USGS; 2019). National Water Information System, <https://maps.waterdata.usgs.gov/mapper/index.html> (February 15, 2019).

Wall, G., Gazoorian, C., and Garver, J.I. (2013). "USGS Ice Jam and Flood Monitoring: Mohawk River, Schenectady, NY." 2013 Mohawk River Watershed Symposium. Union College, Schenectady, NY.

Table 3: Documented Ice Jams on the Mohawk River since Construction of Vischer Ferry Dam

Water Year	Date of Peak	Peak Crest (ft)	Transform Methodology	ELEV at Stockade (NAVD88, ft)	Mohawk River Discharge (cfs)	Source	Comments
1913	3/28	228.9	1	228.36	N/E	NWS (2019)	a
1914	3/28	232.9	1	232.36	140000	NWS (2019)	b, c
1916	4/2	227.7	1	227.16	113000	NWS (2019)	c
1936	3/19	229.2	1	228.66	130000	NWS (2019)	d, e
1954	1/2	216.9	1 then 2	217.4	28700	CDM (1976)	f
1959	1/22	221.5	1 then 2	223.63	64400	CDM (1976)	e
1960	2/12	219.3	1 then 2	220.31	41900	CDM (1976)	f
1961	2/26	218.6	1 then 2	222.39	71900	CDM (1976)	e
1964	3/6	224.5	1	223.96	77500	NWS (2019)	f, g, h, i
1974	12/27	220.5	1 then 2	220.88	34400	CDM (1976)	f, j
1976	2/28	223.0	1 then 2	222.83	24600	CDM (1976)	f
1979	3/6	224.46	N/A	N/E	59200	NWS (2019)	f, k
1980	3/22	225.46	N/A	N/E	93700	NWS (2019)	e, k
1981	2/20	221.56	N/A	N/E	22200	NWS (2019)	f, k
1984	12/14	222.71	N/A	N/E	56500	NWS (2019)	f, j, k
1986	3/16	227	1	226.46	67500	NWS (2019)	f, i
1993	3/31	222 to 226	N/A	N/U	74700		e
1996	1/20	228	1	227.46	92600	NWS (2019)	f, i, l
1998	1/10	224.06	N/A	N/E	65900	NWS (2019)	f, k
1999	1/25	222	N/A	222.00	26800	USACE (2019)	f, m
2000	2/27	223	N/A	223.00	26400	USACE (2019)	f
2003	3/18	N/E	N/A	N/E	14700	USACE (2019)	f
2004	3/7	N/E	N/A	N/E	29900	USACE (2019)	f
2005	4/4	225.36	N/A	N/E	64700	NWS (2019)	f, k
2007	3/15	226	1	225.46	24900	NWS (2019)	f, n
2010	1/26	223	1	222.46	31300	NWS (2019)	f
2011	3/7	N/E	N/A	N/E	28200	USACE (2019)	f
2013	Jan	N/E	N/A	N/E	N/E	Wall et. al (2013)	
2014	1/13	20.60	4 then 3	220.25	22900	USGS (2019)	o
2018	2/22	23.82	4 then 3	223.85	46600	USGS (2019)	o, p

Abbreviations:
N/A: Not Applicable
N/E: No Estimate
N/U: Not Used

Table 3, Continued: Documented Ice Jams on the Mohawk River since Construction of Vischer Ferry Dam (Footnotes)

Transform Methodology:
1) Nation Weather Service (2019) elevation (National Geodetic Vertical Datum of 1929) - 0.54 feet.
2) Hydraulic model used to estimate water surface elevation at Stockade. Observed elevation at Rexford Bridge set as internal boundary condition in model and discharge reported in table used to estimate water surface elevation at Stockade.
3) Hydraulic model used to estimate water surface elevation at Stockade. Observed elevation at Freeman's Bridge set as internal boundary condition in model and discharge reported in table used to estimate water surface elevation at Stockade.
4) Peak Stage + Reported Gage Height of 199.46 feet (NAVD88) at USGS 01354500

Comments
a) Scheller et al. (2008) reported peak stage of 21.5ft. With a canal elevation of 209.33ft before the flashboards were installed in 1922, this elevation would correspond to 230.83ft (NAVD88).
b) Scheller et al. (2008) reported peak stage of 23.5ft. With a canal elevation of 209.33ft before the flashboards were installed in 1922, this elevation would correspond to 232.83ft (NAVD88). Gara & Garver (1998) & Lederer and Garver (2008) reported stage elevation of 231.1ft.
c) Peak discharge reported at USGS Gage 01356000 (Mohawk River at Vischer Ferry Dam, NY)
d) Scheller et al. (2008) reported peak stage of 17.5ft. With a canal elevation of 211.58ft when the flash boards are installed (1922), this elevation would correspond to 229.08ft (NAVD88).
e) Annual peak discharge reported at USGS Gage 01357500 (Mohawk River at Cohoes, NY)
f) Mean daily discharge reported at USGS Gage 01357500 (Mohawk River at Cohoes, NY)
g) USACE (1965) reported peak stage of 224.3 relative to the National Geodetic Vertical Datum of 1929 (NGVD29; 223.76 NAVD88) between Western Gateway Bridge and Schenectady Sewage Treatment Plant. Camp et al. (1976) reported peak stage of 219.8 NGVD29 (219.26 NAVD88) at Rexford Bridge.
h) Scheller et at. (2008) reported peak stage of 12ft. With a canal elevation of 211.58ft when the flash boards are installed (1922), this elevation would correspond to 223.58ft (NAVD88).
i) Annual peak discharge at USGS Gage 01357500 affected by ice jam breakup.
j) Event occurred in previous calendar year from reported Water Year (Water Year is October 1 to September 30)
k) Ice jam status unknown
l) Scheller et at. (2008) reported peak stage of 18ft. With a canal elevation of 209.33ft when the flash boards are seasonally removed, this elevation would correspond to 227.33ft (NAVD88).
m) Lederer and Garver (2008) reports that the stage elevation was approximately 2-6 ft lower than the 1996 flood (222 to 226)
n) Garver (2014 and 2007) reports that the stage elevation was 226.5ft (assumed Barge Canal Datum; 224.83 NAVD88)
o) 15-min peak discharge preceding peak stage reported at USGS Gage 01354500 (Mohawk River at Freeman's Bridge)
p) Garver (2018) reported WSE at Stockade of 223.8 (NAVD88).