Climate change overhauling marine nutrient cycles, UC Irvine scientists say

The research is the first field-based confirmation of such climate impacts.

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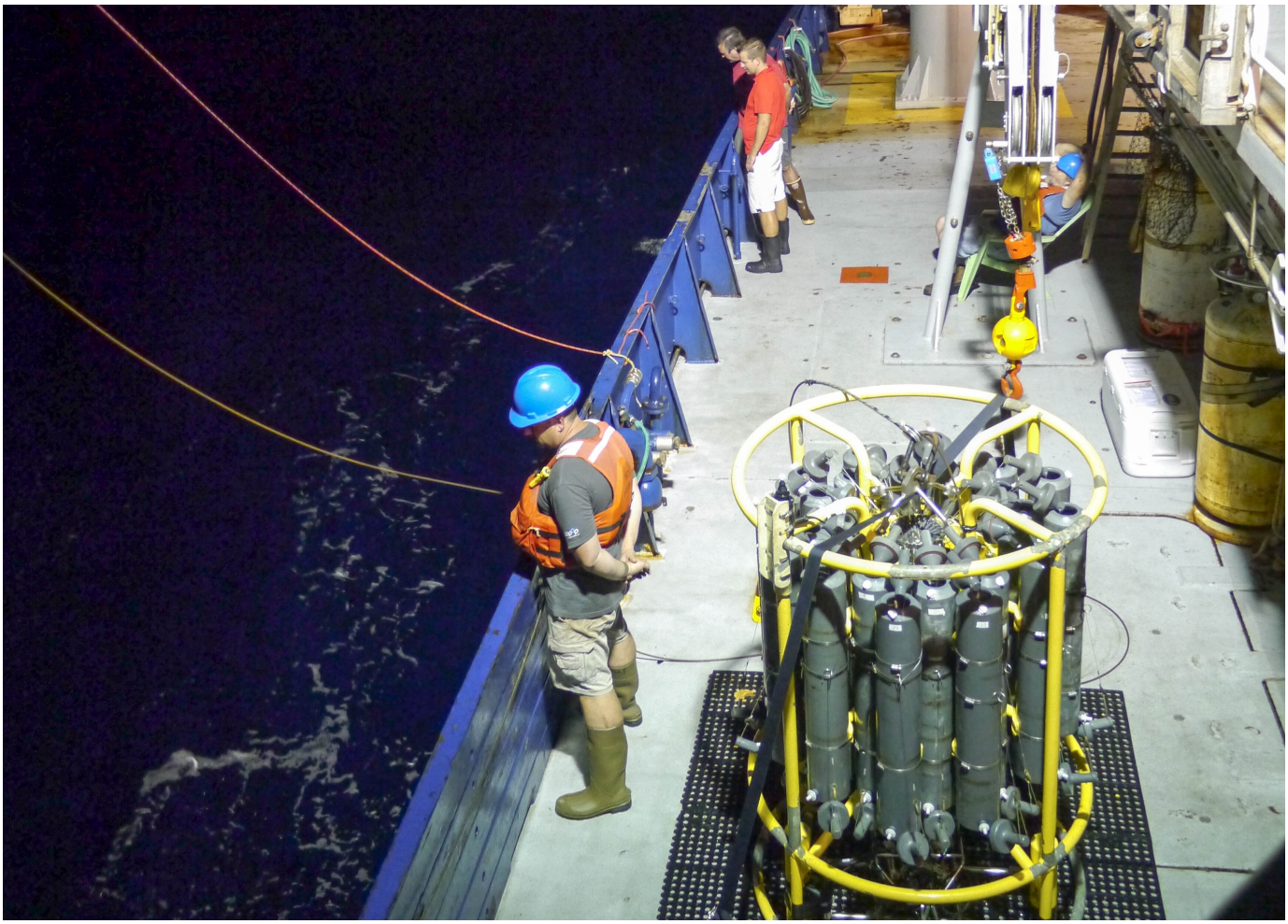


Professor Adam Martiny (middle) participating in ocean shipboard sampling on board the ocean-going Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP).

Picture Credit:

Celine Mouginot / UC Irvine

Irvine, Calif., Feb. 4, 2024—Computer models reveal how human-driven climate change will dramatically overhaul critical nutrient cycles in the ocean. In new research published in *Proceedings of the National Academy of Sciences*, researchers from the University of California, Irvine report evidence that marine nutrient cycles – essential for sustaining ocean ecosystems – are changing in unexpected ways as the planet continues to warm.

“Model studies have suggested that when the ocean warms it gets more stratified, which can drain certain parts of the surface ocean of nutrients,” said Adam Martiny, professor of Earth system science and ecology and evolutionary biology at UC Irvine and one of the study’s lead authors. Although models suggest a connection between ocean temperatures and surface ocean nutrients, this is the first study to confirm climate change’s impacts on nutrient cycles.

The team, led by UC Irvine graduate student Skylar Gerace, analyzed 50 years of nutrient data from the ocean collected as part of the Global Ocean Ship-based Hydrographic Investigations Program (GO-SHIP). They discovered that over the last half-century there’s been a major decline in phosphorus – a nutrient that plays a key role in the health of marine food webs – in southern hemisphere oceans.

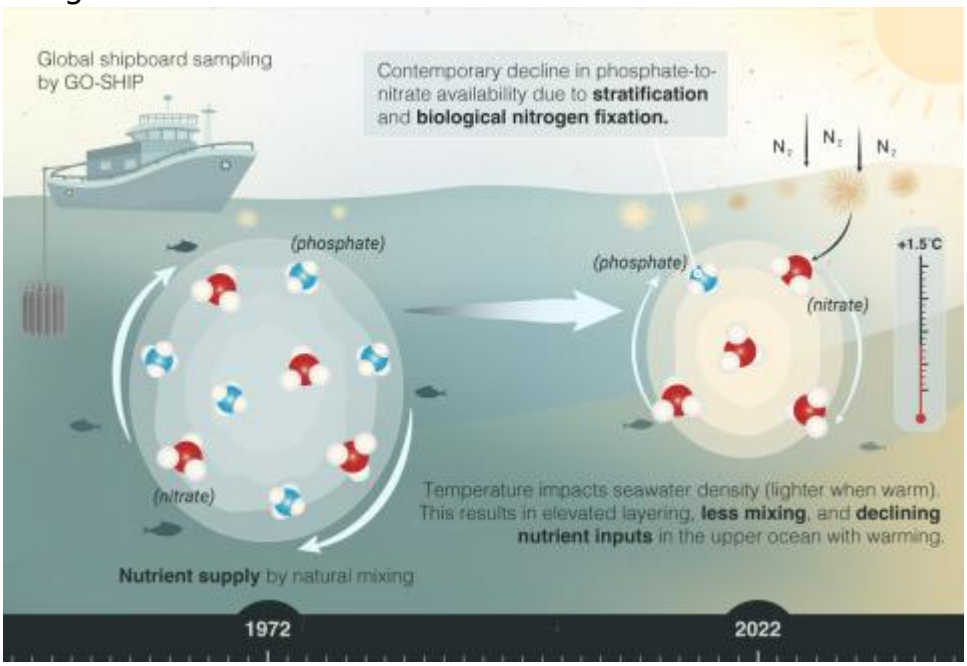
“There can be cascading effects up the food web,” said Gerace, who explained how plankton – microorganisms that form the bases of many marine food webs – rely on phosphorous as a food source. “When phytoplankton have less phosphorus, they become less nutritious, which can impair zooplankton and fish growth rates.”

Surprisingly, concentrations of nitrate – a nutrient the team expected to decline – appear to be remaining steady. Nitrate is crucial for ecosystem functioning, so the fact that it’s not in decline is a good sign, Martiny explained. Nevertheless, nitrate concentrations may still decline in the future as the climate continues to change. “But that we don’t know — that’s just speculation,” he said.

Martiny emphasized the importance of programs like GO-SHIP when it comes to doing science like this; without seafaring missions that collect empirical data on marine ecosystems, there would be no way to confirm if what the climate models are forecasting is actually happening. For instance, models have forecasted that there would by now be declining nitrate levels in ocean water, but direct observations reveal that this is not the case.

“It’s in general really hard to demonstrate long-term climate impacts on the ocean, because there’s so much variability, and ours is now part of a small collection of studies that demonstrates these long-term impacts,” said Martiny. “You can count on a hand the demonstrated long-term trends in ocean chemistry.”

Image



An illustration depicting the observed decline in marine phosphate-to-nitrate availability over the past five decades. Michelle Aung / UC Irvine

Next, the team wants to quantify how changing nutrient cycles impact marine ecosystems in both hemispheres as climate change continues unfolding.

“We aim to investigate how this nutrient metric relates with broader ecosystem dynamics throughout the ocean, such as primary productivity,” said Gerace. “This could further establish measurements like ours as a holistic indicator for monitoring marine ecosystems as the ocean continues to warm and stratify.”

The research was supported by grants from the National Science Foundation, the National Oceanic and Atmospheric Administration, and the National Aeronautics and Space Administration (NASA) to Martiny, and grants from the DOI Office of Biological and Environmental Research and NASA to Professor Keith Moore in the UC Irvine Department of Earth System Science.

UC Irvine’s Brilliant Future campaign: Publicly launched on Oct. 4, 2019, the Brilliant Future campaign aims to raise awareness and support for the university. By engaging 75,000 alumni and garnering $2 billion in philanthropic investment, UC

Irvine seeks to reach new heights of excellence in student success, health and wellness, research and more. The School of Physical Sciences plays a vital role in the success of the campaign. Learn more at https://brilliantfuture.uci.edu/uci-school-of-physical-sciences/.

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