Papers explore massive plankton blooms with very different ecosystem impacts

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The Video Plankton Recorder being recovered after a successful survey. Credit: Dan Brinkhuis, ScienceMedia.nl

"The big mystery about plankton is what controls its distribution and abundance, and what conditions lead to big plankton blooms," said

Dennis McGillicuddy, Senior Scientist and Department Chair in Applied Ocean Physics and Engineering at the Woods Hole Oceanographic Institution (WHOI).

Two new papers explore this question and provide examples of conditions that lead to massive plankton blooms with vastly different potential impacts on the ecosystem, according to McGillicuddy, co-author of both papers. Both papers also point to the importance of using advanced technology—including Video Plankton Recorders, autonomous underwater vehicles, and the Ocean Observatories Initiative's Coastal Pioneer Array—to find and monitor these blooms.

In one paper, "Diatom Hotspots Driven by Western Boundary Current Instability," published in *Geophysical Research Letters (GRL)*, scientists found unexpectedly productive subsurface hotspot blooms of diatom phytoplankton.

In the *GRL* paper, researchers investigated the dynamics controlling primary productivity in a region of the Mid-Atlantic Bight (MAB), one of the world's most productive marine ecosystems. In 2019, they observed unexpected diatom hotspots in the slope region of the bight's euphotic zone, the ocean layer that receives enough light for photosynthesis to occur. Phytoplankton are photosynthetic microorganisms that are the foundation of the aquatic food web.

It was surprising to the researchers that the hotspots occurred in high-salinity water intruding from the Gulf Stream. "While these intrusions of low-nutrient Gulf Stream water have been thought to potentially diminish biological productivity, we present evidence of an unexpectedly productive subsurface diatom bloom resulting from the direct intrusion of a Gulf Stream meander towards the continental shelf," the authors note. They hypothesize that the hotspots were not fueled by Gulf Stream surface water, which is typically low in nutrients and chlorophyll, but rather that the hotspots were fueled by nutrients upwelled into the sunlight zone from deeper Gulf Stream water.

With changing stability of the Gulf Stream, intrusions from the Gulf Stream had become more frequent in recent decades, according to the researchers. "These results suggest that changing large-scale circulation has consequences for regional productivity that are not detectable by satellites by virtue of their occurrence well below the surface," the authors note.

"In this particular case, changing climate has led to an increase in productivity in this particular region, by virtue of a subtle and somewhat unexpected interaction between the physics and biology of the ocean. That same dynamic may not necessarily hold elsewhere in the ocean, and it's quite likely that other areas of the ocean will become less productive over time. That's of great concern," said McGillicuddy. "There are going to be regional differences in the way the ocean responds to climate change. And society needs to be able to intelligently manage from a regional perspective, not just on a global perspective."

The research finding demonstrated "a cool, counterintuitive biological impact of this changing large scale circulation," said the *GRL* paper's lead author, Hilde Oliver, a postdoctoral scholar in Applied Ocean Physics and Engineering at WHOI. She recalled watching the instrument data come in. With typical summertime values of about 1-1.5 micrograms of chlorophyll per liter of seawater, researchers recorded "unheard-of concentrations for chlorophyll in this region in summer," as high as 12 or 13 micrograms per liter, Oliver said.

Oliver, whose Ph.D. focused on modeling, said the cruise helped her to look at phytoplankton blooms from more than a theoretical sense. "To go out into the ocean and see how the physics of the ocean can manifest these blooms in the real world was eye opening to me," she said.

Another paper, "A Regional, Early Spring Bloom of Phaeocystis pouchetii on the New England Continental Shelf," published in the *Journal of Geophysical Research: Oceans (JGR: Oceans)*, also was eye opening. Researchers investigating the biological dynamics of the New England continental shelf in 2018 discovered a huge bloom of the haptophyte phytoplankton Phaeocystis pouchetii.

However, unlike the diatom hotspots described in the *GRL* paper, Phaeocystis is "unpalatable to a lot of different organisms and disrupts the entire food web," said Walker Smith, retired professor at the Virginia Institute of Marine Science William and Mary, who is the lead author on the *JGR: Oceans* paper. The phytoplankton form gelatinous colonies that are millimeters in diameter.

When Phaeocystis blooms, it utilizes nutrients just like any other form of phytoplankton would. However, unlike the diatoms noted in the *GRL* paper, Phaeocystis converts biomass into something that doesn't tend to get passed up the rest of the food chain, said McGillicuddy.

"Understanding the physical-biological interactions in the coastal system provides a basis for predicting these blooms of potentially harmful algae and may lead to a better prediction of their impacts on coastal systems," the authors stated.

Massive blooms of the colonial stage of this and similar species have been reported in many systems in different parts of the world, which Smith has studied. These types of blooms probably occur about every three years in the New England continental shelf and probably have a fairly strong impact on New England waters, food webs, and fisheries, said Smith. Coastal managers need to know about these blooms because they can have economic impacts on aquaculture in coastal areas, he said.

"Despite the fact that the Mid-Atlantic Bight has been well-studied and extensively sampled, there are things that are going on that we still don't really appreciate," said Smith. "One example are these Phaeocystis blooms that are deep in the water and that you are never going to see unless you are there because satellites can't show them. So, the more we look, the more we find out."

More information: Hilde Oliver et al, Diatom Hotspots Driven by Western Boundary Current Instability, *Geophysical Research Letters* (2021). DOI: 10.1029/2020GL091943

Walker O. Smith et al, A Regional, Early Spring Bloom of Phaeocystis pouchetii on the New England Continental Shelf, *Journal of Geophysical Research: Oceans* (2021). DOI: 10.1029/2020JC016856

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