BRIEFING PAPER

Ocean Acidification

Seas turning sour

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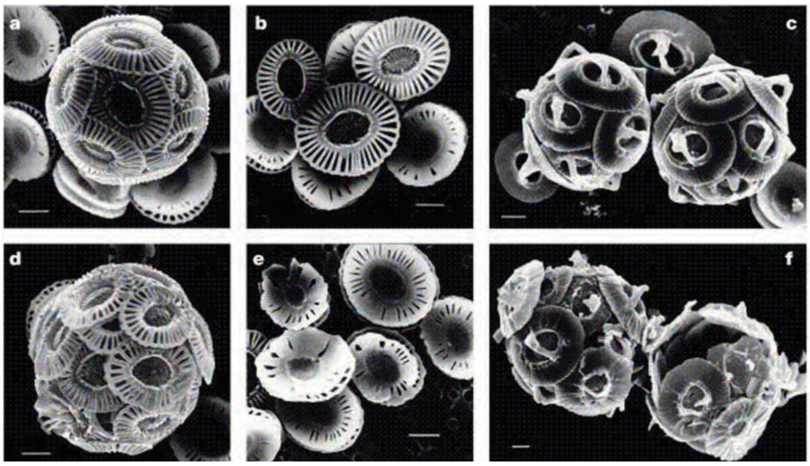

Effects of increased CO_2 on phytoplankton coccolithophores *Emilania huxleyi* and *Gephryocapsa oceanica*: growth and structure are seriously compromised.
Riebesell et al, 2000.

The Science

Ocean acidification is the change in ocean chemistry driven by the uptake of carbon, nitrogen and sulfur compounds by the ocean from the atmosphere. Oceans are an important reservoir for CO_2, absorbing a significant quantity (one-third according to Sabine et al. 2004) produced by anthropogenic activities and effectively buffering climate change. However as atmospheric carbon dioxide increases, the concentration of hydrogen ions in the ocean increases, the concentration of carbonate ions decreases, the pH of the oceans decreases and the oceans become less alkaline – this is the process know as ocean acidification. While there is uncertainty about many aspects of climate change, the geochemical processes driving these changes are highly predictable.

What is happening?

Seawater absorbs CO_2 to produce carbonic acid (H_2CO_3), bicarbonate (HCO_3-) and carbonate ions (CO_3^{2}-). These carbonate ions are essential to the calcification process that allows certain marine organisms to build their calcium carbonate shells and skeletons (e.g. hard tropical corals, cold water corals, certain types of plankton, lobsters, mussels, etc). However, increases in atmospheric CO_2 levels lead to increases in the concentration of carbonic acid and bicarbonate ions, causing a decrease in the concentration of carbonate ions. This affects calcification rates, slowing down the growth rates and decreasing the structural strength of calcifying organisms.

Furthermore, as the concentration of hydrogen ions in the oceans increases the pH decreases. The uptake of atmospheric carbon dioxide is occurring at a rate exceeding the natural buffering capacity of the ocean, and the pH of the ocean surface waters has decreased by about 0.1 units since the beginning of the industrial revolution. If current carbon dioxide emission trends continue, the ocean will continue to undergo acidification, to an extent and at rates that have not occurred for tens of million of years (McLeod et al, 2008). Ocean acidification is largely an invisible, chronic environmental problem. It is also a very recently recognized issue so there is limited empirical data on which to base the identification of exact thresholds.

What is at stake?

A doubling of the concentration of atmospheric carbon dioxide, which could occur in as little as 50 years, could cause major changes in the marine environment, specifically impacting calcium carbonate organisms, such as corals or calcifying plankton. This could in turn have knock-on effects cascading through the food chain, causing damage to very valuable marine ecosystems. Organisms that could be seriously affected include:

Reef-building corals - Calcification rates of tropical corals and coralline algae may decrease by 30% over the next 30-50 years. The growth of reefs as geological structures will be affected by both reduced accretion and increased erosion. Reduced skeletal growth may be manifested as slower growth rates, or weaker coral skeletons that are more susceptible to storm damage. Coral reefs are hugely important sources of food and revenue for hundreds of millions of people, and also support multi-billion tourism and fisheries industries.

Cold water corals – Up to 70% of deep-sea corals are predicted to be undersaturated by 2100. This means their growth rate and structural strength would be severely impacted. Cold water corals provide crucial habitats for many important fish species.

Calcareous benthic invertebrates (including lobsters, mussels and scallops) – There are measurable impacts on growth rates and survival rates of echinoderms and gastropods at 560ppm atmospheric CO_2, which is the projected levels for 2050. Impacts include slower growth rates and lower final weights. This would imply losses of commercially important species such as lobsters, mussels and scallops.

Planktonic calcifiers (such as coccolithophores, foramnifera, euthecosomatous and pteropods) – Experiments have shown that 5 out of 6 species show 6-60% decreases in calcification with decreases in pH. Planktonic calcifiers play a major role in the Earth's Carbon cycle by absorbing CO_2 from the atmosphere and retaining it in the oceans as well as providing food for commercially important fish and cetaceans. Effects on plankton communities could have serious knock-on effects cascading through the entire marine food chain.

Seagrass - Seagrasses use CO_2 for photosynthesis rather than bicarbonate like most marine macroalgae, so certain species could benefit leading to ecological regime shifts. Changes may occur in the competition between seagrass species and between seagrasses and macro-algae

Ocean acidification is thus a major threat to the marine environment, which could have major impacts on marine ecosystems, commercial fisheries and even the climate through changes in plankton communities. The long time-lags inherent in the marine carbon cycle put a penalty on delaying limits on carbon dioxide emissions, and a premium on early action if the worst damages associated with ocean acidification are to be avoided.To combat the worst effects of ocean acidification, a two-pronged mitigation and adaptation approach is needed to buy time. This includes reducing greenhouse gas emissions at source, and improving management of marine resources to boost the resilience of marine ecosystems to allow them to recover from acidification impacts.

What is IUCN doing?

IUCN is involved in the European Project on Ocean Acidification (EPOCA), a collaboration between top European research groups aimed at filling gaps in our understanding of the effects and implications of ocean acidification. It aims to document changes in ocean chemistry and biogeography across space and time and to determine the sensitivity of marine organisms, communities and ecosystems to ocean acidification. Laboratory and field-based experiments will be used to quantify biological responses to ocean acidification, assess the potential for adaptation, and determine the consequences for biogeochemical cycling. They will assess uncertainties, risks and thresholds in the marine environment. IUCN plays an important role in the EPOCA Reference User Group, and will be critical in communicating results from this cutting edge research across the globe.

Moreover, the IUCN Climate Change and Coral Reefs Working Group (IUCN-CCCR) is involved in the Honolulu Declaration on Ocean Acidification and Reef Management, a declaration made by a group of global ocean experts in August 2008 at a workshop convened by The Nature Conservancy in Hawaii. Two major strategies are identified that must be implemented urgently and concurrently to mitigate the impacts of climate change and to safeguard the value of coral reef systems: 1) limit fossil fuel emissions; and 2) build the resilience of tropical marine ecosystems and communities to maximize their ability to resist and recover from climate change impacts. IUCN-CCCR members were instrumental in writing the declaration, and IUCN-CCCR is publishing a guide for coral reef practitioners to manage reefs for resilience to ocean acidification.

More information

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