

Inter-Academy Panel Statement on Ocean Acidification

June 1, 2009

Headline messages

- *Oceans play a critical role in the global carbon cycle by absorbing about a quarter of the CO₂ emitted to the atmosphere from human activities;*
- *The rapid increase in CO₂ emissions since the industrial revolution has increased the acidity of the world's oceans with potentially profound consequences for marine plants and animals especially those that require calcium carbonate to grow and survive, and other species that rely on these for food;*
- *At current emission rates models suggest that all coral reefs and polar ecosystems will be severely affected by 2050 or potentially even earlier;*
- *Marine food supplies are likely to be reduced with significant implications for food production and security in regions dependent on fish protein, and human health and wellbeing;*
- *Ocean acidification is irreversible on timescales of at least tens of thousands of years;*
- *Even with stabilisation of atmospheric CO₂ at 450 ppm ocean acidification will have profound impacts on many marine systems. Large and rapid reductions of global CO₂ emissions are needed globally by at least 50% by 2050.*

1. CO₂ and ocean chemistry

Over the past 200 years the oceans have absorbed approximately a quarter of the CO₂ produced from human activities. This CO₂ would otherwise have accumulated in the atmosphere leading to greater climate change. However, the absorption of this CO₂ has affected ocean chemistry and has caused the oceans (which are on average slightly alkaline) to become more acidic. The average pH of oceanic surface waters has been lowered by 0.1 units since the pre-industrial period. This represents a 30% increase in hydrogen ion activity. Hydrogen ions attack carbonate ions which are the building blocks needed by many marine organisms, such as corals and shellfish, to produce their skeletons, shells and other hard structures. This loss of carbonate ion produces lower

saturation levels for the carbonate minerals, aragonite and calcite, which are used in many shells and skeletons. Carbonate ion concentrations are now lower than at any other time during the last 800,000 years.

Global atmospheric CO₂ concentrations are now at 387 ppm. If current trends in CO₂ emissions continue, model projections suggest that by mid-century CO₂ concentrations will be more than double pre-industrial levels and the oceans will be more acidic than they have been for tens of millions of years. The current rate of change is much more rapid than during any event over the last 65 million years. These changes in ocean chemistry are irreversible for many thousands of years, and the biological consequences could last much longer.

2. Environmental damage from ocean acidification

Ocean acidification impacts on marine life will depend on the rate and magnitude of changes in ocean chemistry and biological responses. While the ocean chemistry changes are predictable with high certainty, our understanding of the impacts is still developing. Nevertheless, there is strong evidence emerging for a range of biological effects and changes in the marine biogeochemical processes that affect the carbon cycle. The long-term consequences of this are difficult to predict.

Impacts are already being observed in the polar and tropical regions. Coral calcification rates have declined in recent decades, although attributing causes for these impacts among multiple drivers (acidification, warming, pollution, etc.) is a challenge. Fundamental ecological ocean processes will be affected as many marine organisms depend directly or indirectly on calcium carbonate saturated waters and are adapted to

current levels of seawater pH for physiological and metabolic processes such as calcification, growth and reproduction. The pH changes expected will exceed the seasonal and regional variations currently experienced naturally.

Ocean acidification is a global issue, however changes in ocean chemistry will be regionally variable with some regions affected more rapidly than others. The high CO₂ waters in polar and upwelling regions such as the eastern Pacific and Bering Sea for example, will experience low pH more rapidly than other regions. Tropical waters, such as those around the Great Barrier Reef will also experience rapid declines in the carbonate ions important for coral reef construction. According to recent model projections almost all tropical and sub-tropical coral reefs were surrounded by waters favourable to coral growth before the industrial revolution. If atmospheric CO₂ is stabilized at 450 ppm only a very small fraction (~8%) of existing tropical and subtropical coral reefs will be surrounded by such water, and at 550 ppm, coral reefs may be dissolving globally. Cold water corals are also vulnerable and are likely to be affected before they have even been fully explored. By 2100, it has been estimated that 70% will be in waters unfavourable for growth.

In the polar regions, model projections using current CO₂ emission rates suggest that parts of the Southern Ocean will be undersaturated for aragonite by 2050. Aragonite undersaturation is projected for 10% of Arctic waters by around 2020, and by 2060, 80% of waters will be undersaturated for aragonite and calcite. This means the waters will be corrosive to Arctic calcifiers such as pteropods, and bivalves such as clams, which play a key role in Arctic food webs.

The ocean chemistry changes projected will exceed the range of natural variability, with is likely to be too rapid for many species to adapt to. Many coastal animals and groups of phytoplankton and zooplankton may be directly affected with implications for fish, marine mammals and the other groups that depend on them for food. Increased CO₂ may be particularly stressful for organisms with high metabolic rates such as squid. The impacts of these changes on oceanic ecosystems and the services they provide, for example in fisheries, coastal protection, tourism, carbon sequestration and climate regulation, cannot yet be estimated accurately but they are potentially large.

Although some species may benefit, most are adapted to current conditions and the impacts on ocean biological diversity and ecosystem functioning will likely be severe. Analysis of past events in Earth's geologic history suggests that chemical recovery will take tens of thousands of years - while the recovery of ecosystem function and biological diversity can take much longer.

3. *Human dimensions of ocean acidification*

The socio-economic effects of ocean acidification have not been directly estimated but are likely to be substantial given that in many parts of the world economies depend on revenue from coral reef systems (eg from fishing and tourism). The reduction or loss of coral reef ecosystems and the fisheries and recreational industries that depend on them would have a major impact on regional food security, and on economies around the world. Reductions in the coastal protection provided by coastal reefs, particularly under future climate change, would also have a major economic effect.

Commercially important fish and shellfish species are also likely to be affected, although this issue has not yet been well researched. Species of shellfish, including crustaceans, molluscs, and echinoderms will be directly affected, as may the fish groups that use calcareous structures for balance and orientation. Many fish also rely on calcifying organisms for food, and reproductive processes for marine animals are known to be pH sensitive. Ocean acidification impacts will be in addition to climate change and will add further pressure to rapidly diminishing fisheries resources, causing significant and long-lasting changes to ocean ecosystems to an extent and in ways that cannot at present be foreseen.

4. *Mitigation*

Ocean acidification is irreversible during our lifetimes and those of many generations to come. To minimise the risk of these large-scale and long-term changes to the oceans the increase in atmospheric CO₂ must be curbed by reducing emissions from human activities.

Recent scenario studies have estimated that stabilisation of atmospheric CO₂ concentrations at 550 ppm will produce enough acidification to be disastrous for sensitive oceanic ecosystems in many parts of the world. Even at 450 ppm more than 10% of the world's oceans, including large

parts of the Southern, North Pacific, and Arctic oceans are likely to be affected.

Mitigation approaches such as adding chemicals to counter the effects of acidification are likely to be expensive, only partly effective and only at a very local scale, and may pose additional unanticipated risks to the marine environment. There has been very little research on the feasibility and impacts of these approaches. Substantial research is needed before these techniques could be applied.

5. *Conclusions and recommendations*

Ocean acidification is a direct consequence of increasing atmospheric CO₂ concentrations. To avoid substantial damage to ocean ecosystems, deep and rapid reductions of global CO₂ emissions by at least 50% by 2050, and much more thereafter are needed.

We call on world leaders to:

- Acknowledge that ocean acidification is a direct and real consequence of increasing atmospheric CO₂ concentrations, is already having an effect at current concentrations, and is likely to cause grave harm to important marine ecosystems as CO₂ concentrations reach 450 ppm and above;
- Recognise that reducing the build up of CO₂ in the atmosphere is the only practicable solution to mitigating ocean acidification;
- Within the context of the UNFCCC negotiations, recognise the direct threats posed by increasing atmospheric CO₂ emissions to the oceans and therefore society, and take action to mitigate this threat;
- Implement action to reduce global CO₂ emissions by at least 50% of 1990 levels by 2050 and continue to reduce them thereafter;
- Reinvigorate action to reduce stressors, such as overfishing and pollution, on marine ecosystems to increase resilience to ocean acidification.

70 instituciones académicas y centros de investigación del Mundo, entre ellos la Real Academia de Ciencias Exactas, Físicas y Naturales, han suscrito el manifiesto.