Global warming and coral reefs

Thomas J Goreau

Coral reefs are the most sensitive of all ecosystems to global warming, pollution, and new diseases. They will be first to go as a result of climate change. As the most important resources for fisheries, tourism, shore protection, and marine biodiversity for more than a hundred countries, this will be a huge disaster.

Almost all reefs have already been heated above their maximum temperature thresholds. Many have already lost most of their corals, and temperature rise in most places gives only a few years before most corals die from heatstroke.

In 1998 most coral reefs in the Indian Ocean suffered widespread dieback. In 2002 the same happened across much of the South Pacific. These were the hottest and second-hottest years measured, but all other years in the last decade were only a few tenths of a degree less. Survival of most remaining coral is only a question of when the next year as hot as 1998 and 2002 hits. Statistically it's already 2005, although if we're lucky natural climatic fluctuations may postpone it for a few years.

At the "Earth Summit" in Rio de Janeiro in 1992, I showed global satellite sea-surface temperature data and told governments that coral reefs were already at their tolerance limits, and could take no further heat. We begged them to stop global warming or we would lose many of our corals in the next ten years (which is what happened).

The United Nations Framework Convention on Climate Change (UNFCCC) only stabilised rates of greenhouse gas and temperature *increases*, not greenhouse gas concentrations and temperatures. As a result the convention is useless for halting the destruction of coral reefs.

Although we got language in the convention stating that its purpose is, among other things, to protect the earth's climate-sensitive ecosystems, this was rendered nonsensical by a failure to do three things:

- identify these ecosystems
- require they be monitored for temperature stress
- include a trigger mechanism to reduce greenhouse gas emissions if such stress was shown.

Further, there was wholesale dishonesty in greenhouse accounting requirements, confusing sources with sinks and net fluxes with gross fluxes. Any accountant who pulled off such tricks with real money would be jailed. Minutes after the treaty was signed, I circulated

leaflets denouncing it as a death sentence for coral reefs.

A model fallacy

In Rio I also presented comparisons of historical changes in temperature, CO2, and sea level over the last 130,000 years recorded in ice-caps versus those predicted by the best models endorsed by the Intergovernmental Panel on Climate Change (IPCC). The real data showed that model predictions seriously underestimate the actual observed sensitivity of the climate system. Changes in temperature due to carbon dioxide, for example, are probably underestimated about tenfold.

By contrast, the models then in use only predict short-term changes which have not come to steady state, because this is much longer than the time horizon IPCC presents to policymakers. The logical fallacy is as if you kick a football, measure how far it moves in one tenth of a second, and confuse this with how far the ball will go!

Most climate-change models miss the "positive feedback mechanisms". We know from correlations between earth's orbital parameters around the sun and climate changes recorded in deep-sea sediments, stalactites, and ice cores that there are very strong internal feedback mechanisms that amplify very small changes in sunlight.

Climate models are still too imprecise to say how hot it will get and how long this will take. So let us ignore model predictions as uncertain and look at the real data. The last time global temperature was 1 degree Centrigrade above today's level, 125,000 years ago (which humans now alive will experience), sea level was not the few centimeters higher predicted by the IPCC models but more than six metres (twenty feet) higher. Crocodiles and hippopotamuses flourished in tropical swamps in London (see them in the Natural History Museum), and Caribbean reefs were flattened by monster hurricanes while huge sand dune islands were built in days.

Carbon dioxide concentrations in the atmosphere at that time were 30% *lower* than today. Conditions then *underestimate* what we will face when we come to equilibrium with the *present* level of CO2, much less the doubling that is likely to take place during this century if present methods of energy production and modes of economic growth continue!

Today, we do not feel the effects of global warming because most of the trapped heat is flowing down to the deep sea. This introduces a 1,000-year timelag, the mean turnover time of the deep ocean to the surface. If you have your furnace on full blast and your attic windows open, you won't feel warm on the ground floor until after the attic warms up because heat flows to the coldest spot. If the circulation shuts down, the heat builds up more quickly. The qualitative argument is solid, but the timing highly uncertain.

A time to act

We are many generations away from feeling the effects of the excess carbon dioxide already in the atmosphere as a result of industrial activities to date, and when this plays out the effects will be much greater than 125,000 years ago, even if we never burn any more coal, oil or gas from today forwards. Sudden changes in temperature and sea level will follow when there are dramatic shifts in ocean surface currents (something taking place already in slow motion), and sudden slipping of ice shelves and glaciers lubricated beneath by meltwater. Eventually the surface ocean layer will become so warm and thick that it can't get dense enough to sink, shutting down deep ocean circulation and greatly speeding surface atmosphere warming.

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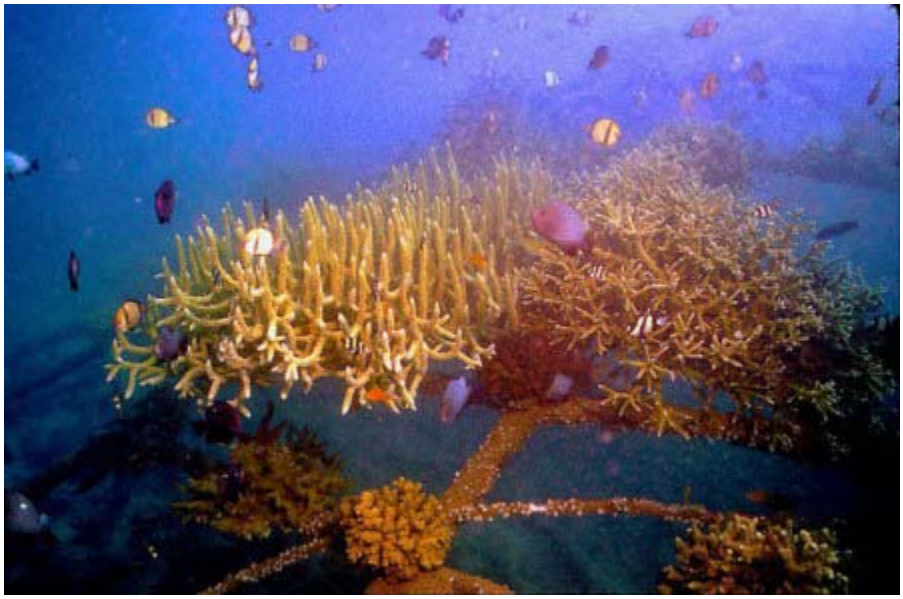
It has been long known that rising carbon dioxide in the atmosphere will raise ocean acidity (that is, lower ocean pH), but this keeps being re- "discovered" as a new problem. But corals will die of global warming long before increased acidity kills them.

Our long-term global satellite coral reef temperature database shows that worldwide changes in ocean circulation are underway, affecting all coral reefs and marine fisheries. Our data shows the crisis is more imminent than policymakers realise. But we can't get them to act because people who have not studied the real data and rely on inaccurate models think the coral crisis is centuries to millennia away.

Large-scale application of Biorock reef restoration technology may offer one of the only long-term hopes for coral reefs, since global warming, pollution, and new diseases are now beyond control. This method allows corals to grow three to five times faster and have a survival rate of high temperatures sixteen to fifty times higher than background. Biorock reefs not only keep corals alive where they would die, they allow us to grow reefs where natural recovery is impossible (for

Bleached corals are starving. If the stress eases they may slowly recover, but if it intensifies they will die. This is the first recorded photograph of bleaching corals. It was taken by the late Prof. Thomas F. Goreau in Jamaica in 1963



Prolific coral and fish growth on a 3 year old Biorock reef in Indonesia shows why these are valued by fishermen and tourists alike. Photo James Cervino, July 2004

The "Vabbbinafau Lotus" - a Biorock facility in the Maldives, thriving after the tsunami of December 2004. Photo Azeez Hakeem

more on this, see our article on work in the Maldives). Fishermen can use them to grow whole reefs supporting huge school s of fish and harvest fish sustainably, becoming reef farmers instead of hunters killing the last big game.

Policymakers and funding agencies must decide to quickly support large-scale restoration of reefs and fisheries, instead of marine-protected areas that will fail even more as global warming, pollution, and new diseases spread out of control. Only Indonesia has made such a commitment, and we must hope other countries and international agencies follow before it is too late and they lose their biodiversity, fisheries, tourism, beaches, and the low-lying islands and coasts.

This article appears as part of openDemocracy's online debate on the politics of climate change. The debate was developed in partnership with the British Council as part of their ZeroCarbonCity initiative – a two year global campaign to raise awareness and stimulate debate around the challenges of climate change.

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