Interreg Mediterranean
MPA-ADAPT
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CLIMATE CHANGE IN THE MEDITERRANEAN SNAPSHOT:

Impact of acidification on MPAs

This factsheet presents the most recent data about acidification, to show what is happening and is likely to happen, and how it can affect Mediterranean MPAs and its ecosystems. It belongs to a series of climate change factsheets specifically developed to keep Mediterranean MPA managers informed.

WHAT ARE THE CAUSES?

When the additional carbon dioxide (CO_2) released into the atmosphere from human activities such as fossil fuel burning, deforestation, and cement production dissolves in sea water, several chemical changes occur which are collectively known as **ocean acidification.**

The CO_2 dissolves in sea water to form carbonic acid, shifting the ocean chemistry towards more acidic conditions. These chemical changes are altering the system's ability to adjust to further changes in CO_2 that naturally occur over the millennia, significantly changing the chemistry of the seas, and leading to progressive acidification.

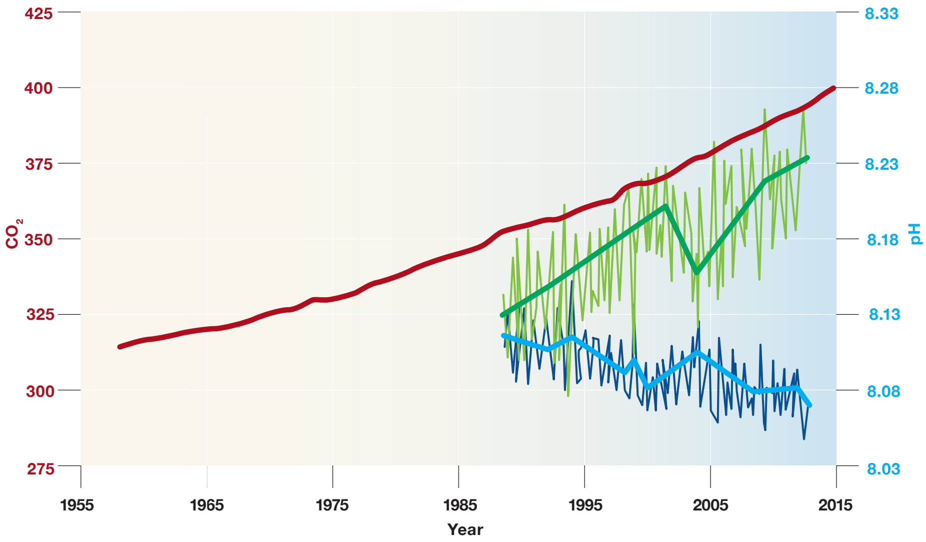
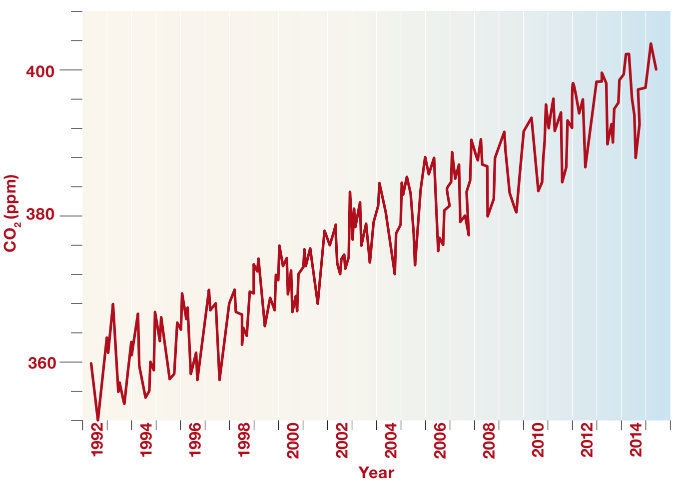


Figure 1: Observing trend how increasing atmospheric CO_2 concentrations is dissolving more CO_2 in the upper ocean, whilst pH of surface seawater is falling.

WHAT ARE THE CURRENT OBSERVATIONS AND PROJECTIONS BOTH GLOBALLY AND FOR THE MEDITERRANEAN?



The oceans are **naturally alkaline,** usually with a pH of around **8.2.** Since the beginning of the Industrial Revolution, the pH of surface ocean waters has fallen by 0.1 pH units due to the increased absorption of some of the additional CO_2 in the atmosphere. This change, even if doesn't seem to be significant, actually represents approximately a 30 % increase in acidity (bringing it to a **pH of 8.1**) unnaturally forcing the acid/base balance of sea water towards more acidic conditions.

Future projections, if CO_2 emissions continue unabated (Business as Usual), show that by 2060, seawater acidity could have increased by 120%.

Figure 2: Monthly mean time series of atmospheric CO_2 concentrations as measured at the Station for Climate Observations on the island of Lampedusa, in central Mediterranean.

Acidification in the Mediterranean Sea

Acidification is affecting all oceans and seas but will not be uniform worldwide. In the Mediterranean Sea, acidification estimates in situ are few, but certain characteristics of this semi-enclosed sea **makes it especially sensitive to increasing atmospheric CO_2 and it seems to be among the world regions that are being most rapidly impacted by acidification.** The result is that the anthropogenic CO_2 concentration for the Mediterranean Sea is higher than in the Atlantic Ocean and the Pacific Ocean at the same latitude, and higher than other marginal seas in the northern hemisphere.

The few, available data sets in-situ from the Mediterranean Sea indicate that over the past two decades, acidity has already increased more than 10%, equivalent to a pH decreased in seawater of~0.04 (0.0022-0.0025 pH units/year). Subregional seas like North Adriatic surrounded by highly industrial activities, has recorded a higher acidification process (of 0.0025 pH units/year).

The current rate of change of acidification in all oceans is over 10 times faster than anything previously experienced in the last 55 million years.

Acidification affects carbonate formation

Acidification reduces the amount of carbonate, a key building block in seawater. Calcium carbonate formation in the sea is controlled by the amount of available carbonate ions, also known as the carbonate saturation state. As seawater pH decreases (towards more acidic conditions), the carbonate saturation state is lowered. This means there is progressively less carbonate available in the seawater as the building block necessary for calcium carbonate ($CaCO_3$) skeleton and shell formation in marine organisms such as corals, shellfish and marine plankton. Moreover, as pH decreases in the surface area of the sea, the saturation depth moves upward, towards surface waters, shrinking the habitat available to the organisms that use calcium carbonate to build their shells and skeletons.

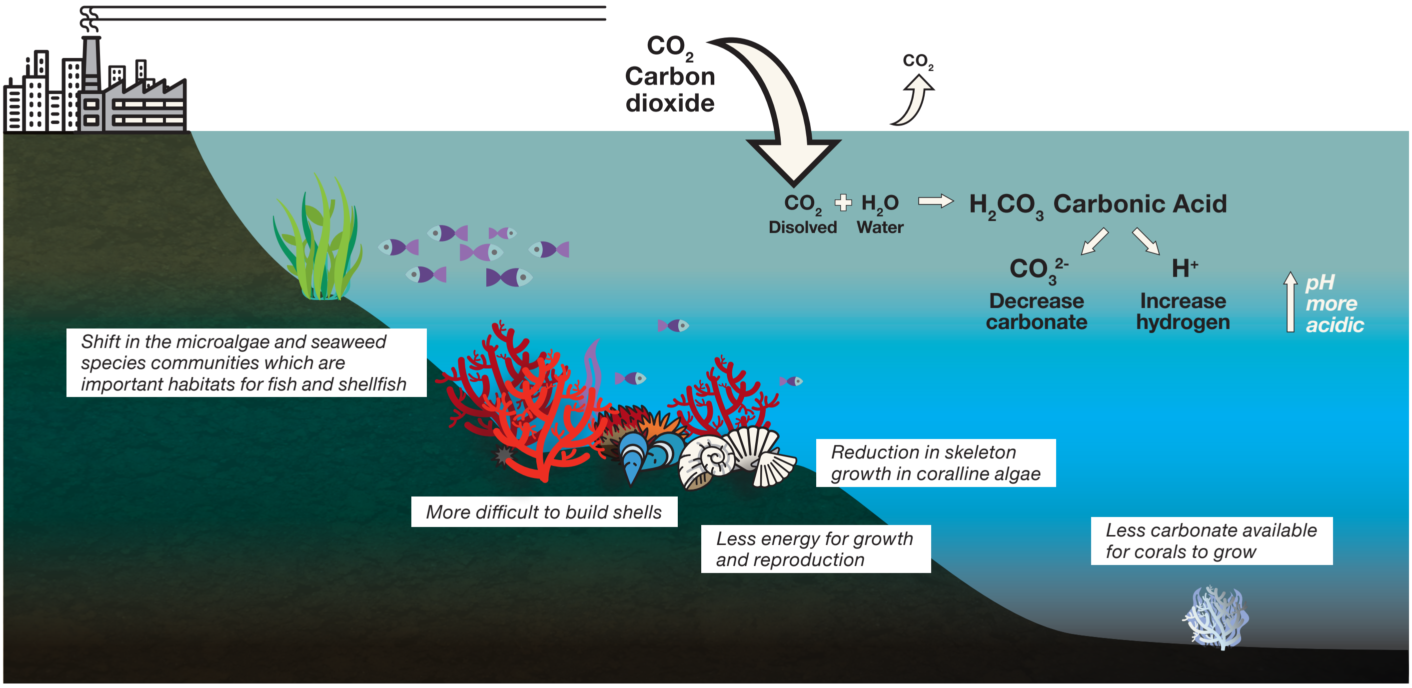
Predicted changes

Future predictions indicate that our oceans and seas will continue to absorb carbon dioxide, further increasing its acidity. The increased CO_2 in the atmosphere is however projected by some in the long term to produce a reduction of the capability of this natural sink to absorb CO_2, with a subsequent faster growth of atmospheric CO_2.

Estimates of future carbon dioxide levels, based on business as usual emission scenarios, indicate that **by the end of this century the surface waters of the ocean could have acidity levels in the region of 120% and maybe even 150 % higher** compared to pre-industrial times. This suggests that under **current projections the seawater pH may reach close to pH 7.7 by the end of this century,** a decline of some 0.5 pH units.

Within the Mediterranean, acidity will be faster in some regions than others. Acidification of the Mediterranean Sea is likely to increase for the next fifty years by 60%, and by 150% at the end of the century, with estimations of pH decrease of 0.07–0.13 units corresponding to a rate of 0.002 ±0.001 pH units per year.

Increase atmospheric CO_2 limits growth in the oceans



HOW IS OCEAN ACIDIFICATION INFLUENCING MPA COASTAL HABITATS AND SPECIES?

Ocean acidification is one of the key processes which is expected to produce a large impact on the marine ecosystems and their capability to absorb CO_2 in the close coming years. Moreover, coastal waters has been found to be exposed to greater variability in pH than the open ocean due to input of carbon and / or nutrients in run off from land.

From shallow to deep waters, experiments and observations show that acidification can have a severe impact on the performance and survival of many organisms with calcium carbonate structures, and consequently affect the composition and productivity of marine communities. There is limited evidence at present, however, about the specific impacts that will have on marine biodiversity overall. Experimental and in situ observations already demonstrated that ocean acidification has the potential to affect individuals' growth, structures, reproduction and activity rates. Some animals will tolerate higher acidity; but the overall community changes will be different at each locality. Shifts in species composition that happen at different pH values suggest that calcified species (e.g. corals, sea urchins, coralligenous algae) will not be able to compete for resources with other, uncalcified organisms (e.g. the brown algae Padina spp.) when coping with lower-pH environments.

Summary on today's knowledge of the impact on **Mediterranean** habitats and species

1. Acidification and warming of the waters have been showed affect some bivalve species (e.g. the mussel *Mytilus galloprovincialis*) and whilst the trend is not always clear as to why some species are more resilient than others, it is more likely to decrease the survival and growth of populations of different bivalve species in the coming decades.

2. Current knowledge (mostly from laboratory experiments) indicates that wild and farm fish species will be relatively resilient to the ongoing ocean acidification, though the larvae may be more sensitive.

3. The change of the carbonate saturation depth towards surface waters, will particularly affect cold, deep water species such as cold water corals affecting their structure, strength and resilience and making them highly vulnerable.

4. Field studies off Vulcano and Ischia (marine sites with natural vents whose conditions are analogues of future high pCO_2-low pH environments) showed that seagrasses *(Posidonia oceanica* and *Cymodocea nodosa)* and certain seaweeds are able to benefit from elevated CO_2 levels. It is most likely that a slight acidification can stimulate plant growth and biomass and may reduce epiphyte cover. Further, it is suggested that it may also enhance the capacity of seagrasses to act as carbon sinks, whilst reducing their other values, such as fish feeding and nursery areas. However, evidence from recent studies indicate that the interactive effects with seawater warming could restrict this capacity.

5. Calcifying coralline algae, important building blocks of Mediterranean rhodolith beds and coralligenous habitats, are thought to be among the organisms most vulnerable to ocean acidification. For example, recent experiments have found that high CO_2 and high temperature conditions decrease the growth rate in the Mediterranean coralline algae Lithophyllum cabiochae by up to 60% and increased necrosis (i.e. death of tissues). This may produce structural changes in the benthic communities at different Mediterranean sites.

6. Overall, current studies indicate that ocean acidification will cause major shifts in the number and abundance of microalgae and seaweed communities with a simplification of shallow community structure along gradients of decreasing pH. The potential loss of some of these flora is worrying as they form important habitats for fish, shellfish and a wide range of other organisms.

7. The acclimation and long term effects on Mediterranean biodiversity remain largely unknown.

VALUE OF MPAs:

How do they contribute to adapt to ocean acidification induced changes and mitigate the risks?

Our seas will be exposed to the effects of CO_2 and acidification process for a long time, even if anthropogenic emissions are largely reduced today.

Marine Protected Areas can help address the impacts of ocean acidification in multiple ways:

- Ensuring that large no-take zones are including as part of the MPA boundaries and these areas include vulnerable species and habitats to acidification so other anthropogenic stresses are reduced as far as practicable.
- Developing appropriate management measures to reduce carbon dioxide emissions, their carbon footprint and using more renewable energy.
- Monitoring their surrounding waters by deploying pH sensors and integrating scientific teams and institutions as part of monitoring programmes. It is important to have in situ measures of the pH changes, and understand better the causes and the impacts on marine life, as to identifying how to respond.
- Enhance the good conservation status of seagrass meadows to potentiate their carbon sink capacity.
- In some MPAs, reducing tourism pressure on vulnerable habitats by regulating dives may also be beneficial.
- Developing restoration efforts targeted to recover calcified species such as corals (e.g. with coral fragments, branches) and ensuring long term monitoring of the recovery of these populations.
- By acting as a focal point for climate-friendly actions including explaining the damaging impacts carbon dioxide emissions are having on our ocean and marine life, and by instigating visitors to reduce their personal carbon footprint.

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www.medsea-project.eu.

The ENEA Station for Climate Observations “R. Sarao” at Lampedusa Island adjacent to MPA of Isole Pelagie.

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