Study warns three-quarters of Indo-Pacific coral reefs may drown as seas rise

August 18, 2026 in **Athmospheric** Reading Time: 5 mins read

0

Study warns three-quarters of Indo-Pacific coral reefs may drown as seas rise

Coral reefs may be running out of time to keep pace with the ocean's rising surface. A new study led by scientists at Nanyang Technological University, Singapore (NTU Singapore), suggests that most reefs across the Indo-Pacific could be unable to grow upward quickly enough to avoid progressive submergence as sea-level rise accelerates. The researchers estimate that 76 per cent of the reef sites they examined would fail to keep up under a high-greenhouse-gas-emissions scenario, potentially weakening one of the planet's most important natural defences against waves, storms and coastal flooding.

The study identifies a critical tipping point for reef survival. When relative sea level rises by more than 5.3 millimetres per year, there is a greater than 90 per cent probability that a reef will not be able to build upward at the rate required to remain near the sea surface. According to the researchers, this threshold could be exceeded within approximately 35 years unless greenhouse-gas emissions are substantially reduced. The finding is significant because reefs do not need to disappear entirely to lose much of their protective and ecological value. Even if living corals remain, a reef that becomes progressively deeper may no longer function as a shallow, wave-breaking structure or provide the same complex habitat for marine life.

For thousands of years, coral reefs have responded to changes in sea level by constructing themselves upward and outward. Reef-building corals and other organisms extract dissolved substances from seawater and convert them into calcium carbonate, the mineral that forms their hard skeletons. Over generations, the accumulation of these skeletons creates a three-dimensional limestone framework. Because corals depend on sunlight, the ability of the reef to remain close to the ocean's surface is crucial. A shallow reef can absorb and scatter incoming wave energy before it reaches the shoreline, while its crevices and ledges provide shelter, feeding grounds and nursery habitat for fish and countless other organisms.

The danger begins when the rate of sea-level rise exceeds the rate at which the reef framework can accumulate. Scientists describe this process as reef drowning. It does not necessarily mean that every coral colony dies immediately. Instead, the reef surface gradually becomes covered by deeper water, reducing the light available to corals and allowing larger waves to pass over the structure with less energy loss. As the reef's elevation relative to the sea surface declines, coastal communities may face greater exposure to erosion and flooding. At the same time, the submerged framework can lose the shallow, intricate architecture that supports the high biodiversity associated with tropical coral reefs.

To investigate the long-term limits of reef growth, the NTU-led team assembled 288 ancient reef records from 92 sites across the Indo-Pacific. The records cover the Holocene, the geological epoch that began roughly 11,700 years ago after the last ice age. During this period, sea levels changed substantially as ice sheets melted and the climate transitioned into the conditions under which many modern reefs developed. The researchers used layers of skeletal carbonate preserved in reef cores and other geological records to reconstruct how quickly entire reef systems grew during earlier episodes of sea-level change. These paleorecords offer a much longer perspective than observations of individual corals or short-term measurements made at living reefs.

That distinction is central to the study. An individual coral colony can grow rapidly under favourable conditions, but the upward growth of a complete reef depends on far more than coral biology alone. The final reef framework reflects the combined effects of coral calcification, the production of carbonate by other organisms, physical breakage, storms, erosion, dissolution and the movement of sediment. Some material may be produced on the reef but later swept away, while other carbonate may be preserved and added to the structure. By examining the geological record, the researchers could estimate the net rate at which reef architecture accumulated over long periods rather than simply measuring the growth of selected coral colonies.

The analysis indicates that reef growth is governed by an interaction between sea-level change, the composition of coral communities and local physical conditions. Ancient reefs were often dominated by what scientists describe as competitive corals: organisms capable of producing substantial, structurally complex frameworks. Many modern reefs, however, are increasingly occupied by smaller, disturbance-tolerant species sometimes called “weedy” corals. These species can recolonise damaged surfaces quickly after bleaching, storms or other disturbances, but rapid recolonisation does not necessarily translate into rapid construction of a massive reef framework. If coral communities shift toward species that produce less structural material, the ability of the reef to remain close to the surface may decline even before the corals themselves vanish.

The pressures driving these ecological changes are already widespread. Repeated marine heatwaves can cause corals to expel the microscopic algae that live within their tissues, a process known as bleaching. Because these algae provide much of the energy required for coral metabolism and calcification, prolonged bleaching can reduce growth and increase mortality. Ocean acidification, caused by the absorption of carbon dioxide from the atmosphere, makes it more difficult for many marine organisms to build calcium-carbonate skeletons. Pollution, sedimentation, overfishing and physical damage can further disrupt coral communities and reduce the amount of carbonate that remains in the reef. Together, these stressors may make reefs less capable of responding to rapidly rising seas.

The consequences extend well beyond coral biology. Reefs act as offshore barriers that can substantially reduce wave energy before it reaches low-lying islands and tropical coastlines. If a reef surface sits in deeper water, larger waves may travel across it and deliver more force to beaches, mangroves, infrastructure and homes. Greater wave exposure can intensify coastal erosion and increase the risk of flooding during storms and high tides. The loss of complex reef structure could also reduce habitat for fish and other marine organisms, threatening fisheries, tourism and communities whose food supplies and livelihoods depend on healthy reefs. The researchers stress that local action remains valuable: reducing pollution, overfishing and physical damage can help preserve coral communities that still have the capacity to produce reef material. Yet local conservation and restoration alone cannot fully offset a global rise in sea level that outpaces the biological and geological growth of the reef.

“Coral reefs have kept pace with rising seas for thousands of years, but the rate of sea-level rise expected in the coming decades could exceed the limits of most reefs,” said Nanyang Assistant Professor Kyle Morgan, the study’s co-leader and Associate Chair for Graduate Studies at NTU’s Asian School of the Environment. Lead author Dr Riovie Ramos, an NTU Earth Observatory of Singapore Research Fellow, said that reef cores provide a more realistic measure of reef resilience because they record what remains after growth, erosion and other natural processes have acted over time. Published in *Nature Communications*, the study, titled “Paleorecords inform the limits of Indo-Pacific coral reef survival under accelerating sea-level rise,” was supported by Singapore’s National Research Foundation through its Fellowship scheme. Its findings turn ancient reef history into a warning for the future: the fate of coral reefs may depend not only on whether corals can survive, but on whether they can build fast enough to keep the ocean from overtaking them.