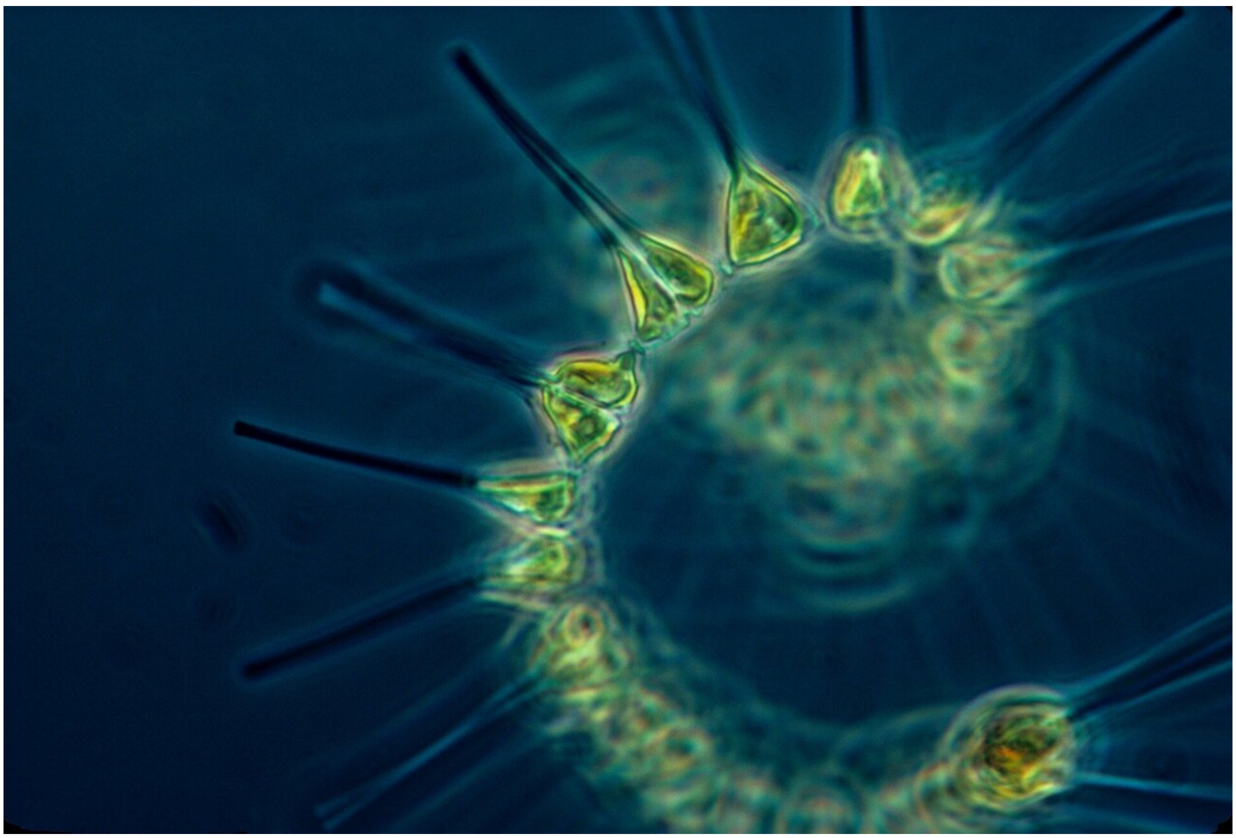
Oceanographers predict increase in phytoplankton by 2100

January 27 2020



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A neural network-driven Earth system model has led University of California, Irvine oceanographers to a surprising conclusion: phytoplankton populations will grow in low-latitude waters by the end of the 21st century.

The unexpected simulation outcome runs counter to the longstanding belief by many in the environmental science community that future global climate change will make tropical oceans inhospitable to phytoplankton, which are the base of the aquatic food web. The UCI researchers provide the evidence for their findings in a paper published today in *Nature Geoscience*.

Senior author Adam Martiny, UCI professor in oceanography, explained that the prevalent thinking on phytoplankton biomass is based on an increasingly stratified ocean. Warming seas inhibit mixing between the heavier cold layer in the deep and lighter warm water closer to the surface. With less circulation between the levels, fewer nutrients reach the higher strata where they can be accessed by hungry plankton.

"All the climate models have this mechanism built into them, and it has led to these well-established predictions that phytoplankton productivity, biomass and export into the deep ocean will all decline with climate change," he said. "Earth system models are largely based upon laboratory studies of phytoplankton, but of course laboratory studies of plankton are not the real ocean."

According to Martiny, scientists traditionally account for plankton by measuring the amount of chlorophyll in the water. There is considerably less of the green stuff in low-latitude regions that are very hot compared to cooler regions further away from the equator.

"The problem is that chlorophyll is not everything that's in a cell, and actually in low latitudes, many plankton are characterized by having a very small amount of it; there's so much sunlight, plankton only need a few chlorophyll molecules to get enough energy to grow," he noted. "In reality, we have had so far very little data to actually demonstrate whether or not there is more or less biomass in regions undergoing stratification. As a result, the empirical basis for less biomass in warmer regions is not that strong."

These doubts led Martiny and his UCI colleagues to conduct their own phytoplankton census. Analyzing samples from more than 10,000 locations around the world, the team created a global synthesis of the key phytoplankton groups that grow in warm regions.

The vast majority of these species are very tiny cells known as picophytoplankton. Ten times smaller in diameter than the strains of plankton one would find off the California coast—and 1,000 times less voluminous—picophytoplankton are nonetheless great in number, making up 80 to 90 percent of plankton biomass in most warm regions.

The group built global maps and compared the quantity of biomass along the gradient of temperature, a key parameter, according to Martiny. Conducting a machine learning analysis to determine the difference now versus the year 2100, they found a big surprise: "In many regions there would be an increase of 10 to 20 percent of plankton biomass, rather than a decline," Martiny said.

"Machine learning is not biased by the human mind," he said. "We just give the model tons and tons of data, but they can help us challenge existing paradigms."

One of the theories the team explored to explain the growth, with help from co-author Francois Primeau, UCI professor of Earth system science, had to do with what happens to phytoplankton at the end of their life cycle.

"When plankton die—especially these small species—they sit around for a while longer, and maybe at high temperature other plankton can more easily degrade them and recycle the nutrients back to build new biomass," Martiny said.

Such ecosystem features are not easily taken into account by traditional, mechanistic Earth system models, according to Martiny, but they were part of the geographically diverse dataset the team used to train its neural network-derived quantitative niche model.

Martiny said that this study as a follow-up to research published last summer is further evidence as to the diversity and resilience of phytoplankton.

"We could obviously let climate change get out of hand and go into completely uncharted territory, and then all bets are off," he said. "But at least for a while, I think the adaptive capabilities in these diverse plankton communities will help them maintain high biomass despite these environmental changes."

Joining Martiny and Primeau were fellow authors Pedro Flombaum, former UCI postdoctoral researcher and later visiting scholar in Earth system science (currently a professor at the University of Buenos Aires, Argentina), and Weilei Wang, UCI postdoctoral scholar in Earth system science. The study received support from the National Science Foundation's Ten Big Ideas program and the U.S. Department of Energy Office of Biological and Environmental Research.

More information: Global picophytoplankton niche partitioning predicts overall positive response to ocean warming, *Nature Geoscience* (2020). DOI: 10.1038/s41561-019-0524-2 , nature.com/articles/s41561-019-0524-2

Provided by University of California, Irvine