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EDITOR'S WELCOME

Uncovering the Potential of Blue Carbon

By Kira Coley, Senior Editor

Between 27 June to 1 July at the **UN Ocean Conference**, the ocean was – for only the second time in history - placed at the forefront of global affairs. World leaders travelled to Lisbon to accelerate the adoption of innovative and scalable solutions to address the many deep-rooted problems impacting 71 percent of Earth's blue surface. Given the rise of projects over the last decade, it was perhaps no surprise that **blue carbon** was one of the main talking points dominating several high-profile events throughout the week.

The potential of blue carbon goes well beyond the restoration of important coastal habitats and mitigating climate change. If done right, there is also potential to grow economies, improve the livelihoods of local communities and see financial returns for those willing to invest. But before we race ahead and begin launching ambitious international projects, there are still challenges and knowledge-gaps around carbon credits and offsetting, quantifying the size of blue carbon stores, and the global adoption of best practices for planting, restoration, and long-term monitoring.

For this special issue, world-leading experts have come together to explore the challenges and opportunities of the complex topic. To help shape the discussion, we are excited to partner with the **Gallifrey Foundation, Fair Carbon and Conservation International.**

Together with the **International Union for Conservation of Nature (IUCN)** and the **Intergovernmental Oceanographic Commission (IOC) of UNESCO, Conservation International** is leading the International Blue Carbon Initiative, which focuses on mitigating climate change by conserving and restoring coastal marine ecosystems globally. Most recently, they helped launch **Vida Manglar**, the first blue carbon project to fully measure – and value – the carbon that mangroves sequester in their soil, using a newly developed methodology for producing carbon credits for the voluntary market.

The **Gallifrey Foundation** identifies collaborative opportunities to tackle ocean conservation issues by identifying synergies that could be exploited and roadblocks that could be overcome by working together. In 2021, they launched the **Fair Carbon project** which collaborates with leading conservation NGOs and other stakeholders to make it easier to design, register, and validate natural carbon projects that meet or surpass carbon standards' strict requirements.

Within these pages, you will find a wealth of information on the latest **blue carbon research, policy and finance, tools and methods for mapping and restoration**, and outlooks on the **future of blue carbon**. Many of the projects and discussions featured here will be a step towards helping businesses understand the many ways they can get involved in this fast-growing sector and, we hope, a useful aid for academics, NGOs and investors exploring the potential of blue carbon ecosystems.

We also want to thank to our sponsors **AquaTech Consultants**, **BioMar**, **IUCN**, **RBR**, **PryoScience**, **Verra**, **Wetlands International**, **EOMAP** and **CSA Ocean Sciences**, who have made this special issue possible.

As the UN Ocean Conference came to a close in Lisbon, it was clear the interest in ocean-based solutions for carbon capture is quickly gaining momentum. Using nature to mitigate against climate change brings with it a throng of benefits for resilience, biodiversity and local communities. Blue carbon may be one solution within the diverse arsenal needed for climate adaptation and mitigation but, if we can expand our knowledge and install the right frameworks to effectively scale-up projects, the potential it offers across governments, industry and conservation makes it an intriguing and vital tool.

Happy reading!

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ECO's mission is to inform, connect and inspire the global ocean community. Through original storytelling, we aim to help the discovery of viable solutions for the ocean's most prevalent issues by facilitating knowledge-sharing and increasing topic awareness to a fast-growing international audience of ocean stakeholders.

Editor's Welcome

Partner Message

Cover: Sea lions in seagrass.
Photo Credit: Jeff Hester / Ocean Image Bank

Blue Carbon Research

Policy and Finance

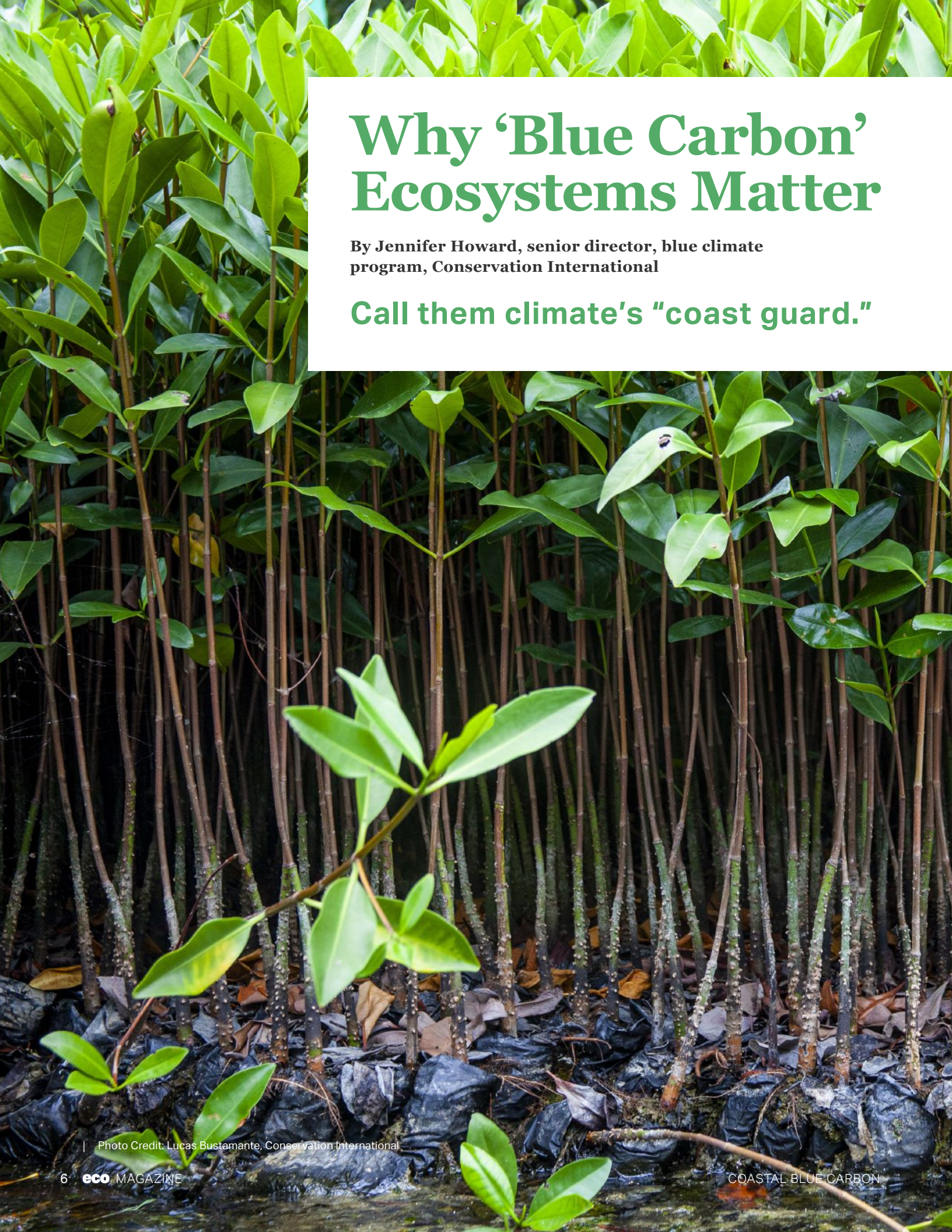
Mapping and Restoration

Future of Blue Carbon

Why ‘Blue Carbon’ Ecosystems Matter

By Jennifer Howard, senior director, blue climate program, Conservation International

Call them climate’s “coast guard.”



| Photo Credit: Lucas Bustamante, Conservation International

The ecosystems that line coasts throughout the tropics are sometimes called the last line of defense against climate catastrophe. Locked in these unheralded marine and coastal habitats — mangrove forests as well as seagrasses, tidal marshes and more — are several millennia's worth of "blue" carbon.

To destroy these ecosystems — as humanity continues to do with astonishing haste — is akin to setting off a slow-motion carbon bomb. It's estimated that half a billion tons of carbon dioxide are released annually from degraded coastal ecosystems.

In the battle to prevent the worst effects of climate change, humanity's last line of defense is thinning, and fast. Now, researchers and policymakers are scrambling to shore up protections for blue carbon ecosystems.

Climate Superstars

For the most part, when it comes to blue carbon, mangroves tend to get most of the attention. It's not undue: Mangroves are climate superstars.

In the water-logged soils of their coastal environs, these fast-growing forests are incomparably capable of locking away carbon for centuries to millennia.

Mangroves' benefits extend beyond carbon. They act as barriers against tidal waves and storm surges while serving as nurseries for the countless marine species that provide food security and livelihoods for coastal communities. (In fact, harboring wildlife is a *critical* and often-overlooked aspect of blue carbon ecosystems, providing a one-two punch against both the climate and biodiversity crises.)

Yet barely half of the world's original mangroves remain, most having been cleared in the past half-century. The main reason: shrimp and fishponds and other coastal development. Dams, firewood harvesting and pollution are also contributing factors.

The short-term payoff of clearing a stretch of mangroves pales next to its climate impact: The carbon footprint of a steak and shrimp dinner — were it to come from shrimp farms and pasture formerly occupied by mangroves — is the same as driving a small car across the continental United States, a 2017 study found.

Destroying blue carbon ecosystems can also have more visibly devastating effects: In some places like the Philippines, over half of the countries' mangroves have been converted to shrimp ponds. As coastal communities in these countries are now discovering, this has left them highly exposed to typhoons that impact the country every year.

In 2013, Typhoon Haiyan devastated large areas in the central Philippines with 20-foot storm surges and floods several meters deep; 6,300 people died. While a number of factors contributed to the devastation, the loss of mangroves left the coasts exposed and communities highly vulnerable. In the Visayas Islands region, hit hard by Haiyan, more than 80 percent of the mangrove forests had been cleared.

In response to the many services mangroves provide, local efforts to protect these habitats have sprouted up. In northern Brazil, for example, nonprofits assisted a local community in protecting its mangrove forests through sustainable crab-fishing cooperatives, which doubled workers' incomes within a year.

However, many projects are conceived without addressing the underlying causes of loss, resulting in those projects failing to sustain any initial gains in mangrove coverage. Even more projects fail due to poor techniques — like planting in the wrong areas or planting the wrong species. To date, mangrove restoration has tried to emulate land-based reforestation efforts, relying on single-species mangrove planting and on fast-growing species that are rarely suited to local conditions. (While effective mangrove restoration approaches have been developed and implemented in isolated cases, this capacity and knowledge is not broadly available.) Sometimes, though, it's too difficult to re-establish the conditions that gave rise to these ecosystems. In some cases, restoring these ecosystems is possible, but it can be so expensive as to be cost-prohibitive.

In any case, habitat restoration can't fix things overnight. Even after a mangrove, marsh or seagrass has been restored, it takes centuries to bring back the carbon that was released into the atmosphere when the ecosystem was destroyed.

Unfortunately, local conservation efforts are on their own not enough to turn the tide. Until the global community understands the full value of mangroves to humanity, these trees will continue to be felled for short-term gain.

Now, an effort to account for the value of these blue carbon ecosystems is taking root.

A New Business Model

On the mangrove-rich Caribbean coast of Colombia, a group of local and international partners came together in a place called Cispatá Bay to flip the economic script that so far has rendered mangroves more valuable dead than alive.

The project, known as "Vida Manglar" (Spanish for "mangrove life"), is the first conservation project to fully measure — and value — the carbon that mangroves sequester in their soil, using a newly developed methodology for producing carbon credits for the voluntary market.

The resulting blue carbon credits — that is, verifiable emissions reductions tied to carbon stored in marine ecosystems — were issued in May 2021. The vast majority of these revenues (a whopping 92 percent) will be invested in Cispatá Bay's conservation management plan to protect the mangroves and maintain the benefits they provide to more than 12,000 people who live in the region.

At the same time, Cispatá Bay's 11,000-hectare (27,000-acre) mangrove forest is expected to sequester nearly 1 million metric tons of carbon dioxide over the 30-year lifespan of the project — equivalent to taking 184,000 cars off the road for one year.

What this means is that commitments to keep blue carbon ecosystems intact can be purchased and traded on the global market to compensate for carbon emissions made elsewhere — a critical first step to protecting nature, communities, and of course the climate.

If humanity is to stave off a climate catastrophe, our last line of defense must hold.

The Importance of Defining Blue Carbon and the Status of Carbon Offsetting

By Gallifrey Foundation and Fair Carbon

Blue Carbon Workshop at the UN Ocean Conference, Featuring Fair Carbon and Conservation International

| Photo credit: Mark Beeston.

"Blue Carbon"

is a term used to describe the carbon stored in ocean and coastal ecosystems such as mangrove forests, seagrass meadows, and saltwater marshes.

Recently, as interest in blue carbon has grown, the term was repurposed and used as an umbrella to group "Blue Carbon Ecosystems" together defined by their ability to capture and store carbon.

We shouldn't need to place a dollar value on ecosystems and habitats to justify their continued existence. But, for blue carbon systems, the removal and storage of atmospheric CO_2, quantified and packaged as carbon credits, creates a business case for conservation.

There is potential in the voluntary carbon market to create sustainable incomes, for decades, for community or conservation projects which protect or restore ecosystems such as mangroves. The concept is not new – the first blue carbon project was certified in 2012 – but with Net Zero commitments looming and an urgent need to reduce emissions or remove what cannot be mitigated, the interest in blue carbon has never been greater.

For potential project proponents though, accessing this income source is problematic. The combined technical expertise, social engagement and up-front finance required, coupled with legal and political grey areas for project operation, see many potential blue carbon projects abandoned at the concept stage. Larger, well funded NGOs such as Conservation International and Blue Ventures have shown leadership in supporting the implementation of ethical high quality projects, combined with local capacity building for replication and long-term management.

Fair Carbon are engaged at both ends of the value chain, providing advice directly to projects and building understanding of how to navigate the accreditation process. The lessons learned through this process contribute to the ongoing development of modular guides to accreditation, including feasibility reports, carbon models and PDD documents. For buyers and investors in blue carbon credits, Fair Carbon has been a consistent voice of reason amongst the hype.

The Value of Blue Carbon

There is now a rush to ascribe a "blue carbon" value to other marine creatures and ecosystems which contribute to ocean carbon storage, such as giant kelp and seaweeds, phytoplankton, zooplankton, and whales.

All these habitats are complex and dynamic and provide a range of ecosystem services, not just carbon storage. For example, kelp forests provide fish nurseries, reduce erosion or flood risk, support biodiversity, and provide food, fuel and materials for human users. These services are commonly referred to by the market as "co-benefits" and vary between habitat types.

For coastal blue carbon habitats such as mangroves, though, it is critical to recognise that in some locations, entire communities may rely on the resources these systems provide to meet their day-to-day needs. While the market focuses on the carbon values, land managers and policymakers need to place the human value of blue carbon systems at the forefront of their decision-making.

Blue carbon can provide multiple "wins" for people and the planet, but only if the funds available are applied wisely. For some ecosystems we still need methods to measure and model carbon impacts, and we need to better understand the economic and social values of all blue carbon habitats.

Blue carbon ecosystems, and the current status of carbon offsetting for each, are summarised below:

Seagrass: Seagrasses are true plants, growing both intertidally and subtidally in shallow seawater, and can form extensive underwater meadows. Found everywhere except polar extremes, the global extent of seagrass has not yet been accurately mapped.

There is an accepted methodology for generating carbon offsets from seagrass, with a trial site in Virginia pending registration under the Verra VCS standard. In Kenya, there is currently research underway to explore whether it's feasible to add a seagrass component to the successful Mikoko Pimoja project under the Plan Vivo Standard. At the UN Oceans Conference in Lisbon, an ambitious initiative to manage vast areas of seagrass in the Bahamas was announced, making it the first of its kind. Currently, there are not any carbon credits available from seagrass.

Saltmarshes: Salt-tolerant scrub habitat in the upper intertidal or subject to episodic saltwater intrusions.

Verra published a methodology for carbon accreditation of saltmarsh, and large NGOs have begun feasibility studies of trial sites. There are not yet any registered tidal marsh offsetting projects offering credits on the voluntary market or any in an advanced stage of development where credits may soon be available.

Mangroves: Mangroves are trees and shrubs that evolved to tolerate exposure to saltwater and grow in the intertidal zones along equatorial and tropical coastlines. Mangroves store carbon in the trees' biomass but also capture particulate matter in their complex root systems, sequestering carbon in deep muddy sediments for hundreds of years.

The science behind mangrove carbon projects is well established, with Mikoko Pimoja certified in 2012. Potential projects now have a wider range of accepted methodologies and accrediting standard choices. However, due to the cost of expertise and time required, there are still only a handful of certified projects after ten years.

Other ecosystems:

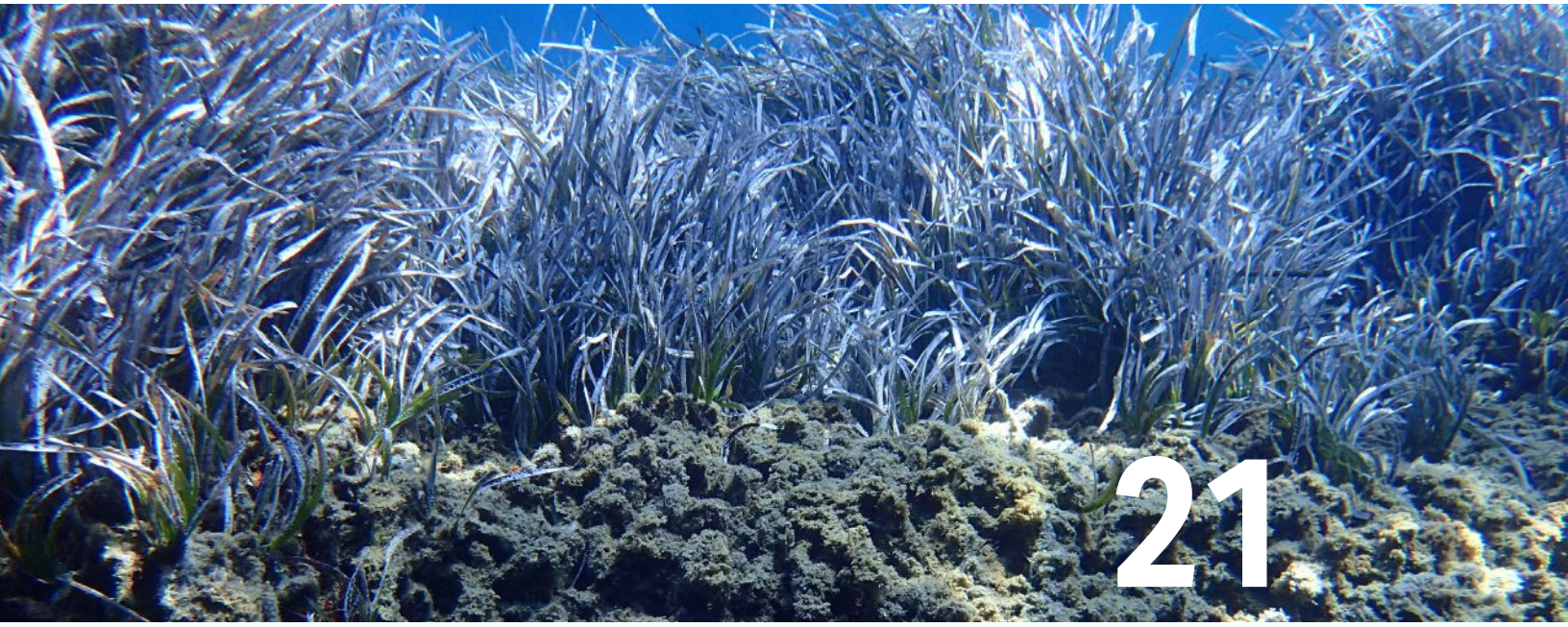
Kelp (and other macroalgaes): Multiple different types of algae and seaweeds ranging from a few centimetres in size to tens of metres. There is not yet an accepted methodology for generating offsets from the carbon incorporated in kelp and other seaweeds as they grow. There remain challenges in modelling the fate of carbon in natural systems, and for farmed seaweeds, of what to do with the macroalgae once it is harvested to ensure that carbon remains stored and is not released back into the environment.

Ocean Biomass: Fish, whales, and large animals hold carbon in their physical tissue. Migration and death of these organisms can transport tissue and carbon to the deep where it can be stored.

The continual removal of marine biomass by fishing, pollution, or ocean acidification can hinder or reduce natural ecosystem carbon cycling, sequestration, and storage. Quantifying how changes in ocean management can reinvigorate portions of the oceanic carbon pump is vital to inform policy decisions and manage ecosystems more effectively. Ocean biomass carbon is unlikely to result in the private production of carbon offsets in the near future. There is potential to assign other incentives to alter practices that degrade natural carbon storage systems.

With the earth seeing record temperatures again this year, and with biodiversity and human livelihoods all suffering, we need to understand and utilise every tool at our disposal to address ever-increasing levels of CO_2 and other greenhouse gases, before it's too late. Blue carbon is not a silver bullet, but it does have a role to play.


12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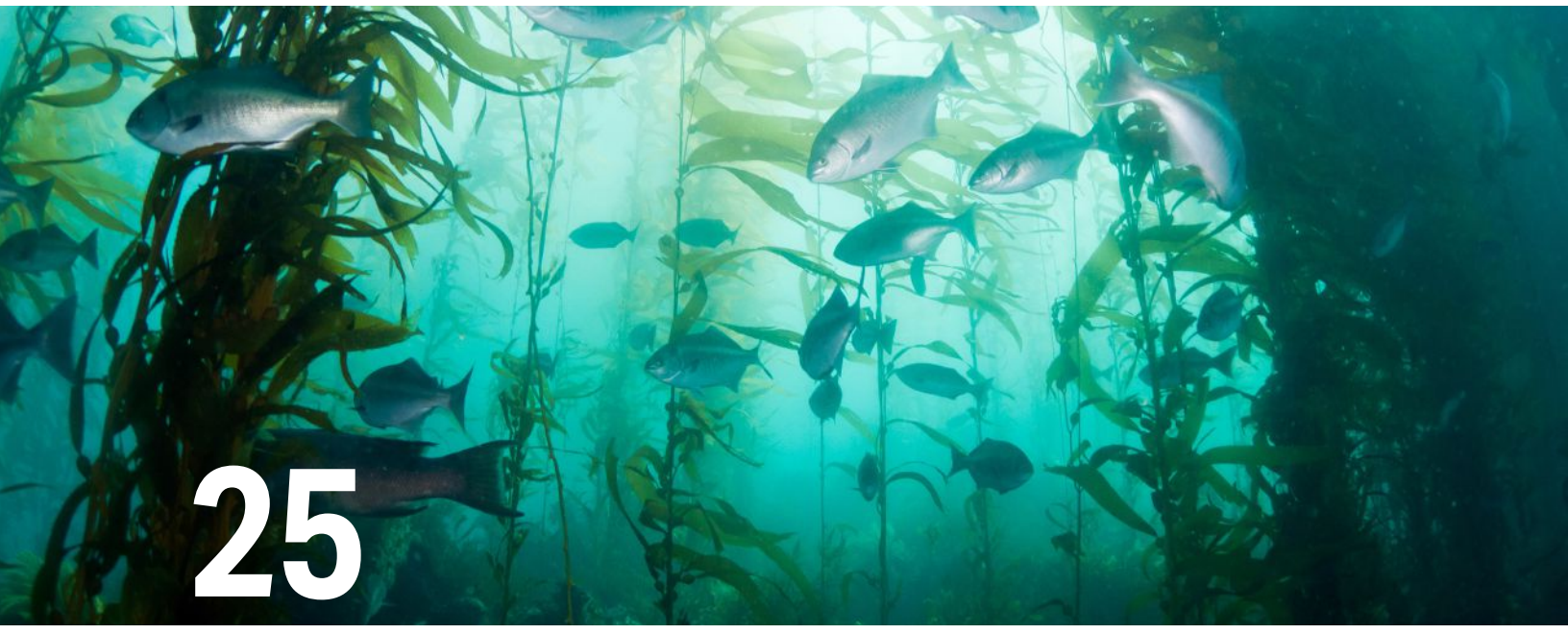

25

Blue Carbon Research

| Red Maqngrove *(Rhizophora mangle)*

Belize Blue Carbon:
Comprehensive National Mangrove Carbon Estimates

The key to blue carbon research success starts with collaborative efforts and local investment

By Dr. Hannah Morrissette, Smithsonian Institution; Dr. Steve Canty, Smithsonian Marine Station; Ninon Martinez, University of Belize Environmental Research Institute; and Kevin Novelo, University of Belize Environmental Research Institute

Mangroves are at the core of many tropical coastal communities and ecosystems.

They are no ordinary plants; mangroves are supporters of life, protectors of the coastline, and dynamic reminders of why biological diversity is so important.

Their vast root systems provide many ecologically and economically valuable services, known as ecosystem services, yet mangroves face environmental and human-derived challenges to their survival.

Field work to collect soil cores. (Photo credit: Hannah Morrissette, Smithsonian Marine Station)

All life is connected to the coast. Just as you do not have to see a mangrove to be touched by its influence, your actions can influence their health and endurance.

A very real way that mangroves affect your daily life is their role as natural solutions to mitigating the effects of climate change. Not only are they the first line of coastal defense against storms, absorbing wave and wind energy, they provide a buffer to pollution and habitat to economically important fish species, such as grouper and snapper. Mangroves are also extremely effective accumulators of carbon, pulling carbon in from the atmosphere and surrounding environments. They store this carbon temporarily in their branches and roots, then in their sediments for long periods of time: forever, if undisturbed.

Due to this inherent ability to fight climate change, many countries with expansive coastal wetlands have prioritized the protection and restoration of these ecosystems. Belize is one of such countries leading the way.

Belize recently updated their nationally determined contribution (NDC; climate action plan to reduce nationwide emissions as part of the Paris Climate Agreement) to restore 4,000 hectares and conserve an additional 12,000 hectares of mangrove forests by 2030. Their ambitious plans are ever evolving, emerging from a unified effort to protect their backyard.

"Belize cannot thrive without its mangroves" says Ninon Martinez, the marine monitoring specialist at the University of Belize Environmental Research Institute (UB ERI). "This is something that all organizations – academic institutions, governmental agencies, and environmental NGOs – can agree on." Her marine monitoring colleague at UB ERI, Kevin Novelo, adds that this regional and national buy-in after years of a seemingly stark "disconnect between conservation practices and development" is what drives Belizean efforts.

Quantifying the Carbon

To augment the actions set forth by their national climate change policies, the *Belize Blue Carbon Project*– led by the Smithsonian Institution and UB ERI with support from the Pew Charitable Trusts, WWF, and Silvestrum Climate Associates – was created to fill the gaps in Belize's mangrove carbon knowledge.

Environmental NGOs and government agencies such as the Belize Forestry Department have conducted previous monitoring and sampling efforts to assess health and the carbon content in the mangrove biomass. In September 2021, we combined that background knowledge with an internationally collaborative field team to get the first ever comprehensive (above- and belowground) estimate of carbon stored in Belize's extensive mangrove ecosystems. As the stock residing in the deep sediments was previously unknown, this was a profound contribution to understanding the Blue Carbon potential of the mangroves of Belize.

Ten sites, with wide differences in their biological, physical, and hydrological characteristics, were sampled along the coastal zones of Belize, capturing lagoonal, riverine, and offshore caye ecosystems. Sampling for carbon content consists of biomass data (aboveground measurements of tree height, canopy width, and trunk diameter), sediment cores (belowground sampling of sediment beneath the trees), and qualitative observations of overall health.

The methods, summarized by the Coastal Blue Carbon Manual, are non-destructive and comprehensive. The course of the field work resulted in more than 1,300 sediment samples and the measurements of almost 4,000 trees. The depth of this effort led to extensive on-the-ground variation: every site that was visited was vastly different from the last.

Curiosity (and coffee) permeated the air of each field day morning as the team loaded gear onto the boat, wondering aloud what our experience in the forest that day would be. The obvious differences noted in the field between sites, even within the sites themselves, and the subsequent variability seen in the processed soil cores, immediately showcases the necessity of regional on-the-ground sampling efforts instead of global estimates.

Field work to analyze blue carbon is intensive, with six plots per transect to collect soil cores (left) and measure biomass (right). (Photo credit: Hannah Morrissette, Smithsonian Marine Station)

Sites vary widely in several characteristics, such as ecotype, geographic distribution, protected status, and tree height (dwarf, top; tall, bottom). (Photo credit: Hannah Morrissette, Smithsonian Marine Station)

Collaboration is Key

With a team of more than 35 individuals from 14 institutions, organizations located up and down the coastline of Belize were trained in consistent blue carbon sampling methods to expand local capacity. Ninon has hope in this project model, stating that, "Building local capacity and partnerships is how we can combat the regional threats to mangrove ecosystems."

That capacity was put to the test: a Belizean team of experts sampled the Turneffe Atoll in March 2022, successfully gathering a new set of data and training additional field team members. This ripple effect of training, collecting, sharing data, and repeating that process is of critical importance for the evolution of blue carbon science. "This project has been a great example of how different sectors need to come together to work towards environmental solutions, each bringing their knowledge and skill sets to work towards the common goal of improving mangrove protection," says Steve Canty from the Smithsonian Marine Station. Creating a collaborative effort that pulls in procedural expertise, combined with in-depth background knowledge of sampling sites from local coastal communities, sets up the region for environmental success.

The importance of this project comes from its applied nature, as summarized by Stacy Baez at Pew Charitable Trusts, "This project advances blue carbon science for mangroves in Belize and directly supports the country in its effort to protect and restore mangroves as a tool to meet climate mitigation and adaptation goals."

The data can and will be used to inform coastal policy and management as the country increases management and conservation actions on these critical ecosystems. National, regional, and site-specific estimates of carbon stock within mangrove forests are the basis of truly understanding these environments and their services, highlighting the immense value of their conservation.

This project, while considered a scientific success in the large amount of data collected, is really a story of collaborative success: building national and international partnerships, providing real-time application to the data, and connecting communities with the preservation of their dynamic coastal ecosystems.

The efforts and the dedication of all of the partners in this project can serve as a blueprint for other countries seeking to conserve natural blue carbon sinks in meeting their climate targets. Stay tuned as this project wraps up and provides the first ever national comprehensive carbon stock for Belizean mangrove forests, regional patterns of carbon accumulation, and guides to carbon hotspots for future restoration and conservation goals.

Mangrove conservation is, and will continue to be, essential in the fight against climate change.

Read the Coastal Blue Carbon Manual (Howard et al., 2014):

> www.thebluecarboninitiative.org/manual/

Levelling Up Our Understanding of Blue Carbon

A massive new research project from the Blue Marine Foundation is about to take our understanding of blue carbon to the next level

By Tom Horan

Since it was founded in 2011, Blue Marine Foundation has achieved significant gains in ocean protection. Through grassroots initiatives and legal interventions, the campaigning charity tackles overfishing and invasive practices that degrade the ocean and cut its ability to stabilise the climate. To date, Blue Marine has secured protection for more than four million square kilometres of ocean around the world — an area eight times the size of Spain.

The UK-based organisation strives to identify conservation opportunities that are feasible, verifiable and achieve benefits for both marine environments and local communities. Having done much in the UK to unlock and crystalise the concept of the ocean as the world's largest carbon sink — with the power to mitigate against climate change — Blue Marine is an established thought leader in the blue carbon space.

Understanding that the emerging topic of blue carbon could play a huge role in the future protection and restoration of the ocean, at the start of 2021 the charity established a dedicated blue carbon unit, led by development director Dan Crockett. Blue Marine believes it can have a major strategic impact in the ocean climate space, and improve the way in which the world values the ocean as a climate change solution.

One area expanding rapidly is the interest in blue-carbon credits within the voluntary carbon market. Companies are now seeking projects that offer not only carbon potential but other benefits, such as biodiversity impact. The UK has the opportunity to build an innovative blue-carbon market; Blue Marine aims to be the catalyst that pulls the appropriate stakeholders together to champion a robust, equitable, trusted market that works for all.

To this end, Blue Marine is examining key areas of blue carbon through projects that include:

- measuring the impact of bottom trawling on seabed sediment and carbon emissions
- quantifying the carbon sequestration and storage potential of the seabed, in partnership with the University of Exeter
- funding carbon mapping, and exploring the impact of mobile contact bottom fishing on carbon stocks and the carbon cycle
- examining the co-benefits provided by conserving and restoring blue carbon ecosystems, and how these can be measure and quantified
- focusing on the coordination of blue carbon stakeholders to push forward the blue carbon agenda, especially in the UK

In the past 18 months the charity has also championed blue carbon as a climate solution through three key initiatives. In June last year, Blue Marine convened and hosted the UK's first Blue Carbon Conference, to create a sense of community among those engaged in the subject, and build ambition ahead of the COP26 summit in Glasgow. 'Blue Carbon: a New Frontier for Conservation?' brought together leading international scientists and policymakers to share evidence about the human impact in the health of blue carbon.

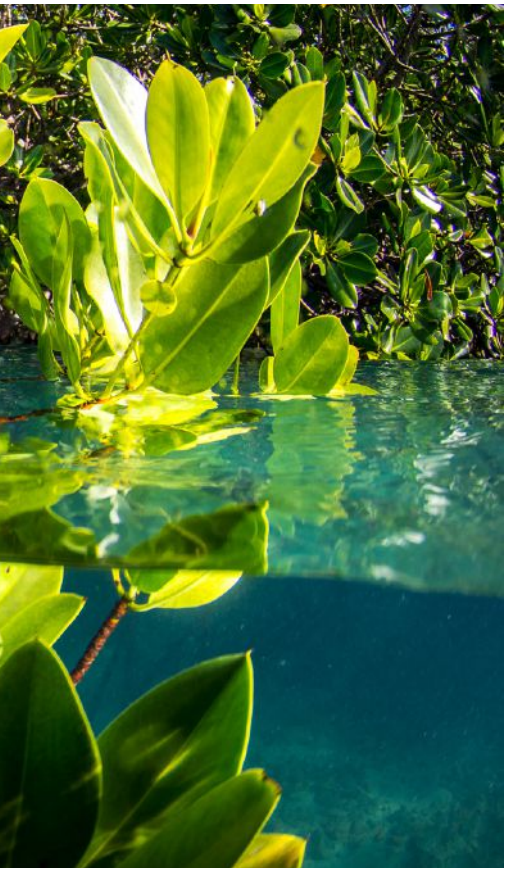
In an all-day program, conference delegates recognised the need for better coordination between scientists, government agencies, and NGOs and for putting sustainable ocean management at the core of climate change agendas. They agreed that commercial activities at sea, such as deep-sea trawling, must be at the core of debates on the health of the ocean, and therefore of the environment, which makes the engagement of coastal communities and broader politics crucial for the success and growth of blue carbon projects.

Throughout COP26 itself, Blue Marine showcased blue carbon habitats on a huge screen in the meeting's key Blue Zone. This was a video version of an interactive digital platform, theseawebeathe.com, narrated by British actor Stephen Fry and developed by Blue Marine in partnership with Bristol creative agency Green Chameleon. Submerging viewers in precious habitats such as mangroves, and connecting them almost tangibly to the natural climate solutions of the ocean, the platform went on to win an award at the 2021 Webbys, the Oscars of the internet.

While COP26 was running, Blue Marine announced its co-foundation of the UK Blue Carbon Forum, a group of more than 60 research institutions, government agencies and NGOs, that it brought together to share evidence and ambitions, and try to expedite smart policy on this topic. Through the connections afforded by the Forum, these groups are now able to refine and coordinate multiple workstreams that share the same goal.

The Forum exists to strengthen the link between climate mitigation and ecological benefits. It also seeks to improve communications and build support for nature-based solutions, as well as standardising and aligning methodologies to accurately assess the blue-carbon potential of habitats. In addition, its goal is to support a route for a blue-carbon market to give economic value to ecosystem services, and pave the way for future opportunities to restore and conserve blue-carbon habitats.

But perhaps the most ambitious and innovative of Blue Marine's interventions on blue carbon is launching this year. Once more in partnership with the University of Exeter, the Convex Seascape



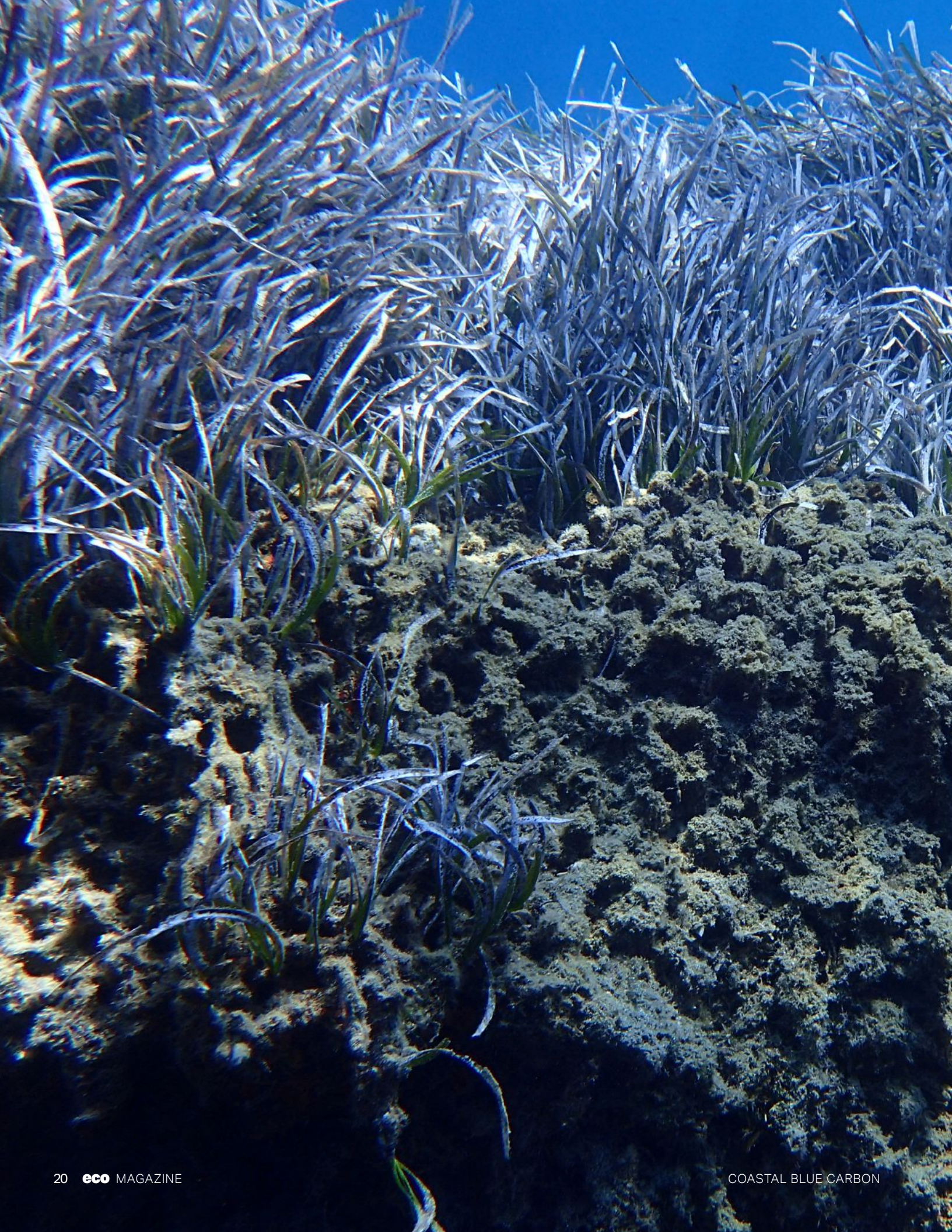
Survey is a research project that will encompass nine institutions and 16 expeditions. The multi-million-dollar funding that has made it possible comes not from a national research council but through a private donation, from Stephen Catlin of Convex Insurance, who has funded two previous huge ocean research projects, one looking at the Arctic, and one at the world's coral reefs.

Spanning the next five years, the Convex Seascape Survey aims to answer key questions around the role in global climate change of shelf seabed carbon stores, the human influence on seascape carbon, and where this carbon is located. The Convex Seascape Survey will seek to examine three overarching themes: Seascape carbon, where is it, where did it come from, how did it get there and when; the human influence on seascape carbon; and the role of life and biodiversity on seascape stores

There has never before been a specific study of blue carbon on the scale of the Convex Seascape Survey. Blue Marine's research partners are some of the leading blue carbon and marine science institutions in the world, including the University of Exeter (UK); University of Utrecht (Netherlands); King Abdullah University of Science and Technology (Saudi Arabia); National Oceanography Centre, University of Southampton (UK); Plymouth Marine Laboratory (UK); Sheffield University (UK); Bangor University (UK).

The hope is that the survey will shine a light on the true capacity of the ocean as a carbon sink, and the co-benefits it provides. Its findings have the potential to drive the proper integration of the ocean into global political efforts to address climate change. Blue Marine is a champion of a seascape-wide approach. Highly Protected Marine Areas could be a crucial tool in combating climate change, as well as delivering the many co-benefits that have already been established through the use of Marine Protected Areas, which has been so successful in protecting those four million square kilometres of sea.

Blue carbon is the gift of an ocean intact and healthy, thriving at full potential — a solution on a grand scale, based in nature. Blue Marine believes the blue carbon message is simple and clear: if we save the ocean, the ocean will save us.



Seagrass As Blue Carbon

By Dr. Mark S. Fonseca (CSA Ocean Sciences) and Dr. Stacey M. Trevathan-Tackett (Deakin University)

If you have not put March 1st on your calendar, you are probably not alone. On May 23, 2022, the United Nations adopted a Sri Lankan-sponsored resolution declaring March 1st as 'World Seagrass Day,' recognizing the importance of seagrasses as carbon sinks and the wide range of ecosystem services they provide. Historically, however, unlike charismatic ecosystems such as rain forests, coral reefs, or terrestrial savannahs, you would be lucky to find movingly narrated documentaries extolling the virtues of seagrasses. Lacking that special 'x-factor,' seagrass meadows are rarely considered vacation destinations, and few government programs are dedicated to their conservation. Often submerged and out of sight, sometimes with unappealing common names like "eelgrass," these arguably monotonous ocean meadows are not widely held as a natural wonder. But in Australia, areas of the Mediterranean, and other locales worldwide, seagrasses are beginning to penetrate the public's awareness and are slowly achieving a more charismatic status.

This emergent awareness is appropriate because the unsung seagrass ecosystem is one of the most productive on the planet, generating production levels that rival subsidized croplands. Moreover, their unique position in shallow coastal waters, limited only by water clarity, creates an oasis for many species, including fish, sea turtles, crabs, octopuses, urchins, sponges, clams, squid, and many other easily recognizable organisms. In one square meter, seagrass can shelter hundreds of small fish, shrimp, crabs, and other animals and plants, acting as a nursery and foundation for ecologically and economically valuable species. Seagrasses also slow currents and waves and stabilize the seafloor and nearby shorelines. But it is their ability to capture massive amounts of carbon that is propelling seagrass ecosystems into the limelight.

Most seagrasses have a lifestyle not unlike lawn grasses (although they are actually not a grass and are more closely related to lilies) spreading across the seafloor by tillering and branching horizontally through the top centimeters of sediment while also setting seed. As a result, they can form massive meadows easily seen from space. While individual seagrass plants may only live for a few weeks, they can exist as a genetically related and persistent meadow for tens of thousands of years as an interconnected, clonal organism. In fact, one giant clone in Australia was recently recognized as the world's largest single plant at approximately 200 square kilometers (77 square miles) or about the size of Washington, D.C.

Neptune Grass *(Posidonia oceanica)* in the Mediterranean atop its massive root and runner necromass, dating back hundreds or thousands of years. Blades are approximately 50 cm long. (Photo credit: Oscar Serrano)

Currently, there are estimated to be between 177,000 to 600,000 km² of seagrasses worldwide[1] (the latter being roughly the size of Texas). However, that number continues to decline due to human development of the coastal oceans and estuaries[2]. For example, Waycott et al. estimated that seagrass was disappearing at a rate of 110 km²/yr since 1980 and that 29 percent of the known area has disappeared since seagrass areas were initially recorded in 1879. This loss has destabilized shorelines, disrupted food supplies, and had cascading effects on food webs, one of the most notable resulting in the regional mass starvation of manatees in Florida.

While seagrasses (like all plants) are light-limited and only live in comparatively (to the rest of the ocean) shallow waters, they (quoting from McKenzie et al. [2020]) "account for less than 0.2 percent of the world's oceans but are responsible for 10 percent of the carbon stored in the oceans annually. Up to 83,000 metric tons of carbon is stored in sediments of seagrass meadows per square kilometer; twice as much as the carbon stored in temperate and terrestrial forests. This makes them a vital component in combating global climate change." That is the mass of about nine Great Pyramids of Egypt per year.

Because this carbon being stored by seagrass is in the ocean, it qualifies as "blue carbon." Like other blue carbon ecosystems, seagrass ecosystems fix and sequester or capture carbon in two important ways. First, the CO_2 seagrasses absorb or 'breathe in' during photosynthesis and gets converted and captured as carbon in their leaves, underground roots, and rhizomes. When the seagrasses die, many leaves are exported from their home by waves and currents. However, some of the leaf material, belowground roots, and rhizomes are buried within the ecosystem. If not consumed or decomposed by microbes and animals, this seagrass carbon has the potential to be sequestered and stored in the sediments. The Mediterranean *Posidonia oceanica* belowground matte is one of the most impressive forms of seagrass necromass.

The second way seagrasses capture carbon is by trapping passerby carbon from carbon-rich soil, sediment, water, and plant material traveling from land to sea. The seagrass leaves collectively slow down the water flow, allowing the foreign carbon to settle and, depending on local waves and currents, be sequestered into the sediment. While there is a great deal of variability in carbon capture by seagrasses worldwide, about half of the carbon in seagrass sediments comes from seagrasses themselves[3].

Depending on the seagrass species, that captured carbon is turned into animal or microbial biomass relatively quickly, as in the case of the genus *Halophila*, within weeks or months. However, in contrast to *Halophila* communities, some seagrasses such as the ancient *Posidonia* or Neptune Grass beds in the Mediterranean bury carbon into the sediment at a rate 35 times faster than tropical rainforests[4] and can form enormous root and runner mats that hold carbon for centuries.

Carbon that gets fixed but is rapidly reallocated to another ecosystem component is said to be labile. Labile blue carbon is also important, such as that which is flushed through large *Halophila*-dominated ecosystems. For example, there is about 800,000 ha of annual *Halophila* off the west coast of Florida in the Gulf of Mexico. Together with benthic microalgae, *Halophila* turns over massive amounts of carbon annually and may fuel much of the eastern Gulf of Mexico nearshore food web. Similar findings can be found worldwide although not always recognized in descriptions of how coastal ecosystems funtion.

Erosional scarp at the edge of an eelgrass (*Zostera marina*) bed on Long Island, New York, showing the exposed complex of carbon-sequestering runners. (Photo credit: Chris Pickerell). Blades are approxmately 20 cm long.

Seagrass carbon capture, unfortunately, is vulnerable to human impacts, such as climate change-related shifts in temperature and salinity/precipitation, as well as physical losses arising from impacts like boating scars, dredging, and nutrient pollution. Loss of seagrass and other blue carbon ecosystems leads not only to the loss of carbon inputs (from the seagrass and trapping of external carbon) but can also lead to the loss of sediment carbon that has been sequestered for decades to millennia. Carbon that gets captured and held in seagrass beds, particularly in the root and runner sediment matrix, is vulnerable to loss and release if the beds are damaged. Re-establishment of the carbon captured in old seagrass bed sediments can take hundreds of years to achieve, such as those of Neptune Grass[5] (other temperate species may only take a decade or less). The full recovery of these ancient seagrass beds is on a scale akin to the re-establishment of a mature, terrestrial redwood forest.

This conversion of captured carbon into greenhouse gases could mean seagrass carbon sinks could turn into carbon sources. For example, the 2010/2011 Shark Bay heatwave in Australia[6] led to a loss of more than a third of the seagrass cover, as well as a loss of stored carbon up to 4 Tg CO_2-eq since the die-off. This is equivalent to increasing emissions by 4-8 percent per year for that country alone.

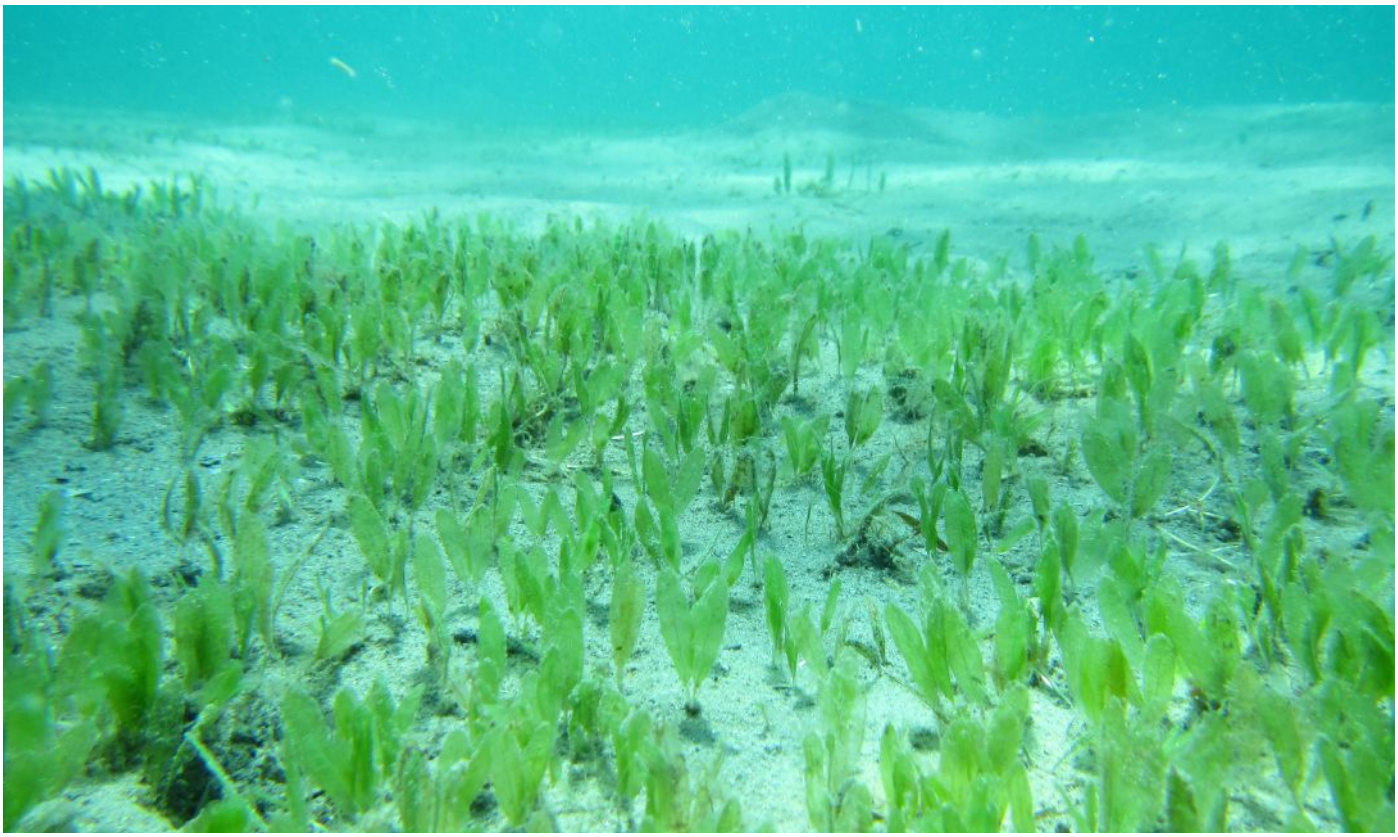
Despite these current and future challenges, there is some good news. As we now are well into the United Nations Decade on Restoration, groups from around the world comprising of scientists, government, industry, and citizen scientists are working to conserve and restore these vital ecosystems. New guidance is emerging from many quarters, and responses to watershed-scale sources of impacts are being recognized, and their mitigation funded. While seagrass restoration comes with challenges, research shows that restoration by transplanting and seeds are sometimes viable solutions for returning ecosystem function. In fact, restoration along the East Coast and the Gulf of Mexico has the potential to help seagrass return carbon stocks to pre-loss levels[7].

Seagrasses, with their charisma appreciated by a limited audience, remain, like many marine ecosystems, a global asset beset by challenges and opportunities. With their ability to exist in estuaries, seagrasses have a unique capacity to claim new geography as the sea level rises. Their ability to accommodate increased CO_2 enrichment of the oceans and their many ways of capturing and sequestering carbon mean they are poised to become even more prominent in the blue carbon equation.

In the meantime, remember to put March 1st on your 2023 calendar and treat yourself to a snorkel in a seagrass bed!

Discover more:

1. McKenzie et al. 2020 *Environmental Research Letters*. https://iopscience.iop.org/article/10.1088/1748-9326/ab7d06/meta
2. Waycott et al. 2009 *PNAS*. https://www.pnas.org/doi/10.1073/pnas.0905620106
3. Kennedy et al. 2010 *Global Biogeochemical Cycles*. https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2010GB003848
4. Macreadie et al. 2015 *Proc. R. Soc. B*. http://dx.doi.org/10.1098/rspb.2015.1537
5. Mancini et al. 2022 *Marine Pollution Bulletin*. https://doi.org/10.1016/j.marpolbul.2022.113683
6. Serrano et al. 2021 *Ecosystem Collapse and Climate Change*. https://link.springer.com/chapter/10.1007/978-3-030-71330-0_13
7. Greiner et al. 2013 *PLoS One*. https://doi.org/10.1371/journal.pone.0072469



A diminutive seagrass species (Paddle grass, *Halophila decipiens*) from the Indian River Lagoon, Florida, USA. Blades are approximately 2-3 cm long. (Photo credit: Mark Fonseca)

Marine Protected Areas:
Part of the Climate Solution Through Blue Carbon

Well-managed marine protected areas (MPAs) protect valuable blue carbon habitats and processes, and they must be included in global and national mitigation and adaptation responses to climate change. Coastal and marine ecosystems play a significant role in the global carbon cycle – sequestering and storing carbon over long timescales.

This presentation reviews the latest science on oceanic and coastal carbon sequestration, raises awareness of the critical importance of the role these systems play, and highlights guiding principles for MPA managers to improve their understanding and management of blue carbon.

To demonstrate application of these ideas, a case study from Greater Farallones National Marine Sanctuary in California is presented, along with lessons learned and next steps.

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AquaTech Eco Consultants (ATEC) was founded in 2014 by Beau Williams after leaving a very successful seagrass restoration career with Seagrass Recovery, Inc. ATEC staff has successfully transplanted, repaired and grown several species of seagrasses and SAV for more than 200 seagrass projects within the United States and the Caribbean. Many of the restoration projects typically achieve measurable results within 12-18 months. Techniques utilized by ATEC have been scientifically peer-reviewed and approved by NOAA as well as by the Florida Fish and Wildlife Conservation Commission.

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IUCN is a union for nature. It is made up of more than 1,400 Member organisations from national governments and civil society, a powerful global force for conservation policy and action on the ground.

IUCN also combines the research and work of more than 18,000 scientists and experts into six IUCN commissions. Separately, the IUCN Secretariat is headquartered in Switzerland, but equally operates through eleven regional offices around the world to make IUCN policy reality, covering over 160 countries.

This diversity and vast expertise make IUCN the global authority on the status of the natural world and the measures needed to safeguard it.

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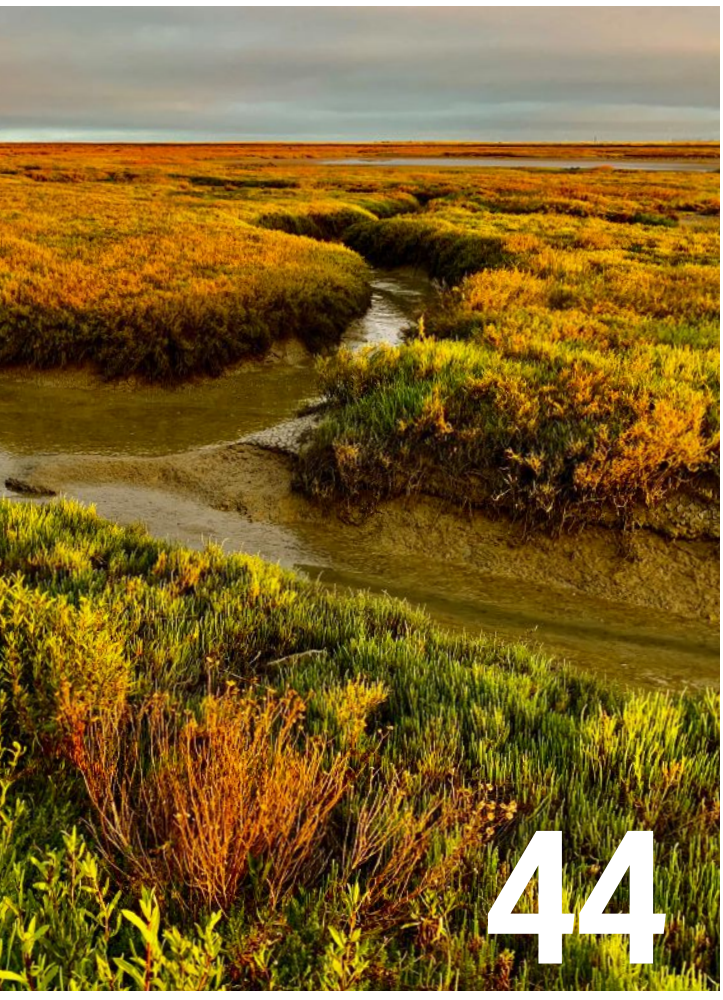
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Policy and Finance

| Photo Credit: Lorenzo Mittiga, Ocean Image Bank

Climate Debt and Carbon Credits – Planning for a Just Transition

By Elizabeth Francis, Lead Project Developer, Fair Carbon and Professor Mark Huxham, Centre for Conservation and Restoration Science, Edinburgh Napier University

When the IPCC published its special report on the feasibility of limiting anthropogenic global warming to 1.5°C this was the quietly devastating summary. In more trenchant language, it called for 'rapid and unprecedented societal transformation' (IPCC 2018; p77) to allow this theoretically possible target to be met. The world's governments mostly endorsed the report and then mostly ignored it. Four years on, the target teeters on the edge of impossibility.

Even if we do achieve the target of 1.5°C the outcomes it implies could be bleak for many ecosystems, including coral reefs. Warm water corals are already committed to functional extinction. But of course, all warming above this level is even worse. So, we must redouble the fight for 1.5°C and align all of our actions to this goal.

What does this mean for Nature-based Solutions (NbS)?

The report describes four illustrative model pathways to 1.5°C by 2100, which incorporate a range of economic, social, and technological assumptions. Three of these pathways assume little or no 'overshoot', whilst one pathway models a world which reaches around 1.7°C above pre-industrial levels, before then cooling back to 1.5°C. These pathways remain our best roadmaps, even if overshoot now looks all but inevitable.

Vanga tree measuring

All pathways imply reaching net zero emissions around 2050. The three pathways with 'little or no overshoot' involve large scale protection and then expansion of forests and other natural sinks. Pathway 1 is the only scenario that does not rely on bioenergy with carbon capture and storage (BECCS). Because carbon capture and storage remains untested and speculative at scale, relying on it as a sole solution could prove dangerous. As such, Pathway 1 is preferred on grounds of biological and technological realism. It projects turning the current net loss of forests to an increase in forested land of up to 9.5 million km² by 2050. In general, options for mitigation using NbS 'are dominated by reduced rates of deforestation, reforestation and forest management, and concentrated in tropical regions' (IPCC Report, p329). Hence the arguments for ecosystem protection and restoration that rest on climate science are compelling, and this is especially the case for the tropics.

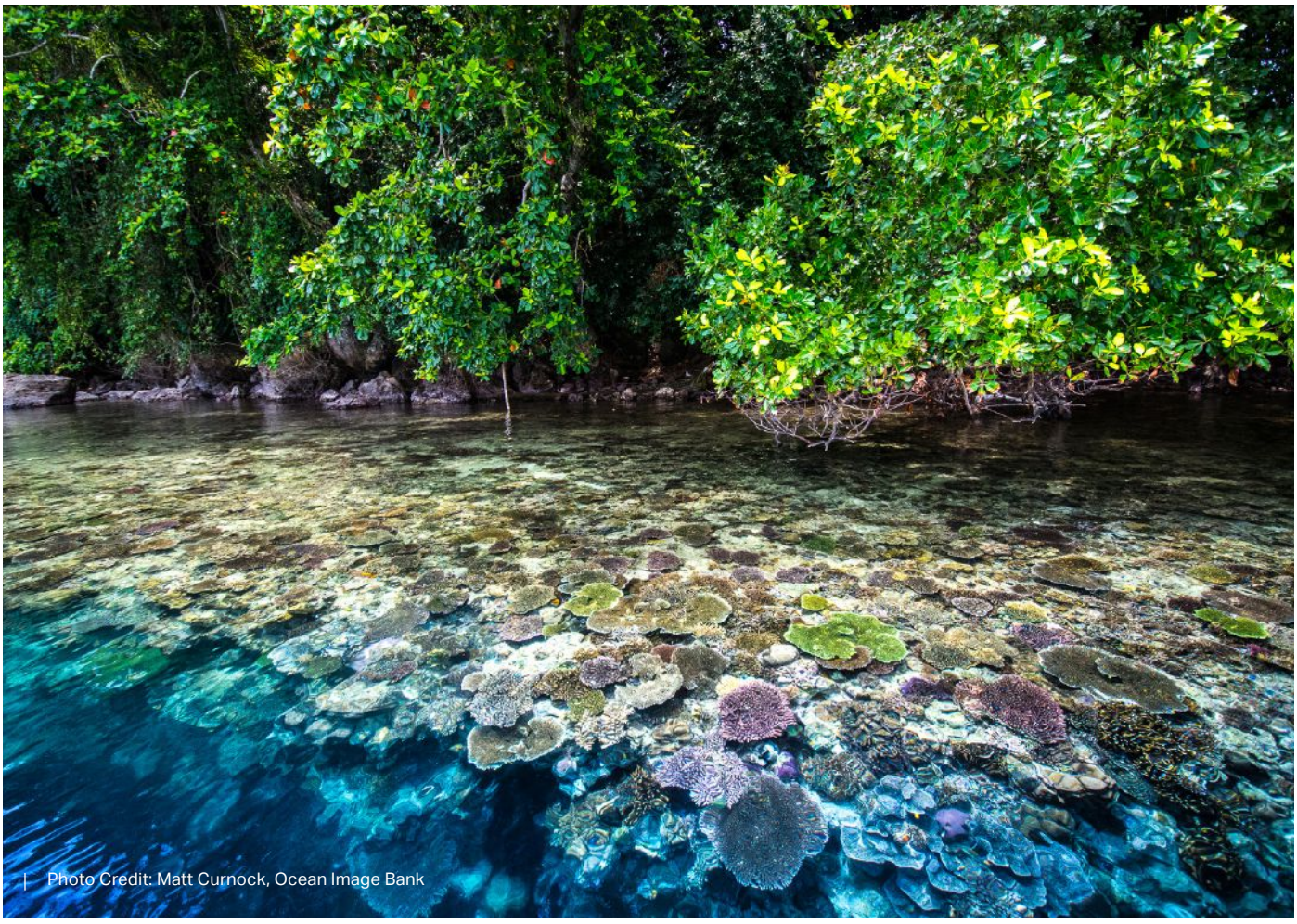
Selling carbon credits on the Voluntary Carbon Market (VCM) is one way to achieve this, with many projects already demonstrating how this can bring new funding for conservation. We know some of the difficulties and risks involved. Double counting (where more than one agent claims the carbon credit), moral hazard (where offsetting is used as an excuse to avoid cutting emissions), carbon colonialism (where powerful outside interests expropriate natural assets) and greenwash (where companies make token investments to burnish tarnished brands) must all be avoided if nature-based credits are to make a genuine contribution to the climate emergency.

What is clear is that offsetting must always come after emission reductions and a push for systemic change towards net zero. But the urgency of the crisis and the proximity of that global net zero target means another challenge is emerging that remains largely ignored or unnoticed by VCM stakeholders.

If we are able to reach net zero by mid-century then carbon offsetting activities, at least by much of civil society and carbon-light industries, may no longer be needed. In theory, emissions will have gone, with offsetting playing its small part in helping the transition. Carbon projects under design now, with typical lifetimes of at least 25 years, must incorporate plans for income after net zero. We should be clear, in our communications and our actions, that carbon offsetting is a transitional tactic, and we should be designing for a world that does not need to offset, but which does need to expand payment for the protection and expansion of carbon rich ecosystems.

The significant upfront costs associated with VCM projects mean many must make returns to investors that can last throughout the project's lifetime. In a net zero world, the sustainability of these projects is threatened due to a lack of credit income, putting local communities at risk of losing their livelihoods and undermine the permanence of stored carbon. Accounting for this future should be integrated into the financial forecasting for projects currently under design.

How then can projects receive the income necessary to continue conservation, bring revenue to local communities and repay investors? They should consider potential future sources of



| Photo Credit: Matt Curnock, Ocean Image Bank

revenue such as ecotourism, non-timber products and, perhaps, sustainable harvesting of wood. They should examine partnering with those sectors that the IPCC predicts will struggle the most to eliminate emissions and, therefore, may still require offsets beyond 2050 (such as agriculture). But a large funding gap will remain, both for existing projects and for the considerable expansion in effort on NbS that is needed.

It is time to look at debt repayment. Global North nations are responsible for 92 percent of the cumulative excess emissions, adjusted for population size, above a safe CO2 concentration of 350 ppm (Hickel, 2020). Sea level rise, increased tropical storms, drought and species migration, will continue well beyond a net zero world and are the responsibility of the largest emitters, nations and companies to correct.

In recent years, some corporations have embraced their climate responsibilities by more closely aligning their goals with public demand for sustainability. But accountability must endure past 2050 to repay historic harm to the world's climate. Repayment of previous harm can be made through reparations payments to nations or projects to ensure they have the capacity to conserve ecosystems and protect livelihoods. Hence, we need to look at legacy credits, encourage those businesses (such as Microsoft) who are already considering historical emissions and start building a pipeline that will bring the necessary finance to where it needs to be spent.

Such a system could be established under existing international processes, such as the United Nations Framework Convention on Climate Change (UNFCCC). This acknowledges the differentiated responsibilities for historical carbon emissions and has tools like The Adaptation Fund that could help direct reparation payments into NbS projects. However, VCM projects would be unwise to rely on such unwieldy international agreements. Instead, the sector needs to engage with civil society and foster a broad conversation on climate debt. This will not be easy, however, the logic is compelling, and there are visionary individuals and companies willing to lead the way.

1.5°C may now be beyond reach. This realisation should galvanise all our efforts to limit global heating. For NbS projects using the VCM, this means making the case, loudly and confidently, for the conservation and protection of ecosystems and planning for a world where offsetting of current emissions is no longer needed.

References

Hickel, J (2020). Quantifying national responsibility for climate breakdown: an equality-based attribution approach for carbon dioxide emissions in excess of the planetary boundary. *Lancet Planet Health* 2020; 4: e399–404

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| Survey Gazi

The International Partnership for Blue Carbon: Connecting Multisector Partners

By Coordinator Team and Focal Group of the International Partnership for Blue Carbon

The International Partnership for Blue Carbon (IPBC; www.bluecarbonpartnership.org/) connects national government agencies with non-governmental organisations, intergovernmental organisations and research institutions from around the world, with a joint vision to protect, sustainably manage and restore global coastal blue carbon ecosystems, contributing to climate change mitigation, adaptation, biodiversity, ocean economies and livelihoods of coastal communities. The Partnership was launched at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties (COP 21) in Paris in 2015 by nine founding Partners and has since expanded to more than 50 Partners in 2022.

Together, Partners hold an extensive range and depth of knowledge and expertise on blue carbon science, policy development and program implementation. Government Partners especially benefit from being directly connected with global blue carbon

practitioners, enabling them to gain insights into the latest blue carbon science, international policy developments and creating opportunities for action. The diversity and expertise of Partners is a fundamental strength of the Partnership. It enables the Partnership to be recognised as a source of credible information, tools and guidance, which are made available to all countries, organisations, governments or individuals that wish to make a difference in blue carbon protection and restoration.

To achieve its vision, the Partnership's activities are directed towards contributing to three goals:

1. Increase international commitments to protect coastal blue carbon ecosystems.
2. Improve national policies to conserve, protect and restore coastal blue carbon ecosystems.
3. Accelerate on-the-ground implementation of blue carbon conservation, protection and restoration activities.

Increasing International Commitments to Protect Coastal Blue Carbon Ecosystems

Government commitments under the Paris Agreement and through Nationally Determined Contributions (NDCs) and National Adaptation Plans (NAPs) are a key driver for countries to develop and implement national climate change policies for greenhouse gas mitigation and adaptation. To support increased international commitments on blue carbon, the Partnership organises high profile side events at the UNFCCC Conference of the Parties. However, Partners also interact with other global conventions and frameworks such as the Ramsar Convention on Wetlands of International Importance, the UN Convention on Biological Diversity (CBD) and the 2030 Agenda for Sustainable Development, which have long recognised coastal ecosystems as critical to biodiversity and livelihoods. Similarly, Partners are engaging in global ocean policy as related to the blue economy, fisheries, reef health and human-derived impacts on the ocean, and are leading conversations on Nature-based Solutions. Raising awareness of the mitigation and adaptation potential of coastal blue carbon ecosystems among these forums strengthens the case for protection and can lead to international commitments by country governments.

Learn more about the international frameworks and conventions that value coastal blue carbon ecosystems in this overview:

> https://bit.ly/3OcHeTx

Improving National Policies to Conserve, Protect and Restore Coastal Blue Carbon Ecosystems

Nationally Determined Contributions under the Paris Agreement offer a globally accepted mechanism for countries to state their own climate change commitments and are a key driver for countries to develop and implement national climate change policies for greenhouse gas mitigation and adaptation. Frameworks for reporting international climate change commitments under the Paris Agreement have been established through decisions of the UNFCCC and rely on the implementation of technical guidance from the Intergovernmental Panel on Climate Change (IPCC). The IPCC Guidelines for National Greenhouse Gas Inventories and the 2013 IPCC Wetlands Supplement provide methods to aid countries estimate emissions and removals of greenhouse gases from managed coastal wetlands (mangroves, seagrasses, and tidal marshes) and drained soils, for reporting blue carbon in their national inventory. These guidelines provide a solid basis for countries to develop their national reporting of emissions and removals to track efficacy of climate mitigation policies. However, gaps in science and data, as well as limited technical capacity and institutional arrangements, can present barriers to credible greenhouse gas emissions and removals reporting, which subsequently can hinder national policy development and implementation of emission reduction activities. The Partnership helps disseminate knowledge and connect expertise on blue carbon science, inventory reporting and policy development and assists in identifying opportunities for collaborative engagements among Partners. A suite of training materials is made available to Partners through a dedicated online catalogue of resources and via ad hoc workshops (www.bluecarbonpartnership.org/resources/).

Accelerating On-The-Ground Implementation of Blue Carbon Conservation, Protection and Restoration Activities

The Partnership recognises that, if implemented effectively, local or community driven on-the-ground blue carbon projects have the potential to provide biodiversity, food security and sustainable livelihoods benefits, but are also crucial to achieving global climate change goals now and in the future. To accelerate and scale up project implementation, the Partnership provides a platform for Partners (and the communities they work with) to share knowledge, expertise and experience in implementing blue carbon projects (such as the recent virtual Knowledge Exchange Session) and encourages collaboration between projects and programmes. Importantly, the Partnership also investigates potential sources of blue carbon financing. This may include direct engagement with private sector businesses or organisations to ascertain barriers and identify approaches for investment, or with international finance mechanisms.

Spotlight on IPBC Partners Activity: The Blue Carbon Accelerator Fund

The Blue Carbon Accelerator Fund (BCAF; www.bluenaturalcapital.org/bcaf/) is an initiative delivered in partnership between the Australian Government and the International Union for Conservation of Nature (IUCN), with a vision to support blue carbon restoration and conservation projects in developing countries and to help prepare for private sector investment in these Nature-based Solutions.

The BCAF was originally conceived through the IPBC, whose expert Partners identified the gap between the supply of market-ready projects and finance as a barrier to implementing blue carbon restoration and conservation. In 2021, Australia and the IUCN initiated the BCAF to assist developing countries to restore and protect their blue carbon ecosystems.

Design decisions also include addressing more specific obstacles that were identified by the IPBC to scaling up blue carbon restoration, such as complexity of project set-up and early-stage support, brokering interest from the private sector, and monitoring for both carbon and non-carbon outcomes.

The BCAF will provide funds to help project developers prepare projects for future private finance – growing the global portfolio of credible and investment-ready blue carbon projects. Funding will also support the actual on-the-ground restoration and conservation activities that provide measurable benefits, addressing climate change mitigation and adaptation while supporting biodiversity and coastal communities. All BCAF-supported projects will have access to technical guidance, collaborative networks and exposure to opportunities for future financing.

The BCAF builds on the strong work and templates for success of the Blue Natural Capital Financing Facility (BNCFF), which supports a wide variety of marine and coastal conservation projects on their path to becoming sustainable, climate resilient blue natural capital businesses that appeal to private investors.

Go to Chapter 2 page 36 for a BNCFF podcast series on Investing for Ocean Impact.

Spotlight on IPBC Partners Activity: The Global Ocean Decade Programme for Blue Carbon

The Global Ocean Decade Programme for Blue Carbon (GO-BC; www.oceandecade.org/actions/global-ocean-decade-programme-for-blue-carbon/) is one of the programmes under the banner of the United Nations Decade of Ocean Science for Sustainable Development (2021-2030), which will contribute to generating new knowledge and solutions to the impacts of climate change and other stressors on the ocean through collaborative approaches, as well as reducing the gaps between science and policy. GO-BC recognises the multiple roles blue carbon ecosystems play beyond mitigation, including adaptation and resilience to the effects of climate change. The main objectives of the programme are to:

- Co-design and implement new research to promote Nature-based Solutions for better ocean sustainability.
- Enhance global to regional collaborative efforts.
- Coordinate capacity building in blue carbon science.
- Communicate and deliver outputs to policy makers and communities.

Joining the IPBC

INTERNATIONAL PARTNERSHIP FOR BLUE CARBON

Organisations and countries seeking IPBC membership should have the capacity or the ambition to contribute to international efforts to protect and restore coastal blue carbon ecosystems.

There is no fee for joining the Partnership. However, Partners are asked to actively participate or contribute to IPBC activities through:

- hosting of workshops or side-events at international climate change or other relevant meetings
- allocating in-kind resources to participate in policy and technical discussion groups, or to support
- communication and guidance products funding or in-kind support for administration and communication activities of the IPBC secretariat.

Interested organisations can contact the IPBC Coordinator ON ipbc@awe.gov.au to become a Partner or to collaborate with the Partnership on current activities and engagements.

> www.bluecarbonpartnership.org/the-partnership/

> https://bit.ly/3ne7IHP

The Earth is in trouble.

Investing for Ocean Impact

A new podcast that helps demystify ocean investments for both the conservation and private finance world

Discover the reasons to invest in our ocean in *Investing for Ocean Impact* – a podcast brought to you by the International Union for Conservation of Nature (IUCN).

The ocean and the world's coastlines offer many solutions to help us tackle climate change and the biodiversity crisis. But currently, these solutions do not receive enough money to realize them. While governments and philanthropists should provide more funding, investments from the private sector are equally key to success.

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The time to invest in our ocean is now.

IUCN BNCFF Blue Natural Capital Financing Facility

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Global thinking around financing ocean conservation is changing. Are we on the right path? And what does the future of ocean investments look like?

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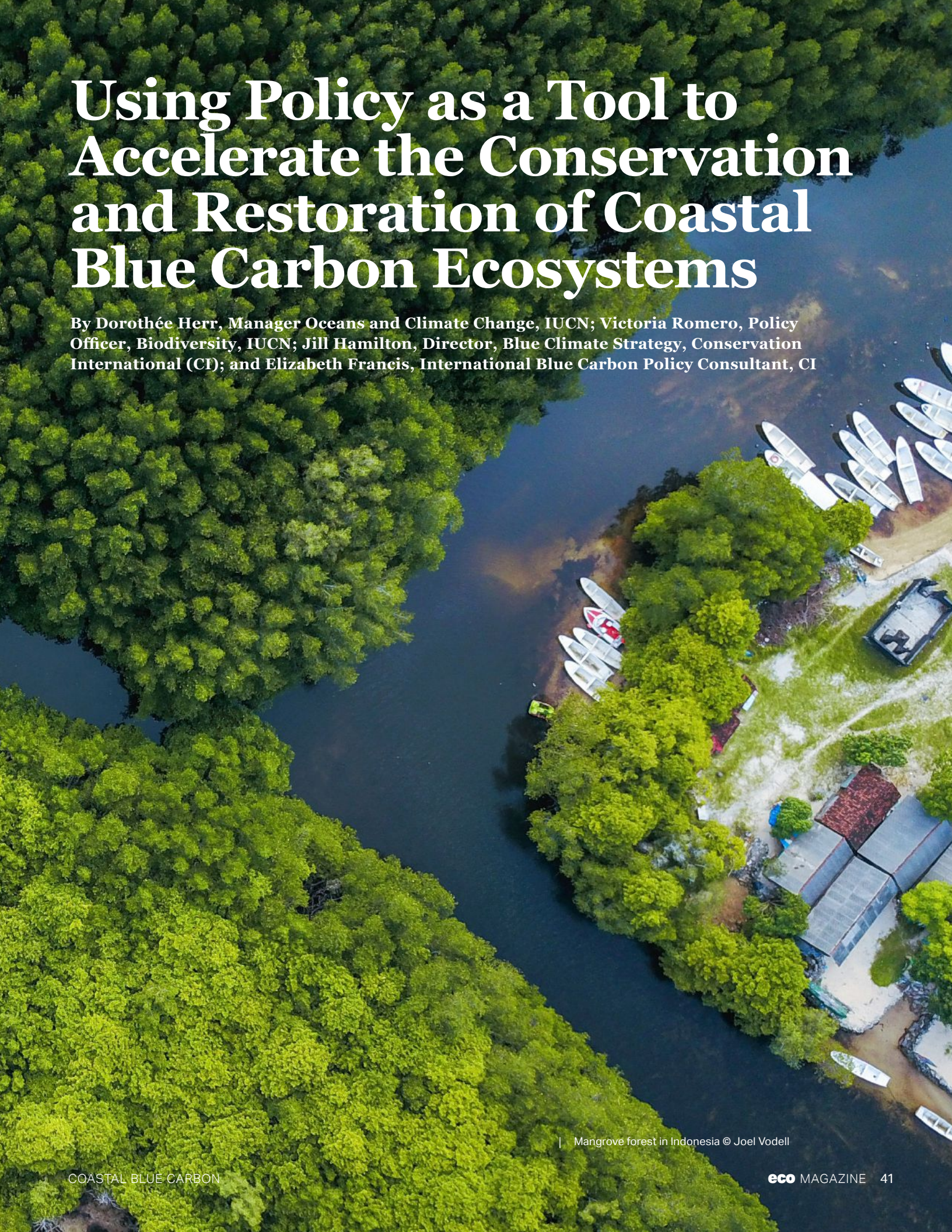
Get ready for Season 2 with our UN Ocean Conference special

In 2015, the world agreed to ambitious goals to create a more sustainable future for us all: the Sustainable Development Goals. Seven years later – ahead of the UN Ocean Conference – we decided to take stock of SDG 14 and ask three leading experts the questions: Are we swimming? Or are we drowning?

Our UN Ocean Conference special sets the stage for the second season of *Investing for Ocean Impact,* which is dropping on your favorite podcast platform in October 2022.

Using Policy as a Tool to Accelerate the Conservation and Restoration of Coastal Blue Carbon Ecosystems

By Dorothée Herr, Manager Oceans and Climate Change, IUCN; Victoria Romero, Policy Officer, Biodiversity, IUCN; Jill Hamilton, Director, Blue Climate Strategy, Conservation International (CI); and Elizabeth Francis, International Blue Carbon Policy Consultant, CI



| Mangrove forest in Indonesia © Joel Vodell

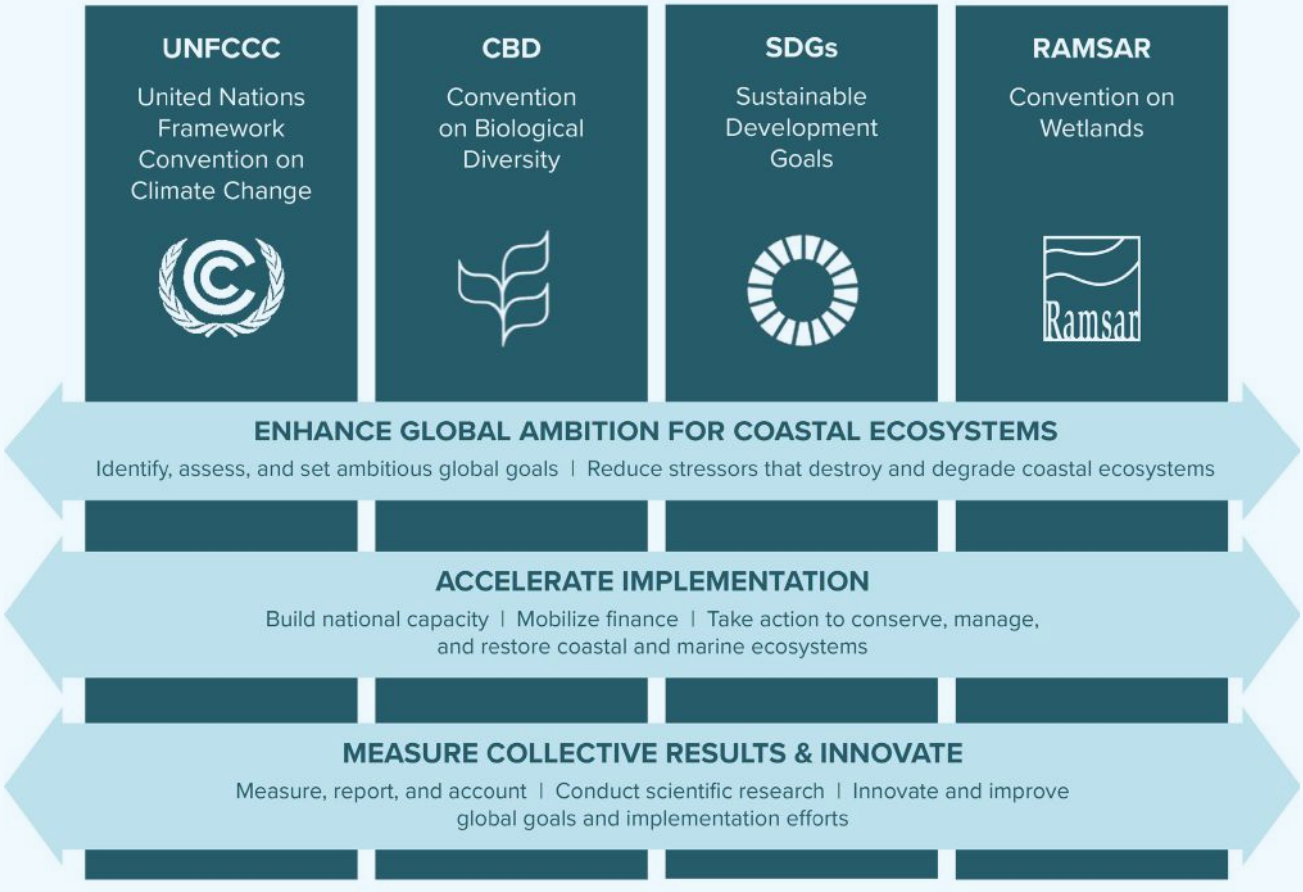
If you have made it this far into this Blue Carbon Special edition, then you know that coastal blue carbon ecosystems, including mangroves, seagrasses and tidal marshes, are critically important for humanity and the survival of our planet. They protect coastlines from erosion by dissipating wave energy, taking the first brunt of increasingly strong storms, providing critical habitat for numerous species of fish, birds and other animals, protecting coastal communities, and sequestering and storeing vast amounts of carbon, helping to mitigate climate change and, maybe most importantly, to adapt to it. Many coastal communities also create an income from and around blue carbon ecosystems: as fishermen and women, as scientists, and as tourism operators, among many other roles.

Recognizing that most environmental issues are best addressed through international cooperation, today there are a myriad of international policy processes meant to address the pressing challenges of climate change, biodiversity loss and sustainable development. The world of international policy – one of conference centres and country name plates; far away from mangrove forests – plays a key role in increasing global action to conserve and protect coastal blue carbon ecosystems. Within these international policy processes, such as the United Nations conventions on climate change and biodiversity, countries come together to set ambitious goals, take on-the-ground action at the national level, and share what they have achieved to date.

However, while numerous international policy processes exist to tackle pressing environmental issues, many of these processes were established decades ago, in isolation from each other, often making it difficult for countries to collaborate across their closely-related themes of climate change, biodiversity and sustainable development.

To help address this challenge, Conservation International and IUCN, along with partners, are working to accelerate the conservation and restoration of blue carbon ecosystems globally by increasing synergies across these often siloed, disconnected conversations. The United Nations Framework Convention on Climate Change (UNFCCC), the 2030 Agenda and related Sustainable Development Goals (SDGs), the Ramsar Convention on Wetlands, and the Convention on Biological Diversity (CBD) are the key policy processes relevant to conserving and restoring blue carbon ecosystems. Shifting from traditionally siloed approaches to integrated approaches across these policy processes holds the potential to deliver high-quality outcomes for coastal blue carbon ecosystems, which will allow countries to

1) enhance ambition,
2) accelerate implementation and
3) measure results (Figure 1).



| Figure 1. Opportunities to align actions across policy processes to enhance ambition, accelerate implementation, and measure results.

Here are some of the key reasons to support increased synergy and collaboration across policy processes, and steps countries can take to achieve these goals:

(1) Aligning goals for blue carbon ecosystems can increase global ambition, leading to more – and better — outcomes on the ground.

Setting ambitious goals – whether you're a government, business, or private citizen – can serve as a guidepost for action. For countries working within international policy processes, this crystalizes in the development of ambitious commitments related to tackling the climate, biodiversity and sustainable development challenges, and developing strategies to achieve them. Some examples of countries' commitments include Nationally Determined Contributions (NDCs) under the UNFCCCC, and National Biodiversity Strategies and Action Plans (NBSAPs) under the CBD.

Ideally, the commitments and national plans that countries make would be closely aligned and lead to a coherent set of national-level policies to tackle climate change, biodiversity loss and sustainable development – however, they seldom do.

Aligning goals and related commitments for blue carbon ecosystem conservation and restoration across international policies and countries' national-level plans can promote streamlined on-the-ground action and lead to stronger future commitments. Capitalizing on synergies across international policy processes can enable the creation of more ambitious goals while simultaneously accelerating the achievement of these goals across processes.

(2) On-the-ground conservation and restoration can be implemented more efficiently and effectively.

After setting ambitious goals for conserving and restoring blue carbon ecosystems, countries must take action on the ground. Following through on commitments made in Nationally Determined Contributions (NDCs), National Biodiversity Strategy and Action Plans (NBSAPs) and National Development Plans requires knowledge, capacity and funding. Aligning support for on-the-ground action across policy processes can ease capacity and financial limitations by facilitating easier pathways to implementation.

On-the-ground action is often hindered by a lack of information, understanding and technical capacity to effectively conserve and restore blue carbon ecosystems. Information and guidance provided by groups such as the Intergovernmental Panel on Climate Change (IPCC), the Ramsar Scientific and Technical Review Panel (STRP), and others can be leveraged to supplement, inform, and build capacity to implement coastal restoration and conservation national policies, programs and projects. Similarly, guidance and work conducted by programs, expert groups and thematic groups across policy processes can be integrated into blue carbon projects.

(3) Supporting synergies can promote innovation and better measurement of conservation and restoration outcomes.

Measuring results from on-the-ground conservation and restoration work, and innovating to move efforts forward, are essential to meeting the goals set for blue carbon ecosystems, and the broader international goals and targets agreed upon under these policy processes. Using a common set of indicators to measure progress across policy processes would serve as a key step forward.

Scientists, project developers and, above all, the coastal communities depending on the services, benefits and jobs they derive from the coastal blue carbon ecosystems need more funding and financing to achieve high-quality conservation and restoration projects on the ground. In many cases, it's the international policy negotiations, and ultimately the recognition of common priorities, that can help unlock crucial support for these communities and countries.

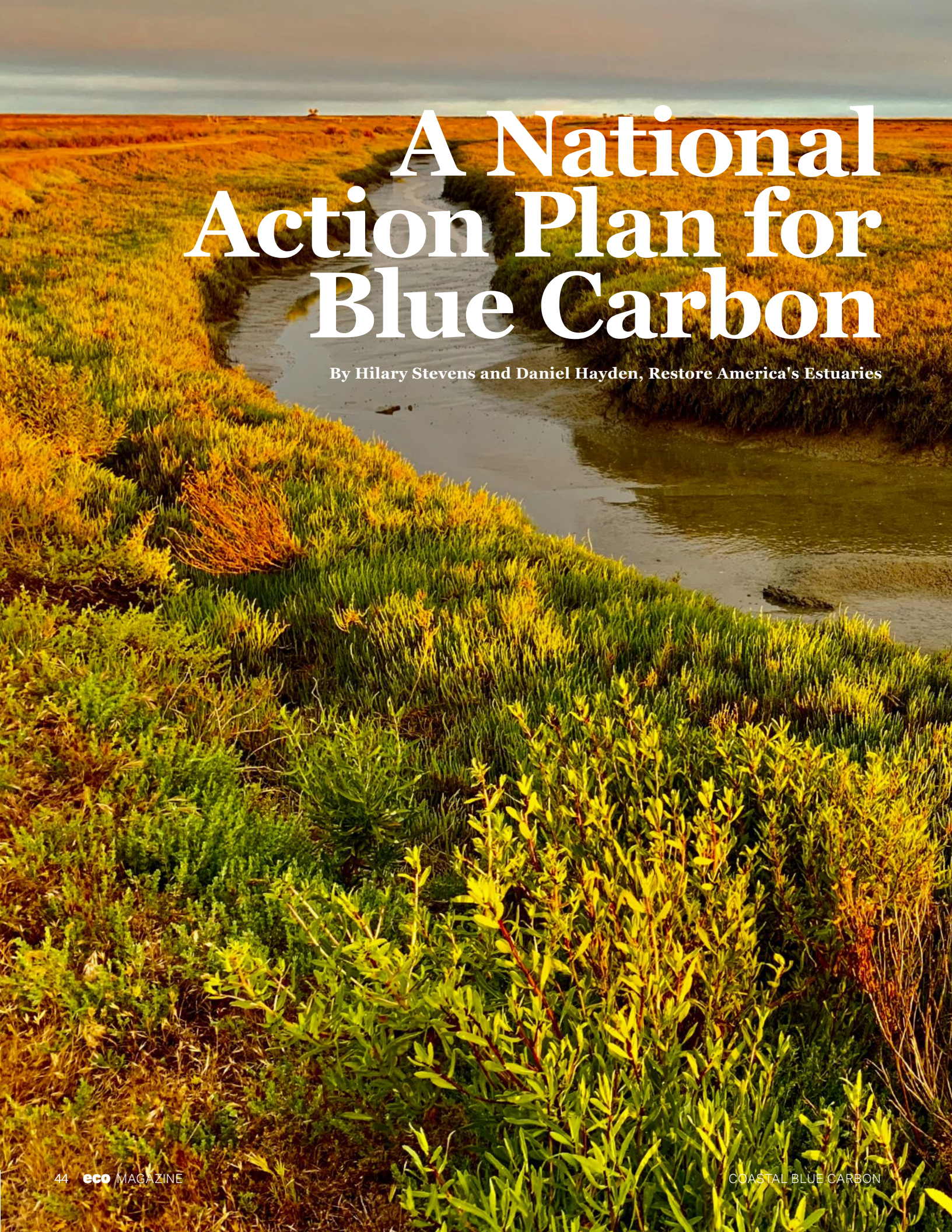
Further details on how the conservation and restoration of coastal blue carbon ecosystems can be accelerated and enhanced through aligned international policies, including recommendations for countries to take action, can be found in Conservation International and IUCN's Blue Carbon Policy Framework[1]. We welcome your feedback on the draft framework, which is available for consultation. A final version of the framework will be shared later this year.

1. https://static1.squarespace.com/static/603e674744293f085766ad7d/t/62a45e04609e520572f7c0e8/1654939286198/Draft+Blue+Carbon+Policy+Framework+for+Consultation

Red Mangrove displaying impressive arching root system. Shot in Exuma Cays Land and Sea Park, Bahamas. © Jeff Yonover

A National Action Plan for Blue Carbon

By Hilary Stevens and Daniel Hayden, Restore America's Estuaries



If you are one of the roughly 130 million Americans living along the coast, you likely pass a coastal wetland, tidal river, or estuary on your ride to work or visit one on the weekend to relax. Whether the ecosystem is comprised of a waterfront park, salt marsh, working port, or the seagrass and oyster beds below the surface, for those living in coastal regions it is a reminder of the value these ecosystems provide in maintaining water quality, reducing flood risk, supporting vibrant wildlife and fisheries, and healthy communities.

We are learning more every day about how coastal ecosystems benefit everyone – not just people who live on the coast. As the climate becomes more volatile, coastal ecosystems impede floods and protect property. Just as importantly, they sequester large amounts of carbon dioxide from the atmosphere. In vibrant coastal ecosystems, plants draw carbon from the atmosphere and transform it into leaves, stems, and roots that are buried over time, a process that happens in mangroves and coastal wetlands up to ten times faster than mature tropical forests, according to NOAA research.

While there are many laws at the federal, state and local levels that protect coastal ecosystems, the US continues to lose wetlands every year. Importantly, according to research from Restore America's Estuaries (RAE), there are no federal laws or regulations that recognize the role coastal ecosystems play in sequestering carbon and there are no administrative guidelines on which agencies should assess and protect their value. Consequently, RAE is working to promote policies that would address the policy gaps, clearly recognize the role of blue carbon in climate change mitigation, and foster carbon markets to stimulate restoration and promote conservation.

Benefits of Coastal Ecosystems

The need to protect and restore our coastal ecosystems transcends their climate benefits. Coastal areas are small places with huge benefits – while comprising just four percent of continental US landmass, they are home to 40 percent of the US population and 47 percent of the economy, according to a recent RAE analysis.

Eight of the ten largest cities in the US are on the coasts. Coastal wetlands protect these urban areas, including their ports that are so critical to the supply chain, from flood damage. According to the Nature Conservancy, lands behind existing salt marshes have, on average, 20 percent less property damage from storm surge when compared to areas where salt marshes have been lost.

Estuaries function as nursery grounds for our most valuable fisheries, and are also among the most popular destinations for recreation. In many areas, estuaries underpin cultural heritage, including food sovereignty of Indigenous peoples.

Estuaries also play a vital role in carbon cycling and climate change. In these ecosystems, most of the carbon is stored stably below ground. To date, coastal wetlands are the only marine ecosystem for which the Intergovernmental Panel on Climate Change has developed methodologies for measuring carbon dynamics – an essential element in brining carbon credits to market. Restore America's Estuaries and its partners have invested in the methodologies to bring these credits to the market. One missing element is the ambiguity of policy and support at the federal level.

Recommendations for a National Blue Carbon Action Plan:

Restore America's Estuaries developed a National Blue Carbon Action Plan that has four core Actions:

1. Advance an "all of government" approach to Blue Carbon through dedicated resources and coordination of Federal activities including a research agenda.
2. Strengthen protections for Blue Carbon ecosystems.
3. Remove barriers to Blue Carbon restoration projects.
4. Advance policies and funding that support climate-related financing, public-private partnerships and market-based mechanisms.

Action #1: Advance an "all of government" approach to Blue Carbon through dedicated resources and coordination of Federal activities including a research agenda.

We Recommend:

- Creating a Blue Carbon Interagency Working Group within the U.S. Global Change Research Program.
- Developing a map of high priority Blue Carbon ecosystems.
- Including a national research program within the strategic plan to improve our understanding of carbon flux in coastal and nearshore ecosystems.
- Developing authoritative model(s) that coastal managers and project proponents can use to estimate greenhouse gas emissions.

Action #2: Strengthen protection for Blue Carbon ecosystems.

We Recommend:

- Impacts to carbon sequestration are considered under the Clean Water Act Section 404 program, where appropriate.
- All coastal states revise their coastal zone management programs to consider strategies to increase carbon sequestration and prevent emissions through degradation.
- The Council on Environmental Quality consider Blue Carbon ecosystems in its review of the 2016 Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews.
- The National Marine Fisheries Service work with regional fishery management councils to consider designating Blue Carbon ecosystems as habitat areas of particular concern.
- Strengthening cooperation with landowners around federally managed coastal areas.

Action #3: Remove barriers to Blue Carbon restoration projects.

We Recommend:

- Congress and the Administration assess the best practices for streamlining permitting in support of restoration and incorporate improvements into agency regulatory programs.
- Congress and the Administration direct agency land holders who manage coastal landscapes (e.g. USFWS, National Park Service) to identify opportunities for Blue Carbon protection and restoration and assess barriers for implementation.

Action #4: Advance policies and funding that support climate-related financing, public-private partnerships, and market-based mechanisms.

Incorporate strategies to conserve Blue Carbon into existing federal programs

Healthy coastal wetlands provide carbon capture and storage services "for free." There is an opportunity for the U.S. to better account for this climate mitigation role and dedicate funding to prevent further loss and accelerate restoration.

We Recommend:

- USDA modify the Wetland Reserve Program to incentivize farmers in coastal areas to limit soil erosion.
- EPA's Brownfields Program be utilized to increase Blue Carbon.
- The federal government scale up demonstration projects on federally owned coastal lands.
- Federal agencies coordinate in support of a Blue Carbon grant program.

Create policies that incentivize dynamic public-private financing

| Photo Credit: Tanpa Bay Watch

Despite the Federal government owning 640 million acres of land — nearly 30 percent of the U.S. — it lacks a legal framework to complete carbon development projects. For that reason, these projects occur predominately on private land, where a landowner or non-profit entity retains unambiguous title to the carbon sequestration occurring on the property. As federal agencies look to finance habitat restoration, these agencies are missing an important funding source — private capital.

We Recommend:

- Congress explore the legislative changes needed to allow federal agencies to lease carbon rights on federally managed lands to support restoration projects that provide carbon sequestration.

Leverage market-based mechanisms

With infrastructure projects, it is sometimes impracticable to avoid environmental impacts, and the only solution is to offset those impacts by restoring degraded habitat. This practice is a form of "compensatory mitigation". A "mitigation bank" is a financial construct where one entity restores habitat and then sells credits to permittees who need them. From the perspective of a permittee, purchasing credits from a mitigation bank is typically more cost-effective than designing and implementing its own habitat restoration project.

There is no guarantee that a mitigation bank quickly sells its credits, meaning that sponsors must wait for credits to sell until they have the means to undertake new habitat restoration projects. For this reason, there is a strong interest in designing multipurpose or "joint banks" that would allow a mitigation bank to sell its credits under multiple regulatory programs. For example, a mitigation bank that restores aquatic habitat where imperiled species also benefit could sell credits to permittees under the Clean Water Act Section 404 program or under the Endangered Species Act.

We Recommend:

- Extending this concept to allow project proponents to sell verified carbon credits.

Conclusion

Coastal ecosystems are both beautiful and economically vital, and we now understand that carbon sequestration is another valuable benefit. However, we need more planning to identify which locations provide the greatest opportunity, more technical assistance to aid interested communities, and more flexibility in federal and state laws to facilitate carbon sequestration on public lands. By advancing the science, policy and markets we can invest in these places that provide us so much.

| Photo Credit: Save the Bay - San Francisco

| Photo Credit: Tanpa Bay Watch

Restore America's Estuaries Podcast

Restore America's Estuaries would like to thank Congresswoman Suzanne Bonamici (OR-1) for taking the time to join us and discuss important legislation she and her colleagues in Congress are working on to address the climate crisis and advance blue carbon science and research.

Rep. Bonamici has long been a leader on Blue Carbon in Washington, D.C., serving as the Co-Chair of both the Congressional Estuary Caucus and the House Oceans Caucus. In the interview, we'll take a deep dive into the win-win-win potential of coastal blue carbon ecosystems.

We hope you enjoy this conversation and feel free to reach out with any questions:

> www.estuaries.org.

Podcast:

Unlocking Carbon Finance for Wetlands While Ensuring Socio-Environmental Integrity

By Moritz von Unger (Silvestrum Climate Associates LLC), Femke H. Tonneijck (Wetlands International), and Cinthia Soto (Wetlands International)

The context for safeguarding and restoring our world's wetlands

Healthy wetlands store vast amounts of carbon in their soils and biomass, but they can become a huge source of emissions upon degradation. Peatland drainage and conversion causes no less than five percent of global emissions, despite occupying only three percent land area. Coastal wetlands, including mangroves, salt marshes and seagrasses, are also crucial carbon stores. Mangroves, for instance, typically hold five times as much carbon as a similar area of rainforest, according to the authors of "Mangroves among the most carbon-rich forests in the tropics" in *Nature Geoscience Journal* in 2011.

Wetlands are at the centre of the planet's triple crisis of climate change, biodiversity loss, and land degradation. More than two-thirds of natural wetlands have been lost or degraded, the vast majority of which has taken place over the past century, according to IUCN and Nick Davidson in his report on "How much wetlands has the world lost? Long-term and recent trends in global wetland area", published in 2014. Similarly, Global Wetland Outlook 2018 states that some 35 percent of wetland loss occurred between 1970-2015 alone, and annual rates of loss have accelerated overall since 2000.

The degradation of wetlands causes unimaginable destruction of biodiversity, as wetlands contain a greater concentration of life than anywhere else. Degraded wetlands fail to sustain essential ecosystem services such as food, freshwater supply, erosion prevention, and flood control; all vital in the context of climate change adaptation, sustainable livelihoods, and food security.

Upon degradation, wetlands keep on releasing massive amounts of CO_2 alongside CH_4 (methane) and N_2O (nitrous oxide) from their soils, adding to global warming. A staggering 0.86 billion tonnes of CO_2e[1] could be emitted from peatlands annually[2] and 2.4 – 3.4 billion tonnes CO_2e from mangroves[3] across the globe.

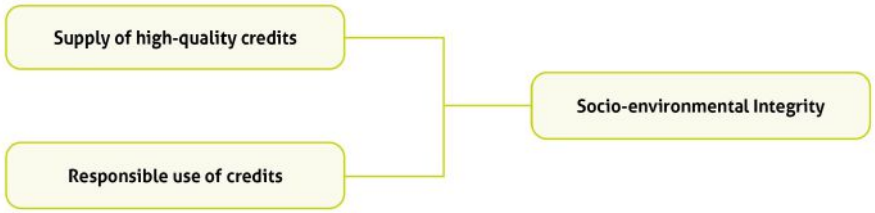
This should make protecting and restoring our wetlands a number one global priority. But we need the funding to do it, now. According to UN Environment (UNEP) in their report *State of Finance for Nature 2021,* mangrove restoration alone requires US $15 billion between 2021 and 2050.

Unlocking private finance for wetlands

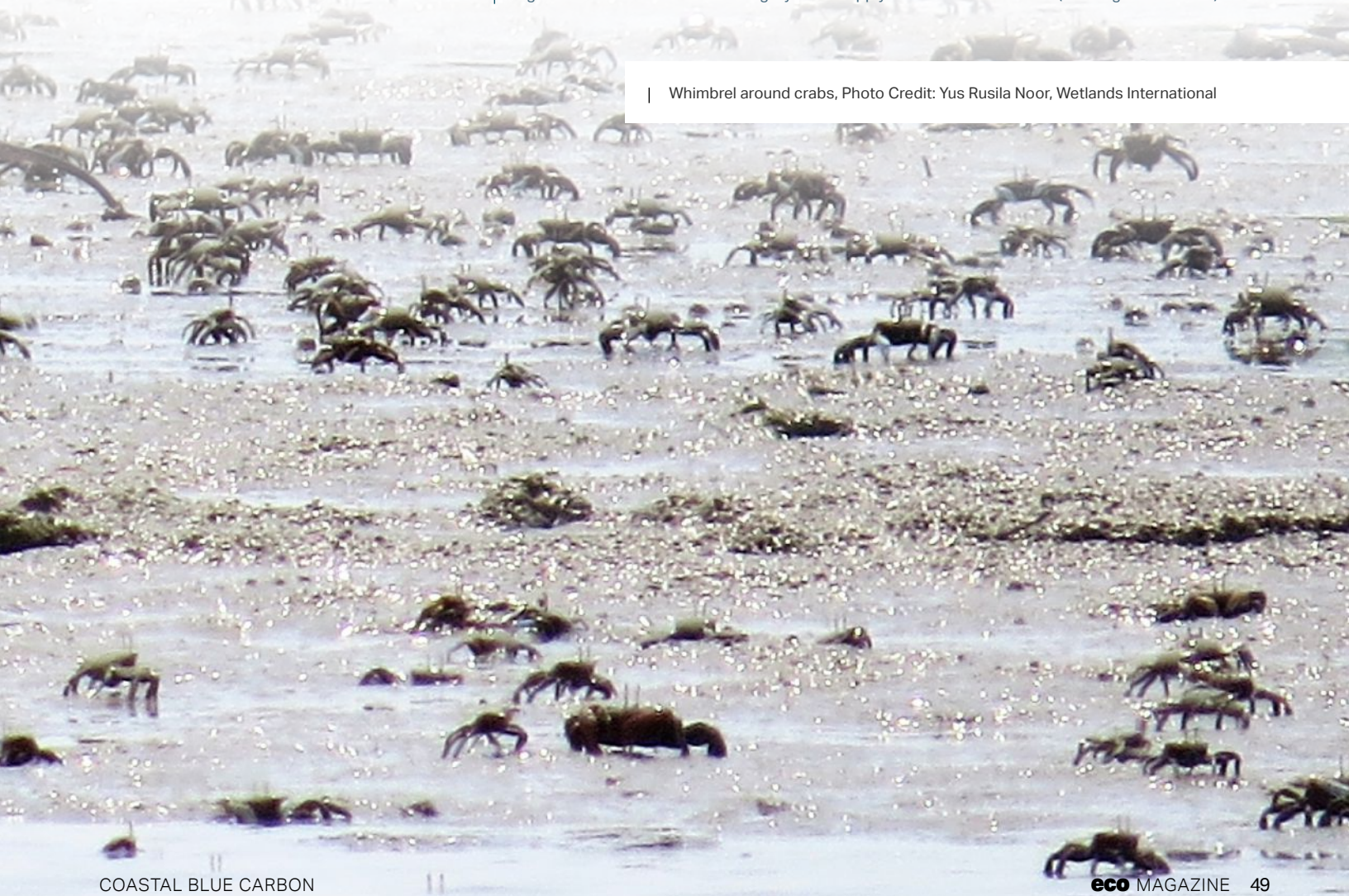
Governments and public financing cannot foot the bill with the urgency needed. Private sector funding must be mobilized at scale and at speed, and carbon markets offer a unique opportunity to channel domestic and international investment into wetland conservation and restoration.

Nature-Based Solutions (NBS) or Natural Climate Solutions (NCS) – including peat and coastal wetland conservation as well as restoration – could generate up to 12 billion tCO_2e in mitigation benefits per year, according to McKinsey report in 2021. This level of supply largely meets current expectations concerning the demand from voluntary carbon markets (1.5 - 2 billion tCO_2e). This is a means of supporting nature projects which was largely ignored by the Kyoto mechanisms. They have been a model for the design of new methodologies, at times paving the way for compliance markets, in which companies and governments who are regulated by mandatory national, regional, or international emission reduction regimes can trade their emission permits (allowances) or offsets to comply with their regulatory obligations.

Voluntary carbon markets have the potential to channel much-needed finance to wetlands in the short term. However, to permit habitat restoration of wetlands and other ecosystems at scale, the carbon price floor needs to lift considerably. Connected to this, socio-environmental integrity should constitute an all-decisive touchstone for climate and market success. A supply of high-quality credits which are fair, equitable, and accepted by the leading carbon credit verification bodies needs to be secured along with the responsible corporate climate action (see Figure 1).



| Figure 1: Socio-environmental integrity in the supply and demand of credits. (von Unger et al. 2022)



| Whimbrel around crabs, Photo Credit: Yus Rusila Noor, Wetlands International

Ensuring the supply of high-quality credits

Land-use carbon projects are, in essence, a means of achieving climate change mitigation impact. They need to be developed in close consultation with, and directed at positively impacting, local communities. Climate change mitigation can be achieved by either reducing or avoiding GHG emissions, or in the form of GHG removal or sustainable sequestration.

In the case of wetlands, both reducing conversion to other land-uses and degradation as well as restoration result in emission reductions (this is different in the case of forests, see table 1). On top of that, wetland restoration can result in emission removals. This is because most wetlands have very carbon rich soils – containing decomposing vegetation that has accumulated over millennia - that continue to emit GHG upon conversion and degradation or that continue to sequester GHG (albeit slowly) when restored. This makes the case for wetlands a no-brainer.

Over the past decades, voluntary carbon markets for NBS or NCS have been hotly debated, which has resulted in a set of quality benchmarks, safeguards and co-benefits that are defined and upheld by several voluntary carbon standards to guide and assess carbon projects. Complex topics notably include results-based-payments, baselines, additionality, leakage, non-permanence, stakeholder engagement, safeguards against negative impacts, and lastly co-benefits, such as enhanced biodiversity, resilience, and poverty reduction.

After two decades of practice, the key voluntary standards have proved that their land-use projects largely comply with high standards of quality. Effort is continuously being made to make them even more stringent. This means that supply of high-quality credits can be ensured.

Project action \ Impact	GHG Emission Reductions	GHG sequestration
Reducing conversion and degradation	• Forests • Wetlands	• Wetlands (albeit slowly)
Restoration	• Wetlands (particularly peatlands)	• Forests • Wetlands (particularly mangroves)

Table 1: Emission reductions and removals in the case of forests and wetlands. (von Unger et al. 2022)

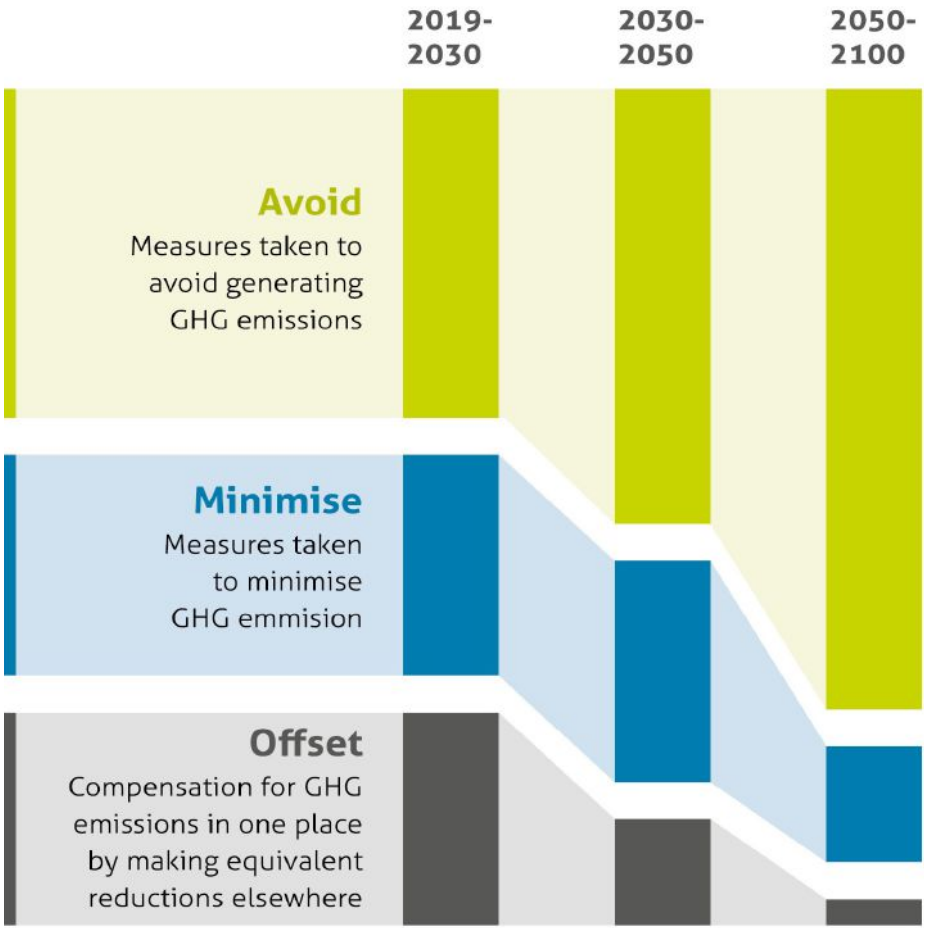


Figure 2: The mitigation hierarchy applied to climate action in a temporal dimension. (von Unger et al. 20220, adapted from World Business Council for Sustainable Development and Nature4Climate (2020))

Natural mangrove Senegal, by Pieter van Eijk, Wetlands International

Ensuring responsible use of credits

Much of the recent demand for credits is owed to "carbon neutrality" and "net zero" concepts that have caught on with many corporations. While there is extensive guidance on product-level carbon-neutrality claims, there is surprisingly little guidance at the corporate level concerning appropriate strategies for offsetting. This needs to be addressed urgently. And while net zero pledges have been growing, corporate performance to date is still relatively limited. Companies sitting idle far outnumber those taking an active position.

In the context of climate mitigation action, the mitigation hierarchy constitutes best practice, starting with GHG emissions avoidance, reductions and carbon stock restoration *within* the supply chain (each considered a form of *"insetting"),* and finally turning to compensation, implying emission reduction or sequestration efforts outside of the supply chain *("offsetting").* The role of offsets is to remedy residual (unavoidable) emissions, especially during the process of decarbonization (see Figure 2):

The mitigation hierarchy demands that the primary corporate responsibility is to avoid and reduce the GHG emissions in one's supply chain. In our context this pertains particularly to GHG emissions related to direct or indirect impacts on wetlands. Note that many sectors have a direct or indirect impact on wetlands which needs mapping, not only the land use sector. For example, the engineering sector affects coastal wetlands because seawalls and land reclamations cause changes in sediment dynamics or hydrology. Offsetting is a complementary measure to remedy interim and residual emissions on the pathway to net zero. In our view, as in Figure 2, we believe that offsetting is part of a broader decarbonization strategy which initially has higher volume needs (particularly during this decade, then decreasing) and which will allow corporations and investors to move to net zero targets in parallel with ambitious mitigation actions within and outside their supply chain.

Conclusions

If we are to reach the 1.5° target of the Paris Agreement, we need to urgently safeguard and restore wetland carbon stores to avoid emissions and enhance sequestration. Voluntary carbon markets present a funding opportunity to conserve and restore wetlands. Current key voluntary standards have gone a long way to develop and strengthen high standards of quality, particularly in the land-use sector. They are sufficient to take action now towards wetland conservation and restoration. And while robust standards and guidelines are essential, care should be taken not to make them overly complex, to ensure accessibility to practitioners and to enable urgent action at scale.

On the other hand, voluntary carbon markets must not be used to justify business-as-usual GHG emissions by companies if we are to achieve the 1.5° target. It is essential to guarantee environmental and social integrity also in the sense of ambition towards, and compliance with, a net zero pathway. Companies should set and disclose robust, science-informed, and high-ambition targets along with a roadmap with shorter- and longer-term milestones which follows the mitigation hierarchy. It is imperative that companies avoid and reduce emissions – particularly also those related to wetlands - while simultaneously offsetting residual emissions that cannot yet be addressed.

We believe that market mechanisms are just an instrument, whether they function well depends on clear, transparent, and fair rules.

Endnotes

1. CO_2e or "carbon dioxide equivalent" means the number of metric tons of CO2 emissions with the same global warming potential as one metric ton of another. Note that 1 tonne = 1000 kg = 1 million gram (106).
2. Huang, Y., Ciais, P., Luo, Y. et al. Tradeoff of CO_2 and CH_4 emissions from global peatlands under water-table drawdown. *Nat. Clim. Chang.* 11, 618–622 (2021). https://doi.org/10.1038/s41558-021-01059-w
3. Adame, M.F., Connolly, R.M., Turschwell, M.P., Lovelock, C.E., Fatoyinbo, T., Lagomasino, D., Goldberg, L.A., Holdorf, J., Friess, D.A., Sasmito, S.D., Sanderman, J., Sievers, M., Buelow, C., Kauffman, J.B., Bryan-Brown, D. and Brown, C.J. (2021), Future carbon emissions from global mangrove forest loss. *Glob Change Biol,* 27: 2856-2866. https://doi.org/10.1111/gcb.15571

This article is based on a policy report: von Unger, M., Tonneijck, F.H. and Soto, C. (2022). Voluntary Carbon Markets for Wetland Conservation and Restoration (Wetlands International). Further references can be found there.

Community member doing ecological mangrove restoration, Guinea Bissau, by Abdoulaye Ndiaye, Wetlands International

Picking mangrove fruits, Indonesia, by Nanang Sujan

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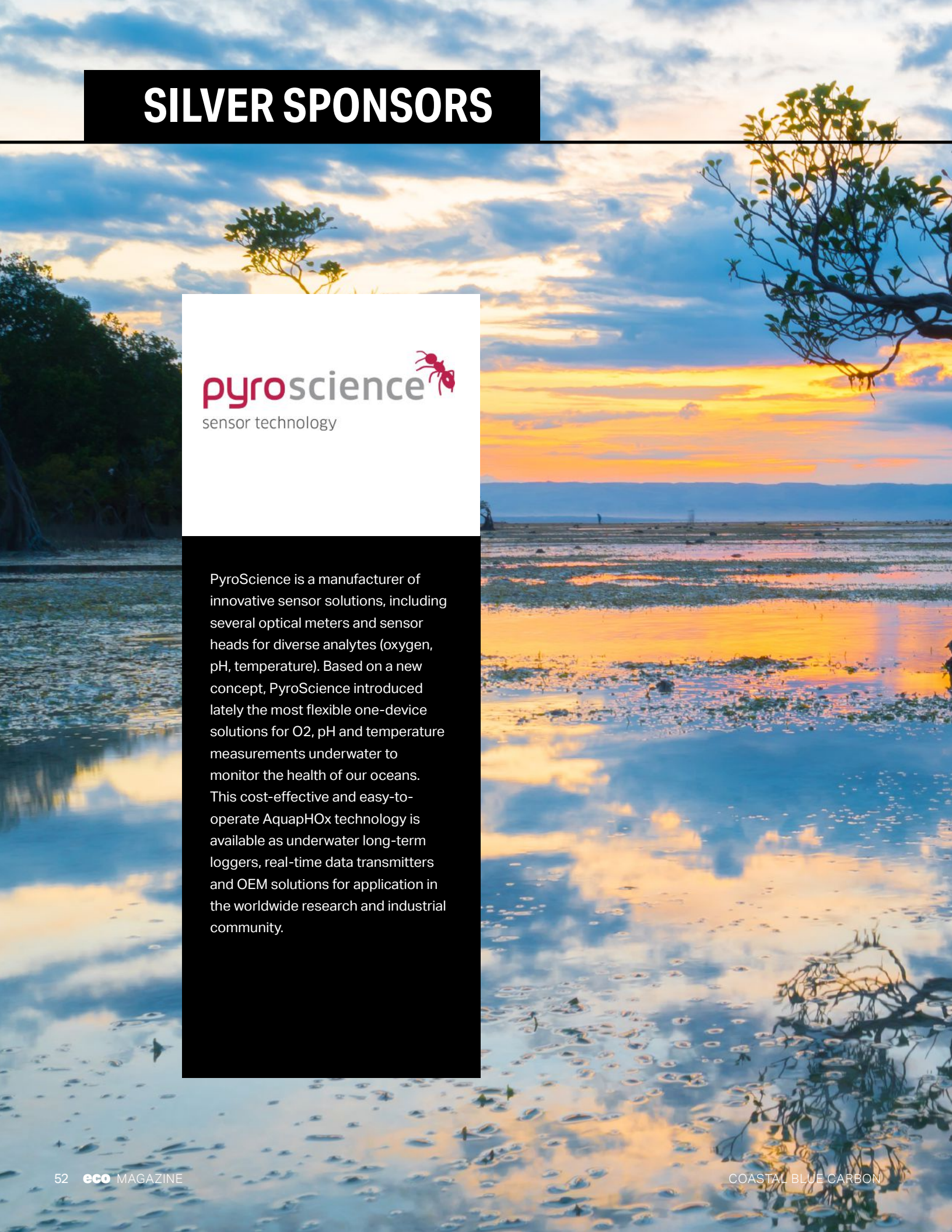

pyroscience
sensor technology

PyroScience is a manufacturer of innovative sensor solutions, including several optical meters and sensor heads for diverse analytes (oxygen, pH, temperature). Based on a new concept, PyroScience introduced lately the most flexible one-device solutions for O2, pH and temperature measurements underwater to monitor the health of our oceans. This cost-effective and easy-to-operate AquapHOx technology is available as underwater long-term loggers, real-time data transmitters and OEM solutions for application in the worldwide research and industrial community.

VERRA

Standards for a Sustainable Future

Verra is a nonprofit organization that operates the world's leading carbon crediting program, the Verified Carbon Standard (VCS) Program, as well as other standards in environmental and social markets. Verra is committed to helping reduce greenhouse gas emissions, improve livelihoods, and protect natural resources by working with the private and public sectors. We support climate action and sustainable development with standards, tools, and programs that credibly, transparently, and robustly assess environmental and social impacts and enable funding for sustaining and scaling up projects that verifiably deliver these benefits.


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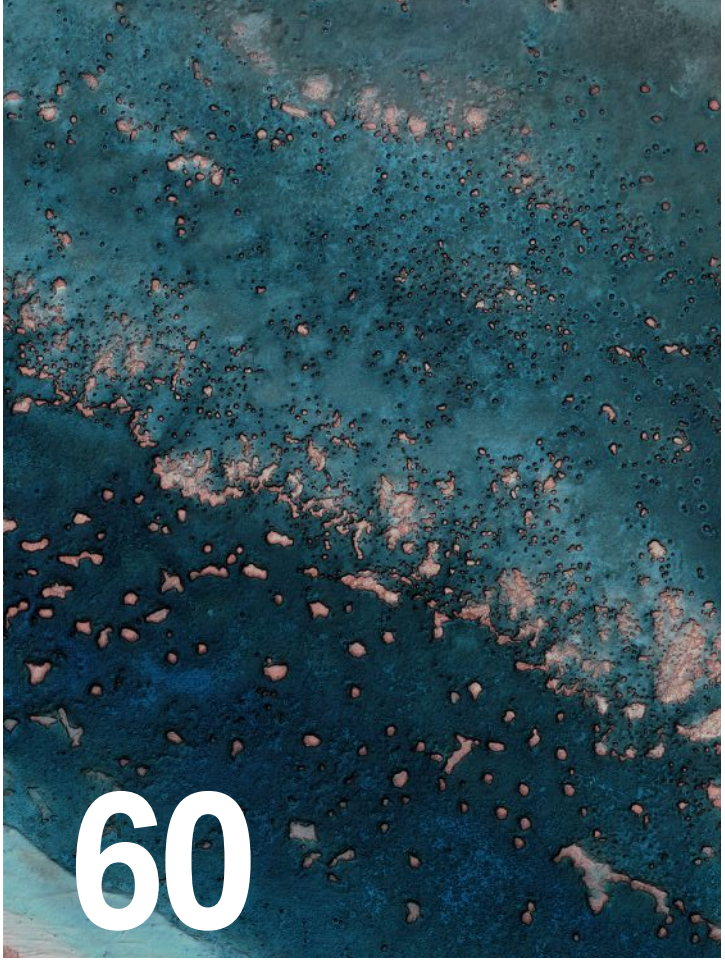
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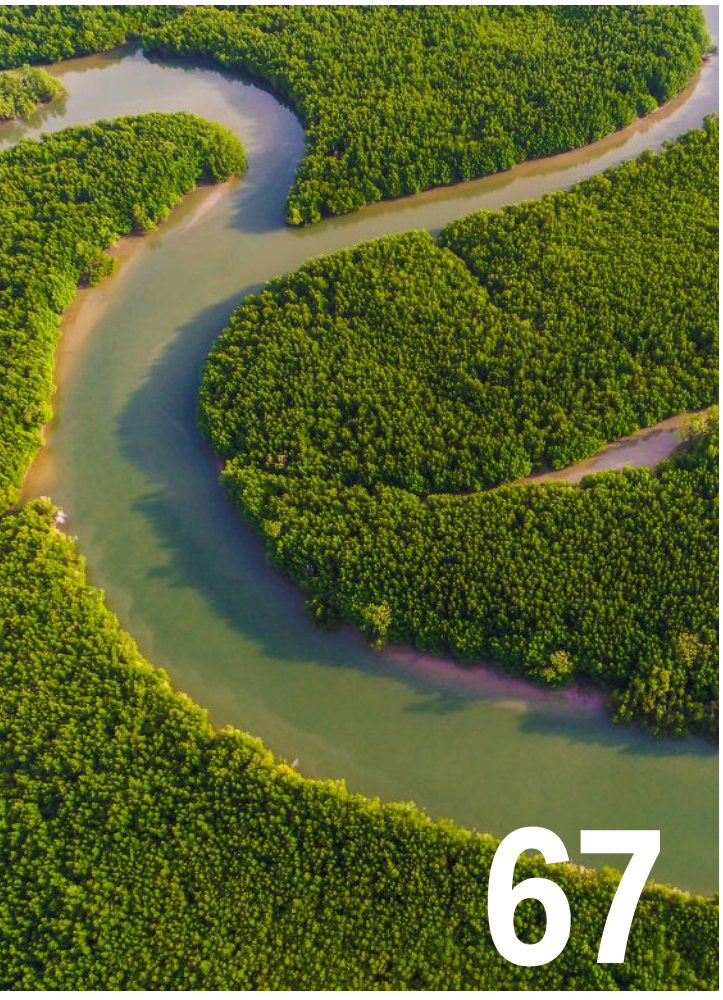
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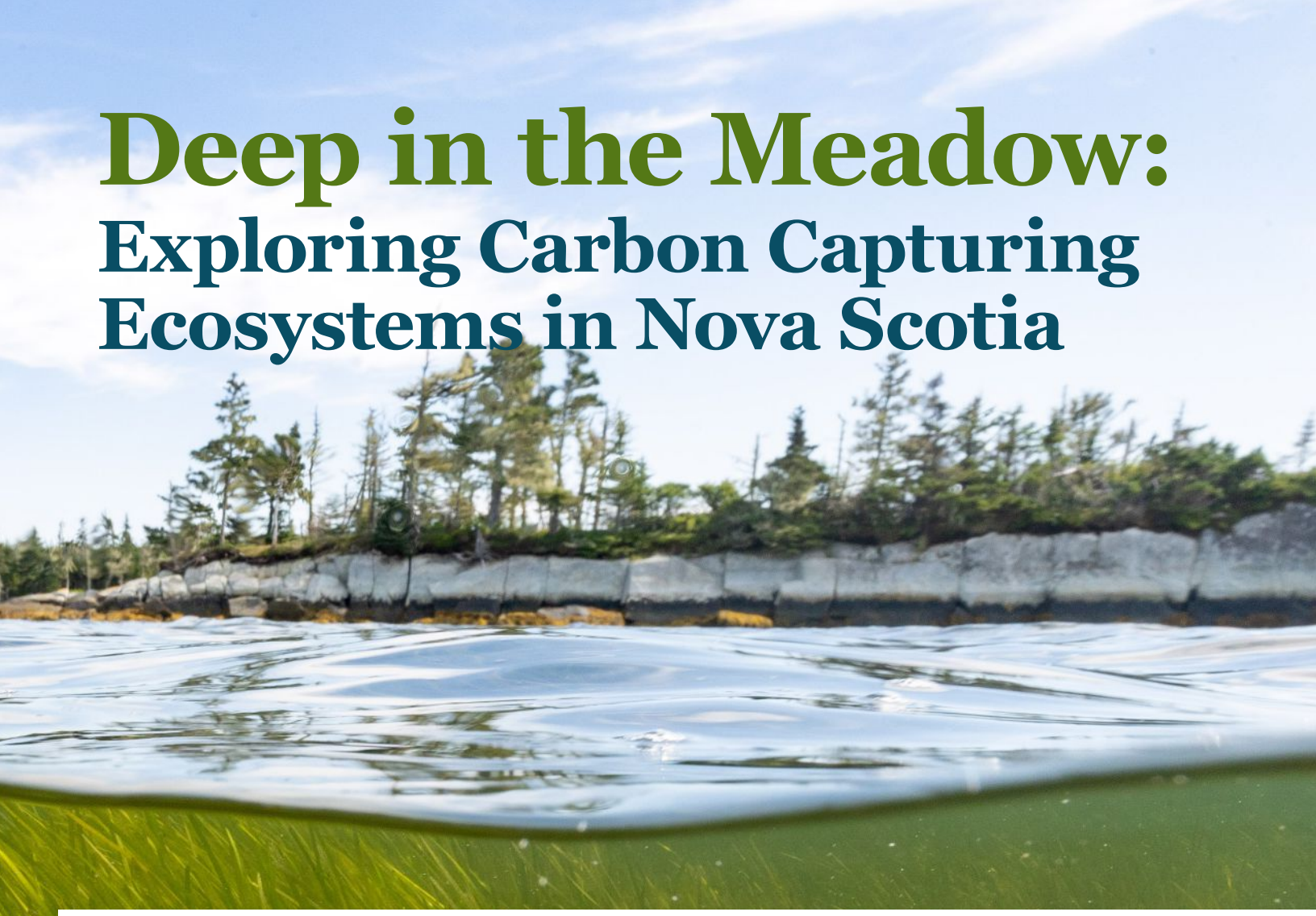
Mapping and Restoration

Deep in the Meadow:
Exploring Carbon Capturing Ecosystems in Nova Scotia



By Kristina Boerder, Amy Irvine, Lauren Laporte (Future of Marine Ecosystem Research Lab, Dalhousie University), and Andrea Bryndum-Buchholz (Fisheries and Marine Institute, Memorial University of Newfoundland)

Tucked away next to the coastal community of Little Harbour in Owls Head, Nova Scotia, just beyond the reach of the bustling capital Halifax, is a small slice of paradise. Gulls dive out of the sky into the blue coastal water, their distinct calls resounding through the small fishing community as they follow the colorful lobster boats returning to the wharf with their catch. Seals laze, undisturbed, on islands just off the rocky shores. White sand beaches glisten in the sun, rimmed by vibrantly green blades of eelgrass bending in the gentle current of the shallow bay. Within these lush eelgrass meadows, fishes, crustaceans and many other kinds of marine life take refuge and thrive; an underwater oasis from which they disperse and help to support the livelihoods of the local fishers here on Canada's East Coast.

As we arrive in Little Harbour on a sunny day, we squeeze out of the car that barely fits our team of five, hauling out equipment as we look into the white fog that hovers offshore. Presently, our expert is preparing to launch his aerial drone, the technological eye helping us determine how far and wide the eelgrass grows along the shores of Owls Head. As the drone lifts into the sky, we see through its camera the gorgeous combinations of greens that stretch out beneath the waves, the palette and textures that create this vibrant eelgrass ecosystem.

Next to Little Harbour lies the reason we are here - Owls Head Provincial Park (OHPP), known for its wide headland hosting endangered species, a globally rare ecosystem and extensive coastal habitats of rockweed, kelp, and eelgrass. Since the 1970s, the area has been listed as a candidate for protection in the Nova Scotia's Our Parks and Protected Areas Plan and only recently legally designated as a park, after an untiring campaign against business development plans of OHPP. In 2019, OHPP was secretly delisted by the Provincial Government of Nova Scotia in a backroom deal that allowed for a private business owner to make an offer to purchase the area. The new owner's intent

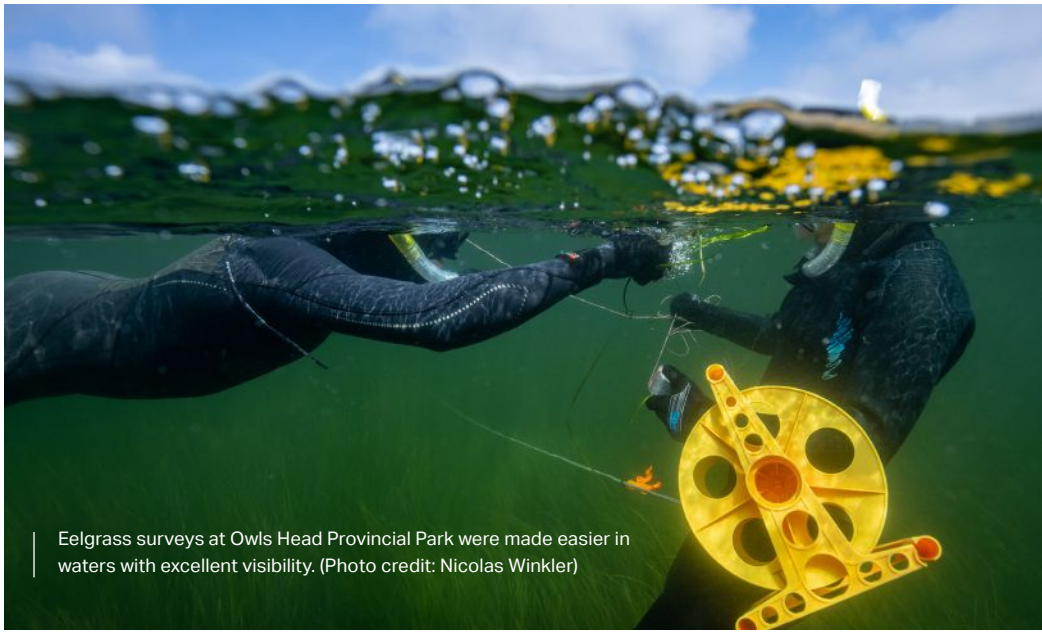
| Eelgrass meadow off the rocky shore of Owls Head Provincial Park. (Photo credit: Nicolas Winkler)

was to build three golf courses and draw business to the area. However, in December 2019, a whistleblower shared secret documents with a CBC reporter, who informed the public of this plan. The report ignited a furore at the silent attempt to push through development and a powerful two-year campaign across the province to protect OHPP ensued, bringing together a diverse coalition of the public, Indigenous groups, NGOs and local scientists.

The purchase of the land eventually fell through and by mid-2022 Nova Scotia announced the legal protection of Owls Head as a Provincial Park. Supporting the campaign with research and scientific information throughout the years was a team from Dalhousie University, studying the area's biodiverse ecosystems both on land and in the water.

Now, as we stand at the shores of OHPP and marvel at the drone footage, another important aspect of having this unique area fully and indefinitely protected becomes clear. The seagrass meadows are incredibly dense and rich, the green shoots supported by mounds of roots and rhizomes that have accrued over time, locking up carbon as they do so. In fact, OHPP is home to three carbon-sequestering powerhouse ecosystems - wetlands, salt marshes, and eelgrass beds, all of which naturally capture and store carbon from the atmosphere and water, thus helping in the fight against climate change.

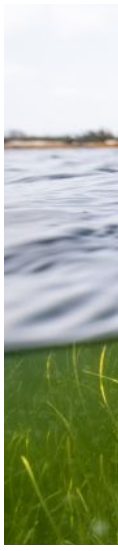
For today's work, we focus on one of these champions for climate change mitigation - the eelgrass (*Zostera marina*). Remarkably, seagrasses such as eelgrass are the only flowering plants in our ocean, and capture carbon dioxide from the water to power their photosynthesis and growth, turning it into breathable oxygen and storing it as carbon, just like trees in terrestrial ecosystems. Yet little-known is the fact that eelgrass does this at a rate that is 10 to 40 times higher per unit area than forests on land. Within their extensive root and interconnected rhizome system, they can store carbon in the sediment for millennia if undisturbed, sometimes far longer than living terrestrial trees. In this way, just one acre of eelgrass, an area approximately equal to 2.5 NHL hockey rinks, has the potential to store about 330 kg of carbon every single year, equalling the amount of carbon emitted driving a car for over 6,000 km – greater than the distance from Halifax to Vancouver. If these ecosystems are disturbed or destroyed, all of this carbon that has been accumulating over decades or centuries would be



Eelgrass surveys at Owls Head Provincial Park were made easier in waters with excellent visibility. (Photo credit: Nicolas Winkler)

Aerial shot of the research team laying a transect to survey the eelgrass in the shallow bay. (Photo credit: Nicolas Winkler)

Dalhousie University research team gearing up to study the health of eelgrass beds off Owls Head. (Photo credit: Nicolas Winkler)



released - and the benefits of future carbon sequestration lost.

In addition to its role in climate change mitigation, eelgrass provides for us in several other ways. The dense beds of eelgrass disperse the power of waves, protecting coastlines from erosion. Eelgrass improves water quality and provides a home and nursery ground for rich biodiversity, including many commercially important species fished along these coasts, including over one fifth of the world's 25 largest fisheries, such as for lobster, scallop, herring, and cod. Thriving eelgrass ecosystems are also of great cultural importance to the Indigenous Mi'kmaq people, who fish for eels and shellfish in the beds.

Despite this ecosystem providing us with so many benefits and facing such a multitude of threats, eelgrass does not receive much consideration in environmental management and protection in Nova Scotia. Local research on its role in mitigating the impacts of climate change and how the eelgrass meadows in this part of the world compare to others is limited. This is why we are here today: to learn exactly how widely the eelgrass grows and just how much carbon it actually stores off the coast of OHPP.

We pull out the long plastic tubes known as sediment corers and wade into the still chilly coastal waters. Using a sledge hammer, we drive the corers into the substrate beneath the eelgrass then pull the tube back up with layers of sandy and muddy sediment trapped within. This simple tube of plastic is the closest that we can get to a time-machine: the deeper the sediment, the further back in time it accumulated and was built on by the eelgrass swaying overhead. The sediment core thus tells us how carbon storage has changed over time - if there is more carbon stored in the deeper or shallower sediment - and how long it has been locked up. By combining this data with our aerial maps of the area created from the drone flights today, we can better understand the extent of eelgrass beds, their density, and their capacity to store carbon.

With climate change solutions becoming a priority globally, this research will help us understand how much Nova Scotia's eelgrass contributes to carbon capture and storage. More importantly, we will also assess how much carbon could potentially be released if the beds get disturbed or destroyed. A big focus for us is to encourage a better understanding of carbon-capturing ecosystems, so we are working to develop a generalizable protocol for Nova Scotia to take stock of its coastal carbon sinks like eelgrass beds. Ultimately, recognizing the importance of these ecosystems for both biodiversity and carbon storage may lead to better protection for them.

The lessons learnt today will also be useful for another project this summer: together with a local environmental organization and the support of citizen scientists, fishers and Indigenous communities, we will be testing different methods to replant eelgrass along the coasts of Nova Scotia. Ultimately, protecting and restoring these important habitats will help to maintain healthy marine ecosystems and to ensure their long-term benefits to people. Developing and using cheap, replicable methods that can be applied broadly is essential for effective and large-scale mapping and restoring of Nova Scotia's eelgrass meadows.Knowing their potential not only for maintaining biodiversity, but also for carbon storage, provides strong evidence that by protecting these ecosystems we will be preserving all its benefits and wonders for future generations.

When the fog begins to roll in, we pack up our gear, pile into the car and drive back along the winding coastal roads to the city. As the scenery changes from open coastlines to the busy downtown environment, we are reminded that, if we want to continue to receive the many benefits eelgrass beds provide for us, we in return need to ensure their prosperity. With each restored and protected eelgrass meadow, we will take one more step towards rebuilding the land relationship needed to foster biodiversity along our shores while countering climate change at the same time.

The research team training the muddy art of taking sediment cores in shallow waters. (Photo credit: Aaron Clausen, Ecology Action Centre)

Snorkeler recording marine biodiversity along a transect in the eelgrass bed. (Photo credit: Nicolas Winkler)

Mapping Blue Carbon Ecosystems from Space

Mangrove forests and seagrass meadows count among the most species-rich habitats. In addition, they effectively protect coastlines and store carbon dioxide. Satellite-derived information on these shallow waters can improve the work of surveyors, modellers and scientists. They gain valuable insights into bathymetry, benthic habitat and coastal development. Moreover, new software solutions processing these big data offer dramatic time and cost savings.

According to the recent IPPC Report on the Ocean and Cryosphere in a Changing Climate, global warming has led to mangrove encroachment into subtropical salt marshes in the past 50 years. Furthermore, seagrass meadows and kelp forests suffer from contracting at low-latitudes. Experts need to understand all impacts on these shallow waters and thus require accurate information – at fair costs.

Safer Decisions Thanks to Satellite Data

For coastal decision makers, satellite data analytics can be a game changer. They allow significant time savings when it comes to site evaluations, predicting development scenarios and environmental reporting. By space-based information, not only questions on bathymetry, water quality and seabed morphology can be answered. The technology also allows experts to go back up to 30 years in time – thus revealing coastal dynamics.

Hurricane Impacts and Seagrass Habitats

Throughout the last 20 years, EOMAP has supported environmental stakeholders with cost-effective remote sensing information. On Grand Cayman, for example, satellite analytics quantified the devastation that Hurricane Ivan had on mangrove forests, but also their recovery to almost the same coverage as before the cyclone by 2021. Smith Warner International sub-contracted EOMAP for this. The shallow waters of the German Baltic in the state of Schleswig-Holstein were another insightful case. There, seafloor was mapped and monitored, including seagrass meadows and densities down to 12-meters depth. The benefit is a highly crucial dataset for calculating carbon storage, but also for environmental reporting and monitoring purposes.

Mapping European and Caribbean Seafloors

Combining satellite data with underwater video records is currently tackled by the EU Horizon2020 project 4S and innovations powered by the European Space Agency, such as the SyriUS project. In the latter, satellite analytics (by EOMAP) are combined with autonomous surface vehicles (by Maritime Robotics) plus artificial intelligence identifying seafloor species and habitats. For the UK Hydrographic Office, EOMAP has just delivered high-density bathymetry grids including seafloor classification for Belize (Figure 1). All these cases foster a better understanding of seabed habitats and carbon storage potential.

New Tools for Time Savings

Future development, offering more and better sensors, multispectral information, new algorithms and cloud-processing will speed up the impressive rise of remote sensing. This will lead to even more precise and up-to-date spatial big data. And calls for translating these into actionable input for coastal stakeholders. Therefore, new software tools are key, allowing to easily query data and generate time series and reports – thus streamlining environmental studies. EOMAP's new WebApp for Satellite-Derived Bathymetry "SDB-Online", for example, bridges the gap from imagery to ready-to-use knowledge. Users create high-density bathymetry grids from the comfort of their desk – within minutes.

About EOMAP

Since 2006, EOMAP has provided satellite-derived data and services on aquatic environments. Experts across the globe trust its patented technology and teams in Germany, the US, Indonesia, UAE and Australia. EOMAP is addressing water-related sustainability goals in many business and research projects. Find out more at: **www.eomap.com**

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Figure 1: Satellite reflectance product of Lighthouse Reef, Belize. (By EOMAP – © MAXAR)

The Unexpected, Underwater Plant Fighting Climate Change

Once considered the ugly duckling of environmental conservation, seagrass is emerging as a powerful tool for climate action. From drawing down carbon to filtering plastic pollution, marine scientist Carlos M. Duarte details the incredible things this oceanic hero does for our planet -- and shows ingenious ways he and his team are protecting and rebuilding marine life.

This talk was presented at an official TED conference.

TED Ideas worth spreading

Unlocking Australia's Blue Carbon Potential on the Great Barrier Reef

By Melissa Rodgers (Great Barrier Reef Foundation), Nathan Waltham (James Cook University), Emma Jackson (Central Queensland University)

Australia holds around 10 percent of the world's Blue Carbon ecosystems, which are hugely instrumental in mitigating climate change.

Coastal habitats such as seagrasses, mangroves and tidal marshes are highly effective carbon sinks, sequestering carbon 30-50 times more efficiently than terrestrial rainforests. Coastal habitats cover less than two percent of the total ocean area but account for nearly half of the total carbon sequestered in ocean sediments.

The Great Barrier Reef is home to the largest seagrass ecosystem on the planet at more than 4.5 million hectares (11 percent of the global seagrass stock).

This seagrass ecosystem on the Great Barrier Reef stores approximately 404 million tonnes of carbon, with another 70 million tonnes of carbon being stored by Reef mangrove stocks.

Yet these ecosystems have value that extends far beyond their carbon sequestration and water quality capacity. They are critically important for increasing marine and terrestrial biodiversity, preserving cultural practices of the Reef's Traditional Owners, and enhancing the resilience of coastal habitats by mitigating floods and protecting shorelines.

However, these ecosystems have suffered loss, from land-based pollution, changed land use, and increased severity of storm events due to climate change. This ecosystem loss is a double-edged sword – not only do we lose the capacity to store carbon in the future, but the loss of these ecosystems triggers the release of historic carbon deposits and further increases emissions.

Coral reefs are on the frontline of climate change. In 2022, the Great Barrier Reef has experienced its fourth mass coral bleaching in just six years due to rising sea temperatures, and even more alarmingly, its first in a La Nina year which traditionally signals cooler conditions.

Coral reefs and blue carbon ecosystems are deeply interconnected; functioning blue carbon ecosystems are critically important to support coral reefs as they reduce the threats of climate change and poor water quality.

In Australia, current blue carbon restoration work is small-scale, fragmented and largely focused on carbon sequestration. There is an urgent need for coordinated effort to overcome key barriers and fill critical gaps that prevent the development of large-scale, investment-ready blue carbon restoration projects that also deliver a full suite of environmental, cultural and social-economic benefits.

We must act now to scale up climate change mitigation and adaptation efforts for there to be real hope for functional coral reefs into the next century.

The Great Barrier Reef Foundation, in consultation with world-leading blue carbon experts, Traditional Owners, government, community groups and Australia's environmental NGO community, has developed a Blue Carbon Program which strategically targets these barriers, in an ambitious plan to accelerate and scale the blue carbon potential within the Great Barrier Reef.

The program will pilot and prove methods for restoring and enhancing the resilience of blue carbon ecosystems, leading to improved reef health and climate mitigation. But it extends well beyond the traditional bounds of current interventions, methodologies and understanding, by trialling new and innovative approaches and technologies for protecting and restoring ecosystems, and unlocking blue carbon potential in Australia at a scale not yet attempted.

Through this collaborative framework, the Great Barrier Reef Foundation is working with numerous partners to understand the important work already happening in this space, identify the gaps, and bring projects together in a coordinated way – to create transformative change and unlock Australia's blue carbon potential.

The Program is designed around five themes:

1. Critical baseline knowledge – Addressing critical research and data gaps that are essential to accelerate the blue carbon potential.
2. Pilot place-based wildlife sanctuaries – Piloting on-ground blue carbon restoration activities by restoring coastal wetlands and protecting and restoring seagrass meadows, to demonstrate the carbon, critical ecosystem services, and other social and economic co-benefits that restoration brings.
3. Capacity building – Working across multiple partners and project sites to share learnings, which is crucial for scale, impact and enduring legacy.
4. Advocacy/Leadership – Showing the way by piloting projects that demonstrate the value of blue carbon ecosystems for coastal protection, carbon sinks and multiple ecosystem co-benefits. The program is designed to unlock and accelerate the potential of blue carbon as a key nature-based solution to tackle emissions. Pilot projects will develop the new knowledge and innovations needed to tackle climate change, and through an extensive national and international network this work will be positioned to have the greatest impact.
5. Amplify – Well-developed strategies and paths to scale are key to the success of a 'pilot and prove' model for conservation. This includes strategies for communicating impact and sharing project success and failures, developing tools and technologies that enable large-scale deployment of blue carbon restoration at reef-wide scales, and market-based mechanisms to encourage financial investment in nature.

Pilot Projects

Initiating pilot projects is integral to the Blue Carbon Program.

Leading Australian retail company Coles and the Great Barrier Reef Foundation have begun a 10-year, $10 million Blue Carbon partnership to help strengthen the regeneration and resilience of the Great Barrier Reef. Through the partnership, Coles will fund a number of innovative projects, including the Program's first two on-ground pilot projects.

These include the largest blue carbon project to date in Queensland's Great Barrier Reef catchment, working with farmers to restore a coastal wetland, and developing the Reef's first large-scale seagrass nursery.

These two pilot projects will be the first to provide practical, on-ground demonstrations of blue carbon ecosystem restoration and help address the practical barriers that still exist in implementing these types of projects. They will also demonstrate the multiple co-benefits of blue carbon ecosystems to the Reef and Reef communities, showing how blue carbon ecosystems are a key nature-based solution to help tackle emissions.

Restoring coastal wetland – returning tidal flows

Coastal wetlands on floodplains along the Great Barrier Reef's 2,300 kilometer coastline provide incredible ecosystem services including environmental, social, cultural and economic values. Despite these values, they have been modified for urban, industrial and agricultural expansion.

For instance, tidal bund walls were initially constructed in many places along the Reef coastline to provide cattle with food during the dry season. Excluding seawater allowed freshwater plants to grow, providing an inexpensive and accessible source of food for livestock throughout long, dry winters. While this increased the resilience of farms to droughts, the natural tidal flows of coastal ecosystems were affected.

Removing tidal bunds to restore estuarine habitats has multiple benefits including carbon sequestration in soils and plants, reducing greenhouse gas emissions from freshwater ponded pastures, improving water quality, and returning biodiversity through restoring fish and water bird habitat.

The site selected for the pilot project has the potential to be the largest blue carbon project in the Great Barrier Reef catchment, creating a 'blueprint' for future wetland restoration, and aiding in reef protection more broadly.

Working directly with the landholder, the project team led by James Cook University is starting with understanding and quantifying the available options, balancing the site's potential with the costs of site works to maximise environmental outcomes, and current land use and profitability. This investigation will present the cases for remaining in current land use, developing a restoration site that attracts payments for ecosystems services, or a combination of both.

An impressive outcome of this approach is that it allows the project team and landholder to understand the range of restoration options, full costs, and payment return potential, to ensure all parties are clear and aligned on the restoration goals – an essential ingredient for success.

First large-scale seagrass nursery on the Great Barrier Reef

Despite efforts to protect Queensland's seagrass, monitoring shows that seagrasses have been declining at a concerning rate. Natural recovery from disturbances is being redefined by climate change, and degradation from multiple years of La Niña climate have led to substantial longer-term loss. Seagrass meadows reduce the impact of catchment run-off, provide breeding grounds for fish and shellfish, as well as capturing and storing carbon, so intervention is necessary to support the resilience of these important ecosystems.

Researchers led by Central Queensland University are developing the first large-scale carbon neutral seagrass nursery in partnership with Traditional Owners of the Reef. For the first time, they are trialling large-scale restoration to help unlock the science needed to support seagrass restoration at a scale that makes a meaningful difference.

The preferred approach to restoring seagrass meadows uses seeds, which both minimises damage to donor meadows and maintains the genetic diversity required for seagrass populations to adapt to changing environments. Only some species of seagrass can actually produce enough seeds for this method to be effective. Fortunately, the coastal species *Zostera muelleri* found in the Great Barrier Reef catchment produces large numbers of flowers and seeds.

Nursery facilities are key to enable enough seeds to be collected to attempt large scale restoration. The process involves collecting plants and flowers from the wild, growing them in dedicated nursery facilities, and collecting and storing the seeds, before dispersing the seeds at low tide to restore seagrass sites which the program plans to utilise volunteers to help implement.

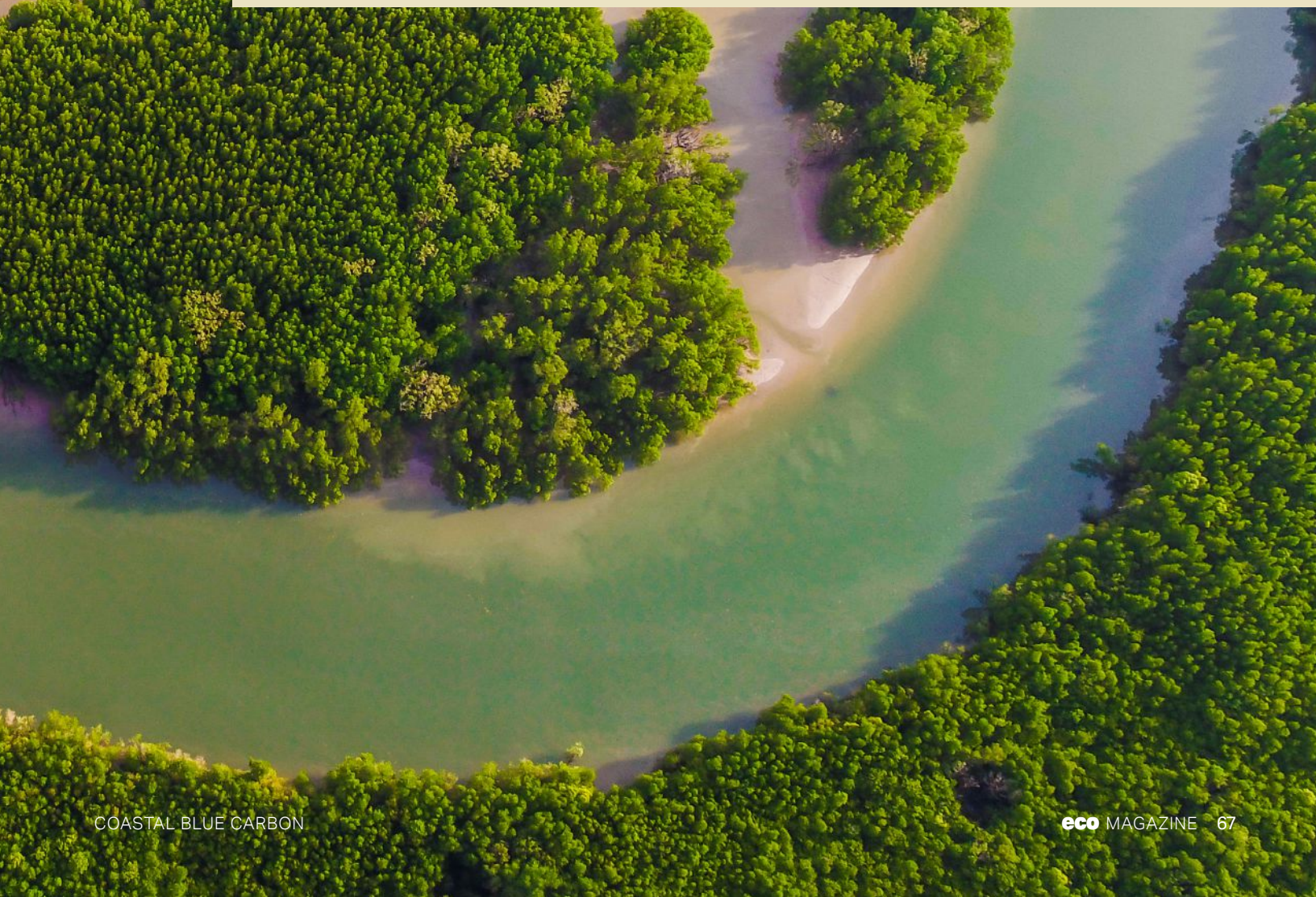
The research conducted at the nursery will establish protocols and best practice to successfully propagate seagrass seeds and plants. Training the next generation of restoration practitioners will also help ensure the nursery's long-term success.

Importantly, the project's protocols and training programs will be replicable to support the establishment of seagrass nurseries in other parts of the Great Barrier Reef and potentially beyond.

How to Restore the Roots of the Sea

By Dr. Laura Michie, Mangrove Action Project

Mangrove forests have gained a newfound spotlight in the global conservation movement over the past decade, mainly due to the huge amounts of carbon they can sequester. They were once considered unimportant wastelands, making them easy to exploit, but are now widely valued as unique habitats that are some of the most productive and biodiverse on the planet. At the interface between land and sea, mangroves cross the boundary from terrestrial to marine forests, living with their roots submerged in water, thriving in hot, muddy, salty conditions that would quickly kill most plants. The dense roots of mangrove trees help to stabilize sediments and protect coastlines from erosion, they also provide a nursery ground for many commercially important fish species and endangered marine organisms.



Mangroves also protect coastline from storms and sea level rise, regulate coastal water quality, and provide food for millions of people around the world. Despite these benefits and services, mangroves are one of the most threatened ecosystems on earth. They have declined rapidly over the last few decades, with the land being turned into shrimp farms, tourist resorts and agriculture, and the trees being cut for fuel wood, charcoal and construction. When degraded or lost, mangrove ecosystems can become significant sources of carbon dioxide, releasing thousands of tonnes of carbon which has accumulated in their soils over millennia.

With their newfound spotlight, mangrove restoration is becoming more popular. Sadly, many attempts to restore these valuable ecosystems fail, largely due to a lack of understanding of underlying ecological and social pressures.

Mangrove planting initiatives around the world have met an unfortunately high rate of failure. The reasons for failure vary, but overly ambitious targets combined with a lack of basic mangrove knowledge often result in people planting in unsuitable areas – such as tidal mudflats or seagrass meadows - which cannot support mangrove trees. Mangroves are more dynamic than terrestrial habitats, they are submerged in water for part of each day as the tides comes in and out. If the water level isn't right, the trees don't stand a chance at survival.

But it's not all bad news. Mangrove restoration can work, and if done properly it can restore biodiverse forests that help mitigate climate change, protect coastlines and provide livelihoods for coastal communities. An award-winning technique by Mangrove Action Project (MAP), a US-based NGO, works alongside nature and takes into account mangrove ecology and biology to restore degraded mangroves. The 'Community-Based Ecological Mangrove Restoration' (CBEMR) method has seen worldwide success and demonstrates an effective and sustainable approach to mangrove restoration.

Unlike many planting projects, CBEMR works with nature to restore degraded mangroves by mimicking natural processes. Planting mangrove trees is not inherently bad but planting the wrong species in the wrong place is. Natural regeneration has the advantage of not only producing a more biodiverse mangrove, which increases its resilience to climate change, but is also potentially more economical as it avoids the costs of nurseries and planting.

The CBEMR method is derived from the Ecological Mangrove Restoration approach developed by conservationist and activist Robin Lewis. This approach steered mangrove restoration away from the conventional wisdom of 'gardening' – building a nursey, growing seedlings, and replanting mangroves – towards the restoration of fundamental ecological processes, such as hydrology, that once enabled healthy mangroves to thrive. Some small-scale planting is often used, but in order for a truly biodiverse ecosystem to be restored, the ultimate aim for MAP and the communities they work with, is to recreate the conditions in which nature can flourish.

"Good hydrology is vital for a healthy functioning mangrove, it is key to natural regeneration as the flushing brings in all the available seeds and propagules and puts them in the appropriate place," says Dr Dominic Wodehouse, Executive Director at MAP. "Where necessary, hydrology should be improved by digging channels and restoring water flow, and then let nature do the rest."

The CBEMR approach works to build capacity and empower local stakeholders and communities by teaching them how to restore mangrove forests. Working with local communities is integral to the success of projects, ensuring that those living within the area will be involved in the restoration efforts.

Community involvement, as well as local NGOs and government staff, begins at the planning stage, and includes implementation right the way through to monitoring and management. This way, local coastal communities are empowered to become stewards of the mangrove, taking ownership of the restoration project and maintaining the long-term benefits of the ecosystem.

As well as restoring and replanting mangroves, protecting existing forests is essential in the fight against climate change. At a time when many restoration targets are focused on planting, there is a danger that an emphasis on tree planting distracts from the priority, which is to conserve existing forests. Mature mangrove forests are irreplaceable and removing these forests will result in the rapid mass release of carbon. Planting new forests cannot compensate for such losses on a timescale relevant to the immediate climate emergency.

There is no single solution to mangrove restoration. Rather we need to stop and think through the right interventions for each site and context to produce diverse and resilient forests.

Top Left and Right: CBEMR Workshop Kenya. (Photo Credit Mangrove Action)

Bottom Left: MAP CBEMR Workshop in Thailand. (Photo Credit Mangrove Action)

Bottom Right: CBEMR Workshop in the Bahamas. (Photo Credit Mangrove Action)

| Photo credit: Alasdair O'Dell, Scottish Association for Marine Science

Blue Carbon – What's on Our Own Doorstep?

By Euan Paterson, Scottish Association for Marine Science

There's a saying in marine research, when discussing ocean literacy and public awareness, that the ocean produces half the world's oxygen, yet trees get all the credit.

Similarly, the crucial role of plants in drawing down and storing carbon is typically referenced in campaigns to save rainforests and other terrestrial habitats. It seems the ocean is the lesser-celebrated hero when it comes to supporting life on Earth.

Part of the problem is the uncertainty around quantifying the contribution of marine ecosystems to carbon storage – so-called 'blue carbon' – even in our own coastal seas.

The coastal ecosystems of mangroves, tidal marshes and seagrass meadows contain large stores of carbon deposited by vegetation and various natural processes over centuries. These ecosystems sequester and store more carbon per unit area than terrestrial forests. The ability of these vegetated ecosystems to remove and store carbon dioxide (CO_2) from the atmosphere makes them significant carbon sinks and they are now being recognised for their role in mitigating climate change.

As an island nation, the UK has already established many reasons to protect our precious coastal waters. A growing number of Marine Protected Areas (MPAs) have been created to reflect their contribution to preserving marine habitats and species, and promote sustainable use of marine resources.

But could we be overlooking their greatest contribution?

We know that our coastal seas draw down carbon from the atmosphere through organisms like plankton, seagrasses and kelp forests and store carbon in sediment and sand. Coastal marine habitats alone are estimated to store over 50 percent of carbon sequestered in marine sediments. However, our understanding of how blue carbon is captured and stored is limited.

Furthermore, quantifying this contribution has only recently become a priority – the term blue carbon was only coined in 2009.

Through the newly-launched Blue Carbon Mapping Project, the UK will become the first country to produce a complete account of its blue carbon stores. The project will assess the carbon storage and sequestration potential of all UK seas, including current MPAs.

Led by the Scottish Association for Marine Science (SAMS), and funded by WWF-UK in collaboration with The Wildlife Trusts and RSPB, the final report is expected by the summer of 2023. With two-thirds of the UK underwater, the study will be critical in helping the UK achieve its commitments to net-zero and to protect at least 30 percent of UK seas for nature by 2030.

Understanding and mapping blue carbon stores will allow UK Governments to plan and prioritise how we use our marine environments in the future. This includes exploring the impacts of human activities on blue carbon stores, such as fishing and the installation of renewable energy platforms, which can disturb carbon that has been stored for thousands of years.

Prof Michael Burrows of SAMS, who will lead the research has already done similar work in Scotland and believes that understanding the contribution of blue carbon to the capacity of the oceans to sequester carbon (by removing carbon dioxide to mitigate the effects of climate change) demands a system-wide synthesis at a national level.

He added: "Only by linking coastal blue carbon habitats with carbon flows in the wider ocean can we start to appreciate the scale of the contribution of blue carbon at national and international levels.

"The UK's exclusive economic zone (EEZ) – an area of the sea up to 200 nautical miles from the shoreline – is larger than the land mass. Added to that are environments like Scottish sea lochs, which are unusually carbon rich, so it is crucial for us to understand the true blue carbon potential of such areas within the UK's jurisdiction.

All photos credit: Alasdair O'Dell, Scottish Association for Marine Science

"This project will provide baseline information for key policy decisions. For example, we don't know how much carbon is released through dredging and there are currently no large-scale efforts to restore seagrasses because of a lack of knowledge around their contribution. Should carbon storage be a justifiable basis on which to create new MPAs?"

"A significant component of the better management of MPA networks involves understanding the services provided by these protected habitats, particularly in relation to blue carbon and the implications of global climate change.

"Integrating the carbon value of marine habitats, such as those found in MPAs, into decisions relating to marine management would potentially improve the protection of these habitats and enhance their capacity to provide a carbon sink."

The work will also potentially give the UK a clearer view of the contribution of its coastal habitats and waters to its Nationally Determined Contribution (NDC), an assessment of carbon contributions by country, which currently excludes the marine environment.

The project follows a pilot study in the North Sea which was published last year and gave the first indication of how important UK seas are for tackling climate change. The report found:

Carbon stores in the English North Sea amount to nearly 20 percent of that held in UK forests and woodlands; 98 percent of the total organic carbon is stored in seabed sediments like sand and mud; and seabed sediments are thus by far the most important habitat for carbon storage in this region.

Perhaps by exploring the role of our coastal seas more fully, we can better understand the crucial role of our entire marine environment in carbon storage.

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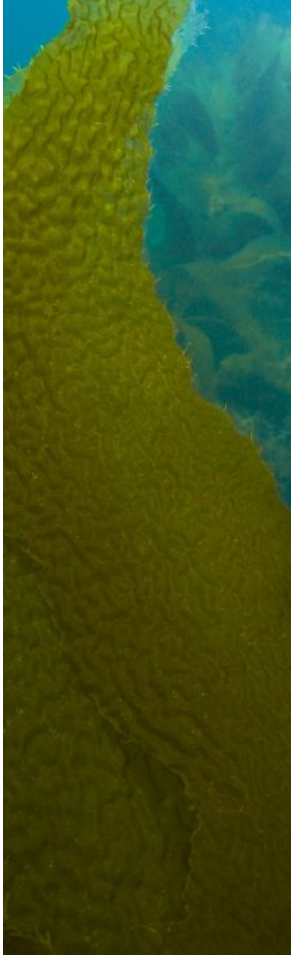
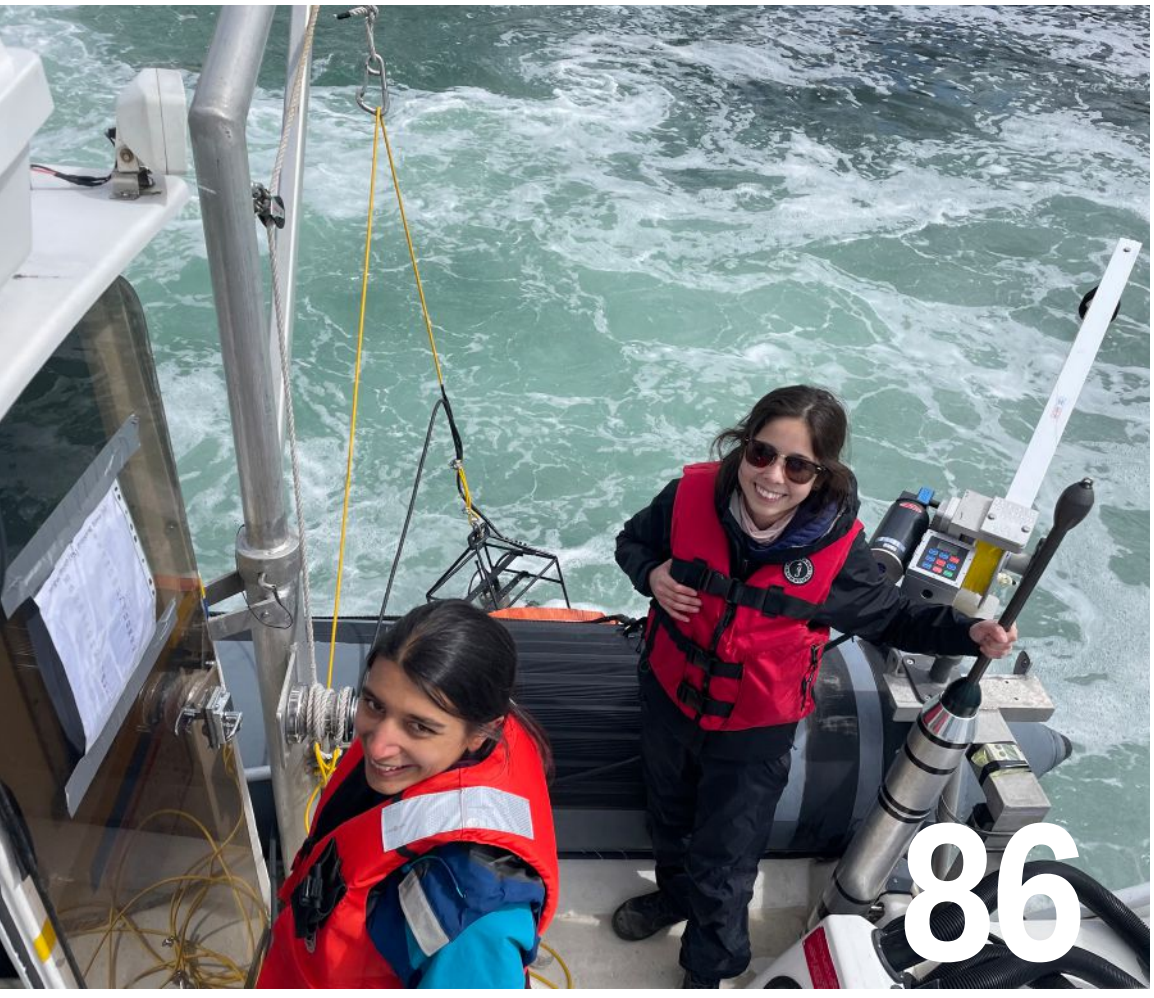
Since 2006, EOMAP has been pioneering in satellite-derived data and software services on aquatic environments. Experts across the globe trust our patented technology and teams in Germany, the US, Indonesia, UAE and Australia. EOMAP is addressing water-related sustainability goals in many research and business projects, such as monitoring plastic litter in rivers, surveying drinking water reservoirs or mapping benthic habitats.
Find out more at: www.eomap.com

CSA Ocean Sciences, a marine environmental consulting firm, specializes in multidisciplinary projects concerning potential environmental impacts throughout the world and offers a wide variety of desktop and field survey services. Our approach provides clients with objective data collected in the field while maintaining an appreciation for the environmental, legal, and political sensitivities frequently associated with controversial marine projects. Since 1970, our corporate track record has resulted unbiased scientific analyses and reporting and reliable technical performance.


79




86

Future of Blue Carbon

Is Pink the New Blue?

By Dr Regina Kolzenburg, Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)

You don't need to snorkel far off the coast before you find large schools of fish and hear the sounds of snapping shrimp as the waves break on the distant sandy beaches. If you stay in one spot for long enough it's likely you will notice that you are actually surrounded by a huge amount of marine diversity as more fish come out of their hiding places along with a multitude of different crab species, sponges, starfish and brittle stars, sea cucumbers, clams and jellyfish. But this is no ordinary snorkelling tour on the tropical Great Barrier Reef or in the coral triangle; you are off the coast of Italy, England, or maybe even Iceland, and you are snorkelling across a bed of coralline algae.

| Photo credit: Pedro Neves

A Unknown Biodiversity Hotspot

Coralline algae are pink or purple algae and they come in various shapes and sizes. One type in particular, rhodoliths, form individual "pink pebbles" or "living pebbles" that cover the ocean floor. They deposit calcium carbonate (lime) in their cell walls and whilst they grow, create a hard but brittle skeleton. One of the reasons why they are called coralline algae is because they were historically mistaken for corals – not only do they look similar, but they also suffer mass bleaching events.

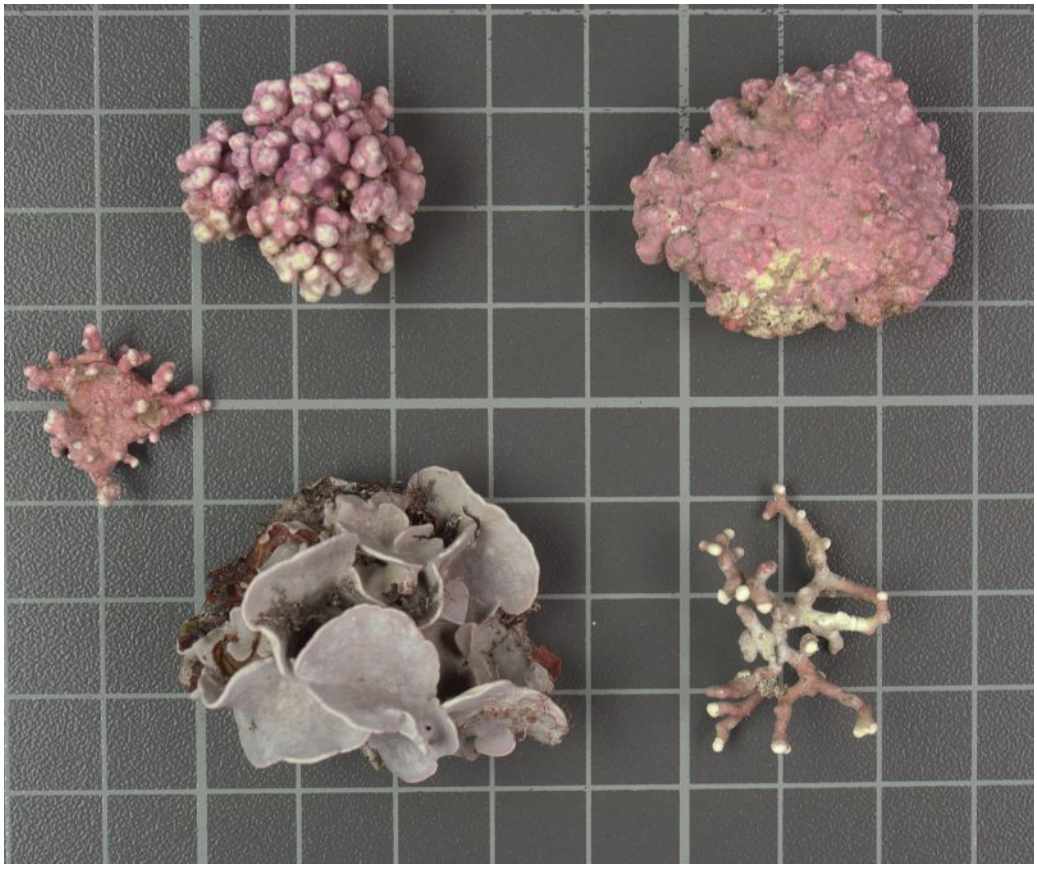
Coralline algae are important ecosystem engineers, meaning they provide vital direct or indirect modifications to their surroundings. As a result, they increase resource availability for other organisms that otherwise wouldn't have been accessible. For example, they change seawater chemistry to create a more favourable and constant habitat as compared to high fluctuations outside the area. They build 3D habitats for the organisms you see during your typical snorkel trip – providing them a place to hide, settle on or feed off. Because of the ecosystem services they provide, this undervalued algal bed is actually a biodiversity hotspot and nursery ground for commercially important fish species. Another outstanding fact is their ability to exist in greater depths than most other algae.

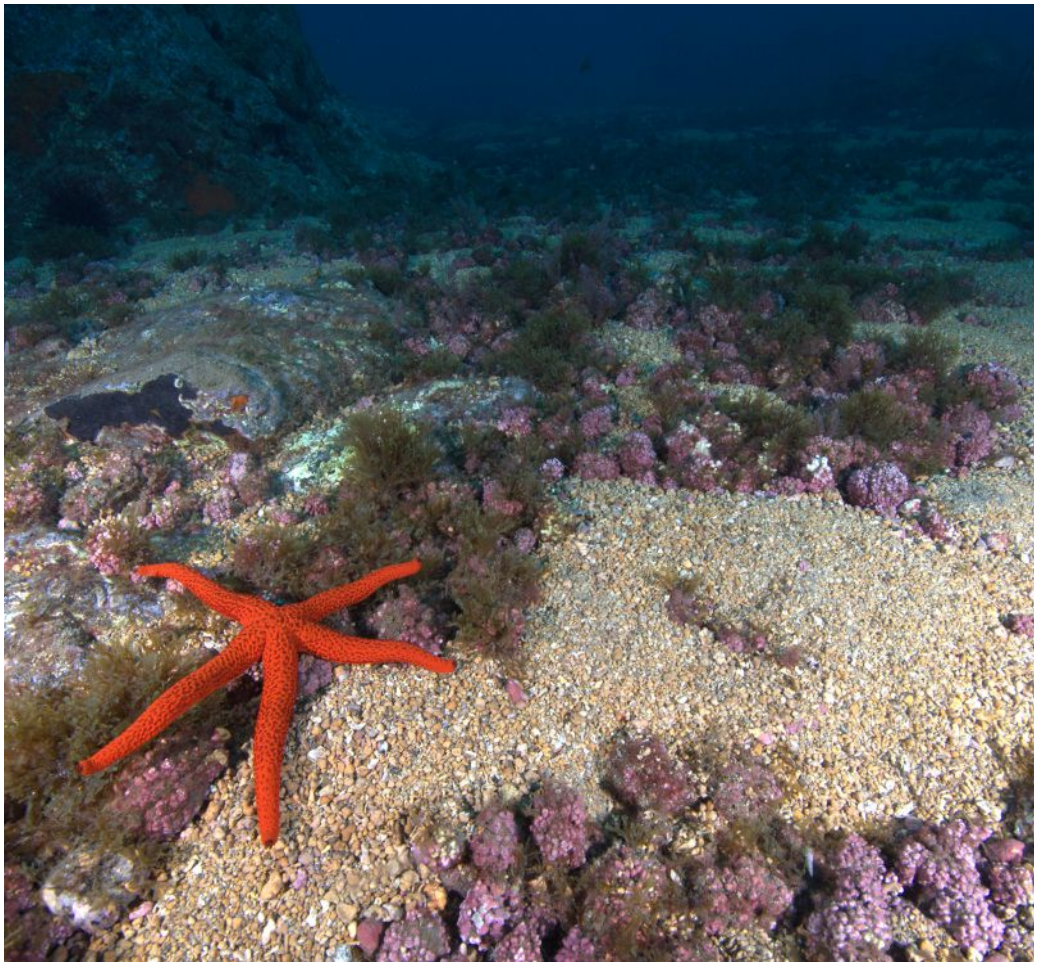
Creating this skeletal structure also provides important long-term storage for calcium carbonate. But they are becoming increasingly vulnerable. Due to their slow growth and growing human-derived pressures, such as bottom trawling fisheries or calcareous sediment mining, rhodolith beds were recently added to the OSPAR Convention (the Convention for the Protection of the Marine Environment of the North-East Atlantic) as a habitat of special interest. This vulnerability could lead to a reduction in carbon storage and cycling in affected areas and may also cause a cascading effect on local biodiversity and climate.

Blue Carbon: The Unspoken Contribution of Pink Pebbles

Rhodoliths, our "pink pebbles", are found from shallow to mesophotic (dim light) zones up to 150 metres depth. Like other coralline algae, by producing the calcium carbonate skeleton, rhodoliths reduce the carbonate in their surrounding waters, having an immediate effect on the nearby seawaters' carbonate system.

| Photos credit: Pedro Neves





In fact, coralline algae beds cover approximately 4.1 million km² of the ocean floor globally, an area far larger than those of other ecosystems considered important for marine carbon cycling and storage (e.g., kelp forests, seagrass meadows or coral reefs). This suggests that rhodolith beds could be important contributors to the oceanic carbon cycle.

While most scientific studies focus on the production of organic and inorganic carbon in the more commonly known ecosystems, very little is known about the carbon of rhodolith beds and whether it can be classified as Blue Carbon.

Most research investigates community compositions and associated biodiversity. Yet, despite their importance and global abundance – and similarly to the more prominent ecosystems such as kelp forests, seagrass meadows, salt marshes and coral reefs – there is limited research on carbon production and storage in rhodolith beds. Could we be overlooking their role in the marine carbon cycle and their potential for carbon sequestration to help mitigate climate change related impacts?

More research is needed to understand the importance of these undervalued ecosystems and their potential as nature-based solutions in the fight against climate change.

Investigations will determine the missing information that could catapult coralline algae to the forefront of climate mitigating organisms alongside kelp forests, seagrass meadows, salt marshes, and coral reefs. At the same time, we must keep in mind that ecosystems are not working in isolation but are linked together; from open waters where larvae are transported over wide distances to nursery grounds such as coralline algae beds or seagrass meadows.

A snorkel trip along your favourite coastline or reef might not be as idyllic as it once was. Unfortunately, it's all too easy to find examples of how our planet is increasingly changing, where we are losing biodiversity, and how the climate is struggling to maintain its status quo. Therefore, Blue Carbon sources and their conservation and future-focused restoration are vital to help consistently and sustainably mitigate drastic changes that are already or are predicted to occur sooner rather than later.

This forces us to think outside the box and explore all possible Blue Carbon sinks, with coralline algae potentially being one of them.

If you are interested in supporting this research as a collaborator or funder, please email regina.kolzenburg@gmail.com

Seaforestation:

The Next Conservation Frontier for the Climate, Biodiversity, and People

First Nations, NGOs and businesses are working towards a "carbon plus" future, with kelp forests at the helm

By Andrew Lang Wong, Seaforestation specialist at Ocean Wise

Humans have been tied to seaweed for millennia. In fact, the "Kelp Highway Hypothesis" suggests that the first inhabitants of the Americas may have followed kelp beds along pathways to new lands.

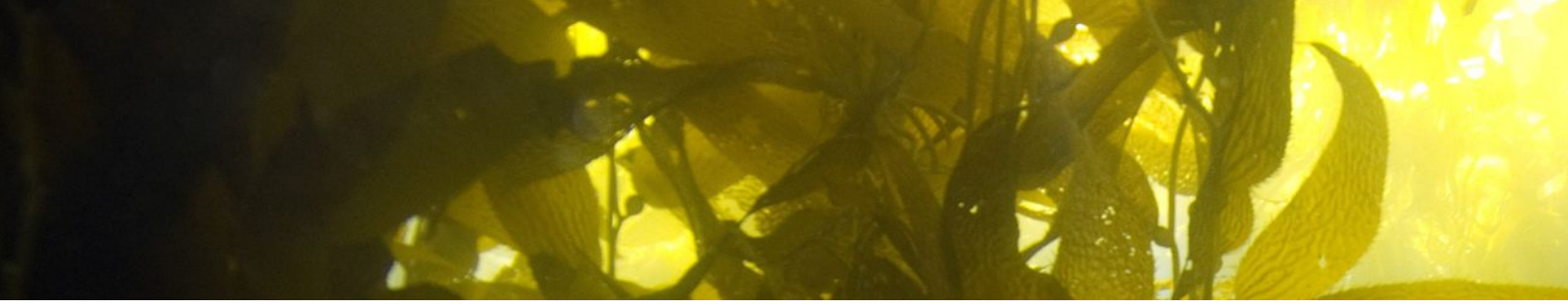
For many coastal Indigenous Peoples – some separated by vast distances from the Pacific Northwest of Canada to the Southeast Pacific in Chile – this hypothesis rings true. Much traditional ecological knowledge surrounds kelp and its important role in sustenance, the environment, stories, and symbolism. As with so many things in life, what is old becomes new again, and kelp is on the brink of playing an increasingly important role once more: drawing down greenhouse gases, stimulating economic activity and fostering food security for coastal communities.

The Power of Kelp Forests

Sometimes called the "sequoias of the sea," towering kelp forests create some of the most bustling, biodiverse ecosystems in our ocean. One of the fastest growing plants on earth, they cover 28 percent of the world's coastline. That is five times more ocean area than coral reefs. Despite these impressive stats, kelp forests are in decline, and often remain overlooked by conservationists, academics, and ocean advocates. The result is a lack of government, philanthropic and development funding – an issue which exists within the larger trend of a chronic lack of funding to our oceans.

While the true extent of how much carbon is sequestered by kelp remains unknown, we do have reason to believe that kelp forests are extremely efficient carbon sinks. An evaluation of Australia's kelp forests suggests they sequester 4.8-10.3 million tonnes of CO_2 per year, which accounts for more than 30 percent of the blue carbon stored around the continent[1].

Current research estimates around 11 percent of the carbon absorbed during the growth of naturally occurring seaweed is sequestered long-term in ocean sediment, representing a vast amount of carbon globally[2]. Kelp, which grows 30 times faster than trees, can absorb and store $C0_2$ for centuries. In addition, kelp forests sequester carbon year-on year, meaning the amount of carbon does not plateau and decline as is the case in terrestrial forests. The true potential of kelp rests with how much additional underwater forest is deployed, as part of a responsible expansion of restoration and cultivation to scale.



Carbon + Biodiversity + Jobs

Kelp creates localized micro habitats, delaying the consequences of changes in ocean chemical composition. They remove excess nutrients from the water, buffer oceans from acidification and hypoxia, protect coasts from erosion during extreme weather events, offer cultural and economic value, and provide critical ecosystems on which many coastal fisheries depend. Each year we realize more and more that the Indigenous peoples of the Pacific Northwest and Southeast Pacific who live on the waters know something we overlooked. Where kelp thrives, so do people.

Canopy forming kelp species such as Bull kelp (*Nereocystis luetkeana*) and Giant kelp (*Macrocystis pyrifera*) have recently been valued at between $131,000 USD/hectare/year and up to $177,000 USD/hectare/year for the ecosystems services they provide.

Much like terrestrial forests, kelp forests provide habitat, shelter, and food for a multitude of ocean organisms – forming the foundation for an ecosystem that fosters high levels of biodiversity and is deeply linked to the food sovereignty of many coastal Indigenous Peoples. In Canada, these forests are crucial habitats for several species identified under the Canadian Species at Risk Act. This includes sea otters, northern abalone, and yellow-eyed rockfish. Likewise, in Chile, there is a similar case with coastal endangered species.

Additionally, carbon-intensive products can be replaced with bioplastics, agricultural fertilizers and biofuels synthesized from seaweed, while products such as seaweed enriched cattle feed can reduce methane emitted from cattle by 40-90 percent and greatly contribute to Canada's emission reduction goals.

As written in the UN Global Compact, 2021, "Seaweed is arguably one of the most scalable nature-based solutions, offering possibilities for both decarbonizing the economy and sequestering carbon from the surface of the ocean."

Kelp Forests in Decline

Given the benefits above, it is particularly troubling that kelp forests are declining rapidly at a rate two times faster than coral reefs. From Los Lagos, Chile to the cost of California and up to the northern tip of Haida Gwaii, pacific kelp beds have seen extensive declines.

Declines in kelp abundance have already caused large socioeconomic impacts, examples including closure of abalone fisheries in California and Rock Lobster fisheries in Australia.

The primary cause of the decline is anthropogenic forcing. This includes climate change, warming oceans, direct erosion, and the overfishing or hunting of keystone species.

A well-cited example of this is the extensive hunting of sea otters, a keystone species, off the coast of British Columbia, Canada in the 18th and 19th centuries. Without sea otters as predators, the sea urchin population exploded, and kelp declined rapidly as urchins quickly wiped-out entire forests.

Another example is the bull kelp forests of Northern California, which have seen a 90 percent decline due to a series of ocean warming events combined with the decimation of the sunflower star population, another key predator of urchins, from an outbreak of Sea Star Wasting Disease in 2013.

In Chile, the human pressures on kelp are also worrisome, as thousands of tons are extracted yearly to supply the alginate and abalone industries, resulting in an unsustainable harvest.

Now for the good news - kelp forests hold great restoration potential, thanks to their rapid re-establishment and quick growth rate.

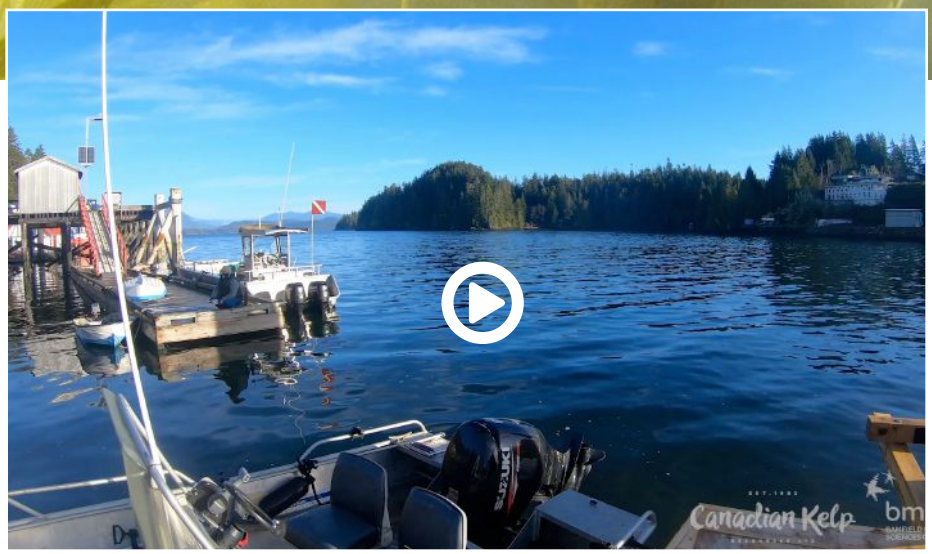
Ocean Wise Seaforestation, a Carbon Plus Solution

Until recently, the potential of kelp and other seaweed to sequester carbon has been overlooked in the arsenal of nature-based climate solutions. However, emerging research places seaweed as a powerful and scalable solution, offering carbon draw-down alongside various co-benefits.

Ocean Wise (www.ocean.org), a not-for-profit ocean conservation organization with global headquarters in Vancouver, Canada, launched a robust Seaforestation initiative in 2020 (www.ocean.org/climate-change/seaforestation). The program is aimed at restoring, protecting, and cultivating kelp forests in British Columbia, Canada, as well as in Chile through a partnership with the Indigenous communities of Mapulahual, Caulin and Haulaihué.

Ocean Wise considers kelp forests to be a "Carbon Plus" solution. Seaforestation, the restoration, planting, management, and care of underwater seaweed forests,

Green Gravel. Photo Credit: OceanWise



Deploying Green Gravel in Bamfield BC

is a climate solution that presents multiple pathways for removing carbon dioxide from the atmosphere while improving the health of ocean ecosystems, contributing to community food security, and creating environmentally focused jobs.

Ocean Wise's approach is to develop and implement cost-efficient, effective, and scalable restoration methods, as part of a regenerative, ocean-positive approach to Seaforestation. This includes planting Green Gravel, small pebbles which have been seeded with kelp "sporophytes" (juvenile kelp plants), into degraded kelp sites for growth. This solution has potential for scalability and presents the opportunity to co-construct our restoration knowledge with Indigenous communities and inform restoration interventions with traditional ways of knowing. Recently, Ocean Wise's team began using eDNA to measure changes in biodiversity before and after kelp restoration. This low barrier and cost-effective technique can help capture the biodiversity benefits that restored kelp forests offer during the first year of their establishment and track these benefits over the following years.

In Southern Chile, Ocean Wise is committed to cooperating with Indigenous communities and their associates to restore and cultivate five thousand hectares by 2025 and at least 14,600 tons of CO_2 will be captured annually in the coastal areas of Caulín, Haulaihué, Mapulawal and Ralco.

What's Next for Kelp?

More research is needed into restoring kelp forests in a changing climate. Restoration efforts should target areas in climate refugia unlikely to be impacted by severe warming events in the future. More research into thermotolerant strains must be explored, as that may be the only way to revitalize kelp forests in a warming world.

Ocean Wise is soon releasing a report, *Seaforestation: benefits to the climate, the ecosystems, and the people of British Columbia,* which outlines key recommendations for the restoration of kelp forests.

Recommendations include innovation in restoration techniques, financial and regulatory incentives, a legal framework for restoration, and the development of a carbon plus methodology to raise awareness and investment in the conservation and restoration of kelp forests worldwide.

Kelp forests, like the ones Ocean Wise is restoring off the coasts of Canada and Chile, are a powerful tool. If we can scale responsible Seaforestation around the globe, kelp will become a global superpower in fighting climate change, restoring ocean health and securing long-term ecosystem services for coastal communities.

Kelp forests hold a legacy of providing sustenance and balance to our ecosystems. The next step of this legacy may just be ensuring the survival of life on our blue planet.

Journal References:

1. Filbee-Dexter, K., Wernberg, T. Substantial blue carbon in overlooked Australian kelp forests. *Sci Rep* 10, 12341 (2020). https://doi.org/10.1038/s41598-020-69258-7

2. Krause-Jensen, D., Duarte, C. Substantial role of macroalgae in marine carbon sequestration. *Nature Geosci* 9, 737–742 (2016). https://doi.org/10.1038/ngeo2790

Seaforestation

Beyond Blue Carbon: On the Efficacy and Safety of Ocean Alkalinity Enhancement

By RBR

In 2019, Macreadie et. al. published a paper in *Nature* that highlights the need for future blue carbon science to also quantify other key processes, such as air-water CO_2 fluxes and organic and inorganic carbon dynamics in water, to fully understand the role of these ecosystems in climate change mitigation. Quoting the authors, they note that "Although recent studies related to the role of BC [Blue Carbon] in climate change mitigation are beginning to address the abundance and burial rate of C_{inorg} [inorganic carbon] in soils, studies investigating the full suite of key processes for air–water CO_2 fluxes, such as carbon chemistry and C_{org} [organic carbon] dynamics in shallow coastal waters and sediments, are still scarce."

While Ocean Alkalinity Enhancement (OAE) doesn't fall into the traditional definition of Blue Carbon, it is an emerging area of parallel research which could help support Blue Carbon projects by expanding our understanding of carbon chemistry dynamics in coastal waters, and offer a relatively safe way of storing CO_2 in the ocean, potentially for thousands of years.

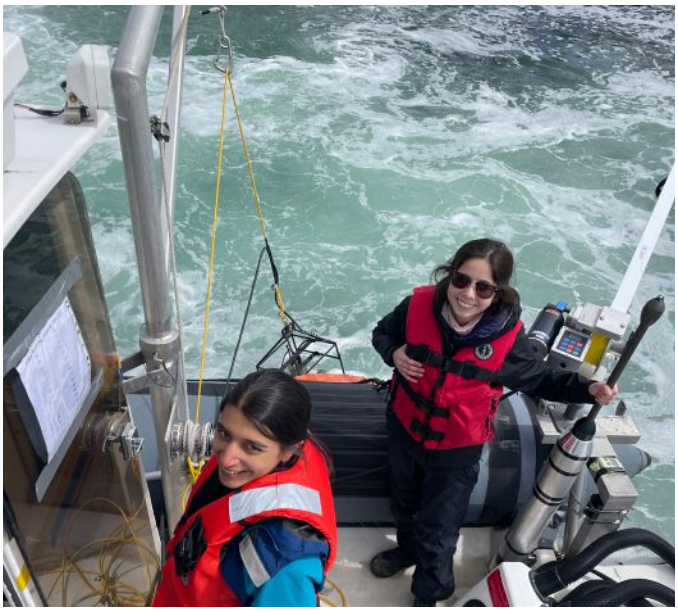
OAE technique mimics natural weathering processes but accelerates them by adding low doses of alkalinity to the ocean's surface, slightly increasing its pH and enhancing its ability to absorb CO_2 from the atmosphere. Despite the enormous potential for OAE to help tackle the climate crisis, there are still many questions and challenges associated with it.

In 2021, scientists from Dalhousie University and Planetary Technologies, working in Halifax, Canada, started a joint industry-academic project to investigate the efficacy and safety of OAE. Funded by the ClimateWorks Foundation, the Thistledown Foundation, and a Natural Sciences and Engineering Research Council of Canada (NSERC) Alliance Grant, this multifaceted project applies expertise from many talented researchers in academia, industry, and government. At the core of the project are Drs. Douglas Wallace, Hugh MacIntyre, and Ruth Musgrave from Dalhousie University, and Drs. Will Burt and Greg Rau from Planetary Technologies.

The team chose Bedford Basin, located in Halifax Harbour, as a site for future experimental alkalinity additions. This basin is small and relatively enclosed, making it easy to characterise in both time and space, and it has been monitored weekly for almost 30 years by researchers at the Bedford Institute of Oceanography and, more recently, Dalhousie. This makes it the perfect location for a controlled experiment. Before they can add alkalinity to the basin, however, the team needs to complete considerable foundational work, including measuring baseline characteristics of the basin.

Musgrave focuses on the physical processes within the basin and aims to predict where alkalinity additions could end up, and over what timescales. Anything added to the ocean's surface will both move horizontally and diffuse (mix) downward. This rate of mixing downwards is particularly important for determining OAE feasibility.

Increasing alkalinity at the ocean surface creates a region of relatively low CO_2 concentration, commonly characterised as pCO_2 (partial pressure of CO_2). For OAE to be effective, this region of low-pCO_2 water needs to maintain contact with the atmosphere to facilitate further exchange and take up CO_2 from the atmosphere. This



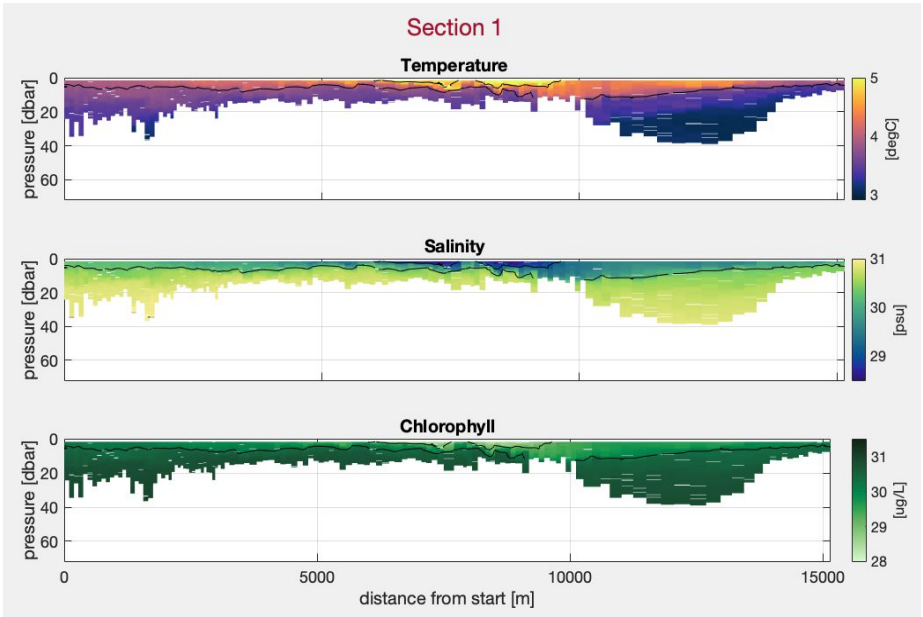
exchange is relatively slow (on the order of months). However, vertical mixing could occur much faster. Fast rates of vertical mixing would move this high-alkalinity, low-pCO_2 water downwards too soon, essentially making the alkalinity addition ineffective at drawing down atmospheric CO_2 on the short timescales (weeks to months) necessary for this process to be commercially viable.

To characterise these processes in the Bedford Basin, Musgrave and PhD candidate Ruby Yee are developing a high-resolution, 3D numerical model of the basin. In their model, they release both a passive dye tracer and alkalinity, which will help characterise the spatial variability and residence time of any future alkalinity additions. However, Musgrave notes that "a model really is just a work of fiction until you can validate it." Together with Dr. Mathieu Dever, Musgrave and Yee have been sampling the 3D variability of the basin since December 2021 to both establish a baseline and to provide data to evaluate the model's performance. Dever, a research scientist at RBR and an adjunct researcher at the Woods Hole Oceanographic Institution, developed a fast underway profiler called the EcoCTD that allows the team to capture extremely high-resolution temperature and salinity observations of the entire basin over short timescales.

At the heart of the EcoCTD is an RBR*concerto*³ CTD, equipped with a fast-response thermistor and augmented with additional bio-optical sensors such as a fluorometer. While the ship is underway and moving at speeds of three to six knots, the EcoCTD, which is attached to a lightweight winch, cycles between free falling to the desired depth and subsequently being reeled up to the surface, taking measurements the entire time. With this setup, the team can cover roughly 15 kilometers in about two hours with a resolution of 100-200 meters between each CTD profile. The team samples the oval-shaped Bedford Basin every few months, completing one transect along the length of the basin and a couple across. They hope to increase sampling frequency soon.

For Musgrave, a great observational dataset of more than 600 CTD profiles has already been collected, which will soon be combined with her numerical model. This is, of course, only one aspect of a larger project. Once the physical model is validated, the researchers will add in a biogeochemical modeling component and further comparison with observations. Wallace, the team's chemical oceanographer, is determining what concentrations of alkalinity to add and at what rate. Researchers at Planetary Technologies are investigating how to create alkalinity additions without being carbon intensive, potentially by repurposing mine tailings. MacIntyre focuses on the impact of OAE, performing lab and field experiments to determine how alkalinity added in a concentrated region affects phytoplankton growth rates and community structure. More biologists will likely be brought into the project to explore other aspects of the ecosystem.

As a reflection of this ever-evolving project, the monitoring plan has grown, demonstrating its importance and interest to the scientific community. What was originally just three scientists (Musgrave, Dever, and Yee) in a zodiac, the team now includes members of Wallace's lab group taking pCO_2 measurements and using two autonomous underwater vehicles to measure temperature and conductivity. It will soon include biologists taking water samples to characterise the 3D structure of phytoplankton and zooplankton. The result is an invaluable 3D grid of observations, helping the team learn more and more about the basin and the potential of OAE. The team is also developing strategies to monitor future alkalinity additions. This is perhaps one of the biggest hurdles of the project, as they need to observe in real time that the alkalinity addition does trap CO_2. The EcoCTD with the RBR*concerto*³ CTD should be a particularly well-suited instrument for the task.



Climate, Kelp, and Mangroves: Why Blue Carbon Has Taken So Long to Materialize

By Kelli Barrett and Elizabeth Guinessey

Scientists have known for more than 40 years that mangroves and kelp provide a bulwark against climate change by pulling greenhouse gas from the atmosphere and infusing carbon into the ocean floor, but it wasn't until almost 2010 that the term "blue carbon" entered the vernacular.

The term refers to carbon stored in coastal ecosystems, including mangroves, seagrasses, and salt marshes. Environmentalists spent the ensuing decade developing procedures for financing the protection and expansion of mangroves under standard-setting body Verra's Verified Carbon Standard (VCS). In 2021, Verra recognized the world's first blue carbon conservation project: Colombia's *Vida Manglar,* which is Spanish for "Mangrove Life".

Listed in the Verra registry as "Blue Carbon Project Gulf of Morrosquillo[1]," *Vida Manglar* is located in one of the Caribbean Coast's most ecologically significant areas, and it will sequester almost one million tonnes of carbon dioxide over the next 30 years. This, in turn, will generate carbon credits that finance the protection of endangered habitat for manatees and other animals while promoting sustainable livelihoods, such as ecotourism and bee-keeping.

To quantify the project's carbon-storing powers, developers utilized a framework that was revised to include tidal wetland conservation and restoration activities in 2020 – raising the question: "What took so long?"

Answer: It's complicated.

Blue Carbon and Natural Climate Solutions

Although they cover less than 2 percent of total ocean area, blue carbon ecosystems account for half the carbon stored in oceans due to their ability to draw down atmospheric carbon and trap it for long periods. Scaling up blue carbon activities is therefore critical to meeting the climate challenge.

Blue carbon is what's known as a natural climate solution, a method of climate action that involves capturing carbon and reducing emissions through forests, coastal wetlands and other ecosystems. The concept dates back to a seminal 1976 paper entitled "Can We Control the Carbon Dioxide in the Atmosphere?"

"A worldwide shift from fossil to non-fossil fuels could not be carried out in a few years," the paper concluded, but an "emergency plant-growing program would provide the necessary short-term response to hold the CO_2 at bay while the shift away from fossil fuels is being implemented."

Three years later, delegates to the UN's first World Climate Conference (WCC) unanimously declared that "deforestation and changes of land use" were two of the three leading sources of man-emitted carbon dioxide.

| Sunset of a wetland lagoon in La Guajira, Colombia

Why Have Blue Carbon Conservation Projects Taken so Long to Materialize?

Practitioners working in the blue carbon space are, in a sense, playing catchup. Until recently, coastal wetlands had been overlooked, disregarded as wastelands, or simply seen as land to clear for waterfront development.

On top of this, it takes time, and a rigorous process, to develop nuanced and detailed procedures – AKA "methodologies" – for quantifying the real greenhouse gas benefits of climate mitigation projects.

Verra rarely initiates methodologies on its own but instead provides a framework within which environmental NGOs and other entities who see an unfunded climate solution can develop their own methodology and put it through the wringer of expert review and public consultation.

Specifically, any proposed methodology must pass muster with a panel of recognized experts before going out for a 30-day public consultation period where external stakeholders are invited to submit input. After the consultation, each public comment is addressed, and the methodology is amended to address shortcomings. The methodology is then assessed by independent auditors and either rejected or refined and sent out for further public consultation.

Developers working on blue carbon methodologies must operate within the confines of this laborious and, at times, cumbersome process. When compared to other methodologies for nature-based projects, such as for terrestrial forests, blue carbon has additional layers of complexity.

Mangroves, salt marshes, and seagrass, for example, bury carbon into the rich soil pools that lay beaneath them, making it more difficult and expensive to measure compared to other nature-based quantifications.

Kelp and other macroalgae, meanwhile, drop and dribble carbon down to the seabed, which is even harder to measure and a key reason why kelp and macroalgae methodologies remain especially elusive.

Despite recent media hype, the science on developing kelp and macroalgae methodologies isn't ready for prime time. So Verra has initiated the Seascape Carbon Initiative[2] to fill key science gaps in order to develop methodologies that can credit activities like kelp and seaweed farming.

Blue Carbon is Finally Scaling Up

Despite these challenges, we must scale up conservation and drive finance towards blue carbon activities if we're to meet the climate challenge - not to mention build coastal resilience against storms and sea level rise.

That's why Restore America's Estuaries and Silvestrum Climate Associates waded out into the weeds with Verra and other actors in the space to hammer out a methodology for blue carbon. The result was the aforementioned revision to one of Verra's methodologies[3], so it's applicable to tidal conservation and restoration activities in mangroves, seagrasses, and salt marshes.

It was the first methodology developed under a major greenhouse gas program that can drive finance, by generating credits, to blue carbon conservation. Just one year later, Conservation International and South Pole used the methodology to create *Vida Manglar,* demonstrating the interest and demand for blue carbon.

Today, Verra has three active methodologies under the VCS that can generate credits from conservation or restoration of blue carbon ecosystems, with plans to streamline existing frameworks. There are multiple blue carbon projects that are active and generating credits in the Verra Registry[4] and streamlined methodologies could have a significant impact on scaling up projects.

Types of Coastal Ecosystems

Tidal Marsh

Tidal marshes are communities of grasses, herbs, and low shrubs that are tolerant of flooding and occupy the tidal zone mostly above mean sea level. The composition of tidal marshes is influenced by flooding frequency and salinity. Tidal marshes are found from subpolar regions to subtropics, though at lower latitude they are out competed by mangroves.

Mangrove

A mangrove is a tree, shrub, palm, or ground fern, generally exceeding one-half meter in height that normally grows above mean sea level in the intertidal zone of marine coastal environments and estuarine margins. The term mangrove also refers to tidal habitat comprised of such trees and shrubs. Mangroves are frost-sensitive and so limited to tropical and subtropical regions.

Seagrass

Seagrasses are flowering plants found in diverse regions, from the tropics to the Arctic. They belong to four plant families, all in the order of Alismatales, which grow in marine, fully saline environments. There are twelve genera with some 58 species known.

Source: "A Blue Carbon Primer: the State of Coastal Wetland Carbon Science, Practice and Policy"

Edited By Lisamarie Windham-Myers, Stephen Crooks, Tiffany G. Troxler

Discover more:

1. https://registry.verra.org/app/projectDetail/VCS/2290
2. https://verra.org/project/vcs-program/projects-and-jnr-programs/seascape-carbon-initiative/
3. https://verra.org/methodology/vm0007-redd-methodology-framework-redd-mf-v1-6/
4. https://registry.verra.org/app/search/VCS/All%20Projects

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