The severe red tide event in Florida this year has attracted a lot of attention across the nation to a tiny organism called Karenia brevis. News coverage has included horrific images of beaches strewn with dead sea animals, as well as accounts of health problems among coastal residents. The fishing and tourism industries have suffered enormous economic losses. These issues have led many to wonder how science can help protect coastal communities and fisheries from such events in the future. The effort to understand the organism causing the phenomenon, its causes and impacts, and to develop strategies to manage it presents some surprising scientific challenges.

Red tide is caused by a bloom, or a sudden proliferation of algae. The most important red tide species is Karenia brevis, a single-celled dinoflagellate that looks somewhat like a package tied with string. It produces a class of chemicals called brevetoxins, which are responsible for the toxic effects of red tide events, including the infamous fish kills. When fish ingest the red tide algae, brevetoxins can damage their nervous systems, causing symptoms including reduced muscle coordination and lack of gill function. Fish essentially suffocate.

Animals higher in the food chain may consume fish with brevetoxins accumulated in their flesh, giving the predator a concentrated dose. Even herbivorous animals can be affected. Manatees, for example, can consume contaminated sea grasses, ingesting enough brevetoxin to cause die-offs. A still more indirect method of harm is when a fish kill occurs, and the bacteria involved in the decomposition of the mass of dead animals cause the depletion of oxygen in the water column. This can lead to large “dead zones” - areas where a lack of oxygen makes the water unfit for marine life. The 2018 red tide has seen a particularly devastating death toll of fish, dolphins, turtles and other marine life, but losses have occurred along the Florida and Texas coasts on the Gulf of Mexico on a near-yearly basis for decades.

Given these impacts, and the general understanding that coastal pollution contributes to the growth of algae, it seems natural to assume that tighter controls on the quality of water entering the Gulf of Mexico would effectively prevent severe red tide events. However, some unique features of K. brevis show that the answers are not that simple.

One surprising fact about K. brevis is that blooms of the species do not start near shore where potentially polluted water enters the Gulf. The initiation phase of a red tide bloom occurs miles from the shore, and deep under the surface, where direct exposure to coastal pollution is limited. Once the bloom has begun, however, and deep ocean currents bring the algae closer to shore, nutrient pollution plays a role in increasing the population.

However, K. brevis grows and reproduces much more slowly than many other species of phytoplankton, which does not explain the rapid development of a bloom. Scientists are finding that the complex relationships between K. brevis and other microorganisms determine how the excess nutrients are used and cycled through the food web. These relationships are important keys to understanding whether conditions will favor a red tide bloom.

An example of these complex, far-reaching relationships among phytoplankton species may extend as far away as the continent of Africa. As the Saharan Desert grows, huge dust storms carry soil particles high into the atmosphere. From there, wind currents carry those sediments across the Atlantic Ocean, depositing some of them in the waters of the Gulf of Mexico. Some of these sediments are rich in iron, which is a scarce nutrient in certain ocean waters, and which is necessary for the growth of certain species of microorganisms. When wind-borne dust adds iron to the system, the populations of these organisms increase, and they can then interact with K. brevis in complex ways. Scientists have hypothesized that this Saharan dust, through its effect on microscopic food webs, may play a role in the development of red tide blooms.

The relative contributions of industrial, municipal and agricultural pollutants through river discharge, groundwater flows, aerosol deposition and other means are all important parts of this puzzle. As the relationships between these processes and red tide development are better understood, strategies for minimizing impacts can be developed.

The ability to detect, forecast and track algal blooms using remote sensing and other technologies is another important research area where advancements have been made, such as NOAA’s red tide forecasting and reporting systems. These valuable resources, as well as scientific advancement, depend on data being collected regularly by various universities and federal, state, and local government agencies. Private groups are crucial partners in this effort.

Red tide is not new, but its severity and frequency have increased in recent years. The intensifying demands on ocean ecosystems, together with the complexities of climate and land use change, have added to the need for much more sophisticated management of red tide impacts to prevent damage to coastal communities and fisheries. The collaborative efforts of scientists along the coast and around the world are needed now more than ever to help protect the marine ecosystems, sports and industries we treasure.

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