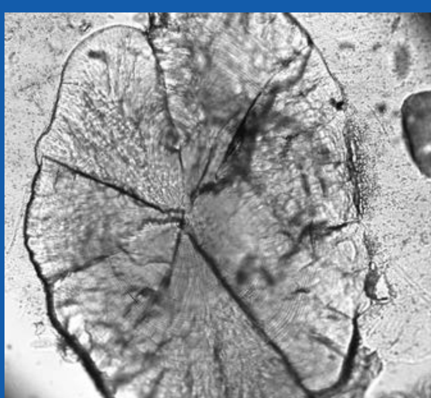
Searching for the menace of mercury

Researchers examine small fish, shellfish for traces of toxic heavy metal

By JUDY BENSON



An image of an otolith, a small bone used to age fish, viewed under a microscope. Photo: Julie Pringle

Just a little bit of mercury can do a lot of damage, especially to the developing brain and spinal cord of a fetus or young child.

Since that's true for humans, those same effects could be magnified in other creatures. Take, for example, clams, oysters and copepods, microscopic cousins of shrimp. These all eat tiny amounts in their everyday diets of single-celled plants called phytoplankton that absorb mercury directly from sea water. For small fish and shellfish, the buildup of this heavy metal in their systems could be having some adverse impacts. Considering that these are the main food for shorebirds, larger fish and sea mammals, that means mercury is being passed up through the marine ecosystem, all the way to the types of fish regularly consumed by people.

Working with that premise, Zofia Baumann and her team of researchers at the University of Connecticut have been trying to understand precisely how and where mercury is entering the marine food chain by focusing on Atlantic silversides. These small finfish live in coves and inlets from Florida to the Magdalen Islands in eastern Canada.

"Silversides are really important forage fish," said Baumann, adding that they're a main food for two species favored by recreational and subsistence fishermen in Long Island Sound – bluefish and striped bass. "This fish is a stepping stone for mercury bioaccumulation to larger predators."

Hardshell clams and oysters are also being studied, along with meat samples from larger fish caught in waters off New Haven. Those were provided by the New Haven Bioregional Group, an advocacy organization concerned about whether subsistence fishermen who rely on their catch as a main source of protein for their families are getting too much mercury in their diets.

"We know that there are a lot of subsistence fishermen in New Haven," said Lynne Bonnett, a member of the group who helped collect the samples. "It's an environmental justice issue."

Baumann, assistant research professor in the UConn Marine Sciences Department, said that while people should be encouraged to eat fish and shellfish for good health, she wanted to learn whether there is also a risk they should know about. Subsistence fishermen and their family members – especially women of child-bearing age and young children – could be unwittingly accumulating mercury in their systems through regular consumption of catch from certain areas.

"What is the potential risk of exposure over time and in different locations?" she asked.

Baumann and Robert Mason, professor in the marine sciences and chemistry departments at UConn, began working to answer that question in 2016. That's when they launched a two-year project funded by Connecticut Sea Grant to quantify levels of mercury found in these species at five embayments, from Mumford Cove in Groton near the eastern end of the Sound to Calf Pasture Beach in Norwalk near the western end. Their research is examining how one specific type of mercury – methylmercury, an organic compound of mercury that is the most common source of mercury poisoning in humans – passes through the food webs of these embayments. A third question they are studying is whether there's an optimal nitrogen level in the water that tempers the magnitude of mercury bioaccumulation in finfish and shellfish, and identify what that level is.

"If you add nitrogen, you stimulate growth over the whole scope of the food web," Baumann said. "But how much is too much is such a fine line. People are very concerned that there's too much nitrogen in the Sound, for good reason. But I don't believe things are just linear."

In other words, while the excess nitrogen entering the Sound from sewage plant effluent, agricultural runoff, lawn fertilizers and other sources chokes off the Sound's oxygen supply when it gets too high, at a lower but still undefined "sweet spot," nitrogen could be acting as a buffer for mercury bioaccumulation. Identifying that level could inform projects to remove excess nitrogen from the Sound, so that limited funds for sewage plant upgrades and runoff capture are spent wisely.

The researchers started by first looking at maps created for earlier projects showing levels of mercury in sediments in the Sound, the legacy of generations of industry in Connecticut and beyond. The mercury came down rivers in discharges from factories, and from the atmosphere through emissions of coal-fired power plants that fall to earth and travel into waterways. Once airborne, it circulates widely.

"The crazy thing with mercury is that when it's in its gaseous state, it stays in the atmosphere for up to two years, and travels a far distance," Baumann said. "It's a global pollutant but local sources and associated implications are important to examine."

The maps, Baumann said, showed mercury levels higher in the western sound, where discharges from the hat making industry of the late 1800s in Danbury ended up, along with decades of effluent from New York City. But the maps, Baumann said, only showed mercury levels in the sediments of the open waters of the Sound, not in the many coves and inlets where the bottom-of-the-food chain species congregate. These are also the areas where subsistence and recreational fishermen get most of their catch.

"Nobody had tested the embayments," she said. "One of our goals was to fill in that knowledge gap, to find out if the embayments are following the same pattern as the deeper parts of the Sound."

Once the questions had been articulated, the painstaking research process began. That involved enlisting graduate students to wade into the five shallow coves to net dozens of the little fish – most under four inches long – and collect dozens of hardshell clams and oysters.

On a bright day at low tide last August, Gunnar Hansen sloshed through the soft sand in Mumford Cove with Wesley Huffman. Both doctoral students in marine sciences, they had left their labs and laptops for the morning in pursuit of clams. Rakes in hand, they tilled the bottom repeatedly for their harvest.

"Ideally, we're looking for clams that are under two years old, about two inches wide," Hansen said. "The bottom here is pretty soft, which is nice, because when I feel something, it's usually a clam."

After about 15 minutes of raking and turning, Huffman called to Hansen across the cove.

"How many do you have so far?" he asked.

"Like, three," Hansen replied.

"How many do we need?"

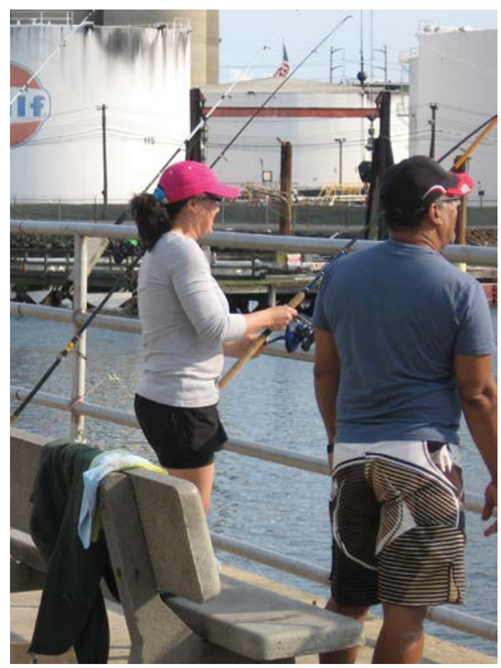
"Fifteen," said Hansen.

A few days earlier, Hansen had been in a lab at UConn's Avery Point campus carefully measuring a dry white powder with little resemblance to its original state. It was the meat of clams he had harvested earlier that had been freeze-dried for the mercury tests.

In an adjacent lab, graduate student Julie Pringle and Charles Dyke, a marine sciences undergraduate in his senior year, applied some unique skills to the project. Both are advised by Baumann's husband Hannes, who is an assistant professor of marine sciences at UConn.

Dyke sat at a lab table, holding a clamp with partially dissected silverside in one hand while he used tweezers to extract a tiny speck of bone called an otolith from the head. Roughly the size of a grain of rock salt, otoliths are essential parts of the hearing systems of vertebrates including those of humans. To fisheries biologists, they are valuable storehouses of information about the rates and patterns of growth of individual fish. Once extracted by Dyke, Pringle prepared each otolith onto a slide to view it under a microscope.

"The width of each ring is proportional to the growth of the fish," Pringle explained, showing a striking black-and-white image on her computer screen resembling a cross section of a tree trunk with a vivid pattern of rings. "Each ring represents one day of growth. We're go-



Anglers fish in New Haven harbor, where samples from large fish were taken and tested for methhylmercury, Photo: Lynne Bonnett

continued on next page...

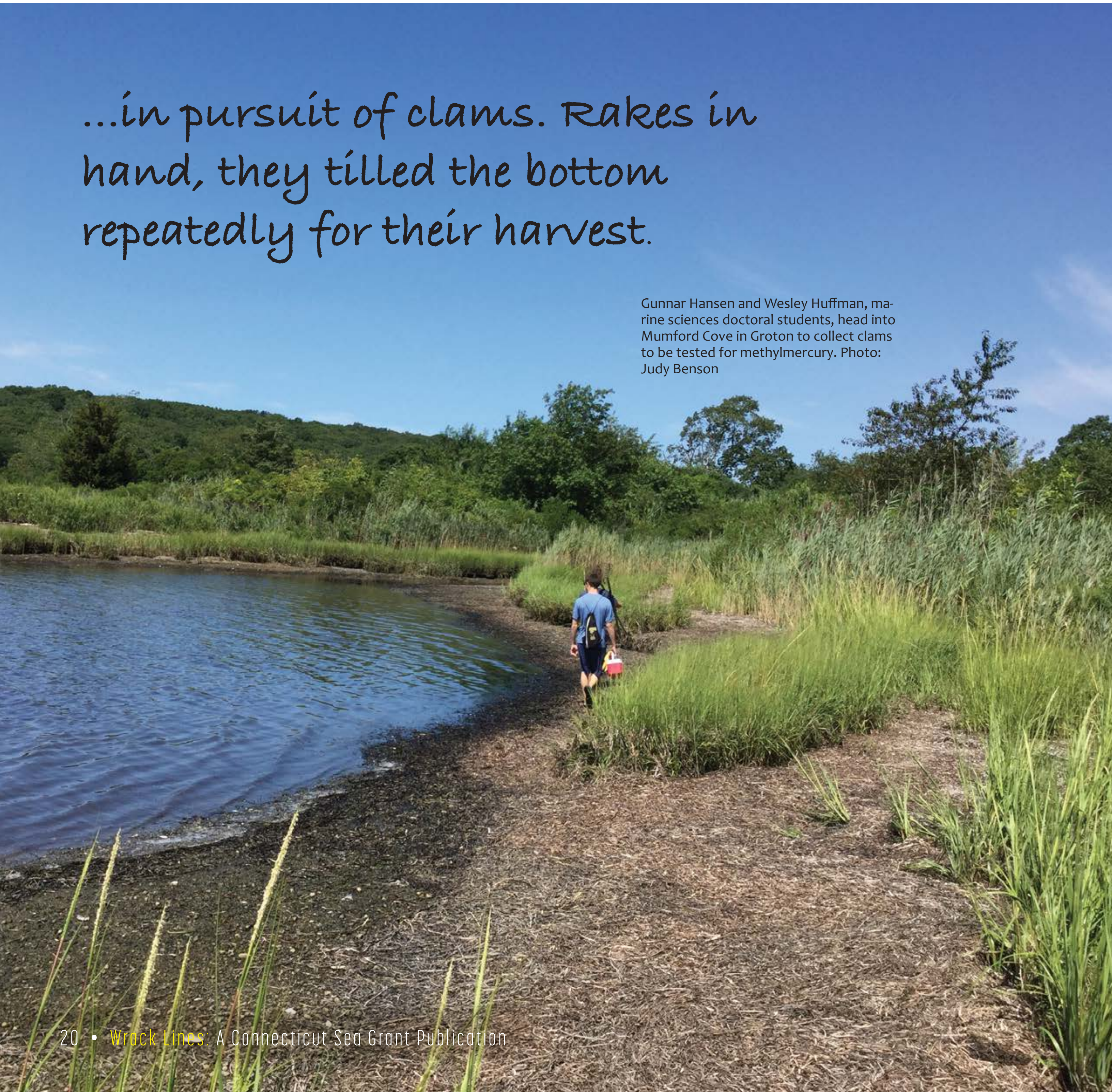
ing to go through and count all those rings to see how old the fish is."

Once the fish is aged, that information is paired with the amount of methylmercury measured in its muscle tissue, Baumann explained. To do that, a complex process is used in which a sample of fish tissue is freeze dried, then ground into a powder. It is then diluted and mixed with chemicals that enable detection of methylmercury with a highly sensitive instrument, the Tekran Model 2700 Automated Methylmercury Analysis System.

"The theory is that faster growing fish have less mercury in them," Baumann said.

In a third section of the lab, Alexandra Swift, a high school senior from Darien interning there for the summer, examined a spreadsheet of data from fish tissue samples on a computer screen as Baumann looked on. Earlier that summer, Swift had learned how to extract the otoliths, providing many of the ones Pringle used for the slides.

As of September, Baumann said, the project was about three-



...in pursuit of clams. Rakes in hand, they tilled the bottom repeatedly for their harvest.

Gunnar Hansen and Wesley Huffman, marine sciences doctoral students, head into Mumford Cove in Groton to collect clams to be tested for methylmercury. Photo: Judy Benson quarters of the way completed, with all the field samples collected and lab analysis well underway. Preliminary results, presented at a conference in Providence in July, show mercury concentrations are highest in fish and shellfish from the western and eastern ends of the Sound, and lowest in samples from the New Haven area, Baumann said.

Ultimately, the research will contribute to the overall picture of how mercury is persisting and moving through the environment, and could also have some practical applications to everyday life. The state Department of Public Health, Baumann noted, issues advisories about fish consumption that include especially strong warnings for pregnant women and children. For Long Island Sound, consumption advisories are mostly based on contaminants other than methylmercury. Very few fish harvested from the Sound are analyzed for this toxin, Baumann said.

"They were only able to test a narrow range of fish," Baumann said. "And they were measuring total mercury, not methylmercury."

The difference, she said, is that methylmercury levels are more significant in assessing the overall risk of fish consumption. In marine fish, 95 percent of mercury is methylmercury, but the percentage can be lower in fish from estuaries such as the Sound, she noted. Since eating fish should be encouraged as part of a healthy diet, Baumann said, basing the warnings on more precise information would be an important public service. She noted that because detecting methylmercury levels is more difficult and time consuming, fewer methylmercury measurements are available.

"This science is going to inform policies and guidelines for protecting human health," she said.

Locations of fish and shellfish sampling:

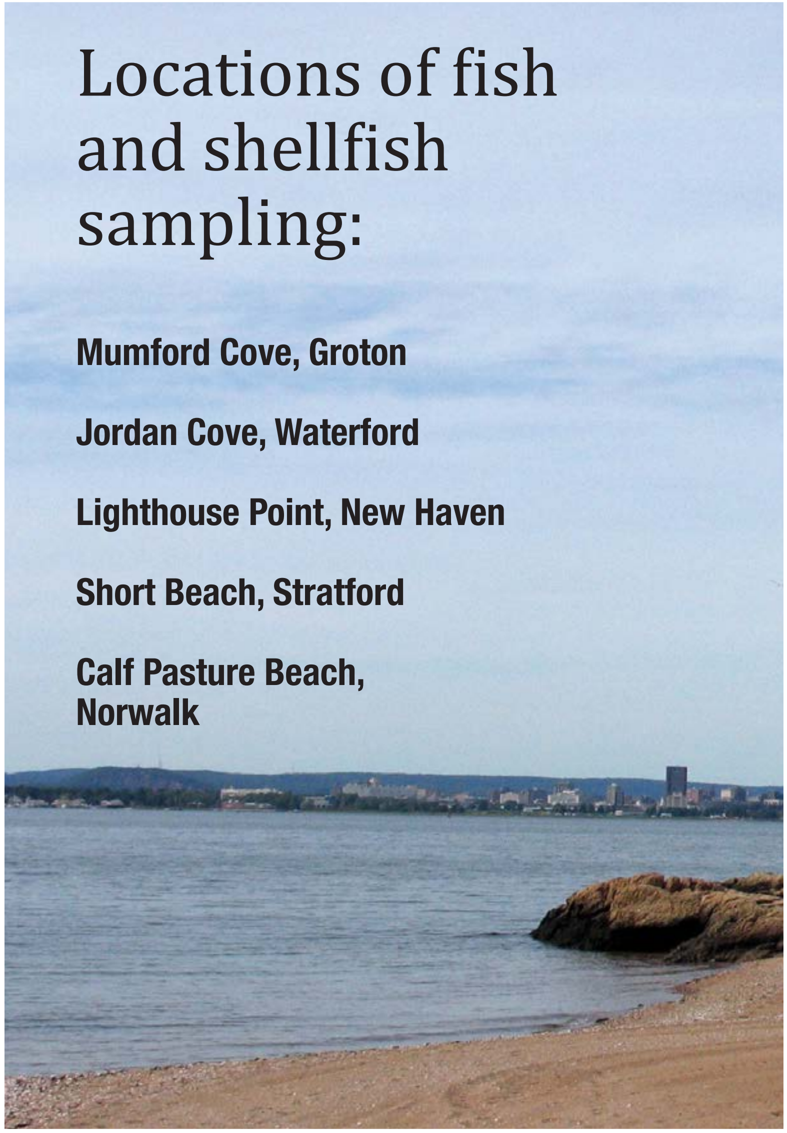
Mumford Cove, Groton

Jordan Cove, Waterford

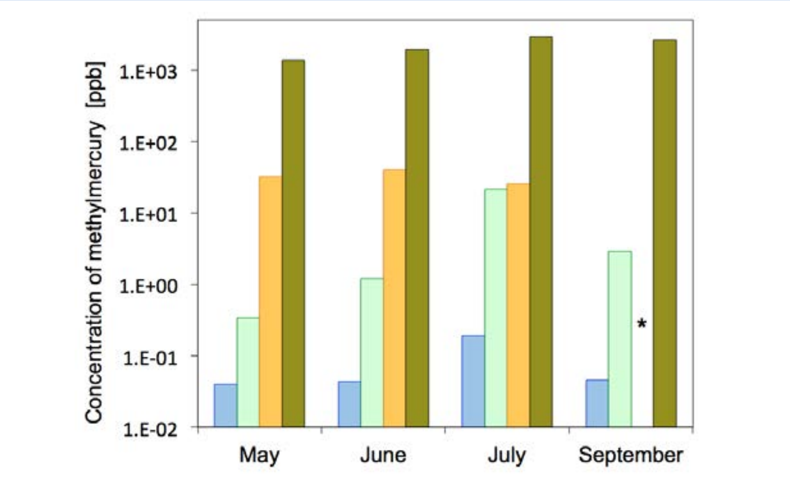
Lighthouse Point, New Haven

Short Beach, Stratford

Calf Pasture Beach, Norwalk



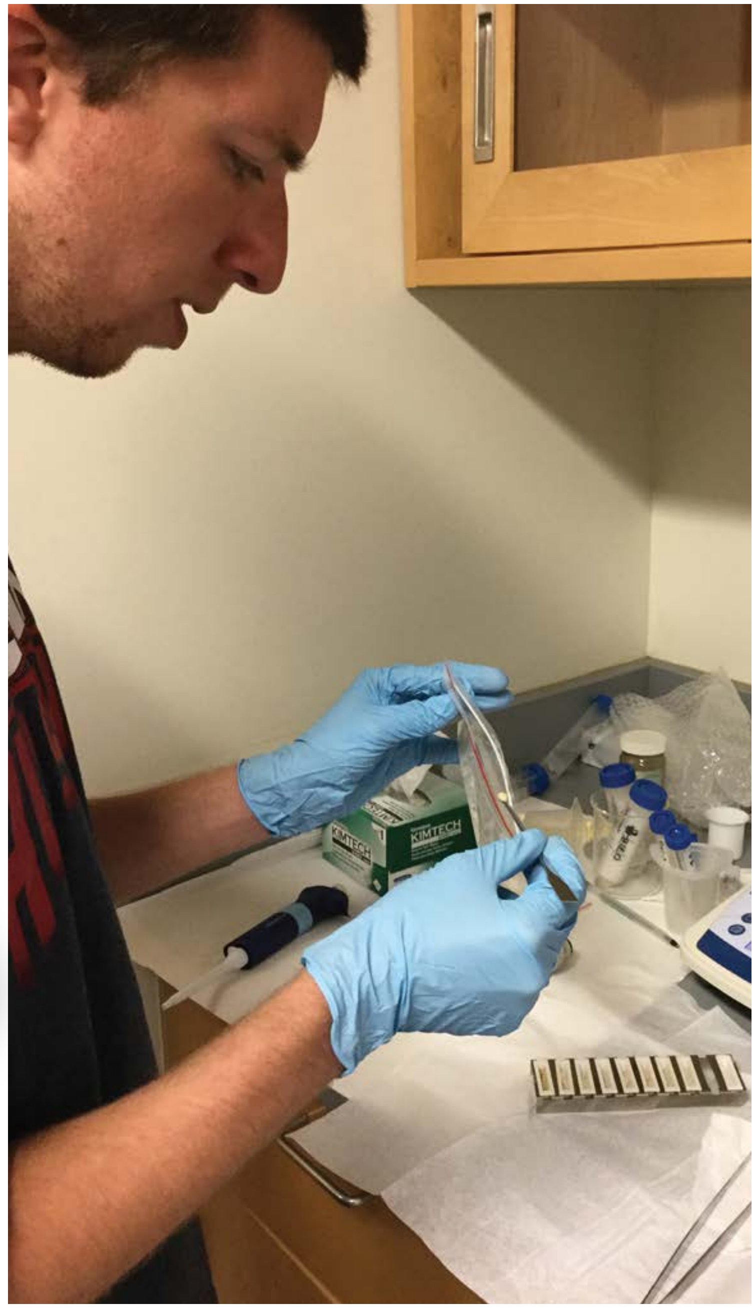
The concentrations of methylmercury in seawater are shown in blue; concentrations in phytoplankton are shown in light green; concentrations in copepods are shown in yellow; and concentrations in Atlantic silversides are shown in dark green. The graph also shows how concentrations change during the spring-summer season. Graphic: Zofia Baumann



A volunteer from the New Haven Bioregional Group scrapes off a sample of tissue from a fish caught in New Haven harbor to be tested for methylmercury at the UConn labs. Photo: Lynne Bonnett

Prof. Zofia Baumann holds one of the Atlantic silversides being tested for methylmercury. Photo: Judy Benson

Numbers of samples:



Gunnar Hansen measures a sample of dehydrated clam that will be analyzed for methylmercury levels. Photo: Judy Benson

Dehydrated clam samples await testing for methylmercury in one of the marine sciences labs at the University of Connecticut's Avery Point campus. Photo: Judy Benson