

Ocean Acidification: Frequently Asked Questions about OA

What is ocean acidification? Isn't all this climate change stuff a matter of opinion, anyway?

Ocean acidification is a verifiable, worldwide decrease in ocean pH occurring now that has nothing to do with climate change. Human activities are causing atmospheric CO₂ levels to rise much more quickly than ever before. As the ocean, which is normally slightly basic, takes up carbon dioxide (CO₂) from the atmosphere, its pH decreases and becomes more acidic. Ocean acidification especially harms ocean organisms that depend on mineral shells and skeletons, like corals, crustaceans (lobsters, crabs), shellfish (oysters, clams), and tiny organisms at the base of the food chain such as coccolithophores and foraminifera.

Can't we fix ocean acidification by giving the ocean an antacid?

It's not practical on a large scale. Reversing or stopping OA in the whole ocean would require mining, transporting, and mixing enormous amounts of "antacids," or alkaline minerals, into the deep ocean. Such an ambitious project would require a great deal of energy and would destroy a great deal of land. Furthermore, correcting the acid-base balance of the ocean with minerals would skew natural ocean mineral chemistry. Re-balancing ocean minerals to natural levels would not completely cancel ocean acidification. Either "fix" would still change the marine environment from its natural, preindustrial state.

What can we do about ocean acidification?

The only sure way to limit or stop OA is to limit or stop fossil fuel carbon dioxide releases into the atmosphere, but this is politically, socially, economically, and technically difficult. Many solutions that overcome these hurdles (for example, pumping atmospheric CO₂ deep underground) are being researched. In the meantime, ocean species will naturally begin adjusting to OA by changing their habitats or behavior. However, OA is accelerating more quickly than many less flexible organisms can cope with the changes, so many organisms are at risk. In addition to limiting atmospheric CO₂ releases, we can also reduce stresses on the marine environment using strategies such as fishing limits and marine protected areas.

Why are scientists making such a big deal over such a tiny change?

In the past, the ocean's size and its strong pH buffering resisted wholesale chemistry changes so that most organisms did not experience shifts in their local environments. Chemical factors like pH directly control the tiniest organisms' cellular processes and the largest organisms' respiration and excretion. Since preindustrial times, ocean acidification has decreased ocean pH by 0.1 unit and is expected to decrease pH by 0.1 to 0.4 pH units more in the near future. Because pH is measured on a logarithmic scale, this means that the oceanic concentration of hydrogen ([H⁺]) ions has increased 30% since preindustrial times, and it will increase by as much as 70% if OA continues unchecked. This large shift in ocean chemistry will affect many organisms' feeding and reproductive habits, thus changing the food chain. For example, OA will likely decrease the calcification of coral reefs but increase their algae populations, which will harm many shelter-seeking juvenile fish yet benefit a few reef-grazing species, like parrotfish.

I don't live near any coral reefs, so why should I care about ocean acidification?

Ocean acidification will affect only warm-water coral reefs, but also cold-water coral reefs deep in the ocean, shellfish, and microscopic organisms at the bottom of the food chain. Without the homes and nourishment that coral reefs provide for countless species, these organisms may dwindle or disappear. Removing small calcifying organisms from the food chain will leave less food for their predators all the way up the food chain to whales, seals, and humans. Some nations depend entirely on fish for protein, and the [World Health Organization](#) estimates that 20% of the world's population gets one-fifth of its animal protein from fish. OA could therefore cause worldwide food shortages. Furthermore, losing reef biodiversity may hinder drug discovery studies, and losses will definitely harm tourism and supporting industries in coastal areas. Economic and lifestyle impacts from OA will be felt worldwide, even by people living far from the coasts.

Why haven't I heard about ocean acidification before?

Scientists have understood the basic chemistry behind ocean acidification for many decades, but recent ocean datasets and computer models have shown exactly how and where the ocean is taking up fossil fuel CO₂ from the atmosphere. Long-term ocean datasets like the ones from Hawaii and Bermuda show detectable pH changes occurring over at least a decade. Recent studies have shown that organisms and food webs are more vulnerable to pH changes than previously thought. Meanwhile, CO₂ emissions continue to rise. Because the only solution to OA is to cut atmospheric CO₂ emissions (see above), which is economically, socially, and technologically difficult, we must minimize stress on the ocean regions most vulnerable and sensitive to OA.

Which organisms or areas are most vulnerable?

Organisms that make one particular type of carbonate called aragonite are most susceptible. These include corals, crustaceans (like lobsters and crabs), mollusks (like oysters, clams, scallops, and snails), and macroalgae. Already, only a small fraction of the world's ocean preserves aragonite, and it continues to shrink. At current CO₂ emission rates, polar and subpolar areas will become "hostile" to aragonite by the end of this century (Kleypas et al., 2005). Live aragonite-forming organisms placed in simulated hostile conditions begin to dissolve after just a short period (Orr et al., 2005). As a result, OA is expected to cause large behavior and geographic-distribution shifts in carbonate-forming organisms, starting with those that make aragonite shells.

Is there a "safe" level of atmospheric CO₂ for the ocean?

Before human activities began increasing atmospheric CO₂, the preindustrial atmosphere contained 280 uatm CO₂, and average ocean pH was 8.18. These values were the result of a 100 million-year change from pH 7.5 and 2500 uatm atmospheric CO₂ (Ridgwell and Zeebe, 2005). In the preindustrial world, the geological carbon cycle drove fluctuations in atmospheric CO₂ and ocean pH over thousands or millions of years. Gradually increasing atmospheric CO₂ levels were accompanied by changes in slow processes like rock weathering, mineral deposition, and organic matter burial that modulated ocean carbon chemistry and pH. The present-day 100-

uatm increase in atmospheric CO2 and 0.1 unit decrease in ocean pH have occurred over just two centuries, which is much faster than geological processes can keep up with. The level of atmospheric CO2 is not triggering the ocean acidification problem; rather, the rate of atmospheric CO2 change is.

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