Ocean acidification: a threat to life

Wiebina Heesterman examines the other threat from carbon dioxide emissions: that of ocean acidification.

Healthy oceans are essential to our existence – and not only humans suffer from the deteriorating state of the world's oceans; biodiversity is also critically at risk. Seafood, both caught in the wild and farmed, forms the main source of protein of some three billion people,[1] while it is a staple for nearly one billion, mainly in the developing world.[2] Seas and oceans play an important role in sequestering carbon dioxide: over 30% is taken up by our oceans, which are still continuing to absorb about a million tonnes per hour.[3] As expressed on the UN 'Oceans Day 2015' website:
"Oceans and climate are intertwined, with oceans driving climate and climate change affecting ocean health and coastal and island peoples. Oceans cycle over 93% of carbon dioxide in the atmosphere, produce 50% of the oxygen we breathe, store 50% of all naturally sequestered carbon, and absorb 90% of the heat added to the global system in the past 200 years."[4]

The menace of climate change due to increasing CO_2 emissions from human activities is, of course, well known. However, the constant exchange of this gas between the atmosphere and oceans leads to a second global problem: that of ocean acidification. In this article, I will examine this threat by focusing on three broad habitats where the impacts are very different: the open oceans and coral reef seas; ice-covered polar seas; and volcanic deep-sea vents.

The open ocean and coral reef seas

Some of the carbon that goes into the top ocean layers is taken up by phytoplankton, the tiniest algae that drift close to the surface. There sufficient sunlight penetrates to allow plants to make sugars from CO_2 by photosynthesis – and also provide the world with some more breathable oxygen. These tiny plantlets get consumed by all kinds of sea creatures, above all the multi-trillions of roaming zooplankton who migrate up from the seafloor to feed at night, returning to their bottom dwelling place by day. At their death, the tiny bodies gradually sink to the seafloor with the CO_2 safely deposited in the form of organic carbon which can be recycled into nutrients by bacteria, to be consumed again by other creatures. But the bulk of this massive ocean life – estimated to amount to some 90% of all marine biomass – is eaten during their migration by larger marine life such as sea butterflies, krill, shrimps, jellyfish and blue whales. The smaller of these are, in turn, eaten by other sea creatures, such as fish, and at the top of the chain there are sharks, sea otters, seals, sea birds, and not to forget humans.

Unfortunately, much of the CO_2 absorbed by the oceans does not go down with the zooplankton; instead it dissolves and combines with seawater. This may rise back up into the much warmer atmosphere in places of major upwelling, as for instance at the Chilean coast, where the nutrient-rich Antarctic water[5] from the Humboldt Current emerges. The remaining unsequestered CO_2 has the unfortunate effect of changing ocean chemistry for the worse. Whereas ocean water is slightly more alkaline than tap-water, the dissolved CO_2 combines with seawater to form carbonic acid – no more than a fairly weak acid, but still sufficiently so to affect shell-forming organisms. These include life-forms at the bottom of the food chain as well as many higher up such as sea butterflies, shellfish and corals. Coral reefs suffer a 'double whammy' from climate change: warmer water leads to coral bleaching,[6] in effect robbing the coralline seaweeds that serve as glue to keep corals together of their brilliant colours, while the loss of alkalinity attacks the fabric of the reefs. As these support a scarcely imaginable variety of life – their demise would be a catastrophe for organisms dependent on marine food webs.

Ice-covered polar seas

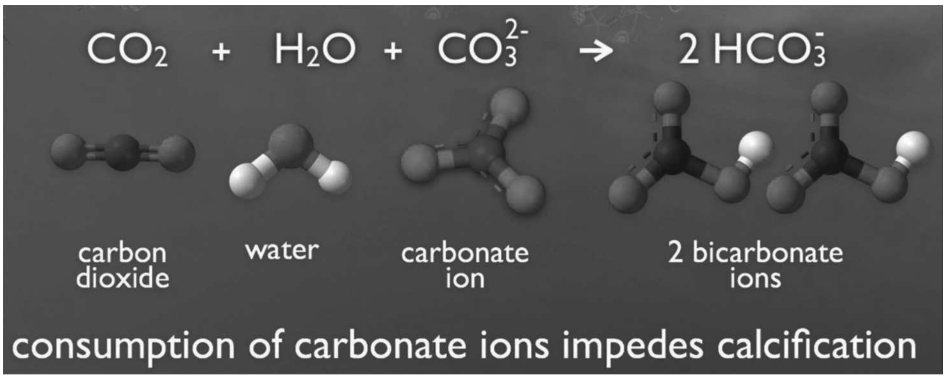
In polar habitats, such as under the shelf ice of the Antarctic Peninsula, diatoms (a type of phytoplankton) grow suspended from the drifting ice,[7] which still lets a small quantity of sunlight through. Otherwise the food chain is roughly similar to the one described above, but with very different marine life. Unfortunately, weakening of the alkaline character of seawater is strongest at high latitudes,[8] while warming there too is climbing much faster than elsewhere. In consequence, Arctic sea life is likely also to be attacked by predators migrating poleward, such as king crabs, already observed climbing the Antarctic slopes and devouring much of the bottom level of the food chain.[9]

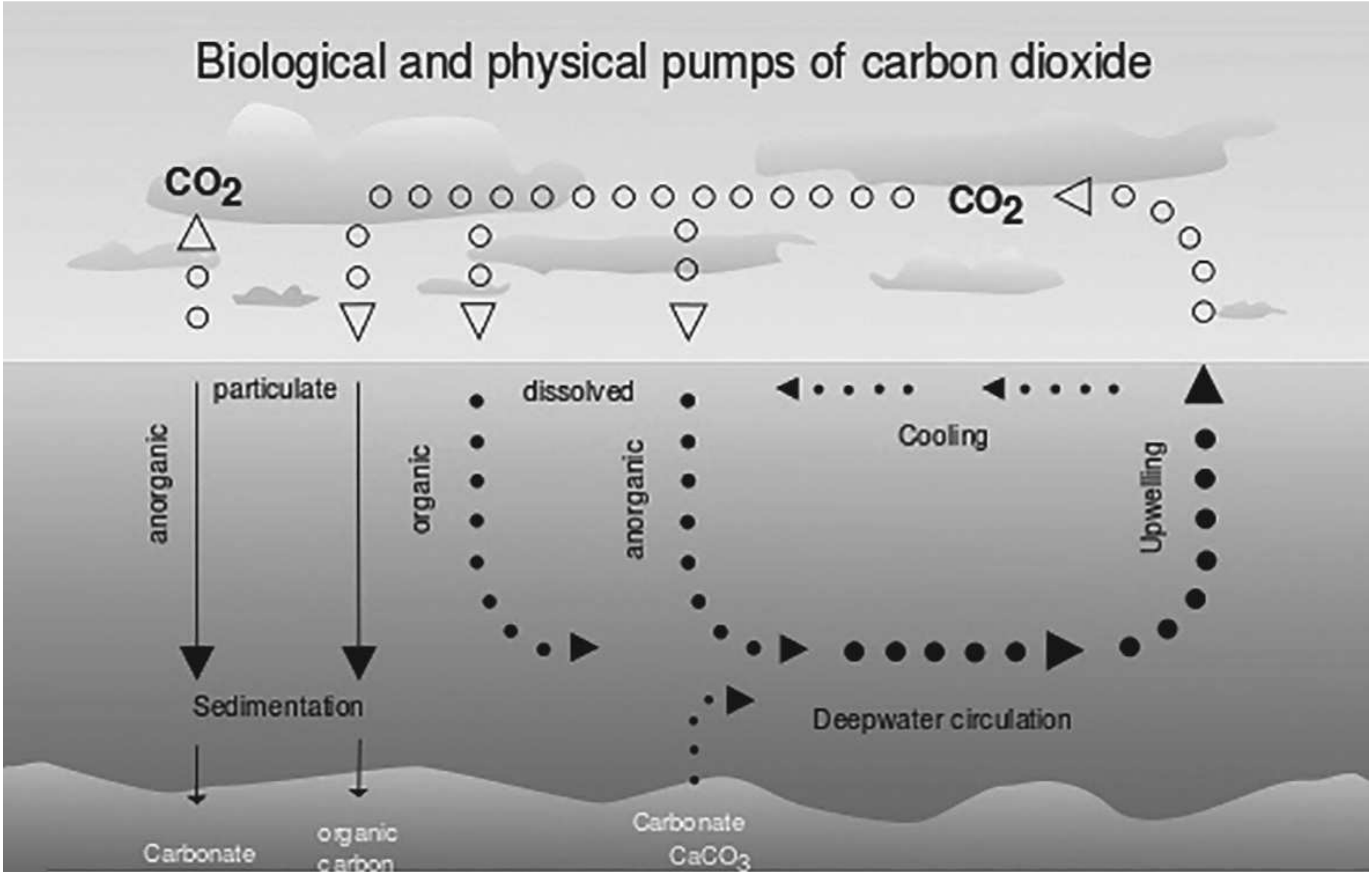
Volcanic deep-sea vents

Volcanic deep-sea vents tend to be highly acidic and may be as hot as 400°C. They are characterised by the absence of calcifying shellfish. Studies at a much shallower volcanic vent near Castello Aragonese, west of Naples, which is continually subjected to CO_2 bubbling up from the depths, give a good idea of the effects of low alkalinity on ocean life.[10] While there may be diatoms, phytoplankton sporting a silica shell in surface waters close to shallow vents, the sea water is too acidic to permit the forming of aragonite or calcium carbonate shells or of corals. In fact, subjecting tiny shellfish such as sea butterflies to seawater of pH 7.8 (still more alkaline than tap-water) can lead to buckling and deformation of their hair thin shells.[11] Low alkalinity even affects non-calcifying organisms, such as the semen of lugworms, common near British coasts, when in combination with copper pollution.[12]

The magnitude of the threat

If CO_2 emissions continue to follow a 'business-as-usual' scenario, marine scientists expect the alkalinity of the oceans to decrease to pH 7.8, the figure of the sea butterfly test above, by the end of the century, i.e. less alkaline by 150% (the pH scale is logarithmic). The fact that the sea water is warming is not good news for other oceanic creatures either. Many people will have read about coral bleaching. This refers to the dying of a range of algae, which live in symbiosis with corals; even a slight warming is fatal for many species. As to the effect of a high CO_2 environment on reefs, this is how the Intergovernmental Panel on Climate Change puts it: "Ocean acidification poses substantial risks to marine ecosystems, especially polar ecosystems and coral reefs, associated with impacts on the physiology, behavior, and population





Air-sea exchange of CO_2, (Creative Commons CC-BY-SA-2.5, original Hannes Grobe, August 2006 (UTC), Alfred Wegener Institute for Polar and Marine Research)

dynamics of individual species from phytoplankton to animals. Calcified molluscs, echinoderms, and reef-building corals are more sensitive than crustaceans (high confidence) and fishes (low confidence), with potentially detrimental consequences for fisheries and livelihoods."[13]

Protecting the 'whale pump'

Can something be done to mitigate the consequences of ocean acidification? There have been attempts to sow the ocean with iron filings or crushed olivine to boost diatom growth. Before resorting to unproven techno-fixes, we should protect what Roman and McCarthy call 'the whale pump'. Whales and other cetaceans feed near the seafloor, bringing nutrient-rich matter back to the surface in their excrement, which tends to remain in suspension near the surface in the form of a faecal plume.[14]

These nutrients are consumed by phytoplankton, allowing them to thrive. In addition, the huge whale skeletons, sunk to the ocean floor, store impressive amounts of carbon and nutrients, while providing shelter. Although the decline of baleen and sperm whales is well over 66%, Roman and McCarthy think recovery is still possible and would be of huge benefit for the oceanic ecosystem: "Dozens, possibly hundreds, of species depend on these whale falls in the deep sea," The more whales are valued and protected, the greater the gain for biodiversity. Roman and colleagues even speak of whales as "marine ecosystem engineers" in their latest paper.[15] If we want to preserve ocean health, the world needs more whale sanctuaries in addition to the two existing ones[16] as well as a permanent ban on commercial whaling and a firm commitment to limit greenhouse gas emissions.

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