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Ocean acidification effect on Coral reef

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Introduction

Coral reefs, often referred to as the rainforests of the sea, are among the most biodiverse and productive ecosystems on the planet. They provide critical habitat for a multitude of marine species, protect coastlines from erosion, and support fishing and tourism industries that benefit millions of people worldwide. However, these vibrant ecosystems are increasingly threatened by a phenomenon known as coral bleaching, exacerbated by climate change and ocean acidification.

Coral bleaching occurs when corals, stressed by changes in their environment, expel the symbiotic algae (zooxanthellae) that live in their tissues. These algae are crucial for coral health, providing them with food through photosynthesis and giving them their color. Without these algae, corals not only lose their vibrant hues and turn white (hence the term 'bleaching'), but they also suffer from reduced energy intake, which can lead to increased susceptibility to disease and, if stressful conditions persist, eventual death.

Coral bleaching

Three categories of reef builders were employed, which include staghorn corals (Acropora intermedia), enormous corals (Poriteslobata), and crustose coralline algae (*Porolithon onkodes*). These groups of reef builders are among the most prevalent and functionally significant benthic species on coral reefs. Crustose coralline algae (CCA), namely *P. onkodes*, have been shown to exhibit decreased growth and recruitment in the presence of high CO_2 (Kuffner et al., 2008). These algae are crucial for the formation of reefs and the consolidation of dead reef matrix.

The primary driver of coral bleaching is elevated sea temperatures. Climate change, driven by increased greenhouse gas emissions, has led to a significant rise in global ocean temperatures. Corals are highly sensitive to temperature changes, and even an increase of 1-2 degrees Celsius above their normal range can trigger bleaching. Prolonged exposure to higher temperatures causes prolonged bleaching events, leading to widespread coral mortality. Major bleaching events, such as those that occurred in the Great Barrier

Reef in 2016 and 2017, have been directly linked to these elevated sea temperatures.

In addition to warming waters, ocean acidification poses a serious threat to coral reefs. The ocean absorbs approximately 30% of atmospheric carbon dioxide (CO_2), which reacts with seawater to form carbonic acid. This process decreases the pH of the ocean, making it more acidic. Acidification impairs the ability of corals to produce calcium carbonate, the essential building block of their skeletons. Weaker skeletons mean that corals are less resilient to physical stresses and more susceptible to erosion and breakage.

Bleaching, productivity, and calcification responses of crustosecoralline algae (CCA) and branching (Acropora) and massive (Porites) coral species:

CO_2 dosing led to 40- 50% bleaching for the CCA and Acropora. Porites was less sensitive and bleached to a maximum of 20% in the high-CO_2/high-temperature. High CO_2 dosing led to dramatic reductions in daily productivity (as hourly rates of photosynthesis minus respiration integrated over the day) of the CCA. At low temperature, intermediate-CO_2 dosing (pH 7.85–7.95) resulted in a 50% reduction in productivity relative to the control. High-CO_2 dosing (pH 7.60–7.70) led to a further reduction in productivity to near zero. Interestingly, acidification affected net rate of photosynthesis. CCA calcification was highly sensitive to the highest CO2 dosing and the effect was exacerbated by warming, Intermediate-CO_2 dosing and warming led to a 50% drop in the CCA calcification rate (Anthony *et al.*, 2008).

Coral reef recovery:

The recovery of coral reefs from bleaching has not been thoroughly assessed globally to date. Wilkinson (2004) summarized reports on coral reef health from 240 contributors in 98 countries, stating that 40% of reefs that were seriously damaged by bleaching in 1998 had either "recovered" or were "recovering well." However, no additional quantitative assessments have been conducted to date, so here we attempt to synthesize the available data in order to compare rates, degrees, and patterns of recovery. Coral bleaching, accompanied by high mortality, was classified as an acute disturbance with indirect effects on the environment. Connell found that these kinds of disturbances resulted in greater recovery of live coral cover compared to chronic disturbances with long-term direct effects on the environment. Given the predicted increase in the frequency and severity of coral reef bleaching (Kleypas, 2007), it is likely that bleaching can now be considered a chronic disturbance in many reef regions. The longest recovery times looked at in Connell's bleaching examples were 13 years. In this study, longer recovery times of up to 20–25 years, as well as recovery rates and patterns, along with some more recent research on community changes. Recovery is still ongoing in many areas because returning to pre-disturbance states (with statistically equal levels of live coral cover, species diversity, and topographic relief) may take decades to restore previous levels of coral cover and species diversity or even centuries to reconstruct lost reef frameworks. Reefs exposed to numerous consecutive bleaching events now have more difficulty distinguishing their different recovery trajectories due to the chronic nature of bleaching.

Conclusion

The combined effects of ocean warming and acidification create a compounding threat to coral reefs. As the frequency and intensity of bleaching events increase, so does the likelihood of long-term damage to reef structures. Acidification further hampers recovery by inhibiting the growth of new corals. The degradation of coral reefs has profound implications not only for marine biodiversity but also for human communities that rely on these ecosystems for food, coastal protection, and economic activities.

Efforts to mitigate climate change by reducing greenhouse gas emissions are critical to slowing the rate of ocean warming and acidification. Additionally, local conservation actions, such as establishing marine protected areas and reducing pollution, can help enhance the resilience of coral reefs. However, without significant global action to address climate change, the future of coral reefs remains precarious.

In summary, coral reef bleaching due to climate change and ocean acidification is a clear indication of the profound impact human activities have on marine ecosystems. Protecting these invaluable ecosystems requires urgent and coordinated action to mitigate climate change and safeguard the biodiversity and services that coral reefs provide.

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