Jeremy Bishop, Pexels

Ocean acidification

Carla Edworthy tells us about the threat to the world's marine environment, and research advances in South Africa

It is now widely accepted that ever-increasing emissions of carbon dioxide (CO_2) from fossil-fuel burning and other human activities are causing global climate change. Some of the better-known consequences for our oceans are increasing temperatures, sea level rise and more frequent or intense storm events. But by continuously releasing CO_2 into the atmosphere, humans are significantly altering the chemistry of the oceans too. Although it is not as widely known, ocean acidification is considered the 'evil twin' of global climate change.

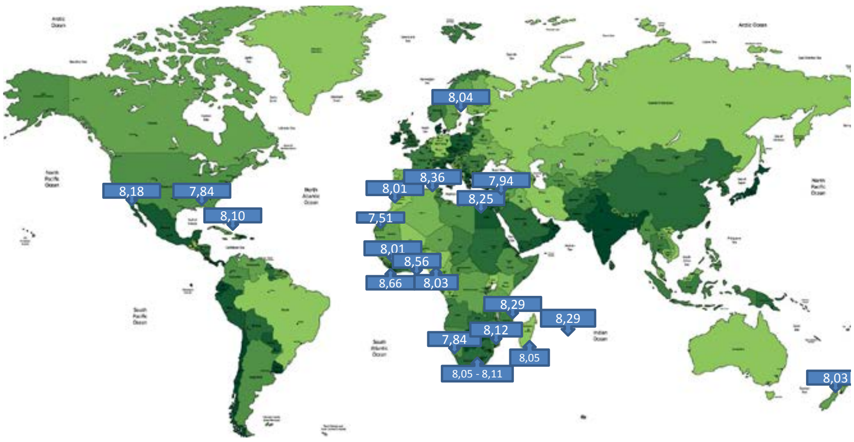
The oceans act as a giant sink for carbon because CO_2 dissolves rapidly in seawater, initiating a succession of chemical reactions. The ultimate result of these reactions is a decline in the pH of seawater. Although the global average pH is currently about 8.1, this is slowly decreasing as CO_2 continues to be absorbed by the oceans from the atmosphere. By the end of the century, the global average pH is predicted to fall to approximately 7.7 if global CO_2 emissions continue unabated, which is considered a worst-case scenario. Since pH is measured on a log scale, a drop in pH of one unit actually represents a tenfold decrease in acidity. This means that even a small change in pH significantly changes the acidity of seawater.

Changes in pH, and the resulting changes in seawater chemistry, throw everything out of balance for marine organisms by altering their external and internal acidity levels. Marine organisms are adapted to live within a range of specific environmental conditions. Different species survive and thrive within different optimal ranges of temperature, oxygen concentration, depth, light, pressure and pH. Any change in environmental conditions may affect their energy metabolism, growth, behaviour and reproduction – and ultimately threaten their survival.

In the case of pH, research has shown that even a small reduction can be detrimental to organisms that use calcium carbonate to build their shells or skeletons, such as sea urchins and corals. Furthermore, organisms not adapted to regulating internal pH levels need to allocate more energy to maintaining their internal pH, which can come at a cost to their growth and other survival processes. Many marine organisms also use chemical signals that may be disrupted at low pH levels, either by affecting the signal molecules themselves or by affecting the organisms' chemosensory receptors that allow them to detect the signals. Experimental studies have shown that reducing the pH of seawater changes the behaviour of some fish and crabs, for instance, by affecting their ability to smell or hear, which would compromise

Carla Edworthy

This device, which measures seawater pH and temperature every half hour, is deployed in shallow water in Algoa Bay (Port Elizabeth / Gqeberha) for a few days at a time to monitor ocean acidification.



OA-Africa Network

This map summarises the pH data collected by scientists and citizens in Africa and supporting countries on OA-day in 2017, organised by the OA-Africa Network.

routine survival activities like finding food, avoiding predators or selecting a mate.

Despite the negative impacts of acidification, organisms that are tolerant of low pH conditions do exist. For example, in some coastal environments where pH is typically lower than the rest of the ocean, species are adapted to tolerate large pH fluctuations and relatively low pH levels. These organisms have the energetic capacity to withstand changing pH levels in the environment by using mechanisms to regulate their internal pH. However, there is still uncertainty around long-term changes in pH that will occur with ocean acidification in these environments, and whether organisms will be able to tolerate persistently lower pH levels predicted for the future.

Although relatively little data on ocean acidification has been collected in Africa to date, research in the region is steadily gaining momentum. A network called OA-Africa has been established with the assistance of international advisors to coordinate and promote ocean acidification research in Africa, and this forms part of the broader Global Ocean Acidification Observing Network (GOA-ON).

In South Africa, researchers from the west, south and east coasts are collaborating to monitor local ocean acidification in coastal and oceanic environments, by measuring pH and other environmental parameters on a regular basis. They also use both field and laboratory experiments to identify the impacts of future ocean acidification conditions on key seafood species, as well as species that are integral to maintaining functional ecosystems such as coral reefs.

Researchers from South Africa have participated in several training events and capacity development programmes hosted by international organisations, such as GOA-ON and regional networks, and are contributing data on ocean acidification and its impacts to international databases. Target 14.3 of the Sustainable Development Goals adopted by the United Nations member states is to “minimise and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels” and its indicator requires that pH is measured at an agreed suite of representative sampling stations. Various online data platforms have therefore been set up internationally to facilitate the submission, collection, storage and sharing of data on ocean acidification and biological responses.

In June 2017 researchers in South Africa, in collaboration with international organisations, participated in an event called ‘OA-day’, aimed at increasing awareness of ocean acidification in science communities and society. Several activities were organised, including a coordinated effort from both scientists and citizens across the country to measure pH at multiple locations along the coastline. Videos, social media posts, popular articles and interviews on national radio and television were shared in order to spread the word about ocean acidification. The event was hosted concurrently in a number of other African countries and was considered a huge success. Similar events are planned for the future to continue the momentum of creating awareness of ocean acidification within society.

Much research still needs to be done, in South Africa and internationally, in order to understand the rate at which acidification occurs in the various marine environments and how it will affect marine ecosystems in future. The only real solution to ocean acidification is to reduce CO_2 emissions on a global scale. Increased awareness of ocean acidification and other climate change issues is imperative to encourage both personal and governmental action in reducing emissions. Such action is vital to mitigate the impacts on marine ecosystems as well as coastal communities, who look to the oceans as a source of food, economic benefit, cultural identity and recreation.

Richard Llewellyn

Carla Edworthy (in red jacket, standing) with other scientists participating in OA-day in 2017 by measuring the pH of seawater at a coastal site in Algoa Bay.

Dr Carla Edworthy submitted her doctoral thesis on ‘Coastal pH variability and the eco-physiological and behavioural response of a coastal fish species in light of future ocean acidification’ at the end of 2020, and was awarded her PhD by Rhodes University in April 2021. She is currently a postdoctoral researcher at the South African Institute for Aquatic Biodiversity (SAIAB), monitoring ocean acidification and its impacts in coastal environments and vegetated habitats.