The University of Vermont
Rubenstein School of Environment and Natural Resources

Spring / Summer 2006

The Fault Line

Newsletter of the Rubenstein Ecosystem Science Laboratory

The Fault Line name comes from the world famous Champlain Overthrust Fault depicted in the brickwork of our building.

Director's Welcome from Dr. Mary Watzin

All of us at the Rubenstein Lab work with many partners throughout the region to promote good stewardship of Lake Champlain. Our prime location on the campus of the Leahy Center for Lake Champlain, adjacent to ECHO lake aquarium and science center, brings us into daily contact with many partners. Our work benefits directly from support we receive from the Lake Champlain Basin Program, the State of Vermont, the Lake Champlain Committee, Friends of Missisquoi Bay, and many others. This winter, the Rubenstein Lab became the home of the Watershed Alliance, a unique partnership between UVM Extension, Lake Champlain Sea Grant, and the Rubenstein School of Environment and Natural Resources. We are pleased to support the Alliance in its efforts to provide hands-on learning for middle and high school students; Caitrin Noel, who leads the program, shares more on page 5. We are also pleased to welcome several new graduate students to the lab who work with Dr. Bowden and other faculty. Their work, both here in the watersheds of Vermont and in Alaska, is featured in this newsletter. Finally, our good friends and supporters continue to inspire us – on the back page, former UVM trustee Fred Hackett shares his thoughts on the importance of a healthy lake.

White Perch and Algae Blooms in Missisquoi Bay

by Sam Couture, RSENR Graduate Student

The persistent problems with blue-green algae blooms in Missisquoi Bay have attracted considerable public attention in the last few years because sometimes these dense collections of algae can produce toxins that interfere with recreation and other uses of the water. Clearly, the high levels of nutrients entering the bay support vigorous algae growth, but beneath the highly visible scums that can form during the summer, other less evident ecosystem changes may also be supporting these blooms.

One of these ecosystem changes has been the invasion of white perch in the last decade. White perch are not native to the lake; they entered the lake through the Champlain Canal at the southern end of Lake Champlain in the early 1980s. By the mid 1990s, a few white perch were present in Missisquoi Bay; but by 2003, the Quebec Ministry of Environment found significant numbers in northern Missisquoi Bay. Supported by grants from the National Oceanic and Atmospheric Administration and private sources to

Sam and Dr. Watzin measure zooplankton in tanks after white perch have fed.

Dr. Mary Watzin, we sampled the fish community in Missisquoi Bay throughout the summer of 2005, and found that white perch made up over 70% of our catch!

Is it possible that the dominance of blue-green algae in Missisquoi Bay could somehow be related to the expansion of the white perch

(continued on page 5)

From the MELOSIRA…

by Captain Dick Furbush

UVM's research vessel *MELOSIRA* is a floating classroom, a floating laboratory, and platform for sophisticated equipment used to support a diversity of activities. Our hydraulic A-frame at the stern of the vessel is our most visible piece of research equipment, but inside the boat, we have many other tools of the trade. Ever wonder how we find our way back to retrieve sampling materials we deploy in the lake? We do it with an extremely precise computer navigation system linked to our GPS (Global Positioning System) receiver. Our latest addition to our suite of electronics is a high precision autopilot, a gift from Mr. Fred Doane. It is coupled to the GPS and computer navigation system allowing very precise scientific surveys.

Every angler knows that depth finders find more than the bottom of the lake – ours not only shows us depth and temperature, but also shows us schools of fish and other underwater objects. Many of the water quality probes and other sampling devices we send over the stern of the vessel record data electronically, while they are underwater. When we bring these back aboard we can download the data and immediately plot the information on our shipboard computers. Often we use the temperature probe to plan where to place fishing trawls and other collectors to capture fish and plankton.

The *MELOSIRA* dry-docked at Shelburne Shipyard.

Watch for us on the lake! We hope all the work we do leads to a healthier lake in the future.

Cyanobacteria in Lake Champlain: Research Update

by Dr. Mary Watzin

As far as we know, cyanobacteria (also called "blue-green algae") have always been a relatively harmless part of the Lake Champlain ecosystem. But in the summer of 1999, scientists and the public got a wake-up call when two dogs died from drinking lake water containing high concentrations of a toxic substance produced by some types of cyanobacteria. Since 2000, our studies have documented the regular presence of potentially toxic cyanobacteria in the waters of Lake Champlain and the occasional presence of two groups of toxins, the microcystins, and anatoxin-a. Both of these toxins can cause harm to people, as well as their pets.

Susan Fuller identifies and quantifies cyanobacteria.

Because of the potential implications of these toxins for public health, our research focused first on developing a monitoring program that could be used to identify areas of the lake where "blooms," or high concentrations of cyanobacteria, were occurring and whether these blooms were toxic. Our goal was to provide accurate and timely information to public health officials so that they could take whatever measures were necessary to protect people and their pets. To implement our monitoring program, we have collaborated with the Lake Champlain Basin Program and the Vermont Department of Environmental Conservation, who already regularly visit 14 sampling stations across the lake, and established a very successful citizen monitoring program that now covers 15 shoreline areas in Vermont and New York. In 2005, our staff and graduate students analyzed over 700 samples for cyanobacteria and their toxins.

Our field sampling starts in early June and continues into the fall. Each week, we provide the results of our analyses to public health officials in Vermont, New York and Quebec. Beginning in 2005, we have worked with the Vermont Department of Health (VTDOH) to post our monitoring results on their website. You can access the site at www.healthvermont.gov/enviro. The site includes background information on cyanobacteria, a map that shows the locations of any blooms on the lake, and public health information and any advisories that VTDOH issues.

Through our experience, we have discovered that Missisquoi Bay, St. Albans Bay, and the north lake are the areas most likely to experience persistent blue-green algae blooms. However, blooms can occur anywhere on the lake, and we have seen them in

(continued on page 6)

Linking Urban Land Use to Stream Geomorphology and Biotic Integrity in the Lake Champlain Basin

by Evan P. Fitzgerald, RSENR Graduate Student

Since the year 2000, the Vermont Agency of Natural Resources (ANR) has been working to develop a state-of-the-art methodology for stream geomorphic assessments (SGA). The SGA protocols are intended to be used by natural resource managers to identify how land use changes affect the hydrologic regime and in so doing, alter the physical structure and habitat of streams in the state. Although the protocols have been tested widely in different streams throughout the state, the methodology is still in development and their use in highly urbanized areas (e.g., Chittenden County) has been limited to date. A baseline of SGA data for stormwater impaired streams in Chittenden County is needed to evaluate how well they work in these settings and to understand changes in urban streams over time.

Evan measuring erosion from storm drain pipe in Centennial Brook watershed.

With funding from ANR to Dr. Breck Bowden, my research project began with an effort to complete the SGA Phase I (GIS-based analysis) and Phase II (field-based rapid stream assessment) level assessments for the stormwater impaired streams in Chittenden County and to select a group of nearby streams that are attaining their water quality standards (attainment streams) that could be used for comparison. In 2005, I collected data on streams in 9 impaired watersheds and 5 attainment watersheds, including a total of 143 reaches. The reach-level assessment data included measures of geomorphic stability, channel evolution and morphology, and physical habitat condition. These measures are summarized in two composite scores – the RGA (Rapid Geomorphic Assessment) and RHA (Rapid Habitat Assessment) scores – that can be used for comparisons across reaches. I am combining these data with other land use and aquatic biota data collected by ANR to: 1) develop a GIS model to measure the influence of urban land use and inherent watershed characteristics on the geomorphic stability and physical habitat condition of small streams; 2) develop hydraulic geometry curves (HGC) to measure the influence of urban land use and inherent river corridor characteristics on stream channel morphology; and 3) estimate the influence of channel geomorphic stability and physical habitat condition on aquatic biota. When my project is completed, I hope to be able to provide ANR with feedback on the utility of the SGA protocols for watershed management.

Stormwater Management in Vermont: Linking Hydrologic and Land Use Assessment in a Practical Framework for Permitting

by Julie Foley, RSENR Graduate Student

For the last several years, the Vermont Agency of Natural Resources (ANR) has been working to address concerns about stormwater impacts in urban areas. A diverse group of stakeholders including local, state and government agencies, statewide and regional business groups, environmental advocates, professional engineers, academics and the agricultural community all have different interests in the outcomes, ranging from resource conservation to recreation and tourism to economic growth. The goal is a stormwater management approach that protects natural waters, while allowing for economic development and viability in urban centers.

Many of Vermont's streams are being adversely affected by stormwater runoff, and 17 of these have been listed by the state as impaired waters because of stormwater. Stormwater runoff is especially prevalent in more urbanized communities where pavement, roofs, sidewalks and other impervious surfaces cover large areas and prevent infiltration of rainfall. If infiltration is diminished because of development (increased imperviousness), then increased runoff volume, peak flow, peak flow duration, stream temperature, sediment loading, and decreased base flows result. These changes may lead to flooding, habitat loss, erosion, channel widening, and streambed alteration.

Working with Dr. Breck Bowden and with funding provided by ANR, I have developed a protocol that can be used to objectively identify targets for stormwater reduction and to locate areas for priority permit actions. The protocol is based on predicted stream flows estimated from flow duration curves (FDC) that were derived from a simple stormwater hydrologic model. Using statistical clustering methods, we identified groupings of stormwater impaired and attainment watersheds (those meeting their water quality standards) for target setting. A hierarchical cluster analysis of

(continued on page 4)

Stream Research in Arctic Alaska: Responses to Global Climate Change

by Morgan Johnston Greenwald, RSENR Graduate Student

The North Slope of Alaska, like many parts of the Arctic, is underlain by continuous permafrost and is covered with tundra vegetation. During the warm season, the tundra surface thaws, but the ground underneath stays permanently frozen. This surface thaw also extends under streams and rivers, as the moving water warms the bed, forming an area called the "thaw bulb." Because many processes unique to Arctic systems depend on the delicate balance of frozen and thawed areas, sensitive Arctic tundra ecosystems are likely to be among the first to show the impacts of global climate change.

As water flows downstream, it can infiltrate the streambed and flow through the sediments of the thaw bulb. This area of infiltration, known as the hyporheic zone, is an important area of biogeochemical transformation, where bacteria decompose organic matter and provide stream algae with the important nutrients they need.

Morgan samples water from an Arctic stream.

Supported by a National Science Foundation grant to Dr. Breck Bowden, my research has three main objectives. The first is to better understand what portion of the thaw bulb is actually functioning as a hyporheic zone. The second is to explore the biogeochemical processes in the hyporheic zone. The third is to compare these physical and biogeochemical characteristics in two different types of streams: a cobble-bottom stream with a relatively steep slope and a peat-bottom stream with a gentler slope. The cobble stream is known to have a deeper thaw bulb than the peat stream during the warm season.

To address these objectives, we installed sampling devices that allowed us to collect water from distinct depths in the hyporheic zones of the two streams. We then added a tracer dye to the stream water at the top of a reach and monitored its concentration over time at downstream locations both in the stream and at multiple subsurface locations along the reach using the sampling devices. This allowed us to see how water moves through the stream reaches in both the surface and subsurface environments. We also analyzed both stream and hyporheic water samples for concentrations of dissolved oxygen, dissolved organic carbon and three important nutrients: nitrate, ammonium and phosphate.

Preliminary results of my study have shown that depth of stream water penetration into the hyporheic zone is greater in the cobble stream than in the peat stream. This is likely due to the greater slope of the cobble stream. In both streams, nutrient concentrations in the actively exchanging hyporheic zone were often higher than in the stream water. Furthermore, the deep subsurface water not actively exchanging with the stream often showed much higher concentrations of ammonium and phosphate and relatively low concentrations of dissolved oxygen and nitrate, indicating long water residence times and a lack of connection to the stream at those depths. Interaction of stream water with subsurface sediments and microbes is very important to the internal cycling of organic matter and nutrients in these streams.

These findings help us to understand how stream systems in the Arctic are functioning. If we can understand the physical structure and functions of the hyporheic zone in Arctic streams, we can begin to predict how changes in the thaw bulb and stream geomorphology resulting from climate change may alter these unique ecosystems.

(continued from page 3, Stormwater Management)

inherent watershed characteristics was used to identify watersheds with similar physical characteristics, regardless of water quality. Within these groupings, we used the mean 1-day estimated flow values for the attainment watersheds as flow targets for the corresponding impaired watersheds. A risk assessment method was then developed using logistic regression analysis to find those subcatchments within the impaired watersheds that were most likely to be contributing to the impairment. Those sub-catchments will be targeted for priority management actions, and improvements will be estimated as the reductions in flow that can be achieved. This approach uses readily available data, employs simple models, is acceptable to a wide array of stakeholders, and is amenable to adaptive management.

Julie measures water depth in a scour pool.

Watershed Alliance Finds New Home at the Rubenstein Lab

by Caitrin Noel, Watershed Alliance Coordinator

The UVM Watershed Alliance (www.uvm.edu/~watershd), a statewide watershed education and stream monitoring program for Vermont students, is now based out of the Rubenstein Lab. The Alliance strives to educate youth about pollution prevention and best practices for water management, as well as provide quality hands-on, inquiry-based science education. As Watershed Alliance Coordinator, I am excited about the move. This is a great opportunity for the program. We are planning to increase our programming to make use of the resources here, including the Teaching Laboratory and the R/V *MELOSIRA*, which will provide amazing and unique learning possibilities for Vermont students.

Current Alliance programming includes annual professional development workshops for teachers, the Urban Watershed Education Project at Edmunds Middle School, as well as the biannual Watershed Education and Stream Investigation Program (WESIP), held each fall and spring. This spring the Alliance worked with classes in 11 schools located throughout the state. With assistance and guidance from undergraduate interns Kyle Palmer (RSENR '07), Erin Affronti (RESNR' 07), Peter Spartos (ENSC '08), Sarah Friend (ENSC '07), and Jennifer Cookson (ENSC ' 06), participating students collect data about local streams and submit it to the Vermont Water Quality Gateway (www.vtwatergateway.org), an online repository for student data managed by the Watershed Alliance.

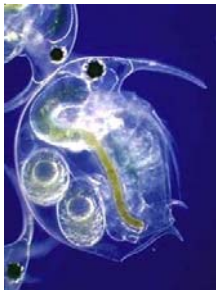
Students from U-32 High School collect benthic macroinvertrebrates in the Winooski River.

For more information about the UVM Watershed Alliance, please contact us at (802) 859-3086 x305 or Caitrin.Noel@uvm.edu.

***the UVM Watershed Alliance is a UVM Extension program, in partnership with Sea Grant Lake Champlain and the Rubenstein School of Environment and Natural Resources.*

(continued from page 1, White Perch and Algae Blooms)

population? To answer this question, we needed to determine what white perch were eating in Missisquoi Bay. So, we brought the fish we caught back to the Rubenstein Lab and opened up their stomachs to examine their diet. We also sampled the plankton to see what potential prey were available for white perch to select. In another group of experiments, we put live fish into large tanks in the Lab and gave them a choice of small animals to eat in order to more thoroughly study what their favorite foods might be. We were especially interested in whether white perch liked to eat *Daphnia*, a small animal that lives in the plankton. *Daphnia* is a very efficient algae grazer, and it also retains more phosphorus in its body compared to other types of small grazers. Therefore, if all the *Daphnia* are eaten by white perch, the remaining small grazers won't store as much of this nutrient, making it more available to support the growth of algae.



Collecting white perch for gut contents analysis (mostly *Daphnia*, shown magnified above).

Although the data from our fish collections, diet studies, and lab feeding experiments are still being analyzed, preliminary results suggest that white perch do in fact feed on *Daphnia*. Early in the summer, when *Daphnia* is very abundant in Missisquoi Bay, white perch consume them vigorously. Later in the summer, *Daphnia* disappear from the plankton. Some early results from the laboratory feeding experiments show that white perch can significantly reduce the numbers of *Daphnia* in the plankton community.

Once we combine our knowledge of white perch diets in Missisquoi Bay with the results of our prey selection experiments in the lab, we can consider whether or not white perch feeding can deplete *Daphnia* in Lake Champlain and thus might be one of the factors that has contributed to the shift to blue-green algae dominance in Missisquoi Bay. Through an increased understanding of these food web relationships, we may learn how to predict or prevent similar ecosystem shifts in other areas of the lake, and we will have a another piece of the puzzle solved for Missisquoi Bay.

Critical Need for Lake Research: an Interview with Fred Hackett

by Dr. Mary Watzin

Lake Champlain is a distinctive and critically important feature of the Vermont landscape that impacts quality of life, economic and recreational opportunities, property values, and the special "mystique" that defines Vermont. And, as former UVM Trustee and friend of the Rubenstein Lab, Mr. Fred Hackett recently reminded me, "the health of Lake Champlain is intimately intertwined with the vitality of Vermont, including its citizens, culture, policies, and economic drivers."

However, like many freshwater ecosystems around the world, Lake Champlain is experiencing unprecedented levels of human use and alteration. Rising levels of water pollution, noxious, and sometime toxic algae blooms, increasing fragmentation of habitats, and the introduction of exotic species are just a few of the problems that are the result of an expanding human population and increasing levels of development. In the face of this growth, **critical choices** must be made in order to ensure the conservation and sustainable use and development of the lake and its resources.

The work of the Rubenstein Lab is centered on providing practical information to inform those choices, focusing not just on documenting problems, but also on **crafting solutions that will lead to a healthier lake in the future.**

Meghan Kreider takes a net sample to study phytoplankton in Missisquoi Bay.

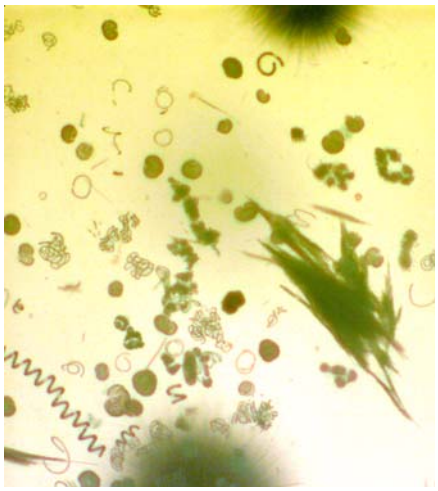
As Fred pointed out, "a healthy lake is fundamental to a healthy economy. It's not just an issue for environmentalists! Informed decision-making (we can't afford to invest without **knowing**) must optimize investments by picking those management activities that have the highest likelihood of success and give the biggest bang for the buck. We need to attack the things we can address **now** – at the same time as we gather the data necessary to adapt in the future. I support the Lab because it helps people to understand science, empowering them to make informed decisions that support the environmental values they hold."

As the visibility of the Rubenstein Lab continues to grow, our hope is that we can catalyze real change, by training the next generation of practical scientists and problem solvers, and contributing to effective management of Lake Champlain and its resources.

(continued from page 2, Cyanobacteria Update)

Burlington Bay, and as far south as Long Point in Ferrisburgh. The highest concentrations of toxin are generally found in the scums that can occur along the shoreline and in protected bays and coves. This is why our citizen monitors are so essential. In fact, we would not have documented some of the most severe risks to people and pets without these citizen monitors.

Not all cyanobacteria blooms are toxic, but you cannot determine whether a bloom is toxic or not simply by looking at it. The safest strategy when you see a bloom is to avoid swimming in those waters. Shoreline property owners who draw drinking water directly from the lake need to be especially vigilant and contact their local public health officers if they notice a problem. Fortunately, much of the lake is likely to be generally safe for most of the summer, but awareness is key.



Several species of cyanobacteria under the microscope.

Now that we have an efficient and effective monitoring program in place, we are turning our attention to trying to determine some of the causes of the blooms. We know that high phosphorus concentrations are one of keys, but other factors might also be important, including changes in the food web (see white perch story on page 1), release of nitrogen and phosphorus from the sediments at the bottom of the lake, water clarity, and water temperature. As we learn more, we hope to be able to help guide a multi-pronged approach to solving the problem.

To learn more about any of our activities, please contact:

Dr. Mary Watzin, Director
Rubenstein Ecosystem Science Laboratory
Rubenstein School of Environment and Natural Resources
The University of Vermont
3 College Street, Burlington, VT 05401
Rubenstein@uvm.edu