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NSF grant will support research on toxin production by algal blooms

By Kristin Cobb

Toxic algae periodically bloom in Monterey Bay and other coastal waters, sometimes poisoning seabirds and marine mammals and interfering with economically important fisheries. It can take weeks, however, for scientists to determine that an algal bloom is producing a potentially deadly toxin.

Now UCSC researchers hope to catch toxin-producing algae in the act by following their genetic footprints, thanks to a $1 million grant from the National Science Foundation.

Scientists aboard the research vessel *Point Sur* process water samples as part of an investigation of toxin-producing algae. Photo: R. Kudela

The three-year project will focus on harmful algal blooms caused by certain species of diatoms (single-celled algae with glass shells) in the genus *Pseudo-nitzschia*. Led by assistant professor of ocean sciences Raphael Kudela, the project also involves researchers at the University of Washington in Seattle and Moss Landing Marine Laboratories.

Pseudo-nitzschia blooms in Monterey Bay from late spring to early fall. The algae produce domoic acid, a potent neurotoxin that can cause nervous twitching, disorientation, short-term memory loss and even seizures and brain damage in vertebrates.

Domoic acid is passed up the food chain from diatoms to small fish and copepods to larger fish, seabirds, sea mammals, and even humans. Domoic acid was first recognized in 1987 on Prince Edward Island, Canada, when 150 people became ill and four died from eating blue mussels that were contaminated with domoic acid. Domoic acid was also blamed for the deaths of 100 brown pelicans and cormorants in Monterey Bay in 1991 and 50 sea lions that washed up along the coast of California from San Luis Obispo to Santa Cruz in 1998.

But not all *Pseudo-nitzschia* blooms are toxic.

"Pseudo-nitzschia can turn toxin production on and off," Kudela said. "Right now we can use molecular probes to tell us whether or not *Pseudo-nitzschia* is in the water, but it can take several weeks to determine if there is toxin in the water. We have to tell people to stop fishing while we're waiting for results, even though the toxin may not be there."

In addition to Kudela, the research team includes UCSC professor of ocean sciences Jonathan Zehr, Virginia Ambrust at the University of Washington, and G. Jason Smith at Moss Landing. The project seeks to identify genes that are activated when toxin production is switched on in *Pseudo-nitzschia,* and to make probes that will identify when these genes are active. Such probes can be used to test for toxin production in the field and to measure toxin output under various laboratory stress tests.

The team will search for genes associated with domoic acid production by identifying the genes that are active only in toxic *Pseudo-nitzschia.* Scientists can identify all the genes active in a cell at one time by fishing out intermediary copies of the gene that are only made when a gene is turned on. *Pseudo-nitzschia* algae can be made toxic in the lab by depriving them of silica, the nutrient they use to make their glass shells. Kudela's team will make separate libraries of all the active genes in nontoxic *Pseudo-nitzschia* and those in toxic *Pseudo-nitzschia,* and compare the two collections.

"We just subtract one set of genes away from the other set, and we should be left with a handful of genes that went from being turned off to being turned on when the algae went from being not toxic to toxic," Kudela explained.

From there, it would be straightforward to make a gene chip that lights up when it catches domoic acid-related gene products in seawater. Such a chip would be a "huge advantage" in monitoring for toxin production in the field, said Kudela.

The chip could also be used to answer the question of why *Pseudo-nitzschia* makes domoic acid. The diatoms produce domoic acid "anytime they're not happy," Kudela said. But scientists don't know exactly what makes them unhappy. The gene chip could be used to test domoic acid production in potentially stressful conditions, such as nutrient shortages and excesses.

Kudela said he plans to test *Pseudo-nitzschia* in a low-iron setting, because he suspects that *Pseudo-nitzschia* may secrete domoic acid to help bind and sequester iron, based on results published by UCSC ocean sciences professor Kenneth Bruland and his lab group.

"It may be possible that, once we know exactly why they're producing domoic acid, we could come up with strategies to keep them from doing it," Kudela said. For example, if domoic acid production is related to iron deficiencies, a solution might be to add iron to the ocean during algal blooms.

People have been studying *Pseudo-nitzschia* since at least 1991 and have come up with many suggestions for when and why domoic acid is made, but they don't have a lot of concrete answers, Kudela said. "If we tackle it from a molecular perspective and look at what's happening in the cell, maybe it will become more obvious," he said.

Kudela's grant was obtained through the Ecology and Oceanography of Harmful Algal Blooms program (ECOHAB). ECOHAB is an interagency research program that supports studies on harmful algal species. Participating agencies are the National Science Foundation, the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, and the Office of Naval Research.

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Return to Front Page