Seagrass restoration in practice: methods, challenges and lessons from the field

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EMB ECOP Wednesdays
Online webinar

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European MARINE BOARD
Advancing Seas & Ocean Science

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MaReS-grass
Mapping, Restoring and Sharing Seagrass Meadows in Portugal

"la Caixa" Foundation

UAlg
UNIVERSIDADE DO ALGARVE

CCMAR
Centro de Ciências do Mar
Algarve

YOUTH4 OCEAN

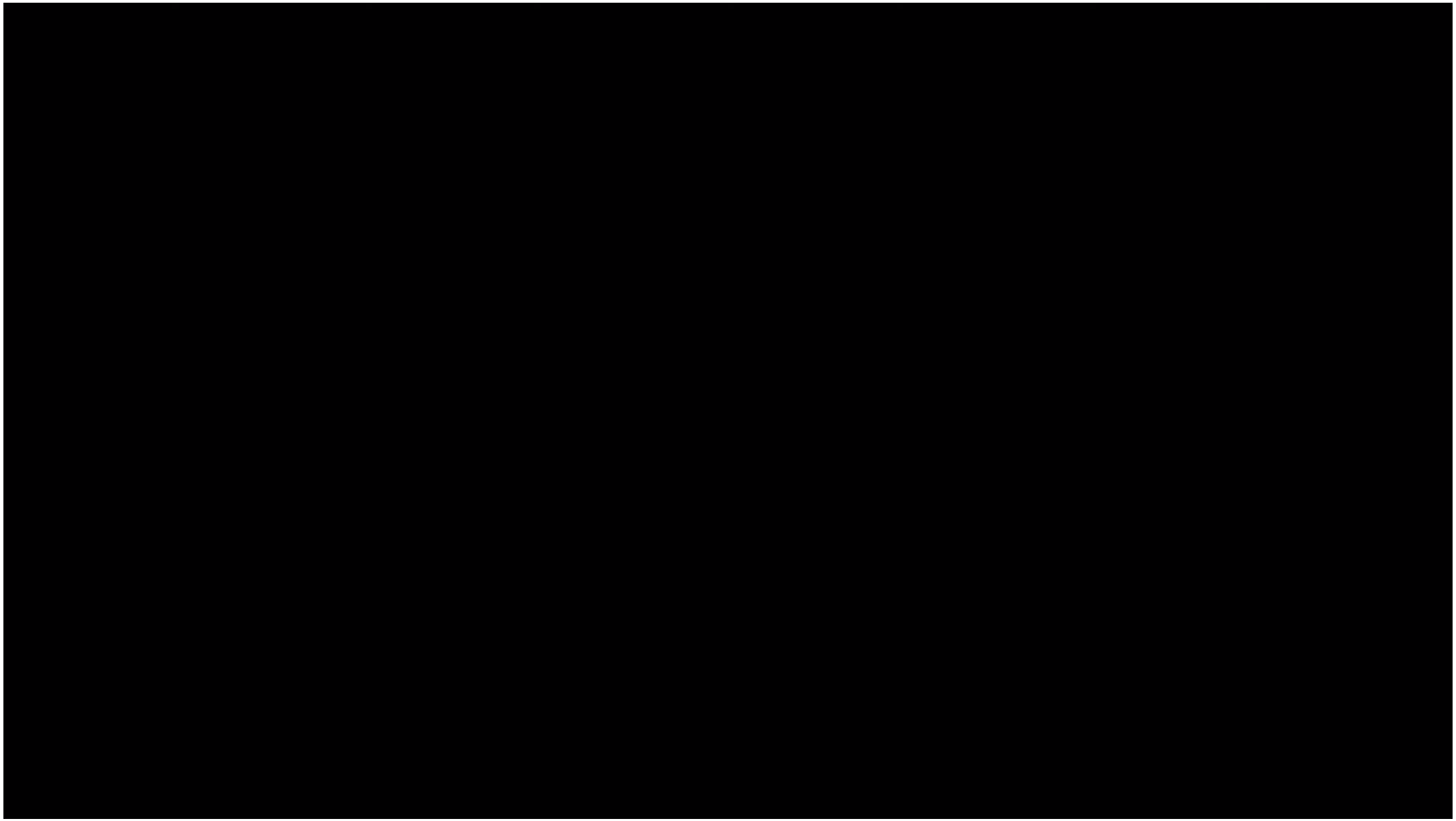
CCMAR
SCIENTIFIC DIVE CENTER

MMEB
Marine Microbial Ecology & Biotechnology

RESTORE SEAGRASS

Life

NATURA 2000

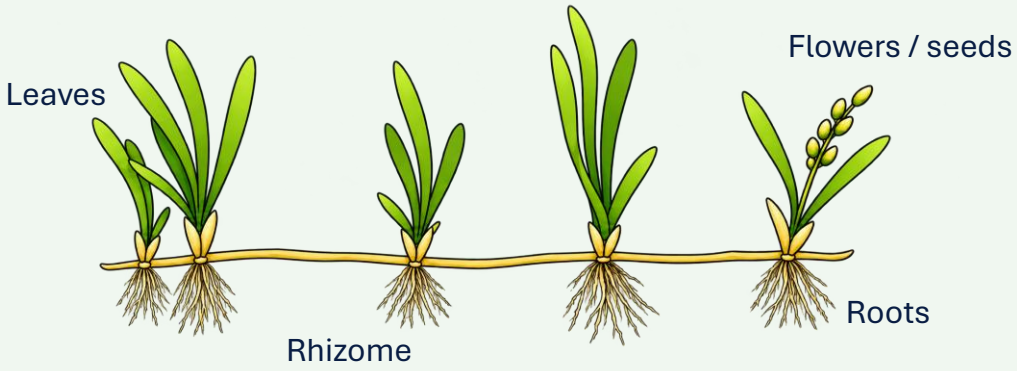


Full “Lungs of the Ocean” documentary: https://www.youtube.com/watch?v=NAEbD0fmtWM&list=PLEdlFXiU-H3dfxsouflEnDfUFd-hoXiQL

Seagrasses are not seaweeds or algae

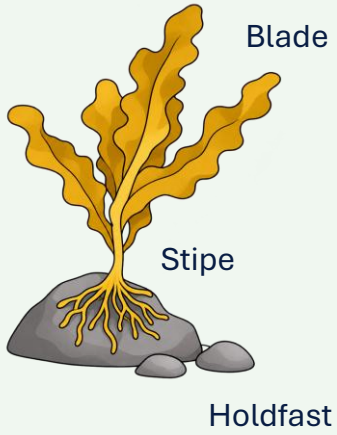
Seagrasses

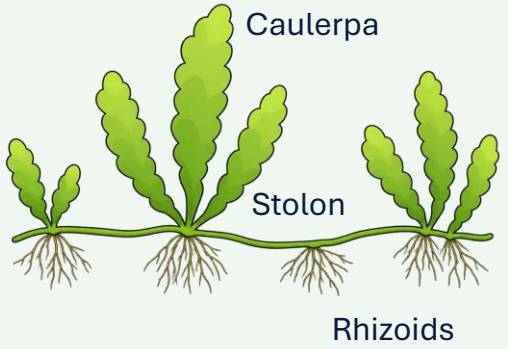
- Marine flowering plants
- Grow in sand or mud in shallow coastal waters
- True roots anchor plants in sediment
- Take up nutrients through roots and leaves
- Reproduce through flowers, seeds and rhizome growth



Seaweeds / Algae

- Grow on rocks, in sediment, or float
- Holdfasts or rhizoids anchor them; no true roots
- Take up nutrients across their surface
- Reproduce through spores or fragmentation

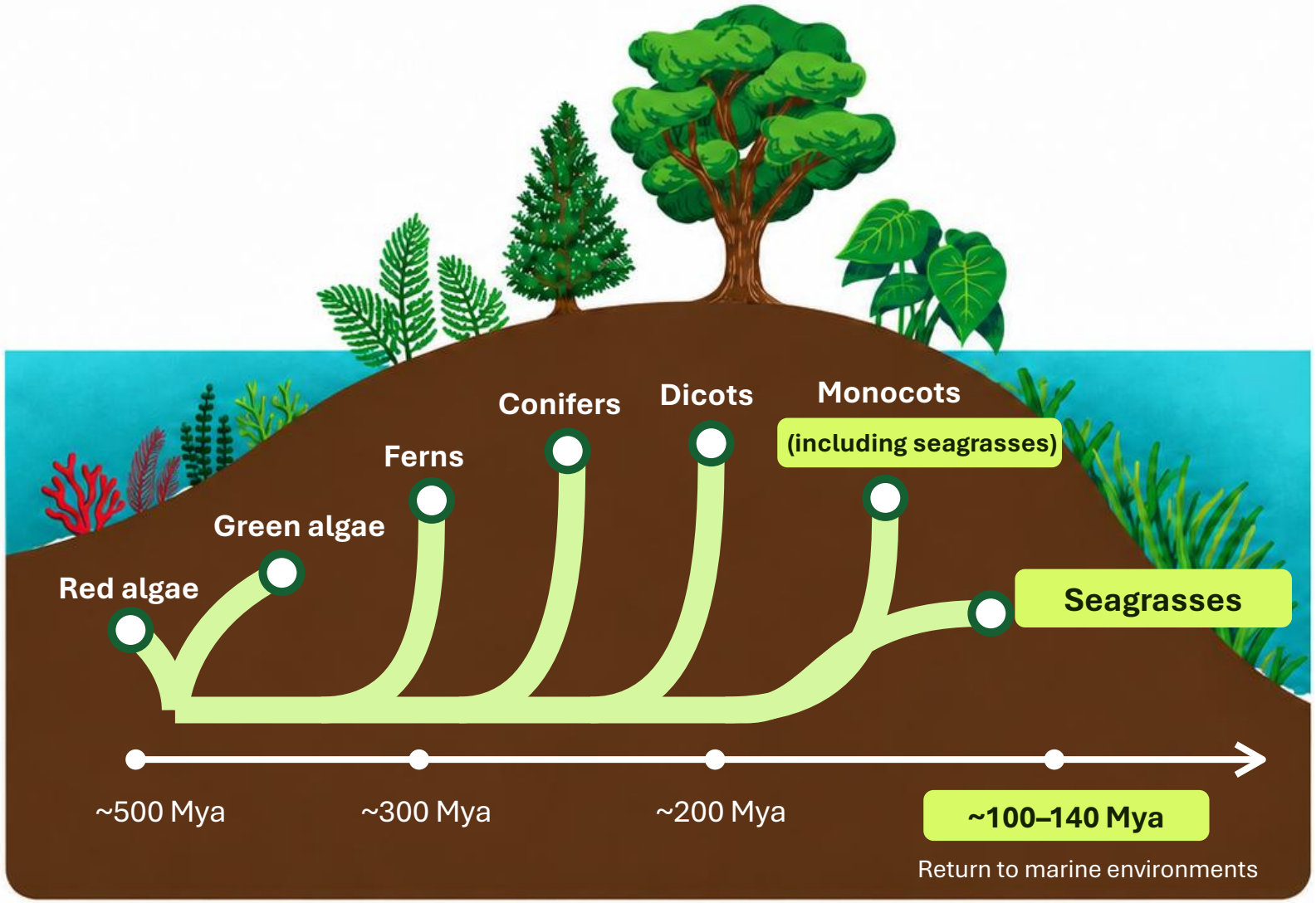






Miley Cyrus - Flowers

Seagrasses returned to the sea



Marine flowering vascular plants (angiosperms)

Belonging to the monocot order *Alismatales*

Returned to the oceans during the Cretaceous, approximately

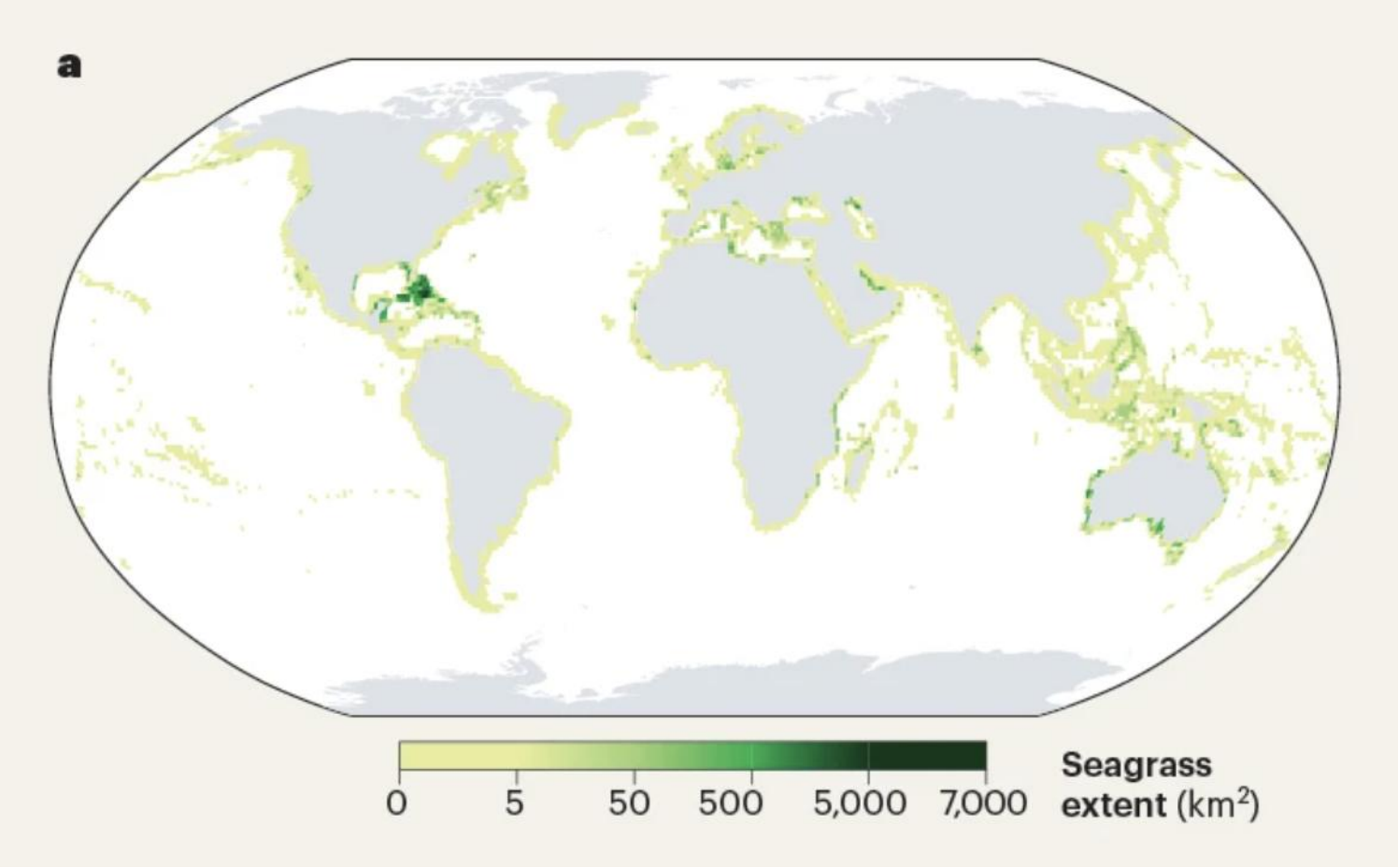
100-140 million years ago

Evolved independently

at least 3 times

in different plant lineages

Seagrasses are found in every continent apart from Antarctica



(Nature, Peng et al. 2026)

69% seagrass area concentrated in The Bahamas, Cuba, USA, Australia & Indonesia

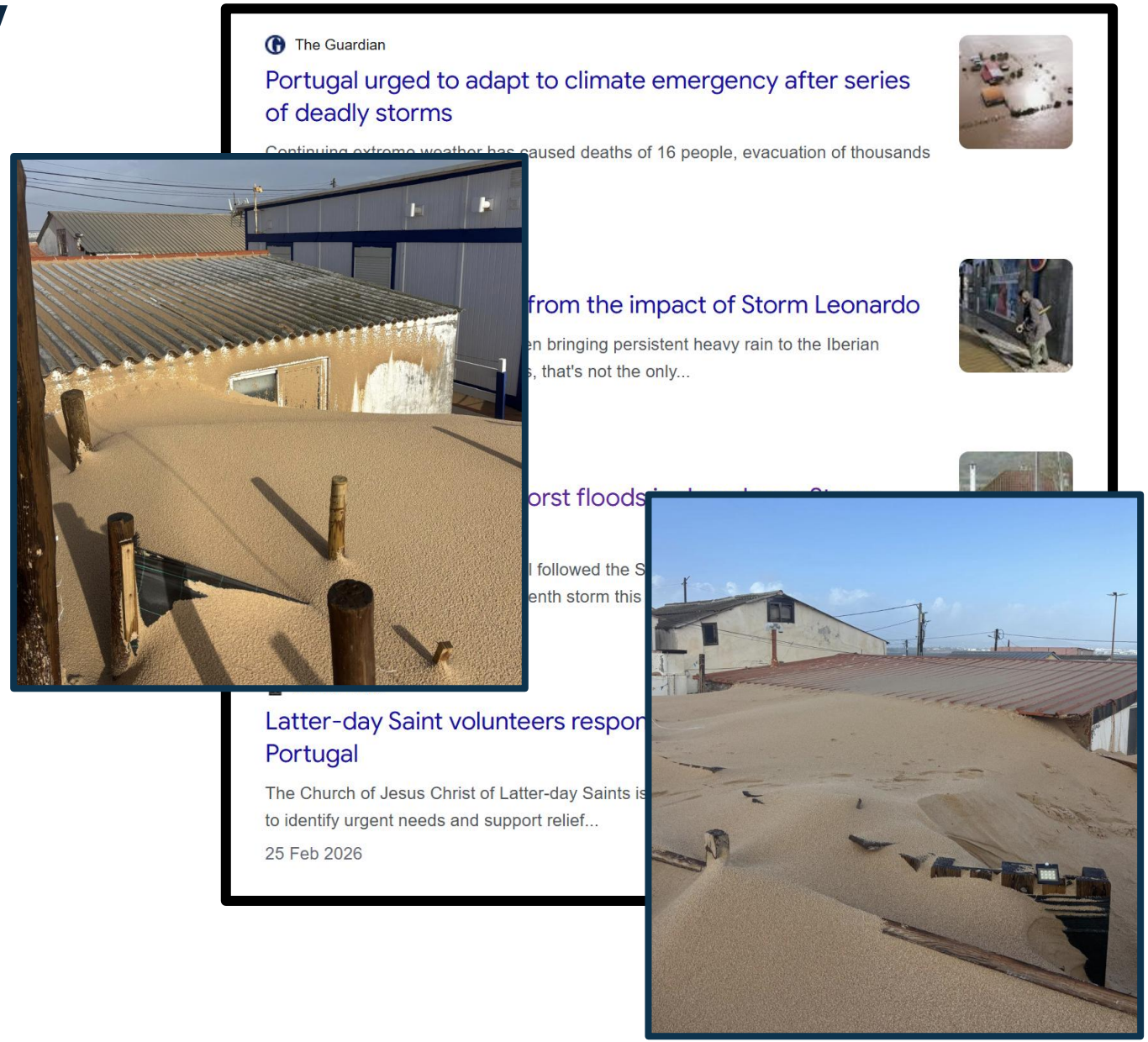
21% of seagrass are within marine protected areas

Seagrass meadows are **important marine ecosystems**

- Biodiversity support
- Fisheries support
- Food security
- Climate regulation – carbon storage
- Water quality enhancement
- Human health & well-being
- Coastal protection
- Recreation & tourism
- Education & research

Seagrass loss and degradation is accelerating globally

- Dredging
- Fisheries
- Moorings & boating
- Diseases
- Coastal construction
- Increased storm pressures



Portugal is home to three main seagrass species





Cymodocea nodosa



Zostera marina



Nanozostera noltei (Syn. *Zostera noltei*)

Other seagrasses/ aquatic angiosperms

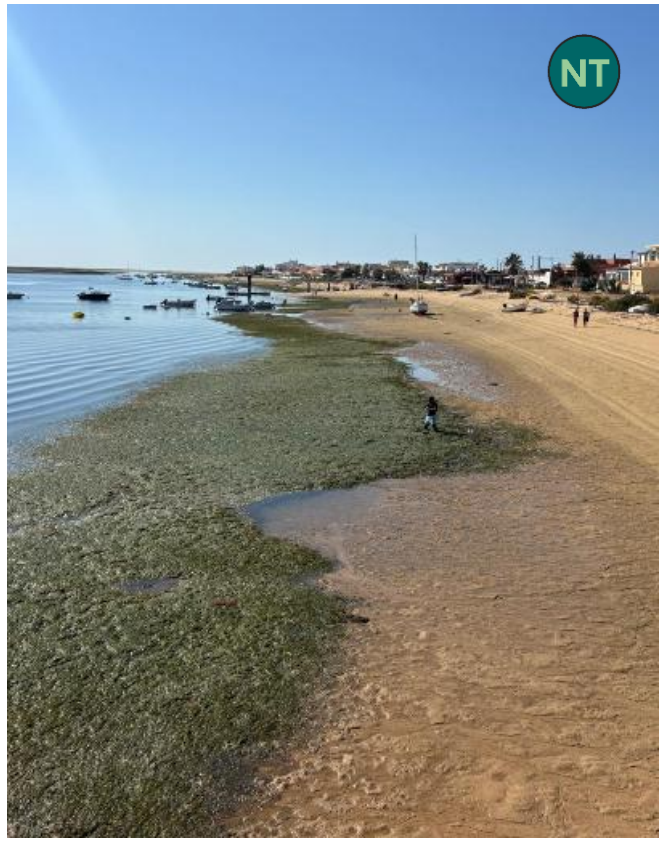
- *Ruppia martima*
- *Ruppia spiralis*
- *Ruppia drepanensis*
- *Athenia filiformis*



Cymodocea nodosa

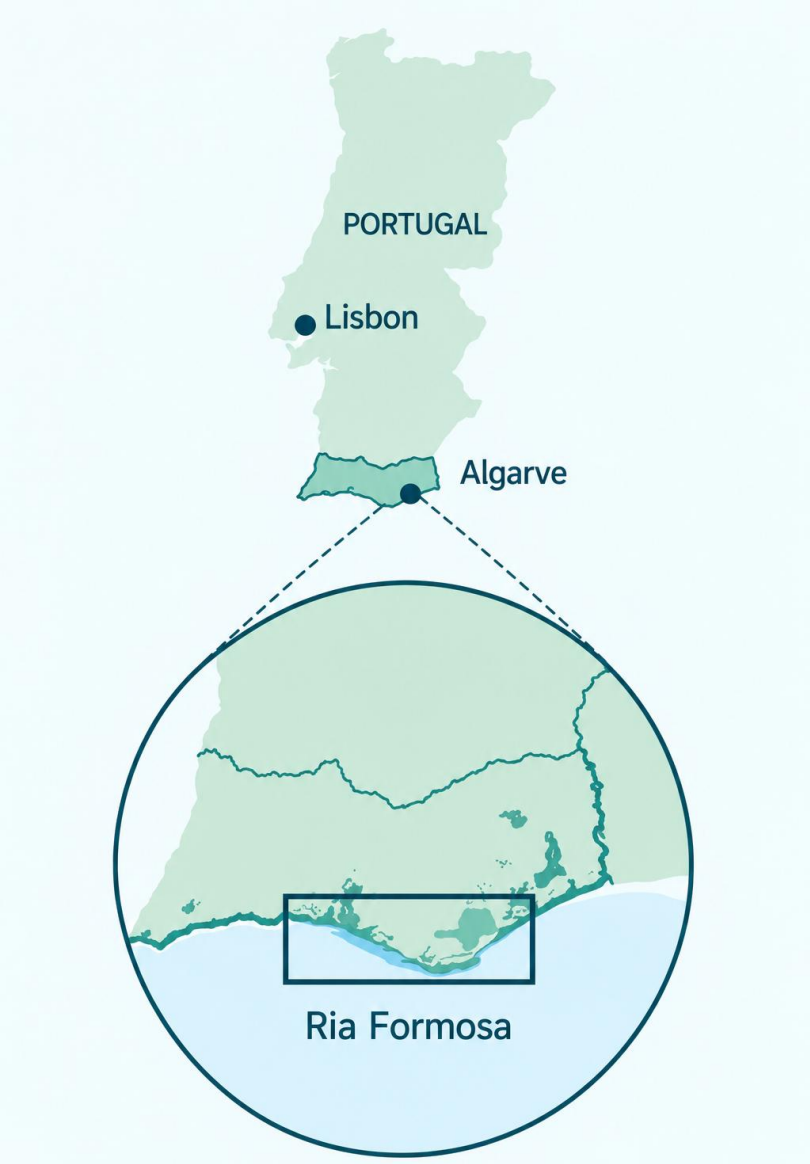


Zostera marina



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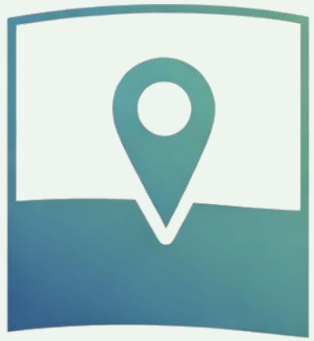
The Ria Formosa, the Algarve, southern Portugal





Ria Formosa coastal lagoonal system, Algarve, Pt

Protecting and restoring seagrass meadows



Map & monitor

Where are seagrasses, and how are they changing?



Protect & restore

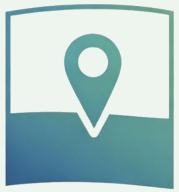
Reduce pressures and help degraded meadows recover



Engage people

Involve stakeholders & communities

Challenges in seagrass conservation & restoration



Knowledge gaps
Where are seagrasses, and what threatens them?

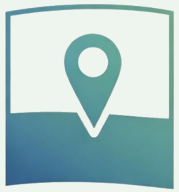


Restoration barriers
How can we restore seagrasses at scale?



Societal challenges
How do we ensure long-term conservation & restoration success?

Challenges in seagrass conservation & restoration



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Seagrass mapping: key challenges



Satellite imagery

- Wide spatial coverage (regional to national)
- But limited underwater visibility in **turbid & dynamic** waters
- Fewer usable images due to **cloud cover** & revisit intervals (e.g. ~5 days Sentinel-2)



Drone imagery

- High-resolution, fine-scale mapping (cm-dm)
- But require **alignment** of multiple **optimal conditions:**

Low tide
(shallow, clear water)

No cloud cover

Right sun angle
(minimal reflection)

Low wind
(stable flight & image quality)

→ All of these conditions are **challenging** to meet **simultaneously**

Turbidity is the main challenge in Portuguese coastal waters, requiring high-resolution, site-specific mapping with drones

Drone-mapping examples

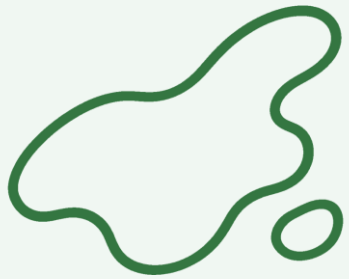


Drone-mapping requires ground-truthing



Mapping shows where seagrasses are; field surveys reveal their condition

Map spatial extent



Delineate the areal extent of seagrass meadows (e.g. satellite, drone or manual mapping)

Assess meadow condition & pressures

Field surveys reveal meadow health and the pressures acting on it.

Quadrats

(e.g. 0.25 m^2)

Photo-quadrats

(documented coverage)

Density

(shoots m^{-2})

Species

Z. marina, C. nodosa, N. noltei

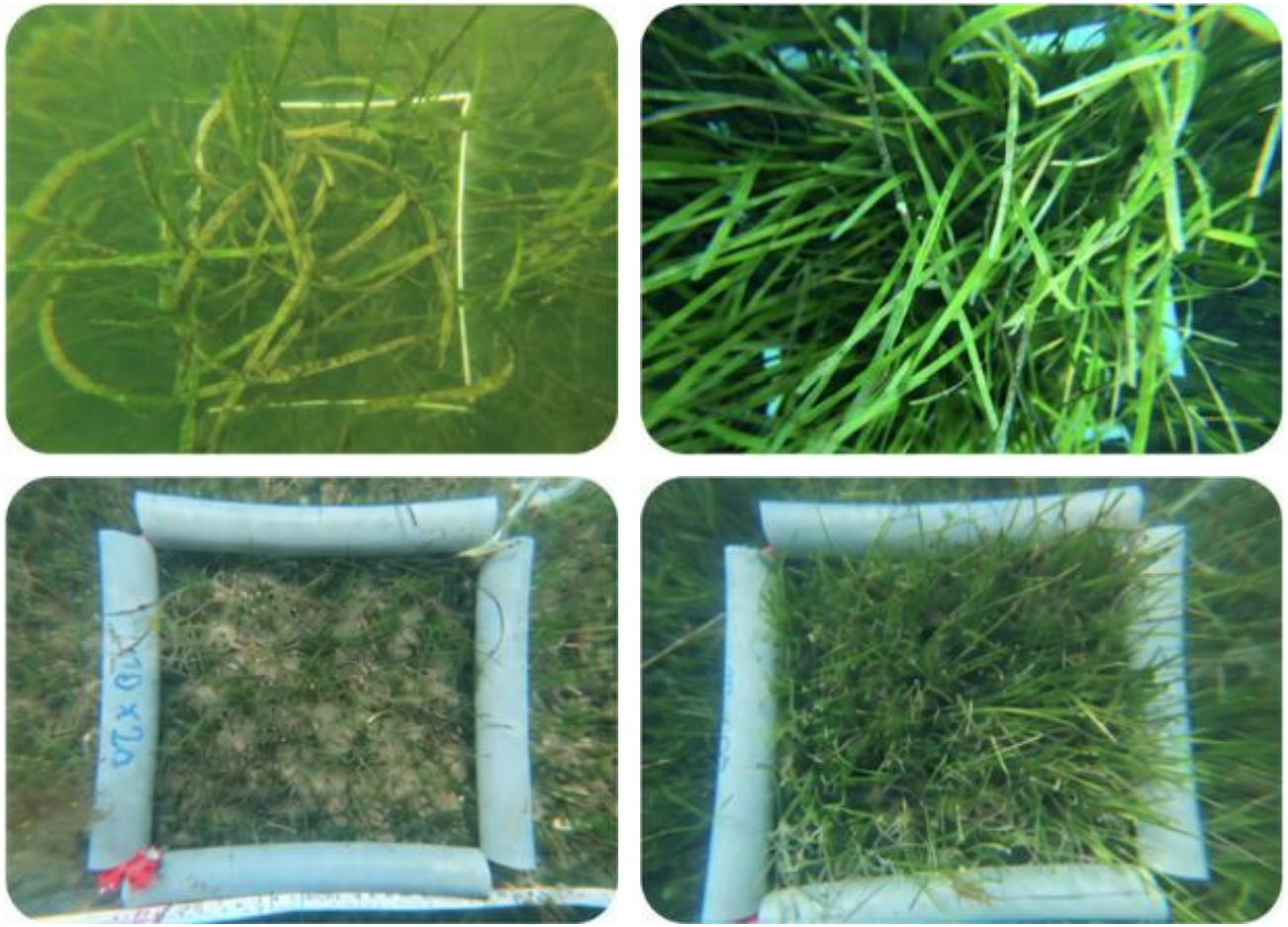
Threats & disturbances

(e.g. anchoring, invasive species, trash)

In restricted areas, such as near airports, drones cannot be used
➔ meadows must be mapped manually (e.g. diver + GPS above water)

Mapping shows where seagrasses are; field surveys reveal their condition

- **Go to a site**
- **Take quadrats** (e.g. 0.25 m^2)
- **Count density per species** (e.g. shoots m^{-2})
- **Write down in field notes** (e.g. species, condition, disturbances)
- **Take a picture per quadrat** (photo-quadrats)



Disturbance examples



Working with local authorities to protect seagrass habitats



N. noltii, *Z. marina & C. nodosa*, overlap seagrass with anchoring areas

Working with local authorities to protect seagrass habitats



N. noltei, *Z. marina & C. nodosa*, overlap seagrass with anchoring (proposed)

Protecting and restoring seagrass meadows



Map & monitor

Where are seagrasses, and how are they changing?



Protect & restore

Reduce pressures and help degraded meadows recover

Engage people

Involve stakeholders & communities

Challenges in seagrass conservation & restoration



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Societal challenges

How do we ensure long-term conservation & restoration success?

Seagrass restoration: key challenges



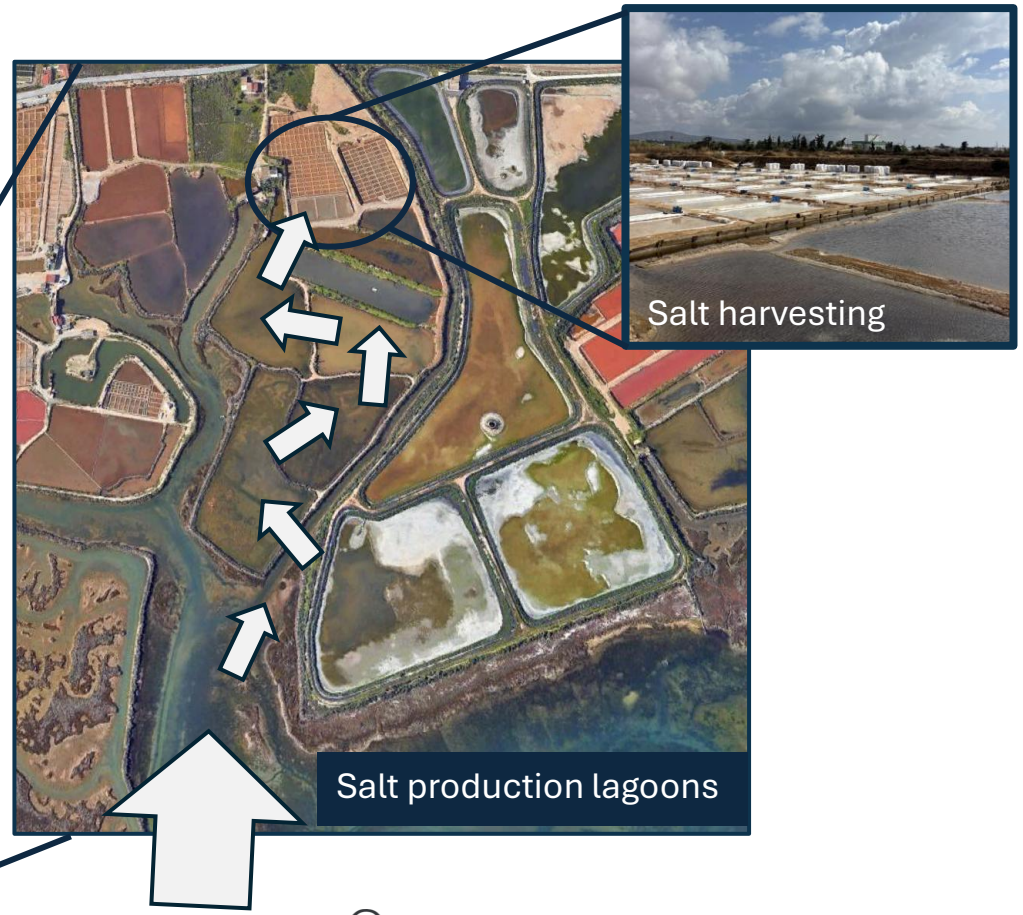
- Donor limitations
- Labour-intensive + difficult to scale
- Variable success

Need for scalable & reliable restoration methods

Can **salt-production lagoons** provide space for seagrass cultivation?

Ria formosa

→ Testing an alternative space for seagrass cultivation



necton, Olhão

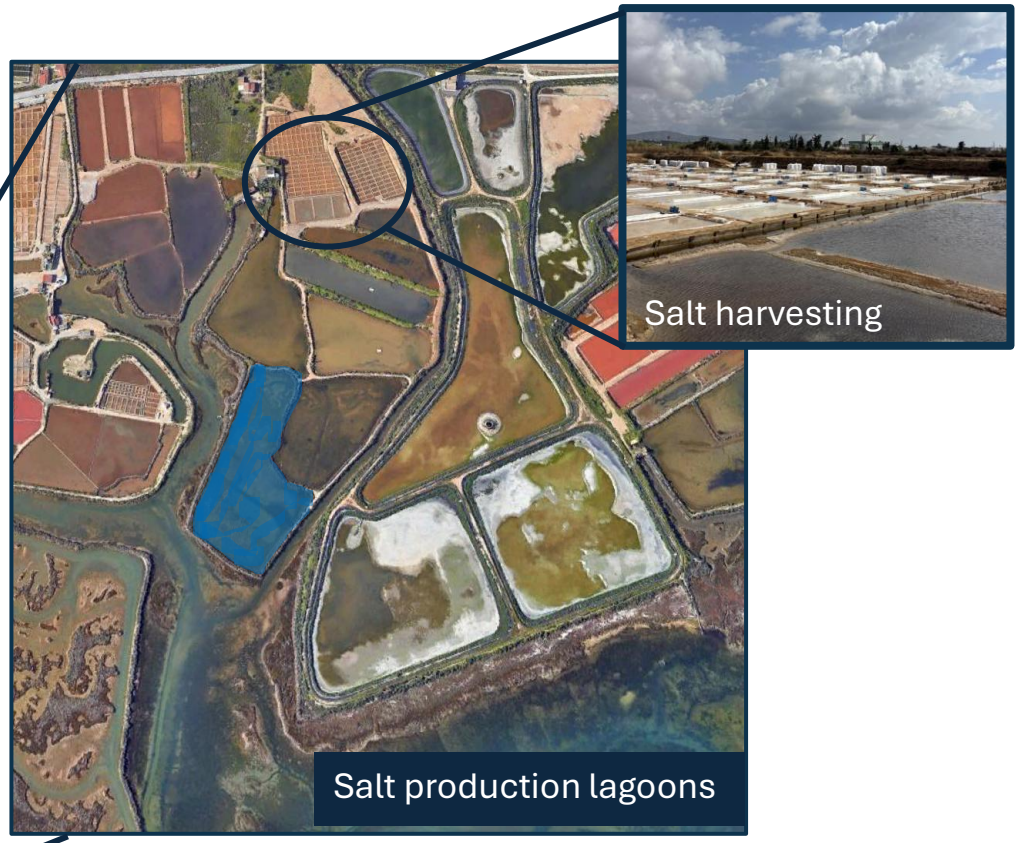
1.5 ha

Tidal influence
+ gate regulation every 2 weeks

Can **salt-production lagoons** provide space for seagrass cultivation?

Ria formosa

→ Testing an alternative space for seagrass cultivation



necton, Olhão

1.5 ha

Tidal influence
+ gate regulation every 2 weeks

Nursery performance was evaluated against reference and donor meadows

DONOR MEADOWS

Healthy seagrass meadows

Source material for transplantation



transplants

Compared with

NURSERY

Salt production lagoon

Experimental system where transplants are cultivated



Compared with

REFERENCE SYSTEM

Tidal lagoon with natural seagrass colonization

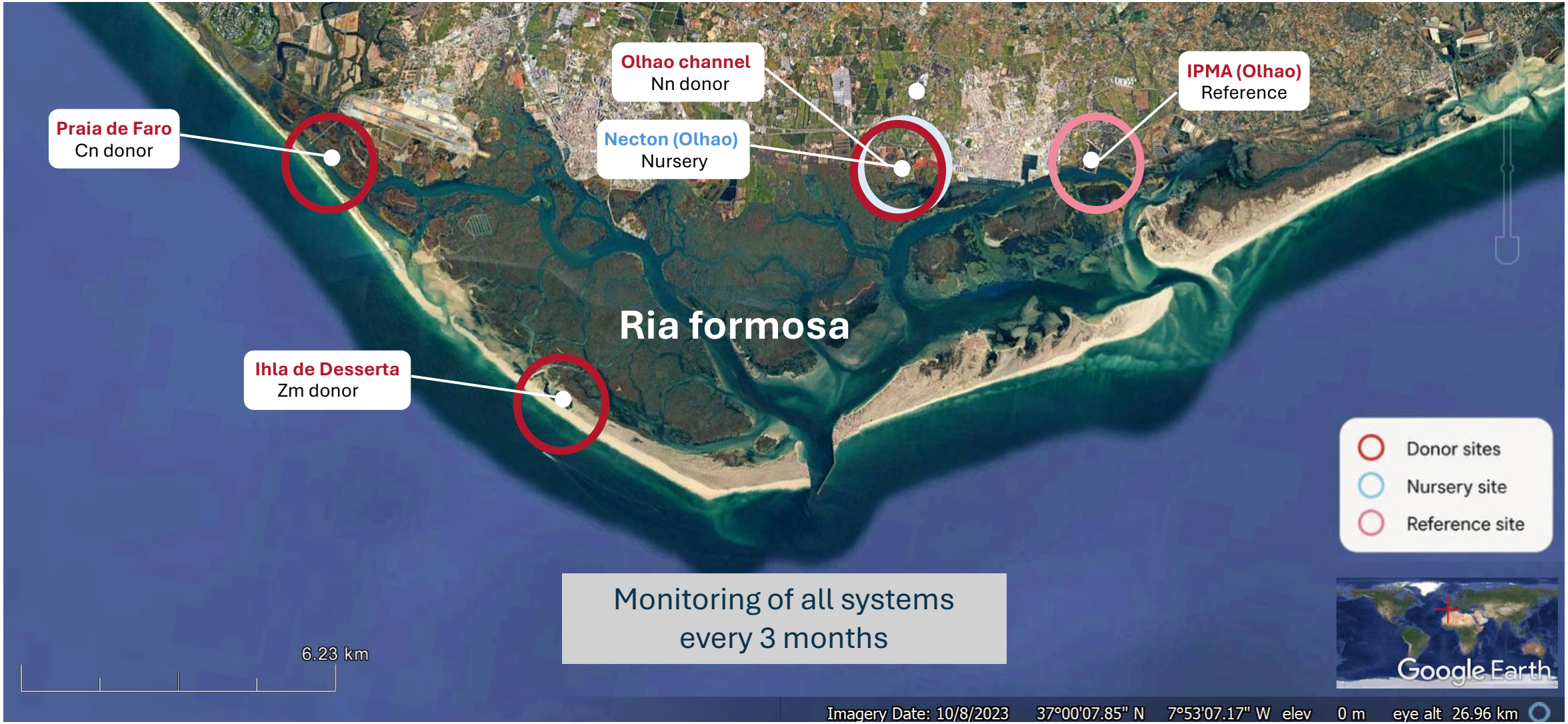
Reference system for natural conditions



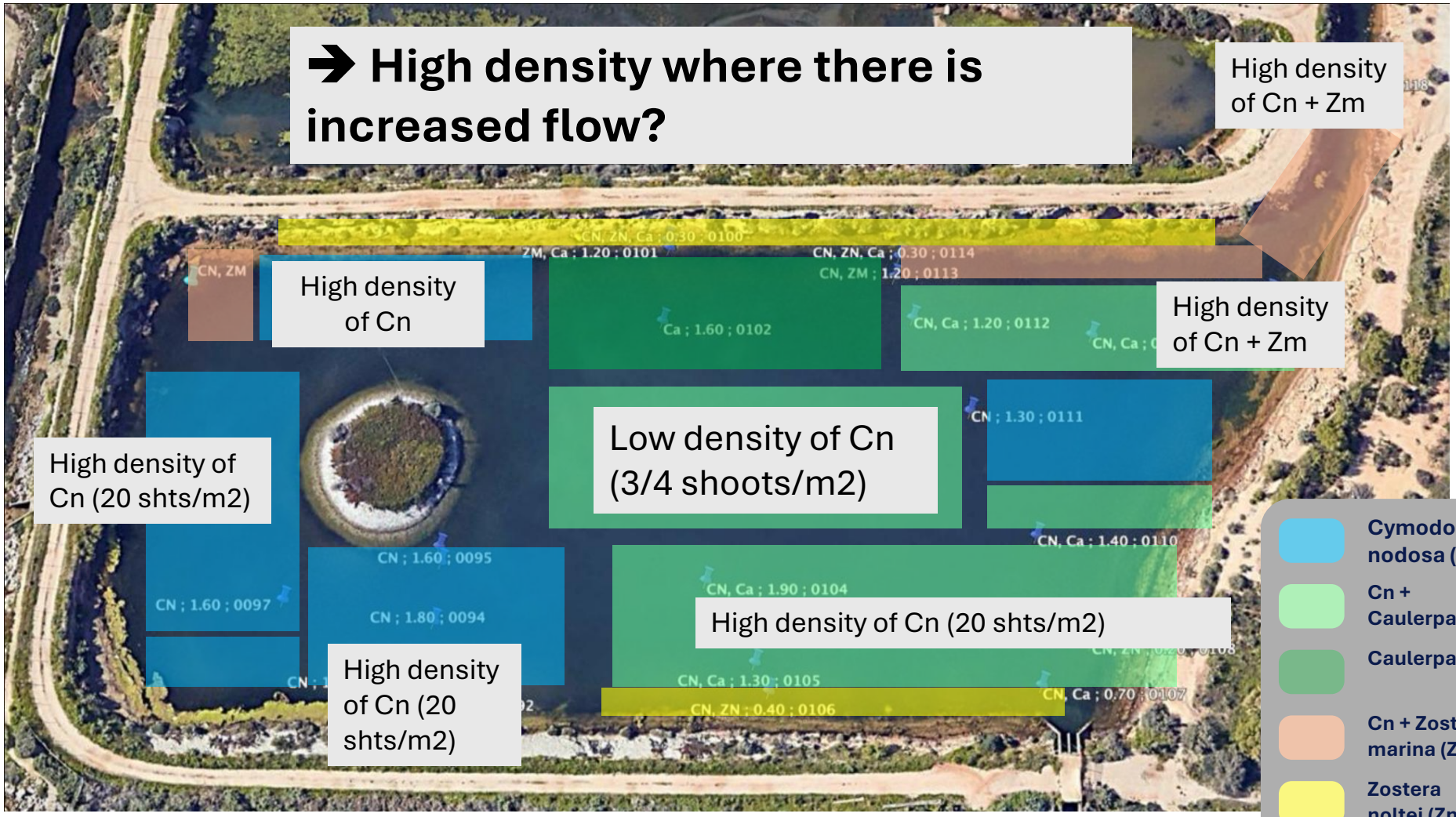
*every 3 months

*every 3 months

Donor, reference & nursery sites in the Ria Formosa



Reference site assessment: natural seagrass distribution



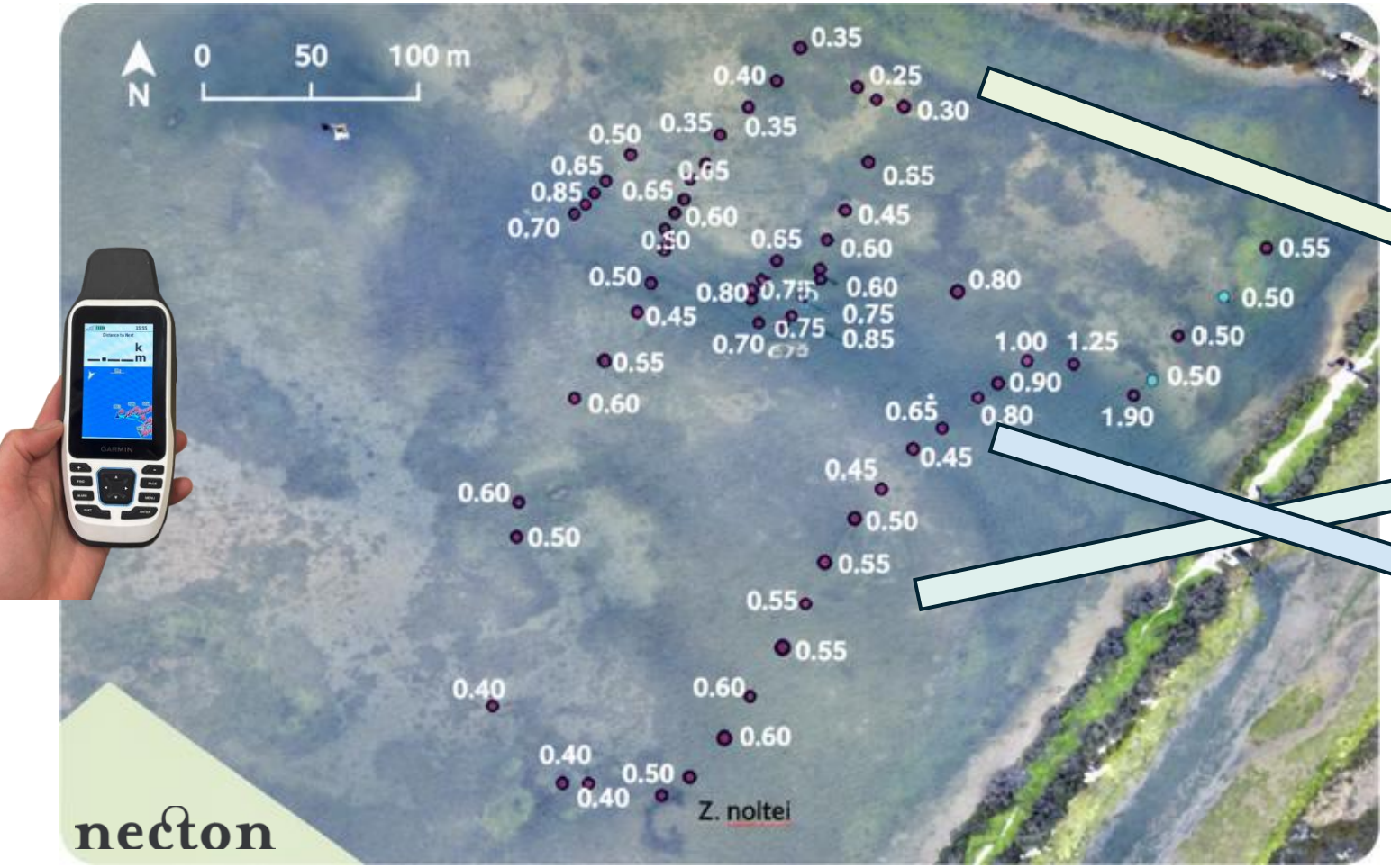
Natural seagrass colonisation

Patchy vegetation patterns

Spatial variation in density

IPMA
Instituto Português do Mar e da Atmosfera

Nursery site assessment: mapping water depth



Approximate planting-area depth categories

Shallow areas
≈ 25–50 cm

Intermediate areas
≈ 40–60 cm

Deeper channel
≈ 70–80 cm

Natural *Nanozostera noltei* present

➡ **Depth mapping helped identify suitable areas for different transplantation treatments**

Test transplantation: first on-site trial



5–6 March | **Objective:** test the full transplantation methodology and timing

1 Collect donor material



2 Transplant & set up plots

(2 × 10 m^2, bamboo markers)



3 Record timing & logistics

- Collection (boat, diving, transport)
- Transport to lagoon
- Transplantation
- Plot setup (bamboo)

Key finding:

a thick algal mat covered the lagoon



Ulva spp.

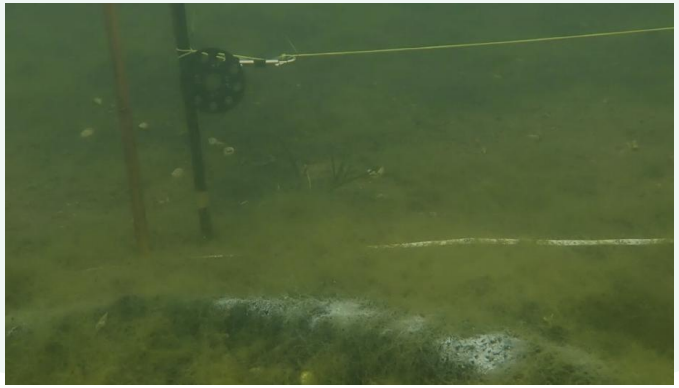
necton

Test transplantation: first on-site trial

The challenge

Nursery floor completely covered by a thick, decomposing algae layer





Our solution: a team effort

1 Mobilise support



We contacted the local community & gathered volunteers

2 Collect underwater



We used dive boxes with holes, so the water could drain out

3 Transport



The filled boxes were placed on DIY “seaweed taxis” to transport them

4 Dispose at sea



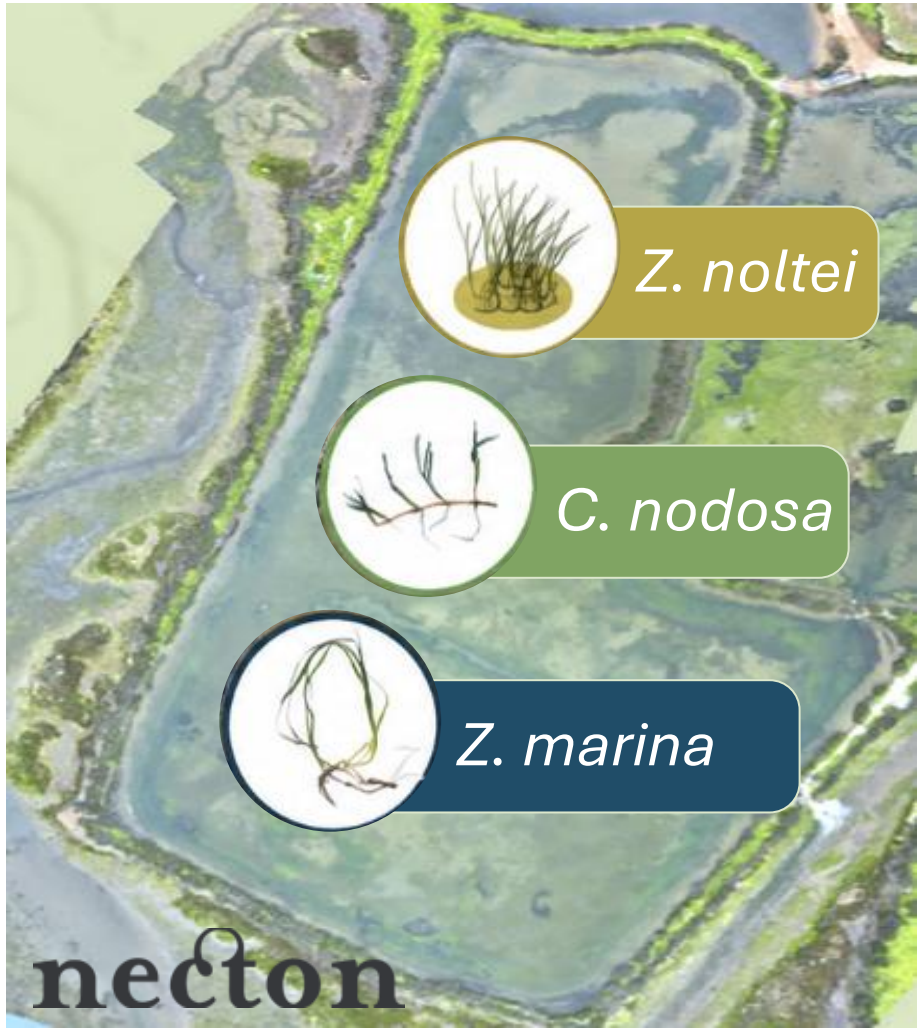
The algae was then taken offshore and released at sea

With the help of 31 volunteers, we cleared ≈ 140 m² of algae

Algae removal in action



Transplanting all 3 species into the lagoon



Objective

Test transplantation & cultivation of
3 seagrass species in the Necton lagoon

Approach

Transplanting donor material & testing
different cultivation strategies

Monitoring

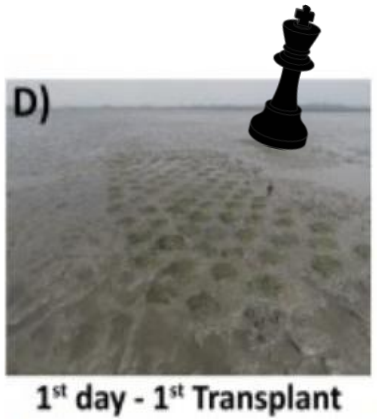
Assessing establishment (survival + growth)
over time

Collection method differed among species

Collection sods

Nanozostera noltei
(Syn. *Zostera noltei*)





(Oliveria et al. 2025)

Collect patches with shovel and transport in trays (diving/standing)

More suitable in high hydrodynamic systems

Collection individual fragments

Cymodocea nodosa



Zostera marina



Diving at edges of seagrass meadow

Low impact on donor population

Less suitable in high hydrodynamic systems

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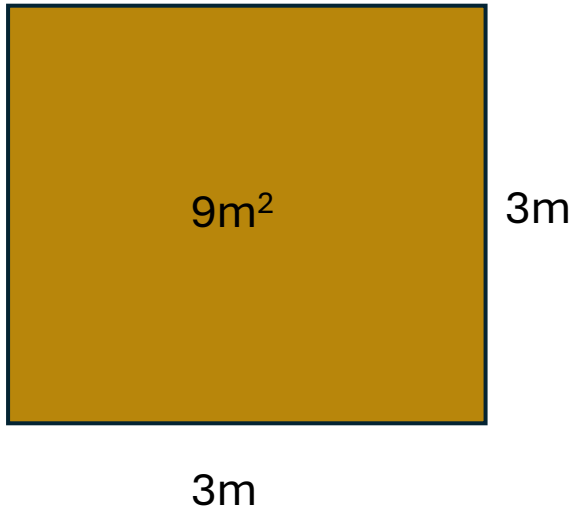


Diving at edges of seagrass meadow

Low impact on donor population

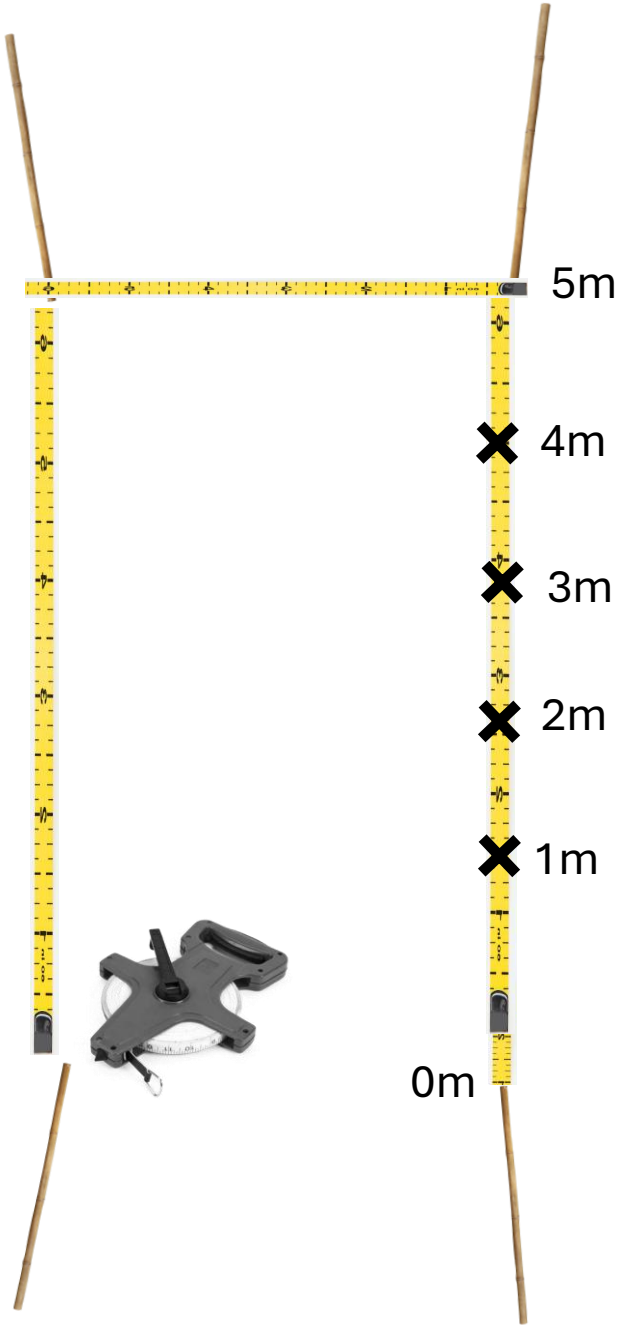
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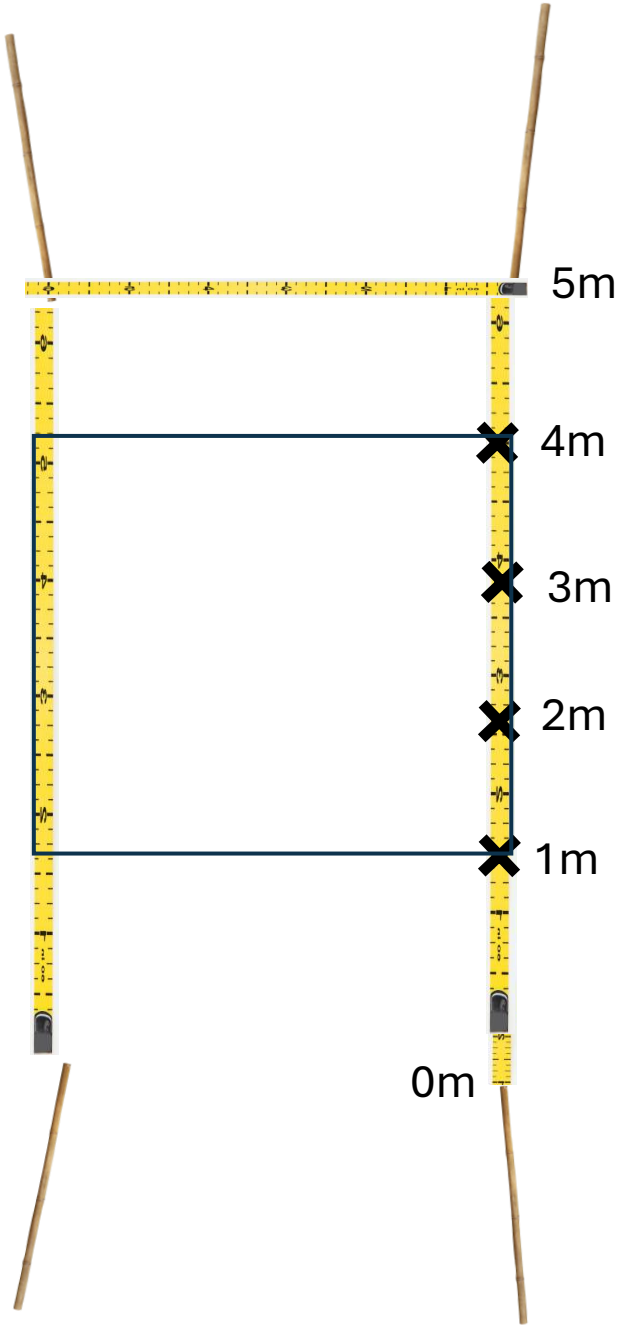
Setting up the plots underwater in the nursery lagoon

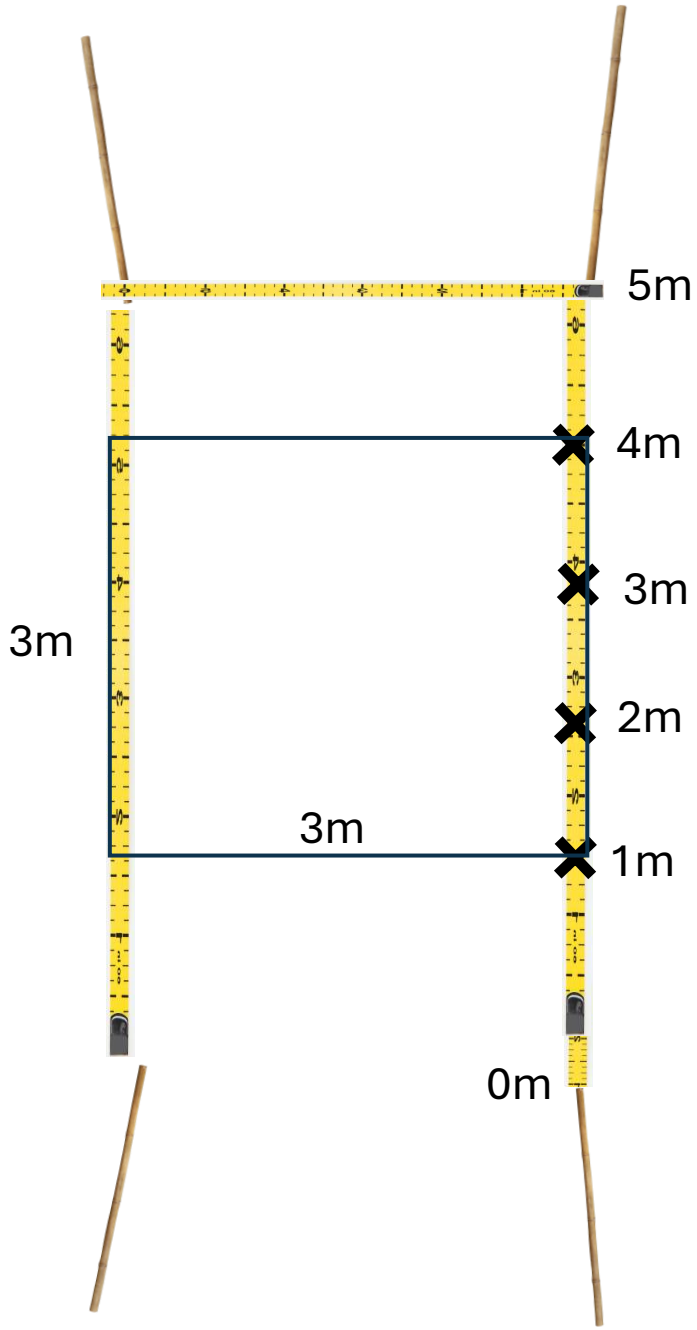


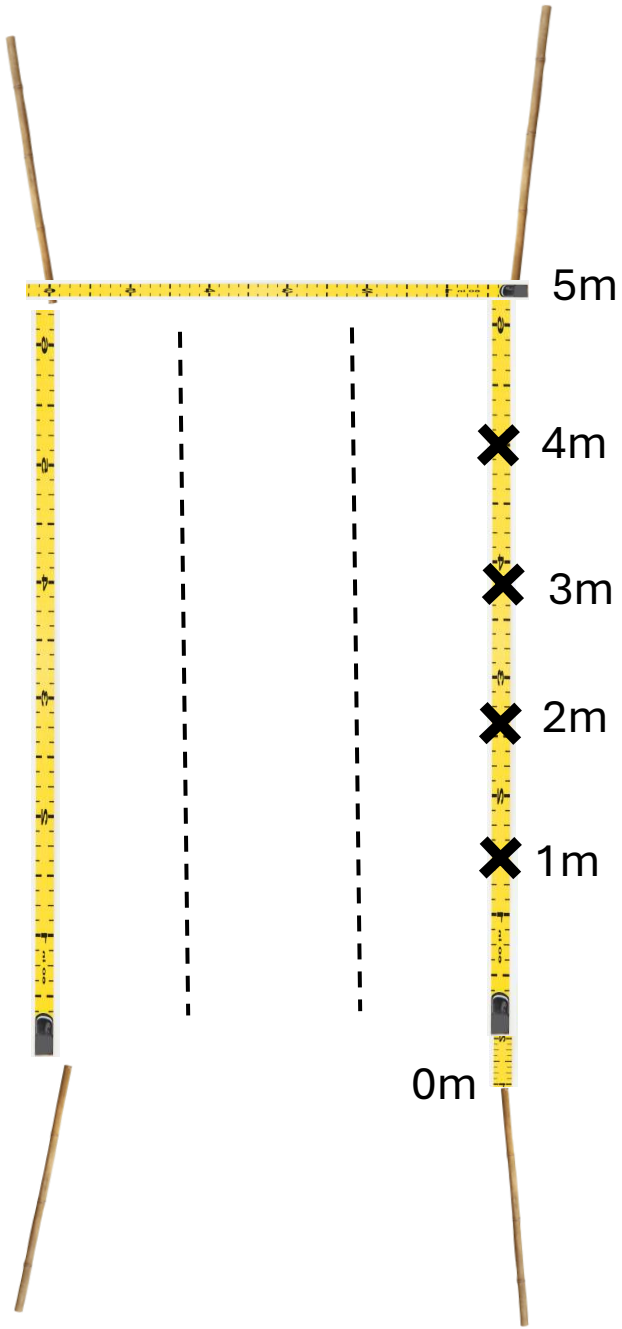


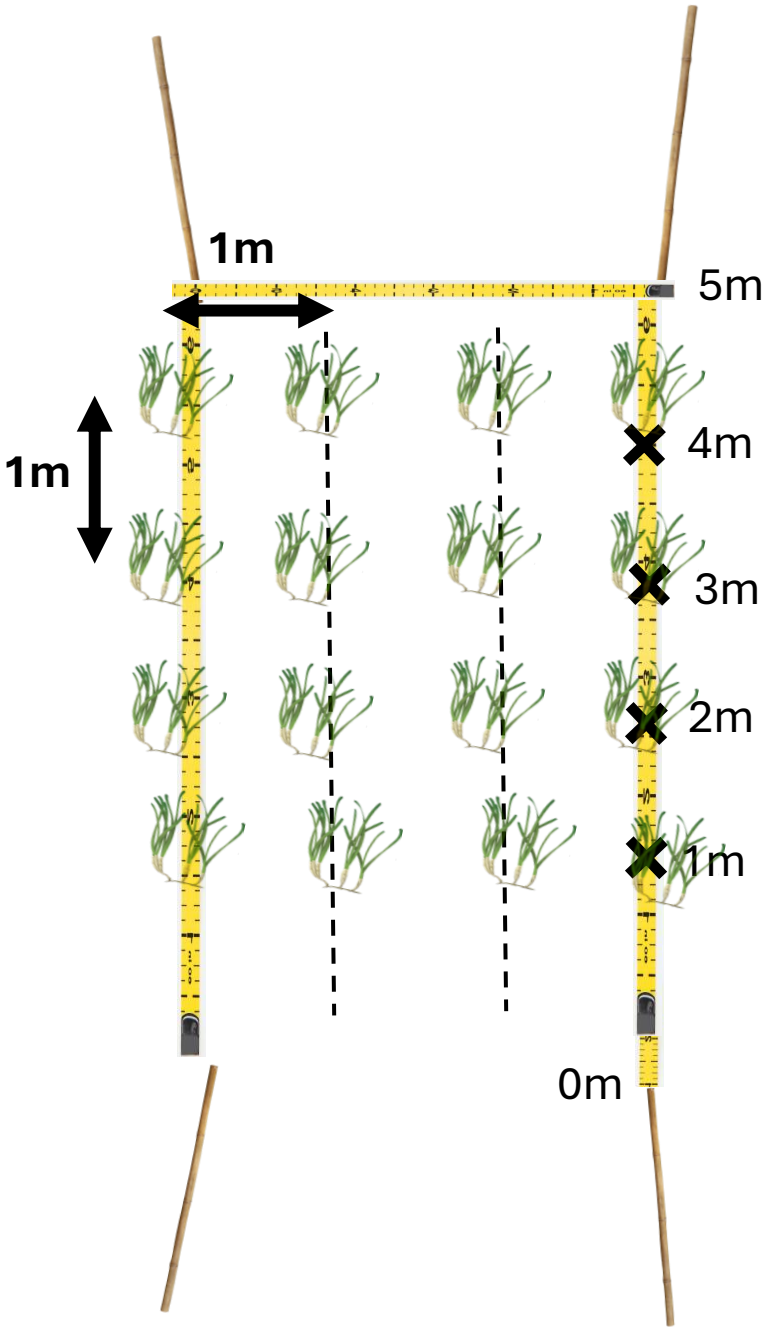



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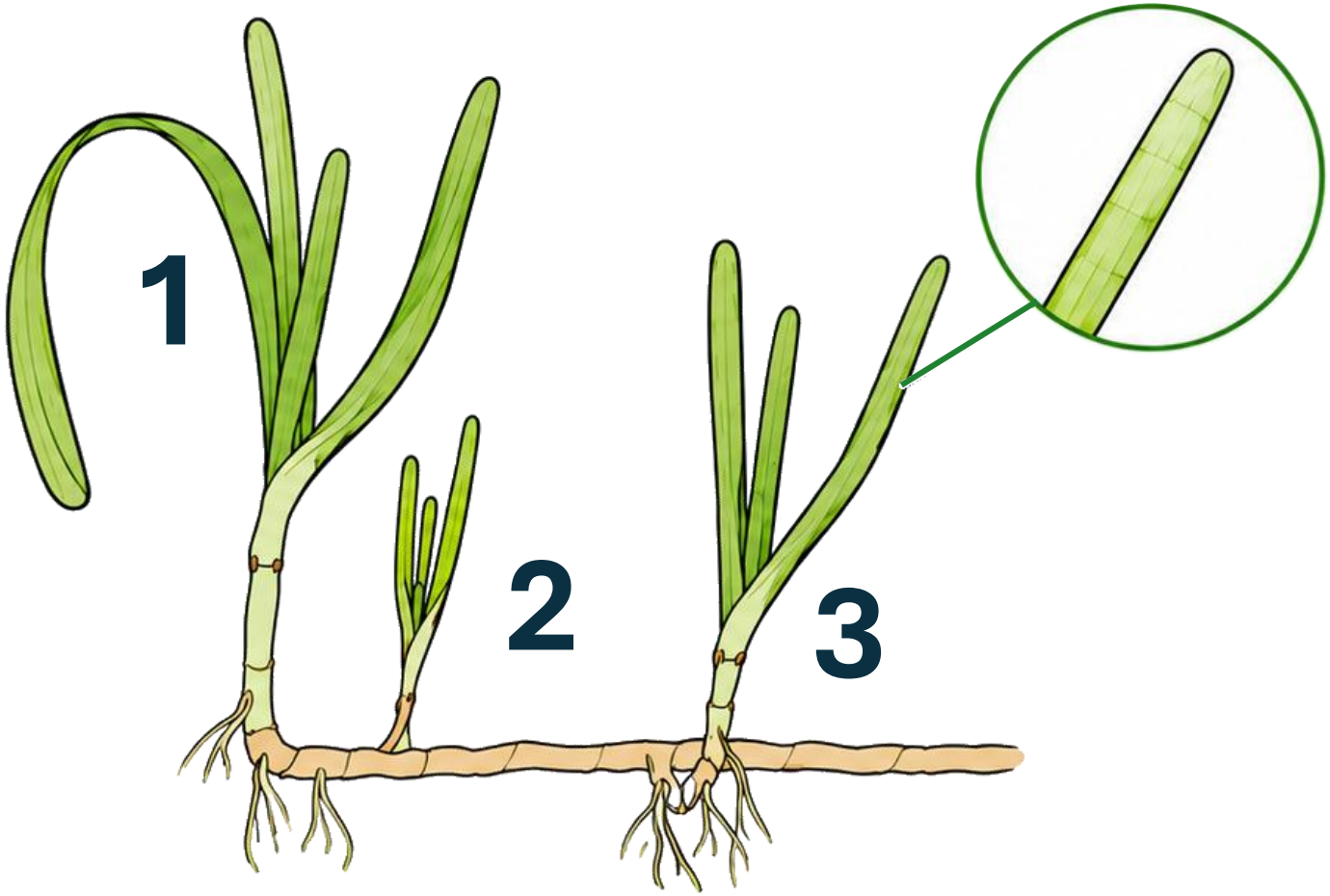

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75A

Seagrass plant anatomy: overview

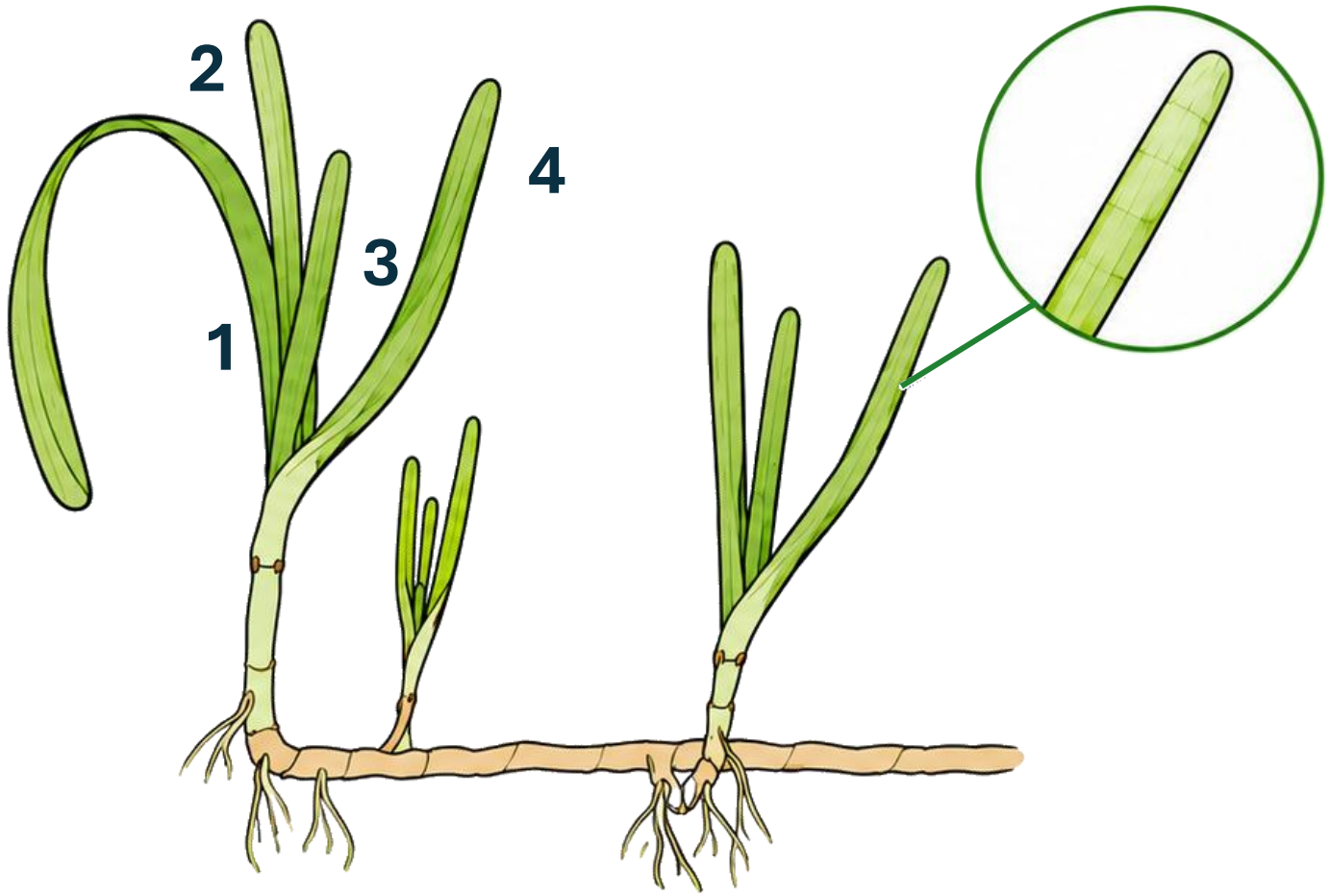


Key structures

Shoot

Leaves growing together from a base

Seagrass plant anatomy: overview

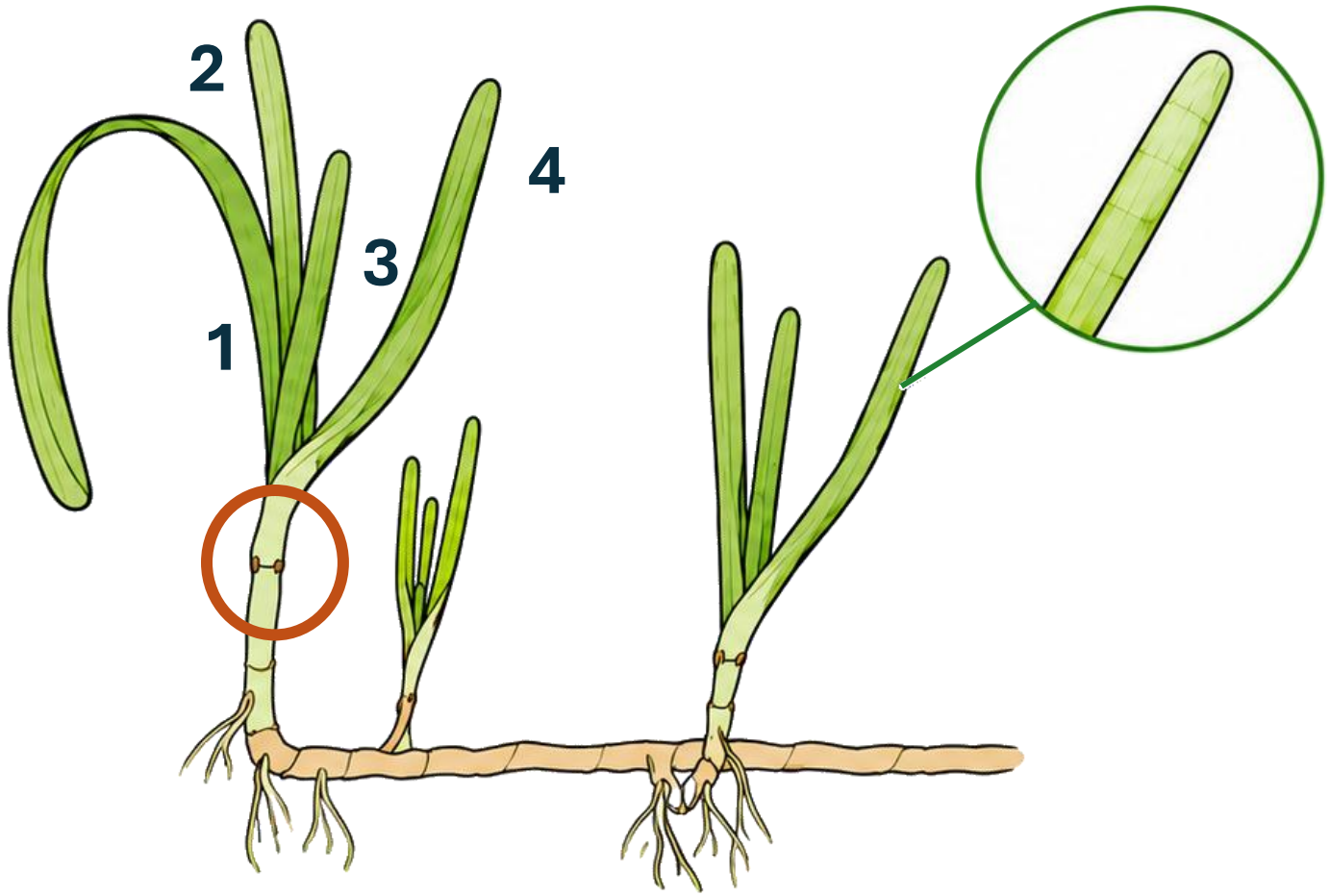


Key structures

Shoot
Leaves growing together from a base

Leaves
Long blades above the sheath.

Seagrass plant anatomy: overview

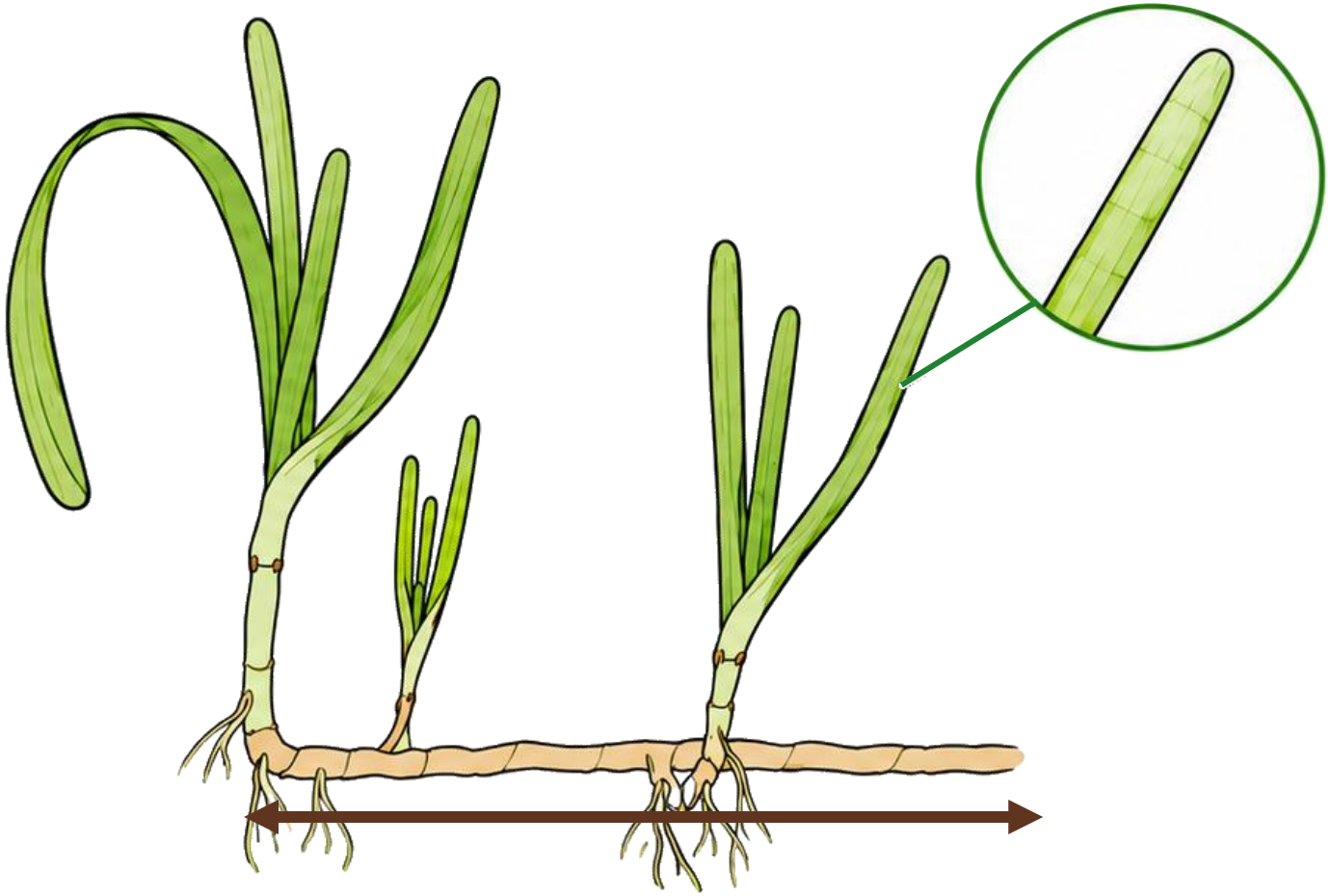


Key structures

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Seagrass plant anatomy: overview



Key structures

Shoot
Leaves growing together from a base

Leaves
Long blades above the sheath

Rhizome
Horizontal stem with nodes & roots

How do we monitor seagrasses?

What do we measure?

Survival
Is the transplanted fragment still alive?

Shoot development
Are new shoots appearing?

Leaf production
How many new leaves are produced?

Leaf growth
How much have the leaves elongated?

Areal extent
How much space is taken
in by seagrass cover?

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Hole-marking method



Initial marking

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Initial marking

1 Mark
Punch a small hole through the leaves at a fixed position near the base.



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Hole-marking method


Initial marking


Growth after marking

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Punch a small hole through the leaves at a fixed position near the base.



2 Grow
New leaf tissue develops from the basal growth region, moving the mark farther from the base.



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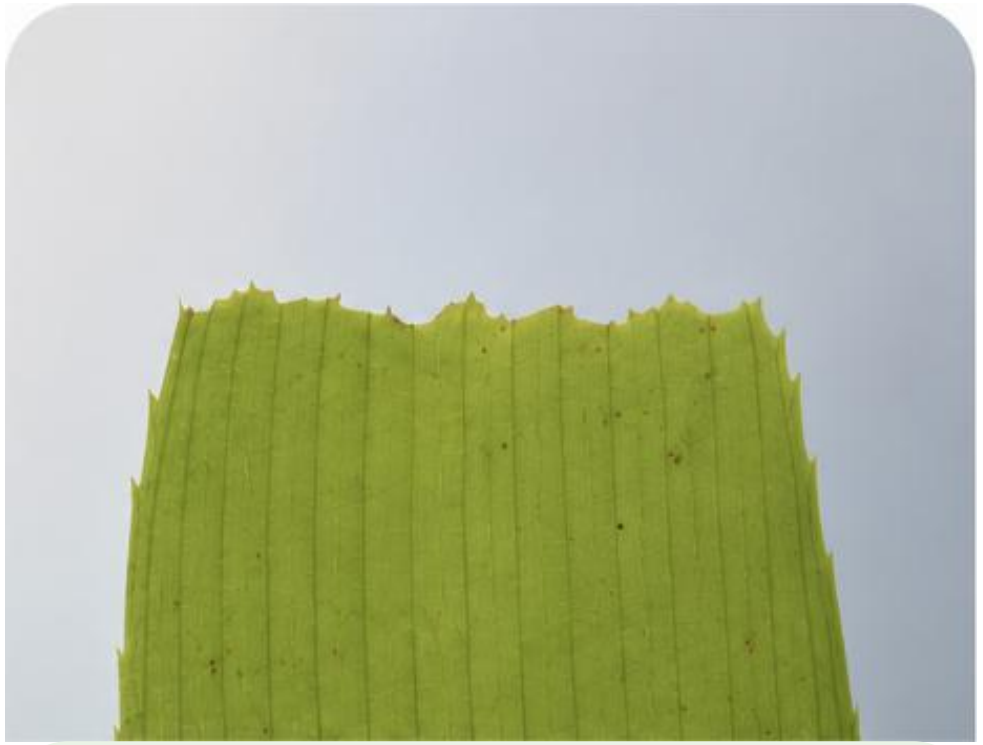
3 Measure
Measure the change in distance between the mark and the leaf base over time to estimate leaf elongation.



How do we monitor seagrasses?



No herbivory
Intact leaf edge



Herbivory
Irregular, grazed edge













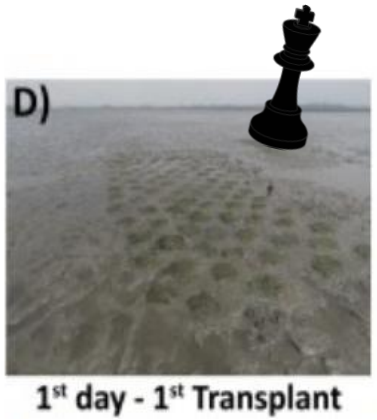


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More suitable in high hydrodynamic systems

Collection individual fragments

Cymodocea nodosa



Zostera marina



Diving at edges of seagrass meadow

Low impact on donor population

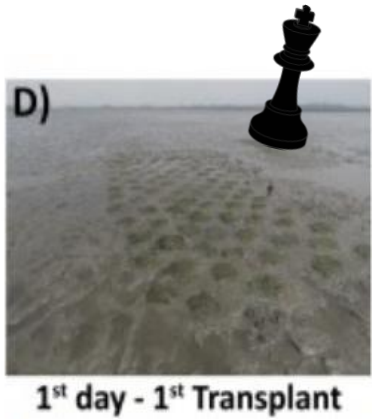
Less suitable in high hydrodynamic systems

Collection method differed among species

Collection sods

Nanozostera noltei
(Syn. *Zostera noltei*)





(Oliveria et al. 2025)

Collect patches with shovel and transport in trays (diving/standing)

More suitable in high hydrodynamic systems

Nanozostera noltei transplantation

1 Collect seagrass with shovels & boxes



We collected intact *Nanozostera noltei* “cakes” from a health donor meadow with shovels

Nanozostera noltei transplantation

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Nanozostera noltei transplantation

1 Collect seagrass with shovels & boxes



We collected intact *Nanozostera noltei* “cakes” from a health donor meadow with shovels

2 Transport & planting





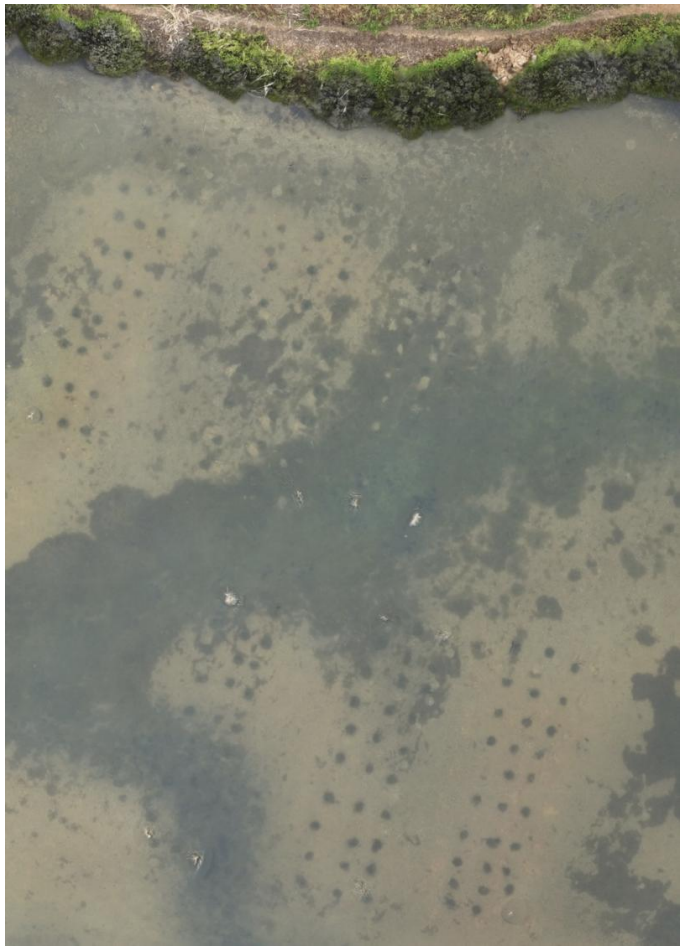
The "cakes" are places in boxes & transported to the restoration area

3 Result



Picture taken 3 months after transplantation

Measuring areal extent using drones



April



Nanozostera noltei

Area

X2.7





DJI Mavic 3

July

Protecting and restoring seagrass meadows



Map & monitor

Where are seagrasses, and how are they changing?



Protect & restore

Reduce pressures and help degraded meadows recover



Engage people

Involve stakeholders & communities

Challenges in seagrass conservation & restoration



Knowledge gaps
Where are seagrasses, and what threatens them?



Restoration barriers
How can we restore seagrasses at scale?



Societal challenges
How do we ensure long-term conservation & restoration success?

Societal challenges for seagrass restoration

How do we ensure long-term conservation & restoration success?



Competing uses of coastal space

Boating, anchoring, fishing, tourism & coastal development can **conflict** with seagrass protection



Limited public awareness

Seagrasses **underwater** is often overlooked + many people **don't know importance** or existence of seagrasses



Different stakeholder priorities

Scientists, municipalities, fishers, tourism operators & conservation authorities may have **different interests & expectations**



Governance & enforcement

Conservation measures require **coordination** between authorities, **clear responsibilities** & effective implementation

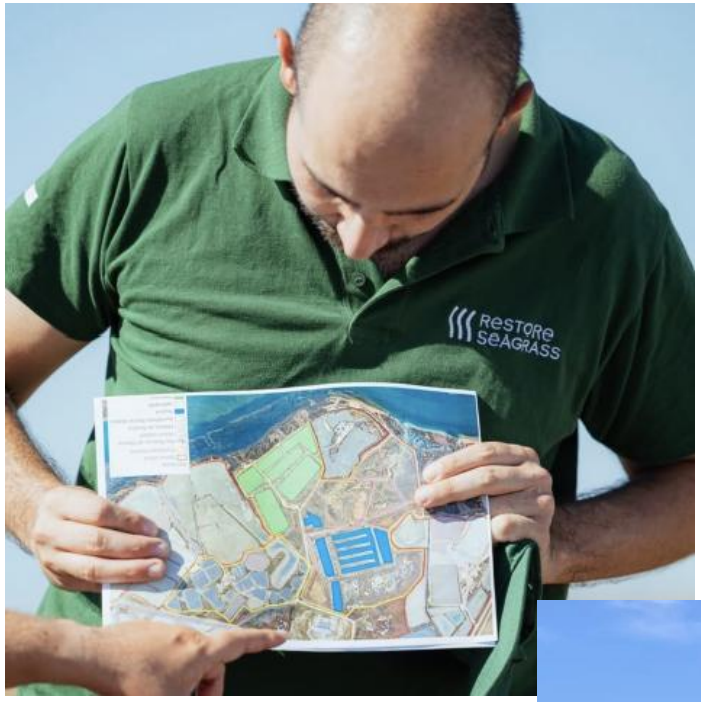


Long-term commitment & funding

Restoration requires **years of monitoring, maintenance & support**, often beyond the duration of individual projects

From science to conservation action

- Working with municipalities & ICNF
- Discussing management measures (e.g. anchoring areas) to reduce impacts on seagrass meadows



ICNF
Instituto da Conservação da Natureza e das Florestas



People in restoration

Volunteers supporting fieldwork and restoration (e.g. lagoon preparation, transplantation & monitoring)









Outreach & ocean literacy

- Bringing seagrass science to a wider audience
- Open science days
- Summer campaigns in the Ria Formosa
- Presentations & workshops in schools









Outreach & ocean literacy

Airport exhibitions
- entry to the Ria Formosa

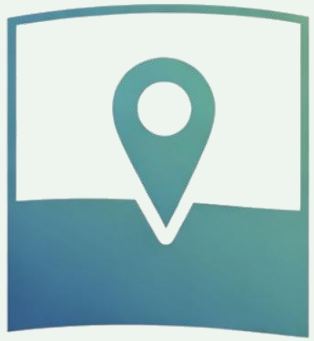




ANA Aeroportos de Portugal



Protecting and restoring seagrass meadows



Map & monitor

Where are seagrasses,
and how are they changing?



Protect & restore

Reduce pressures and help
degraded meadows recover.



Engage people

Involve stakeholders &
communities

**Effective seagrass recovery requires scientific knowledge,
active conservation and restoration, and long-term stakeholder involvement.**



Thank you!

Sari Ponnet
PhD student

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MaReS-grass

Mapping, Restoring and Sharing Seagrass Meadows in Portugal

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"la Caixa" Foundation

YOUTH4 OCEAN

RESTORE SEAGRASS

CCMAR Centro de Ciências do Mar Algarve

CCMAR SCIENTIFIC DIVE CENTER

MMEB Marine Microbial Ecology & Biotechnology

Life

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