Research shows negative impact of nutrients on coastal ecosystems

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Healthy salt marsh creeks at Plum Island Estuary, Massachusetts, are lined with lush, smooth cordgrass. The plant's below-ground roots and above-ground leaves build and maintain salt marshes. Credit: David S. Johnson/MBL

LSU's John Fleeger, professor emeritus in LSU's Department of Biological Sciences, is part of a multi-disciplinary national research group that recently discovered the impact of nutrient enrichment on salt marsh ecosystems is marsh loss and that such loss is seen much faster than previously thought. Globally between a quarter and half of the area of the world's tidal marshes has already been lost, and although multiple factors – sea-level rise, development, loss of sediment supply – are

known to contribute to marsh loss, in some locations the causes have remained unexplained.

Researchers on the team include lead scientist and LSU alumna Linda A. Deegan of the Ecosystems Center at the Marine Biological Laboratory at Woods Hole, as well as Bruce J. Peterson of the same affiliation; David Samuel Johnson, another LSU alumnus who is affiliated with both Woods Hole and Sewanee University; R. Scott Warren of Connecticut College; Sergio Fagherazzi of Boston University; and Wilfred M. Wollheim of the University of New Hampshire. Their work, titled "Coastal eutrophication as a driver of salt marsh loss," will be published in the Oct. 18 issue of *Nature*, one of the most prestigious scientific publications available.

This research, which began in 2002, strove to create the most accurate natural-scale experiments looking at the impact of fertilizers on salt marshes.

"Other research programs have used plots and add nutrients to these small areas in unnaturally high concentrations; however, this doesn't mimic reality," said Fleeger. "When tides rise, they rise over large areas, not just small plots of land. We knew we wanted to take a different approach."

But the question remained – how to simulate something on such a grand scale?

To do so, Fleeger and the others found a large marsh in northeastern Massachusetts that was relatively untouched by nutrient pollution. As they progressed, replicated areas were held separate from the others without fertilizer addition in order to have a reference environment for comparison.

Using a hydrographic model, the team was able to recreate nutrient introduction into other creeks in the same manner it happens in natural environments, as dissolved fertilizer entering creeks on rising tides. What they found was that fertilizer and its associated runoff has a definitive and rapid negative impact on salt marsh ecosystems by stimulating marsh loss.

"We got to observe nutrient enrichment from its starting point, not years after it began, which has never been done before at the landscape level," said Fleeger. "But we certainly didn't anticipate these results. In only five to seven years, the edge of the marsh is literally falling apart."

First, cordgrass, or Spartina alterniflora, a plant that grows on the creek-side edge in salt marshes, quickly soaks up some of the extra nutrients, shifting natural growth patterns and causing a focus on upward, aboveground growth rather than growth of roots and rhizomes belowground. This loosens the creek side soil, making it more vulnerable to erosion and collapse.

Secondly, when excess nutrients are introduced, the researchers found that it stimulates bacterial growth, breaking down peat and other vital components of the soil at a much faster rate than normal.

Normally, the environment sees creek sides calving off large chunks, but they grow back over time. However, nutrient enriched creeks are seeing a much greater rate of calving, and a bigger change in the morphology and overall look of the creek. In effect, creeks are widening and the salt marsh is retreating with nutrient enrichment.

"Two things alter the integrity of the soil with nutrient enrichment," said Fleeger. "The soil water level goes up while soil cohesiveness goes down. That's when we see cracks on the marsh edge start to form. Cordgrass grows taller, then falls over into the creek, and large areas of the marsh

edge slump into the creek bed, disrupting the water flow and making the creek wider at the same time, increasing the impact of the nutrients. Muddy bottoms replace vegetated soil in fertilized creeks."

But the impact doesn't stop there. Coastal marshes help protect cities from storm surges and flooding; they sequester carbon and remove nutrients before they reach the ocean; and birds, fish and shellfish rely on these ecosystems for hiding, nesting, food and more. When the look and makeup of the marsh is altered, these natural services provided by the marsh suffer as well.

"When we first started this work, it was thought that salt marshes would be able to sequester excess nutrients and neutralize them with little impact on the marsh itself, but that hasn't proven to be the case," said Fleeger. "While they are in effect 'grabbing' the nutrients from the water, it is most definitely having an impact on the stability and function of the ecosystem."

The group's next step is to determine what these changes in marsh geomorphology mean in the long term for the function of saltmarsh ecosystems. For example, will nutrient enrichment worsen the impact of sea-level rise on salt marshes?

"Our work shows that the current rate at which nutrients enter many coastal ecosystems has overwhelmed the capacity of marshes to remove nutrients without negative effects on the marsh itself," said Fleeger. "Fertilizer use will undoubtedly increase as we produce more food for an expanding human population over the next few decades. Unfortunately, deterioration of coastal marshes due to eutrophication will make it harder to manage nutrients while meeting these increased food production needs."

More information: Deegan LA, Johnson DS, Warren RS, Peterson

BJ, Fleeger JW, Fagherazzi S, and Wollheim WM (18 Oct 2012) "Coastal Eutrophication as a Driver of Salt Marsh Loss" *Nature*.

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