To win back the health of Little Narragansett Bay, researchers first help diagnose the problem

CHANGING WATER CHEMISTRY CAUSES EXPLOSION OF INVASIVE SEAWEED

By Nancy Balcom

Researcher Veronica Rollinson, right, heads out with UConn student Holly Westbrook to the first sampling trip in January 2018.

Below: *Cladophora* mats collect in one of the inlets at Elihu Island in Stonington. Photos courtesy of Veronica Rollinson

Stonington Harbor became famous for a battle with the British Navy in the War of 1812.

In recent decades, a very different kind of battle has been waged in the waters of the state's easternmost community. Unlike the earlier conflict, this adversary has made a gradual, stealthy and successful advance to domination. Stopping and ultimately reversing the damage required a different sort of foot soldier—one armed with water collection tubes and an understanding of the complex chemistry that happens when rivers carry too much of what flows off the land with them to the sea.

"I grew up around here and this was happening in my own backyard," said Veronica Rollinson, who earned her master's degree in marine science working on the research project. "I was intrigued as I've boated with my family on Little Narragansett Bay. We didn't notice this happening as we weren't digging up the bottom or spending time on the beaches, but it is something very near and dear to my heart."

The enemy in this case is the invasive filamentous green seaweed *Cladophora* that had taken over the bottom of Little Narragansett Bay. A scenic area popular with recreational boaters, the bay is shared by Stonington and Westerly, R.I., its neighbor across the Pawcatuck River that divides the two states. In the bay, fresh water flowing from the river mixes with salt water from Long Island Sound—typically the ideal conditions for a rich marine ecosystem.

That was the case until the early 1990s, when eelgrass beds and bay scallops were abundant there. Then different seaweeds began replacing the eelgrass—seen as an indicator of a healthy ecosystem because it thrives when nutrients from water flowing off the land are at optimal low levels. By 2010, *Cladophora* had won, turning the bay into a virtual monoculture.

Residents' complaints about the seaweed increased as gooey mats some three feet thick left boat propellers entangled and beaches covered in mounds of putrid decaying seaweed.

Oddly, according to Jane Sawyers, supervising environmental scientist with the R.I. Department of Environmental Management (RI DEM), *Cladophora* mats are not as apparent on the Rhode Island side of the bay, presenting another mystery about how the freshwater and estuarine parts of the watershed are functioning.

Excess levels of nutrients, particularly nitrogen, were super-fueling the growth

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of *Cladophora*. Decomposition was following explosive growth, reducing the amount of oxygen present in the water to levels that couldn't support animal life. Frequent nighttime low oxygen events in the shallow coves of Little Narragansett Bay have been linked to the abundant *Cladophora*. This process of eutrophication has long been a focus of water quality improvement programs.

Proper management of the amount of nitrogen entering the Pawcatuck River and ultimately Little Narragansett Bay requires an understanding of how much is being loaded and from which sources. That means parsing out the so-called "point sources"— those that originate from an identified outfall pipe, for example—from "nonpoint sources"— those that flow off land and pavement as individual trickles that accumulate.

Within the Pawcatuck River watershed and estuary, there are two wastewater treatment plants (WWTPs) in Westerly and Stonington, and an industrial facility in Kenyon, R.I., all potential point sources of nitrogen (and all currently meeting their discharge permit requirements).

Nonpoint sources include runoff from urban, residential or agricultural activities into surface waters or groundwater discharges. The majority of the Pawcatuck's watershed is in Rhode Island with a small section in eastern Connecticut. The sparsely populated upper watershed has forests, wetlands and numerous turf farms. The lower watershed, closer to the mouth of the river, is more densely populated.

With Connecticut Sea Grant support, University of Connecticut marine science faculty Julie Granger and Jamie Vaudrey led a two-year study to identify and quantify the sources of nitrogen entering the Pawcatuck River and Little Narragansett Bay, spurred on in part by the massive blooms of *Cladophora*.

The researchers instituted four sampling methods, undertaken over 12 months between 2018 and 2019. Weekly samples were collected near the Stillman Bridge at the mouth of the freshwater portion of the river and at the limit of seawater intrusion, near the Route 1 bridge connecting Pawcatuck to Westerly. Weekly effluent samples from the Westerly WWTP were analyzed. Three seasonal surveys of 15 locations along the river were conducted and rainwater collected at UConn-Avery Point.

"The sampling was intense overall," said Rollinson. "It was weekly sampling from two primary locations and then seasonally we added a third location. On top of that, there were the river transects themselves. It was a behemoth effort to organize the sampling alone, and then the processing of the samples…I believe there were 375 sampling grabs and over 7,500 unique data points in the end."

As a quick refresher of long-forgotten chemistry lessons, nitrogen is an important component of proteins, essential to plant and animal growth. In its gaseous state, nitrogen comprises more than 70% of the atmosphere but is not available for protein building. "Reactive nitrogen" refers to interrelated nitrogen compounds, such as ammonia, nitrate and nitrite, that can support protein building and therefore growth. These compounds change constantly in the environment, and while essential, too much reactive nitrogen can lead to serious environmental consequences such as eutrophication and acid rain.

UConn Marine Sciences faculty Jamie Vaudrey, left, and Julie Granger, center, worked with graduate student Veronica Rollinson on the project. Photo: Judy Benson

The research team monitored the concentration of reactive nitrogen species delivered from the Pawcatuck River into Little Narragansett Bay. They measured naturally occurring stable isotope ratios of nitrate to trace nitrogen sources and cycling, enabling them to determine the dominant sources of nitrogen entering the watershed, including industrial fertilizers, livestock farms, septic systems and natural sources. Similar analyses were conducted on the effluent samples from the WWTP. The samples collected during the seasonal river surveys were used to identify distinct nitrogen sources from the watershed.

"We brought oceanography to land," said Granger, associate professor of marine sciences, who led the research team. "We used an interpretational scheme for the nitrogen isotope ratios of nitrate that was more oceanographic than what has traditionally been done with river studies, an empirical framework {meaning verifiable through observation} that hadn't been tested in rivers before, whereas in the ocean it has been more rigorously tested.

"We were very ambitious and ended up sampling and measuring far more than we could include in her thesis," Granger added. "We focused on the river exclusively for this project but Veronica collected a ton of samples from the estuary too. Overall a heroic number of samples… unprecedented for a master's degree, I'd say."

The sampling days often started by sunrise and ended by dusk. Sometimes Rollinson had help from undergraduate volunteers and other days she completed the sampling by herself. Off the water and back in the lab, she then preserved and organized samples before ending exhausting 12-to-16-hour days. Figuring out the best way to manage such a large volume of samples proved to be an education in and of itself and Rollinson learned that

Students from a marine science class kayak into the upper Pawcatuck River to collect water samples for a class project in the fall of 2019. Photo courtesy of Veronica Rollinson

sometimes the best laid sampling plans on paper must be scrapped when put to the test in the field.

"When sampling the upper river, we first tried to kayak with two groups and while we had this whole huge plan, logistically it didn't work out," she said. Undergraduate students enrolled in the course titled, "Measurement and Analysis in Coastal Ecosystems" applied their new knowledge in the field by helping to collect and analyze some of the samples.

What did this astronomical amount of data tell the research team about how nitrogen cycles through the Pawcatuck River? The two WWTPs contributed very little nitrogen to the overall loading amount during the winter months, when the discharge of nitrogen from the Pawcatuck River was at a seasonal high.
During the warmer, drier months, the decrease in the nitrogen discharge from the river elevated the significance of the WWTPs' and the industrial plant's nitrogen contributions to the total estuary loading. The larger fraction of riverine nitrogen in the Pawcatuck during drier months otherwise originated from deeper groundwater in the agricultural areas of the upper watershed and in urbanized portions of the lower watershed, the researchers found. During wetter, colder months, reactive nitrogen in the river originated disproportionately from shallower groundwater and surface waters.

Comparison of their data to historical measurements revealed that nitrogen discharge from the Pawcatuck River has increased in the last 20 years, an environmental change that could help explain the disappearance of eelgrass beds and persistence of *Cladophora*.

Their findings stress the importance of considering seasonality of riverine nitrogen sources and loading to mitigate eutrophication in receiving estuaries, perhaps paving the way for the return of eelgrass beds in the future. According to Vaudrey, assistant research professor of marine sciences and co-leader of the research project, 80% of the nitrogen would have to be removed from the system to spur the return of eelgrass, based on their nitrogen loading model.

Amanda Dostie, UConn Marine Sciences student and IDEA grant recipient, scoops *Cladophora* from the waters of Little Narragansett Bay in summer of 2014. Photo: Jamie Vaudrey

"The management of nutrients focuses on the summertime period," said Vaudrey, "and that seems short-sighted to me as we're getting warmer winters. Winter reductions are more important than people think.

"*Cladophora* is bright and green in winter," she added. "It is not dormant but growing slowly, although not at the levels of summer when it rapidly cycles nutrients for growth."

Watershed management for the Pawcatuck River watershed and estuary is the focus of an ongoing collaboration between the Connecticut Department of Energy and Environmental Protection (CT DEEP) and RI DEM, backed by the public's interest in nutrients and the health of coastal embayments. With funding from the U.S. EPA and Restore America's Estuaries, the two agencies are collaborating on a watershed grant to evaluate nutrient loadings to the Pawcatuck River estuary and Little Narragansett Bay. The goal is to develop a new watershed-focused approach to analyzing and managing nutrient impacts on coastal estuaries.

"This collaborative project with Rhode Island involves pairing two models, one describing water quality in the freshwater upland portion and the other, water quality in the estuarine waters," said Traci Iott, a supervising environmental analyst with CT DEEP. "We chose the Pawcatuck River watershed for this pilot effort after reviewing Dr. Vaudrey's previous modeling work that ranked Long Island Sound embayments based on nutrient levels and hope to apply the process to other embayments."

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Granger and Rollinson said that their data have been shared with both CT DEEP and RI DEM, in the hopes that their research can contribute to both the ongoing paired modeling effort and ultimately, the restoration plan for this watershed.

"We are collecting data for this watershed from wherever we can find it—including EPA, USGS (U.S. Geological Survey) CUSH (Clean Up Sound & Harbors), Rhode Island and the Unified Water Study," said Iott. "The data from this {Sea Grant-supported} study will be evaluated for inclusion in the model looking at water quality in the estuary."

Once both models are calibrated, validated and linked, they will be used to set water quality targets for the embayment, most likely focused on clarity and dissolved oxygen. Identifying the nutrient levels in the estuary is necessary to support these water quality goals.

"From there, we determine what nutrient load reductions need to occur in the upland part of the watershed to achieve these targets," Iott said. "It will be a fully public process as we go."

What three steps would the UConn research team take first if they were managing this watershed?

"I always tell managers, don't put your outfall in a river, move it to the ocean where it's diluted," said Vaudrey. "I know it's expensive but it's worked for Boston Harbor and other places. Next, go after the nonpoint sources of nitrogen that are concentrated, like getting the turf farms to pay attention to the amount of fertilizer they require."

Noted Granger: "Fertilizer is so cheap, the incentives are not there to monitor how much you use."

Vaudrey agreed.

"It's a hard angle to go after without some kind of legislation requiring it," she said.

Industrial plants like the one situated in the upper watershed "could be directing their outfall into a created wetland," Vaudrey said. "Forests have been created to remove nitrogen, toxins and help sequester carbon. There are just so many other options than just dumping it in the {nearest} river."

Through these complementary efforts to understand nitrogen loading and establish targets to reduce nitrogen inputs from different sources, this coastal embayment has a strong chance to return to a healthier state, and the lost bottom retaken from *Cladophora*.

MORE INFORMATION

CT DEEP – RI DEM Pawcatuck River Watershed Nutrient Project https://portal.ct.gov/DEEP/Water/TMDL/Pawcatuck-Watershed-Nutrient-Project

USGS – U.S. Geological Survey; CUSH – Clean Up Sound and Harbors
www.cushinc.org