When a Hurricane Burps an Estuary

Marine science researchers at UNC have found that estuaries generate natural defenses against the effects of global warming — until a hurricane hits.

Imagine being stuck on I-40 during rush hour. Picture all the car exhaust rising from idling engines. Now imagine how much worse it would be with 8 million more cars on the road. That's how much carbon dioxide — 8 million cars' worth — was emitted into the atmosphere when Hurricane Irene hit the East Coast in 2011, according to UNC researchers.

But the carbon dioxide released in that storm didn't come from cars — or anything made by humans, for that matter. It came from our coast's estuaries. The water, marsh and mud of an estuary act as a natural sponge for carbon dioxide, says Hans Paerl, the Kenan Professor of marine and environmental sciences at UNC's Institute of Marine Sciences.

The marsh grasses, sea grasses and microscopic algae in the water perform photosynthesis, and the thick marsh mud and surrounding water "ingest" the organic carbon, packing it down into sediment for long-term storage. "In normal conditions, the estuary takes in more CO_2 than it gives out — using photosynthesis to fix carbon dioxide into organic matter," Paerl said. "But when a storm comes, all bets are off."

This diagram shows conditions before and after a major storm. On page 15, Hans Paerl and doctoral student Joey Crosswell in Paerl's lab at UNC's Institute of Marine Sciences in Morehead City.

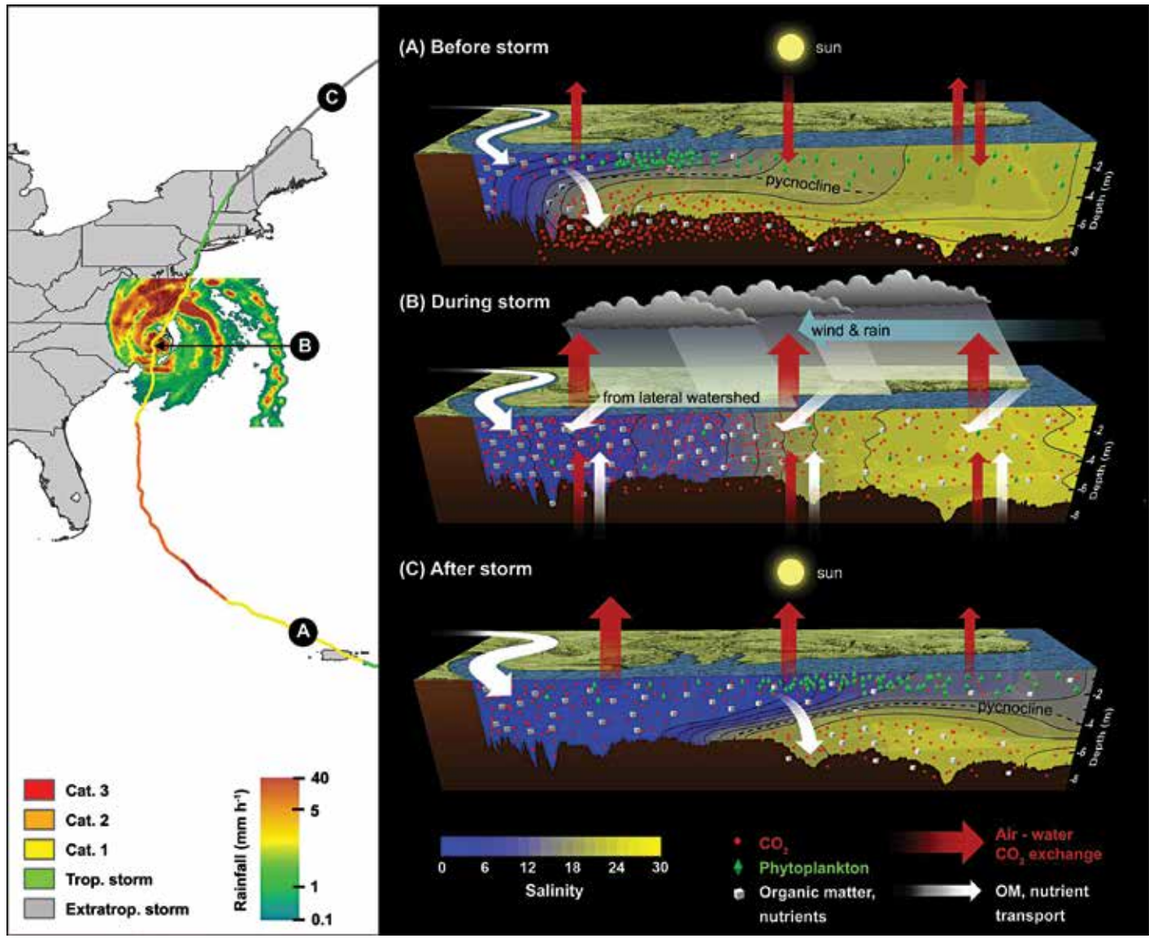

DIAGRAM BY J. CROSSWELL/A. JOYNER; PHOTO BY A. JOYNER/UNC INSTITUTE OF MARINE SCIENCES

when a storm comes, all bets are off."

For the past four years, Paerl and his students and technicians have been studying how estuaries in North Carolina fix carbon and what happens when that process is interrupted by a major weather event such as a hurricane. "The hypothesis was that when a major storm comes in, some of the CO_2 that was stored in the estuary must be released back up into the atmosphere," Paerl said.

Two big things happen when an estuary is hit by a major weather event. First, the system mixes violently, churning the waters and suspending much of the sediment in the water. The organic matter that has been packed into the mud is degraded by microbes and is converted back into carbon dioxide. Meanwhile, the water turns murky, making photosynthesis almost impossible. The perturbation also causes carbon dioxide to leave through gas transfer. All of these actions result in a massive carbon release, or a "burp," back into the atmosphere.

The study began in 2010 — the third-most-active Atlantic hurricane season on record — but no storms hit North Carolina until August 2011. Irene was large enough in diameter to cause major damage and open a new inlet across the Outer Banks, but it was not nearly the most destructive storm North Carolina has ever seen.

In addition to knocking out power, flooding streets and uprooting trees, Irene also released about 600,000 metric tons of the greenhouse gas carbon dioxide from the Albemarle-Pamlico Sound estuarine system. Paerl's group calculated that it had taken two years for the estuary to fix that amount of carbon — and then it was all released back into the air in one day.

To put the amount in perspective, "it would be like adding 2 million more cars to the road for an entire month," said Joey Crosswell, a doctoral student in Paerl's lab who conducted much of the field work. After hammering eastern North Carolina, Irene also hit the Chesapeake Bay, the Delaware Bay and Long Island Sound. "If you scale things up to include all of those waters, the numbers really become impressive, equaling approximately 8 million cars," Paerl said.

That release of carbon dioxide leads to atmospheric warming, which increases the surface temperature of the ocean, which in turn generates more frequent and more intense storms, which promote more carbon dioxide venting from coastal systems. "But that sequence can't operate forever. You have to have fuel to keep that engine running," Paerl said. "The fuel is the stuff that gets washed into the estuary — the new carbon. It's a super-huge positive feedback loop."

So we can't stop a hurricane's trek across the Atlantic to our coast, but is there anything to be done about diminishing the feedback loop?

"When I discuss this issue with my students, I always ask, 'What are the knobs we can tweak to help control the loop?' " Paerl said. "The knobs we can tweak deal with how much terrestrial 'stuff' ends up washing into the estuary."

The "terrestrial stuff" includes everything that flows off the land and into the estuary during a storm. To reduce the amount of that stuff, Paerl says we must minimize the runoff of nitrogen and phosphorus-rich fertilizers, washout of wetlands and loss of the landscape by erosion, all of which contain these nutrients as well as plant and animal matter that eventually can be converted to nutrients and carbon dioxide by microbes in the estuary. "The nutrients support algae blooms," Paerl said. More algae blooms mean more organic matter entering the estuary that can be converted to carbon dioxide and burped back into the atmosphere during storm events.

Paerl says it all comes down to protecting our watersheds: dealing with septic systems responsibly, reducing sedimentation and properly handling stormwater runoff on farms and in urban areas. "If you take the long view, the total frequency and intensity of hurricanes has gone up worldwide. Things are happening to maintain this feedback loop."

— Mary Lide Parker '11

Endeavors, UNC's online research magazine at **endeavors.unc.edu**, also includes:

▼ Empowering young scientists: Anna Atencio thought she wanted to go to N.C. State to become an engineer. The Chancellor's Science Scholars Program at UNC changed her mind.

EMILY WOODWARD/UNC INSTITUTE OF MARINE SCIENCES

MAX ENGLUND

▲ What really causes jet lag? UNC researchers have figured out what makes the circadian clock tick.