BRIEFING

# What is ocean acidification?

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Since pre-industrial times, the ocean has absorbed around a third of humanity's carbon dioxide emissions. As a result, the ocean is becoming more acidic.

Together with other impacts of climate change such as warming water and lack of oxygen (hypoxia), acidification threatens the existence of coral reefs and some other marine life. The cost of losing coral reefs alone could amount to $1 trillion annually by the end of the century.

Acidification perturbs the senses of some fish, affecting their ability to detect prey and predators. Image: David Siu, Creative Commons licence

**How ocean acidification happens**

The ongoing absorption of carbon dioxide ($CO_2$) by the oceans is changing the chemistry of seawater.

**Acidity, alkalinity and pH**

- Acidity and the reverse phenomenon, alkalinity, are measured on the pH scale
- Seven is neutral
- The lower the number below seven, the more acidic the water; the higher the number above seven, the more alkaline

As seawater absorbs carbon dioxide from the air, it becomes progressively more acidic. The average pH of water at the ocean surface has already fallen by 0.1 pH units since pre-industrial times to 8.1, which represents about a 30% increase in acidity.

Ocean acidification is thought to be happening faster than at any time in the last 65 million years, and possibly the last 300 million years.

As more $CO_2$ enters the atmosphere, ocean acidification is forecast to continue.

If emissions are constrained tightly in the next decade and then fall to zero in the second half of the century, ocean pH is projected to fall by a further 0.1 units by 2100. If emissions continue rising at their current rate, the figure is likely to be a further 0.3 pH units. That would mean the ocean would be more acidic than it has been for 50 million years.

These are global average figures, and local variations are projected. For example, pH in the northern Gulf of Mexico is projected to fall twice as quickly as the global average.

As ocean pH is coming down towards seven – the neutral point on the pH scale – it would be more accurate to call this phenomenon a reduction in alkalinity rather than an increase in acidity.

However, the phrase 'ocean acidification' has stuck. And from the point of view of ocean life, it is an irrelevant point; life has adapted to an average pH around 8.2, and may not be able to adapt to changes, particularly rapid ones.

Ocean acidification is less well known than other aspects of climate change. According to a survey in 2014, only one-fifth of the UK public are aware of it.

**Impacts of ocean acidification**

The most obvious threat is to creatures with shells. Higher acidity compromises shell growth. This would affect many organisms including seafood favourites such as oysters, clams, scallops, lobsters, crabs and shrimp.

Some places in the ocean are 'natural laboratories' for studying ocean acidification. Here, carbon dioxide bubbling into the sea from underwater volcanoes makes the water unusually acidic, mimicking conditions of the future.

One of these areas is off the western coast of Italy, a second in Papua New Guinea. In both places, sea life is characterised by the absence of shelled animals such as coral, and domination by seagrasses.

Acidification also appears to impede the capacity of some fish to hunt and to sense predators, by affecting their senses of hearing and smell. Other animals such as squid and sea urchins may also be affected directly.

Impacts of acidification will be felt all the way up the food chain. For example, marine snails (pteropods), whose shells are now thinning in Antarctic waters and off the US West Coast, are an important feedstock for fish, squid and birds.

**Will coral reefs survive?**

Coral reefs not only face higher acidity under climate change, but also higher temperatures.

Warm water can cause coral reefs to 'bleach'. This happens when coral polyps expel the algae that live in them, as a direct consequence of warming up. The coral turns completely white. If the algae are not quickly reabsorbed, the coral will die.

Temperature increases of only 1-2 Celsius above normal during summer can induce bleaching. Reefs across much of East Asia bleached during the 1997-8 El Niño event. Scientists have found that coral bleaching could become the norm as early as the 2050s.

Studies have found reef growth to be 40% lower than in the 1970s owing to warming and acidifying waters. All coral reefs could start to disintegrate by the end of the century, with mass die-off events likely every 1-2 years in several regions.

This has led to warnings that the world only has a small 'window of opportunity' to preserve coral reefs. But the 'window' is closing; protecting more than 10% of reefs worldwide would require limiting global warming since pre-industrial times to 1.5 Celsius, which is regarded as increasingly unlikely as emissions continue to rise. Global warming of 2°C would still see most reefs undergo severe degradation.

Coral reefs contain thousands of fish species, and are essential spawning, nursery, breeding and feeding grounds. Estimates of the biodiversity of coral reefs vary but they are thought to rival terrestrial rainforests.

Acidification and warming water will add to the stresses that reefs are already facing from disease, invasive species, direct damage from fishing and tourism, and pollution.

**Impacts for humanity**

Ocean acidification is already affecting human society.

Along the West Coast of North America, seawater that is naturally more acidic than average wells up from the deep ocean. The additional acidity caused by carbon dioxide emissions is now adding to the natural acidity and causing problems for shellfish farmers, with consequent financial losses.

Coral reefs are valuable economic resources. The UN Convention on Biological Diversity (CDB) estimates that 400 million people worldwide live within 100km of a tropical coral reef, and that damage to reefs by the end of the century alone would carry a loss of $1 trillion annually.

Since seawater is absorbing CO2, the oceans slow the rate of climate change experienced by humanity. However, the more the ocean contains, the less it can absorb. So the proportion of human emissions entering the ocean is decreasing, leaving more in the atmosphere to warm the planet.