

# Biologists devise new way to assess carbon in the ocean

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A new USC study puts ocean microbes in a new light with important implications for global warming.

The study, published Tuesday in the *Proceedings of the National Academy of Sciences*, provides a universal accounting method to measure how [carbon](#)-based matter accumulates and cycles in the [ocean](#). While competing theories have often been debated, the new computational framework reconciles the differences and explains how oceans regulate [organic carbon](#) across time.

Surprisingly, most of the action involving carbon occurs not in the sky but underfoot and undersea. The Earth's plants, oceans and mud store five times more carbon than the atmosphere. It accumulates in trees and soil, algae and sediment, microorganisms and seawater.

"The ocean is a huge carbon reservoir with the potential to mitigate or enhance global warming," said Naomi Levine, senior author of the study and assistant professor in the biological sciences department at the USC Dornsife College of Letters, Arts and Sciences. "Carbon cycling is critical for understanding global climate because it sets the temperature, which in turn sets climate and weather patterns. By predicting how carbon cycling and storage works, we can better understand how climate will change in the future."

Processes governing how organic matter—decaying plant and animal matter in the environment akin to the material gardeners add to soil—accumulates are critical to the Earth's carbon cycle. However, scientists don't have good tools to predict when and how organic matter piles up. That's a problem because a better reconciling of organic carbon can inform computer models that forecast [global warming](#) and support public policy.

## **New USC framework can gauge organic carbon increases in the ocean**

In recent years, scientists have offered three competing theories to explain how organic matter accumulates, and each has its limitations. For example, one idea is some organic matter is intrinsically persistent, similar to an orange peel. Sometimes carbon is too diluted so microbes can't locate and eat it, as if they're trying to find a single yellow jellybean in a jar full of white ones. And sometimes, the right microbe isn't in the right place at the right time to intercept organic matter due to environmental conditions.

While each theory explains some observations, the USC study shows how this new framework can provide a much more comprehensive picture and explain the ecological dynamics important for organic matter accumulation in the ocean. The solution has wide utility.

For example, it can help interpret data from any condition in the ocean. When linked into a full ecosystem model, the framework accounts for diverse types of microbes, water temperature, nutrients, reproduction rates, sunlight and heat, ocean depth and more. Through its ability to represent diverse environmental conditions worldwide, the model can predict how organic carbon will accumulate in various complex scenarios—a powerful tool at a time when oceans are warming and the Earth is rapidly changing.

"Predicting why organic carbon accumulates has been an unsolved challenge," said Emily Zakem, a study co-author and postdoctoral scholar at USC Dornsife. "We show that the accumulation of carbon can be predicted using this computational framework."

## **Assessing the past—and the future—of Earth's oceans**

The tool can also potentially be used to model past ocean conditions as a

predictor of what may be in store for the Earth as the planet warms largely due to manmade greenhouse gas emissions.

Specifically, the model is capable of looking at how marine microbes can flip the world's carbon balance. The tool can show how microbes process organic matter in the water column throughout a given year, as well as at millennial timescales. Using that feature, the model confirms—as has been previously predicted—that microbes will consume more [organic matter](#) and rerelease it as carbon dioxide as the ocean warms, which ultimately will increase atmospheric carbon concentrations and increase warming. Moreover, the study says this phenomenon can occur rapidly, in a non-linear way, once a threshold is reached—a possible explanation for some of the whipsaw climate extremes that occurred in Earth's distant past.

"This suggests that changes in climate, such as warming, may result in large changes in organic carbon stores and that we can now generate hypotheses as to when this might occur," Levine said.

Finally, the [research paper](#) says the new tool can model how carbon moves through soil and sediment in the terrestrial environment, too, though those applications were not part of the study.

**More information:** Emily J. Zakem et al, A unified theory for organic matter accumulation, *Proceedings of the National Academy of Sciences* (2021). [DOI: 10.1073/pnas.2016896118](https://doi.org/10.1073/pnas.2016896118)

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