Ocean acidification

The Great Barrier Reef has lost half its coral cover in the past thirty years. Most of that loss is due to storms, crown-of-thorns starfish, and bleaching due to extended periods of increased summer sea temperature. However other factors are also contributing to the ability of the Reef to respond to and recover from these impacts. Ocean acidity has the potential to slow growth of coral and is likely to have a larger impact in the coming decades.

About half of the extra carbon dioxide (CO_2) that humankind is injecting into the atmosphere is being absorbed by the oceans. This anthropogenic CO_2 is increasing the acidity of the oceans. What affect is this having today? What will be the impact on the Reef in coming decades? And how does it affect the Reef's capacity for repair?

Coral growth is slowing on the Reef and around the world

We know this from studies of long coral core records. Coral growth can be measured by coral calcification—the speed at which their calcium carbonate skeleton is deposited. Sustained calcification is essential for coral recovery, and for repair to the Reef after physical erosion (such as from storms) and biological erosion.

The decline in coral calcification between 1990 and 2005 is unprecedented in at least the past 400 years.

The recent slowing of coral growth rates has also been reported for several other reef locations around the world. The observed decline in calcification is likely to be warming seas. Laboratory experiments indicate that future declines in calcification will be driven by both ocean warming and acidification.

Rising carbon dioxide levels will be bad for coral but good for seagrass

Rising carbon dioxide in the atmosphere will lead to ocean acidification and other changes in the seawater chemistry. Such acidification can reduce coral calcification and growth, and lead to a decline in coral diversity. Fish behaviour is also impacted by ocean acidification, increasing the risk of mortality of some species.

Ocean acidification may also encourage the growth of seaweeds, which compete for space with corals. The growth of seagrasses also benefits from ocean acidification as long as light levels are high. We know this from studies of naturally occurring carbon dioxide seeps in Papua New Guinea.

AIMS scientists have been researching the effects of ocean acidification on coral reef organisms and ecosystems using controlled experiments, field research and models.

Sneak peek: the future of coral reefs in acidifying oceans

When carbon dioxide dissolves in water, it forms carbonic acid, lowering the pH of the water and reducing the availability of the calcium carbonate that coral and molluscs need to form their shells and skeletons.

Naturally occurring volcanic CO_2 'seeps' in Papua New Guinea offer an insight into the effect of ocean acidification on coral reef communities. At these seeps at Normanby Island in Milne Bay Province you can watch carbon dioxide bubbling from the sea floor.

A few hundred metres from the seeps all is normal with a wide diversity of branching corals and the animals that live around them. Closer to the seep large brown boulder corals are dominant. Then all the coral disappears and seaweed is dominant.

Coral reefs in Milne Bay Province at ambient CO_2 (top) and one at one of the CO_2 seeps exposed to elevated CO_2 (bottom). The lack of structural complexity leads to substantial losses in reef biodiversity. Photos: Sam Noonan, AIMS.

What will be the impact of acidification?

AIMS has been leading research at the Papua New Guinea seeps that has already involved 35 researchers from 20 institutions from nine countries. It's a natural laboratory that is revealing the fate awaiting tropical marine ecosystems in coming decades if carbon dioxide levels continue to increase.

The team linked changes in coral reef communities directly to the effects of ocean acidification. They showed that reefs exposed to high CO_2 levels are dominated by massive corals and lose diversity and structural complexity. The team also documented the severe implications of such changes in coral communities for the biodiversity and abundance of reef-associated organisms, as more CO_2-tolerant crabs, shrimps and mussels lose their home of branching coral.

Back on the Great Barrier Reef, AIMS researchers have found that CO_2 levels vary across the Reef. The variations in CO_2 are due to biological activity, oceanographic processes and what comes down the rivers.

Controlled experiments in SeaSim aquaria complement the work in Papua New Guinea, helping us to better understand the overall effects of ocean acidification and the interactions with other pressures such as light limitation, increased temperature, and reduced water quality.

Three recent papers illustrated the complex impacts of CO_2. The first showed that seagrasses will be the 'winners' of ocean acidification. They suffer no ill effects from higher CO_2 concentration, increasing their rates of photosynthesis, which leads to greater seagrass cover and productivity in areas of good water quality.

Some seaweeds, such as calcareous *Halimeda*, at the PNG seeps can acclimatise, grow and calcify in extremely high CO_2 conditions – even those exceeding the most pessimistic future CO_2 projections. This is different from *Halimeda* species in the Mediterranean Sea.

But crustose coralline algae are affected negatively in the early stages of development if exposed to high CO_2 levels. These algae are the preferred settling ground for coral larvae.

SeaSim OA experiment conducted by Kristen Anderson and Neal Cantin. Photo: Brecht Vanoverbeke.

Further reading

http://www.aims.gov.au/co2_seeps

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