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EARTH SCIENCES
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BLUE CARBON ECOSYSTEMS: OCEAN HEROES IN THE FIGHT AGAINST CLIMATE CHANGE

Peter I. Macreadie[1*], Micheli D. P. Costa[1], Trisha B. Atwood[2], Daniel A. Friess[3], Jeffrey J. Kelleway[4], Hilary Kennedy[5], Catherine E. Lovelock[6], Oscar Serrano[7], Tallulah Davey[1] and Carlos M. Duarte[8]

[1] *Deakin Marine Research and Innovation Centre, School of Life and Environmental Sciences, Deakin University, Burwood, VIC, Australia*

[2] *Department of Watershed Sciences and Ecology Center, Utah State University, Logan, UT, United States*

[3] *Department of Earth and Environmental Sciences, Tulane University, New Orleans, LA, United States*

[4] *School of Earth, Atmospheric and Life Sciences and Environmental Futures Research Centre, University of Wollongong, Wollongong, NSW, Australia*

[5] *School of Ocean Sciences, Bangor University, Bangor, United Kingdom*

[6] *School of Environment, The University of Queensland, St. Lucia, QLD, Australia*

[7] *Centro de Estudios Avanzados de Blanes, Consejo Superior de Investigaciones Científicas, Blanes, Spain*

[8] *Red Sea Research Center and Computational Bioscience Research Center, King Abdullah University of Science and Technology, Thuwal, Saudi Arabia*

YOUNG REVIEWERS:


JUDE
AGE: 15


MILES
AGE: 13

Our planet is facing a critical challenge: climate change. This is caused by human activities that release carbon dioxide and other greenhouse gases into Earth's atmosphere. As temperatures rise and weather becomes more extreme, scientists are searching for solutions. Blue carbon ecosystems could be part of the answer! These ecosystems include mangrove forests, tidal marshes, and seagrass meadows—ocean and coastal ecosystems that capture and store carbon, keeping it out of the atmosphere. In our research, we found that these ecosystems cover a huge area of Earth's surface, up

to the size of Mexico. They store a whopping 30 billion tons of carbon, which is huge! If we stop destroying blue carbon ecosystems and restore the ones we have lost, it could balance out 3% of the greenhouse gases we put into the atmosphere. Pretty important, right! Overall, blue carbon ecosystems are nature's heroes in the fight against climate change.

OCEANS AS A LIFE SOURCE

Did you know that the oceans cover 71% of our planet's surface? That makes them the largest ecosystem in the world. They are also a life-support for the Earth and are critical to human survival. Oceans provide things that humans depend on, such as food and energy, and they are home to millions (if not billions) of sea creatures. Oceans also help regulate Earth's climate. They absorb excess heat from the atmosphere, and they influence when and where it rains. The famous marine conservationist Dr Sylvia Earle once said: "*If you think the ocean isn't important, imagine Earth without it. Mars comes to mind. No ocean, no life support system*".

BLUE CARBON ECOSYSTEMS

Coastal habitats, like mangrove forests, seagrasses, and tidal marshes, are three marine ecosystems that play a big role in regulating Earth's climate (Figure 1) [1]. Seagrasses are underwater flowering plants, like the grass you see on land, but living in the sea. Mangrove forests are made up of trees with clusters of tangled roots that grow in saltwater, and tidal marshes are made up of plants like herbs, grasses, and shrubs, growing on land where the tides flow in and out. Scientists have found that these ecosystems, sometimes called **blue carbon ecosystems** ("blue" as they are near the oceans, which look blue) are very good at capturing carbon dioxide (CO_2) from the atmosphere and trapping it. This is important because when CO_2 builds up in Earth's atmosphere it can trap heat from the sun and cause weird and dangerous weather, similar to what people all around the world have been witnessing in recent years.

BLUE CARBON

Carbon that is captured and stored by coasts and oceans; in particular, by coastal vegetation such as seagrasses, mangroves, and tidal marshes.

ECOSYSTEM

An area where organisms (like animals, plants, bugs) interact with the physical environment (like water, dirt, rocks, nutrients, and sunlight).

How do blue carbon ecosystems capture and store CO_2? Think back to your lessons on photosynthesis and how trees and other plants capture and store carbon. Just like plants on land, mangroves, seagrasses, and marsh plants capture CO_2 from the atmosphere and store it in their leaves and roots. But blue carbon ecosystems have a secret weapon for storing carbon longer than most plants on land can—they bury it in the ground and trap it there for thousands of years. This is because their roots are in wet, muddy soil, where there is very little oxygen and decomposition is very slow. This long-term

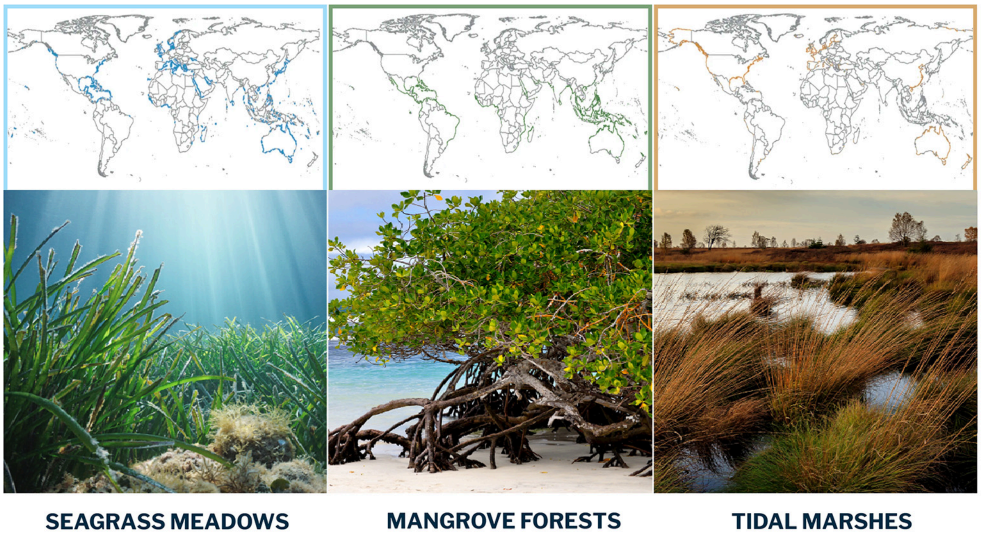

Figure 1

Figure 1

The bottom of each panel shows what blue carbon ecosystems (seagrass meadows, mangrove forests and tidal marshes) look like, and the top part shows where they can be found in the world. Tidal marshes are sometimes called saltmarshes.

carbon storage is important for keeping CO_2 out of the atmosphere and reducing climate change (Figure 2).

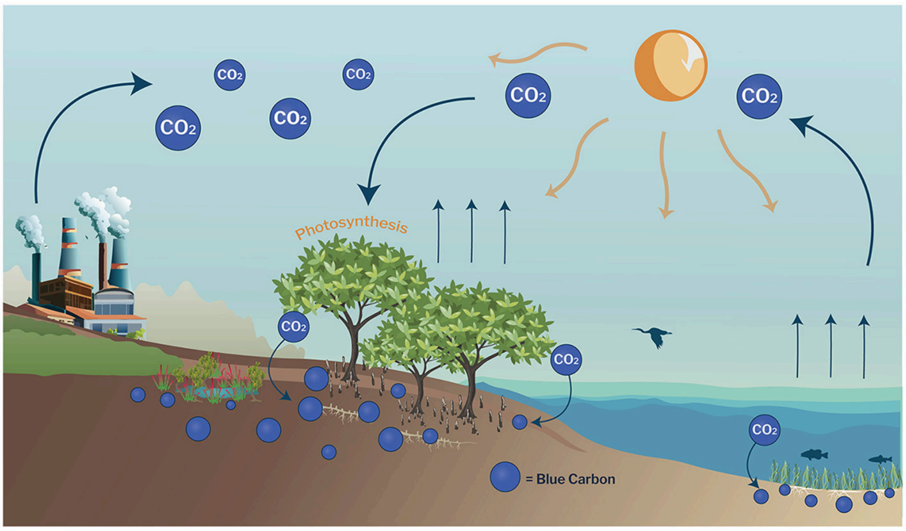

Figure 2

Figure 2

This is how blue carbon ecosystems capture and store carbon dioxide (CO_2). CO_2 produced by human activities enters the atmosphere and contributes to global warming. Through photosynthesis, plants use some of the CO_2 (along with energy from sunlight) to grow. When the plants in blue carbon ecosystems (seagrasses, mangroves, and tidal marshes) take up CO_2, they capture and store it e.g., in leaves, roots, and soil. This way, they help to store carbon deep in the ground. Blue carbon ecosystems are great at storing carbon because wetland soil is thick, muddy, and low in oxygen. Under these conditions, it takes a long time for plant materials to break down, so the carbon is locked away for thousands of years.

BEYOND CLIMATE CHANGE

Blue carbon ecosystems offer more than just their remarkable carbon capture and storage functions. Blue carbon ecosystems provide valuable services to humans and the environment (Figure 3). They act as natural shields that protect coastlines and coastal cities from the fury of big waves and storms, and they help clean pollutants from the water. These special ecosystems are also home to many marine animals, including animals that people like to catch and eat, such as fish and crabs. They are also nature's storehouses, supplying communities with important resources including wood, medicine, and recreational opportunities. Who does not enjoy a day outdoors marveling at all the birds, fish, interesting plants, and other incredible creatures that call blue carbon ecosystems home?

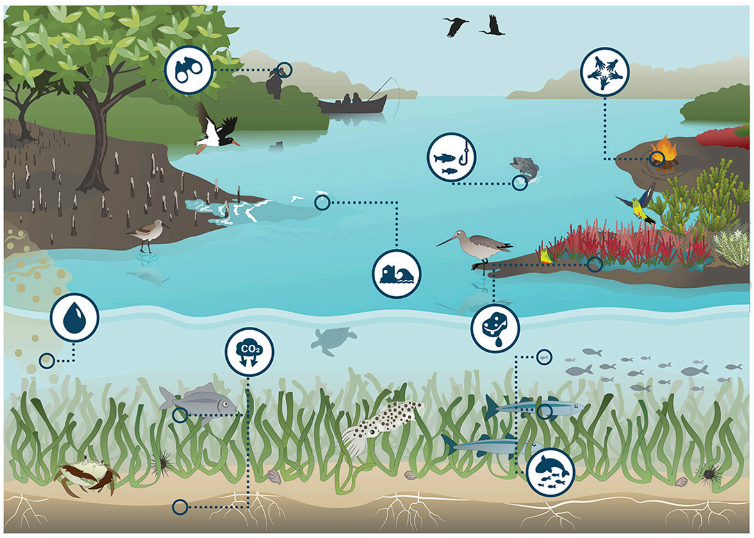

Figure 3

Figure 3

Blue carbon ecosystems have many benefits in addition to storing carbon. They are great places for recreation (birdwatching, fishing, and learning), and are important to the culture and survival of many Indigenous communities, who have a deep connection to the lands and waters (hunting, fishing, gathering resources, holding cultural ceremonies). These ecosystems are great places for animals to live, which can feed people and support jobs, and to raise their young, acting as nurseries for young animals. The plants in blue carbon ecosystems filter pollutants from the water, making it cleaner and healthier for other plants and wildlife. They also act like sponges, soaking up flood waters and reducing floods, while the plants and roots help to protect coastlines from erosion.

THE BIG QUESTIONS

Our team of scientists has been studying blue carbon ecosystems for over a decade. We have been trying to answer some big, important questions about how tidal marshes, mangrove forests, and seagrasses help control Earth's climate [2]. One of our first discoveries was that good information on exactly where these ecosystems are found or how they have changed over time did not exist. We needed to find out this important information because it tells us how many of these valuable blue carbon ecosystems have disappeared (Spoiler alert: more than 50% of our blue carbon ecosystems have already vanished [3]). We also needed to know how much carbon is being trapped by blue carbon ecosystems, and what happens to all the carbon trapped in the ground when these ecosystems are destroyed. After all, if that carbon gets released back into the atmosphere as CO_2, it will make climate change worse—yikes! Finally, we wanted to know whether bringing back the blue carbon ecosystems we have lost, a process called **restoration**, can help us battle climate change in a big way.

RESTORATION

Actions taken to repair natural ecosystems that have suffered from human or natural impacts. For example, replanting mangrove trees after they were chopped down for firewood.

In general, we can combine all of our research questions into one big question: What can we achieve if we use blue carbon as a natural solution to Earth's changing climate [4]?

WHAT WE DISCOVERED

Through our research, we made a number of fascinating discoveries about blue carbon ecosystems. First, we found that when we add up all of Earth's blue carbon ecosystems, they cover an area that is somewhere between 0.36 million km^2 (about the size of Japan) and 1.85 million km^2 (about the size of Mexico). That is a super wide range, and it illustrates just how uncertain we are about how much of Earth's surface is made up of blue carbon ecosystems. The biggest problem is that we do not have good tools for finding seagrass ecosystems. We can use satellites to search for mangrove forests and tidal marshes from space, because their plants mostly grow above the water's surface, making them easy for satellites to spot. However, seagrasses grow beneath the water, where satellites cannot see them so well.

Using our estimates of the size of blue carbon ecosystems, as well as other data like the amount and condition of plants and soil in them, we can use advanced calculations to estimate how much blue carbon exists on Earth. We found that the total amount of carbon stored in mangroves, seagrasses, and tidal marshes ranges from 10–30 billion tons. That is a really large number! To put it into perspective, an adult blue whale weighs about 140 tons. That means all the Earth's blue carbon ecosystems together are storing the equivalent weight of more than 100 million blue whales!

Finally, we found that protecting the blue carbon ecosystems that remain and restoring the ones that have been lost are powerful tools in the fight against climate change. By protecting current blue carbon ecosystems from human-caused destruction, we can prevent 300 million tons of CO_2 from escaping to the atmosphere each year. To put that in perspective, that is the same amount of CO_2 emitted into the atmosphere yearly by the country of Australia. Additionally, if we restore the blue carbon ecosystems that have been lost, we can trap an additional 840 million tons of CO_2 each year. If we take care of the blue carbon ecosystems that remain and work on restoring the ones that have been lost, it could balance out 3% of the **greenhouse gases** we put into the atmosphere! And do not forget that when blue carbon ecosystems trap carbon, it remains buried in those systems for thousands of years!

GREENHOUSE GAS (GHG)

Gases in Earth's atmosphere that trap heat from the sun. The most concerning greenhouse gases produced by humans are the ones causing global warming, which include carbon dioxide and methane.

TAKING ACTION TOGETHER

In conclusion, this article reveals the hidden heroes of our planet: blue carbon ecosystems. These incredible marine ecosystems play a vital role in fighting climate change by capturing CO_2 and keeping it safely stored underground for thousands of years. By protecting and restoring blue carbon ecosystems, communities can make a significant contribution to reducing climate change, safeguarding coastlines, and preserving the homes of millions of sea creatures. So, what can young people do to help blue carbon ecosystems thrive? Learning about these incredible environments and spreading awareness about their importance is a significant step—you can help others to understand how critical these ecosystems are to our planet! Supporting conservation activities and being mindful of actions that might harm blue carbon ecosystems can also make a real impact. As future stewards of Earth, you hold the key to ensuring the health and survival of blue carbon ecosystems and, therefore, a healthier and safer planet for all living beings. Let us embark on this journey together and celebrate the wonders of nature's natural climate solutions!

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ORIGINAL SOURCE ARTICLE

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YOUNG REVIEWERS

JUDE, AGE: 15

I am a big fan of both dogs and cats, I have trained my cat to walk on a lead so we can go for walks together in my spare time. I also love music and spend a lot of time playing my guitar. I enjoy reading about biochemistry (especially plant related) and one day would like to study the subject at university.

MILES, AGE: 13

My name is Miles, and I live in California. I am a 7th-grade student, and I love science. I have a few pets at home and enjoy learning about all creatures, big, and small.

AUTHORS

PETER I. MACREADIE

Peter is a professor in marine science at Deakin University, Australia and leads the Blue Carbon Lab. A lot of his research focuses on understanding the impacts of global change on blue carbon ecosystems, such as mangroves, tidal marshes, and seagrass, and he is especially interested in creating novel research solutions to reduce the effects of climate change. He loves snorkeling with his three kids; Millicent, Henry, and Loretta. *p.macreadie@deakin.edu.au

MICHELI D. P. COSTA

Micheli is a marine biologist and senior research fellow at the Blue Carbon Lab, where she co-leads the Blue Carbon research team. Micheli's main interests are in marine ecology, where she calculates the numbers of living things in marine ecosystems, and coastal conservation, where she uses maps and modeling to better understand and protect blue carbon ecosystems. A lot of Micheli's research focuses on making smart decisions to help conserve blue carbon ecosystems and inform their management. As part of her work, she works closely with different people from universities, companies, and governments in Australia and internationally.

TRISHA B. ATWOOD

Trisha is a professor at Utah State University, USA and leads the Aquatic Ecology and Global Change Lab. Her research focuses across all aquatic ecosystems and her research looks at aquatic food webs and species interactions, the effects of global change, and the role aquatic ecosystems can play in reducing the effects of climate change and conserving biodiversity. By focusing on these topics, her research has taken her all over the world, with studies in Hawaii, Canada, Costa Rica, and Australia, including the Great Barrier Reef.

DANIEL A. FRIESS

Dan is a coastal scientist at Tulane University, USA. His research focuses on blue carbon and ecosystem services in mangrove forests; threats to mangroves, such as deforestation and sea-level rise; and the use of blue carbon to promote mangrove conservation and restoration. His research includes modeling, collecting field data, and social science methods. As part of his research, he works closely with government and other groups, such as non-governmental organizations and companies, particularly in Southeast Asia.

JEFFREY J. KELLEWAY

Jeff is an environmental scientist at the University of Wollongong, Australia. Through his research, Jeff aims to better understand wetlands and their ecosystem function—that is, the roles they play within nature and the services they provide for humans. He is especially interested in the carbon-capture potential of blue carbon ecosystems, such as mangroves, saltmarshes, and supratidal forested wetlands. He aims to improve our understanding of blue carbon stocks in coastal wetlands, and their response to environmental change.

HILARY KENNEDY

Hilary is a marine scientist and professor in Chemical Oceanography at Bangor University, UK. She is interested in studying tiny particles called stable isotopes, which are like tags, to understand how things move in nature. She uses these tags to reconstruct and describe what the environment looked like a long time ago. Her research also focuses on the importance of seagrass meadows as coastal carbon sinks.

CATHERINE E. LOVELOCK

Catherine is a marine ecologist at the University of Queensland, Australia. Her research focusses on the influence of environmental change, including climate change, on the ecology of coastal and marine plant communities and on providing knowledge to better understand the conservation and restoration of these ecosystems now and in the future. She leads projects in Australia and internationally that focus on adapting to climate change, carbon capture, and restoring mangrove forests.

OSCAR SERRANO

Oscar is an environmental scientist at the Spanish National Research Council. His work focuses on the study of how humans impacted the landscape over the past centuries. His research contributes to understand how we can manage coastal ecosystems to mitigate climate change and to preserve the biodiversity of plants and animals living in our coasts. His research influences policy and management, and spans multiple countries and regions, including South America, Australia, and the Mediterranean.

TALLULAH DAVEY

Tallulah is a marine ecologist, based at the Blue Carbon Lab at Deakin University, Australia. She has a keen interest in conserving biodiversity and helping to reduce climate change using nature-based solutions. She is passionate about driving a positive change for the planet through research, science-communication and community engagement.

CARLOS M. DUARTE

Carlos is a marine researcher who, after nearly four decades documenting how human pressures impact marine life, wants to drive a science-based global effort to rebuild the abundance of marine life. He loves dogs and enjoys being away in the open sea, as well as reading, swimming, snorkeling, walking, and playing with his grandson Oliver.