Spread of algal toxin through marine food web broke records in 2015

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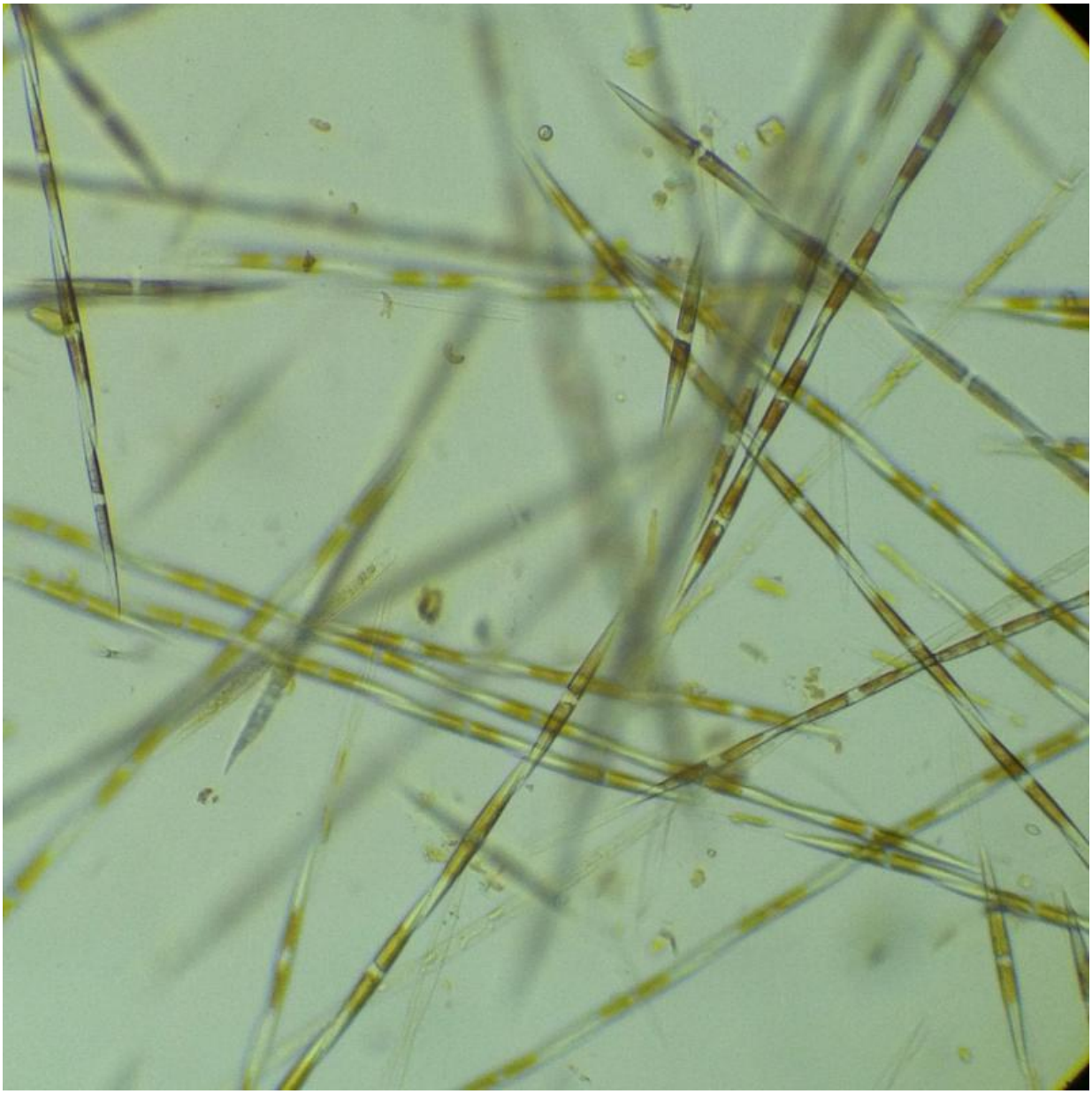

Cells of the diatom *Pseudo-nitzschia*, a type of single-celled algae, produce the neurotoxin domoic acid under certain conditions. This image is from a water sample collected in Monterey Bay in 2015. Credit: Alyssa Gellene

Researchers monitoring the unprecedented bloom of toxic algae along the west coast of North America in 2015 found record levels of the algal toxin domoic acid in samples from a wide range of marine organisms. The toxin was also detected for the first time in the muscle tissue or filet of several commercial fish species.

Investigations led by scientists at the University of California, Santa Cruz, help explain the extraordinary duration and intensity of the 2015 domoic acid event, the spread of the toxin through the marine food web, and its persistence in Dungeness crab months after the algal bloom disappeared from coastal waters. Ocean scientist Raphael Kudela, the Lynn Professor of Ocean Health at UC Santa Cruz, will present the latest research findings at the American Geophysical Union (AGU) Fall Meeting in San Francisco on Friday, Dec. 18, 2015.

Domoic acid is a potent neurotoxin produced by a type of microscopic algae called *Pseudo-nitzschia* that occurs naturally in coastal waters. Blooms of the toxic algae along the California coast typically occur in the spring and fall and last just a few weeks. This year, however, unusual oceanographic conditions (unrelated to El Niño) led to the largest and longest-lasting bloom ever recorded.

"The duration of the bloom and the intensity of the toxicity were unprecedented, and that led to record levels of the toxin in species such as anchovies, razor clams, and crabs," Kudela said. "We also saw the toxin in organisms and parts of organisms where we thought it was not supposed to be, like the filets of fish."

Monitoring programs are in place to ensure the safety of seafood for human consumption, leading to the closure of several west coast fisheries and the delayed opening of the Dungeness crab season. In humans, domoic acid poisoning is also known as amnesic shellfish poisoning because it may cause permanent loss of short-term memory, as well as neurological and gastrointestinal symptoms. In 1987, four people died of domoic acid poisoning in Canada after eating contaminated mussels, but such cases are rare.

The levels of toxin detected this year in the filets of salmon, rockfish, and ling cod were well below the regulatory limits, Kudela said. But once the toxin gets into the muscle tissue, it will stay in the fish and in the food web much longer than if it is just in the intestinal track.

"Before this year, it was a big question whether it gets into the filet at all," he said. "We think what happened is the bloom lasted so long and was so toxic that the prolonged exposure allowed the toxin to perfuse into the muscle tissue, and it also worked its way into the food web to an extent that we hadn't seen before."

The prolonged bloom probably also allowed a lot of toxin to build up in sediments on the seafloor, which would explain why Dungeness crabs are still showing high levels of toxin. Previous studies by Kudela's team showed that sediments on the seafloor can hold a reservoir of toxin that lasts for months after the algal bloom goes away. "The crabs are feeding on the seafloor, and all the things they would typically eat can hold the toxin for months," he said. "It could be another month or longer before the toxin in crabs drops below the regulatory limit everywhere in California."

The good news, Kudela said, is that scientists now have a much better understanding of the factors that lead to *Pseudo-nitzschia* blooms. His lab has developed a forecasting model that has performed well at predicting

where and when domoic acid will be a problem.

A combination of warm water and nutrients creates ideal conditions for a toxic bloom of *Pseudo-nitzschia*, Kudela said. That's a relatively uncommon combination along the west coast, where wind-driven upwelling of cold deep water is a major source of nutrients in coastal ecosystems. When there's no upwelling of cold water, the layer of warm water on the surface tends to be low in nutrients. *Pseudo-nitzschia* blooms typically occur during the transitional periods in the spring and fall, when upwelling is getting started or winding down and nutrients mix with warm water for a few weeks.

In 2015, however, the usual patterns were disrupted by a warm-water anomaly known as the 'warm blob,' which first appeared in the North Pacific west of Seattle in late 2013. In 2014, a second warm blob developed off of southern California, and in 2015 they spread into the coastal waters. "We had two pools of warm water hitting the coast in the Pacific Northwest and southern California and merging, so all at once there were warm waters over the whole west coast," Kudela said.

That warm water then interacted with coastal upwelling to create perfect conditions for *Pseudo-nitzschia*. Normally, the northerly winds that start in the spring blow the warm surface waters offshore, driving the upwelling of cold deep water and creating a regime of cold, nutrient-rich coastal waters that lasts until fall. In 2015, weak upwelling provided periodic injections of nutrients, but every time the upwelling got started the warm blob pushed back onto the coast.

The result was a record-breaking toxic algae bloom that started in April and lasted into early October. The size of the bloom was also unprecedented, extending from Santa Barbara to Alaska. Even in December, water samples were still occasionally showing up with domoic acid, Kudela said. "We think it's just moving offshore, and each

time conditions are right it comes back in to the coast," he said. "Once a series of big winter storms comes through, that's when we'll see it go away until the following spring."

Now the big question is what the impact of El Niño will be in 2016, because El Niño also brings warm water conditions that can favor toxic algae blooms. Most of the warm water along the California coast in 2015 was from the warm blob, although El Niño probably began contributing to it later in the summer. Historically, El Niño periods have been associated with larger than normal blooms of Pseudo-nitzschia, Kudela said.

"The predictions are for this El Niño to be as strong as the one in 1997-98, when the warm water lasted through 1998. So we could be looking at a big bloom again next year," he said.

Provided by University of California - Santa Cruz