



# SECOND INTERNATIONAL SYMPOSIUM ON THE OCEAN IN A HIGH-CO<sub>2</sub> WORLD

MONACO - OCTOBER 6-9, 2008



## Monaco Declaration



It was while taking part in the working sessions of the scientific community, which met in Monaco last October for the second international symposium *The Ocean in a High-CO<sub>2</sub> World*, that I expressed my earnest wishes for the *Monaco Declaration* to be drafted. The seas and oceans absorb one-fourth of the carbon dioxide emitted to the atmosphere from human activities, which in turn is driving their acidification at a rate that is unprecedented.

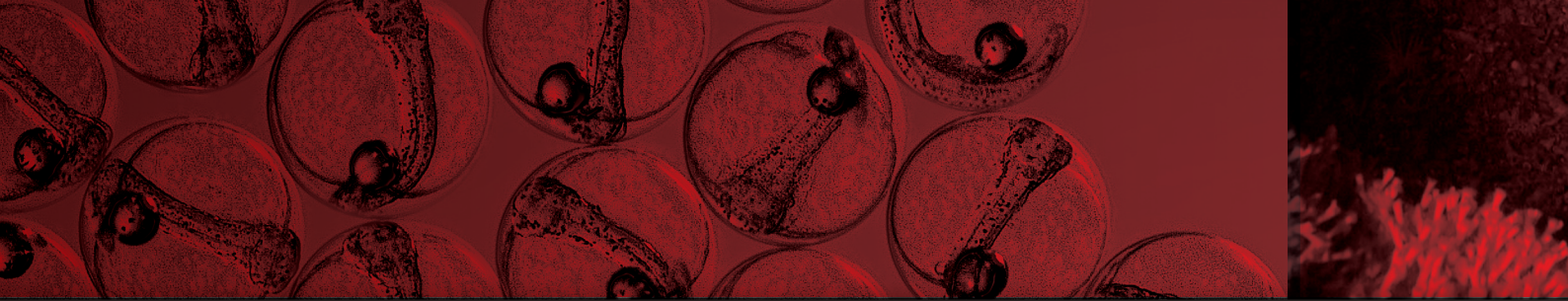
This chemical modification will alter marine ecosystems, upon which over half of the world's population depends for its primary source of food. This declaration, based on irrefutable scientific findings and signed by 155 scientists from 26 nations, sets forth recommendations, calling for policymakers to address this immense problem.

I strongly support this declaration, which is in full accord with my efforts and those of my Foundation to alleviate climate change. I hope that it will be heard by all the political leaders meeting in Copenhagen in December 2009.

H.S.H. Prince Albert II

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**W**e scientists who met in Monaco to review what is known about ocean acidification declare that we are deeply concerned by recent, rapid changes in ocean chemistry and their potential, within decades, to severely affect marine organisms, food webs, biodiversity, and fisheries. To avoid severe and widespread damages, all of which are ultimately driven by increasing concentrations of atmospheric carbon dioxide (CO<sub>2</sub>), we call for policymakers to act quickly to incorporate these concerns into plans to stabilize atmospheric CO<sub>2</sub> at a safe level to avoid not only dangerous climate change but also dangerous ocean acidification.

### **Ocean acidification is underway**

The surface ocean currently absorbs about one-fourth of the CO<sub>2</sub> emitted to the atmosphere from human activities, namely from fossil-fuel combustion, deforestation, and cement production. As this CO<sub>2</sub> dissolves in seawater, it forms carbonic acid, increasing ocean acidity. Since industrialization began in the 18th century, surface-ocean acidity has increased by 30%. This ongoing ocean acidification is decreasing the ability of many marine organisms to build their shells and skeletal structure. Increasing acidity and related changes in seawater chemistry also affect reproduction, behaviour, and general physiological functions of some marine organisms, such as oysters, sea urchins, and squid.

### **Ocean acidification is already detectable**

Observations collected over the last 25 years show consistent trends of increasing acidity in surface waters that follow increasing atmospheric CO<sub>2</sub>. These trends match precisely what is expected based on basic marine chemistry and continuous measurements of atmospheric CO<sub>2</sub>. A range of field studies suggest that impacts of acidification on some major marine calcifiers may already be detectable. Also, naturally high-CO<sub>2</sub> marine environments exhibit major shifts in marine ecosystems following trends expected from laboratory experiments. Ocean acidification has altered some coastal waters to the extent that recently during spring they have become corrosive to the shells of some bottom-dwelling organisms. Within decades these shell-dissolving conditions are projected to be reached and to persist throughout most of the year in the polar oceans.

### **Ocean acidification is accelerating and severe damages are imminent**

Currently the average concentration of atmospheric CO<sub>2</sub> is 385 parts per million (ppm), which is 38% more than the preindustrial level of 280 ppm. Half of that increase has occurred in the last 30 years. Current CO<sub>2</sub> emissions are greater than projected for the worst-case scenario formulated a decade ago. And along with increasing emissions, the increase in atmospheric CO<sub>2</sub> is accelerating. By mid-century, the average atmospheric CO<sub>2</sub> concentration could easily reach double the preindustrial concentration. At that 560-ppm level, it is expected that coral calcification rates would decline by about one-third. Yet even before that happens, formation of many coral reefs is expected to slow to the point that reef erosion will dominate. Reefs would no longer be sustainable. By the time that atmospheric CO<sub>2</sub> reaches 450 ppm, it is projected that large areas of the polar oceans will have become corrosive to shells of key marine calcifiers.

### **Ocean acidification will have socioeconomic impacts**

Ocean acidification could affect marine food webs and lead to substantial changes in commercial fish stocks, threatening protein supply and food security for millions of people as well as the multi-billion dollar fishing industry. Coral reefs provide fish habitat, generate billions of dollars annually in tourism, protect shorelines from erosion and flooding, and provide the foundation for tremendous biodiversity, equivalent to that found in tropical rain forests. Yet by mid-century, ocean acidification may render most regions chemically inhospitable to coral reefs. These and other acidification-related changes could affect a wealth of marine goods and services, such as our ability to use the ocean to manage waste, to provide chemicals to make new medicines, and to benefit from its natural capacity to regulate climate. For instance, ocean acidification will reduce the ocean's capacity to absorb anthropogenic CO<sub>2</sub>, which will exacerbate climate change.

### **Ocean acidification is rapid, but recovery will be slow**

The current increase in ocean acidity is a hundred times faster than any previous natural change that has occurred over the last many millions of years. By the end of this century, if atmospheric CO<sub>2</sub> is not stabilized, the level of ocean acidity could increase to three times the preindustrial level. Recovery from this large, rapid, human-induced perturbation will require thousands of years for the Earth system to reestablish ocean chemical conditions that even partially resemble those

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found today; hundreds of thousands to millions of years will be required for coral reefs to return, based on the past record of natural coral-reef extinction events.

## Ocean acidification can be controlled only by limiting future atmospheric CO<sub>2</sub> levels

So-called *geo-engineering* strategies that would not aim to restrict future atmospheric CO<sub>2</sub> concentrations would not reduce ocean acidification. Mitigation strategies that aim to transfer CO<sub>2</sub> to the ocean, for example by direct deep-sea disposal of CO<sub>2</sub> or by fertilising the ocean to stimulate biological productivity, would enhance ocean acidification in some areas while reducing it in others. Climate-change negotiations focused on stabilizing greenhouse gases must consider not only the total radiation balance; they must also consider atmospheric CO<sub>2</sub> as a pollutant, an acid gas whose release to the atmosphere must be curtailed in order to limit ocean acidification. Hence, limits (stabilization targets) for atmospheric CO<sub>2</sub> defined based on ocean acidification may differ from those based on surface temperature increases and climate change.

Despite a seemingly bleak outlook, there remains hope. We have a choice, and there is still time to act if serious and sustained actions are initiated without further delay. First and foremost, policymakers need to realize that ocean acidification is not a peripheral issue. It is *the other CO<sub>2</sub> problem* that must be grappled with alongside climate change. Reining in this double threat, caused by our dependence on fossil fuels, is the challenge of the century. Solving this problem will require a monumental worldwide effort. All countries must contribute, and developed countries must lead by example and by engineering new technologies to help solve the problem. Promoting these technologies will be rewarded economically, and prevention of severe environmental degradation will be far less costly for all nations than would be trying to live with the consequences of the present approach where CO<sub>2</sub> emissions and atmospheric CO<sub>2</sub> concentrations continue to increase, year after year.

Fortunately, partial remedies already on the table, if implemented together, could solve most of the problem. We must start to act now because it will take years to change the energy infrastructure and to overcome the atmosphere's accumulation of excess CO<sub>2</sub>, which takes time to invade the ocean.

### Therefore, we urge policymakers to launch four types of initiatives:

- to help improve understanding of **impacts of ocean acidification** by promoting research in this field, which is still in its infancy;
- to help build **links between economists and scientists** that are needed to evaluate the socioeconomic extent of impacts and costs for action versus inaction;
- to help **improve communication between policymakers and scientists** so that *i)* new policies are based on current findings and *ii)* scientific studies can be widened to include the most policy-relevant questions;
- to **prevent severe damages from ocean acidification** by developing ambitious, urgent plans to cut emissions drastically.

### An example to illustrate the intense effort needed:

To stay below an atmospheric CO<sub>2</sub> level of about 550 ppm, the current increase in total CO<sub>2</sub> emissions of 3% per year must be reversed by 2020. Even steeper reductions will be needed to keep most polar waters from becoming corrosive to the shells of key marine species and to maintain favourable conditions for coral growth. If negotiations at COP-15 in Copenhagen in December 2009 fall short of these objectives, still higher atmospheric CO<sub>2</sub> levels will be inevitable.

**\*Declaration approved by 155 scientists from 26 countries**, leaders of research into ocean acidification and its impacts.

This document is based on the report *Research Priorities for Ocean Acidification*

(available at <http://ioc3.unesco.org/oanet/HighCO2World.html> along with the Declaration, endorsements, and photo credits).

*This declaration does not necessarily reflect the views of the organizers and financial sponsors of the symposium or the organizations to which the approving scientists are associated.*

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