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Coral Reef Ecosystem under Changing Climatic Condition

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Abstract

Human activities such as the usage of fossil energy, destruction of forests, and change in land use and has dramatically altered the intensity of greenhouse gases in the atmosphere, such as methane and carbon dioxide. These changes have resulted in global warming and ocean acidification, and both of which imply significant threats to reef ecosystems due to rising thermal stress and acidification of the oceans, in addition to decreasing carbonate ion concentrations. On coral reefs, there has been increased mass coral bleaching, decreasing calcification rates, and a wide range of other changes to subtle but important ecological and physiological processes. However, limiting the increase of CO_2 in the atmosphere, while also reducing local stresses such as illegal fishing and decreasing water quality, provides significant chance for avoiding this grim outlook for coral reefs. Given the significance of corals to the living standards of millions of individuals, such actions should be pursued as soon as possible.

Introduction

Coral reefs, also known as "Rainforests of the Sea" can be found in the world's tropical and subtropical oceans, and they serve as home to more than a quarter of all types of marine fishes. Coral reefs provide food and shelter to over five hundred million people around the world, the majority of who live in under developed countries. More than eight hundred and fifty million people survive within hundred kilometres of coral reefs, the vast majority of whom benefit directly and indirectly from the income, food, and protection. Climate change is the key economic, environment and social issue of our time, and there is no longer any reasonable suspicion that accelerated increases in atmospheric CO_2 and other GHGs' since the Industrial Period's beginning have exacerbated substantial changes to the earth environment (Solomon *et al.*, 2007). Amidst their biodiversity, productivity, and societal importance, cold and warm-water coral reefs are now being severely harmed by anthropogenic activities on a global and local scale. As a result, several coral reefs worldwide are rapidly deteriorating.

Coral Reefs Structure and Environment

Coral reefs composed of polyps and stomach that opens at only one end called the mouth surrounded by a circle of tentacles. Food entered the stomach through the mouth and waste products were expelled through the same opening. Coral captures their food using stinging cells called nematocysts, which are found in the tentacles and outer tissues of coral polyps (Figure 1). Photosynthetic algae, sharing space, gas exchange and nutrients to survive in the coral reefs were zooxanthellae. Corals provide a safe environment and compounds (as by-products of cellular respiration, produce carbon dioxide and water), and the algae produce oxygen and assist the coral in waste disposal (amino acids, glycerol, and glucose that are the products of photosynthesis). These products are used by the coral to produce proteins, fats, carbohydrates, and calcium carbonate.

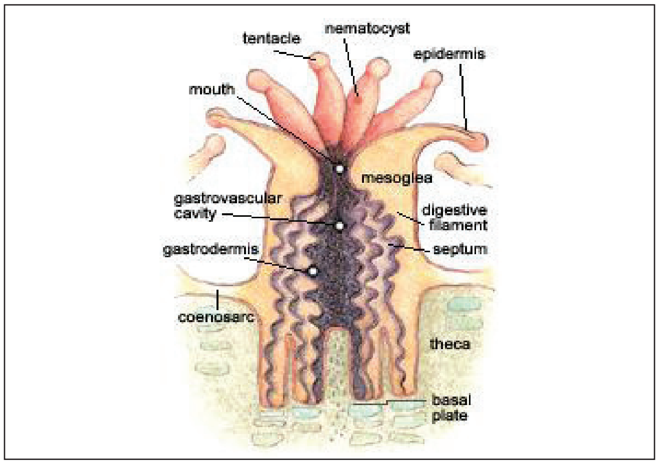

Figure 1: Structure of coral reefs

Ocean Acidification and Sea Rise

Carbon dioxide concentrations in the Earth's atmosphere now exceed 380 ppm, which is approximately than 80 ppm greater than the highest values of the previous 1 million years. Increasing CO_2 concentrations in the oceans increased mean temperature by a level of 0.74 °C and sea level by 17 cm during the twentieth century, while decreasing sea water carbonate concentration by 30 mmol kg^{-1} and acid content by 0.1 pH unit. By 2100, thermal expansion and glacial melting were expected to cause the sea-level to rise by 0.26 to 0.98 meters. Over the last half century, the global mean sea level rise by about 2-3 mm $year^{-1}$. Approximately 25% of the CO_2 released from all the anthropogenic sources (9.1 Pg C $year^{-1}$) currently enters the ocean, where it reacts with H_2O to create carbonic acid. Carbonic acid disintegrates into bicarbonate ions and the protons, which further react with carbonate ions to form more bicarbonate ions, reducing carbonate availability to biological systems (Figure 2). Decreasing carbonate-ion concentrations reduce the rate of calcification of marine organisms such as reef-building corals, ultimately favouring erosion at ~ 200 mmol kg^{-1} seawater (Hoegh-Guldberg *et al.*, 2007).

Coral Bleaching and Its Impact

The bleaching of coral tissues is caused primarily by the loss of pigments and/or cells of their essential symbiotic dinoflagellates (Symbiodinium). It is caused by a variety of factors, including increased temperature and irradiance.

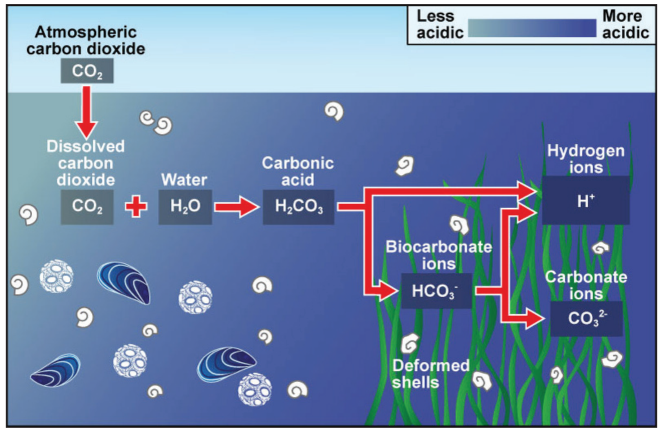

Figure 2: Process of Ocean acidification

Bleaching was a stress response and the Coral-zooxanthellae relationship breaks down due to the ocean acidification. Zooxanthellae were expelled from the coral host or when pigments within the zooxanthellae were degraded. White calcium carbonate coral skeleton will be made visible through the transparent tissue after the expulsion of zooxanthellae which result in bright white or 'bleached' corals. Large-scale 'mass' coral bleaching began in the early 1980s in Panama, Florida, and other Caribbean locations, with corals across large areas of reef literally turning white over a period of weeks. Mass bleaching episodes had occurred over the years (Heron *et al.*, 2017) and presented in the table 1. A recent study of brain corals in Bermuda found that calcification rates have declined by 25% over the past 50 years and ocean acidification is a likely contributing factor (Cantin *et al.*, 2010). Results showed that it would increase susceptibility to bleaching and disease and also decrease the ability of organisms to fend off predators and compete for food and habitat. It also altered the behaviour patterns and further reduced the capacity to tolerate ultraviolet radiation, increase rates of bio-erosion, and increase damage from cyclones.

Table 1: Coral bleaching in large scale over years

Year	Global event
1983	Mass coral bleaching.
1998-99	First global mass bleaching event.
2010	The second global event.
June 2014 -May 2017	Third global coral bleaching event.

Conclusion and Future Directions

Current and future rates of change in ocean temperature and acidity pose a serious danger to coral reef ecosystem. Coral reefs would reach, and quickly exceed, critical thresholds associated with their thermal tolerance and carbonate ion requirements if current trends in atmospheric CO_2 concentrations continue to increase. Simultaneously, other factors such as sea-level rise, storm intensity, and rainfall intensity were expected to exacerbate along tropical/ subtropical coastlines. Corals which make up the structure of coral reefs would become rare on tropical/ subtropical reef systems under these conditions, and also the abundance and distribution of carbonate coral reefs would contract dramatically. This will have a direct impact on many species that rely on coral corals and the calcareous structures they create.

Prospects for rapid evolution of corals and/or their dinoflagellate symbionts are largely unsupported, and it appears unlikely that they will keep up with the rapid rate of anthropogenic change. Given the grave threat that global climate change poses to coral reefs, governments worldwide must act quickly to reduce carbon dioxide emissions while assisting developing nations in mitigating the impact of local stresses such as overfishing and unsustainable coastal development on coral reefs.

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