

Climate Change Threatens the Survival of Coral Reefs



Bleaching coral reef in American Samoa, 2015 (photo: XL Catlin Seaview Survey)

Coral reefs are structures created by coral animals and are among the most biologically diverse ecosystems on the planet. They provide goods and services worth at least US\$30 billion per year (and possibly much more) and support (through such activities as fisheries and tourism) at least 500 million people worldwide.

Coral reefs, however, are threatened with effective collapse under rapid climate change. In particular, increasing sea temperatures are causing widespread coral bleaching and mortality. In addition, elevated carbon dioxide levels are causing ocean acidification that may further accelerate coral reef loss. The death of corals leads in turn to the loss of most of the fish and invertebrate populations that they support.

Over recent decades, 33-50% of coral reefs have been largely or completely degraded by a combination of local factors and global climate change. Reefs in many regions have lost half or more of their live corals. Additional extensive degradation will inevitably occur over the next two decades as temperatures continue to rise.

As a result of reef ecosystem destruction, a quarter of all marine species are at risk, while the associated economic losses will expose hundreds of millions of people to decreasing food security and increased poverty.

If average global surface temperatures increase by 2°C or more, relative to the pre-industrial period, the resultant ocean warming, along with acidification, will lead to continued widespread destruction of coral reef ecosystems over the next few decades. The emission reduction pledges submitted to date by the international community fall well short of what is required to avoid this biodiversity catastrophe.

The International Society for Reef Studies thus calls on all nations and negotiators at the Paris Climate Change Conference to commit to limiting atmospheric carbon dioxide (CO₂) concentrations to no more than 450 ppm in the short-term, and reducing them to 350ppm in the long-term.

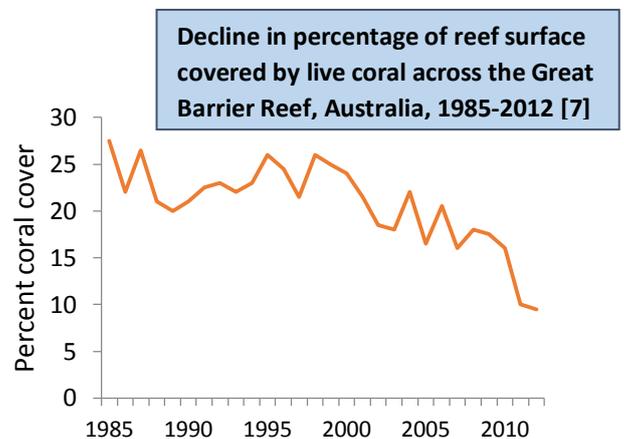
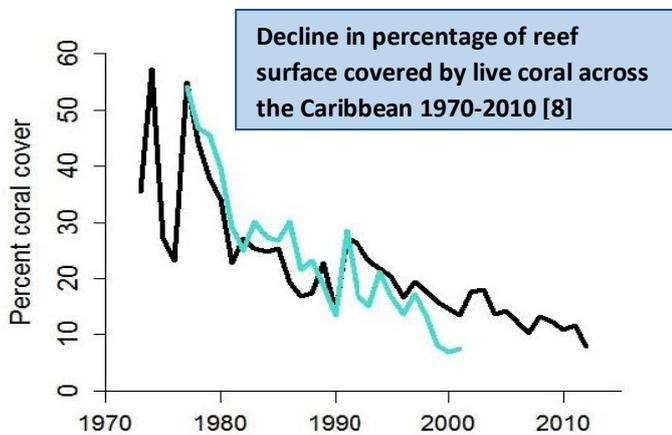
This should keep average global temperature increase to less than 2°C (or 3.6°F) in the short-term, and less than 1.5°C (or 2.7°F) in the long-term, relative to the pre-industrial period. This would prevent global collapse of coral reef ecosystems and allow coral reefs to survive in perpetuity.



The International Society for Reef Studies (ISRS) is the leading international association for coral reef scientists and managers. Its members carry out and publish work that promotes scientific knowledge and understanding of coral reef ecosystems.

www.coralreefs.org

*ISRS Consensus Statement on Climate Change and Coral Bleaching, October 2015
Prepared for the 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change, Paris, December 2015.*



Warming oceans and bleaching reefs

There is overwhelming consensus within the scientific community, and robust evidence, that the surface layers of the world's oceans have warmed since the beginning of the 20th century. This warming has taken place at a faster rate than at any previous time for which we have evidence, including the fossil record for those ocean regions where coral reef ecosystems have grown for millions of years [1].

This is due to changes in the composition of the atmosphere, in particular the large increase in concentration of atmospheric carbon dioxide (CO₂) from a mean of about 280ppm during pre-industrial times, to close to 400ppm at the present time [2]. Burning of fossil fuels by humans has accelerated over the past 50 years and is the primary cause of this increase. Projected rates of change indicate that under existing patterns of human activity tropical waters will be 3-4°C (5.4-7.2° F) warmer by 2100.

Coral reefs grow in warm shallow seas and have experienced relatively stable temperatures over thousands of years. Since the early 1980s, however, as sea surface temperatures have rapidly increased, corals have experienced large-scale bleaching and subsequent mortality [3]. Bleaching events occur in response to periods during which surface waters become so warm that there is a breakdown of the symbiosis between corals and the microalgae that live in great numbers within their cells. The loss of these symbiotic algae causes whitening (bleaching) of the coral animals and leads to their starvation, sickness and, in many cases, death.

In 1998, when extremely high mean sea temperatures were recorded, an estimated 16% of the world's coral communities bleached and died [4,5]. Since then many more widespread coral bleaching and mortality events have affected Indo-Pacific and Caribbean reefs, in response to raised sea surface temperatures, with the extent of these

impacts having increased over subsequent decades [1,5]. An estimated 33-50% of coral reefs have now been largely or completely degraded by a combination of local factors and global climate change [5], with reefs in many regions already having lost half or more of their living coral cover [6-8]. Additional extensive degradation will inevitably occur over the next two decades, as temperatures continue to rise.

Experimental, field, and remote sensing studies have led to a scientific consensus that projected changes in atmospheric CO₂ concentration will soon push average global land and sea surface temperature increases to 2°C or more above pre-industrial levels. These changes are already leading to ocean temperatures which are beyond the temperature tolerance of reef building corals and of many other reef organisms [9,10]. NOAA satellites are able to predict reasonably accurately when and where mass coral bleaching is likely to occur by tracking positive thermal anomalies. Current warming anomalies indicate that the global extent of coral bleaching during 2015-2016, now declared a "global coral reef bleaching event", could be equal to or worse than events that have occurred at any time in the past [11].

Ocean acidification

An additional threat to coral reefs is ocean acidification. This arises from increasing amounts of CO₂ entering the ocean, where it reacts with water to produce a mild acid, which decreases pH and causes a cascade of changes to seawater chemistry. Experimental studies show that acidification has negative effects on calcification, metabolism, sensory systems, survivorship, reproductive stages, and many other fundamental processes on coral reefs [1,2], and also accelerates destructive processes including erosion and dissolution of the reef structure.

Ocean acidification is taking place at a rate which is faster than anything seen over the past 65 million years, if not the past 300 million years [12], bringing into question whether corals, with such long generation times, can adapt rapidly enough to persist.

Acidification has the potential to lead to slower reef ecosystem recovery from other impacts including not only coral bleaching, but also disease, predation, cyclones and destructive fishing. It will thus promote subsequent reef loss and, in many cases, consequent coastline erosion.

Most functioning coral reefs will disappear by mid-century without urgent action to reduce CO₂

Ocean warming and acidification, because of their effects on corals, are jointly driving fundamental shifts in the structure and function of coral reef ecosystems, turning reefs into low diversity and low productivity systems, as well as eroding their structure. While coral populations can recover from brief exposure to warm water, the combination of increasing ocean temperatures, acidification and more local pressures such as pollution and overfishing is causing cumulative damage [2]. As coral reefs disappear, so will the habitat of a quarter of all marine species, many of which require the three-dimensional structure and high productivity of these unique and diverse environments to survive.

Coral reefs provide food and income for hundreds of millions of people spread across dozens of countries, and the loss of these ecosystems will have an unimaginable impact, with serious damage already visible. The potential net benefit streams per year from the world's coral reefs were estimated over ten years ago at close to US\$30 billion per year [13], through benefits such as fisheries, tourism and coastal protection, and may now be much more [14].

Mass coral bleaching and mortality of coral reef ecosystems is one of the most visible impacts of climate change, and warns us of the dangerous world that we are entering as our climate warms. The loss of most if not all functioning coral reef ecosystems from the world's oceans would be an unthinkable tragedy. Unfortunately, that tragedy is on our doorstep today, but is avoidable given the required international leadership.



Call to action: Governments must achieve minimal CO₂ emissions over the next 3 decades

Negotiators and global leaders at the Paris Climate Change Conference (COP21) hope to set a target that will limit average global land and sea surface temperature rise to less than 2°C above pre-industrial levels and to eventually stabilise ocean pH at close to today's levels. However, the Intended Nationally Determined Contributions (INDCs) pledges made prior to COP21 fall far short of this goal. As such, they will not prevent the degradation of coral dominated reef systems throughout large parts of the globe.

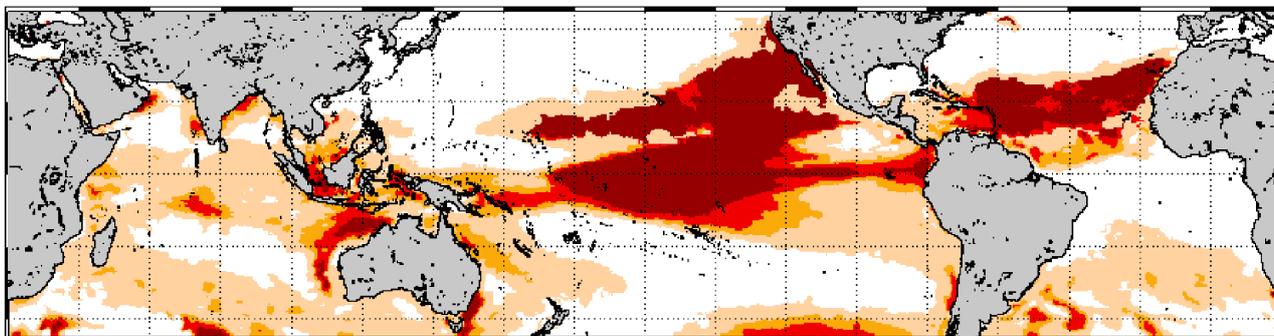
ISRS is therefore calling for nations to commit to reducing CO₂ emissions to the point where atmospheric concentrations reach no more than 450 ppm in the short-term, and 350ppm in the long-term. Reducing emissions to this lower level will have a high probability of stabilizing temperatures at 1.5°C above the preindustrial period (350 ppm) in the long-term.

Reduction of CO₂ concentrations to the levels necessary to save coral reef ecosystems will require major initiatives to **reduce both CO₂ emissions and our carbon footprint**. Such global scale measures will be critical, not only for the survival of coral reefs and many other types of marine life, but also for the stability of human communities. Negotiators must reach an agreement that results in deep and fundamental cuts to CO₂ emissions

immediately, given the long periods of time needed for the ocean to equilibrate with the atmosphere. CO₂ budgets associated with keeping average sea surface temperature increases to less than 2°C above pre-industrial times require that total emissions due to use of fossil fuels be limited to no more than 1000 GT of CO₂ after the year 2000

[15,16]. Since human activity has already emitted approximately 600 GT of CO₂ since that date, a rapid reduction of net CO₂ emissions to near zero over the next 20 years is necessary if functional coral reef ecosystems are to be saved for the benefit of future generations. This means that most fossil fuels must be left in the ground.

2015 Oct 6 NOAA Coral Reef Watch 60% Probability Coral Bleaching Thermal Stress for Oct-Jan 2016



Potential Stress Level: Watch Warning Alert Level 1 Alert Level 2

Predicted global distribution and intensity of coral bleaching based on modelling of sea surface temperatures October 2015 – January 2016. US National Ocean and Atmospheric Administration: Coral Reef Watch [11]

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