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# Ocean Acidification

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## Issue

The term ocean acidification refers to the decrease in pH of seawater that results from the increased dissolution of atmospheric carbon dioxide ($CO_2$), which forms carbonic acid in the world's oceans. The oceans are taking up about one third of anthropogenic $CO_2$, tempering the global climate response to the greenhouse gas. But this oceanic uptake of $CO_2$ is not benign, as it affects ocean chemistry. Anthropogenic acidification of the sea is now a serious global issue, with potential negative impacts that are underappreciated by the public at large.

## Background

The chemical parameter "pH" is a measure of acid content; more acidic conditions have lower pH, and more alkaline, a higher pH. The pH of the sea has been relatively constant for thousands of years, giving plants and animals plenty of time to adapt to its chemistry. But since the onset of industrialization, the pH at the sea surface has fallen from an average 8.21 to 8.1, and a further decrease by up to 0.4 pH units is expected at the end of this century in the "business as usual" scenario for $CO_2$ emissions.[i] The pH scale is a logarithmic measure of acidity, so a decrease by 0.5 points translates into roughly a 3-fold increase in acidity. In other words: the ocean is becoming more corrosive.

To the best of our knowledge, this rate of change in ocean pH is unprecedented in the history of our planet. It is first felt in the surface layer of the ocean, which is in direct contact with the atmosphere. This is also the part of the ocean where the bulk of oceanic production occurs. The organisms living in the surface ocean form the basis of the marine food chain and are vital to marine ecosystems – including those sustaining our most valued fisheries.

**Impacts**

Ocean acidification poses two main challenges for marine organisms: dissolution of calcium carbonate shells and skeletons, and changes in nutrient availability.[ii] As seawater becomes more acidic, there will be an increasing tendency for calcium carbonate to dissolve. This poses a problem for organisms such as mussels, oysters and clams that form protective shells made from calcium carbonate. Studies have shown that these animals tend to build thinner shells when grown at lower pH, which may render them more vulnerable to predators. As well, their reproductive success seems to be negatively affected by ocean acidification.

Calcifying corals are another group that struggles with ocean acidification. They build protective skeletons from calcium carbonate, but studies have shown that their skeletons are very sensitive to seawater pH. In one case, the skeletons of two coral species disappeared altogether when grown at a pH of 7.4 (as compared to pH = 8.2), then grew back when the corals were returned to seawater with a pH of 8.2.[iii] The corals themselves stayed alive throughout this experiment, but they were much more exposed without their carbonate skeletons.

There are also planktonic organisms that build calcium carbonate shells. These include small animals such as swimming sea snails, which are about the size of a pea, and plants such as coccolithophores, which are even smaller. The sea snails are an important food source for young salmon in the North Pacific. Very few studies have been carried out to test their response to a decrease in ocean pH, but the data that exist show that their shells erode in an acidified environment.

Aside from the dissolution of calcium carbonate, ocean acidification may alter the availability of nutrients to plankton. Bacteria and tiny plants, called phytoplankton, would be especially affected by such changes, as they rely on nutrients in the seawater for their growth. These organisms form the basis of the marine food chain, so any change in their abundance will have a ripple effect through the entire food web.

**Impacts in British Columbia**

Ocean acidification is poised to threaten important BC industries such as shellfish aquaculture and the wild salmon fishery. The cold waters of the North Pacific readily take up

$CO_2$ from the atmosphere, and wind-driven upwelling of corrosive waters along the coast further lowers the pH.[iv]

Shellfish reproduction and shell formation is sensitive to the acidity of the water, so adverse effects can be expected as the ocean continues to absorb $CO_2$. On the West coast of the United States, upwelling of corrosive waters may have contributed to the crisis of the oyster industry, which began in 2005. While the detailed cause and effect in this case is still being investigated, it's worth noting that the BC shellfish aquaculture is valued at around 30 million dollars per year.[v]

The wild salmon fishery of British Columbia brings in between 130 and 220 million dollars annually.[v] Juvenile salmon, as well as countless other species including cod, herring and mackerel, rely heavily on sea snails for their diet. If the snail population decreases by just 10 percent due to ocean acidification, this could translate into a 20 percent drop in body weight of the average adult salmon.

**Conclusions**

- Ocean acidification is a direct consequence of increased $CO_2$ concentrations in the atmosphere.
- Ocean acidification threatens marine species, communities and food webs. It is unclear if and how species will adapt to the change.
- The unprecedented rate of decrease in ocean pH makes it more difficult for organisms to adapt to the change. It increases the likelihood of species extinctions.
- In British Columbia, the livelihoods of thousands of people depend on the harvesting and processing of marine organisms. These livelihoods may be threatened by ocean acidification.
- Importantly, at the global scale, geo-engineering solutions aimed at slowing global warming without reduction of atmospheric $CO_2$ will not reduce ocean acidification.

**References**

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