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# IAP STATEMENT ON OCEAN ACIDIFICATION

## Headline messages

- Oceans play a critical role in the global carbon cycle by absorbing about a quarter of the $CO_2$ emitted to the atmosphere from human activities;
- The rapid increase in $CO_2$ 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 $CO_2$ at 450 ppm, ocean acidification will have profound impacts on many marine systems. Large and rapid reductions of global $CO_2$ emissions are needed globally by at least 50% by 2050.

## 1. $CO_2$ and ocean chemistry

Over the past 200 years, the oceans have absorbed approximately a quarter of the $CO_2$ produced from human activities. This $CO_2$ would otherwise have accumulated in the atmosphere leading to greater climate change. However, the absorption of this $CO_2$ 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 ions produce 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 $CO_2$ concentrations are now at 387 ppm. If current trends in $CO_2$ emissions continue, model projections suggest that by mid-century $CO_2$ 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.

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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 $CO_2$ 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 $CO_2$ 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 $CO_2$ 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, which 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 $CO_2$ 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.

## 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 $CO_2$ must be curbed by reducing emissions from human activities.

Recent scenario studies have estimated that stabilisation of atmospheric $CO_2$ 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 will be impacted including large parts of the Southern, North Pacific, and Arctic oceans.

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 $CO_2$ concentrations. To avoid substantial damage to ocean ecosystems, deep and rapid reductions of global $CO_2$ emissions by at least 50% by 2050, and much more thereafter are needed.

We, the academies of science working through the InterAcademy Panel on International Issues (IAP), call on world leaders to:

- Acknowledge that ocean acidification is a direct and real consequence of increasing atmospheric $CO_2$ concentrations, is already having an effect at current concentrations, and is likely to cause grave harm to important marine ecosystems as $CO_2$ concentrations reach 450 ppm and above;
- Recognise that reducing the build up of $CO_2$ in the atmosphere is the only practicable solution to mitigating ocean acidification;
- Within the context of the UNFCCC negotiations in the run up to Copenhagen 2009, recognise the direct threats posed by increasing atmospheric $CO_2$ emissions to the oceans and therefore society, and take action to mitigate this threat;
- Implement action to reduce global $CO_2$ 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.

The following academies have endorsed this statement.

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- TWAS, the academy of sciences for the developing world
- Albanian Academy of Sciences
- National Academy of Exact, Physical and Natural Sciences, Argentina
- Australian Academy of Science
- Bangladesh Academy of Sciences
- The Royal Academies for Science and the Arts of Belgium
- Brazilian Academy of Sciences
- Bulgarian Academy of Sciences
- Cameroon Academy of Sciences
- RSC: The Academies of Arts, Humanities and Sciences of Canada
- Academia Chilena de Ciencias
- Chinese Academy of Sciences
- Colombian Academy of Exact, Physical and Natural Sciences
- Croatian Academy of Arts and Sciences
- Cuban Academy of Sciences
- Academy of Sciences of the Czech Republic
- Royal Danish Academy of Sciences and Letters
- Academia de Ciencias de la República Dominicana
- Academy of Scientific Research and Technology, Egypt
- The Delegation of the Finnish Academies of Science and Letters
- Académie des Sciences, France
- Georgian Academy of Sciences
- Union der Deutschen Akademien der Wissenschaften
- Deutsche Akademie der Naturforscher Leopoldina
- The Academy of Athens
- Academia de Ciencias Medicas, Fisicas y Naturales de Guatemala
- Indian National Science Academy
- Indonesian Academy of Sciences
- Academy of Sciences of the Islamic Republic of Iran
- Royal Irish Academy
- Israel Academy of Sciences and Humanities
- Accademia Nazionale dei Lincei
- Science Council of Japan
- Royal Scientific Society of Jordan
- Islamic World Academy of Sciences
- African Academy of Sciences
- Kenya National Academy of Sciences
- The Korean Academy of Science and Technology
- Kosovo Academy of Sciences and Arts
- National Academy of Sciences of the Kyrgyz Republic
- Akademi Sains Malaysia
- Mauritius Academy of Science and Technology
- Academia Mexicana de Ciencias
- Montenegrin Academy of Sciences and Arts
- The Royal Netherlands Academy of Arts and Sciences
- Academy of the Royal Society of New Zealand
- Nigerian Academy of Sciences
- Norwegian Academy of Sciences and Letters
- Pakistan Academy of Sciences
- Palestine Academy for Science and Technology
- Academia Nacional de Ciencias del Peru
- Academia das Ciencias de Lisboa
- Académie des Sciences et Techniques du Sénégal
- Serbian Academy of Sciences and Arts
- Slovak Academy of Sciences
- Slovenian Academy of Sciences and Arts
- Academy of Science of South Africa
- Royal Academy of Exact, Physical and Natural Sciences of Spain
- National Academy of Sciences, Sri Lanka
- Sudanese National Academy of Science
- Royal Swedish Academy of Sciences
- Academia Sinica, Taiwan, China
- Tanzania Academy of Sciences
- The Caribbean Academy of Sciences
- Turkish Academy of Sciences
- The Uganda National Academy of Sciences
- The Royal Society, UK
- US National Academy of Sciences
- Academia de Ciencias Físicas, Matemáticas y Naturales de Venezuela
- Zimbabwe Academy of Sciences