Oxygen Monitoring on the Bay

NBEP and Partners Mark Tenth Year of Landmark Surveys

Thomas Ardito

In 1999, a diverse group of scientists organized by the Narragansett Bay Estuary Program began going out in boats at night on Narragansett Bay to measure dissolved oxygen in the water. At the time, it was an obscure study, but the researchers had reason to believe that trouble might be lurking beneath the surface. Within a year or two, they were seeing disturbing results.

Dave Murray was part of this group—the self-titled Insomniacs—from its inception. In addition to his work as a marine scientist at Brown University, Murray speaks to high school students and teachers, to inform them about Narragansett Bay. Recently he described some of his conversations with the students during the early years of the Insomniacs.

"I'd tell the kids, the only way anybody's going to pay attention to us is if a bunch of dead fish wash up on rich people's lawns. In 2003, that happened, and we got a lot of attention."

In August of that year, an estimated million small menhaden died in Greenwich Bay, on the west side of Narragansett Bay, along with uncounted numbers of tiny steamer clams and a variety of other marine animals, from crabs to eels. A boat-based team from NBEP and the R.I. Dept. of Environmental Management (RIDEM) responded to the event. Using water quality sampling instruments, they found that the water column throughout Greenwich Bay was virtually anoxic—dissolved oxygen (DO) levels were near zero. The fish and shellfish, which normally extract oxygen from the water through their gills in order to breathe, had literally suffocated.

The data from the Insomniac surveys proved critical to the response of policy-makers. Chris Deacutis, senior scientist with NBEP and organizer of the surveys, developed a report which, beyond documenting the fish kill, showed that low oxygen was a persistent and ongoing problem in upper Narragansett Bay.

"Some people were arguing it was kind of a perfect storm, a one-time event," Angelo Liberti of RIDEM said of the fish kill. With the Insomniacs data, he said, "Chris was able to say that low oxygen was not new." The report demonstrated the geographic extent of the problem as well. "It showed it wasn't just the Providence River and Greenwich Bay—but there were more areas of the Bay" subject to low oxygen, said Liberti, who credits the Insomniacs with building public support for legislative action to address the problem.

The year after the fish kill, the R.I. General Assembly passed a law mandating 50 percent reduction by 2008 in the amount of nitrogen released from wastewater treatment plants. The process of tightening the plants' discharge permits and upgrading their facilities is now underway, although behind schedule, according to Liberti.

Candace Oviatt, an oceanographer at University of Rhode Island who has also been involved in the surveys since their inception, credits them with improving researchers' understanding of the Bay. The surveys, she said, "are providing a measure of the extent of low oxygen as it occurs in the Bay—which is a lot more than we used to think ten years ago. We were surprised to see that it extended down to Dutch Island one year," she added, noting that low oxygen is often seen as far south as Quonset Point in summer.

Jessica Morgan of NBEP uses a secchi disk to measure water clarity in Narragansett Bay. *Photo:* NBJ

Throughout the world, dissolved oxygen is used as an indicator of estuarine health. Vast low-oxygen "dead zones" in Chesapeake Bay, the Gulf of Mexico and the Baltic Sea have made a great deal of news recently; but elsewhere, in virtually every major U.S. estuary, scientists monitor DO in order to track the impacts of pollution on marine life. DO is useful to policymakers because it can reflect the impact of waste water on the biology of the estuary. Nutrients such as nitrogen, from wastewater treatment plants and other sources, fuel low-oxygen events by fertilizing "blooms"—the rapid growth of plants in the water, from microscopic plankton to large seaweeds. Rapid growth is followed by rapid decomposition, which consumes oxygen in the water and can lead to hypoxia—low-oxygen conditions—or worse, anoxia.

In most of Narragansett Bay, this boom-and-bust growth pattern is necessary, but not sufficient, to cause a severe low-oxygen event. If the water column is stirred up by winds, waves or tides—"well-mixed" in the parlance of marine scientists—then oxygen re-enters the water from the atmosphere. Hypoxia and anoxia occur in Narragansett Bay when the water is stratified or layered—typically during hot, calm weather from June to September. At these times, a layer of light, fresh water from the Bay's rivers floats on top of a layer of heavier salt water from the ocean. Particularly during periods of weak tides, the stratification becomes so pronounced that oxygen from the surface doesn't penetrate the deeper waters. If decomposing plant material is consuming oxygen, the bottom waters become hypoxic or anoxic.

Less dramatic than fish kills, but perhaps more harmful, are the chronic impacts of low DO on bottom habitats. Areas of upper Narragansett Bay such as the Providence and Seekonk Rivers, subject to frequent low-oxygen events, lack the diversity of shellfish, marine worms and other bottom-dwellers which serve as the foundation of the estuarine food web—and are characteristic of less degraded environments. Low oxygen kills off the more sensitive organisms, leaving only the toughest creatures. One species which often thrives in such environments is the quahog.

"Quahogs are probably the hardiest large bottom organism there is," said Deacutis. "They can literally hold their breath for a couple of months."

Deacutis offers Greenwich Bay as an example of the way that high nitrogen loadings and attendant low-oxygen events can alter Bay habitats. During the late 19th and early 20th centuries, the area was known for its abundant bay scallop fishery. Bay scallops require clear waters; their preferred habitat is eelgrass, a nutrient-sensitive plant which was present in Greenwich Bay until about the 1950's. Today, the eelgrass is gone and bay scallops are rare, replaced by quahogs in Greenwich Bay as elsewhere throughout Narragansett Bay.

According to a paper published in the journal *Science* last year, the interrelated problems of nutrient pollution and hypoxia are increasing worldwide. In "Spreading Dead Zones and Consequences for Marine Ecosystems," authors Robert J. Diaz and Rutger Rosenberg report that areas of coastal hypoxia have "spread exponentially" since the 1960's, leading to the collapse or decline of fisheries, including Norwegian lobster and Baltic cod, and note that global warming may exacerbate the problem in the future.

This concern is shared by scientists on Narragansett Bay, where climate change has yielded warmer waters, more rainfall and weaker westerly winds in summer—increasing the prevalence of physical conditions necessary for hypoxia to occur.

"We didn't used to get big rain events in the summer," said Oviatt, a leading researcher on the impact of climate change on the Bay. "But now you can get an inch, two inches—and *wham!*—that stratifies the system."

The Insomniac surveys were funded, in part, by the "Bay Window" program, a federal line-item appropriation beginning in 1999. Bay Window has funded several other important, and closely related, monitoring projects, including installation and maintenance of a dozen water-quality monitoring buoys which continuously measure DO in upper Narragansett Bay. Bay Window also funded development and deployment of a one-of-a-kind instrument, the Mariner Shuttle, which is towed monthly along an established route through Narragansett Bay by RIDEM's research vessel *Chafee*.

NBEP's boat-based DO surveys have evolved over time. The former Insomniacs are now the "Day Trippers." Deacutis initially organized the surveys at night to catch what was believed to be an ephemeral event; the research revealed, however, that low-oxygen conditions generally persist for a day or more, allowing for daytime sampling trips which are safer and less exhausting for the scientists. The boat-based surveys are still important to the mix of scientific information.

"The boat-based surveys provide spatial coverage, while the buoy network provides temporal coverage," said Oviatt.

Together, these programs have greatly improved scientific understanding of Narragansett Bay's chemistry, biology and even its physics. We can better appreciate, now, the subtler influences of tide on the Bay's biology—it turns out that low-DO events are more likely to occur during weak neap tides, while the greater amplitude of spring tides packs enough punch to break up stratification. The Bay's internal gyres or circulation patterns are becoming more apparent—although there is still much to learn. It is clearer

Chris Deacutis deploys a water quality monitoring device or sonde which measures DO and other parameters. *Photo:* NBJ

now than it was ten years ago that much of the ocean water which enters the Bay does so through the East Passage, while much of it exits through the West Passage—setting up a counter-clockwise circulation pattern or net transport of salt water through the lower Bay. Meanwhile, fresh water from the rivers of the watershed flows out like a sheet across the surface, creating under some conditions the stratification of the upper Bay which sets the stage for hypoxic events.

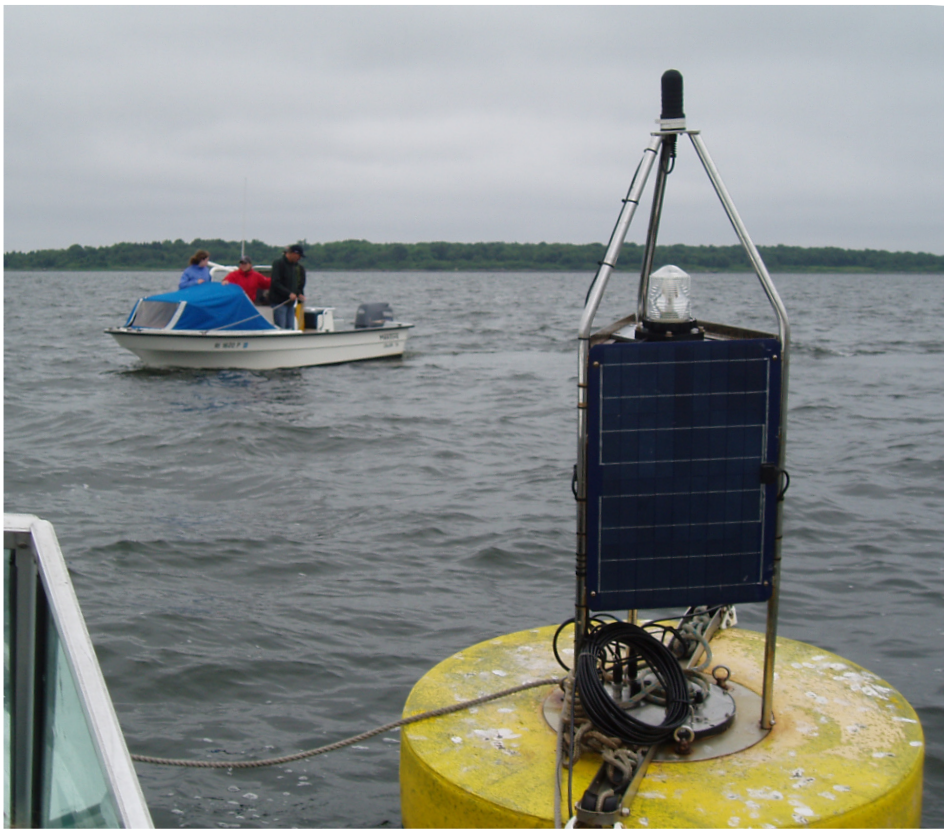
Despite their value, the future of all these monitoring programs is in doubt. Funding for Bay Window will end after next summer; the Coastal Hypoxia Research Program, another federal grant which has supported a variety of water quality work in the Bay, including computer modeling of the Bay's oxygen dynamics, is ending this year as well. No funding has yet been identified to continue the research or maintain the buoys.

With construction underway to upgrade wastewater treatment plants and the recent completion of the Narragansett Bay Commission's combined-sewer storage tunnel in Providence, continued monitoring is essential. Without it, policy-makers may be unable to determine whether hundreds of millions of dollars of public investment in pollution control have been effective, or whether additional nutrient reduction is warranted.

"As we crank down the nutrients from the sewage treatment plants and as we change freshwater runoff, we should be watching the Bay closely," said Oviatt. "We're causing this huge change in the Bay."

Scientists and policy-makers expect that change to be a significant improvement. But only through the continuation of comprehensive oxygen monitoring on Narragansett Bay—building on the work begun by the Insomniacs a decade ago—can we know for sure.

–Thomas Ardito is editor of the Narragansett Bay Journal.



Buoys and boats are two of the principal platforms for measuring DO on Narragansett Bay. *Photo: Chris Deacutis*

Go Deeper!

To learn more about dissolved oxygen in the Bay and view water quality maps produced by the insomniacs and Day Trippers, visit www.nbep.org and follow the link to Brown University's Insomniacs page.

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tom@gso.uri.edu