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Will a cleaner San Francisco Bay be a more toxic one?

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San Francisco Bay enthusiasts are pleased that the waters of San Francisco Bay are becoming cleaner and clearer, but researchers are worried that this might invite a new problem – blooms of toxic phytoplankton. Although these microscopic, toxin-producing algae are already found in the Bay, with clearer waters permitting more light to reach these photosynthetic algae, it's feared that the Bay could turn into a toxic soup of both freshwater and marine harmful algae, potentially impacting shellfish and even the marine mammals that are finally starting to re-populate the Bay.

Student and staff researchers at SF State's Estuary & Ocean Science (EOS) Center are working with scientists from the San Francisco Estuary Institute (SFEI) to find out if we can expect a better or worse "recuperated" SF Bay now that its muddy waters are becoming clearer.

Like microscopic plants, phytoplankton require nutrients and sunlight to grow. When both of these are in abundance, these algae flourish and rapidly reproduce, thus forming what's known as a phytoplankton "bloom." Usually this rapid reproduction is a 'good thing', forming the productive base of the whole aquatic food web – but when some of these phytoplankton produce biotoxins, other members of the ecosystem, including birds, marine mammals and even humans can become ill and even die if they consume enough toxin-contaminated shellfish.

San Francisco Bay is recognized as a special environment. Unlike most estuaries, SF Bay rarely experiences massive blooms of phytoplankton despite the plentiful supply of growth-stimulating nutrients in the Bay such as nitrogen and phosphorus that come primarily from the 37 large wastewater treatment facilities that continually discharge into the Bay. Lesser amounts emanate from non point sources such as runoff from streets, farms and hillsides along SF Bay's perimeter.

Sunlight only penetrates a very short distance into the Bay's murky waters due to the large amount of sediment suspended in the water ("the muddiness factor"), which constrains the rate that these phytoplankton can grow even with an abundance of nutrients. However, this appears to be changing, and researchers are now seeing a gradual clearing of the waters.

Submitted by Pat Lamson
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Since the mid-1990s, the amount of suspended sediment in the Bay, especially in south SF Bay, has decreased by approximately 40 percent – which translates into a 40 percent increase in how quickly phytoplankton can grow. This increase in light penetration has resulted in overall more phytoplankton biomass in the past few years, so now researchers are readying themselves to test whether toxin-producing harmful algae will increase in this "clearer' Bay as well. This would not be a good thing.

The United States Geological Survey has carefully monitored the deeper waters of the Bay for water quality, nutrients and phytoplankton for over 50 years, but recently researchers from the EOS Center and SFEI have started checking the shallow waters along the shores of the Bay for evidence of increased biotoxins produced by these toxic algae. Here we are using Nature's own sampling system – naturally occurring mussels, which we are analyzing every two weeks from eight different sites around the Bay. These bivalve mollusks constantly filter the water for suspended particles including microscopic algae which are their main food source. In doing so they accumulate any biotoxins that the algae may have been producing. So far, this work has shown that these mussels contain not only biotoxins from marine microscopic algae, but also toxins produced by freshwater harmful algae found further upstream in the Delta – luckily both toxin types are normally found at very low concentrations.

These harmful algae seasonally bloom along our productive California coastline including right off the Golden Gate, and they are commonly found within the Bay in very low numbers. So far, environmental conditions in the Bay have not permitted them to bloom to high abundances and produce toxins at harmful levels — but the Bay is not finished changing.

Not only is more light reaching deeper into the water column, but the ocean's rising sea level from climate change is expected to push more salty water further into the Bay and increase the overall water depth of the Bay. That increase would submerge many of the Bay's mudflats and further decrease the amount of sediment suspended in the water. These increases in salinity and light availability from an advancing sea, and increased temperature from a warmer climate will likely expand the area in which harmful algae can grow and flourish.

SF Bay's sole commercial fishery is the herring – a foraging species that swims open-mouthed in the water, directly eating phytoplankton, and not discriminating between the good and harmful algae. It's also an important nursery for many marine animals and a critical stopover point along the Pacific Flyway migration route of shorebirds and waterfowl.

So, will a warmer, brighter and saltier SF Bay become more toxic? Here at the EOS Center, we have been investigating how environmental factors associated with human population changes, climate change and extreme weather events contribute to accelerated growth and enhanced toxicity of some of the most problematic harmful algae in California, including those found in SF Bay.

Most notably, our research has focused on toxigenic diatoms – a group of algae belonging to the Pseudo-nitzschia genus – the same kind that caused massive toxic blooms all along the West Coast in 2015, killing hundreds of marine mammals, and closing the Dungeness crab fishery – California's most valuable commercial fishery. The results of our research will help scientists forecast harmful algal blooms and provide a proactive way to minimize exposure when ecosystems are expected to turn toxic. Currently, there are no reliable studies demonstrating how changing environmental factors such as light, temperature, or salinity impact the growth and toxicity of harmful algae in the coastal waters of California and SF Bay. We plan to change that.

Dr. William Cochlan is a Senior Research Scientist at the Estuary & Ocean Science Center in Tiburon CA, and a Research Professor in the Department of Biology at San Francisco State University. His phytoplankton ecophysiology lab at the EOS Center concentrates on the study of harmful algal blooms both locally and worldwide. This is one of an occasional series about the Bay and sea around us through the eyes of researchers at San Francisco State University's Estuary and Ocean Science Center.