

Unprecedented, man-made trends in ocean's acidity

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These are yellow tangs frolicking among corals. Credit: Dwayne Meadows, NOAA

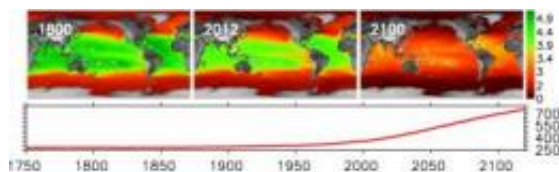
Recent carbon dioxide emissions have pushed the level of seawater acidity far above the range of the natural variability that existed for thousands of years, affecting the calcification rates of shell-forming organism. These findings by an international team of scientists appear in the Jan. 22 online issue of *Nature Climate Change*.

Nearly one-third of CO₂ emissions due to human activities enters the world's oceans. By reacting with seawater, CO₂ increases the water's acidity, which may significantly reduce the calcification rate of such marine organisms as corals and mollusks. The extent to which human activities have raised the surface level of acidity, however, has been

difficult to detect on regional scales because it varies naturally from one season and one year to the next, and between regions, and direct observations go back only 30 years.

Combining computer modeling with observations, an international team of scientists concluded that anthropogenic CO₂ emissions over the last 100 to 200 years have already raised ocean acidity far beyond the range of natural variations. The study is published in the January 22 online issue of *Nature* [Climate Change](#).

The team of climate modelers, marine conservationists, ocean chemists, biologists and ecologists, led by Tobias Friedrich and Axel Timmermann at the International Pacific Research Center, University of Hawaii at Manoa, came to their conclusions by using Earth system models that simulate climate and [ocean conditions](#) 21,000 years back in time, to the Last Glacial Maximum, and forward in time to the end of the 21st century. They studied in their models changes in the saturation level of aragonite (a form of [calcium carbonate](#)) typically used to measure of [ocean acidification](#). As acidity of seawater rises, the saturation level of aragonite drops. Their models captured well the current observed seasonal and annual variations in this quantity in several key coral reef regions.



The upper panels show simulated surface aragonite saturation for the years 1800, 2012 and 2100, respectively. White dots indicate present-day main coral reef locations. The lower panel shows atmospheric CO₂ concentration in parts per million simulated for the years 1750 to 2100. Credit: Tobias Friedrich

Today's levels of aragonite saturation in these locations have already dropped five times below the pre-industrial range of natural variability. For example, if the yearly cycle in aragonite saturation varied between 4.7 and 4.8, it varies now between 4.2 and 4.3, which – based on another recent study – may translate into a decrease in overall calcification rates of corals and other aragonite shell-forming organisms by 15%. Given the continued human use of fossil fuels, the saturation levels will drop further, potentially reducing calcification rates of some [marine organisms](#) by more than 40% of their pre-industrial values within the next 90 years.

"Any significant drop below the minimum level of aragonite to which the organisms have been exposed to for thousands of years and have successfully adapted will very likely stress them and their associated ecosystems," says lead author Postdoctoral Fellow Tobias Friedrich.

"In some regions, the man-made rate of change in ocean acidity since the Industrial Revolution is hundred times greater than the natural rate of change between the Last Glacial Maximum and pre-industrial times," emphasizes Friedrich. "When Earth started to warm 17,000 years ago, terminating the last glacial period, atmospheric CO₂ levels rose from 190 parts per million (ppm) to 280 ppm over 6,000 years. Marine ecosystems had ample time to adjust. Now, for a similar rise in CO₂ concentration to the present level of 392 ppm, the adjustment time is reduced to only 100 – 200 years."

On a global scale, [coral reefs](#) are currently found in places where open-ocean aragonite saturation reaches levels of 3.5 or higher. Such conditions exist today in about 50% of the ocean – mostly in the tropics. By end of the 21st century this fraction is projected to be less than 5%. The Hawaiian Islands, which sit just on the northern edge of the tropics, will be one of the first to feel the impact.

The study suggests that some regions, such as the eastern tropical Pacific, will be less stressed than others because greater underlying natural variability of seawater acidity helps to buffer anthropogenic changes. The aragonite saturation in the Caribbean and the western Equatorial Pacific, both biodiversity hotspots, shows very little natural variability, making these regions particularly vulnerable to human-induced ocean acidification.

"Our results suggest that severe reductions are likely to occur in coral reef diversity, structural complexity and resilience by the middle of this century," says co-author Professor Axel Timmermann."

More information: T. Friedrich, A. Timmermann, A. Abe-Ouchi, N. R. Bates, M. O. Chikamoto, M. J. Church, J. E. Dore, D. K. Gledhill, M. González-Dávila, M. Heinemann, T. Ilyina, J. H. Jungclaus, E. McLeod, A. Mouchet, and J. M. Santana-Casiano: Detecting regional anthropogenic trends in ocean acidification against natural variability. *Nature Climate Change*, [DOI: 10.1038/NCLIMATE1372](https://doi.org/10.1038/NCLIMATE1372)

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