

SO UNMID

Ferries Keep Watch

Researchers in North Carolina are developing a new approach to understanding the behavior of a critical waterway, the Pamlico Sound. Hans Paerl, Kenan Professor of Marine and Environmental Sciences at the University of North Carolina Institute of Marine Sciences in Morehead City, and Joseph S. Ramus, a professor of biological oceanography at Duke University in Durham, have put together an innovative project called FerryMon to use that state's extensive coastal ferry system to actively monitor water quality in the rivers and open waters of the sound. The system connects the mainland with the state's barrier islands (the Outer Banks) and crosses rivers in historically rural coastal North Carolina.

The sound, a broad body of water touching land, sea, and freshwater environments, is part of the extensive Albemarle-Pamlico estuary system, where rivers from Virginia and North Carolina flow to the Atlantic Ocean. It is the second largest estuary in the United States, smaller only than the nearby Chesapeake Bay system. "The Pamlico Sound is the single most important fisheries nursery for the U.S. Atlantic coast," Paerl says. "It also handles about half of the freshwater runoff for the state of North Carolina."

Nutrient loads in the freshwater runoff are increasing, though, Paerl says. "The coast is experiencing growth, and all growth-related activities are impacting on the estuarine system." Wholesale land use change throughout the state including increased urbanization has resulted in excess nitrogen draining into the estuary.

Excess nitrogen promotes eutrophication, or accelerated biologic production in coastal waters. Eutrophication can fundamentally change the ecology of the coast by stimulating algal blooms and affecting

the life cycles of economically important fish, shellfish, and marine plants. "There's a grand-scale experiment going on with respect to excess nutrients," Ramus says. "But the bottom line is, we don't have a clue how the Pamlico Sound system, which receives drained water from across the state, functions [to process nutrients] in the first place."

Environmental shifts can also lead to changes in dissolved organic carbon. Dissolved organic carbon is correlated to the presence of fecal coliform bacteria such as *Escherichia coli* and disease-bearing organisms such as *Vibrio* and *Clostridium* species, says Ramus.

The FerryMon project will measure water quality indicators, day in and day out, along well-defined routes across the extensive body of water. Over time, measurements will characterize baseline water quality within the sound, allowing researchers to study how environmental changes ranging from alterations in nutrients to arrival of sudden storms affect the sound's water quality and how the estuary

rebounds from these changes. This knowledge will provide insight for remediating the environmental and health effects of ecological change on the coast.

A Fleet of Opportunity

Water monitoring within the Pamlico Sound has traditionally taken advantage of fixed sampling sites including coastal locations and stationary buoys. FerryMon brings a new dimension to water sampling. "The sound is huge," says Paerl. "It's 1,700 square miles, and it's shallow, so it can be unfriendly to small boats. But the state has a 'fleet of opportunity' in the ferries, and they cut across the sound in some very strategic places." By fitting sampling equipment on the passenger/automotive ferries traveling established routes through the sound, the researchers have gained a new platform for frequent water quality sampling.

FerryMon depends on low-maintenance equipment produced by the Massachusetts-based environmental monitoring device designer Endeco/YSI Incorporated, a corporation that develops hardy monitoring systems for long-term environmental deployment. The "black box" equipment (so called because the user doesn't need to know anything about it to operate it) is stashed in the ferry's sea chest and samples sound water drawn in through cooling water intakes. "The chief engineers who serve on the individual ferries do a little daily operational preparation for the system," says Dan Noe of the North Carolina Department of Transportation Ferry Division, who is working with Ramus and Paerl to outfit the ferries. "But that involves maybe five minutes in the evening and one minute in the morning. So it's pretty inconsequential as far as our workload is concerned."

SCIENCE

on Coastal Waters

The system can be installed without interfering with normal ferry operations. It actively monitors a number of water quality indicators including salinity, temperature, turbidity, dissolved oxygen, pH, and chlorophyll content (a measure of phytoplankton biomass). The system records the data as the ferry travels its route throughout the day, then uses a cell phone modem to send the results to a computer in Ramus's laboratory each evening. The monitoring tools also include a refrigerated collector that allows for transporting water samples to the laboratory for further analysis such as measurement of dissolved organic carbon and microbiologic examination.

Monitoring from the ferry *M/V Floyd J. Lupton*, which makes a 20-minute passage across the mouth of the Neuse River 40 times a day, has been ongoing since September 2000. The ferry *M/V Carteret*, which makes a passage of more than two hours between the Outer Banks island of Ocracoke and the mainland town of Cedar Island to the southwest, began monitoring water quality the next winter, in February. The ferry *M/V Governor Edward Hyde*, which travels northwest from Ocracoke to the town of Swan Quarter, will begin automated water quality monitoring in the near future.

Paerl says funding for outfitting the first three ferries has come from state dollars set aside for relief from Hurricane Floyd, the

1999 storm that precipitated massive floods across eastern North Carolina and considerable runoff of nutrient-rich water into the sound. According to Ramus, the initial cost of outfitting a ferry was about \$40,000, but improvements have lowered the cost to about \$30,000 for each new boat that comes on line. There are additional laboratory costs for nutrient, dissolved organic carbon, and chlorophyll analyses, as well as costs for data management, says Paerl.

In addition to the water sampling, other types of data are used to take a "snapshot" of the sound, Ramus says. "We also want to see the whole surface of the sound, so we rely on remote indicators such as ocean color and sea surface temperature that are recorded by satellite." Coordination of such data with Global Positioning System satellites allows precise measurement of the positions at which samples are taken by each of the ferries.

This information will be useful for calibrating satellite data, thus making the satellite data more interpretable.

Waves of Information

Monitoring from the ferries will not give a complete picture of the sound, however. "As long as people realize the limitations of sampling methods, it is possible to get useful data," says Kevin Summers, who runs the Environmental Protection Agency's (EPA) Coastal 2000 program, a five-year effort to coordinate water quality, sediment quality, and biologic indicators in 24 coastal states and Puerto Rico to characterize U.S. estuaries and how they behave over time. "The concern would be that someone would take the data from the ferry routes and use it to extrapolate to the whole North Carolina coast," he says.

Coastal 2000 provides a complement to the ferry data, using probabilistic methods



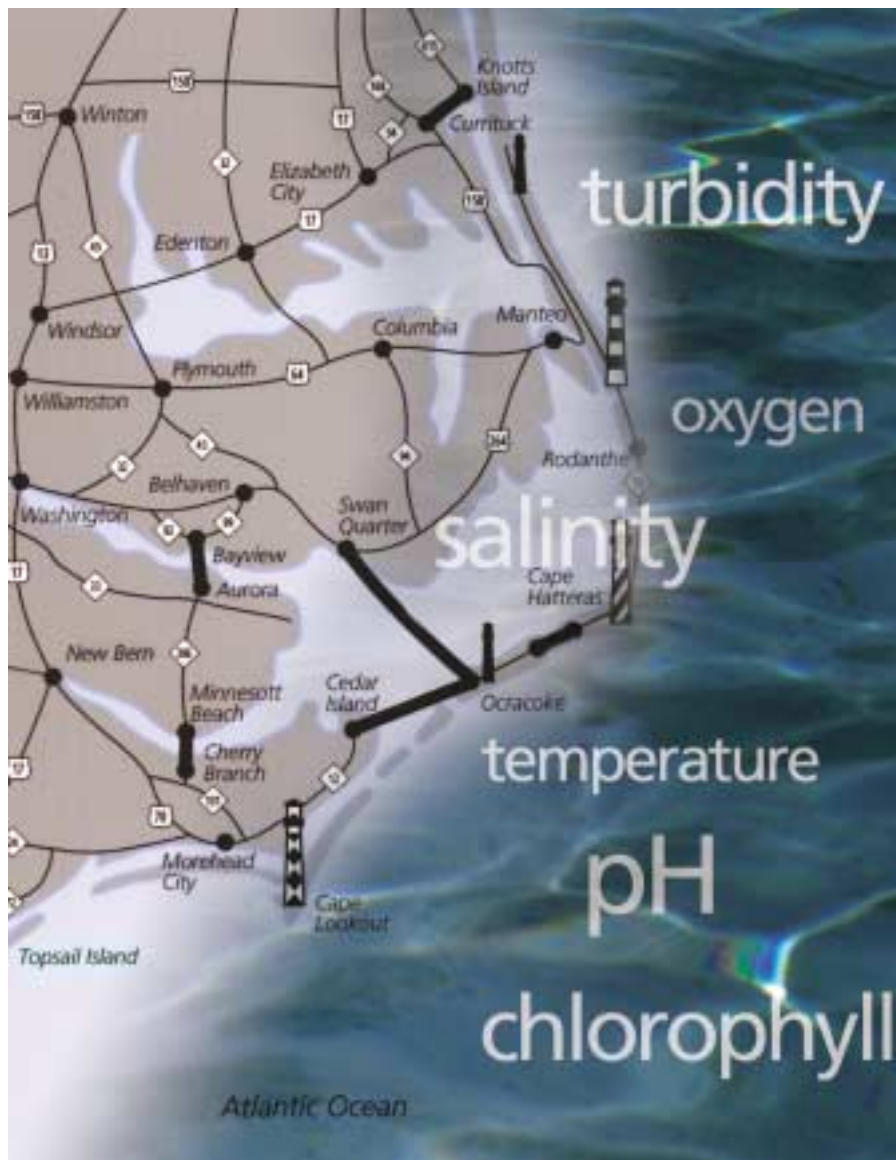
M/V Governor James Baxter Hunt, Jr.

to choose sample sites from varied statistically selected representative sites along the coast. This avoids the problem of overreliance on data from individual sites that may prove unrepresentative of the coast as a whole. Coastal 2000 records data from waterways around the United States, including North Carolina's coasts, in the EPA's Environmental Monitoring and Assessment Program database, a research tool that compiles ecological data for trends and status analysis. The data collected by the FerryMon project will be made available to the public. Data from both approaches are already available to the scientific community from the researchers and the EPA (the EPA data are part of the Coastal Assessment & Data Synthesis System maintained by the National Oceanic and Atmospheric Administration, available online at <http://cads.nos.noaa.gov/>).

FerryMon is the first effort to use regular ship routes to monitor water quality along several transects in a relatively compact area. However, it is not the first to use ferries to monitor water quality. Since 1992 the Finnish Institute of Marine Research has used long-range passenger ferries (including the *GTS Finnjet*, one of the largest ferries in the world) to measure water quality indicators and to sample phytoplankton in the Baltic Sea between Helsinki and Travemünde, Germany. The Finnish work illustrates both the power and the problems of this approach. Gathering data over the very long distances—more than 600 miles—traveled by the trans-Baltic ferry produces a remarkably detailed picture of water quality along the ferry's transect, but not away from it. Since ferry routes are fairly constant, a great deal of data is collected about a very limited segment of the sea, while the characterization of nearby water remains relatively data-poor.

Within these limitations, though, the ferry systems may prove to be more generally valuable for monitoring water quality indicators in coastal areas. Paerl notes that there is interest around the United States, particularly in coastal areas of the northeast and northwest, in developing similar ferry-based water monitoring systems. And in North Carolina, the program is welcomed by those who make their living on the waters. "On their time off," Noe notes, "most of the guys who work on the ferries go boating or fishing or crabbing or shrimping. They are very aware of water quality and are behind this one hundred percent. They see that anything that can be done to help the water quality can't be anything but helpful in the long run."

Victoria McGovern



Floating treasure. The FerryMon project takes advantage of the North Carolina ferry system to actively monitor environmental indicators of water quality.

Suggested Reading

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