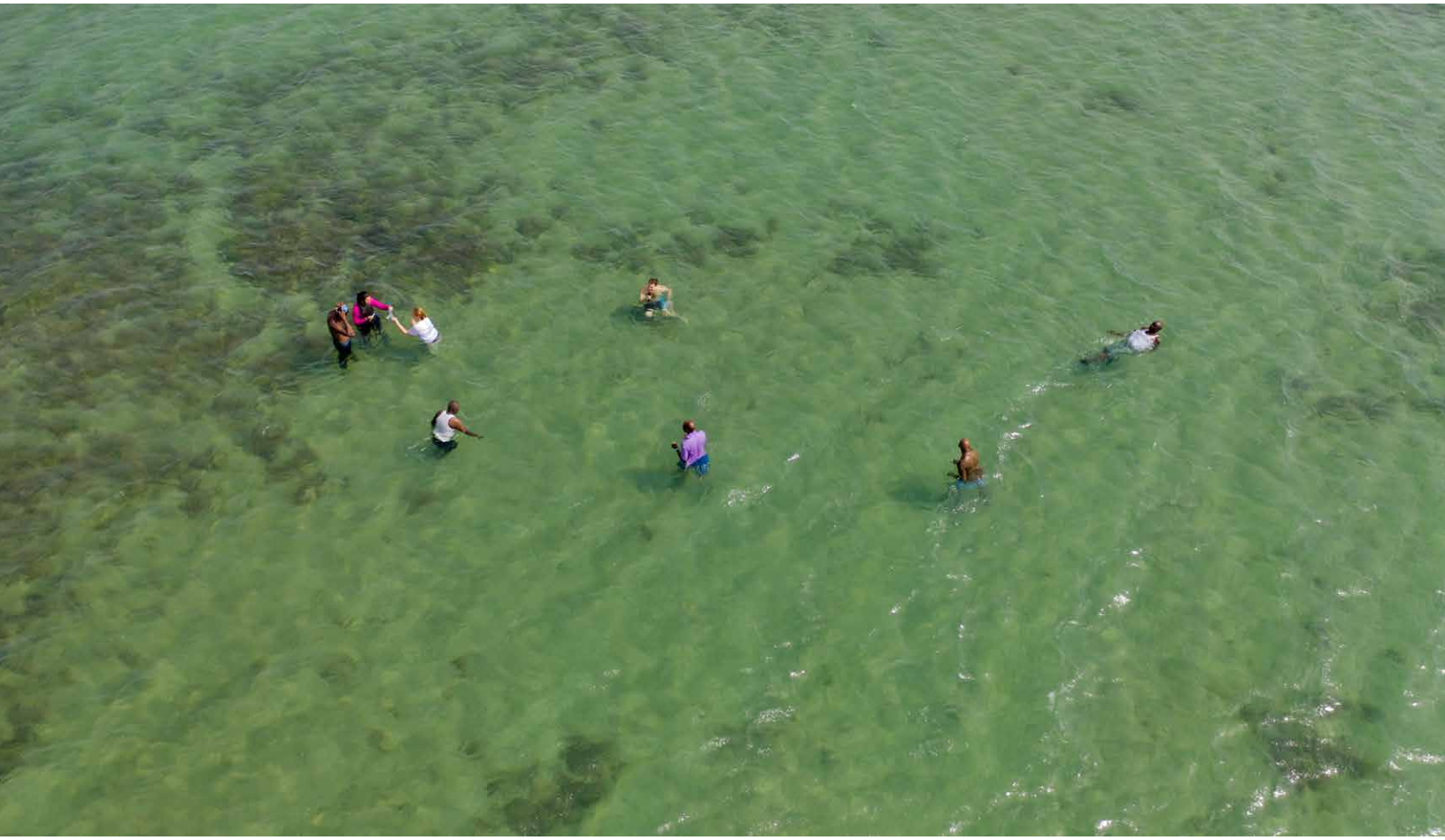
MEADOWS OF KNOWLEDGE

PUTTING WEST AFRICA ON THE GLOBAL SEAGRASS MAP



ResilienSEA

MAVA
FONDATION POUR LA NATURE

ISBN: 978-82-7701-210-0

Suggested citation: GRID-Arendal (2022) *Meadows of Knowledge: Putting West Africa on the global seagrass map*. ResilienSEA (GRID-Arendal/ RAMPAO/WIACO): Arendal, Norway. 80 pp.

Acknowledgements

This report was prepared as an account of work sponsored by the MAVA Foundation. The MAVA Foundation for Nature / GRID-Arendal neither makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, nor usefulness of the information provided. The views and opinions of authors expressedherein do not necessarily state or reflect those of the MAVA Foundation or GRID-Arendal.

Many individuals provided invaluable support, guidance, and input to the ResilienSEA project and to this publication. The editors would like to express their sincere and heartfelt gratitude to the contributing authors and technical support team for taking time to review our reports, provide comments, feedback, data as well as for the opportunity to present multiple deliverables within the course of the project. We are additionally thankful for the participation, time and effort that multiple stakeholders across the region who participated in the multitude of meetings and dialogue.

The authors of the report wish to express the utmost gratitude to the MAVA Foundation for its financial and technical support to the ResilienSEA project.

Editorial team

Olivia Polkinghorne, GRID-Arendal, Norway
Marco Vinaccia, GRID-Arendal, Norway
Maria Potouroglou, World Resources Institute, United Kingdom
Mohamed Ahmed Sidi Cheikh, Caisse des Depots and Development (CDD), Mauritania
Salomão Bandeira, Eduardo Mondlane University, Mozambique

Contributing authors

Louis Pille-Schneider, GRID-Arendal, Norway
Lemhaba Ould Yarba, Banc d'Arguin National Park, Mauritania
Hama Cheikh Mohamed El Havedh, Banc d'Arguin National Park, Mauritania
Lisdália Moreira, National Directorate for the Environment, Ministry of the Environment, Cabo Verde
Zofia Radwan, National Directorate for the Environment, Ministry of the Environment, Cabo Verde
Seydouba Soumah, Atlantic Technical University, Cabo Verde
Serigne Abdou Aziz Ndiaye, Department of Community Marine Protected Areas (DAMCP), Senegal
Elisabeth Diouf, University of Dakar, Senegal
Omar Sanneh, Department of Parks and Wildlife Management (DPWM), Gambia
Ousainou Touray, Department of Parks and Wildlife Management (DPWM), Gambia
Noelo Cardoso, Center of Applied Fisheries Research (CIPA), Guinea-Bissau
Emanuel Dias, Institute of Biodiversity and Protected Areas (IBAP), Guinea-Bissau
Udimila Kadija Queta, Institute of Biodiversity and Protected Areas (IBAP), Guinea-Bissau
Jeremias Intchama, Center of Applied Fisheries Research (CIPA), Guinea-Bissau
Iya Camara, Center for the Protection of the Marine Environment and Areas (CPMZC), Guinea
Paul A. Lamin, Environment Protection Agency, Sierra Leone
Melissa Ndure, Environment Protection Agency, Sierra Leone
Joseph Sapunka Turay, Environment Protection Agency, Sierra Leone
Lynette John, Institute of Marine Biology and Oceanography (IMBO), Sierra Leone

Technical support

Iderlindo Santos, Wetlands International Africa (WIACO), Senegal
Rokhaya Thiam, Wetlands International Africa (WIACO), Senegal
Tanya Bryan, GRID-Arendal, Norway
Richard Dacosta, GRID-Arendal, Norway
Adam Ceesay, Wetlands International Africa (WIACO), Senegal
Ester Sarrão, The University of Algarve, Portugal
Taibou Ba, Ecological Monitoring Center (CSE), Senegal
Syed Hasan Abbas, GRID-Arendal, Norway
Salla Ba, MAVA Foundation, Switzerland

Cartography

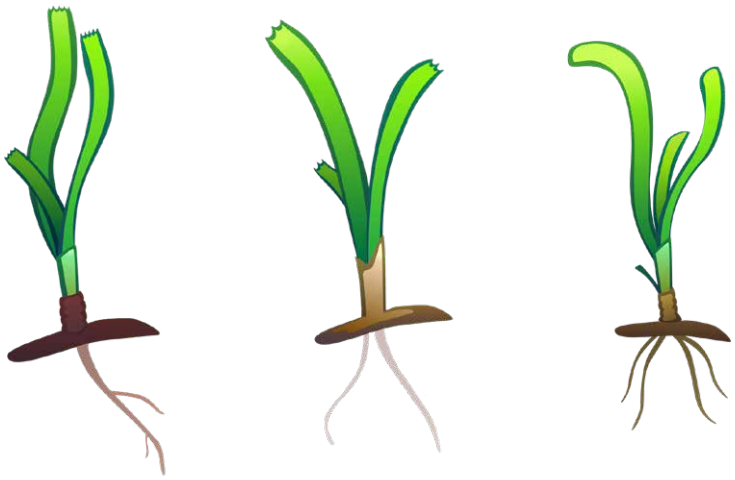
Georgios Fylakis, GRID-Arendal, Norway
Remco Lameijer, GRID-Arendal, Norway

Layout

GRID-Arendal, Norway

MEADOWS OF KNOWLEDGE

PUTTING WEST AFRICA ON THE GLOBAL SEAGRASS MAP



Foreword

In 2016, the MAVA Foundation started a new and last grant-making cycle. Thematic Outcome Action Plans (OAP) were developed with our partners on a few priority topics in the West Africa Programme. One of the identified priorities was the protection and conservation of seagrass ecosystems. Although seagrass beds are globally recognized for the numerous ecosystem services they provide, they received until then little attention in most West African countries. While the extensive presence of these treasured meadows was identified and documented in the *Parc National du Banc d´Arguin*, in Mauritania, there was little evidence of their occurrence in other countries. As a result of this lack of knowledge, threats could not be spelt out nor addressed properly.

Given the importance of this ecosystem, MAVA decided to invest resources to expand the knowledge about its distribution and identify the main threats it is facing in the region, so that in the long term conservation programs may be implemented to protect biodiversity and secure the services provided by seagrass beds in this part of the world. Scientific research was therefore identified as one of the priorities of this OAP, along with capacity building, information, sensitization, and policy advocacy. As shown in this atlas, some crucial discoveries of seagrass presence were made along the way in several countries. Data about seagrass distribution in the seven countries has increased significantly.

Capacity development was especially timely to ensure the sustainability of these activities. While international experts were welcome to share their seagrass knowledge and expertise, it was vital that a suite of regional managers, researchers, students, experts, community representatives and decision makers were trained to continue working on seagrass conservation in the long-term. This has been one of the most important achievements of ResilienSEA today, and we are confident that the local experts are in a position to continue their excellent work mapping, monitoring, and protecting these invaluable ecosystems.

As an "engaged donor", adaptive management has been a pivotal element for MAVA throughout its work. Mid-way through the ResilienSEA project, we carried out with all the partners, a joint reflection on lessons from the initial two years of the project's first phase, in order to better plan for the second phase. This included a change in some of the partners´ roles, to ensure even more regional buy-in and leadership, as well as a stronger focus on regional cooperation, with even greater knowledge exchange across the seven countries.

In spite of the differences among the countries, the committed national Implementation teams have demonstrated unity and solidarity and worked to uplift every country and help them move in the same direction towards a common goal. This is best exemplified by the fact that a regional protocol is being developed and championed by some of the ministers of environment in the region, to ensure these precious ecosystems can thrive in future. Moreover, national policies are being implemented at local levels, through the inclusion of seagrass conservation within the planning and management tools of Marine Protected Areas (MPAs).

The above will not happen without financial resources, and while the MAVA Foundation is phasing out at the end of 2022, we are supporting our partners in the region in their fundraising efforts, to allow them to sustain their achievements and continue to work for the benefit of coastal communities and biodiversity in West Africa.

After four years of hard work, I can proudly say that we have succeeded in putting West Africa on the global seagrass map.

Charlotte Karibuhoye
MAVA Foundation Head of Strategic Alliances & Director, West Africa

Preface

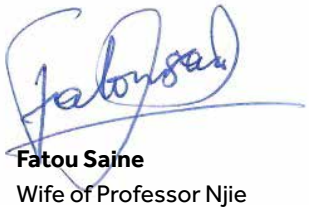
Seagrasses are vital components of the planet's coastal and marine ecosystems. As we begin to realise their full value, from being carbon sinks to young fish refugia and first line defenders of our coasts, ever-greater efforts are being made to protect what remains and to restore what has been degraded or lost.

But all these efforts can only be effective if we know where seagrasses are and when people are equipped with the tools to safeguard these critical ecosystems. West Africa had historically been the least-studied region in seagrass science, and this is the reason why the project ResilienSEA (short for Resilient Seagrasses) was initiated in 2018. The ultimate goal and motto was to put 'West Africa on the global seagrass map'. Now four years after, we couldn't be prouder of what the people of ResilienSEA have achieved.

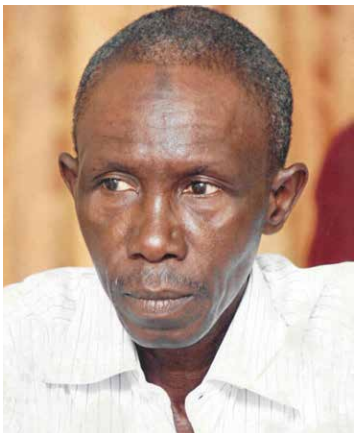
Together the seven country members have developed and exchanged knowledge, guidance and tools on mapping and monitoring seagrasses, integrated management practices in their national plans, and even incorporated seagrasses in the highest-level of climate strategies and policies. This Atlas represents the amalgamation of these efforts and for the first time you can learn how the countries have been working to strengthen conservation on the ground, by taking global best-practice guidance and adjusting it to their national circumstances and environments, how they have mobilised joint implementation activities with a broad range of stakeholders, how their work and progress has been directly informing and enhancing mapping and monitoring efforts, and how they have raised the profile of seagrasses within their community, country and region.

There is a recipe to success, and ResilenSEA followed it to the letter; *'It's only through actions supported by national partners and local communities that will help us achieve the gains we so urgently need'*. ResilienSEA always relied on their dedicated national implementation teams, pooling complementary experiences and knowledge. And by doing so, seagrass champions are now spread in every corner of West Africa inspiring and urging others to follow them in their mission to secure a future for these beautiful – and essential to our livelihoods – underwater meadows..

Dr. Maria Potouroglou
World Resources Institute

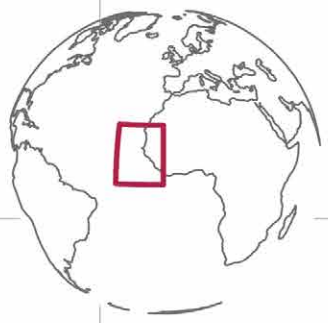


Fatou Saine
Wife of Professor Njie



In memory of Professor Njie, a great teacher, a kind heart and an ever-giving soul.

Contents



21°N

18°N

15°N

12°N

9°N

6°N

3°N

24°W

21°W

18°W

15°W

12°W

Mauritania

Nouakchott

Cabo Verde

Praia

Dakar

Senegal

Gambia

Guinea - Bissau

Bissau

Guinea

Atlantic Ocean

Conakry

Sierra Leone

Freetown

Confirmed seagrass presence

Fishing Activity (hours)

200 - 1000

1000 - 3000

3000 - 5000

>5000

Sources: Confirmed seagrass: National Implementation Team of Countries, 2022.
Fishing activity: Leurs, G., van der Reijden, K. J., Lemrabott, S. Y., Barry, I., Nonque, D. M., Olff, H., Ledo Pontes, S., Regalla, A., & Govers, L. (2021). https://doi.org/10.3389/fmars.2021.602917

Photo: Rob Barnes 2019

WEST AFRICAN SEAGRASS: AN INTRODUCTION

Field team monitoring shallow seagrasses in the Saloum Delta National Park. Photo: Senegal national implementation team 2021

The ResilienSEA project

Seagrass meadows are a coastal ecosystem with indisputable value for life below and above water (Nordlund *et al.* 2017; United Nations Environment Programme [UNEP] 2020). On a global scale, seagrass plays a major role in terms of food security (de la Torre-Castro and Rönnbäck 2004; Unsworth, Nordlund and Cullen-Unsworth 2019), shoreline protection (Ondiviela *et al.* 2014), carbon sequestration (UNEP 2020), provision of livelihoods for coastal communities (Nordlund *et al.* 2010) and biodiversity enhancement, by providing habitats for megafauna of special interest and endangered species such as dugongs, seahorses and sea turtles, among countless others.

Despite the presence of seagrass meadows in West Africa, this region has historically been one of the least studied areas of seagrasses in the world (UNEP 2020). Without adequate data and knowledge of seagrasses in West Africa, these ecosystems have often been omitted from protection, conservation and management policies. A recent seagrass programme funded by the MAVA foundation has supported research and capacity-building activities to map and monitor seagrasses within seven West African pilot countries: Cabo Verde, Gambia, Guinea, Guinea-Bissau, Mauritania, Senegal and Sierra Leone. Through this programme, the ResilienSEA (Resilient Seagrasses) project (2018–2022) was launched and has sought to enhance scientific expertise and build capacity to improve seagrass protection within these countries.

Over the past five years, these pilot countries have mapped the presence of seagrasses at various national pilot sites, where further research, management and outreach activities have been conducted. Approximately 83,288 ha of seagrasses have been documented within these countries to date (Sidi Cheikh *et al.* 2022, in-press), and monitoring activities have even prompted the discovery of several previously unknown seagrass meadows. This marine atlas aims to showcase the recent strides made in West Africa to discover, map and monitor seagrass meadows. It therefore provides a baseline for the status of seagrasses in this region as of 2022. By documenting each nation's experiences with mapping and monitoring seagrasses, this atlas will also delve into the challenges, lessons learned, successes and potential opportunities that lay ahead for incorporating seagrass meadows into national and regional protection and conservation policies.

Seagrasses were already known to exist along the shorelines of some pilot countries, such as Cabo Verde, Mauritania and Senegal, prior to the start of the ResilienSEA project, but they had not been comprehensively mapped (Sidi Cheikh *et al.* 2022, in-press). This is particularly true for Mauritania, where researchers have studied seagrasses since the 1990's (e.g. Hemminga and Nieuwenhuize 1990; van Lent, Nienhuis and Verschuure 1991; Vermaat *et al.* 1993; van der Laan and Wolff 2006; El-Hacen *et al.* 2020). Therefore, the goal of monitoring national seagrass meadows in Mauritania is to better understand and attribute economic value to the ecosystem services provided by seagrasses, while also furthering their protection within national policy and international climate treaties.

For other countries, the national awareness and subsequent management of seagrass meadows is just beginning. The factors that contribute to the lack of coastal ecosystems management and protection vary by country, although challenges such as insufficient financing and the limited capacity and training of managers and practioners are consistent throughout the region. Nevertheless, significant progress has been made within pilot countries, in terms of local capacity-building and national policy accomplishments.

In Cabo Verde and Sierra Leone, seagrass meadows were incorporated into both countries' nationally determined contribution (NDC), which are non-binding commitments submitted to the United Nations Framework Convention on Climate Change (UNFCCC) to reduce national emissions and adapt to the impacts of climate change. Both countries are among the first to specifically include seagrasses within their NDCs, not just in Africa but in the world (UNEP 2020). In Guinea-Bissau, new fisheries policies now specifically include language for the protection of seagrasses. Seagrass meadows in Guinea have also been incorporated into marine protected area (MPA) management plans, while the project's seagrass monitoring sites in Gambia and Guinea-Bissau aare in consideration to become new MPAs. Beyond policy, this project has also engaged university students and experts within pilot countries to continue monitoring these ecosystems. Provided that financial resources are available in the medium to long term, there is significant potential for similar efforts to be replicated and enhanced throughout the region to advance the protection and conservation of seagrasses in West Africa.

Seagrass species

A subtidal meadow of Halodule wrightii in the Bijagós Archipelago, Guinea-Bissau. Photo: National implementation team of Guinea-Bissau, 2021

Seagrasses are flowering plants that grow in muddy or sandy sediment on the sea floor and have erect, elongate leaves and a buried root-like structure. There are around 70 described species of seagrasses worldwide, within 13 genera, five families and two orders found on all continents except Antarctica (Green and Short 2003; Hartog and Kuo 2006). They typically occur in shallow, soft-bottomed marine coastlines and estuaries. Seagrasses form biodiversity rich meadows that consist of just one or multiple seagrass species, with as many as 14 species found growing together (Short *et al.* 2007). Having evolved from terrestrial plants, seagrasses have several characteristics that make them unique as a marine species: for example, as angiosperms, seagrasses are the only flowering marine plants submerged below water that have a root and rhizome structure (Short *et al.* 2007). This structure connects individual shoots through a network of rhizome nodes, which transports nutrients and encourages growth, leading to the formation of meadows that can withstand wave energy.

Seagrass meadows are among the most common and oldest coastal habitats on Earth, potentially covering more than 300,000 km^2 in at least 159 countries (UNEP 2020). Seagrass meadows can be found in both intertidal and subtidal zones, and the depth in which seagrasses occur is contingent upon their tolerance to desiccation in shallow areas or the amount of sunlight received in deeper waters (Hemminga and Duarte 2000). Indeed, light is the most limiting factor for the vertical distribution of seagrass (Duarte 1991). The accessibility to the light is then regulated by the depth, the particulate filler of the column of water (turbidity) and the rate of foliar epiphytotic. The depth may be subject to tidal regime, and the load of particles and epiphytes is, in turn, based on the hydrodynamics and the level of external inputs of nutrients. The majority of identified seagrass grows in intertidal and subtidal zones of less than 30 meters, although depths up to 90 meters have been reported (Duarte 1991).

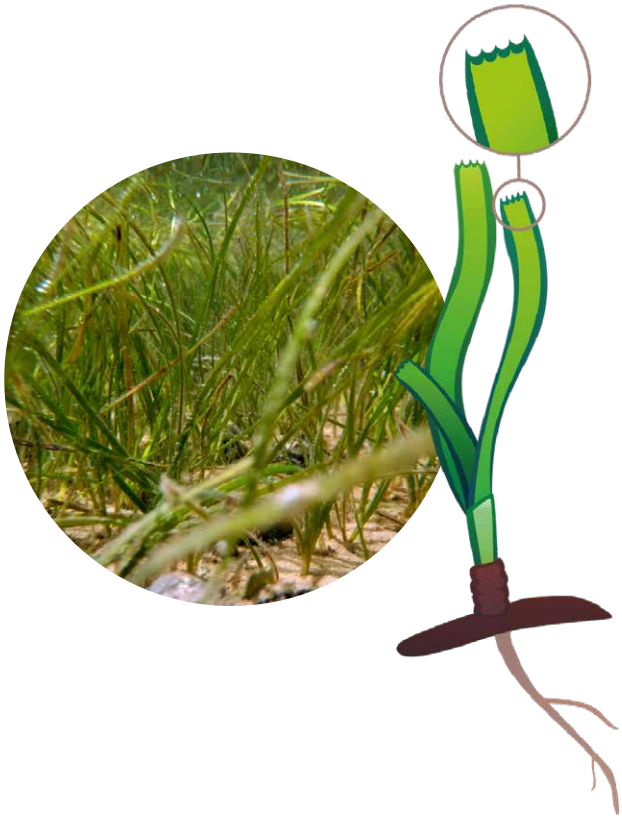
At the broadest level, seagrasses are differentiated into temperate and tropical species. The seagrasses found off the coast of West Africa have different biogeographic affinities (Green and Short 2003; Short *et al.* 2007). At the northern-most point of West Africa, Mauritania contains a mix of temperate and tropical seagrasses with moderate diversity (Short *et al.* 2007). South of Mauritania, the seagrass found are typically tropical, and the level of biodiversity is high (Short *et al.* 2007).

Within the region of West Africa that is of interest for this atlas, the three most commonly found marine seagrass species are *Cymodocea nodosa*, *Halodule wrightii* and *Zostera noltei*. While *Ruppia maritima* is also found in West Africa (Martinez-Garrido *et al.* 2017), it can be categorized as a salt-tolerant freshwater species, although the IUCN red list of seagrasses includes all species of the genus *Ruppia* as seagrasses, which occur from freshwater to hypersaline marine waters across the world. Given their variable habitats, this atlas primarily excludes the genus *Ruppia*, therefore the distribution of *R. maritima* will not be discussed.

Seagrasses within this region occur in a variety of coastal areas, with most meadows found in predominately sheltered soft-bottomed marine coastlines and estuaries. Due to high turbidity and limited light intake, seagrasses in West Africa tend to thrive in shallower waters. The distribution of each species per pilot country is displayed in Table 1. Despite the limited diversity of seagrass species in the region, these ecosystems are greatly important for West African marine life as they provide sheltered, nutrient-rich habitats for diverse flora and fauna.

Table 1. Distribution of *Cymodocea nodosa*, *Halodule wrightii* and *Zostera noltei* per country

Country	*C. nodosa*	*H. wrightii*	*Z. noltei*
Mauritania	✓	✓	✓
Cabo Verde		✓	
Senegal	✓	✓	✓
Gambia	✓	✓	
Guinea-Bissau		✓	
Guinea		✓	
Sierra Leone		✓	



Cymodocea nodosa

C. nodosa is a temperate, subtidal seagrass species that can be identified by its serrated leaf tip and pink rhizome. *C. nodosa* shoots usually comprise 3–4 leaves, which can be up to 60 cm in length (Borum *et al.* (eds.) 2004). In West Africa, this species is often found at a depth of 4 m or less, growing in sandy or muddy sediment. *C. nodosa* can thrive in sheltered regions as well as more exposed coastal waters. As observed in monitoring areas in Gambia, Mauritania and Senegal, *C. nodosa* can occur mixed with *H. wrightii* (Sidi Cheikh *et al.* 2022, in-press).

Halodule wrightii

H. wrightii is the only tropical species found within the West African region of interest, and it is also the only species consistently found throughout all the pilot countries. It is primarily found in the subtidal zone and, in West Africa, rarely exceeds a depth of 2 m. The species grows in both sandy and muddy sediment, usually in sheltered locations. *H. wrightii* is characterized by a concave leaf tip, usually with a darker central nerve at the apex. The rhizomes are pale to white in colour, with each shoot of the plant containing between two and four leaves with a maximum length of 30 cm (Sidi Cheikh *et al.* 2022, in-press).

Zostera noltei

Z. noltei is a temperate seagrass species with a high tolerance to desiccation, meaning that it can be found in very shallow intertidal zones, where it is often exposed to the air for extended periods of time during low tide. *Z. noltei* can be identified by its smooth leaf tip, translucent veins and a yellow-brown rhizome colour. Each shoot of the *Z. noltei* plant typically contains 2–5 leaves, reaching a maximum length of 53 cm (Borum *et al.* (eds.) 2004). In West Africa, this temperate species was previously thought to occur only in Mauritania. However, during a ResilienSEA field expedition in 2019, an extensive *Z. noltei* meadow was recorded for the first time in the Saloum Delta, Senegal, thus extending the southernmost limit of its distribution to Senegal (Sidi Cheikh *et al.* 2022, in-press).

Ecosystem services

It is estimated that over 1 billion people live within 100 km of a seagrass meadow worldwide (UNEP 2020). Seagrasses are believed to be one of the most valuable and important coastal marine ecosystems due to the ecosystem services and benefits they provide for life below and above water. Ecosystem services are the direct and indirect benefits provided by an ecosystem that contribute to human welfare. These services can be broken down into four categories: supporting, regulating, provisioning and cultural. There is a geographic literature gap of ecosystem service assessments, with very few studies of this nature completed in West Africa to date (Vegh and Potouroglou (eds.) no date; Tuya *et al.* 2014; Trégarot *et al.* 2019). While forthcoming studies on seagrass ecosystem services in Cabo Verde, Guinea-Bissau and Senegal aim to identify these benefits specifically within the countries, further research is needed. Thus, this section describes the general benefits that can be derived from seagrass ecosystem services while citing examples throughout the region.

Food security and fisheries

High production rates of fisheries are often linked to the high primary production rates of adjacent seagrasses, with the average fisheries nursery function of seagrasses estimated at $618,505 per hectare per year based on global assessments (Dewsbury, Bhat and Fourqurean 2016; Scott *et al.* 2000). In Western Africa, a 2014 study from the Canary Islands estimates the fish habitats provided by *C. nodosa* to have an economic value of $1,226 per hectare per year (Tuya *et al.* 2014). Indeed, seagrass meadows provide nursery habitats and foraging grounds for commercially valuable fish and shellfish, supporting

Ecosystem services

Supporting services maintain fundamental ecosystem functions. These processes are considered the foundation for all other ecosystem services through nutrient cycling, soil formation, habitat provision and primary production, which generally occurs through photosynthesis.

Regulating services seek to establish balance within an ecosystem through processes such as water filtration, carbon sequestration and climate regulation, pollination and coastline protection through disturbance regulation.

Provisioning services represent the most direct and tangible benefits to humans. These services include providing food, raw materials, energy and fuel, medicinal resources and ornamental resources (i.e. fashion, crafts and decoration).

Cultural services are the sociocultural benefits provided by ecosystems, which are often involved in identity formation. These benefits cover a spectrum of services including aesthetics, recreation and tourism, education and historical or spiritual value

A seagrass meadow in Greece. Photo: Dimitris Poursanidis 2013

Serer woman harvesting ark clams (Senilia senilis) near seagrass meadows in Joal-Fadiouth, Senegal. Photo: Rob Barnes, GRID-Arendal 2019

A day's work of harvesting ark clams (Senilia senilis) in Joal-Fadiouth, Senegal. Photo: Rob Barnes, GRID-Arendal 2019

approximately 20 per cent of the world's largest fisheries (Unsworth, Nordlund and Cullen-Unsworth 2019). Seagrasses also support essential small-scale and artisanal fisheries, which in turn sustain livelihoods and local economies.

In West Africa, this is particularly true for small-scale and traditional fishers, as well as shell gleaners. In Joal Fadiouth, Senegal, for example, seashell harvesting has been a part of the Serer culture for generations. One local women's mariculture and reforestation association, *Mboga Yaye*, sustainably harvests ark shells, clams, mussels and oysters that grow in mangrove and seagrass ecosystems within the local community-based MPA. Ark clams are a fundamental source of income for the local economy, with revenue generated from mariculture activities often covering household expenses and school fees for community members.

Coastal protection

Seagrasses provide shoreline protection from storm surges, sea level rise and floods – factors that exacerbate coastal erosion (Ondiviela *et al.* 2014). Seagrasses reduce wave energy by roughly 40 per cent and accrete 30 mm per year more than unvegetated zones (Potouroglou *et al.* 2017). By stabilizing sediment, seagrasses lessen damage to coastlines and help coastal communities adapt to the local impacts of climate change caused by the increased frequency and intensity of storms (Trégarot *et al.* 2021). In turn, this also helps maintain sandy beaches, which can be economically important for the tourism sector (James *et al.* 2019).

An eroding coastline in Gambia. Photo: Rob Barnes, GRID-Arendal 2019

Sediment under a seagrass meadow in Greece where carbon can potentially be stored. Photo: Dimitris Poursanidis 2013

Water purification

Seagrasses produce oxygen as a by-product of photosynthesis, which helps rid the waters in which they grow of pathogens and bacteria that can be harmful to human and ocean health. Additionally, seagrasses purify water from nutrients, contaminants and other particles through their leaves and roots (UNEP 2020). They dissolve and absorb organic matter from the water column, as well as inorganic nutrients such as nitrates, phosphates and ammonium. Through this process, seagrass meadows are natural biofilters for coastal waters, which greatly benefits economically important fish and bivalves. Due to the bioaccumulating capacity and sensitivity of seagrasses, they are also considered bioindicators – or "coastal canaries" – for water quality (Orth *et al.* 2006; Marbà *et al.* 2013). With global oceans increasingly affected by pollution, water purification is more important than ever for the health and vitality of marine life.

Mitigating ocean acidification

Seagrass meadows also regulate the pH and chemistry of seawater through the uptake of dissolved carbon, making local waters less acidic and less harmful to marine organisms with calcium carbonate skeletons, such as corals, shellfish and crustaceans. Seagrasses are highly productive and remove large quantities of dissolved inorganic carbon from the water column, to be used in photosynthesis. Subsequently, the pH of the water surrounding the seagrass meadows increases, which can help prevent ocean acidification and its negative impacts on the adjacent flora and fauna (Duarte *et al.* 2013).

Climate change mitigation

Although seagrass meadows only cover 0.1 per cent of the ocean floor, they are incredibly efficient carbon sinks. Seagrasses can store up to 18 per cent of the world's oceanic carbon, which is twice as much as the carbon stored in temperate and terrestrial forests (UNEP 2020). In this regard, seagrasses are important ecosystems for mitigating climate change. Countries around the world, including Cabo Verde and Sierra Leone, are beginning to incorporate seagrass meadows as a climate mitigation tool within their NDCs to help them achieve their targets under the Paris Agreement and the UNFCCC.

Supporting biodiversity

Seagrasses form complex habitats that enhance biodiversity and support an abundance of fauna, including many threatened and endangered species, as well as megafauna of special interest, such as dugongs, sea turtles, manatees and sharks (Sievers *et al.* 2019). Indeed, biodiversity in seagrass meadows is shown to be much greater than in adjacent bare or unvegetated areas, with the density of fauna within these meadows higher by magnitudes (Hemminga and Duarte 2000; Orth *et al.* 2006). By providing spaces of shelter, grazing, refuge and nursery grounds, seagrass meadows are also vital for many marine and terrestrial species in West Africa.

Pirogues in Senegal. Photo: Rob Barnes, GRID-Arendal 2019

In Mauritania, for example, the Banc d'Arguin National Park is a significant area for migratory birds – the park is home to more than 2 million wintering shorebirds from Europe, Siberia and Greenland annually, making it the largest concentration of wintering shorebirds in the world (International Union for Conservation of Nature [IUCN] 2020). The dense intertidal seagrass beds are ideal feeding areas for these birds during low tide.

Great white pelicans (Pelecanus onocrotalus) in the Banc d'Arguin, Mauritania. Photo: Flickr/Christophe André 2007

Cultural benefits

Globally, there are many livelihoods and cultural traditions that are linked to seagrass meadows. These often include tourism and recreation but can also pertain to spiritual and religious beliefs (de la Torre-Castro and Rönnbäck 2004). In Cabo Verde, stakeholders and government officials now consider seagrass areas as a point of promotion for tourism, with seagrasses in Gamboa contributing to a "great sense of place". Seagrass meadows are considered symbols of pride – and even hope – in places such as the Bijol Islands in Gambia, where coastal erosion is drastically impacting the shoreline, thus prompting seagrass restoration efforts to help tackle this trend. See page 47 for more information on seagrass restoration initiatives in Gambia.

Seagrass meadows are also a valuable cultural resource for coastal communities and are intrinsic to socioeconomic landscapes. By providing essential habitats for important fish and shellfish species across West Africa, seagrasses indirectly support many culturally significant coastal livelihoods within the region. Additionally, as community awareness of the benefits of seagrass meadows increases, a greater appreciation for these ecosystem services may emerge. In Sierra Leone, for example, community-outreach initiatives have enhanced local knowledge and interest in seagrasses, with some families in the Turtle Islands even setting up small clam farms adjacent to the newly established seagrass monitoring sites due to their ecological productivity.

Threats to seagrass

Since the late nineteenth century, almost 30 per cent of known seagrass area across the globe has been lost (Orth *et al.* 2006). Although some loss can be attributed to natural causes, such as high-intensity storms or wasting disease, most loss of global seagrass meadows is the result of anthropogenic impacts, which continue to degrade and destroy these coastal ecosystems and decrease their ability to provide key ecosystem services. The primary drivers of decline include urban, industrial and agricultural run-off, coastal development, dredging, unregulated fishing and boating activities, and climate change. Climate change-related impacts on seagrasses are projected to accelerate the loss of *Z. noltei* and *C. nodosa* species (Chefaoui *et al.* 2018), while seagrass meadows outside of protected areas are particularly at risk of declining (Turschwell *et al.* 2021).

These drivers appear to be consistent within West Africa as well, though more long-term monitoring and research is needed to measure seagrass change over time. In Cabo Verde, for example, increased coastal development endangers seagrass meadows, as they are not currently included in the national network of protected areas. In one monitoring location, seagrass meadows were found near the Cabo Verde Integrated Resort and Casino tourist development, adjacent to an outflow pipe that discharges directly into the existing meadows. Additionally, there are many other human activities within this urbanized area that could adversely affect the health of these seagrasses, such as fishing and fishing boats, cargo and passenger ships, and coastal tourism and development in the form of casinos, marinas, shops, restaurants, malls and event venues.

Similarly, in Senegal, the combined effects of human development and climate change are threatening the country's environment and biodiversity, including seagrass meadows. Most marine resources are stressed due to destructive fishing practices, mining industries and offshore extraction,

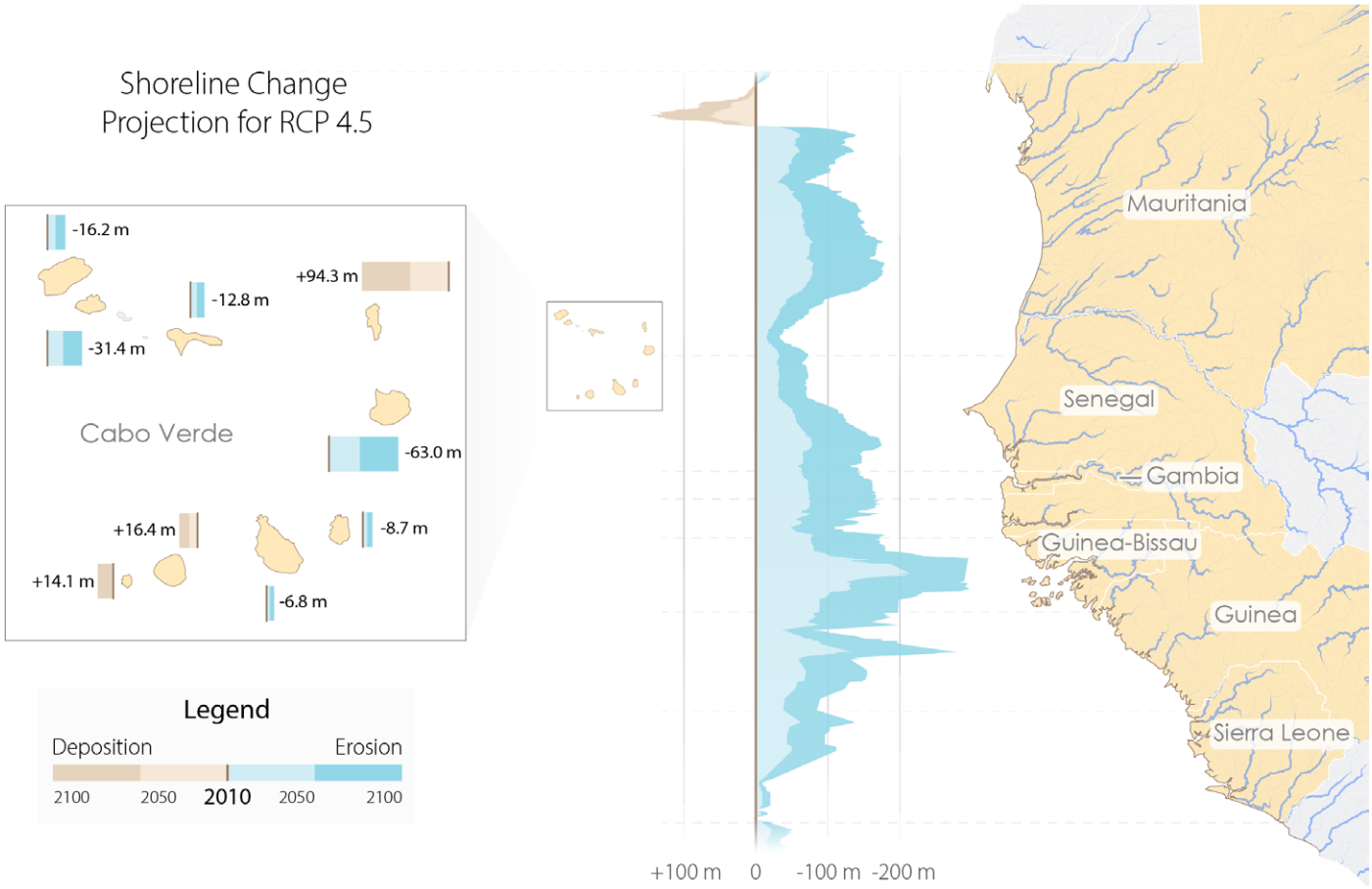


Figure 1. Projection of shoreline change for 2050 and 2100 using data from Vousdoukas *et al.* (2020). Projection considers RCP 4.5 (intermediate scenario) as described by IPCC (2014). Data for mainland smoothed by averaging over latitude using a moving median with k = ~10km. Data for Cabo Verde aggregated as median per island. Source: GRID-Arendal 2022

tourism, coastal development and pollution. Destructive fishing practices are also cited as a major threat to seagrasses in Sierra Leone, as are soil exhaustion and deforestation, and the depletion of natural resources during the civil war. These pressures are in turn exacerbated by climate change, which affects rainfall, accelerates desertification and increases ocean temperatures.

The effects of climate change are felt most severely by island communities in West Africa, where sea level rise and coastal erosion are projected to significantly impact shorelines (see Fig. 1). In the Bijol Islands, Gambia, erosion is already impacting their coastline. These islands provide a habitat for more than 200,000 migratory birds annually, which create nests along coastal trees and shrubs. Locals note that this vegetation is becoming inundated with water, therefore threatening these vital habitats. With mangrove forest dieback and the loss of coastal forest cover on the islands (Komma 2019), seagrass meadows are the only prominent coastal vegetation remaining around the islands' perimeter to help stabilize sediment.

These anthropogenic drivers are also recognized by seagrass experts throughout West Africa. In 2018, a stakeholder assessment was conducted through the ResilienSEA project to evaluate regional experts' perceptions of seagrasses (Vegh and Potouroglou (eds.) no date).

The 18 experts interviewed from the seven pilot countries identified five major threats to seagrasses and ranked them accordingly: 1) human disturbance and development; 2) pollution; 3) unregulated or destructive fishing; 4) climate change; 5) insufficient knowledge or information. Other threats mentioned include offshore oil exploration, coastal erosion, invasive species, silting and ocean acidification.

Despite the significant impact that human activities have on seagrass meadows, non-anthropogenic factors must also be considered when discussing seagrass loss and variability in West Africa. Green sea turtles (*Chelonia mydas*) and African manatees (*Trichechus senegalensis*) native to the region often graze on seagrass meadows (Keith-Diagne 2014; Díaz-Abad *et al.* 2022) – sometimes leading to overgrazing, as field monitors have noted in Gunjur, Gambia. However, seagrasses need these grazers for seed dispersal along this region (Tavares *et al.* 2022). Overfishing of predator species such as sharks can disrupt food webs and lead to overgrazing (Heithaus *et al.* 2014), though scientific research has yet to be completed on this specific threat in West Africa.

Sheen of an oil spill within a seagrass meadow. Photo: Flickr/Ria Tan 2017

Weather effects, such as storm surges and wind dust, have also been shown to impact seagrasses in the region. Waves from Atlantic storms that form during the monsoon season in West Africa can erode seagrass habitats and redistribute sediment in a harmful manner (Trégarot *et al.* 2021). Although storms are naturally occurring weather events, their severity and frequency may increase in time as a result of climate change. In terms of wind dust, the Saharan air layer transports sand and dust from the Sahara and Sahel over the North Atlantic, including off north-western Africa (Goudie and Middleton 2001), which can affect seagrass dynamics.

Despite losses of seagrass meadows globally and within West Africa, a local seagrass expert in Mauritania, Mohamed Ahmed Sidi Cheikh, has recently found that seagrass coverage has increased since the 1990s in one of the country's sampling locations, noting that "the most marked variations in the seagrass meadows seem to be explained by specific conditions related to climate factors, such as dust loading". This example highlights the importance of measuring seagrass change in terms of diversity, distribution and abundance over time. To detect changes that occur through anthropogenic and natural perturbations, it is necessary to first map the distribution and density of existing seagrass meadows. Monitoring the health and condition of seagrasses can then inform and potentially impact national protection and management strategies for coastal ecosystems.

Monitoring seagrass with a quadrat in Banc d'Arguin National Park, Mauritania . Photo: Mohamed Ahmed Sidi Cheikh 2022

Monitoring seagrass

To identify seagrass areas that require conservation measures, the distribution and density of seagrass meadows must first be documented. By monitoring the same sites over time – ideally once a quarter but at least twice a year – the data collected can determine the extent and variability of seagrasses that occur through perturbations, both human-caused and natural (McKenzie 2003). This is particularly important for coastal managers who require a baseline to estimate the statistically significant losses, gains and recovery rates of seagrasses. This information can then inform coastal ecosystem protection measures at the local, national or regional level to ensure that vulnerable seagrass areas are incorporated into such policies.

The field ecology methods used during ResilienSEA monitoring activities primarily include morphological and structural measurements. This involves measuring the seagrass coverage percentage, shoot density and canopy height, alongside identifying the type of species and sediment in which it grows, the adjacent fauna and the percentage of epiphytes and algae present. These methods were adapted from Seagrass-Watch,* a global seagrass monitoring resource (McKenzie 2003).

The process of recording these structural measurements involves collecting data from fixed transects or spots within defined areas – usually three 50-m transects parallel to one another and spaced 25 m apart. The spots are identified through gridded sampling, meaning they should be located 100–500 m apart, depending on the size of the site. Then, three 50x50 cm frames, known as quadrats, can be lowered down to the seabed within a 5-m radius of this spot. These monitoring activities are applicable both for intertidal and subtidal areas. However, the latter is more laborious given the need to use snorkelling equipment with better underwater coordination. Subtidal sampling may use quadrats laid out in a more random pattern, as it can sometimes be difficult to find a gradient in a large completely subtidal area.

A transect is laid out while a quadrat is laid accordingly within the sampling area in the Banc d'Arguin, Mauritania. Photo: Mohamed Ahmed Sidi Cheikh 2022

The tools required for this monitoring process usually include multiple quadrats and transects, a GPS reader, a GoPro or waterproof camera, mud shoes, rulers, snorkelling equipment, plastic bags and gloves for collecting samples, magnifying glasses, waterproof printed sheets to record measurements, multiparameter equipment to record water quality data and a salinometer to measure the water salinity.

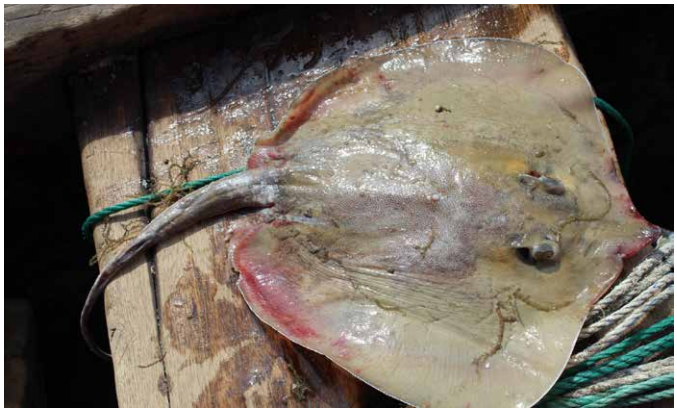
A quadrat in low tide in the Banc d'Arguin, Mauritania (left) and a submerged quadrat in Sierra Leone (right). Photos: Mohamed Ahmed Sidi Cheikh 2022; Sierra Leone national implementation team 2022

* See http://www.seagrasswatch.org

Challenges to monitoring seagrass in West Africa

During the ResilienSEA project, pilot countries have faced several practical challenges associated with monitoring and field research, as well as broader challenges that hinder their abilities to incorporate seagrass meadows into protection and conservation policies. However, these challenges are fundamentally connected: if countries are limited in their ability to accurately monitor seagrass meadows with sufficient frequency, vulnerable seagrass areas are less likely to be included within protection mechanisms.

In terms of monitoring, many challenges can arise in the field. First, the sampling sites within pilot countries differ in terms of accessibility and remoteness. For managers and researchers in Guinea, for example, accessing the monitoring locations in the Tristao Islands entails a four-to-six-hour motorized boat ride. Challenges in accessing sites can lead to less frequent monitoring, ultimately lessening the accuracy of these seagrass monitoring data results. Once in the field, researchers and managers require technical equipment to perform monitoring activities, and in some cases, countries may lack sufficient or appropriate equipment. Hazards, such as stingray attacks and interactions with other dangerous coastal fauna, can also occur when in the field.



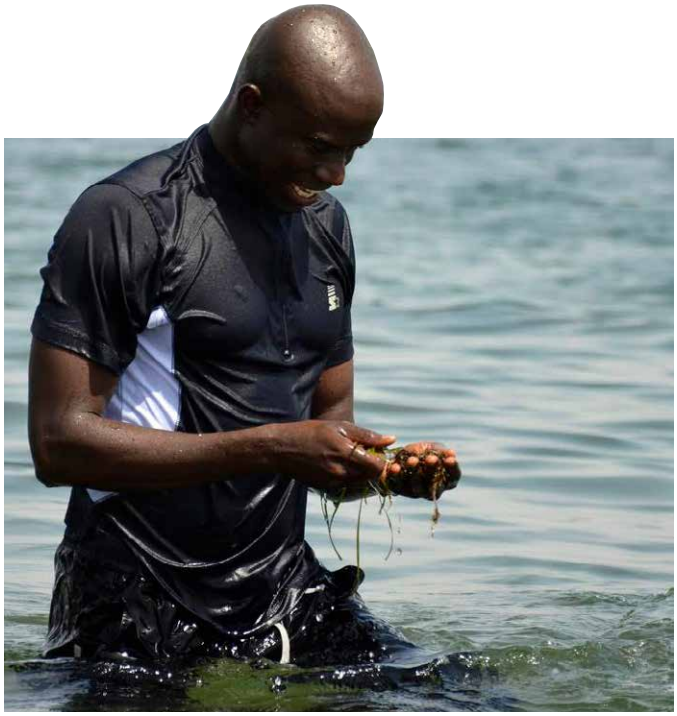
A stingray encountered during field monitoring around Sei Island, Sierra Leone. Photo: Sierra Leone national implementation team 2022

Another challenge experienced by the pilot countries has been the introduction of new cloud-based platforms, where monitoring data can be uploaded and stored. The advantage of using cloud-based platforms is twofold: data can be shared and accessed to support transboundary governance of such ecosystems, and the data are also much more secure when stored on the cloud rather than individual computers. Introducing users to this platform requires workshops and

Field expedition to monitor seagrass in the baie de l´Étoile, Mauritania. Photo: Mohamed Ahmed Sidi Cheikh 2022

training sessions to build local capacity and knowledge so that monitors are comfortable entering these data independently. During the COVID-19 pandemic, training sessions of this nature through the ResilienSEA project were delayed or held online, which can present additional challenges due to the unstable nature of Internet connections in the region.

Language barriers may also present sociocultural challenges when mapping, monitoring and sharing seagrass data within a transboundary setting. The national languages spoken within ResilienSEA pilot countries include English, French, Portuguese and Arabic, with many additional dialects and languages, such as Mandinka, Creole, Serer, Wolof and Pidgin, spoken as well. This can complicate collaborative efforts to share seagrass knowledge and experiences; and even within a country's borders, it presents an interesting question of how to effectively communicate the importance of seagrass protection to local communities and indigenous groups who may not use the same vocabulary to describe seagrass meadows.

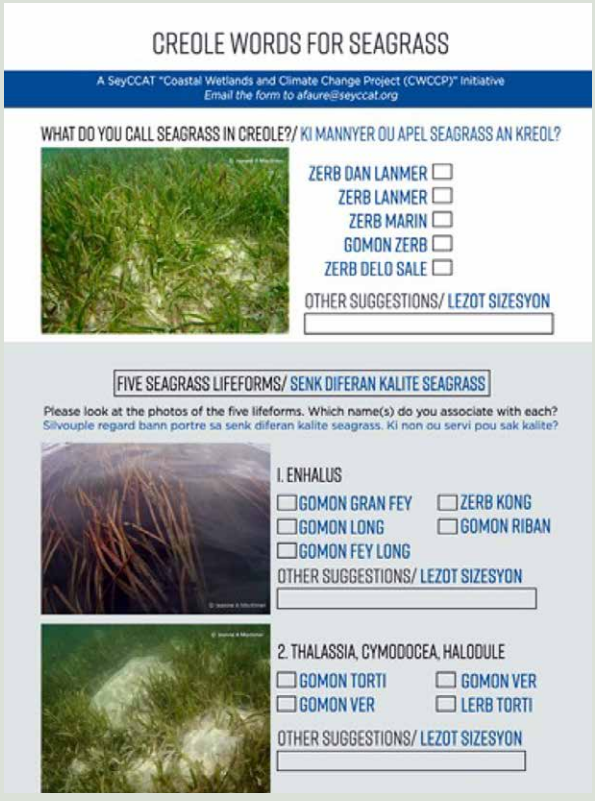


Identifying seagrass in the field at Saloum Delta National Park. Photo: National implementation team of Senegal, 2019

Defining seagrasses in the Seychelles

During the initial phases of the Seagrass Mapping and Carbon Assessment Project led by the Seychelles Conservation and Climate Adaptation Trust (SeyCCAT) in 2020, it quickly became apparent that there was no official, unique term for seagrass or seagrass meadows in the Seychellois Creole language (Baez 2022). Instead, existing terms were often conflated with algae. SeyCCAT solicited suggestions from the public, fishing communities and national experts to identify the five most common terms used locally to refer to seagrass, ultimately deciding to officially include the terms *zerb lanmer* and *gomon zerb* in the next edition of the Creole dictionary (Baez 2022), as well as other common names for the seagrass species native to the Seychelles.

Instead of adopting or borrowing anglophone phrases, local expertise was drawn upon to create a sense of ownership over these terms within the Seychelles. This example therefore illustrates how community engagement and outreach are vital for increasing awareness of seagrass meadows, which is often the first step necessary to manage and protect local ecosystems.



Survey to identify creole words for seagrass in the Seychelles. Photo: SeyCCAT 2021

Photo: Rob Barnes 2019

SEAGRASS IN WEST AFRICA: PILOT COUNTRIES

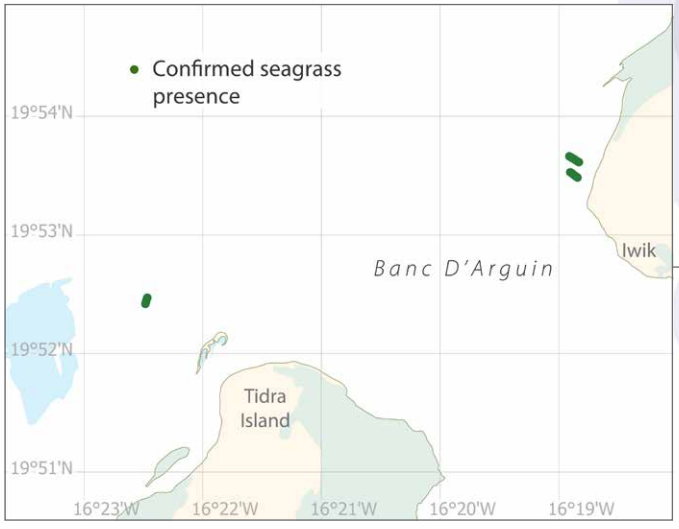
Mauritania

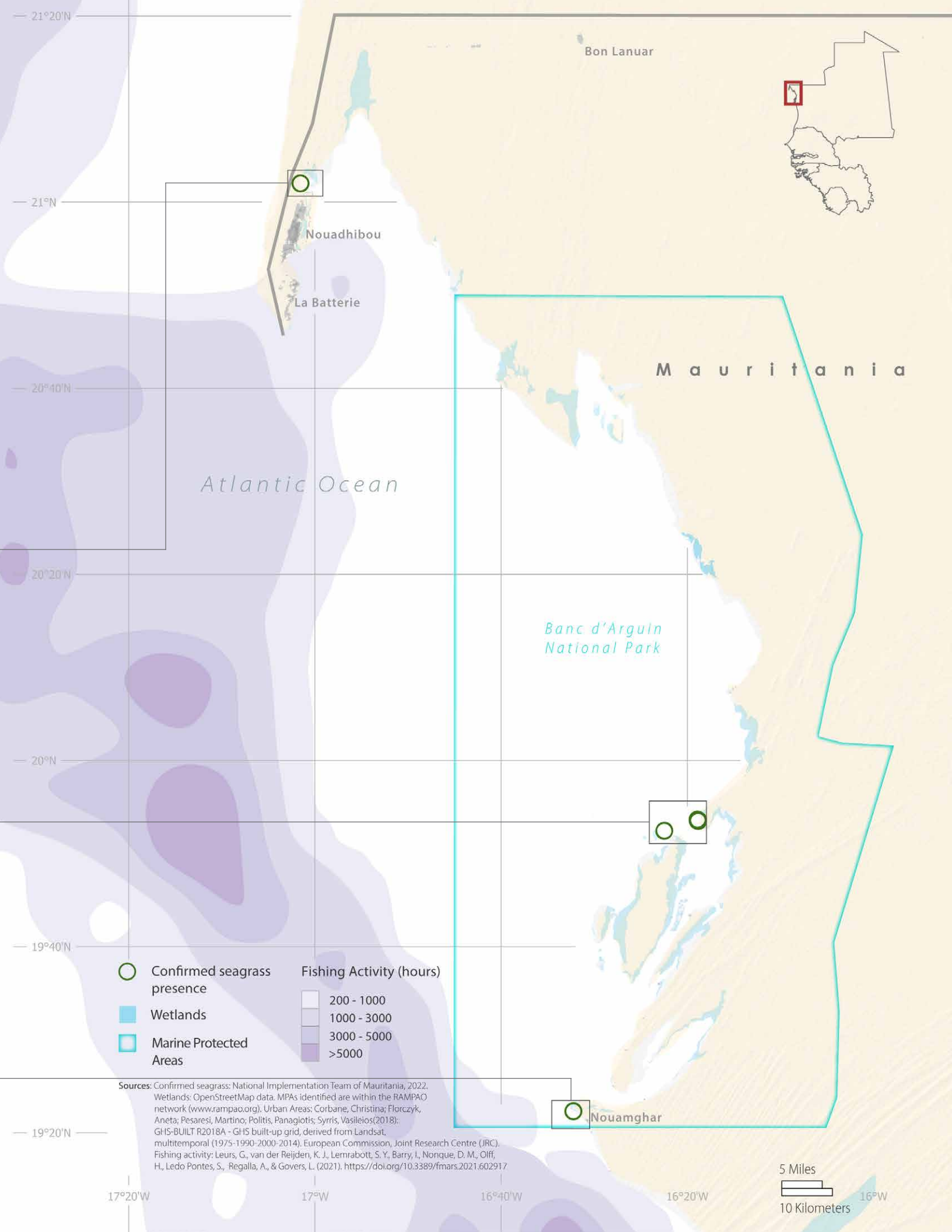
Pilot sites: Banc d'Arguin National Park and the baie de l'Étoile
Seagrass species found: *H. wrightii*, *C. nodosa* and *Z. noltei*
Local terms for seagrass: *ichi* and *magalia*

Baie de l'Étoile

Banc d'Arguin National Park

Banc d'Arguin National Park





Sources: Confirmed seagrass: National Implementation Team of Mauritania, 2022. Wetlands: OpenStreetMap data. MPAs identified are within the RAMPAO network (www.rampao.org). Urban Areas: Corbane, Christina; Florczyk, Aneta; Pesaresi, Martino; Politis, Panagiotis; Syrris, Vasileios(2018): GHS-BUILT R2018A - GHS built-up grid, derived from Landsat, multitemporal (1975-1990-2000-2014). European Commission, Joint Research Centre (JRC). Fishing activity: Leurs, G., van der Reijden, K. J., Lemrabott, S. Y., Barry, I., Nonque, D. M., Olff, H., Ledo Pontes, S., Regalla, A., & Govers, L. (2021). https://doi.org/10.3389/fmars.2021.602917

Mauritania

Mauritania forms a geographic and cultural bridge between the Maghreb and sub-Saharan Africa. The mild climate and fertile soils of the south of the country differ from its northern arid desert. Historically, Mauritanians have been nomads, with 90 per cent of the population still nomadic at the time of decolonization in 1960. However, this tradition has declined as a result of the country's severe droughts, to the extent that only 5 per cent of the population were still classified as nomadic in 2006. Social structures and human settlements are still undergoing profound changes, indicating a new connection with the land. Urbanization has dramatically accelerated as young Mauritanians seek economic opportunities, with most internal migrations made to Nouakchott, Nouadhibou and along the Atlantic coast. In southern Mauritania, agriculture has developed along the Senegal River and supports large parts of the population and economy. Fisheries have also grown following the industrialization of techniques and the opening of the industry to foreign vessels, as have oil exploration and exploitation, which are now the main driver for foreign investments and economic growth in the country. However, these industries pose potential threats to the health of seagrass along Mauritania's coastline, which in turn could impact the productivity of fisheries and marine biodiversity.

Aerial view of the Banc d'Arguin National Park. Photo: J.F. Hellio and N. van Ingen 2006

In Mauritania, seagrass species have different biogeographic affinities: *Z. noltei* and *C. nodosa* occur in temperate waters, while *H. wrightii* is typically a tropical species. In fact, the Banc d'Arguin represents the northernmost distribution of *H. wrightii* (Chefaoui *et al.* 2021; Tavares *et al.* 2022; Sidi Cheikh *et al.* 2022, forthcoming). The monitoring locations identified within the scope of the ResilienSEA project are the Banc d'Arguin National Park and the baie de l'Étoile in Nouadhibou.

Banc d'Arguin National Park

The Banc d'Arguin National Park is located in the north-west of Mauritania, where the Atlantic Ocean meets the Sahara Desert. This intertidal landscape contains vast mudflats, sand banks and dunes, seagrass meadows and mangroves, all of which are crucial habitats for diverse fauna. At 12,000 km², the Banc d'Arguin National Park is one of the largest national parks in Africa.

The Mauritanian Government created the reserve in 1976 to maintain the integrity and productivity of its land, marine and insular ecosystems, and to protect important fauna and flora. Considering the international significance of the wetland, the Banc d'Arguin National Park was classified as a Ramsar site in 1982, was designated a UNESCO World Heritage Site in 1989 and was declared a Gift to the Earth by the World Wide Fund for Nature (WWF) in 2000.

The Banc d'Arguin National Park's exceptional value lies in the contrast between the high biodiversity of its marine area and harsh desert conditions, which results in an extraordinary land- and seascape. During winter months the site is home to more than 2 million wintering shorebirds from northern

BANC D'ARGUIN
Belkhayznaya and El Aîn

SEDIMENT: Sandy-muddy / presence of Senilia senilis

ALGAE & EPIPHYTES: Present

Zostera noltei

AVG. COVERAGE: 26 %

AVG. CANOPY HEIGHT: 11 cm

Box 1. Imraguen fishers and participatory management of the Banc d'Arguin National Park

Within the Banc d'Arguin National Park, approximately 1,000 Imraguen fishers live throughout nine fishing villages (IUCN 2020). The Imraguen population participates in the management of the park's natural resources through a co-management approach based on measures and rules agreed between the resident population, in particular the fishers, and the park's management authority. Negotiation and co-management mechanisms have been in place for several years and take place through committees and consultation workshops.

These ancient fishing peoples sail traditional Latin wooden boats called *lanches* and catch mostly meager (courbine) and yellow mullet, a species commonly found in the park's many hectares of seagrass meadows. The fish are processed by Imraguen women, which is their main income-generating activity. Yellow mullet is the species most commonly processed, but other species of the Cichlidae (tilapias) and Sparidae families (sea breams) are becoming increasingly important. Yellow mullet eggs are salted and dried in the traditional way (*bottarga*), while the flesh is salted, dried and shredded (*tishtar*). Fish oil is also extracted, which is locally referred to as *dhên*. Such activities demonstrate that the Imraguen rely on the ecological integrity of the park for both their cultural heritage and socioeconomic livelihoods.

However, illegal fishing activities threaten the park's ecological balance, with targeted fishing of elasmobranchs for trade by Imraguen, which are only allowed subsistence fishing (>half for self-consumption), and with foreign fishers using motorized boats and poor fishing practices to deplete the fish stocks that the Imraguen depend upon. In an effort to avoid overfishing and control these motorized boats from entering

Imraguen fishers out at sea in Banc d'Arguin National Park. Photo: J.F. Hellio and N. van Ingen 2006

the area, park managers, the Mauritanian coast guard and the Imraguen formed a partnership in the late 1990s to establish a participatory maritime surveillance system for the park (Yarba 2021).

In 2000, the Mauritanian Government passed a law granting ancestral and exclusive rights of fishing resources to the Imarguen, for subsistence only, within the Banc d'Arguin National Park, stipulating the use of traditional fishing methods with a view to preventing overfishing and ecosystem disruption. Imraguen fishers are permitted to use *lanches* but cannot use boats with engines, trawl nets, seines or fine-meshed nets.

The fate of the Banc d'Arguin National Park and the Imraguen depend on each other: by acting as stewards of the park through managing its waters (and subsequently its seagrass meadows), the Imraguen benefit from the healthy ecosystems and abundant fish populations they need to survive

Cymodocea nodosa

AVG. COVERAGE: 39 %

AVG. CANOPY HEIGHT: 16 cm

Halodule wrightii

AVG. COVERAGE: 11 %

AVG. CANOPY HEIGHT: 7 cm

Europe, Greenland and Siberia, making the park one of the largest concentrations of wintering shorebirds in the world (IUCN 2020). The park's environment also supports important fish (45 species), crustaceans (11 species), marine turtles (including green sea turtles, *Chelonia mydas*, which are listed as endangered on the IUCN Red List of Threatened Species) and marine mammals (including bottlenose dolphins and the Atlantic humpback dolphin).

Due to the park's high productivity and sheltering seagrass beds, the area is a major fish spawning and nursery ground for the entire coast of West Africa, with 45 species known to be fished (IUCN 2020). The park's contribution to fisheries is estimated to be approximately €70 million annually (Trégarot *et al.* 2020). Commercial and traditional fisheries rely on the gulf's various mullet species, particularly the yellow mullet (*Mugil cephalus*) and white mullet (*Mugil curema*), as well as groupers (*Epinephelus* spp.) and sea bream (*Sparus* spp.).

Despite the abundance of fish within the Banc d'Arguin National Park, only the Imraguen – an ethnic group living in fishing villages within the gulf – are legally authorized to fish within the park, and only using traditional fishing techniques.

The presence of three different seagrass species – *Z. noltei*, *C. nodosa*, *H. wrightii* – adds to the park's unique value. While *Z. noltei* is found in the intertidal zone and the shallowest waters, *C. nodosa* and *H. wrightii* are found in the slightly deeper waters of the bay. According to local findings, the intertidal and subtidal seagrass beds cover large areas of the Banc d'Arguin, estimated at approximately 1,000 km². There are two ResilienSEA monitoring sites within the Banc d'Arguin National Park: Belkhayznaya and El Aîn. In Belkhayznaya, the sediment comprises a mix of sand and mud, and has a notable abundance of gastropods and bivalves, while in In El Aîn, the sediment varies between sandy and muddy, with algae, epiphytes, gastropods and anemones all present.

Dense seagrass bed found in the Banc d'Arguin National Park. Photo: Mauritania national implementation team 2018

The Mauritania NIT monitored these locations with regular frequency throughout 2020 to 2021 with field visits in March 2020, August 2020, October 2020, December 2020, and April 2021. Throughout this period, the average coverage of *Z. noltei* in Belkhayznaya was 34 per cent with an average canopy height of 11 cm. The most significant contrast in terms of variation within this time period was between August and December 2020, where the average coverage of *Z. noltei* declined from 64 per cent to 1.2 per cent, and average canopy heights also declined from 14.4 cm to 8.6 cm.

All three seagrass species are found in El Aîn, though their abundance varies. Throughout the same monitoring period of 2020 to 2021, the average coverage of *Z. noltei* and *C. nodosa* in El Aîn was 17 per cent and 39 per cent, respectively, while average canopy heights were 8 cm and 16 cm, respectively. For *H. wrightii*, the average coverage observed was 11 per cent, with an average canopy height of 7 cm. In terms of seasonal variation in El Aîn, *Z. noltei* and *C. nodosa* were also most abundant in August 2020, covering an average of 46 per cent and 63 per cent, respectively. By April 2021, the average coverage of *Z. noltei* was just 2 per cent and *C. nodosa* was 20 per cent. Interestingly, this trend was inversed for *H. wrightii* – this species was observed to be most abundant in El Aîn in April 2021 with an average coverage of 15 per cent, while it was only 7 per cent in August 2020.

Baie de l'Étoile

The baie de l'Étoile was recently identified as a secondary ResilienSEA monitoring site within Mauritania, covering around 29 km² in total, 11.4 km² of which is partly maritime. The bay is located on the Cap Blanc peninsula, 13 km north of Nouadhibou on the west façade of the large baie du Lévrier (ERM 2013). The bay can be considered an extension of the Banc d'Arguin and likely has the same composition of bird species (GSE 2021). The baie de l'Étoile is therefore very important for marine and avian diversity, first thanks to its exceptional richness in primary production *in situ*, partly due to the phenomenon of upwelling, the centre of which is located 30 km to the south, and second due to the presence of intertidal mudflats, which shelter rich terrestrial and marine fauna. As a site of exceptional ecological value that extends over a small area, the bay has long been recognized as in need of protection. Until protected, these sensitive habitats remain highly vulnerable to multiple anthropogenic and natural threats (Ly 2009).

In terms of coastal ecosystems, the baie de l'Étoile is characterized by the presence of *Z. noltei* and *C. nodosa* seagrass beds, as well as salt marshes (*Spartina maritima*) and mangroves. Ly (2009) estimated the area covered by *Z. noltei*

Shallow beds of Z. noltei in the baie de l'Étoile. Photo: Mohamed Ahmed Sidi Cheikh 2022

to be 133 ha and the area covered by *C. nodosa* to be 113 ha. As a new monitoring site, there is currently little seagrass data available for the baie de l'Étoile, though observations from an initial field visit in 2022 showed the average coverage of *Z. noltei* to be 53 per cent with an average canopy height of 6.3 cm.

Challenges

One significant challenge that the NIT experienced during the ResilienSEA project relates to the sheer size of the Banc d'Arguin National Park. The large surface area of the park requires a thorough monitoring system that covers all coastal and offshore areas, which must be further developed in the future, especially in deeper waters.

Another challenge in Banc d'Arguin is that the accurate identification of the subtidal vegetation requires visual inspection underwater or removal because there are many other types of marine vegetation that are not seagrass and cannot be distinguished by other means (e.g., large meadows of the green algal genus *Caulerpa* as well as large areas of accumulation of broken unattached seagrass leaves). Diving is needed for ground-truthing.

The NIT also observed that anthropological pressures are impacting seagrass meadows, especially fishing and maritime pollution within the park, as well as motorized fishing, tourism, urban pollution and discharges from facilities that process hazardous material in the baie de l'Étoile. Further protection is therefore required to reduce the impact from these stressors.

National implementation team, Mauritania

The following collaborative institutions play a key role in the implementation of the ResilienSEA project:

- Banc d'Arguin National Park management team
- *École Normale Supérieure* (Nouakchott)
- University of Nouakchott Al Aasriya
- *Association Mauritanienne des Amis des Oiseaux et de la Protection des Espèces Animales Menacées d'Extinction* [Mauritanian Association of Friends of Birds and Protection of Endangered Species – AMISO]
- *Institut Mauritanien de Recherches Océanographiques et de Pêches Mauritanian* [Institute of Oceanographic and Fisheries Research – IMROP]
- *Office National d'Inspection Sanitaire des Produits de Pêche et de l'Aquaculture* [National Office of Sanitary Inspection of Fishery and Aquaculture Products –ONISPA]
- *Institut des Sciences de la Mer* [Institute of Marine Sciences – ISSM]

Focal points:

- Lemhaba Ould Yarba, Banc d'Arguin National Park
- Hama Cheikh Mohamed El Havedh, Banc d'Arguin National Park

BAIE DE L'ETOILE

Zostera noltei

EST. HECTARES: 133

AVG. COVERAGE: 53 %

AVG. CANOPY HEIGHT: 6.3 cm

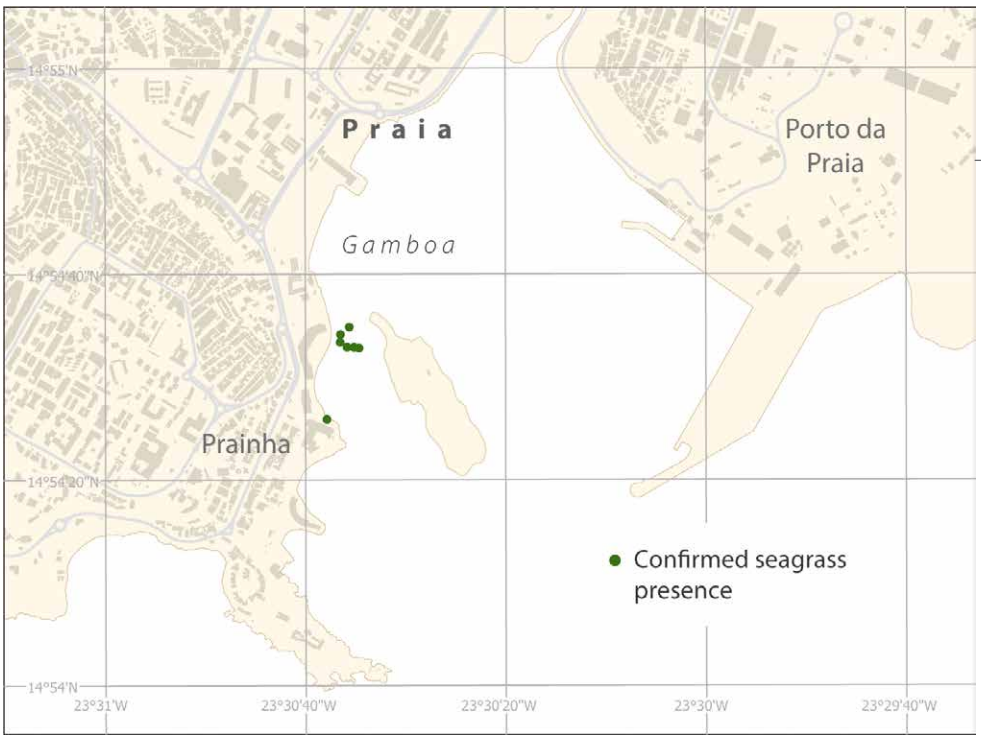
Cymodocea nodosa

EST. HECTARES: 133

Cabo Verde

Pilot site: Praia da Gamboa, Santiago Island
Resident population: 159,027 inhabitants
Seagrass species found: *H. wrightii*

Gamboa



Sources: Confirmed seagrass: National Implementation Team of Cape Verde 2022. MPAs identified are within the RAMPAO network (www.rampao.org). Urban areas: Corbane, Christina; Florczyk, Aneta; Pesaresi, Martino; Politis, Panagiotis; Syrris, Vasileios (2018): GHS-BUILT R2018A - GHS built-up grid, derived from Landsat, multitemporal (1975-1990-2000-2014). European Commission, Joint Research Centre (JRC).

Cabo Verde

Currently, the primary seagrass monitoring site in Cabo Verde is in Gamboa, Santiago Island. Cabo Verde is an archipelago of 10 volcanic islands, located 570 km off the West African coast in the Atlantic Ocean. The 2,000-km coastline is home to a multitude of species. Cabo Verde is a key area for birds, with many of them endemic. It is also the world's third-largest nesting site for sea turtles. The country's rich environment reflects its unique history and diversity.

Because of the harshness of the climate and topography, agriculture has hardly developed. Likewise, the use of fisheries is somewhat limited. Much of the population is urban and concentrated on Santiago Island. Yet, Cabo Verdeans strongly rely on their environment. The large population of endemic species and sea turtles prompted the development of tourism, which became the main driver for economic growth. Moreover, most human activities take place in low-lying coastal areas, which highlights the importance of healthy coastal and marine environments. Seagrass was first recorded in 2015, according to research conducted on Santiago Island (Creed *et al.* 2016). After discovering the existence of seagrass in Cabo Verde, the national implementation team (NIT) has sought to map meadows and further their protection during the ResilienSEA project. This effort has led to Cabo Verde incorporating seagrass meadows into its NDC, a major policy accomplishment (see box 2 for more information).

Gamboa, Santiago Island

Santiago Island is Cabo Verde's main island and is home to half of the nation's population. A ResilienSEA expedition led along its shores, between Gamboa beach and Santa Maria Islet, identified an extensive and healthy *H. wrightii* seagrass meadow. As of 2021, the seagrass area at the Gamboa site is estimated to be 6,243 m^2 (Soumah 2021). The sediment below this meadow is composed of a mix of mud and sand, and there is a notable presence of brown algae (*Phaeophyceae*). The average seagrass coverage throughout the Gamboa monitoring site is above 60 per cent, with canopy heights averaging 9.5 cm. Between 2016 and 2021, parameters such as the total cover, biomass, rhizome and canopy height of *H. wrightii* species have increased,

A H. wrightii seagrass meadow at the Gamboa monitoring site. Photo: Cabo Verde national implementation team 2018

while the shoot density has decreased fivefold (Soumah 2021). Gamboa seagrass appears to fluctuate in response to seasons or disturbance. However, the extent of sediment accumulation and accretion throughout the meadow indicates that the seagrass has been present and undisturbed for a long period of time. As such, this meadow has a high potential for carbon sequestration and is home to important marine fauna, such as sea turtles.

Challenges

A key challenge identified by the Cabo Verde NIT is the difficulty in establishing lasting partnerships for the long-term protection and monitoring of seagrasses nationally. This is particularly relevant for the application of Cabo Verde's NDC, where cross-sectoral governance is necessary to achieve mitigation and adaptation targets. Additionally, the Gamboa pilot site does not currently fall within a protected area. This presents an opportunity for the country to increase the protection status of the known seagrass meadows surrounding Gamboa.

National implementation team, Cabo Verde

The following collaborative institutions play a key role in the implementation of the ResilienSEA project:

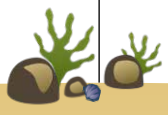
- *Dirección Nacional del Medio Ambiente* [National Environment Directorate – DNA]

GAMBOA

Halodule wrightii

AVG. COVERAGE: 60 %

AVG. CANOPY HEIGHT: 9.5 cm



SEDIMENT: Sandy-muddy

ALGAE & EPIPHYTES: Present

Box 2. Seagrass meadows incorporated into Cabo Verde's NDC

The African continent is considered one of the world's most vulnerable areas to climate change. The Sahel region is particularly vulnerable, with climate change exacerbating chronic droughts, rising temperatures, soil erosion, and environmental degradation. Cabo Verde not only belongs to the Sahel region, but it is also a Small Island Developing State (SID) with an insular archipelago. For these reasons, the country's ecosystems are extremely sensitive to the effects of climate change, as are the people who depend on them.

Given the country's climate vulnerability, the Cabo Verdean government has made ambitious commitments under the Paris Agreement to reach national climate targets by 2030. To achieve this, Cabo Verde's first Nationally Determined Contribution (NDC) was developed to reduce national fossil fuel dependency and lower carbon emissions. There are 14 specific contributions in the NDC (five for mitigation and nine for adaptation) that aim to reduce the country's emissions by at least 20 per cent.

In February 2020, the ResilienSEA project held its first workshop in Cabo Verde to train national technicians on seagrass monitoring. During this forum, a discussion regarding the ecosystem benefits of seagrass meadows – particularly carbon sequestration – ensued, leading to conversations about the possibility of incorporating seagrasses into Cabo Verde's updated NDC. After this workshop, efforts were made to brief decision makers on the presence of seagrass within national territory and its importance as a nursery for commercial fish species, food and refuge for endangered species, coastal protection, and significantly, carbon sequestration.

A school of fish swimming with seagrass meadows in Cabo Verde. Photo: Cabo Verde National Implementation Team 2020

In 2021, Cabo Verde moved to include seagrass meadows within its updated NDC, with the commitment to protect, conserve, and restore these coastal ecosystems. The NDC update process was innovative and cooperative, led by the National Directorate for the Environment, in a participatory process with all stakeholders. Its preparation was based on the current National Strategic Plan for Sustainable Development of Cabo Verde, which brought together a set of projects already underway in the country. Adaptation contribution #6, which refers to the protection of marine resources and coastal zones within the updated NDC, specifically mentions Cabo Verde's intention to inventory its seagrass meadows and develop a strategy of protection and conservation of these ecosystems by 2024. Cabo Verde now belongs to the handful of nations worldwide who have included seagrass meadows within their NDC. These ambitious efforts have even paved the way for other West African countries like Sierra Leone to include seagrass meadows in their NDC.

- *Université du Cap-Vert* [University of Cabo Verde – UNICV]
- *Universidade Técnica do Atlântico* [Technical University of the Atlantic – UTA]
- *Instituto Nacional de Desenvolvimento das Pescas* [National Institute of Fisheries Development – INDP]
- *Direcção Nacional de Pescas e Aquacultura* [National Directorate of Fisheries and Aquaculture – DNPA]
- *Associação para a Defesa do Ambiente e Desenvolvimento* [Association for the Defence of Environment and Development – ADAD]
- *Instituto Marítimo e Portuário* [Maritime and Port Institute – IMP]
- *Associação Lantuna* [Lantuna Association]
- *Associação Caboverdiana de Ecoturismo* [Cabo Verdean Ecotourism Association – ECOCV]
- BIOS Cabo Verde
- Cabo Verde Natura 2000
- *Fundação Maio Biodiversidade* [Maio Biodiversity Foundation]
- *Associação Projeto Biodiversidade* [Project Biodiversity]
- National police/maritime police
- *Instituto Nacional de Gestão do Território* [National Institute of Land Management – INGT]
- Ocean Science Centre Mindelo (OSCM)

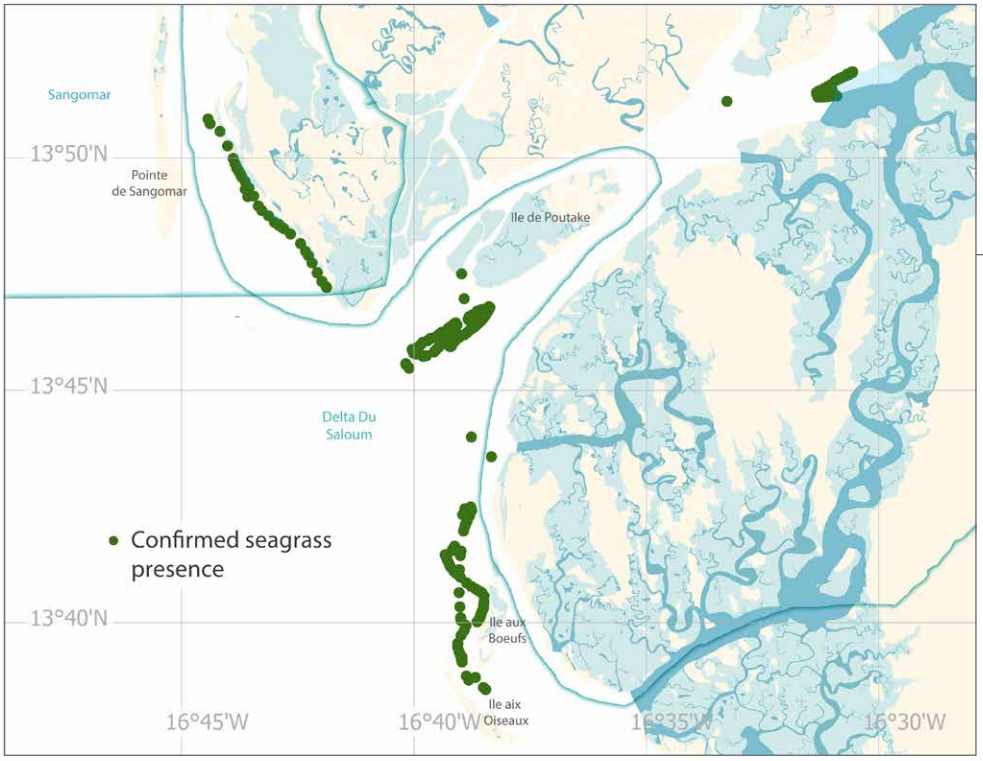
Focal points:

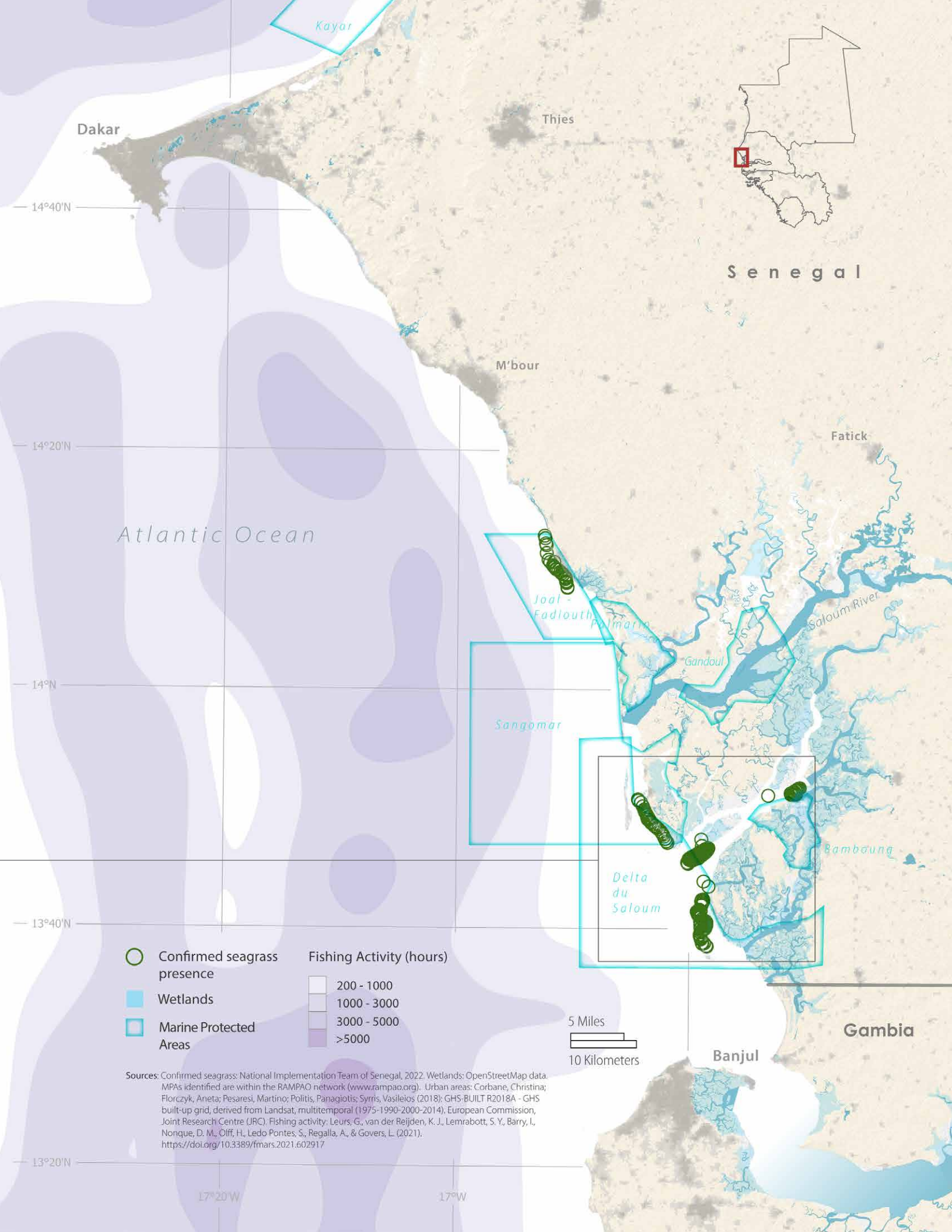
- Lisdália Moreira, Ministry of Agriculture and Environment, Cabo Verde
- Zofia Radwan, Ministry of Agriculture and Environment, Cabo Verde

Senegal

Pilot sites: Saloum Delta National Park
Seagrass species found: *H. wrightii*, *C. nodosa* and *Z. noltei*
Local terms for seagrass: *wassir* and *niakhou guedj*

Saloum Delta National Park





Sources: Confirmed seagrass: National Implementation Team of Senegal, 2022. Wetlands: OpenStreetMap data. MPAs identified are within the RAMPAO network (www.rampao.org). Urban areas: Corbane, Christina; Florczyk, Aneta; Pesaresi, Martino; Politis, Panagiotis; Syrris, Vasileios (2018): GHS-BUILT R2018A - GHS built-up grid, derived from Landsat, multitemporal (1975-1990-2000-2014). European Commission, Joint Research Centre (JRC). Fishing activity: Leurs, G., van der Reijden, K. J., Lemrabott, S. Y., Barry, I., Nonque, D. M., Olff, H., Ledo Pontes, S., Regalla, A., & Govers, L. (2021). https://doi.org/10.3389/fmars.2021.602917

Senegal

Senegal lies at the westernmost point of Africa, bordered by Gambia, Guinea and Guinea-Bissau in the south, Mali in the east and Mauritania in the north. The country has various ecosystems that range from steppes, savannahs and forests, to deltas, estuaries and large beaches. As a result, Senegal benefits from a rich diversity of living systems. According to Senegal's National Biodiversity Strategic Action Plan, it is estimated that the country is home to more than 3,600 vegetal species and 4,330 animal species (Republic of Senegal, Ministry of the Environment and Sustainable Development 2015).

Senegal's political and economic stability is strongly dependent on the exploitation of natural resources. Agriculture is important to the State's development, with most investments being made in extractive industries. In the last decades, fisheries have dramatically grown in Senegal's economy, and the value of fishery-related products has increased following significant investments in the industry. As a result, coastal areas have developed and urbanized with the settlement of fishing industries, shipping ports and workers, thus highlighting how crucial healthy marine and coastal ecosystems are for the country's coastal communities and urban populations. The conservation of seagrass meadows can play a role in preserving Senegal's rich biodiversity along its coasts.

Seagrasses in Senegal occur in various locations, generally in sandy-muddy substrate. While the presence of seagrass has been confirmed in Joal-Fadiouth and Sangomar, the only official ResilienSEA monitoring site in Senegal is the Saloum Delta National Park.

Saloum Delta National Park

As is the case with the MPAs of Sangomar, Bamboung, Gandoule and the Palmarin Community Nature Reserve, the Saloum Delta National Park belongs to the larger Saloum Delta Biosphere Reserve, which was created in 1976. The park covers an area of 76,000 ha and is located in the estuarine area of the Sine-Saloum hydrographic basin in the centre-west of Senegal on the Gambian border.

Although it is a national park, activities such as fishing and molluscs gleaning are authorized in some areas. The species most commonly harvested in the Sine-Saloum estuary are oysters (*Crassostrea gasar*), *yett* molluscs (*Cymbium* spp.), *toufa* molluscs (*Murex* spp, *Thais* spp.), cuttlefish (*Sepia officinalis*) and ark clams (*Senilia senilis*).

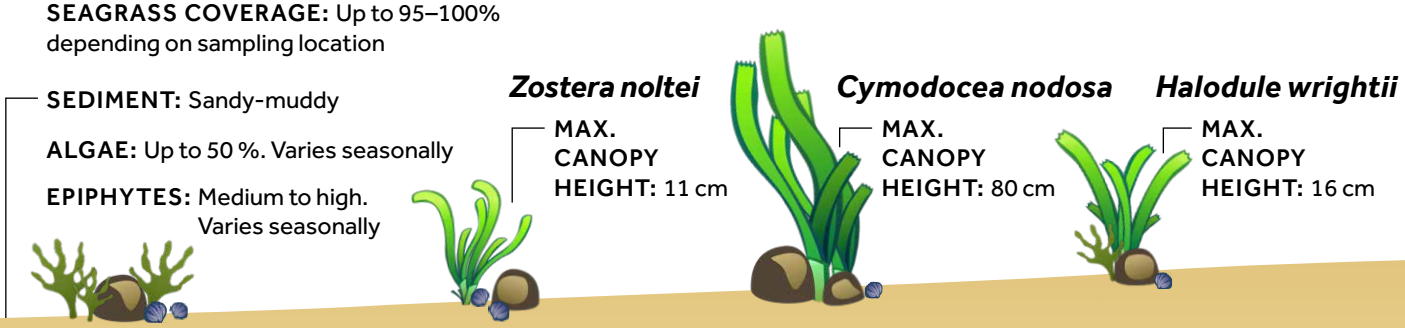
The Saloum Delta National Park has two main ecological environments: a continental habitat rich in savannah and limited in its lower part by mangroves and an amphibious habitat composed of three large groups of islands bordered by a dense network of channels (*belons*) surrounded by mangroves and a maritime habitat. These environments have relatively different ecosystem functions and dynamics.

In other ecosystems, all three seagrass species have a significant presence, with occurrences of *Z. noltei* being the first verified record of the species existing south of Mauritania. In the *C. nodosa* meadows observed, seagrass blades were thick and long, and had a maximum canopy height of 80 cm. In the park's observed *Z. noltei* and *H. wrightii* meadows, both were characteristically thin and not particularly long, with maximum canopy heights of 11 cm and 16 cm, respectively. Within the Saloum Delta National Park, the average coverage of seagrasses varies, but can be 95 per cent or even 100 per cent depending on the sampling location, with high shoot density of the plants generally observed. The proliferation of epiphytes varies significantly (with low-medium-to-high observations made), as does the seasonal occurrence of algae, which was recorded as reaching up to 50 per cent.

Joal-Fadiouth

The Joal-Fadiouth MPA lies on Senegal's Petite Côte, 114 km south from the capital city of Dakar. It was created in 2004 to protect and increase the productivity of fisheries and the

SALOUM DELTA NATIONAL PARK



related ecosystems that help biodiversity thrive, such as seagrasses and mangroves, as well as to improve the economic and social conditions of the local populations. The Joal-Fadiouth MPA covers 17,400 ha and represents a protection area for migratory species such as sea turtles and sea birds, as well as fish, shellfish, manatees and dolphins. It is also an area of cultural importance due to the presence of the Serer people in Fadiouth, to which 99 per cent of its population belong. The organization of fisheries, rituals and ceremonies are embedded in the respect of the sacred fauna and flora in the area, which is also key to maintaining the livelihoods of women who practice mariculture and seashell harvesting.

In Joal-Fadiouth, both *C. nodosa* and *H. wrightii* are fully submerged, even at extreme low tides during spring months. Seagrass meadows have been found within multiple areas of the Joal-Fadiouth MPA. At the first site, known as Mbar Sa Ngoné, *H. wrightii* and *C. nodosa* were encountered at a depth of about 2 m on a sandy-muddy substrate. The average coverage was observed as being 30 per cent, with the two species often found growing adjacent to each other. The second site, Quai de Pêche, also has a sandy-muddy substrate with shells present. *H. wrightii* colonizes the sandy-muddy areas, with the sandiest part of the area home to *C. nodosa*. At the third site, known as the turtle zone, *H. wrightii* and *C. nodosa* are found in the same area on a sandy substrate where there is also a strong presence of shells. In the turtle zone, average coverage was observed as being 40 per cent. The last site, located towards Cap Gaspel, had the highest presence of seagrass coverage observed for *H. wrightii* and *C. nodosa* at an estimated 60 per cent for muddy sediment areas and 35 per cent on the sandy-muddy substrate.

Box 3. Fisherfolk lead participatory management and mapping efforts in the Joal-Fadiouth Marine Protected Area

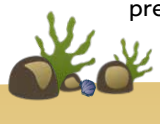
In 2004, the Senegalese Government established the Joal-Fadiouth community-based MPA following strong advocacy from local fisherfolk for its creation. The impetus for implementing the MPA was to increase biodiversity and fishing yields, both of which are crucial for artisanal fisherfolk in the region who depend on healthy coastal ecosystems such as seagrasses for their livelihoods (Semelin 2021). Indeed, fishers in Joal-Fadiouth are keenly aware of the ecosystem benefits they derive from seagrass meadows, recognizing the importance of seagrasses in providing nurseries and foraging habitats for the species they rely upon.

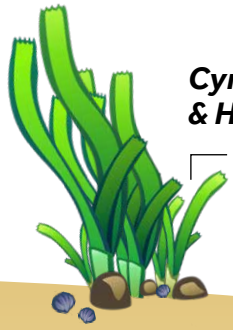
In the late 2010s, the fisherfolk community expressed their desire to map the seagrass meadows in Joal-Fadiouth without heavily relying on international actors and expertise. From 2012 to 2014, the first participatory mapping of seagrasses in Senegal took place, with local fishers completing 70–80 per cent of the mapping work themselves (Semelin 2021). Using Seagrass-Watch and Regional Network of MPAs in West Africa (RAMPAO) field methods, the fishers mapped the presence of *C. nodosa* with tools that included a bathymetric map of the MPA, a GPS tracker, snorkelling gear and underwater clamps (Semelin 2021).

This community-based approach to participatory seagrass mapping exemplifies how drawing on local capacity and knowledge are often key for successful ecosystem management. Utilizing the expertise of local communities can help increase the legitimacy of conservation policies when their implementation process is of a collaborative nature.

JOAL-FADIOUTH
Mbar Sa Ngoné, Turtle Zone and Cap Gaspel

SEDIMENT: Sandy-muddy with presence of shells





Cymodocea nodosa* & *Halodule wrightii

AVERAGE COVERAGE: 30–60 %

Sangomar

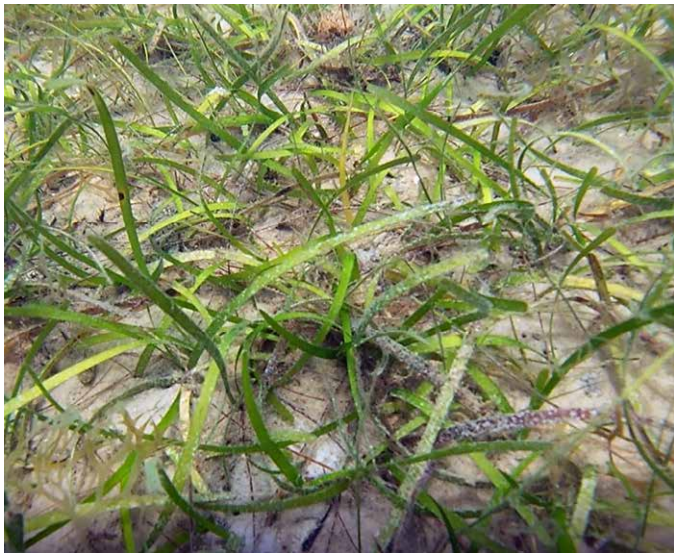
Created in 2014 with the aim of conserving the marine and coastal biodiversity, the Sangomar MPA is located in the region of Fatick. It is bounded by the Joal-Fadiouth MPA in the north, the Saloum Delta National Park in the south and the Palmarin Community Nature Reserve in the east. The Sangomar MPA, much of which is a part of the Saloum Delta Biosphere Reserve, spans an area of 87,400 ha.

The Sangomar MPA is high in biological diversity and composed of different ecosystems, including mangroves, forests, grassy savannahs and mudflats. It is home to highly diversified fauna, which includes migratory birds, fish (more than 60 identified species), reptiles (green turtles, crocodiles) and mammals (humpback dolphins, manatees). In addition, specific zones in the MPA constitute important nursery and feeding grounds for several fishery resources that are of high economic value for the local communities' livelihoods. As in Joal-Fadiouth, Serer culture is central to the organization of fisheries, and gleaning activities are common practices among women.

C. nodosa and *H. wrightii* are the most common species found in the Sangomar MPA, and similar to seagrass meadows in the Joal-Fadiouth MPA are usually fully submerged and grow on a sandy-muddy substrate with small shells and fauna such as shrimp and ark clams. The average canopy height of these seagrasses is approximately 30 cm. The seagrass areas observed within Sangomar MPA are subdivided into three zones according to the abundance of meadows.

Observations from the first area, which had a sandy-muddy substrate and shell fragments, noted an average coverage rate of 10 per cent.

Within the second site, where the density was observed to be slightly higher (30 per cent), the seagrass meadows were clustered on a sandy-muddy substrate. Some algae and epiphytes were present and *C. nodosa* was the dominant species.



A submerged C. nodosa bed within the Sangomar MPA. Photo: Senegal national implementation team 2020

Within the densest seagrass area observed, the average coverage of seagrass meadows was noted as being up to 70 per cent. Again, *C. nodosa* was the dominant species, but there was a greater presence of algae and epiphytes.

Challenges

The Senegal NIT's main challenges related to understanding and recording seagrass meadows while in the field in the Saloum Delta National Park, as well as how to best characterize the various meadows identified. The team was particularly interested in learning more about how seasonal variability influences the life cycle of the seagrasses.

Through training sessions and practice, monitoring teams gained the capacity to accurately identify and characterize all three species – *C. nodosa*, *Z. noltei* and *H. wrightii* – when in the field. Through this process, the teams were also able to observe how these three species can grow on the same substrate and how *C. nodosa* and *H. wrightii* can develop in both subtidal and intertidal zones.

SANGOMAR

SEDIMENT: Sandy-muddy with presence of shells

ALGAE & EPIPHYTES: Present

Cymodocea nodosa

AVG. COVERAGE: 10–70 %

AVG. CANOPY HEIGHT: 30 cm

Measuring seagrass canopy height. Photo: National implementation team of Senegal, 2019

Another challenge in Senegal is that the accurate identification of the subtidal vegetation requires visual inspection underwater or removal because there are many other types of marine vegetation that are not seagrass and cannot be distinguished by other means (e.g., large meadows of the green algal genus *Caulerpa*). Thus, more diving is needed.

National implementation team, Senegal

The following collaborative institutions play a key role in the implementation of the ResilienSEA project:

- *Direction des Aires Marines Communautaires Protégées* [Directorate of Community Marine Protected Areas – DAMCP]
- *Direction des Parcs Nationaux* [Directorate of National Parks – DPN]
- *Centre de Suivi Écologique* [Ecological Monitoring Centre – CSE]
- *Institut des Sciences de l'Environnement* [Institute of Environmental Sciences – ISE], University of Cheikh Anta Diop of Dakar
- *Institut Universitaire de Pêche et Aquaculture* [University Institute for Fisheries and Aquaculture – IUPA], University of Cheikh Anta Diop of Dakar
- *Département de Biologie Végétale* [Department for Vegetal Biology], University of Cheikh Anta Diop of Dakar

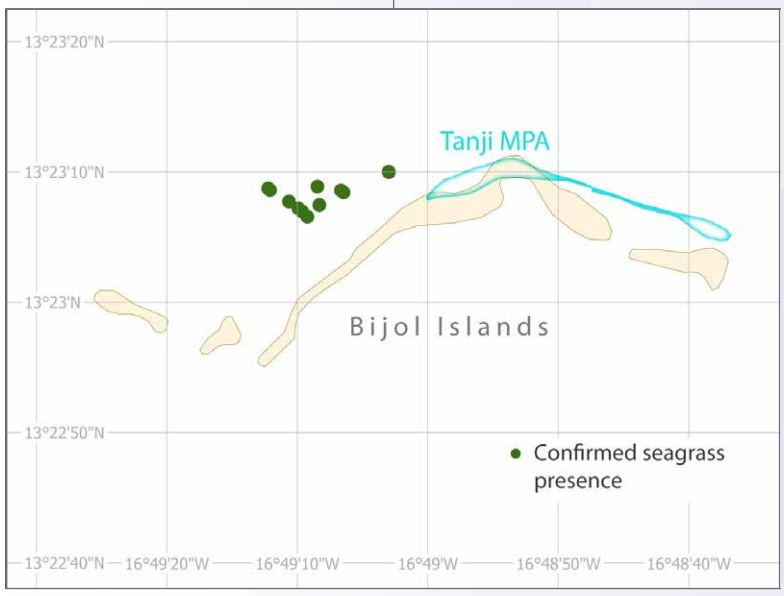
Focal points:

- Serigne Abdou Aziz Ndiaye, assistant to the Director of Marine Protected Areas, ResilienSEA; Senegal focal point
- Elisabeth Mayé Diouf, doctoral student in ecology and ecosystem management (specialization: seagrass beds); assistant to the focal point
- Alassane Sarr, Director of the IUPA, University of Cheikh Anta Diop of Dakar
- Babacar Ndao, CSE
- Abdoul Aziz Camara, Department for Vegetal Biology, University of Cheikh Anta Diop of Dakar
- Amadou Sene, scientific diver and biologist

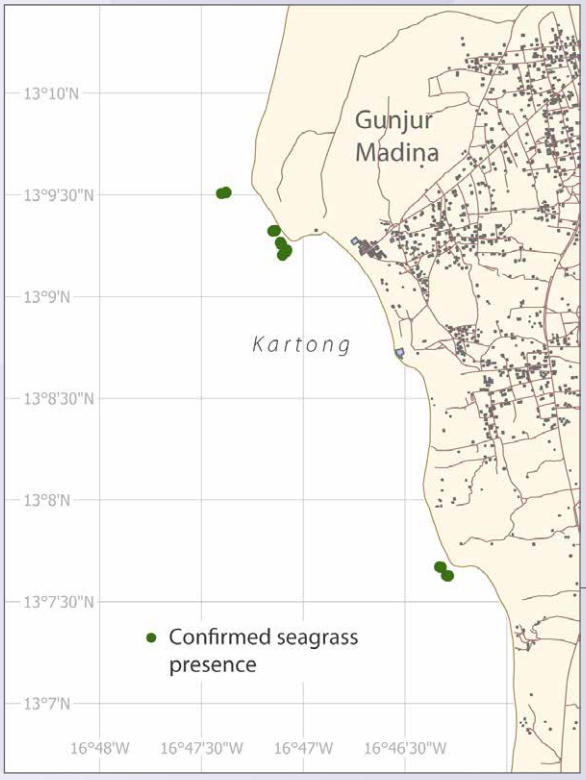
Gambia

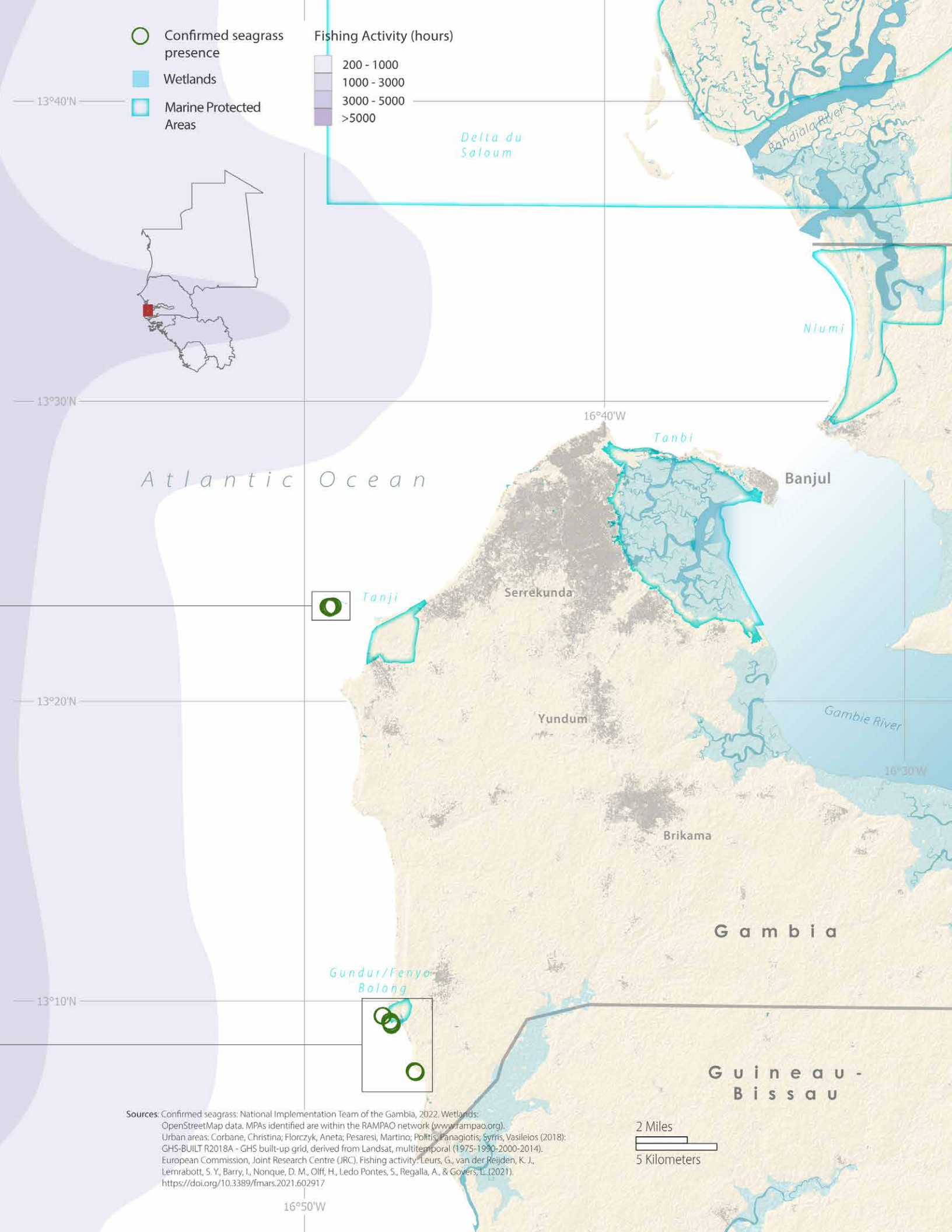
Pilot sites: Bijol Islands, Gunjur and Kartong
Resident population: 42,231 inhabitants
Seagrass species found: *H. wrightii* and *C. nodosa*
Local terms for seagrass: *ba-nyamo* and *karfaya*

Bijol Islands



Gunjur and Kartong





Sources: Confirmed seagrass: National Implementation Team of the Gambia, 2022. Wetlands: OpenStreetMap data. MPAs identified are within the RAMPAO network (www.rampao.org). Urban areas: Corbane, Christina; Florczyk, Aneta; Pesaresi, Martino; Politis, Panagiotis; Syrris, Vasileios (2018): GHS-BUILT R2018A - GHS built-up grid, derived from Landsat, multitemporal (1975-1990-2000-2014). European Commission, Joint Research Centre (JRC). Fishing activity: Leurs, G., van der Reijden, K. J., Lemrabott, S. Y., Barry, I., Nonque, D. M., Olff, H., Ledo Pontes, S., Regalla, A., & Govers, L. (2021). https://doi.org/10.3389/fmars.2021.602917

Gambia

Covering an area of 11,300 km², Gambia is one of the smallest countries in Africa. The country is an enclave within Senegal, bordered by 80 km of Atlantic coast and divided by the Gambie River. Gambia has a unique and luxuriant biodiversity of flora and fauna, partly due to its extensive mangrove swamps and estuarine habitats. There are more than 280 different species of birds, rare mammals (e.g. hippopotamus), various reptiles and a multitude of fish.

Gambia is also a dynamic country, which is currently undergoing profound social, economic and political changes. The efforts initiated by the Government to democratize the regime and to modernize economic structures are inevitably intertwined with environmental preservation. Human development and economic growth increasingly depend on coastal and marine ecosystems and their capacity to deliver services. Most urban areas, such as the capital city of Banjul, are located along the Gambia River and the Atlantic coast. In recent decades, large investments have been made in ecotourism, which benefits coastal communities and accounts for 12 per cent of the gross domestic product. Additionally, agriculture and fishing employ 70 per cent of the population. Along the littoral, rice fields and artisanal and industrial fisheries are crucial for economic and food security.

Field expedition to monitor seagrasses in the Bijol Islands. Photo: Gambia national implementation team 2021

The Gambia NIT has led several explorations as part of the ResilienSEA project. Seagrass sites in Gambia are more easily accessible than in other pilot countries, and their proximity to the shore also makes them ideal for monitoring and any other intervention activities that may be deemed necessary to enhance the status of the seagrass meadows. As of 2022, there are currently three seagrass monitoring locations: Bijol Islands, Gunjur and Kartong.

Bijol Islands

The Bijol Islands lie at the junction between the south of the Gambia River and the Atlantic Ocean. They are part of the Tanji River (Karinti) Bird Reserve, which covers an area of 612 ha and is managed by the Department of Parks and Wildlife Management (DPWM). The reserve boundary encloses the tidal, saline reaches of the small Tanji River, which is bordered by 2 km² of low mangrove forests, salt marshes and mudflats.

The environment is characterized by incredible biodiversity. As these islands are offshore, they provide an ideal habitat for sea birds. Birds found during nesting periods include royal terns, Caspian terns, grey-headed gulls, western reef herons, long-tail cormorants, great white pelicans and pink-backed pelicans. Green turtles also use these islands as their breeding ground. The upwelling current enriches the islands and provides abundant fish resources, making these islands an ideal home for many marine mammals, such as humpback dolphins, otters and sea turtles. The area also serves as a habitat, feeding, roosting and spawning/breeding site for varieties of marine biodiversity, such as marine turtles and various species of fish, crabs and seashells.

BIJOL ISLANDS

SEDIMENT: Mostly sandy with a presence of shells

ALGAE & EPIPHYTES: Low presence

Halodule wrightii

AVG. COVERAGE: 36 %

MAX. CANOPY HEIGHT: 12 cm

AVG. SHOOT DENSITY: 40 %

The Bijol Islands are the primary seagrass data-collection site in Gambia. In particular, the north-west area of the islands is home to approximately 50 ha of continuous *H. wrightii* seagrass meadows, and *C. nodosa* is also found around the islands at a lesser frequency. Monitoring from 2021 observed that year-round, the sediment in this area was primarily sandy with a mix of mud, and there was a high presence of shells and fairly low presence of epiphytes. In January, the average seagrass coverage of *H. wrightii* was 45.5 per cent, with a shoot density of 28 per cent and an average canopy height of 13 cm. Later that year in November, the average seagrass coverage of *H. wrightii* was 26 per cent, with a shoot density of 43 per cent and an average canopy height of 11 cm.

Unfortunately, sea level rise and coastal erosion are significantly impacting the shoreline of the Bijol Islands. These islands provide a habitat for over 200,000 migratory birds each year, which nest in coastal trees and shrubs. Locals note that this vegetation is becoming inundated with water, thus threatening these vital habitats. With mangrove forest dieback and the loss of coastal forest cover on the islands (Komma 2019), seagrass meadows are the only prominent coastal vegetation remaining around the islands' perimeter to help stabilize sediment.

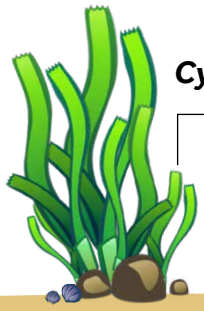
Gunjur

Gunjur village is located in Kombo South District, in the south-west coastal strip of Gambia. It has an estimated population of 27,000 – mostly from the Mandinka, Jola, Fula, Manjago, Balanta, Karoninka and other ethnic groups – who are mainly employed in artisanal fisheries and farming. The settlement is 10 km from Sanyang and 39 km by road from the capital, Banjul. About 3 km from the main town, on the coast, is the bustling fishing village with its fish smokehouses and rows of multicoloured West African canoes. The Bolong Fenyo Community Wildlife Reserve is the first community protected area owned by the community of Gunjur, covering 320 ha. It was granted protected status due to its significant and highly diverse avifauna. The area is an important roosting and feeding site for terns, gulls and other species.

Gunjur has four different data-collection locations around the periphery of the Bolong Fenyo Community Wildlife Reserve, where over 15.5 ha of *H. wrightii* and *C. nodosa* species are found. Currently, Gunjur has the highest concentration of *C. nodosa* in Gambia, with the tallest canopy height and the densest shoot system when compared with the other pilot two sites. In 2021, the data recorded in all locations focused on the *C. nodosa* species, and monitoring occurred in January (winter) and November (autumn). The sediment within all locations was mostly sandy with a mix of mud, and there was a year-round presence of algae and seashells.

In the first location, the average seagrass coverage observed was 68 per cent in both winter and autumn. The average shoot density was 20 per cent in winter and 13 per cent in autumn. The seagrass canopy height was fairly consistent throughout the year, averaging 64 cm in winter and 56 cm in autumn. In the second location, the average coverage of *C. nodosa* was higher, at 85 per cent in winter

Field expedition in Gunjur to monitor C. nodosa meadows. Photo: Gambia national implementation team 2021



Cymodocea nodosa

AVG. COVERAGE: 66 %

AVG. SHOOT DENSITY: 23 %

RANGE OF AVG. CANOPY HEIGHTS: 17–60 cm

GUNJUR

SEDIMENT: Sandy-muddy with a presence of shells

ALGAE & EPIPHYTES: Present

and 79 per cent in autumn. The average shoot density in autumn was 20 per cent. The seagrass canopy height varied by season, averaging 35 cm in winter and 9 cm in autumn.

The average coverage of *C. nodosa* observed in the third location was 56 per cent in winter and 46 per cent in autumn. The average shoot density in autumn was 23 per cent. The seagrass canopy height appeared fairly consistent, averaging 21 cm in winter and 13 cm in autumn. For the fourth location, the average coverage of *C. nodosa* varied notably by season, with 76 per cent coverage observed in winter and 46 per cent in autumn. The shoot density, however, was consistent, averaging 29 per cent in winter and 37 per cent in autumn. The average canopy height observed also varied by season, at 51 cm in winter and 28 cm in autumn.

Because sea turtles are so common in Gunjur, turtle grazing periodically leads to declines in seagrass vegetation. Seagrasses in Gunjur are also diminishing due to other factors, such as coastal erosion and siltation, as well as anthropogenic factors, including run-off, pollution caused by solid waste materials (old clothing, old nets, plastic bags and bottles), drag net fishing and increased seaweed biomass.

Kartong

Kartong village is located in Kombo South District on the southern tip of the coast of Gambia. The rural settlement lies on the Kombo Coastal Road near the international border with Senegal, which is demarcated by the Allahein (San Pedro) River. Kartong (also spelled Kartung) is a multi-ethnic village community, largely made up of Mandinka, followed by Jola and other minority ethnic groups, such as the Karoninka and Balanta. The village has a population of about 5,500 people and is one of the smallest and oldest settlements in Kombo South.

Seagrass meadows are found along the outskirts of Kartong, an area which is locally referred to as Karfaya. Only the *C. nodosa* species has been identified in Karfaya. As in Gunjur and the Bijol Islands, monitoring occurred in the winter and autumn of 2021. The average seagrass coverage observed in Kartong did not notably vary by season, with 51 per cent coverage in winter and 46 per cent in autumn. The average canopy height observed was also fairly consistent between seasons, measuring 38 cm in winter and 31 cm in autumn.

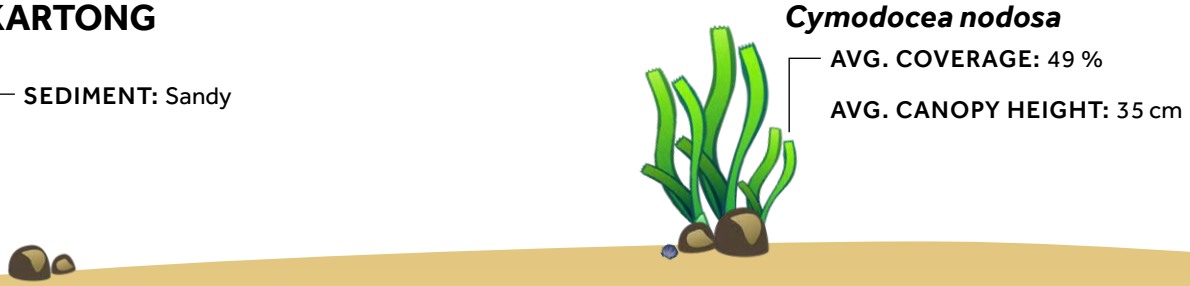
Seagrasses in Kartong are facing serious impacts from coastal erosion and run-off, leading to sand siltation on the seagrass meadows. In fact, one of the sampling locations is entirely covered by sand deposition from the beach. During high tides, waves carry the sand from the nearby sand dunes to the shallow area occupied by the seagrasses. Unlike Gunjur, the seagrass meadows in Kartong are not surrounded by rocks, which would act as natural barriers to prevent siltation or to slow down the impact of coastal erosion and run-off. This is also aggravated by the sea level rise.

Challenges

The main challenges to seagrass monitoring and protection in Gambia under the ResilienSEA project can be attributed to a lack of financing, as well as an underlying lack of seagrass awareness in the region. Some monitoring activities could not be carried out in full due to delays, and this also limited access to field equipment, including multiparameters, salinometers and GoPro cameras.

Budgetary limitations also prevented some community-outreach and awareness-raising activities from taking place. The NIT had hoped to organize a play about seagrass featuring Mandinka- and Wolof-speaking actors as an audiovisual communication tool to increase local awareness. It also wished to conduct on-campus seminars and symposiums for university and college students at least once every semester to increase interest in seagrass among as many students as possible. Although the NIT was successful in engaging with media outlets, it would like to further increase media exposure on seagrass protection in the future, especially by targeting print media and broadcasting channels in Gambia that may already have a keen interest in natural resource conservation topics.

Although seagrass education and awareness in the region is growing, it remains a new phenomenon, which could hinder the progress of protection and conservation policies. However, the NIT has worked to meet this challenge head on by developing a communication, education and public-awareness strategy, as outlined in the protection and policy section. This strategy represents an important first step for increasing seagrass knowledge in Gambia, though there are still gaps as far as awareness and advocacy are concerned.



Box 4. *Ba Nyamo Tanko* – conserving and restoring seagrasses in Gambia

Coastal erosion is significantly impacting the shorelines of Gambia, where populations residing in low-lying areas are increasingly at risk from rising sea levels and inundation (Gomez *et al.* 2020). The predicted land loss for the country's coastal zone is 6 m annually, putting the capital city of Banjul at risk of being submerged (Amuzu *et al.* 2018). This risk from climate change-related hazards not only impacts the landscape, but also socioeconomic development and livelihood opportunities in Gambia, where it is estimated that over 15,560 people per km² are vulnerable to coastal flooding (Amuzu *et al.* 2018).

Through the process of accretion (Potouroglou *et al.* 2017), seagrass meadows help mitigate the effects of coastal erosion, making coastlines with abundant seagrass beds potentially more resilient to inundation than unvegetated zones. The conservation and restoration of seagrass meadows is therefore now becoming a priority area for Gambia. In 2021, the country's first community-led seagrass conservation and restoration project began. The trial project – *Ba Nyamo Tanko* or "conserving seagrasses" in Mandinka – is a joint effort by Gambia's Department of Parks and Wildlife Management, Alma (a British charity) and the Eduardo Mondlane University in Maputo, Mozambique.

The *Ba Nyamo Tanko* project will focus on capacity-building and community involvement to restore seagrasses through the following action areas:

- Design and implement a pilot seagrass restoration project trialling proven restoration methods used in East Africa with the aim of upscaling and replicating the project across West Africa.
- Hold a training workshop on restoration techniques to strengthen the participants' knowledge, skills and competencies in restoration considerations and techniques.
- Create a management network comprising community groups, the project's steering committee (core partners) and the Department of Parks and Wildlife Management project coordinator, ensuring that decision-making is participatory, inclusive and transparent, and that all stakeholders have ownership and feel empowered.
- Develop a communication, education and public-awareness strategy to raise awareness among members of the community about the benefits of protecting seagrasses. This strategy will also foreground the negative impacts of specific fishing equipment (e.g. beach seine nets) and practices (e.g. anchoring) on seagrasses and fish populations to ensure that the project has a real, long-term impact for both the environment and the people.

Signs of erosion at Kololi Beach, Gambia. Photo: Flickr/Jan Kruithof 2014

Through these activities, the project ultimately aims to restore degraded seagrass areas through community participation, enhance ecosystem services provided by seagrasses (including improved fisheries, biodiversity, carbon sequestration and coastal protection) and integrate seagrass conservation into national regulations and sectoral laws. For more information, please visit the project website: https://www.alma-org.co.uk/ba-nyamo-tanko

National implementation team, Gambia

The following collaborative institutions play a key role in the implementation of the ResilienSEA project:

- National Agriculture Research Institute (NARI)
- University of the Gambia (UTG)
- Department of Fisheries (DoFish)
- National Environment Agency (NEA)
- Department of Parks and Wildlife Management (DPWM)
- West African Bird Study Association (WABSA)
- Gambian Navy
- National Association of Artisanal Fisheries Operators (NAAFO)
- Biodiversity Action Journalists (BAJ) – The Point Newspaper
- Gunjur Environmental Protection and Development Group (GEPADG)

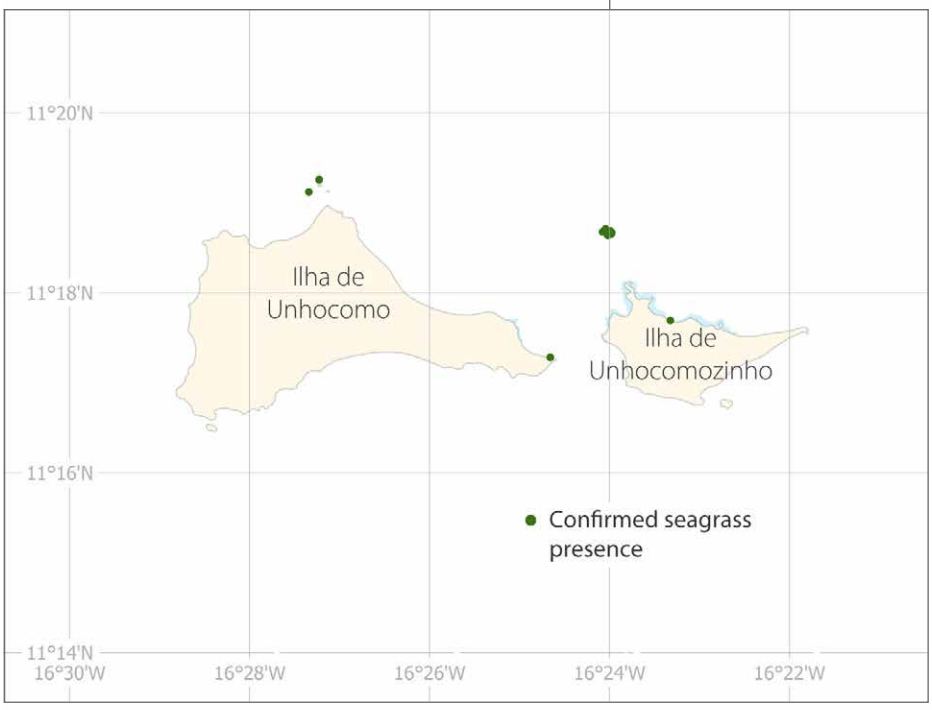
Focal points:

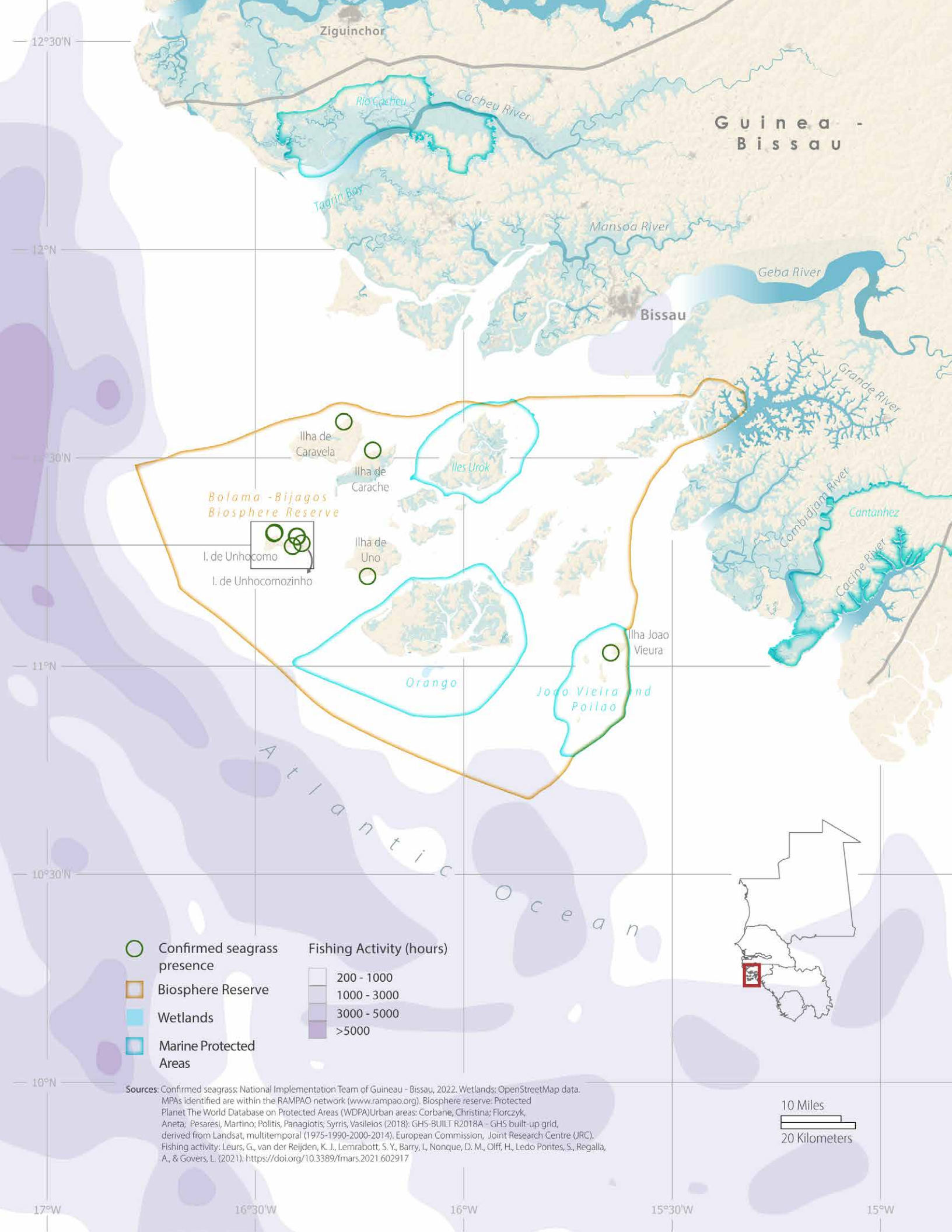
- Omar Sanneh, DPWM
- Ousainou Touray, DPWM

Guinea-Bissau

Pilot sites: Unhocomo and Unhocomozinho islands and the Bijagós archipelago
Resident population: < 300 inhabitants
Seagrass species found: *H. wrightii*
Local terms for seagrass: Creole: *padja de mar*; Bijagós: *emindja*

Unhocomo and Unhocomozinho islands





Sources: Confirmed seagrass: National Implementation Team of Guineau - Bissau, 2022. Wetlands: OpenStreetMap data. MPAs identified are within the RAMPAO network (www.rampao.org). Biosphere reserve: Protected Planet The World Database on Protected Areas (WDPA)Urban areas: Corbane, Christina; Florczyk, Aneta; Pesaresi, Martino; Politis, Panagiotis; Syrris, Vasileios (2018): GHS-BUILT R2018A - GHS built-up grid, derived from Landsat, multitemporal (1975-1990-2000-2014). European Commission, Joint Research Centre (JRC). Fishing activity: Leurs, G., van der Reijden, K. J., Lemrabott, S. Y., Barry, I., Nonque, D. M., Olff, H., Ledo Pontes, S., Regalla, A., & Govers, L. (2021). https://doi.org/10.3389/fmars.2021.602917

Guinea-Bissau

Guinea-Bissau is bounded by Senegal to the north, Guinea to the south and the Atlantic to the west. Its territory is predominantly composed of low-lying coastal plains, with vast archipelagos. The Bolama Bijagós region consists of 88 islands and islets of sedimentary origin covering an area of 10,000 km², and is historically the territory of the Bijagós ethnic group. This territory extends from the mouth of the estuaries of the Cacheu River to the north, and the Grande de Buba River to the south.

This unique topography allows for a diversity of ecosystems of international significance, which led to the region being designated a United Nations Educational, Scientific and Cultural Organization (UNESCO) biosphere reserve in 1996. Additionally, the biological diversity adds to the exceptional value of this territory. It is the second migration site for Palearctic birds off the coast of West Africa after the Banc d'Arguin in Mauritania, and is home to 508 bird species. More than 130 species of mammals (e.g. primates) and reptiles (e.g. turtles and crocodiles) also inhabit the site. In the Esta region, fish species with high commercial value are found, as well as rare and endangered species, such as manatees (*Trichechus senegalensis*), hippopotamuses (*Hippopotamus amphibius*) and dolphins (*Sousa teuszii* and *Tursiops truncates*). The region is also recognized as the most important reproduction site in Africa for green turtles (*Chelonia mydas*), with five of the eight species of sea turtles recorded here (Catry *et al.* 2010).

Young Chelonia mydas sea turtles on the shore of the Boloma Bijagós Biosphere Reserve in Guinea-Bissau. Photo: Institute for Biodiversity and Protected Areas 2019

Ten per cent of the archipelago is densely covered by mangroves. Coastal protection from mangroves helps attenuate the force of the dynamics of seawater and wind. Just a few metres from the edge of the islands' beaches, seagrasses are found at depths varying between 30 and 400 cm, depending on the tide.

According to local populations, the seagrass meadows surrounding the archipelago are in a good state of health, though they may be impacted by fishing activities. Fishing is practised by different ethnic groups, including the Fula, Papei, Balanta, Mandinka, Biafada, Bijagós, Serer, Nhominca, Sierra Leoneans and Susso. While many fishing activities are small in scale and involve families fishing for subsistence, irresponsible and destructive fishing practices are also still used in the area. Seagrass meadows are therefore at risk of physical damage, which can in turn diminish the ecosystem services they provide.

Within this archipelago, the ResilienSEA project NIT carries out seagrass monitoring activities on the islands of Unhocomo and Unhocomozinho. However, several other expeditions have taken place throughout the archipelago through the help of a community-led citizen science team (see Box 5 to learn more).

Unhocomo and Unhocomozinho islands

Unhocomo and Unhocomozinho are member islands of the Boloma Bijagós Biosphere Reserve and are situated 113 km from the city of Bissau. The coastal areas contain three types of marine ecosystems: mangroves, seagrass meadows and macroalgae. To understand the variability of seagrass along the islands, three sampling stations (Ancante, Ancobo and Canneronho) were established. The results show that these monitoring sites are colonized by a single seagrass species, *H. wrightii*.

Ancante station is located 1,040 m from the coast of Unhocomozinho. The site is protected by a circular stone bank, the seabed sediment is sandy and there is a significant slope that characterizes the depth of the area. The average seagrass coverage observed was less than 25 per cent, while the average density was 283 individuals in an area of 50 cm². There was no observable presence of epiphytes, but rocks were colonized with algae and corals. Observations show *H. wrightii* regenerates at a higher rate here than in other monitoring locations.

Cannenoronho is the second station, located 400 m from the coast of Unhocomo. The seabed sediment is sandy with a noted presence of shells, which disintegrate and contribute to the characteristic turbidity of this location. The average seagrass

Box 5. Citizen science efforts in Guinea-Bissau help identify new seagrass areas

Right from the start of the ResilienSEA project, the Guinea-Bissau NIT knew that it wanted to explore other potential seagrass areas beyond the pilot sites of Unhocomo and Unhocomozinho. The presence of seagrass within the Bijagós archipelago was thought to be extensive but had yet to be confirmed in many locations. Facing a limited budget for field expeditions, the NIT decided to enlist the help of community members and form a team of citizen scientists.

During the initial phase, the NIT held meetings at the Orango National Park with local park managers, the Directorate of Marine Protected Areas of Orango and João Vieira, the Centre for Applied Fisheries Research, and the Institute for Biodiversity and Protected Areas of Guinea-Bissau to gather suggestions of which community groups to target. Ultimately, the NIT decided to reach out to youth associations that work in mangrove and sea turtle conservation. From there, it arranged for in-person meetings to form a citizen science team, though the logistics of these meetings proved challenging due to COVID-19 restrictions and the remoteness of many of the islands.

After these initial meetings, the NIT was able to assemble a team of 18 locals from different islands throughout the archipelago. Team members were given information on how to identify seagrass, algae and epiphytes. They were also briefed on the key ecosystem services of seagrass, reinforcing the need to conserve these important ecosystems to support livelihood activities, such as subsistence fishing. After conducting its own field expeditions, the citizen science team sent photos and messages to the NIT about the *H. wrightii* found, as well as the presence of macroalgae and epiphytes. The NIT then sent seagrass experts to confirm these findings, which has led to the discovery of seagrass in Caravela Island, in the João Vieira and Poilão Marine National Park and in other locations in Unhocomo.

A H. wrightii seagrass bed from the Ancante station off the coast of Unhocomozinho. Photo: Guinea-Bissau national implementation team 2019

Although most members of the citizen science team are between 18 and 26 years old, there are also 3–4 women aged around 40 years old. These women work within mariculture to collect seashells and bivalves as a primary source of income. For this demographic, the need to conserve seagrass meadows is imperative – when poor mariculture practices such as trampling damage and destroy seagrass meadows, it is women within this industry who feel the impact, as seagrasses are an important habitat for many of the species they collect.

Indeed, locals are beneficiaries of healthy seagrass meadows. Members of the citizen science team have not only helped confirm the presence of seagrasses in unknown areas, but they have also acted as representatives to help spread the message of seagrass conservation within their respective islands.

UNHOCOMO & UNHOCOMOZINHO
Ancante, Cannenoronho and Ancobo

SEDIMENT: Sandy with a presence of shells

ALGAE: Present on rocks

EPIPHYTES: Present in some locations

Halodule wrightii

AVG. COVERAGE: <25 %

AVG. DENSITY: 232 individuals per 50 cm^2

A H. wrightii seagrass bed from the Cannenoronho station off the coast of Unhocomo. Photo: Guinea-Bissau national implementation team 2019

A H. wrightii seagrass bed with a notable presence of epiphytes and algae from the Ancobo station off the coast of Unhocomozinho. Photo: Guinea-Bissau national implementation team 2019

coverage observed was less than 25 per cent, while the average density was 259 individuals in an area of 50 cm². Again, there was no presence of epiphytes, but rocks were colonized with algae and corals.

Ancobo is the third station, located on the bank of Unhocomozinho. This zone is laterally protected by mangroves and rocks. The seabed sediment is also sandy, and the significant offshore slope characterizes the depth of the zone. The average seagrass coverage was observed less than 25 per cent, while the average density was 155 individuals in an area of 50 cm². Unlike the other two sites, a strong proliferation of epiphytes was observed in the Ancobo area, and the rocks were covered with algae and corals.

Photo: Rob Barnes 2019

Challenges

Balancing local interests and access to coastal resources can be a challenge when enforcing regulations within protected seagrass areas because these sites are frequented by subsistence or small-scale fishers, including mollusc harvesters. These activities must be taken into consideration when enforcing restrictions to protect vulnerable seagrass areas.

To address this, the Guinea-Bissau NIT began working with local communities to increase awareness of seagrass meadows, highlighting the importance of their ecosystem services to fishers. Outreach initiatives also highlighted the ways in which subsistence fishing can be successful without using equipment that damages seagrasses. Moving forward, the NIT notes how seagrass protection laws must continue to be enforced to reduce the anthropogenic impact on these ecosystems.

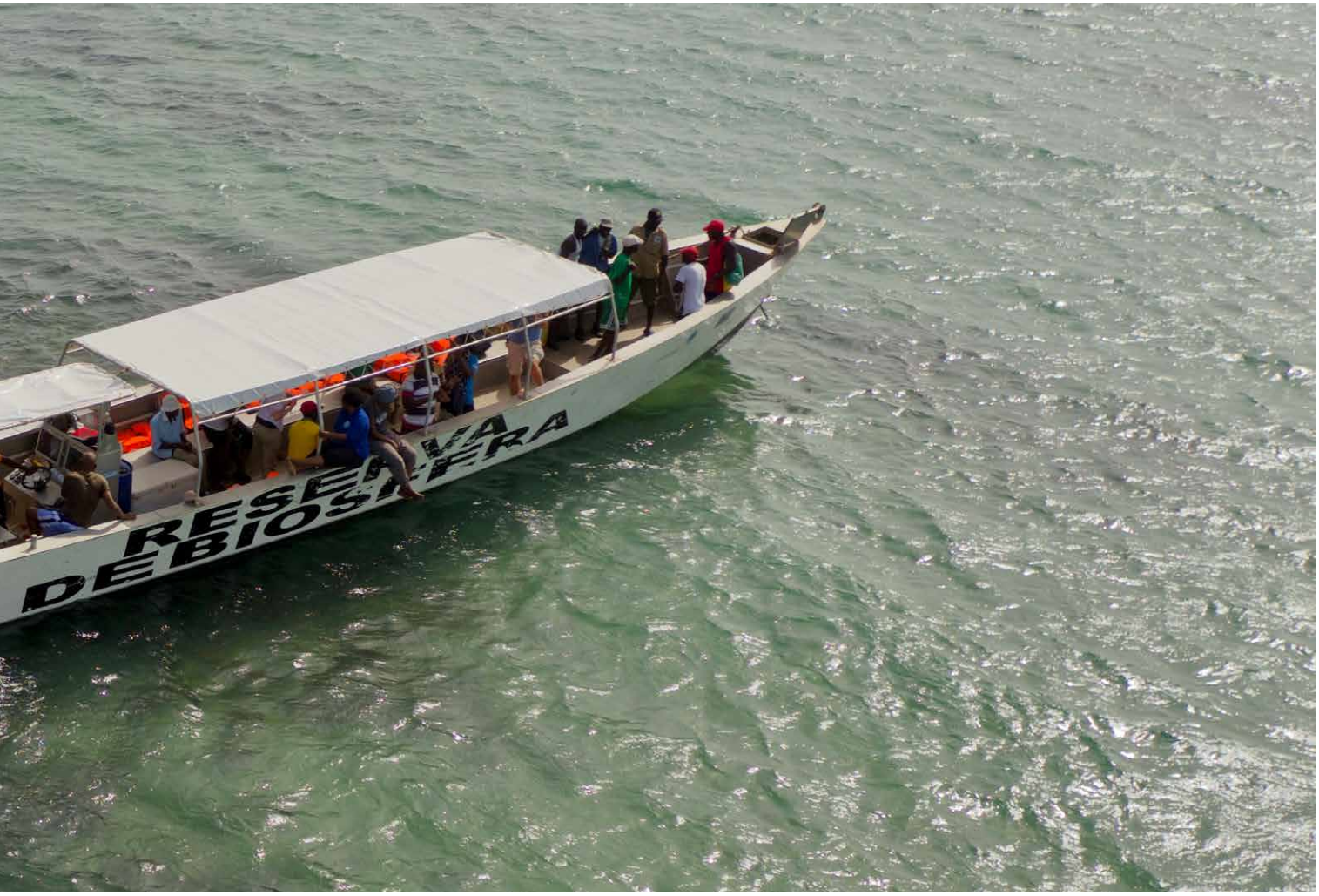
National implementation team, Guinea-Bissau

The following collaborative institutions play a key role in the implementation of the ResilienSEA project:

- *Centro de Investigação Pesqueira Aplicada* [Centre for Applied Fisheries Research – CIPA]
- *Instituto da Biodiversidade e das Áreas Protegidas* [Institute for Biodiversity and Protected Areas – IBAP]
- *Instituto Nacional de Estudos e Pesquisa* [National Institute of Studies and Research – INEP]
- International Union for Conservation of Nature (IUCN)
- *Gabinete De Planificação Costeira* [Coastal Planning Office – GPC]
- *Associação Nacional dos Armadores de Pesca Artesanal* [National Association of Artisanal Fishing Boat owners – ANAPA]
- *Secretária de Estado do Ambiente* [State Secretariat of the Environment – SEA]

Focal points:

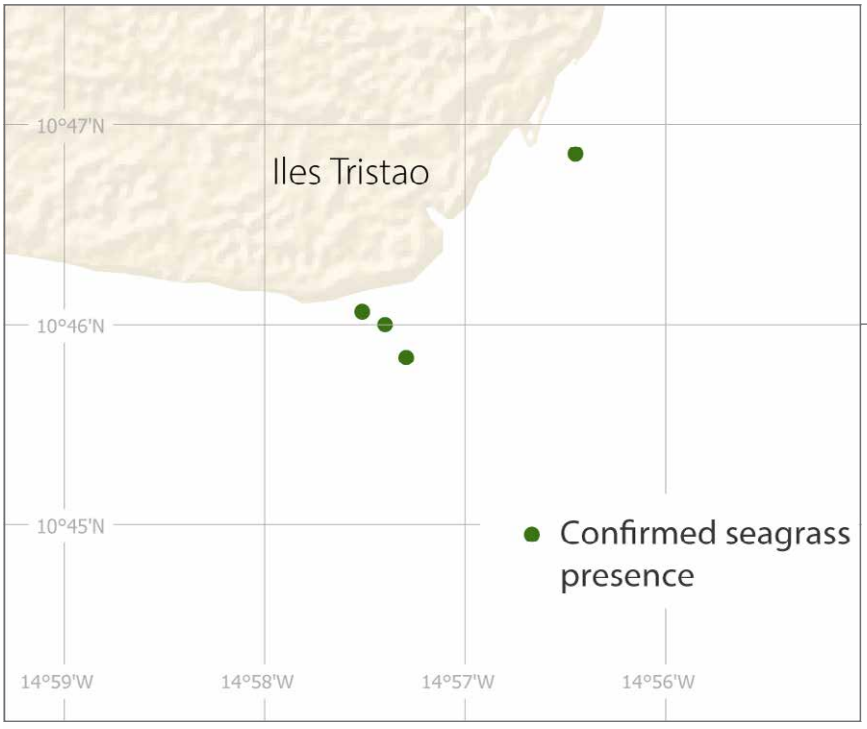
- Noelo Cardoso, ResilienSEA Project Coordination Focal Point; CIPA
- Emanuel Dias, ResilienSEA Project Adjunct Focal Point; IBAP
- Udimila Kadija Queta, ResilienSEA Project Communications Focal Point; IBAP
- Jeremias Intchama, CIPA

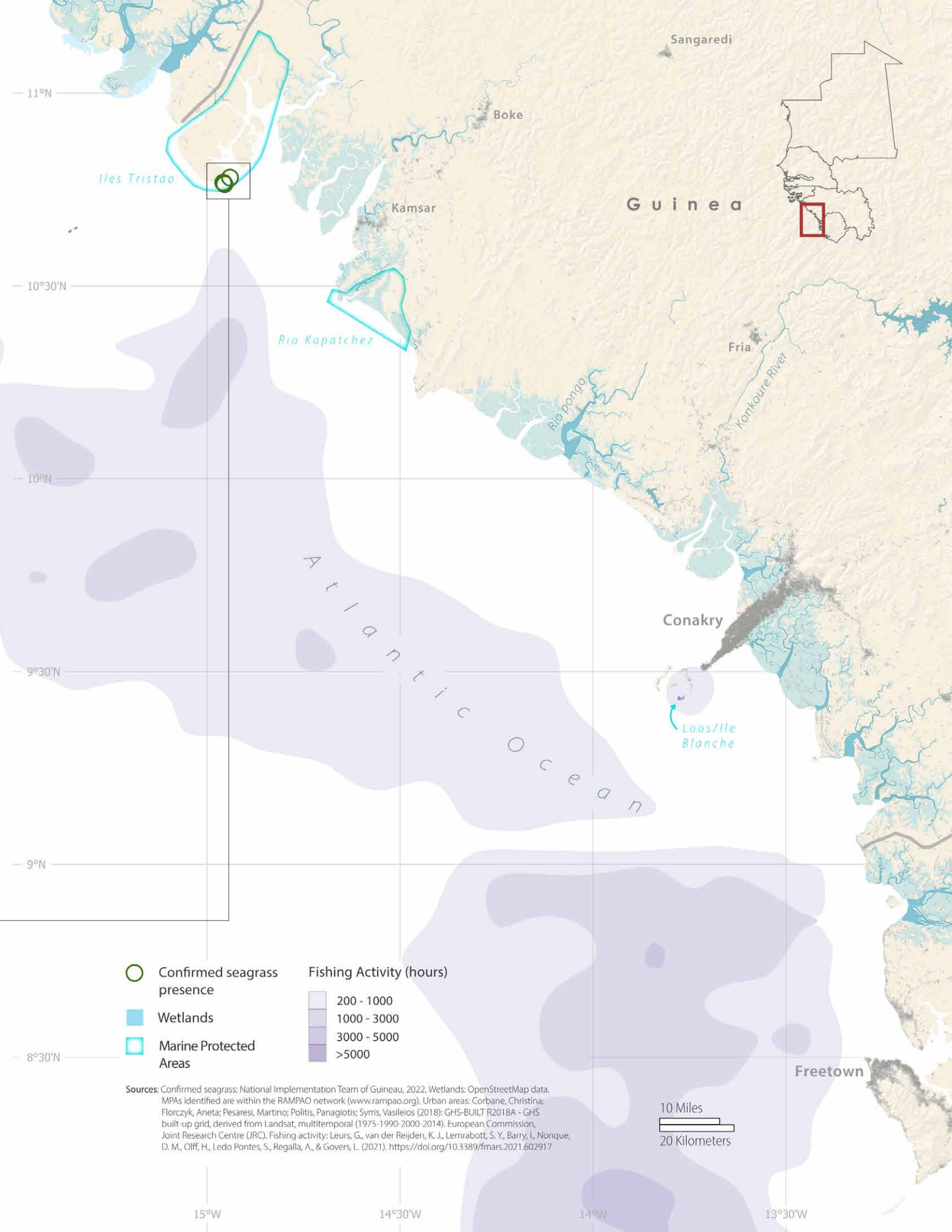


Guinea

Pilot site: Tristao Islands
Resident population: 9,000 inhabitants
Seagrass species found: *H. wrightii*
Local names for seagrass: Nalous dialect on the Tristao Islands: *n'da*

Tristao Islands





Sources: Confirmed seagrass: National Implementation Team of Guineau, 2022. Wetlands: OpenStreetMap data. MPAs identified are within the RAMPAO network (www.rampao.org). Urban areas: Corbane, Christina; Florczyk, Aneta; Pesaresi, Martino; Politis, Panagiotis; Syrris, Vasileios (2018): GHS-BUILT R2018A - GHS built-up grid, derived from Landsat, multitemporal (1975-1990-2000-2014). European Commission, Joint Research Centre (JRC). Fishing activity: Leurs, G., van der Reijden, K. J., Lemrabott, S. Y., Barry, I., Nonque, D. M., Olff, H., Ledo Pontes, S., Regalla, A., & Govers, L. (2021). https://doi.org/10.3389/fmars.2021.602917

Guinea

Guinea is bordered by Guinea-Bissau to the west, Senegal and Mali to the north, Côte d'Ivoire to the east, and Liberia and Sierra Leone to the south. The territory can be divided into four natural regions (Lower or Maritime Guinea, Middle Guinea, Upper Guinea and Forest Guinea), each with its own climate, hydrography and ecology. These climate variations entail a rich biodiversity of habitats and living systems. Savannahs, rainforests, mangroves and mudflats are home to a large variety of mammals, insects, fish, birds, reptiles and amphibians.

Guinea's diverse climates and living systems provide it with high potential in ecotourism, agriculture and fishing, among other activities. Land use centres on the extraction and exploitation of natural resources; the country's growth in gross domestic product, for example, has mainly been driven by exports in minerals (gold, bauxite and diamonds). In addition, agriculture holds a significant place in human development, as 76 per cent of the population is employed in this sector. Coastal and marine zones are equally important. While the occupation of territory is diverse, population density is highest in Maritime Guinea, which is characterized by the predominance of littorals. Fishing is an important source of income and directly employs 800,000 people. Fish consumption is central to the Guinean diet, amounting to 13 kg per capita each year. The conservation of seagrass meadows can play a significant role in preserving Guinea's rich biodiversity and coastline, as well as supporting food security. Currently, the seagrass monitoring sites included in the ResilienSEA project in Guinea are located in the Tristao Islands.

Tristao Islands

Located along the border with Guinea-Bissau, the Tristao Islands Complex was formed by the delta of the Kogon River in northern Guinea. This archipelago comprises four islands and covers approximately 280 km^2. The site is characterized by expanses of sandbanks, mud, rocks, estuaries and mangrove forests, which are home to a multitude of species, including sea turtles, lamantin, crocodiles, sharks and many fish species. Common activities in the area include traditional small-scale fishing and agriculture (particularly rice farming), while illegal industrial fishing persists.

H. wrightii spotted in the Tristao Islands, Guinea. Photo: Guinea national implementation team 2020

The site holds cultural importance for the Nalous and Balant indigenous communities, who have maintained this land for several hundred years. In addition to their reliance on fisheries and agriculture, these communities consider some parts of the islands sacred. Therefore, the Tristao Islands Complex has been registered on the Ramsar List of Wetlands of International Importance since 1992. The site has also been a community MPA since 2008, a status which is intended to preserve and improve its biological, social and cultural diversity.

In March 2020, the *H. wrightii* species was discovered at the tip of the Tristao Islands in the district of Katfoura – an area which is often frequented by sea turtles. Thorough mapping of the site has yet to be completed. Compared with other pilot sites, the Tristao Islands can be difficult to access, which hinders mapping and monitoring of the health and density of seagrass meadows. Additionally, the limits of seagrass bed depths towards the open sea have not yet been established, since special diving equipment is required to explore these areas. Despite these limitations, capacity building efforts are being made within Guinea through the ResilienSEA scholarship program to support young researchers who plan to contribute to the mapping and monitoring of national seagrasses in the future (see Box 6 to learn more).

Of the seagrass areas in the Tristao Islands visited to date, the average coverage of seagrass meadows was between 30 and 40 per cent, with average canopy heights of 14 cm. The sediment within these areas was notably sandy and muddy, and the presence of algae or epiphytes was not recorded.

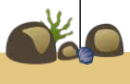
TRISTAO ISLANDS

Halodule wrightii

AVG. COVERAGE: 35 %

AVG. CANOPY HEIGHT: 14 cm

SEDIMENT: Sandy-muddy



Box 6. Capacity building in Guinea through the ResilienSEA Scholarship

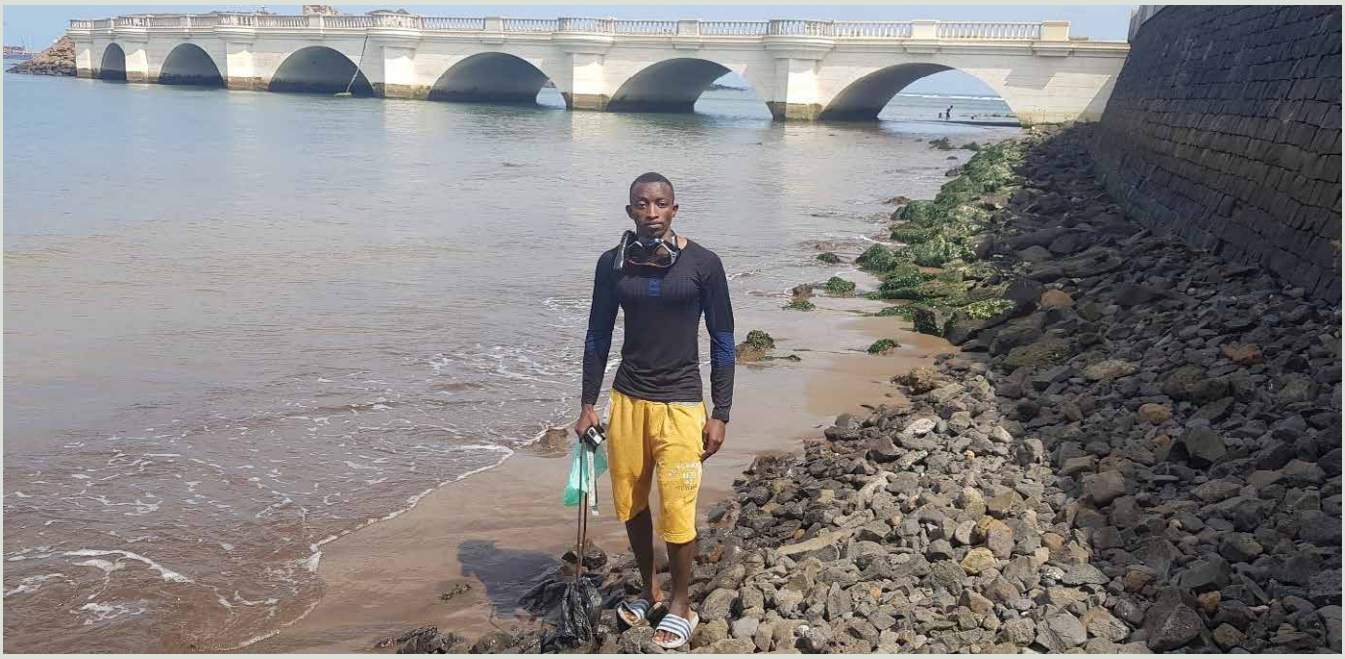
A key component of the ResilienSEA project is capacity building, which aims to improve practical knowledge on West Africa's seagrass meadows and increase the number of experts actively involved in the research and conservation of seagrass in the region. To meet this need, the ResilienSEA project has granted West African master's students with scholarships for them to strengthen their expertise in coastal ecosystems management and assist in gathering seagrass data in project pilot sites.

Seydouba Soumah, a native of Guinea, is one of the master's students who received the ResilienSEA scholarship to further his education and build his career as a researcher in Guinea. Seydouba studied Meteorology at the University of N'Zerekore in Guinea, has an MPhil in Environmental Science from the University of Ghana, Legon, and now holds an MSc in Climate Change and Marine Sciences from the University of Cape Verde.

Though he'd never heard of seagrasses before the start of the ResilienSEA project, his interest was piqued the moment he saw his first meadow during a workshop in Cabo Verde. It was a bed of *Halodule wrightii* on a sandy seafloor, and Seydouba was immediately captivated by the uniqueness of seagrass since it is the only flowering plant that lives entirely in an aquatic environment.

During his time at the University of Cabo Verde, Seydouba underwent a four-month intensive course in English and then proceeded with courses related to climate change and marine sciences such as coastal and marine spatial planning, general oceanography, aquatic ecology, ocean dynamics and changes in ocean circulation, marine governance and law, as well science communications and even diving. After coursework, Seydouba developed and submitted his master's thesis, "Assessing the role of seagrass as a socio-ecological system – A case study of Cape Verde".

The knowledge and experience Seydouba gained during his MSc training and fieldwork will be used to increase awareness and practical skills in his home country of Guinea wherever his contribution is needed. Being an early career scientist, he is eager to continue enhancing his expertise within the topics of seagrass biology, ecology, and functioning through more scientific research. Ultimately, Seydouba hopes to be an element of change within this field by applying his knowledge to help further the conservation of seagrasses in Guinea.



Soumah (pictured) during fieldwork for his master's thesis. Photo: Seydouba Soumah, 2021

Challenges

Political turmoil in Guinea has resulted in significant challenges for the management of ecosystems, including seagrasses. On 5 September 2021, the sitting President of Guinea, Alpha Condé, was removed from office in a coup d'état. The ramifications of this coup have reverberated throughout governing bodies and institutions in Guinea. It has presented challenges for the transboundary governance and management of coastal ecosystems in the region, as well as for the distribution of resources to fund protection and monitoring efforts. Field monitoring expeditions and training sessions have therefore occurred less frequently in Guinea than in other ResilienSEA pilot countries. Although seagrass data from Guinea are currently limited due to these political circumstances, there is immense potential to expand monitoring efforts beyond the Tristao Islands to the nation's other MPAs and Ramsar sites along the coastline.

In addition to political instability, the Guinea NIT faces other circumstantial challenges in defining the full extent of seagrass beds within the pilot site, as well challenges related to the location of the site itself. As mentioned, the remoteness of the Tristao Islands presents logistical difficulties for monitors – the islands are 350 km from the capital city of Conakry, which entails a four-to-six-hour boat ride at sea. This inaccessibility remains a challenge for monitoring teams, making it difficult for them to conduct the fieldwork necessary to frequently study and monitor these seagrass meadows.

National implementation team, Guinea

The following collaborative institutions play a key role in the implementation of the ResilienSEA project:

- *Centre de Protection du Milieu Marin et des Zones Côtières* [Centre for the Protection of the Marine Environment and Coastal Zones – CPMZC]
- *Centre de Recherche Scientifique Conakry Rogbané* [Scientific Research Centre of Conakry Rogbané – CERESCOR]
- *Centre National des Sciences Halieutiques de Boussoura* [National Centre for Fishery Science of Boussoura – CNSHB]
- *Centre d'Observation, de Surveillance et d'Information Environnementales* [Centre for Observation, Monitoring and Environmental Information – COSIE]
- *Herbier National De Guinée* [National Herbarium of Guinea – HNG]
- *Office Guinéen des Parcs et Réserves* [Guinean Office of Parks and Reserves – OGUIPAR]
- *Fédération Guinéenne de la Pêche Artisanale* [Guinean Federation of Artisanal Fishing – FEGUIPA]

Focal point:

- Iya Camara, CPMZC

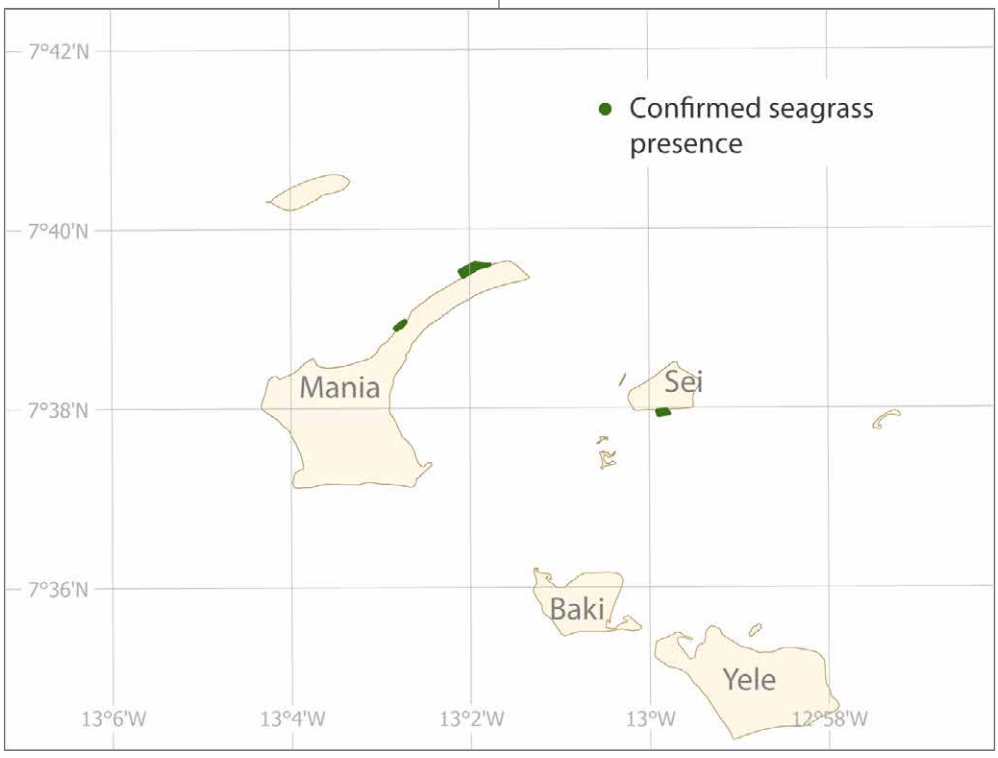
Collecting data on H. wrightii from the Tristao Islands. Photo: Guinea national implementation team 2018

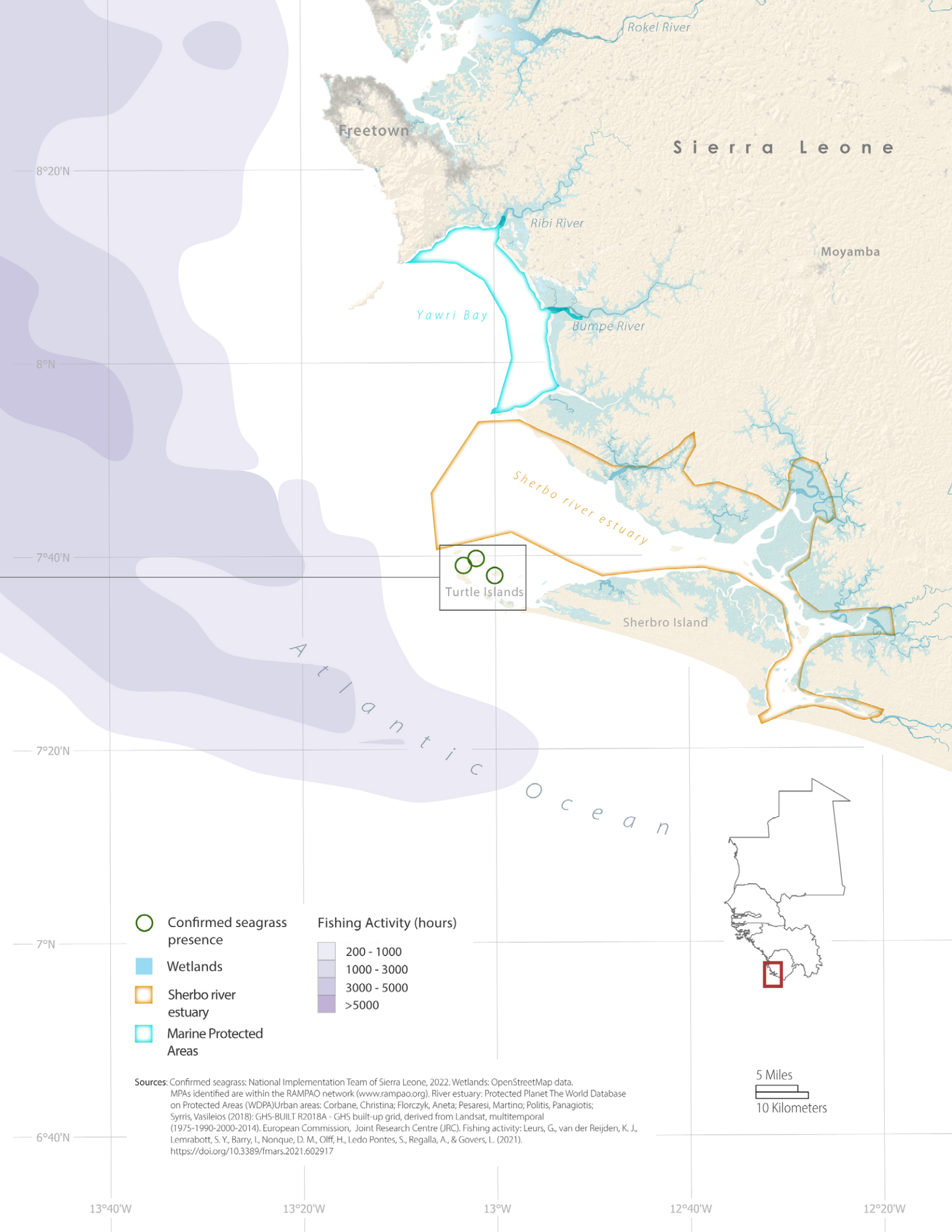
Photo: Guinea national implementation team 2020

Sierra Leone

Pilot sites: Turtle Islands – Bumpetuk Island, Mania and Sei
Resident population: approximately 3,000
Seagrass species found: *H. wrightii*
Local terms for seagrass: shoal grass and *plukɛ*

Turtle Islands





Sources: Confirmed seagrass: National Implementation Team of Sierra Leone, 2022. Wetlands: OpenStreetMap data. MPAs identified are within the RAMPAO network (www.rampao.org). River estuary: Protected Planet The World Database on Protected Areas (WDPA)Urban areas: Corbane, Christina; Florczyk, Aneta; Pesaresi, Martino; Politis, Panagiotis; Syrris, Vasileios (2018): GHS-BUILT R2018A - GHS built-up grid, derived from Landsat, multitemporal (1975-1990-2000-2014). European Commission, Joint Research Centre (JRC). Fishing activity: Leurs, G., van der Reijden, K. J., Lemrabott, S. Y., Barry, I., Nonque, D. M., Olff, H., Ledo Pontes, S., Regalla, A., & Govers, L. (2021). https://doi.org/10.3389/fmars.2021.602917

Sierra Leone

Sierra Leone is located in the south-west of West Africa, bordered by Guinea to the north-east and Liberia to the south-east, with a vast coastline of 402 km along the Atlantic Ocean. As in its West African neighbours, Sierra Leone is rich in biodiversity, with its wide variety of vegetation comprising mangrove swamps and large beaches along its coasts, as well as rivers, mountains, grasslands, woods and savannah on interior plains. These areas are home to a vast array of species, including primates (chimpanzees and the colobus monkey), terrestrial and marine mammals (the bongo antelope), birds and reptiles (crocodiles and sea turtles). Several of these species are listed as rare or endangered, such as the pygmy hippopotamus.

The country's young and diverse population relies on fertile soils, healthy oceans, abundant natural resources and resilient coasts. The highest population densities occur in low-lying areas along the coast and in the peninsula of Freetown. Economic growth and employment are primarily driven by the extraction of natural resources (e.g. iron ore, diamonds), as well as agriculture, which employs more than 60 per cent of the population. Fisheries play a fundamental role in economic development and food security, and are also at the core of coastal communities' cultural and social organization.

Field team monitoring shallow seagrasses around Bumpetuk Island. Photo: Sierra Leone national implementation team 2021

Although the *2003 World Atlas of Seagrasses* indicated that *H. wrightii* was present in Sierra Leone, no specific details or locations of seagrass meadows were established until December 2019, when a successful ResilienSEA project confirmed a large *H. wrightii* meadow along the shores of the Turtle Islands (see Box 7). Since 2019, all subsequent field monitoring has occurred within the Turtle Islands, with monitoring sites established around Bumpetuk Island, Mania and Sei.

Turtle Islands

The Turtle Islands are eight small islands located in the Southern Province of Sierra Leone. They are part of the Sherbro River Estuary MPA, which restricts any form of industrial fishing in the area, as well as some destructive small-scale fishing methods. The islands are mostly inhabited by fishing communities, with main local indigenous groups in the area being Sherbro and Mende. The Turtle Islands' environment has vast mangrove forests, mudflats and sand banks, with the presence of seagrasses adding to this variety of habitats. The seagrass meadows are home to a rich biodiversity of stingrays, starfish and many different species of juvenile fish, and are also a site for sea turtles to lay their eggs and for birds to breed.

Bumpetuk Island, which has an area of 8.75 km^2 and a coastline of 16.75 km, was identified as the primary data-collection site within the ResilienSEA project in 2019. Following the identification of this pilot site, the NIT undertook three monitoring activities and conducted educational programmes for locals and relevant marine institutions on the importance of seagrass, as well as information on seagrass identification and conservation.

BUMPETUK

SEDIMENT: Sandy with some mud

ALGAE & EPIPHYTES: 5–10 % presence

Halodule wrightii

AVG. COVERAGE: <50 %

AVG. CANOPY HEIGHT: 10 cm

Box 7. New seagrass discoveries in Sierra Leone

Prior to the ResilienSEA project, the presence of seagrass meadows along the coastline of Sierra Leone was unconfirmed. In 2019, field expeditions began in an attempt to record potential seagrasses. After several unsuccessful expeditions, a team embarked on a new exploratory mission around the Turtle Islands in December 2019. The team, with representatives from the Environment Protection Agency – Sierra Leone (EPA-SL) and GRID-Arendal, travelled to the Turtle Islands, west of Sherbro Island in the Southern Province of Sierra Leone. This small group of eight islands stretches across an area of shallow waters and white sand banks. The area is relatively remote and difficult to reach, but a high-level geographic information system analysis and local knowledge from fisherfolk indicated that it could be an ideal location for seagrasses.

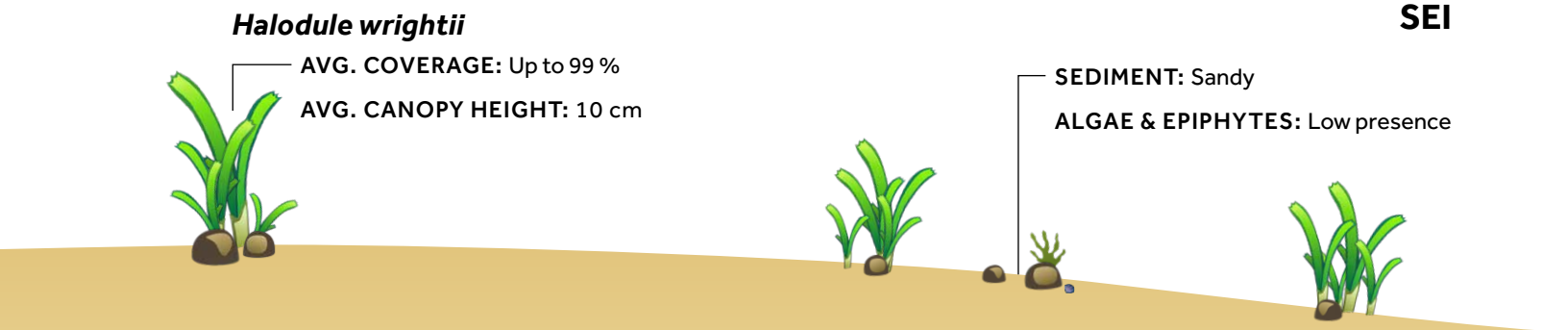
After an overnight stay on Banana Island to the north, the team took a four-hour boat journey to the Turtle Islands. Within minutes of arriving close to Bumpetuk Island (one of the largest of the Turtle Islands), the boat became stuck on a sandbank – a common experience when boating during spring tides, which is when coastal waters recede to their low point. As the team stepped out of the boat to push it to deeper waters, they decided to scan the area for potential seagrass meadows. Despite the area seeming barren at first, one team member, Melissa Ndure of EPA-SL, stumbled upon a large healthy seagrass meadow, which the other team members confirmed as being *H. wrightii*, proving its existence in Sierra Leone.

In addition to the seagrass meadow being in good health, the team found it was also rich in different types of organisms, including stingrays, starfish, turtles, manatees and several species of juvenile fish, which were all using the habitat for food or protection. Since this momentous discovery, several more field expeditions have resulted in the establishment of three seagrass monitoring sites throughout the Turtle Islands.

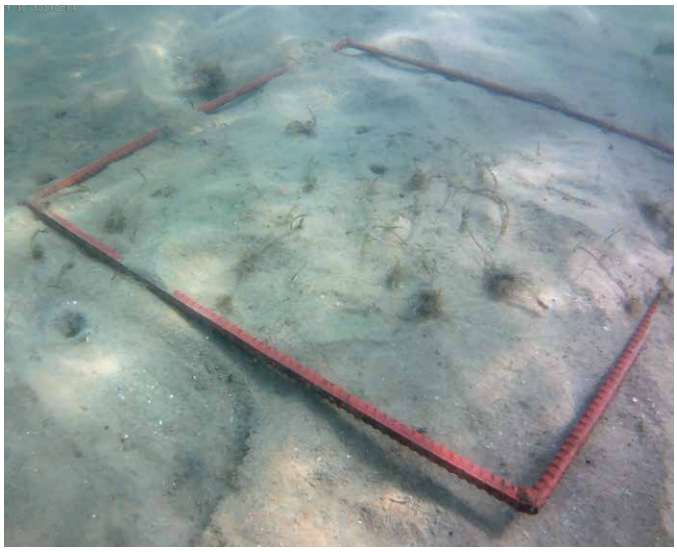
The team discovering a seagrass meadow in the shallow waters of Moot Island. Photo: Rob Barnes, GRID-Arendal 2019

As a result of these efforts, two new data-collection sites were established in 2022 in the nearby villages of Mania and Sei. Community members in Mania were previously unaware of the existence of seagrass meadows in nearby waters, and it was not until two young locals made a discovery that seagrasses were first identified in the area. The discovery of seagrasses around Sei is also particularly important, as the area is a boat landing site and is therefore often impacted by boat and foot traffic, pollution and nutrient contamination. The identification of seagrass meadows in the area has incentivized Sei's community to preserve them and reduce their impact on these ecosystems.

During each monitoring visit to the sites, the field team assessed the health of the seagrass, the species present and abundance



Monitoring H. wrightii around Bumpetuk Island. Photo: Sierra Leone national implementation team 2021



Monitoring submerged H. wrightii seagrasses around Mania. Photo: Sierra Leone national implementation team 2021

in the area. In the Bumpetuk Island pilot area, the seagrass is unevenly distributed in clusters, though all identified seagrass meadows were noted to be in a healthy condition. The H. wrightii species recorded to date have been small, with canopy heights ranging between 3 and 7 cm, at a depth of approximately 1.5 m under water. The average seagrass coverage observed around Bumpetuk during monitoring periods has been below 50 per cent in most areas, which may be due to sand accretion in the area. The presence of epiphytes was approximately 5–10 per cent, and the sediment composition was primarily sandy with a mix of mud.

Photo: Sierra Leone national implementation team 2022

Around Mania, the observed *H. wrightii* bed was at a depth of 2.3 m under water, with coverage also low and an even lower presence of epiphytes. The sediment composition was primarily sandy. The most recent monitoring site at Sei Island was not established until March 2022, so field monitoring activities have been limited. However, early estimations of the site are incredibly promising, with dense *H. wrightii* meadows thought to cover at least 1,000 m^2 and average coverage expected to be between 95 and 99 per cent. Average canopy heights are estimated to be 9–11 cm.

Challenges

Differences in belief systems can occasionally present sociocultural challenges in the field. Hoong Island, for example, is scared to indigenous populations, which believe the presence of women within these areas could have negative consequences. Female field researchers have therefore sometimes been limited in monitoring seagrasses within this archipelago.

Monitoring variability within these sites has also been a challenge for the NIT due to tidal changes, poor weather and the long journey required to travel to the Turtle Islands. Thus, there is an opportunity for more thorough and seasonal monitoring in the future.

National implementation team, Sierra Leone

An NIT was formed by the lead institution, EPA-SL, with representatives from relevant government institutions, universities and civil society. The following collaborative institutions play a key role in the implementation of the ResilienSEA project:

- Sierra Leone Artisanal Fishers' Consortium
- Institute of Marine Biology and Oceanography (IMBO)
- Biological Sciences Department, University of Njala, Freetown
- Reptile and Amphibian Program – Sierra Leone (RAP-SL)
- CEMMATS Group Limited
- Ministry of Fisheries and Marine Resources
- Sierra Leonean Navy
- National Protected Area Authority
- Marine environmental consultants
- Department of Geography, Fourah Bay College
- Sierra Leone Maritime Administration
- Conservation Society – Sierra Leone
- Ministry of the Environment

Focal points:

- Paul A. Lamin, EPA-SL
- Melissa Ndure, EPA-SL
- Lynette John, IMBO
- Joseph Sapunka Turay, EPA-SL

Photo: Rob Barnes 2019

Photo: Rob Barnes 2019

PROJECT IMPACT: CONSERVING SEAGRASS IN WEST AFRICA

Project impact

A key reason for the lack of seagrass protection in the region is the limited information available on some of the most basic aspects of seagrass distribution and health. The ResilienSEA project has aimed to strengthen knowledge on seagrass meadows in West Africa and to increase the availability of seagrass data in the region by conducting monitoring activities. Through these actions, NITs and local communities have worked to increase regional capacity, develop new seagrass management tools and further the protection of seagrasses within governmental frameworks. As a result, seagrass data have increased, as has the number of policy achievements in each pilot country. More efforts are needed to continue building a strong regional database.

Photo: Rob Barnes 2019

Improved data

Prior to the start of the ResilienSEA project, knowledge about the distribution of seagrass species within West Africa was limited. Project activities have sought to discover, map and monitor seagrass meadows throughout the seven pilot countries. The ground-truth field data collected thus far will contribute to two forthcoming publications where predictive seagrass models are used to map the potential presence of seagrass meadows in the region. The preliminary modelling completed by Duke University in 2019 (Sidi Cheikh *et al.* 2022, in-press) has served as a helpful tool for NITs to plan field expeditions to confirm the accuracy of predictions made by the model, and potentially discover new seagrass areas. The model estimates offer initial predictions that are likely to change based on the abundance and quality of field data received in the future.

Beyond predictive modelling, the quantity and quality of ground-truth seagrass data in West Africa has greatly improved since the start of the ResilienSEA project. This comes as a direct result from the efforts of field monitors, who have worked to map the presence of seagrass meadows throughout the region. Field visits have not only yielded more data but have also led to exciting new discoveries. In Guinea and Sierra Leone, *H. wrightii* was discovered for the first time, while in Senegal, the southernmost limit of *Z. noltei* was identified in the Saloum Delta National Park. These findings represent important milestones for the protection of seagrass ecosystems, as mapping their extent is the first step towards strengthening management and conservation policies.

An increase in regional capacity and knowledge has also improved seagrass data in the region. One important component to the ResilienSEA project has been granting West African master's students with scholarships to strengthen their expertise in coastal ecosystems management and to generate useful data from the identified pilot sites. The ResilienSEA scholarship provides sponsorship for four students at renowned universities in West Africa, including the University of Cheikh Anta Diop of Dakar and the University of Cabo Verde in Mindelo. The following students were shortlisted following a rigorous selection process: Soumah Seydouba (Guinea), Feitimatt M'Beirik Belkheire (Mauritania), Noelo Silva Akys Cardoso (Guinea-Bissau), Gnilane Diogoye Diof (Senegal) and Melissa Ndure (Sierra Leone).

Photo: Rob Barnes 2019

Policy and communication developments

As a result of the ResilienSEA project, pilot countries have integrated seagrass conservation into sectoral management plans within governmental and regional frameworks. This section provides an overview of the existing conservation frameworks in place in each country, as well as recent policy and communication developments stemming from project activities.

Mauritania

Significant efforts have been made in the last decades to improve environmental protection in Mauritania and the Banc d'Arguin National Park. The country's increasing engagement in international, multilateral and regional agreements has encouraged such efforts, with two MPAs created to protect important marine and coastal ecosystems (the Banc d'Arguin National Park and Cap Blanc).

The Banc d'Arguin National Park was provided with decision-making and governance tools in 1993 through the creation of a Board of Directors, a Scientific Council and a public, scientific, cultural or professional establishment. Since 2000, the park has implemented one specific law (2000-024) that strengthens its national and international recognition, as well as its political and territorial weight. The Cap Blanc Reserve was created by Decree No. 86-060 of 2 April 1986 and falls under the institutional supervision of the Banc d'Arguin National Park, therefore making it an integral part of the park.

In the baie de l'Étoile, conservation initiatives were formally established in 2010 with the creation of the Orientation and Monitoring Commission of the Directive for the Development of the Coastline of the Baie de l'Étoile under Joint Order No. 2346. A multi-use MPA development and management plan for the baie de l'Étoile was developed and proposed in 2013, with a scientific report on the study of the bay prepared by IMROP and IUCN in January 2014. A feasibility study for the classification of the bay has also been initiated recently (Taleb Sidi 2020).

Field monitoring team in the baie de l'Étoile. Photo: Mohamed Ahmed Sidi Cheikh 2022

There is significant potential for Mauritania to recognize the value of seagrass meadows and their ability to sequester carbon by incorporating seagrasses into the country's NDC. According to UNESCO's 2020 marine World Heritage report, the overall contribution of the Banc d'Arguin National Park's seagrasses to blue carbon reserves is estimated to be 109 million megagrams of carbon (Mg C). Compared with all UNESCO sites globally, this makes the Banc d'Arguin National Park the third-largest site for seagrass carbon stocks, just behind the Everglades National Park in the United States of America (295 million Mg C) and the Great Barrier Reef in Australia (404 million Mg C) (United Nations Educational, Scientific and Cultural Organization [UNESCO] 2020).

In 2018, a multidisciplinary team from the University of Portsmouth carried out an initial assessment of the ecosystem services of the Banc d'Arguin, particularly the amount of carbon stored in the park's seagrass beds, not including carbon stored in sediments. According to the results of this assessment, the share of carbon dioxide (CO_2) sequestered by the park's marine ecosystems in 2020–2030 is expected to reach 7.3 megatons of CO_2 equivalent (MT CO_2eq), which is 22 per cent of the total avoided greenhouse gas emissions referred to in the Paris Agreement (Trégarot *et al.* 2019). Thus, there is immense policy potential for Mauritania to protect seagrass meadows while furthering its climate mitigation goals.

Moving forward, the NIT has prepared a study relating to the analysis of the institutional and regulatory framework on the conservation of marine and coastal biodiversity in Mauritania, specifically seagrasses. The study proposes an action plan for the consideration of seagrass conservation in national policies and regulations.

Cabo Verde

The conservation of seagrass meadows can play a significant role in preserving Cabo Verde's rich biodiversity and coasts, and is therefore part of the country's international commitment to preserve biological diversity (Convention on Biological Diversity). Cabo Verde currently has 46 protected areas and three marine managed areas.

Seagrass beds were first recorded in the country in 2015, based on research carried out around Santiago Island (Creed *et al.* 2016). Once Cabo Verdean policymakers became aware of

Monitoring subtidal seagrass in Gamboa, Santiago Island. Photo: Seydouba Soumah 2020

the existence of seagrasses within the country, seagrass beds were explicitly incorporated into the country's updated NDC made in 2021. Given that just a few other nations worldwide have incorporated seagrass meadows into their NDCs, this effort represents leadership and commitment to protect Cabo Verde's natural biodiversity.

Senegal

Senegal is a signatory to numerous conventions developed within the framework of the sustainable management of natural resources (Convention on Biological Diversity). In this context, a marine and coastal resource management policy has been developed at the national level, which has led to the creation of national parks, MPAs and nature reserves. These conservation sites are subject to management rules aimed at ensuring the sustainability of resources. The largest areas of seagrass meadows identified to date are located in protected areas, and therefore benefit from the numerous restrictions of regulations that apply to the site in question.

Field team monitoring shallow seagrasses in the Saloum Delta National Park. Photo: Senegal national implementation team 2020

Gambia

Successive governments have made considerable commitments and implemented initiatives to preserve Gambia's unique environment. In total, eight reserves, representing 4.27 per cent of Gambia's territory, aim to protect biodiversity and improve climate change resilience. Several national programmes (e.g. the National Adaptation Programme for Action) and international commitments (e.g. the UNFCCC) support this. Considering the importance of marine and coastal ecosystems, specific policies and management are needed, including for the protection of seagrasses, which remain largely unexplored and unprotected.

However, one policy milestone achieved in 2020–2021 was the successful integration of seagrass protection and conservation into the management plans of the Tanji River (Karinti) Bird Reserve and draft Wildlife Act of 2020, which is currently in the process of being enacted by the National Assembly. Thanks to the ResilienSEA project, the Gunjur Community Wildlife Reserve has also extended its patrols to seagrass sites in Gunjur. The NIT is working towards having seagrass sites in Gunjur and Kartong included in two newly proposed MPAs.

Seagrass restoration efforts are also under way in Gambia, thanks to a partnership between the country's Department of Parks and Wildlife Management, Alma and the Eduardo Mondlane University in Maputo, Mozambique (see Box 4 on page 47 for more information).

In terms of building local awareness on seagrasses, the Gambia NIT has worked to increase knowledge and communication efforts by implementing a communication, education and public-awareness strategy. Activities within this strategy include training workshops to strengthen the capacity of park managers, local communities, stakeholder institutions, fishers and fishers' associations and civil society organizations, as well as other influential individuals in the pilot site communities. The workshops held to date have immensely enhanced the skills and knowledge of the participants in seagrass sciences, management and conservation.

The NIT also organized a similar training workshop for university and college students to introduce them to seagrass sciences with the goal of developing their interests in this field to write a thesis on topic. Public awareness is also targeted through the

Community outreach through a local radio station. Photo: Gambia national implementation team 2021

communication, education and public-awareness strategy and its community-outreach efforts, which include participating in community radio talk shows and distributing posters, T-shirts, flyers and banners, among other products geared towards strengthening seagrass awareness and communication throughout the country.

Guinea-Bissau

As part of Guinea-Bissau's commitment to preserving biological diversity and developing resilience actions in the face of climate change (through the Convention on Biological Diversity and the UNFCCC), seagrass conservation is of crucial importance.

The Government of Guinea-Bissau already has a set of frameworks that can contribute to this goal, including the Environmental Management Plan (2004), the National Strategy and Action Plan for Biodiversity and the National Action Plan for Adaptation to Climate Change. In 2021, fisheries legislation incorporated the conservation of seagrass meadows and macroalgae, specifically in the regulation of artisanal fisheries.

To date, Guinea-Bissau has eight protected areas, three of which are marine (João Vieira and Poilão Marine National Park, Orango National Park and the Urok Islands community MPA), as well as three coastal parks (Cacheu, Cantanhez and Lagoas de Cufada) and two terrestrial parks (Dulombi-Boé 1 and 2). It is important to note that the terrestrial parks are home to three animal corridors: Quebo-Cuntabane, Salifo-Xitole and Tchetche, each of which is a conservation unit. Considering the confirmed presence of seagrass meadows in Unhocomo and Unhocomozinho, there is potential for these islands to also become an MPA.

Subtidal seagrass field monitoring expedition. Photo: Guinea-Bissau national implementation team 2018

Guinea

Seagrass conservation is key to the country's environmental commitments. Similar to its neighbouring states, Guinea has signed the Convention on Biological Diversity, the UNFCCC and the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention). At the national level, the country has developed a set of frameworks that can contribute to the conservation of seagrasses, including the Code on the Protection and Highlight of the Environment, the National Action Plan for the Environment and the Strategy and Action Plan on Biological Diversity. To date, Guinea has four MPAs, with plans under way to introduce the protection of seagrass beds within its national MPA management plan.

Intertidal seagrass field monitoring expedition. Photo: Guinea national implementation team 2018

Sierra Leone

As part of Sierras Leone's commitment to preserve biological diversity and tackle climate change (through the Convention on Biological Diversity and the UNFCCC), seagrass conservation is of crucial importance. Sierra Leone has a set of laws and tools in place that can contribute towards this goal, which include the Fisheries and Aquaculture Act of 2018, the National Environmental Policy of 1995, the Environmental Protection Agency Act of 2008 and the National Protected Area Authority and Conservation Trust Fund Act of 2012.

As of 2021, Sierra Leone's updated NDC to the UNFCCC specifically mentions the importance of coastal ecosystems such as seagrass meadows and mangrove forests for the country's blue carbon stock and blue economy. In section 5.1 (mitigation contributions), the NDC notes that Sierra Leone, "will develop a blue carbon initiative for the Sierra Leone River and Bonthe-Sherbro River Estuaries to conserve vast mangrove and seagrass resources while sequestering tree and soil organic carbon" (Republic of Sierra Leone 2021). One component to this is the scaling of MPAs, with it acknowledged that there is a need to improve understanding of variability in the country's blue carbon stock in seagrasses and mangroves over time. The inclusion of seagrass meadows and blue carbon in Sierra Leone's NDC marks a significant step forward for the protection and monitoring of seagrasses. This accomplishment reflects the efforts made by the NIT, local communities and regional experts to increase the awareness of seagrass ecosystems in national policymaking spheres.

Within the Turtle Islands, one crucial component in furthering the protection and management of seagrasses has been increasing local awareness of seagrass meadows. Prior to the start of the ResilienSEA project, communities from the Turtle Islands were not familiar with the presence of seagrass meadows in their waters. In fact, most of the locals had not seen the seagrass meadows before nor heard of their importance to marine life. To increase local awareness of seagrasses, the NIT has conducted three outreach and awareness-raising programmes on Bumpetuk Island, as well as two radio programmes. The NIT plans to expand this outreach to Mania in 2022. Encouragingly, Bumpetuk locals have demonstrated that they are very keen to learn more about the protection and management of seagrass meadows, as well as the economic benefits they provide, with many having stated their willingness to help identify other potential sites in the future and to engage with local policy mechanisms to protect these areas.

Upon the discovery of a new seagrass site around Sei Island, the NIT carried out an informal community consultation about the value and importance of seagrass meadows and held an open discussion on issues such as community engagement on seagrass conservation and how a network on seagrasses could be built across the Turtle Islands archipelago. Community representatives and fisherfolk attended the meeting to discuss the unfolding discovery of seagrass meadows and the urgent need to manage the site. The discussion was not conclusive, but a management network group of some form is likely to follow. This is the first step in establishing an active dialogue between local users regarding seagrass management, community engagement and possible requirements by the community to reinforce the protection of sensitive sites around Sei.

Community-outreach meeting on Bumpetuk Island. Photo: Sierra Leone national implementation team 2021

Priority areas for further advancement

The ResilienSEA project has demonstrated that the pilot countries have the expertise and capacity to continue monitoring the distribution of seagrass meadows, so long as adequate funding and resources are made available in the medium to long term. Mapping and monitoring activities, as well as awareness-raising initiatives, have proven to be effective tools for advancing the conservation of seagrasses throughout West Africa. However, there is still considerable need for the region to further develop seagrass-specific policies within sectoral management plans, as well as to continue with monitoring and outreach activities.

NITs also overwhelmingly state the importance of strengthening seagrass awareness at multiple levels, not only to enhance education and knowledge among communities, but also among policymakers. For some countries, such as Mauritania, the goal of increasing awareness focuses on conveying information around localized threats to seagrasses, as well as further defining the ecosystem services they provide (e.g. carbon sequestration) to help others understand the value of these meadows.

According to the ResilienSEA NITs, there is a need for further research to confirm the presence of seagrass distributions in areas where meadows are thought to exist but that are yet to be verified on the ground. It is also a priority for NITs to continue developing conservation tools, such as marine spatial planning (MSP) and ecological and biologically significant areas, to strengthen regulatory and legislative measures for the protection of seagrass meadows. Revised management plans and more specific regulations are needed for existing MPAs where seagrass meadows have been found. In some cases, particularly Gambia, there is interest in activities to restore degraded or lost seagrass populations, though given the expense and current low success rate of seagrass restoration, managers should always prioritize the protection and conservation of existing meadows. A future focus could be on supporting transboundary efforts, such as between Guinea and Guinea-Bissau, which would allow for common management and monitoring strategies to be in place where possible.

Within the wider Abidjan Convention region, several countries have already expressed interest in determining and mapping the extent of seagrasses in their waters. Expanding the ResilienSEA framework to more countries would allow for a consistent approach throughout the region, creating an opportunity for current NITs to act as mentors and trainers. It could also create political support for a regional protocol on seagrasses to help support and guide countries in their work. Most importantly, a regional effort would continue to ensure that seagrass meadows continue to grow in West Africa. The ResilienSEA project has been instrumental in filling a knowledge gap and sharing the extent and wonders of seagrasses in the region with the international community. It is essential that this dialogue continues and that the West African seagrass map continues to expand.

Photo: Rob Barnes 2019

Photo: Dimitris Poursanidis 2013

References

Amuzu, J., Jallow, B.P., Kabo-bah, A.T. and Yaffa, S. (2018). The socio-economic impact of climate change on the coastal zone of the Gambia. *Natural Resource Conservation* 6(1), 13-26.

Baez, S. (2022). Seychelles' 'grass-roots' effort to name seagrass supports conservation effort, 28 March. Pew Trusts. https://www.pewtrusts.org/en/research-and-analysis/articles/2022/03/28/seychelles-grass-roots-effort-to-name-seagrass-supports-conservation-effort. Accessed 16 June 2022.

Borum, J., Duarte, C.M., Krause-Jensen, D. and Greve, T.M. (eds.) (2004). *European Seagrasses: An Introduction to Monitoring and Management*. The M&MS project.

Catry, P., Barbosa, C., Paris, B., Indjai, B., Almeida, A., Limoges, B. *et al.* (2010). Status, ecology, and conservation of sea turtles in Guinea-Bissau. *Chelonian Conservation and Biology* 8(2), 150-160.

Chefaoui RM, Duarte CM, Serrao EA (2018) Dramatic loss of seagrass habitat under projected climate change in the Mediterranean Sea. *Global Change Biology* 24:4919-4928, https://doi.org/10.1111/gcb.14401

Chefaoui, R.M., Duarte, C.M., Tavares, A.I., Frade, D.G., Sidi Cheikh, M.A., Ba, M.A. *et al.* (2021). Predicted regime shift in the seagrass ecosystem of the Gulf of Arguin driven by climate change. *Global Ecology and Conservation* 32, e01890.

Costanza, R., d'Arge, A., de Groot, R., Farber, S., Grasso, M. and Bruce, H. *et al.* (1997). The value of the world's ecosystem services and natural capital. *Natural* 387, 253-260.

Creed, J.C., Engelen, A.H., D'Oliveira, E.C., Bandeira, S. and Serrao, E.A. (2016). First record of seagrass in Cape Verde, eastern Atlantic. *Marine Biodiversity Records*, 9, 57.

de la Torre-Castro, M. and Rönnbäck, P. (2004). Links between humans and seagrasses—an example from tropical East Africa. *Ocean & Coastal Management* 47(7–8), 361-387.

Dewsbury, B.M., Bhat, M. and Fourqurean, J.W. (2016). A review of seagrass economic valuations: gaps and progress in valuation approaches. *Ecosystem Services* 18, 68-77.

Díaz-Abad, L., Bacco-Mannina, N., Madeira, F.M., Neiva, J., Aires, T., Serrao, E.A. *et al.* (2022). eDNA metabarcoding for diet analyses of green sea turtles (*Chelonia mydas*). *Marine Biology* 169(1), 1-12.

Duarte, C.M. (1991). Seagrass depth limits. *Aquatic Botany*, 40, 363-377.

Duarte, C.M., Losada, I.J., Hendriks, I.E., Mazarrasa, I. and Marbà, N. (2013). The role of coastal plant communities for climate change mitigation and adaptation. *Nature Climate Change* 3(11), 961-968.

Environmental Resources Management (ERM) (2013). *Etude d'Impact Environnemental du projet de production et de transport d'électricité à partir du gaz en Mauritanie*. Société de Production d'Electricité à partir du Gaz (SPEG).

El-Hacen, E.-H.M., Sidi Cheikh, M., Bouma, T.J., Olff, H. and Piersma, T. (2020). Long-term changes in seagrass and benthos at Banc d'Arguin, Mauritania, the premier intertidal system along the East Atlantic Flyway. *Global Ecology and Conservation* 24, e01364.

Gomez, M.L.A., Adelegan, O.J., Ntajal, J. and Trawally, D. (2020). Vulnerability to coastal erosion in The Gambia: empirical experience from Gunjur. *International Journal of Disaster Risk Reduction* 45, 2212-4209.

Goudie, A.S. and Middleton, N.J. (2001). Saharan dust storms: nature and consequences. *Earth-Science Reviews* 56(1–4), 179-204.

Green, E.P. and Short, F.T. (2003). *World Atlas of Seagrasses*. Berkeley, California: University California Press.

GSE (2021). *Etude d'impact Environnemental et Social du Projet TGS de Prospection (Campagne Sismique, Mbes, Carottage) en Zee-mauritanienne*. Nouakchott: TGS.

Hartog, C.D. and Kuo, J. (2006). Taxonomy and biogeography of seagrasses. In *Seagrasses: Biology, Ecology and Conservation*. Larkum, A.W.D., Orth, R.J. and Duarte, C.M. (eds.). Dordrecht, The Netherlands: Springer. 1-23.

Heithaus, M.R., Alcoverro, T., Arthur, R., Burkholder, D.A., Coates, K.A., Christianen, M.J.A. *et al.* (2014). Seagrasses in the age of sea turtle conservation and shark overfishing. *Frontiers in Marine Science* 1, 28.

Hemminga, M.A. and Duarte, C.M. (2000). *Seagrass Ecology*. Cambridge, United Kingdom: Cambridge University Press.

Hemminga, M.A. and Nieuwenhuize, J. (1990). Seagrass wrack-induced dune formation on a tropical coast (Banc d'Arguin, Mauritania). *Estuarine, Coastal and Shelf Science* 31(4), 499-502.

International Union for Conservation of Nature (IUCN) (2020). Banc d'Arguin National Park – 2020 conservation outlook assessment. https://worldheritageoutlook.iucn.org/node/1036/pdf?year=2020. Accessed 16 June 2022.

IPCC (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

James, R.K., Silva, R., van Tussenbroek, B.I., Escudero-Castillo, M., Mariño-Tapia, I., Dijkstra, H.A. *et al.* (2019). Maintaining tropical beaches with seagrass and algae: a promising alternative to engineering solutions. *BioScience* 69(2), 136-142.

Keith-Diagne, L. (2014). Phylogenetics and feeding ecology of the African manatee, *Trichechus senegalensis*. Doctoral dissertation. University of Florida.

Komma, L. (2019). Towards implementing integrated coastal zone management in the Gambia: coastal adaptation to climate change and human impacts in the high risk zone (cell 6). Dissertation. World Maritime University.

Ly, A. (2009). Fonctionnement ecologique et evolution du contexte socio-économique de la baie de l'Etoile : une contribution à l'aménagement du littoral mauritanien et au développement d'un réseau d'aires marines protégées en Afrique de l'Ouest. Thesis. French National Museum of Natural History.

Marbà, N., Krause-Jensen, D., Alcoverro, T., Birk, S., Pedersen, A., Neto, J.M. *et al.* (2013). Diversity of European seagrass indicators: patterns within and across regions. *Hydrobiologia* 704(1), 265-278.

Martinez-Garrido J, Creed J, Martins S, Almada CH, Serrao EA (2017) First record of *Ruppia maritima* in West Africa supported by morphological description and phylogenetic classification. Botanica Marina DOI: https://doi.org/10.1515/bot-2016-0128

McKenzie, L.J. (2003). *Guidelines for the Rapid Assessment and Mapping of Tropical Seagrass Habitats*. Queensland, Australia: Department of Primary Industries.

Nordlund, L.M., Koch, E.W., Barbier, E.B. and Creed, J.C. (2017). Correction: Seagrass ecosystem services and their variability across genera and geographical regions. *PLOS ONE* 12(1), e0169942.

Nordlund, L.M., Erlandsson, J., de la Torre-Castro, M. and Jiddawi, N. (2010). Changes in an East African social-ecological seagrass system: invertebrate harvesting affecting species composition and local livelihood. *Aquatic Living Resources* 23(4), 399-416.

Ondiviela, B., Losada, I.J., Lara, J.L., Maza, M., Galván, C., Bouma, T.J., and van Belzen, J. (2014). The role of seagrasses in coastal protection in a changing climate. *Coastal Engineering* 87, 158-168.

Orth, R.J., Carruthers, T.J.B., Dennison, W.C., Duarte, C.M., Fourqurean, J.W., Heck, K.L. *et al.* (2006). A global crisis for seagrass ecosystems. *BioScience* 56(12), 987-996.

Potouroglou, M., Bull, J.C., Krauss, K.W., Kennedy, H.A., Fusi, M., Daffonchio, D. *et al.* (2017). Measuring the role of seagrasses in regulating sediment surface elevation. *Scientific Reports* 7, 11917.

Republic of Senegal, Ministry of the Environment and Sustainable Development (2015). *National Biodiversity Strategic Action Plan*.

Republic of Sierra Leone (2021). *Updated Nationally Determined Contribution (NDC)*. https://unfccc.int/sites/default/files/NDC/2022-06/210804%202125%20SL%20NDC%20%281%29.pdf.

Scott, L.C., Boland, J.W., Edyvane, K.S. and Jones, G.K. (2000). Development of a seagrass–fish habitat model—I: A Seagrass Residency Index for economically important species. *Environmetrics*, 11, 541-552.

Semelin, J. (2020). Participatory seagrass mapping for biodiversity conservation and sustainable fisheries, 9 November. https://panorama.solutions/en/solution/participatory-seagrass-mapping-biodiversity-conservation-and-sustainable-fisheries. Accessed 16 June 2022.

Short, F., Carruthers, T., Dennison, W. and Waycott, M. (2007). Global seagrass distribution and diversity: a bioregional model. *Journal of Experimental Marine Biology and Ecology* 350(1), 3-20.

Sidi Cheikh, M.A.; Bandeira, S.; Dimosthenis, T.; Poursanidis, D; Vegh, T; Soumah, S.; Diouf, G, Diouf E, Cardoso N,; Kujabie, A,; Ndure, M,; John L.; Moreira L,; Radwan Z., Santos, I,; Ceesay, A.; Vinaccia, M.; Potouroglou, M. (2022). Seagrasses of West Africa: new discoveries, distribution limits, ecosystem services and prospectus for management. [Manuscript submitted for publication]. *Diversity* 2022, 14

Sievers, M., Brown, C.J., Tulloch, V.J.D., Pearson, R.M., Haig, J.A., Turschwell, M.P. *et al.* (2019). The role of vegetated coastal wetlands for marine megafauna conservation. *Trends in Ecology & Evolution* 34(9), 807-817. https://doi.org/10.1016/j.tree.2019.04.004.

Soumah, S. (2021). Assessing the role of seagrasses as a socio-ecological system: a case study from Cape Verde (Gamboa Bay). Master's thesis. Institute of Engineering and Marine Sciences, Atlantic Technical University.

Taleb Ould Sidi, M. (2020). *Etude pour le classement de la baie de l'Etoile de Nouadhibou en reserve naturelle: aire marine protégée dénommée « Reserve Naturelle de la Baie de l'Etoile-RNBE »*. Ministry of Environment and Sustainable Development.

Tavares AI, Assis J, Patricio R, Ferreira R, Cheikh MA, Bandeira S, Regalla A, Santos I, Potouroglou M, Nicolau S, Teodosio MA, Almada C, Santos RO, Pearson GA, Serrao EA (2022) Seagrass connectivity on the west coast of Africa supports the hypothesis of grazer-mediated seed dispersal. Front. Mar. Sci., 06 , https://doi.org/10.3389/fmars.2022.809721

Trégarot, E., Catry, T., Pottier, A., Cornet, C., Maréchal, J.-P., Fayad, V. *et al.* (2019). Évaluation des services écosystémiques du Banc d'Arguin, Mauritanie : rapport final.

Trégarot, E., Meissa, B., Gascuel, D., Sarr, O., El Valy, Y., Wagne, O.H. *et al.* (2020). The role of marine protected areas in sustaining fisheries: The case of the National Park of Banc d'Arguin, Mauritania. *Aquaculture and Fisheries* 5(5), 253-264.

Trégarot, E., Catry, T., Pottier, A., El-Hacen, E.-H.M., Sidi Cheikh, M.A., Cornet, C.C. *et al.* (2021). Coastal protection assessment: a tradeoff between ecological, social, and economic issues. *Ecosphere* 12(2), e03364.

Turschwell, M.P., Connolly, R.M., Dunic, J.C., Sievers, M., Buelow, C.A., Pearson, R.M. *et al.* (2021). Anthropogenic pressures and life history predict trajectories of seagrass meadow extent at a global scale. *Proceedings of the National Academy of Sciences* 118(45), e2110802118.

Tuya F, Haroun R, Espino F. 2014. Economic assessment of ecosystem services: monetary value of seagrass meadows for coastal fisheries. *Ocean & coastal management*. 96:181–187.

United Nations Educational, Scientific and Cultural Organization (UNESCO) (2020). *UNESCO Marine World Heritage: Custodians of the Globe's Blue Carbon Assets*. Paris.

United Nations Environment Programme (UNEP) (2020). *Out of the Blue: The Value of Seagrasses to the Environment and to People*. Nairobi.

Unsworth, R.K.F., Nordlund, L.M. and Cullen-Unsworth, L.C. (2019). Seagrass meadows support global fisheries production. *Conservation Letters* 12(1), e12566.

van der Laan, B.B.P.A. and Wolff, W. (2006). Circular pools in the seagrass beds of the Banc d'Arguin, Mauritania, and their possible origin. *Aquatic Botany* 84(2), 93-100.

van Lent, F., Nienhuis, P.H. and Verschuure, J.M. (1991). Production and biomass of the seagrasses *Zostera noltii* Hornem. and *Cymodocea nodosa* (Ucria) Aschers. at the Banc d'Arguin (Mauritania, NW Africa): a preliminary approach. Aquatic Botany 41(4), 353–367.

Vegh, T. and Potouroglou, M. (eds.) (no date). *High Level Assessment of Seagrass Ecosystem Services in Western Africa: Perception of Stakeholders*. ResilienSEA. https://gridarendal-website-live.s3.amazonaws.com/production/documents/:s_document/519/original/High_Level_Assessment_of_Seagrass_Ecosystem_Services_in_Western_Africa.pdf?1573043035.

Vermaat, J.E., Beijer, J.A.J., Gijlstra, R., Hootsmans, M.J.M., Philippart, C.J.M., van der Brink, N.W. *et al.* (1993). Leaf dynamics and standing stocks of intertidal *Zostera noltii* Hornem. and *Cymodocea nodosa* (Ucria) Ascherson on the Banc d'Arguin (Mauritania). *Hydrobiologia* 258, 59-72.

Vousdoukas, M.I., Ranasinghe, R., Mentaschi, L. *et al.* (2020). Sandy coastlines under threat of erosion. Nat. Clim. Chang. 10, 260–263 https://doi.org/10.1038/s41558-020-0697-0

Yarba, L.O. (2021). Participatory maritime surveillance within the Banc d'Arguin National Park, 7 January. https://panorama.solutions/en/solution/participatory-maritime-surveillance-within-banc-darguin-national-park-0. Accessed 16 June 2022.

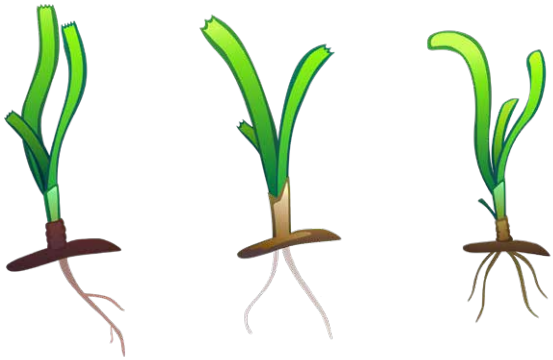


Photo: Rob Barnes 2019

Seagrasses are vital components of the planet's coastal and marine ecosystems. As we begin to realise their full value, from being carbon sinks to young fish refugia and first line defenders of our coasts, ever-greater efforts are being made to protect what remains and to restore what has been degraded or lost.

But all these efforts can only be effective if we know where seagrasses are and when people are equipped with the tools to safeguard these critical ecosystems. West Africa had historically been the least-studied region in seagrass science, and this is the reason why the project ResilienSEA (short for Resilient Seagrasses) was initiated in 2018. The ultimate goal and motto was to put 'West Africa on the global seagrass map'. Now four years after, we couldn't be prouder of what the people of ResilienSEA have achieved.

Photo: Rob Barnes 2019

ResilienSEA

MAVA
FONDATION POUR LA NATURE