What is Ocean Acidification? 1

The greenhouse gas carbon dioxide (CO_2) not only causes climate change – it also makes our oceans and seas more acidic. This process is called ocean acidification (frequently abbreviated "OA"). The reason for ocean acidification is that about one quarter of the CO_2 that is emitted into the atmosphere because of human activity ends up in these water bodies. Part of the CO_2 reacts with water, and forms a compound called carbonic acid. Some of the carbonic acid dissociates into bicarbonate and hydrogen ions. This process leads to acidification (lower pH, i.e. higher concentration of hydrogen ions).

Ocean acidification is a harmful process, because plants, animals and other organisms in the oceans are adapted to the pH conditions that have prevailed in the seas prior to this human-driven acidification process. Because of this, many of them are unable to cope with more acidic conditions. Calcifying organisms (i.e. those that produce shells or skeletons from calcium carbonate) in particular are sensitive to acidification. Examples of calcifying organisms include mussels, sea urchins, and corals. Even shark skin contains structures made from calcium that can corrode in acidic conditions! As many physiological processes are sensitive to pH, other organisms that do not calcify can also be affected, as can the complex ecological interactions between organisms.

Ocean acidification is a threat in itself. In addition, ocean acidification and climate change happen at the same time and can interact to produce even more harmful effects than either process alone. Both of these processes call for strong mitigation measures. They also call for powerful measures to reduce other harmful human-induced changes, such as pollution, eutrophication (especially in enclosed seas and coastal areas), overfishing and habitat destruction. All these measures are needed to reduce the overall impact of harmful changes and help organisms to withstand them.

Acknowledgement. This work was part of the BALSAM project (Baltic Sea Acidification Mitigation), which was funded by the Swedish Institute. The project was a collaboration between AirClim (Sweden), Ecoaction (Ukraine), Friends of the Baltic (Russia), and the Polish Ecological Club Pomeranian Branch (Poland). This publication is module number 1/5 of the Ocean Acidification Action Guide. All modules can be found here: *https://airclim.org/ocean-acidification-working-group*.

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Ocean Acidification (OA) – the Need for Policy Action

2

OA is…

- a threat to ecosystems, economies and societies
- recognised in the United Nation's Sustainable Development goals (SDGs) – SDG 14 Life Below the Water
- highlighted in the work of the IPCC – such as the recent Special Report on the Ocean and the Cryosphere
- a theme within many research projects – for example at European level (AQUACOSM-plus, EPOCA, MEDSEA) and at national level (British UKOA, German BIOACID, Italian ACID.IT)

However, OA is…

- NOT included as a monitoring descriptor in the EU's Marine Strategy Framework Directive (MSFD) to achieve Good Environmental Status in EU waters
- NOT typically included in national Initial Assessment Reports of the MSFD in an adequate way
- NOT effectively governed in European national waters

We need measures on policies and governance that specifically target OA because...

- the consequences of OA are unique
- the geographical distribution of OA is not uniform, nor are effects on ecosystems
- measures to increase resilience of ecosystems require recognition of the threat of OA

We therefore need to influence processes, for instance within… the UN (e.g. the Oceans Conferences, the UNFCCC Conferences of the Parties)

- the EU (the MSFD and the Water Framework Directive (WFD), the European Green Deal, the European Climate Law, and the EU's positions on the UN processes)
- the Regional Conventions of the Seas (e.g. development of OA indicators)
- National governments (e.g. national measures to reach Good Environmental Status, national implementation of the EU's climate policies and Conventions of the Seas, and national positions on the UN processes)

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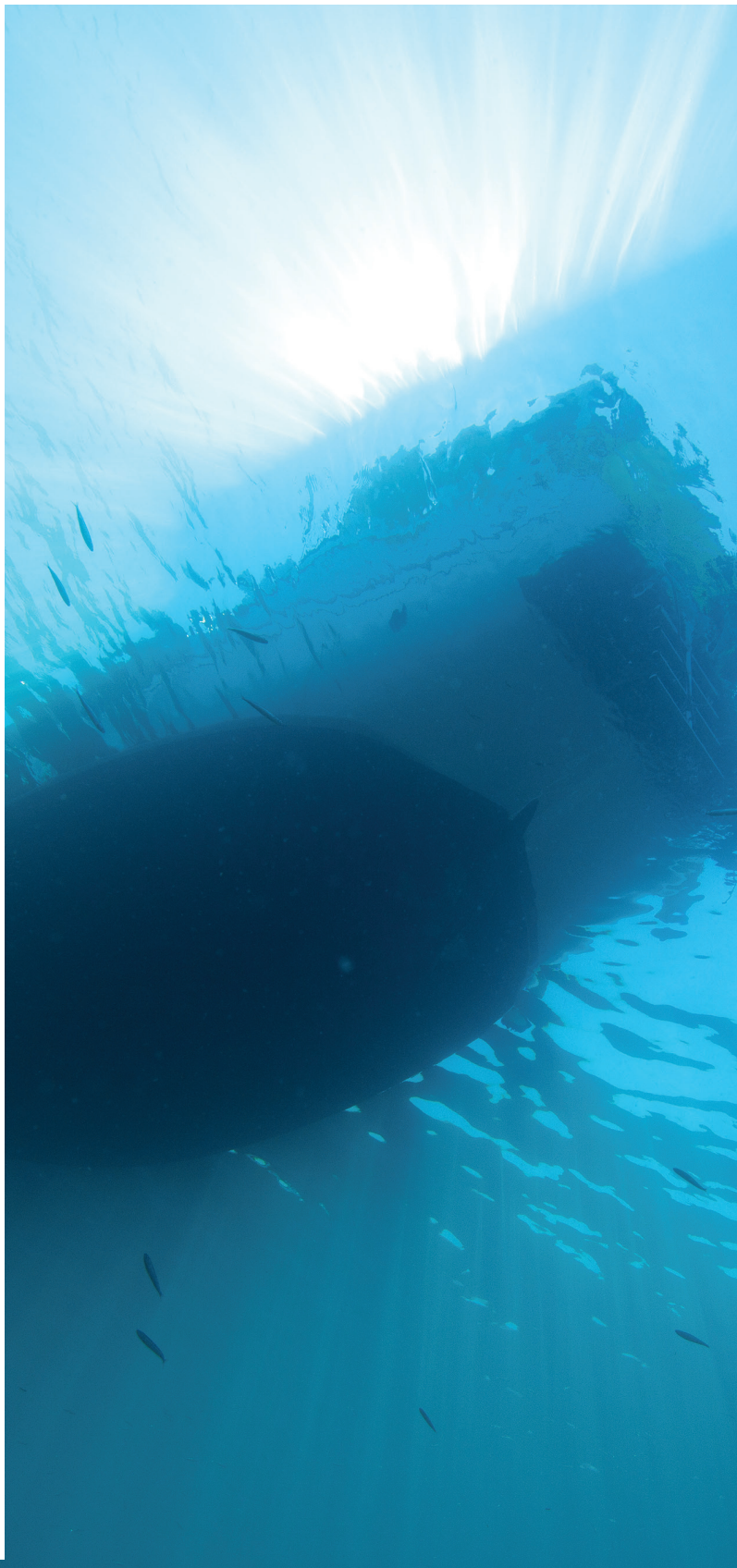

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Ocean acidification

3

"Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels"

Target 3 of the UN Sustainable Development Goal Life below Water

EDITOR: KLIMENT MINDJEV
IMAGES: SHUTTERSTOCK.COM

Fact Sheet for school students and proactive citizens.

BACKGROUND

Acidification refers to a reduction in the pH of the oceans caused primarily by the uptake of CO_2 from the atmosphere, although it may be caused by other chemical additions or subtractions from the ocean.

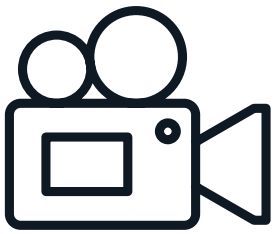
Ocean acidification is expected to have an impact on ocean species to varying degrees:

- Photosynthetic algae and seagrasses may benefit from higher CO_2 levels in the ocean.
- Studies have shown that a more acidic environment has a dramatic effect on some calcifying species. Calcium carbonate minerals are the building blocks for the skeletons and shells of many marine organisms. The acidification of seawater leads to a reduction in the concentration of carbonate ions, which makes building and maintaining shells and other calcium carbonate structures difficult for calcifying organisms such as oysters, clams, sea urchins, shallow water corals, deep sea corals, and calcareous plankton.
- These changes in ocean chemistry can also affect the behaviour of non-calcifying organisms. The ability of certain fish to detect predators decreases in more acidic waters. When these organisms are at risk, the entire food web may also be at risk.
- Ocean acidification affects all the world's oceans, including coastal estuaries and waterways. Many economies are dependent on fish and shellfish, and people worldwide rely on food from the ocean as their primary source of protein.

Ocean acidification is thus an emerging global problem. Over the last decade, many studies have focused on its potential impacts. Predictions suggest that, in the future, the oceans will continue to absorb CO_2 and become even more acidic. Estimates of future CO_2 levels indicate that, by the end of this century, the surface waters of the ocean could be nearly 150 percent more acidic, resulting in a pH level that the oceans have not experienced for more than 20 million years.

With the pace of ocean acidification accelerating, scientists, resource managers and policy makers recognise the urgent need to strengthen the scientific basis of decision making and action.

VIDEO



Chemistry Lesson at the Beach

https://www.youtube.com/watch?v=krC9gsLMw3U (3:35 min)
This **video** is appropriate for elder students.
Activities: Form three groups to trace and explain in more detail the three components (A,B and C) presented in the video: A/ acidification, B/ bioavailability, and C/ calcifers

The effect of ocean acidification on marine sounds

https://www.youtube.com/watch?v=xy6ogOyO-5E (1:39 min)
This video is appropriate for younger students. After the video presentation discuss using the following questions:

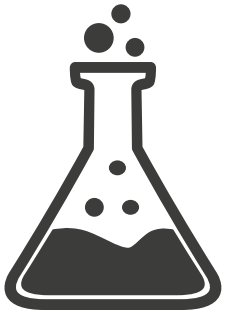
- Is the ocean a silent place?
- Which sea animals emit sounds?
- Why different sounds below water are important for small fish?
- Which are the sources of CO_2 emissions?
- What did the scientific investigations show?
- What are the consequences of acidifying seawater for sound-emitting animals?

Ocean acidification and biodiversity impacts

https://www.youtube.com/watch?v=GL7qJYKzcsk (12 :12 min)
This **video** is suitable for teachers and more curious students who show a strong interest in the process of acidification of the oceans. The availability of automatic translation into different languages facilitates the perception of this part of the information, which is of a more expert nature.

ROLE-PLAYING

Based on the "Ocean acidification and biodiversity impacts" video as well as additional research on Internet, volunteers could take on the roles of different scientists: chemists, biologists, ichthyologists, oceanographers, etc. with the task to organize an impromptu conference where they have to present in more detail different impacts of acidification on the marine life.

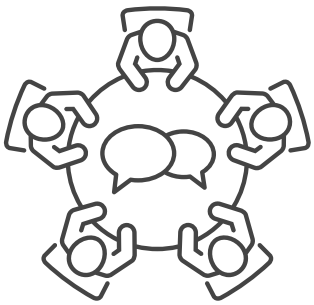


EXPERIMENT

The experts say that oceans absorb around 40–50 percent of the carbon dioxide from the atmosphere. That is the reason to often call oceans "the planet's biggest carbon sink". Step by step the oceans are becoming increasingly acid due to the increase of greenhouse gases and in particular – the carbon dioxide.

Try to simulate ocean acidification on calcareous skeleton by placing a raw chicken egg into a glass with vinegar (eggshell contains calcium carbonate) and leave it for 2–3 days.

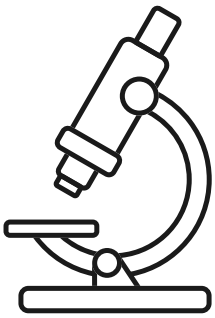
BRAINSTORMING



Discuss the following questions:

- Acidification is no longer regional, but global issue. Which one of your daily habits increases concentration of carbon dioxide and thus the ocean acidification?
- What activities need to be implemented on local and global level in order to reduce further ocean acidification?

How would you explain the message of the scientist Carol Turley from Plymouth Marine Laboratory: "Ocean acidification – it is the silent storm. It can't be heard, it can't be felt, it can't be seen, but scientists are measuring it."



RESEARCH

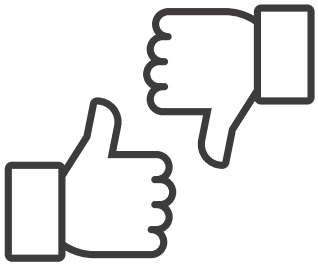
Coral reefs and ocean acidification

Corals are colonies of tiny individual animals called polyps, which have soft bodies and stinging tentacles. In tropical corals, the polyps are protected by a hard, external skeleton made of calcium carbonate. Coral reefs cover less than one percent of the sea floor but are home to 25 percent of marine species. Due to the increased acidification of the ocean all coral reefs are in jeopardy. Find in the available literature and internet the impact on wildlife of this "rainforest of the sea" if corals get extinct due to the increased acidification of the ocean water.

Some of the website addresses can serve as a starting point when searching for more information:

https://climateinterpreter.org/content/effects-ocean-acidification-coral-reefs
https://usa.oceana.org/effects-ocean-acidification-corals
https://www.nationalgeographic.org/media/acidification-reefs/

FOLLOW UP



Share the ocean acidification problems with other members of your family.

Discuss:

- How can an individual impact in order to preserve seas and oceans?
- Can this problem be overcome by developing industry which does not pollute the environment, or we should not prevent the development?

What can you change in your lifestyle in order to reduce your impact on increase of ocean acidification?

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Communicative Action to Mitigate Ocean Acidification

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Ocean Acidification (OA) caused by carbon dioxide from the burning of fossil fuels puts our seas at danger. Corals, cod, salmon, shrimps and shellfish are among the organisms at peril, together with whole ecosystems. The threats to nature are also a great concern for humans, and OA is not only an ecological problem – it also concerns those who rely on nature and the sea – for work, for leisure, for inspiration.

The BALSAM project strongly encourages NGOs and all those concerned about our seas to take action that highlights OA – a phenomenon that is still not well known to everyone.

For inspiration, just a few examples are listed here, but the possibilities are virtually limitless. Here are some of the actions that can be taken:

- Public testing of pH by the shore – to highlight pH as a phenomenon
- Joint action with fishermen – to bring attention to the threat of OA to fisheries
- Work with artists – to illustrate both the aesthetics of our seas, and the dangers ahead
- Exhibitions – at museums etc., to visualise ecosystems and organisms at risk
- Lectures – to spread the testimonies of scientists, fishermen and others
- Press conferences – to increase awareness of OA

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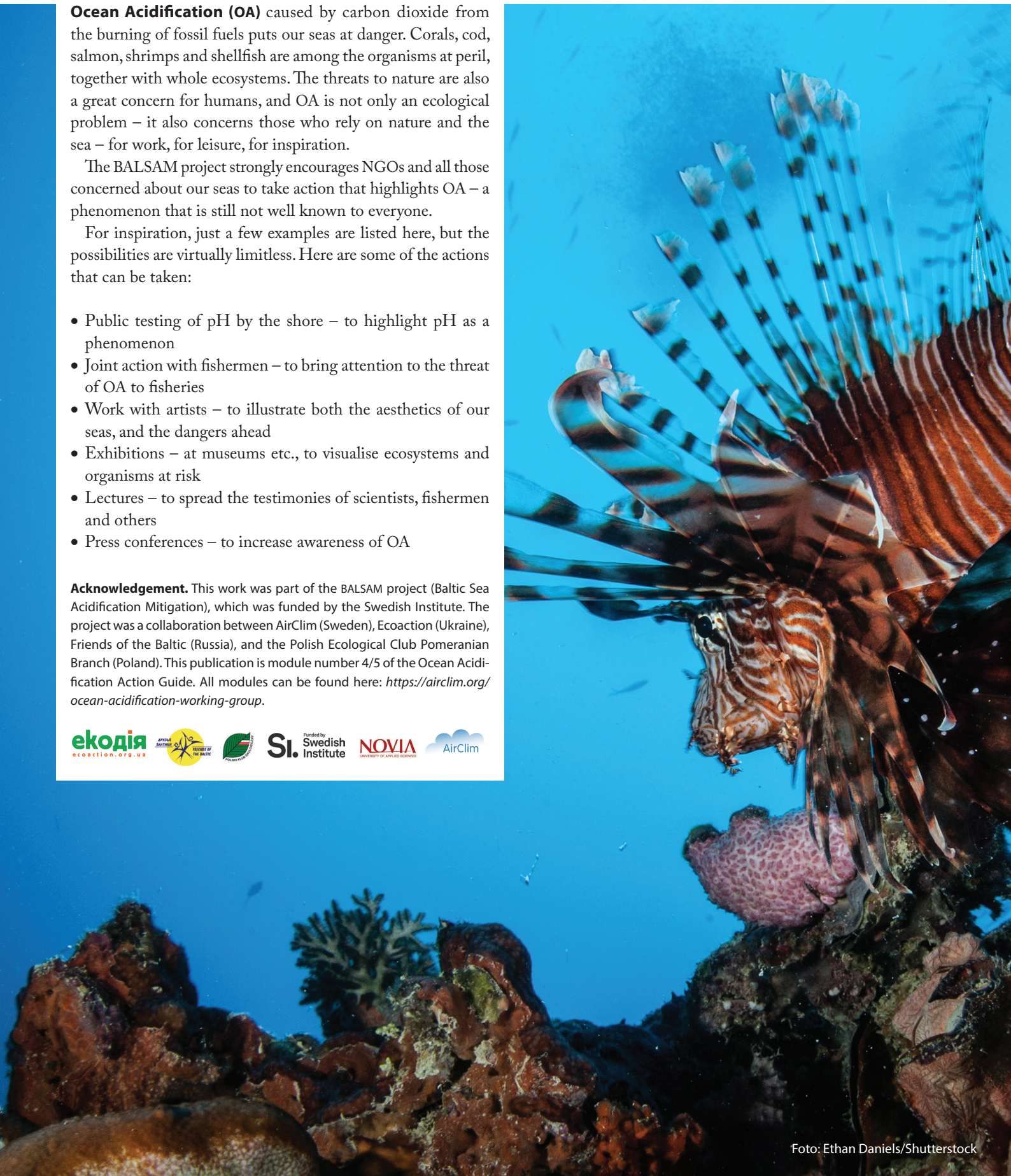

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Adaptation Measures for Ocean Acidification

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Ocean Acidification (OA) is a threat to marine ecosystems. OA cannot be stopped, and harmful effects cannot be avoided without mitigation measures for CO2. In the meantime, however, we can do everything we can to protect our seas from multiple stressors that act together – in combination with OA.

The protection of ecosystems from other stressors in our seas provides synergies with regards to OA. Protection measures that specifically consider OA can furthermore provide explicitly tailored solutions, such as Marine Protected Areas (MPAs) that are allocated appropriately. Scientific studies on the designation of such refugia should be strongly encouraged, and knowledge gaps should be identified and addressed. At the same time, existing suggestions for useful approaches deserve attention. For instance, protecting macrophyte beds (macroalgae and seagrass) can offer a temporal refuge for calcifying organisms otherwise susceptible to OA. Local or regional actions must happen in tandem with other actions, such as alleviation of overfishing and eutrophication to mitigate the ongoing loss of bladderwrack and other macrophytes.

The protection of marine ecosystems in Europe has several existing instruments. The Marine Strategy Framework Directive (MSFD) could guide EU member states to a coordinated view on marine protection in general, and specifically with regard to ocean acidification. The Regional Conventions of the Seas also provide frameworks for nations outside the EU. Protection of marine ecosystems under the Natura2000 network (in EU member countries) and the Emerald Network (also including non-EU countries) could provide a foundation for coherent protection of biodiversity that would also increase resilience against OA. Initiatives by local stakeholders, including those of municipalities and even private property owners, can be found within these MPAs, and some of the MPAs are based on the joint efforts of local initiatives to be part of UNESCO's "World Network of Biosphere Reserves".

Local initiatives to protect marine areas must be strongly encouraged. At the same time, local initiatives need the support of research and planning. European-wide governance is of the utmost importance. Recognising the roles of OA and other stressors in an integrated approach to marine protection provides the opportunity to create science-based transnational marine corridors that increase the resilience of our seas. At present, however, there is an urgent need to improve the use of marine governance instruments in Europe.

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