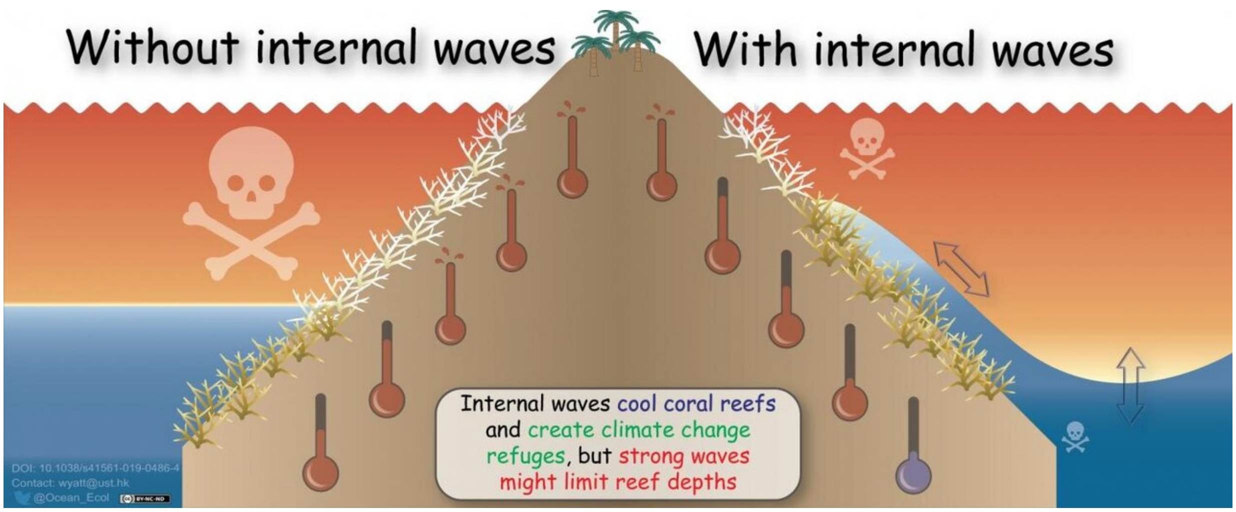
Researchers shed light on modulation of thermal bleaching of coral reefs by internal waves

November 20 2019



Internal waves cool coral reefs and create climate change refuges, but strong waves might limit reef depths. Credit: The Hong Kong University of Science and Technology

Coral reefs around the world are threatened by pan-tropical bleaching events that occur when the surrounding sea water temperatures increase due to ongoing climate change and extreme conditions like El Niño. However, patterns of bleaching occurrence can be very difficult to predict, especially across water depths. Currently, most coral bleaching predictions are based on surface estimates of seawater temperatures, gathered with satellites over large areas of the ocean. While satellite observations are important to understanding large-scale patterns and for studying remote locations, they are only able to detect temperature at the very surface of the ocean and provide averages over relatively large scales.

In this research, Prof. Alex Wyatt, Assistant Professor at HKUST's Department of Ocean Science, collaborated with scientists from The University of Tokyo, Scripps Institute of Oceanography at the University of California San Diego, U.S. Geological Survey and the Florida Institute of Technology, to do a long-term, high-resolution quantitative analysis of temperature records influenced by internal waves, and their effect on coral reefs in the western, central and eastern Pacific Ocean. The team deployed and maintained 50 to 60 high-resolution, continuously recording, electronic thermometers—powered by on-board batteries and containing accurate clocks and large memory storage—across depths at coral reef sites across the Pacific in Japan, French Polynesia and Panama. This captured in situ temperatures for multiple years, most notably during periods of anomalous warming associated with the El Niño event in 2015 and 2016.

Using a novel filtering approach developed by the team, internal wave signals were extracted from the temperature records and used in an analytical experiment to compare heating that would have occurred in the presence and absence of internal waves. The resulting analysis suggests that the presence of internal waves reduced heating, particularly in deeper portions of coral reefs, by up to 88% during the 2015-2016 El Niño. The duration of severe heating events likely to totally kill corals was also reduced at some sites—by 36 to 50%—or prevented entirely at others.

Alex Wyatt maintaining shallow water temperature loggers in Funauki Bay, Iriomote Island, Japan. Credit: The Hong Kong University of Science and Technology

The team also found that natural internal wave cooling increases with depth. Heating was reduced by 20 to 41% at shallowest sites (8 to 10m water depth) and reduced by 54 to 88% in deeper water (30 to 40m water depth). These findings showed that internal waves may be an important process for naturally reducing coral bleaching across most of the world's coral reef depths and ocean locations. Conversely, the results also suggest than in the absence of internal waves, or if internal waves frequency and intensity decrease with climate change, the observed heating of coral reefs could become even more severe.

The results demonstrating widespread cooling by internal waves suggests a degree of hope for coral reefs—that there can be zones of reefs at least partially protected from the dire consequences of climate change, ocean warming, and increasingly frequent bleaching events now widely observed in shallow water. Areas that are naturally cooled by internal waves may already be acting as partial refuges from the serious impacts of climate change on coral reefs. However, because the oceans are warming rapidly, such refuges may offer only short-term protection. Also, we know very little about how climate change and ocean warming will affect the occurrence of internal waves and the depths to which they cool coral reefs in the future. More importantly, there is a wide range of unknown questions stemming from this research, particularly considering the broader biological effects and ecological implications of internal waves for coral reefs.

The results also suggest there might be innovative ways to adapt this information to protecting coral reefs at local scales of particular interest, such as critical habitats for ecological conservation. "Our research on real-world internal wave upwelling suggests that active management approaches such as artificial upwelling may be valid temporarily on local scales and in locations that are not already naturally cooled by internal waves," said Prof. Wyatt. "If successfully harnessed with an artificial upwelling system, it is foreseeable that upwelling could reduce the worst impacts of heating across a small scale over at-risk coral communities identified for special protection. This artificial upwelling would of course be very localized compared to the global-scale cooling naturally occurring over reefs every day during the summer due to internal waves." He added, "it is very important to note that the protection of reefs hinges on immediately reducing greenhouse gas emissions as internal waves can only offer localized, and perhaps temporary, protection from rapid climate heating. Addressing the underlying causes of climate change are, in fact, critical for the future survival of coral reefs."

Globally, coastal communities rely on reefs for shoreline protection, and the biodiversity of reefs support aquaculture, tourism and local economies. Greater understanding of internal waves at various sites can be utilized to create better forecasts about which reefs are at most risk from future warming events, identify potential reef refuge sites, and thus would be a boon for enhanced stewardship of threatened reefs.

More information: Alex S. J. Wyatt et al, Heat accumulation on coral reefs mitigated by internal waves, *Nature Geoscience* (2019). DOI: 10.1038/s41561-019-0486-4

Provided by Hong Kong University of Science and Technology