

The 'great dying': rapid warming caused largest extinction event ever, report says

Up to 96% of all marine species and more than two-thirds of terrestrial species perished 252m years ago

Oliver Milman in New York

@ollemilman

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A model in the study mimicking conditions in the Permian period suggests marine animals essentially suffocated in the warming waters. Photograph: John Raoux/AP

Rapid **global warming** caused the largest extinction event in the Earth's history, which wiped out the vast majority of marine and terrestrial animals on the planet, scientists have found.

The mass extinction, known as the "great dying", occurred around 252m years ago and marked the end of the Permian geologic period. The study of sediments and fossilized creatures show the event was the single greatest calamity ever to befall life on Earth, eclipsing even the extinction of the dinosaurs 65m years ago.

Up to 96% of all marine species perished while more than two-thirds of terrestrial species disappeared. The cataclysm was so severe it wiped out most of the planet's trees, insects, plants, lizards and even microbes.

Scientists have **theorized causes for the extinction**, such as a giant asteroid impact. But US researchers now say they have pinpointed the demise of marine life to a spike in Earth's temperatures, warning that present-day global warming will also have severe ramifications for life on the planet.

"It was a huge event. In the last half a billion years of life on the planet, it was the worst extinction," said Curtis Deutsch, an oceanography expert who co-authored the research, published on Thursday, with his University of Washington colleague Justin Penn along with Stanford University scientists Jonathan Payne and Erik Sperling.

The researchers used paleoceanographic records and built a model to analyse changes in animal metabolism, ocean and **climate** conditions. When they used the model to mimic conditions at the end of the Permian period, they found it matched the extinction records.

According to the study, this suggests that marine animals essentially suffocated as warming waters lacked the oxygen required for survival. "For the first time, we've got a whole lot of confidence that this is what happened," said Deutsch. "It's a very strong argument that rising temperatures and oxygen depletion were to blame."

The great dying event, which occurred over an uncertain timeframe of possibly hundreds of years, saw Earth's temperatures increase by around 10C (18F). Oceans lost around 80% of their oxygen, with parts of the seafloor becoming completely oxygen-free. Scientists believe this warming was caused by a huge spike in greenhouse gas emissions, potentially caused by volcanic activity.

The new research, **published in Science** (<https://doi.org/10.1126/science.aat1327>), found that the drop in oxygen levels was particularly deadly for marine animals living closer to the poles. Experiments that varied oxygen and temperature levels for modern marine species, including shellfish, corals and sharks, helped "bridge the gap" to what the model found, Payne said.

"This really would be a terrible, terrible time to be around on the planet," he added. "It shows us that when the climate and ocean chemistry changes quickly, you can reach a point where species don't survive. It took millions of years to recover from the Permian event, which is essentially permanent from the perspective of human timescales."

Over the past century, the modern world has warmed by around 1C due to the release of greenhouse gases from the burning of fossil fuels such as coal, oil and gas, rather than from volcanic eruptions.

This **warming** is already causing punishing heatwaves, flooding and wildfires around the world, with scientists **warning** that the temperature rise could reach 3C or more by the end of the century unless there are immediate, radical **reductions** in emissions.

At the same time, Earth's species are undergoing what some experts have termed the "sixth great **extinction**" due to habitat loss, poaching, pollution and **climate change**.

"It does terrify me to think we are on a trajectory similar to the Permian because we really don't want to be on that trajectory," Payne said. "It doesn't look like we will warm by around 10C and we haven't lost that amount of biodiversity yet. But even getting halfway there would be something to be very concerned about. The magnitude of change we are currently experiencing is fairly large."

Deutsch said: "We are about a 10th of the way to the Permian. Once you get to 3-4C of warming, that's a significant fraction and life in the ocean is in big trouble, to put it bluntly. There are big implications for humans' domination of the Earth and its ecosystems."

Deutsch added that the only way to avoid a mass aquatic die-off in the oceans was to reduce carbon emissions, given there is no viable way to ameliorate the impact of climate change in the oceans using other measures.

The research group "provide convincing evidence that warmer temperatures and associated lower oxygen levels in the ocean are sufficient to explain the observed extinctions we see in the fossil record", said Pamela Grothe, a paleoclimate scientist at the University of Mary Washington.

"The past holds the key to the future," she added. "Our current rates of carbon dioxide emissions is instantaneous geologically speaking and we are already seeing warming ocean temperatures and lower oxygen in many regions, currently affecting marine ecosystems.

"If we continue in the trajectory we are on with current emission rates, this study highlights the potential that we may see similar rates of extinction in marine species as in the end of the Permian."