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PROJECT SUMMARY

Project summary
See Abstract (Application Form Part A).

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1. RELEVANCE

1.1 Background and general project objectives

Background and general project objectives

Explain the problem and the needs to be addressed in the project. Describe the background, starting point / quantified baseline of the project.

Please explain in which location and/or sector the main activities of the project will take place and justify that choice.

For Nature and Biodiversity:

Provide a clear and quantified description of the conservation issue and threats targeted, as well as relevant background information and quantified figures defining the baseline to justify the proposed Interventions by

At stage 1 (concept note) when relevant, describe the main species/habitats directly targeted by the project: scientific name; refer to the Annex(es) of the EU Birds or Habitats Directive where they are listed; population size within each project area; conservation status; habitat name and Natura 2000 code; % of the cover within each project area; conservation status.

At stage 2 (full proposals), when relevant, provide a brief description of the areas where conservation actions will be implemented and main species and / or main habitats directly targeted by the project, and submit the following annexes:

- *maps*
- *description of sites*
- *description of species and habitats*

Describe the previous conservation efforts in the project area or for the habitats/species targeted.

For Circular Economy and Quality of Life (n/a to Environmental governance topics):

Describe the previous technical preparatory work and results of previous research and development activities, showing the status of technical development achieved for the proposed solution, including the technical readiness level (TRL) where relevant and proving its technical feasibility.

Explain the scale at which such results have been obtained and if prototypes have been already developed and tested. Their scale/dimension and relevant results and conclusions have to be clearly presented. Illustrate available best practices in the relevant sector (state of the art) and clearly and concisely explain the environmental, technical and economical improved performances/ advantages introduced by the proposed solution in case this is claimed to be innovative/ demonstrative.

LIFE SeagrassRIAwild policy context at national, EU and international levels

The needs to halt biodiversity loss, restore ecosystems and use Nature-based Solutions (NbS) for enhanced climate mitigation and adaptation are all recognized in EU policies. Most recently, these have been reinforced under relevant strategies of the European Green Deal, namely the Biodiversity Strategy 2030 and the New EU Strategy on Adaptation to Climate Change, as well as the UN Decade on Ecosystem Restoration. Policies and actions are already in place in various Member States concerning wetlands, floodplains, peatlands, and re-vegetation with relevance both to biodiversity restoration and GHG emissions[1]. These policies acknowledge wetlands' role as paramount to achieve EU objectives regarding climate neutrality, biodiversity protection, zero-pollution, flood protection, circular economy, but also the urgent need for wetlands restoration and conservation, since wetlands, if effectively restored, regain their functional capacity to provide major ecosystem services for the benefit of biodiversity, human health and the climate, namely richer flora and fauna, flood regulation, and carbon sequestration. To this end, the Commission lunched the EU Missions, namely the Mission on Restore our Ocean and Waters, with ambitious targets of the European Green Deal and tangible results to be delivered by 2030. Policy is also being reinforced as the Council and Parliament are now preparing a new EU Nature Restoration Law, proposed by EC in June 2022. The draft Law among others includes targets for restoring carbon-rich ecosystems such as wetlands by 2030, 2040 and 2050. As soon as the EU Nature Restoration Law enters into force, Member States have two years to draw up a National Restoration Plan, thus approximately due in 2026, which will be under the time frame of LIFE SeagrassRIAwild.

In the specific case of seagrass meadows, while they may provide solutions to mitigate some of the most important environmental challenges of our time, it is first necessary to ensure their survival and resilience. At least 30% of seagrass meadows have been lost over the past century, and the rate of loss continues to accelerate. These losses have been mostly due to local pressures such as development, dredging, overfishing or eutrophication.

Seagrass meadow global decline justifies that these are considered a priority habitat under EU Habitats Directive, classified under the **European Red List of Habitats** (**NEA**A5.53 - Seagrass beds on Atlantic infralittoral sand (non-Macaronesian)), and currently assessed as **Critically Endangered** for both the EU 28 and EU 28+.

With the recent declaration of 2021-2030 the UN Decade on Ecosystem Restoration, underpinned by knowledge in the latest IPCC and IPBES reports, large-scale ecosystem restoration is therefore urgent – the window of opportunity is closing rapidly. The EU has just (Jun 2022) stressed the need for more decisive action to achieve the EU climate and biodiversity objectives for 2030 and for 2050, through the proposal of the **Nature Restoration Law**, which aims to bring nature back across the continent for the benefit of biodiversity, climate and people. The overarching objective of the law is to achieve continuous, long term and sustained recovery of biodiverse land and sea areas and increase climate mitigation and adaptation through restoration. Nature-based solutions should be a cornerstone of these efforts going forward, and in Annex VII, the law refers specifically to measures to “Restore seagrass meadows and kelp forests by actively stabilizing the sea bottom, reducing and, where possible, eliminating pressures or by active propagation and planting”.

Seagrass restoration efforts are hence in the spotlight and considered to be the primary strategy to counteract this decline. Restoration programs performed world-wide to compensate or mitigate seagrass losses have been shown to enhance the associated ecosystem services, and that effective management can indeed promote the survival and even enhance the recovery of seagrass meadows, reversing loss trends in some parts of Europe[2].

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[1] EC, *Proposal for an EU Regulation on the inclusion of GHG emissions and removals from LULUFC into the 2030 climate and energy framework and amending Regulation No 525/2013 of the European Parliament and the Council on a mechanism for monitoring and reporting GHG emissions and other information relevant to climate change*. 2021.

[2] de los Santos, C.B., et al., *Recent trend reversal for declining European seagrass meadows.* Nature Communications, 2019. **10**(1): p. 3356.

Relevant examples of LIFE projects targeting seagrass habitats are **LIFE Recreation ReMEDIES** (LIFE18 NAT/UK/000039), **LIFE Posidonia** (LIFE 00/NAT/E/7303), **LIFE SEPOSSO** (LIFE16 GIT/IT/000761), **LIFE BlueNatura** (LIFE14 CCM/ES/000957), with variable success rates. Other restoration programmes, namely in Denmark have reported achieving a 70-fold increase in shoot density after about 2 yrs. of recolonization, allowing a 30% increase in seagrass extension (from 768 m2 to 1282 m^2)[3].
Among seagrasses, *Zostera marina* L. (eelgrass) is one of the most widespread in the northern hemisphere, being however highly susceptible to human driven environmental disturbances. It is presently the most endangered seagrass species in Portugal, as it disappeared from five of eight historical locations and faces extinction from the Portuguese territory if measures are not taken to assure the protection of the last remaining populations[4]. Therefore, following a transdisciplinary approach, LIFE SeagrassRIAwild aims at taking decisive steps to reverse the current conservation status of *Zostera marina* habitat in Ria de Aveiro and Portugal.

LIFE SeagrassRIAwild background and quantified starting point at Ria de Aveiro coastal lagoon
The Ria de Aveiro **coastal lagoon**, at approximately 41°N, 9°W, comprises a combined shallow estuary-coastal lagoon with a complex morphology and productive ecosystem, a priority **habitat listed in Annex I of Habitats Directive** (habitat 1150 – Coastal Lagoons, currently in "bad" conservation status). The physical system is characterized by many branching channels connected to the ocean by a single tidal channel, via an intervening tidal lagoon. It is since 2011 an International Long-Term Ecosystem Research (ILTER) site (http://www. lter-europe.net/), a Long-Term socio-Ecological Research Platform (LTsER) and is a classified site under the Natura 2000 network, entailing a Special Protection Area (SPA) and Site of Community Importance (SCI), respectively under EU Birds and Habitat Directives.
Seagrasses, formerly abundant in the sub-tidal zones of this system, experienced in the 20th century a marked reduction such that they are now completely absent from sub-tidal areas and are found only in restricted intertidal zones[5]. Until the late 70's, *Z. marina* covered large areas of the lagoon but its abundance decreased severely, and its last record had occurred in 2010[4]. Recent studies suggest that European seagrasses are increasing their distribution since the last decades and this seems to be especially noticeable for species of the genus *Zostera*[2]. At Ria de Aveiro coastal lagoon, the seagrass populations' dynamics seem to have followed global trends of decline and recovery trajectories, particularly for *Z. noltei*[5]. Additionally, in 2019, small intertidal patches of *Z. marina*[6] were identified suggesting a decline and resurgence cycle. Seagrass species and spatio-temporal changes at Ria de Aveiro lagoon are summarized in Figure 1. The resurgence of the species in the system indicates favorable conditions for restoration and recolonization plans, and makes **LIFE SeagrassRIAwild,** both relevant and timely, as this is the momentum to actively support this starting passive recovery. The small scale of discovered patches, however, excludes its use for restoration purposes.

[3] Lange, T., et al., *Large-scale eelgrass transplantation: a measure for carbon and nutrient sequestration in estuaries.* Marine Ecology Progress Series, 2022. **685**: p. 97-109.

[4] Cunha, A.H., J.F. Assis, and E.A. Serrão, *Seagrasses in Portugal: A most endangered marine habitat.* Aquatic Botany, 2013. **104**(0): p. 193-203.

[5] Sousa, A.I., et al., *Blue Carbon stock in Zostera noltei meadows at Ria de Aveiro coastal lagoon (Portugal) over a decade.* Scientific Reports, 2019. **9**.

[6] Guerrero-Meseguer, L., et al., *Resurgence of Zostera marina in the Ria de Aveiro lagoon, Portugal.* Aquatic Botany, 2021. **169**.

(LIFE SAP and OAG):

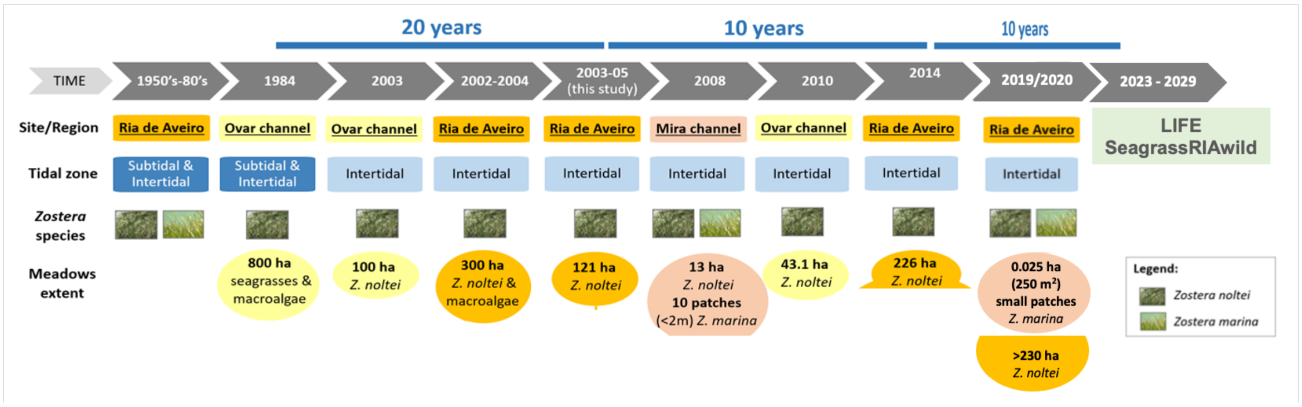

Figure 1 - Seagrass species and spatio-temporal changes at Ria e Aveiro lagoon from 1950's to present (adapted from Sousa et al. 2019 SciRep 9,14387).

Active and/or passive practices:
Active restoration eliminates the source of degradation and disturbance of an ecosystem and implements measures to accelerate its recovery and to overcome obstacles to that recovery.
Passive restoration eliminates the factors of degradation and disturbance and permits natural regeneration of the ecosystem.

Quantified starting point
The most recent distribution map of seagrass meadows (intertidal *Z. noltei*, Figure 2) in the Ria de Aveiro reflects a recovery and expansion process, with an increase of approximately 30% in area in one decade, to a total of 226 Ha, in the surveyed area[5].
Current *Z. marina* distribution is restricted to a few intertidal patches with an overall area of approximately 250 m^2 (intertidal *Z. marina*, Annex 1), after no records since 2010.
From the current *Z. marina* conservation status starting point, 3 relevant questions were identified:
Q1 – How to minimize the impact in donor populations for large-scale restoration efforts?
Q2 – How to foster a win-win between seagrass restoration and socio-economic activities?
Q3 – What are best practices to promote public endorsement and involvement in the restoration program?

These questions drive **LIFE SeagrassRiawild** main objective:

LIFE SeagrassRiawild proposes a paradigm shift in seagrass restoration, enabling large-scale restoration programs with negligible effects on existing natural meadows, through the development of seagrass mariculture to support the plant and seed needs for restoration, and social engagement to enable it. This innovative approach will be showcased in the Ria de Aveiro, along with novel seagrass NbS coupling restoration, conservation and system management.

The previous seagrass conservation efforts at Ria de Aveiro:

Project	Main Action relevant for LIFE SeagrassRIAwild
EU FP7 LAGOONS (2011-2014)	Science-Policy-Stakeholders interface; numerical modelling for habitat suitability
PT FCT PORBIOTA (2017-2022)	LTsER platform datasets on environmental parameters and habitats mapping
EU H2020 AQUACROSS (2015-2018)	Ecosystem-based management applying InVEST GIS based model
OHMI CNRS/INEE C-GRASS (2017-2019)	*Z. noltei* spatio-temporal changes (mapping) and blue carbon stock assessment

PT Mar 2020 BioPradaRia (2018-2022)	*Z. noltei* high resolution mapping, and optimization and implementation of restoration measures applying nature-based solutions
PT Mar 2020 Remoliço (2019-2021)	*Z. noltei* optimal growth conditions and resistance to *in situ* transplantation
PT FCT RemediGrass (2018-2022)	*Z. noltei* transplantation as a remediation tool for historically contaminated areas
OHMI CNRS/INEE FITA (2020-2022)	*Z. marina* mapping and passive restoration measures applying citizen science

This set of projects that started in 2011 has enabled the UAveiro team to gather a unique background knowledge on Ria de Aveiro coastal lagoon regarding:

Policy context – By developing an ecosystem-based management approach to support EU efforts to protect aquatic biodiversity and ensure the provision of aquatic ecosystem services, and aligning the methodology with key EU and global policy objectives (e.g., EU BDS2030, Ramsar Convention, UN SDGs, UN Decade on Ecosystem Restoration).

Governance context – By developing a Science-Policy-Stakeholders interface which facilitated participatory governance of the system based on public mobilization and engagement, empowering citizens to take action and drive the transitions through deliberative democracy, social innovation, citizen science and awareness campaigns.

Stakeholder co-creation process - Through transdisciplinary approaches, with participatory process for stakeholder engagement, facilitating the consideration of scientific results, local community and overall policy interests in the formation, evaluation and adjustment of integrated scenarios. This integrative approach allows for academics to internalise stakeholders' vision as well as their local ecological knowledge (LEK) of Ria de Aveiro, and stakeholders to actively participate and co-design the solutions, encompassing technical, management and policy constraints.

Natura 2000 Habitats – As a LTsER platform, part of the LTER Portugal network, Ria de Aveiro long-term ecological research aims to monitor and create relevant data bases on natural sciences (from organisms to ecosystems) and on social sciences (from citizens to institutions) through transdisciplinary approaches. Environmental data collected under the scope of LTER Ria Aveiro site is stored in DEIMS-SDR database, namely the *Zostera noltei* seagrass meadows habitat mapping (also stored in GBIF- Global Biodiversity Information Facility).

Ecohydrology – Developing numerical modelling tools to evaluate habitat suitability for seagrass settlement, presence or growth; estimate the lagoons response (water dynamics, water quality) to different climate scenarios based on results of climate and land-based river discharges and nutrient inputs modelling performed for the catchments, and its effects on seagrass meadows.

Seagrass biology and ecology – A very strong background on seagrass mapping, management, conservation and restoration methods, with the use of nature-based solutions (NbS). Testing the suitability of seagrass beds as green and blue infrastructures for ecosystem restoration and optimizing transplant methods both at intertidal (*Zostera noltei*) and subtidal areas (*Zostera marina*); Implementing innovative restoration methods (NbS) to mitigate a non-indigenous species (lugworm) disturbance on seagrasses; Assessing the role of seagrasses for climate change mitigation (blue carbon).

***Z. marina* biology and ecology** – After its resurgence in the system, developing *Z. marina* mapping and historical distribution characterization, and passive restoration measures through citizen science actions.

More than a decade of **transdisciplinary work** has provided the UAveiro team, complemented with long-standing collaborations with relevant partners from the academia (namely SDU team, testing methodologies and implementing seagrass restoration plans in the scope of NOVAGRASS (Denmark) and BioPradaRia (Portugal) projects), administration, NGO and private sectors with the necessary knowledge, competences, tools and motivation to address such a demanding, urgent environmental challenge. The timing of the application is clearly justified by the favourable combination of current EU integrated policy approach and funding, environmental conditions and institutional and stakeholder commitment.

(LIFE SAP and OAG):

1.2 Specific project objectives

Specific project objectives

Describe the specific objectives of your project (clear, measureable, realistic and achievable within the duration of the project).

The main objective of **LIFE SeagrassRIAwild** is to showcase in the Ria de Aveiro, following a trans-disciplinary approach, the potential of seagrass mariculture and seagrass NbS as a facilitator of system-wide seagrass restoration programs.
To this end, **SeagrassRIAwild** is framed in the following impact-driven *SMART* (*Specific* (**S**); *Measurable* (**M**); *Achievable* (**A**); *Realistic* (**R**); *Time-bound* (**T**)) objectives:

O1 – **Develop a stakeholder Forum**, that will act as a Community of Practice (CoP) (**S**), for the co-development of restoration solutions and actions, to ensure that stakeholders and end users are actively involved in the process (**M**), enabling awareness of the project developments and results, acceptance of the results as valid tools and adopt them in their workflows (**A**). Co-design with targeted stakeholders ensures that it encompasses technical, management and policy constraints (**R**). Implementation through a variety of virtual and face-to-face tools (*e.g.*, webinars, workshops, exchange visits) (**T**).

O2 – Develop a robust ***Z. marina*** **mariculture** to serve as **source** for restoration actions (**S**) through the re-purpose of a decommissioned salt pan owned by the University of Aveiro (**M**), to serve as a support infrastructure to be colonized from multiple donor populations (**A**) with a starting point of 1 Ha to initiate restoration actions (**R**). This infrastructure will remain as project legacy and mariculture will be incrementally expanded up to its total available area (26Ha) (**T**).

O3 – Optimize **nursery** processes (**harvest, maturation, storage, germination and genetic selection**) (**S**) to support restoration actions. All processes necessary to attain an annual supply of seeds from the mariculture (**M**) will be optimized within the mariculture (harvest, maturation) or in ECOMARE UAveiro facilities (seed storage and germination) (**A**) and will allow for the expansion of the mariculture and for restoration actions combining adult plants and seeds or seedlings (**R**) from M36 onward (**T**).

O4 – Develop a **system-wide seagrass rewilding program** (**S**) encompassing social engagement through citizen science restoration initiatives (**M**) and innovation by implementing seagrass-based green infrastructures (green corridors on channel banks) to maintain channel navigability (**A**), using at most 5% of the mariculture area available (**R**) per year from M36 onward (**T**).

O5 – Monitor and evaluate **Ecosystem Service** recovery (**S**) encompassing biodiversity, blue carbon and sediment accretion (**M**) as result of habitat recovery (**A**) in showcase restored locations supported by cost-benefit analysis of the restoration actions (**R**) with a temporal resolution within and beyond the project lifespan(**T**)

O6 - Develop an **environmental education and training** framework (**S**) encompassing pedagogic visits to the mariculture (M) and training courses for researchers, technicians and restoration practitioners (**A**) in association with relevant NGOs (**R**) to improve professional skills and competencies to support replication and upscaling beyond the timeframe of the project (**T**).

O7 - **Ensure the sustainability of the action:** develop and implement a strategy for Dissemination and Communication, and for Exploitation / uptake of results (**S**); monitoring of actions through outreach indicators (e.g., visits to nurseries; attendees to events) (**M**); ensure outreach to target groups that will benefit from the results (e.g., policymakers; national and local administrative authorities, environmental managers; research community; local communities; general public) (**A**); implement dedicated communication channels and establish synergies with other ongoing and recently funded EU projects (**R**); ensuring that the restoration actions are timely and relevant for the policies and strategies revision cycles (**T**).

1.3 Compliance with LIFE programme objectives and call topic

Compliance with LIFE Programme objectives

Explain how the project contributes to the specific objectives of the LIFE Programme and the sub-programme targeted by the call (Nature and Biodiversity, Circular Economy and Quality of Life, Climate Change Mitigation and Adaptation or Clean Energy Transition).

The main objective of **LIFE SeagrassRIAwild** is entirely pertinent to the work programme objectives, since it embraces an impact-driven approach for the **restoration** of subtidal seagrass meadows of a Natura 2000 site, aiming to revert the loss of biodiversity associated with the disappearance of these **critically endangered habitats**, while promoting **social engagement** through **citizen science** restoration initiatives. The innovative development of a large-scale **seagrass mariculture** will enable the **scalability and replicability**, not only within the system but potentially for other Natura 2000 sites in need of similar actions, while the co-development of **seagrass nature-based solutions** (NbS) for restoration and ecosystem management purposes adds a more complete level of understanding and environmental-economic sustainability.

LIFE SeagrassRIAwild addresses the LIFE Programme objectives through target actions (structured in the complementary WPs) with clear evidence of progress beyond the State of the Art (SotA).

LIFE Programme objective	**Action (WP)**	**Progress beyond (SotA)**
Halting and reversing loss of wildlife habitats and species	System-wide restoration effort of a priority, critically endangered habitat in a Natura 2000 site (WP5)	The development and use of an innovative seagrass mariculture to support restoration activities minimizing damage to donor populations Spill-over effects on the conservation status of 2-3 critically endangered fish species
Development, demonstration, promotion and stimulation of scaling up innovative techniques, including nature-based solutions	Development of seagrass mariculture (B.1-B.3), nursery processes (WP4) and implementation of seagrass-based green infrastructures for system management (WP5)	Upscaling restoration efforts from mariculture plant biomass, supported by a cost-benefit analysis in the context of ecosystem services; Optimization of nursery processes for restoration purposes, following a transdisciplinary approach; Development of innovative, environmental-economic sustainable solutions for Eco-hydrodynamics processes and navigability maintenance
Enhancing capacities of public and private actors and the involvement of civil society, namely through citizen science	Ria de Aveiro Stakeholders forum (WP2), Citizen science restoration efforts (WP5), “Guardiãs da Ria” network (WP7) environmental education and training (WP7)	Stakeholder co-creation process complemented by engagement as multiplier effect for citizen-science activities; Pedagogic visits to promote social awareness, engagement and participation in restoration; Capacity building activities to local fishing communities; Practitioner-oriented capacitation training for upscaling and replication

Compliance with the call topic

Indicate the call topic to which your proposal relates, and explain how the proposed project addresses the scope of the topic description in the Call document.

Within the topic “Nature and Biodiversity”, this proposal is deemed relevant in the scope of the “Space for Nature” intervention area, which aims at improving the condition of species or habitats through **area-based conservation or restoration** measures. “Space for Nature” will prioritize projects that focus their activities on the implementation of conservation objectives for existing Natura 2000 sites, improving the condition of species and habitats for which the sites are designated.

LIFE SeagrassRIAwild interventions towards seagrass rewilding aim at the improvement of a **priority habitat listed in Annex I of Habitats Directive** (1150, Coastal Lagoons) and co-benefit 3 others (1110, 1130, 1140) with "Poor" or "Bad" classification within Natura 2000 site **PTCON0061,** and is therefore completely aligned with this topic and intervention area. Proposed actions will also have a positive impact on 3 seagrass associated species present in the IUCN Red List of Threatened species (*Anguilla Anguilla*, critically endangered and *Hippocampus hippocampus* and *Hippocampus guttulatus*, data deficient). It further supports the implementation of the **EU Biodiversity Strategy for 2030** in its aim to "ensure no deterioration in conservation trends and status of all protected habitats and species by 2030", and that "at least 30% of species and habitats not currently in favourable status are in that category or show a strong positive trend".

More importantly, ***Z. marina* beds** are classified under the **European Red List of Habitats** (NEAA5.53 - Seagrass beds on Atlantic infralittoral sand (non-Macaronesian)) and have been assessed as **Critically Endangered** for both the EU 28 and EU 28+. Actions to restore this habitat will respond directly to another call priority, which aims at restoring **degraded and carbon-rich ecosystems**. According to the EU Biodiversity Strategy, significant areas of degraded and carbon-rich ecosystems (such as primary and old-growth forests, peatlands, grasslands, wetlands, saltmarshes, mangroves, seagrass meadows and deep-sea cold seeps) need to be restored by 2030, for which **LIFE SeagrassRIAwild** will significantly contribute. Furthermore, part of the expected legacy of the project (the seagrass mariculture) will remain available and may act as a steppingstone for future seagrass restoration programs elsewhere.

Finally, the proposed development of **seagrass nature-based solutions** (NbS) for ecosystem management, namely the proposed green seagrass corridors to minimize sediment deposition in navigation channels is also aligned and will contribute to the EU Biodiversity Strategy priority given to deploying Green and Blue Infrastructure as well as other nature-based solutions and restoration actions that would help prevent or reduce the impact of natural disasters.

#§PRJ-OBJ-PO§# #@CON-MET-CM@#

1.4 Concept and methodology

Concept and methodology

Describe the overall intervention logic of the project, including the main idea and assumptions (i.e. how are the proposed activities and steps of your project expected to lead to the intended changes in terms of outcomes and impacts).

Explain the methodology, i.e. the main tools, techniques, methods and procedures you will use to implement the technical part of your project. Justify why the proposed methodology is the most suitable for achieving the project's objectives.

For Clean Energy Transition:

Describe the market barriers, the needs and constraints of market actors, and how your concept will address them concretely.

For Circular Economy and Quality of Life (n/a to Environmental governance topics):

Describe the technical details of the proposed solution (process, material, product etc.) using a flowchart and including, where possible, the general mass and energy balance. Explain how you plan to establish your supply chain.

Specify the scale (e.g. production capacity) and output of the project (e.g. quantity produced/sold during the project). The chosen technical scale should be one that allows the evaluation of the technical and economic viability of the proposed solution. In case of close-to-market conditions the target should be industrial/commercial scale already during the project.

In coastal areas of Europe, protecting and restoring ecosystems, including kelp forests, coastal wetlands, saltmarshes, and seagrasses, does not only serve the purpose of biodiversity conservation and climate mitigation, but these are also key actions for boosting resilience to climate change and a platform to increase engagement with citizens.

The rationale behind **LIFE SeagrassRIAwild** is to take decisive steps towards the reversion of the current **Critically Endangered** status of ***Z. marina*** meadows at the European Western Coast. With that goal in mind, the commitment of relevant, complementary scientific institutions (UAveiro, UVIGO, SDU, GEOMAR, CIIMAR, UC), local administration (CIRA - Inter-municipal Community of the Aveiro Region), national environmental agencies (Portuguese Environmental Agency - APA / ARHCentro , National Institute for Nature Conservation and Forests - ICNF), relevant non-governmental organizations (NGO) (Ocean Alive) and technology-based private sector (HAEDES) ensures the know-how, institutional support and endorsement for the development of an integrated restoration strategy which will be implemented locally, while building the foundations for replication and upscaling at the regional, national and EU level. In more detail, CIRA is responsible for Ria de Aveiro Inter-municipal Master Plan; APA / ARHCentro is responsible for management of the water resources; for the implementation of the WFD and other water related Directives; for spatial planning of water resources, uses (including the economic analysis of water uses) and demands, and law enforcement; and for the strategic and integrated planning of the coastal zone, and ICNF is the national authority for nature conservation, biodiversity and forests; ICNF articulates and promotes the integration of forest policy and the conservation of nature and biodiversity in policies to combat desertification, to mitigate climate change and its effects, and to reduce the country's energy dependence.

Integration as well as inter- and trans-disciplinary research are central parts of the **LIFE SeagrassRIAwild** concept (Figure 2), encompassing Social Science through the development of a Stakeholder Forum (**WP2**) Citizen Science actions (**WP5**), Capacity-building actions **(WP7)**, Engineering for the development of the infrastructure (**WP3**) and Seagrass Nature-based solutions (**WP5**), Physics (numerical modelling in **WP5)**, Biology encompassing Ecology (transplant efforts in **WP3** and **WP5**, monitoring ecosystem services in **WP6**), Plant physiology (monitoring in **WP3** and nursery optimization in **WP4**) and Genetics (population characterization in **WP3** and genetic selection in **WP4**), Socio-Economics (evaluation of ecosystem services recovery value in **WP6**) and Education (**WP7**).

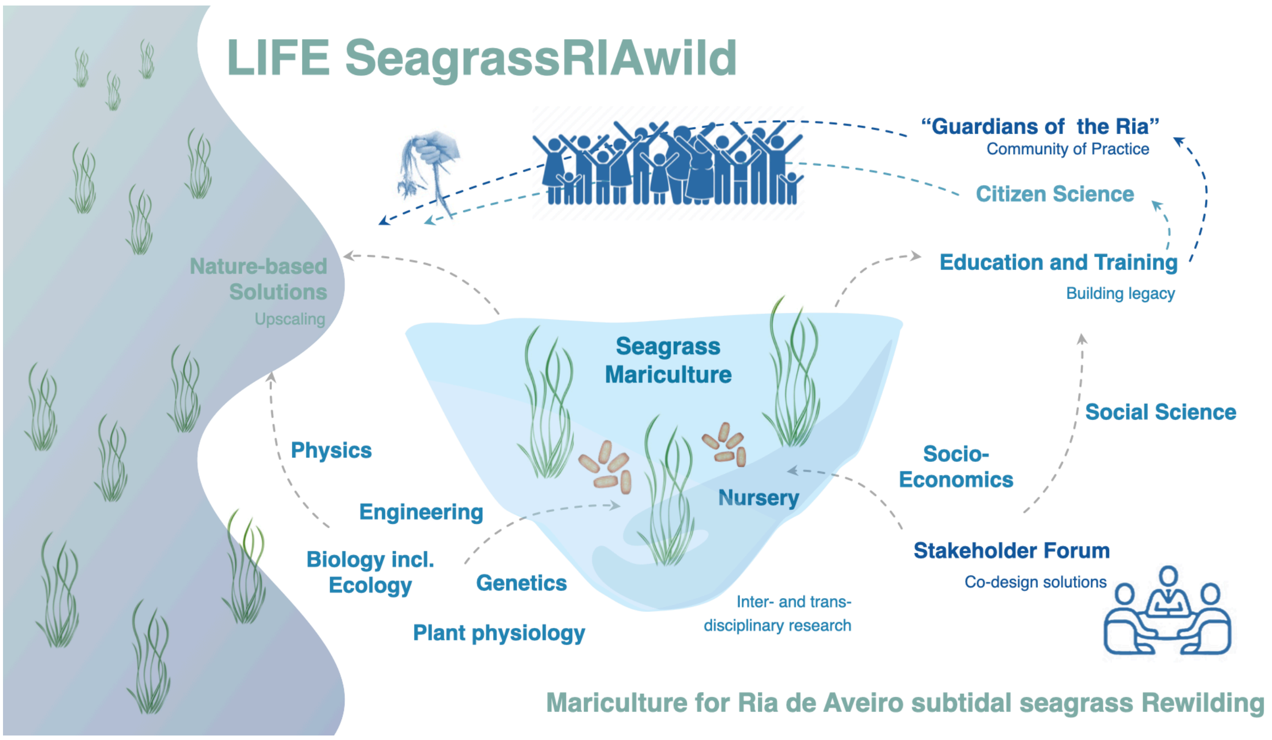

Figure 2 - LIFE SeagrassRIAwild concept infographic

Social Awareness and engagement

Social-participatory approaches are crucial to understand perceptions of social acceptance of conservation measures of the marine environment. However, increasing community awareness has been demonstrated insufficient to motivate widespread action[7]. For conservation measures to have an impact there is often the need for a sustained commitment to restoration efforts and collective action of the local community both through formal and informal institutions[7]. For this reason, co-creation with local stakeholders underpins the project philosophy and will pave the way to involve the local citizens and key stakeholders as custodians of their own natural capital and ensure a community-based approach to restoration for post-project sustainability.

The preparatory phase of the project will consist mainly of the development of a Local Stakeholders Forum, which will facilitate the involvement and engagement of academia, authorities, management agencies, local administration, end-user associations and citizens in the co-design, prioritization and implementation of restoration actions, in a collective mobilization towards a common goal which in our case is to demonstrate that protection and restoration of marine ecosystem could be attained at a large scale using targeted and adaptable Citizen Science initiatives and NbS that are sensitive to local contexts.

This social awareness platform will catalyse the engagement of volunteers for Citizen-Science restoration efforts, for which they will receive training in this preparatory phase. After this Community of Practice (CoP) is functional and volunteers engaged and capacitated for the foreseen restoration measures, the implementation phase of the project will follow. Sharing experiences of “Guardians of the Ria” network (detailed below) with restoration volunteers will also foster their engagement and assure the project legacy. The ultimate aim of establishing a CoP is to lay the foundations for long-term sustainability of the project legacy.

Seagrass Mariculture

The first challenge for the project derives from the current conservation status of the species. ***Z. marina*** has nearly or completely disappeared from most Portuguese estuaries and coastal lagoons, and therefore large, healthy meadows suitable as donors for system-wide restoration efforts do not exist. The solution to Q1 (How to minimize donor impact for large-scale restoration in Ria de Aveiro?) will be seagrass mariculture, which has recently been proposed as a suitable solution to scale-up restoration efforts, providing the infrastructure and techniques to sow, plant, grow, and collect seeds or plants. Going from plant-based to seed-based restoration to domestication-based rewilding, the scale of the restoration effort may increase while maintaining low donor damage[8]. Seagrass mariculture will require relatively sheltered conditions, with good water circulation and some nutrient supply, enough light and a sufficiently low frequency of extreme events[8]. While small scale seagrass mariculture experiments have been successful, highlighting its potential[9], to our knowledge scaling up has yet to be attempted and will be a required step for large-scale restoration efforts worldwide. The development of such a facility will be of paramount importance for regional, national and even EU *Z. marina* restoration efforts, as it will represent an available biomass standing stock for rewilding, and an annual source of seeds.

For that purpose, a former salt pan (with an overall area of 26 Ha, Figure 3), property of UAveiro, was made available by the institution for this purpose, and will therefore be recovered and repurposed for seagrass mariculture in WP3. Native, intertidal ***Z. noltei*** meadows exist in the vicinity, confirming the suitability of local environmental conditions for seagrasses. Having been decommissioned for decades, the infrastructure will require full rehabilitation. The available area will be divided into smaller (4 Ha), independent tanks to allow mariculture of seagrasses from different donor systems and be prepared for an incremental colonization process. All engineering will rely on traditional salt pan building methods, with dried sediment retention walls, which will be covered by native saltmarsh plants (grown in hydroponic systems available at ECOMARE UAveiro

[7] Howard, T. M., & Alter, T. R. (2019). Framing community engagement. In *Community-based control of invasive species* (pp. 74-83). Clayton, Australia: CSIRO Publishing

[8] van Katwijk, M.M., et al., *Rewilding the Sea with Domesticated Seagrass.* BioScience, 2021. **71**(11): p. 1171-1178.

[9] Balestri, E. and C. Lardicci, *Nursery-propagated plants from seed: a novel tool to improve the effectiveness and sustainability of seagrass restoration.* Journal of Applied Ecology, 2012. **49**(6): p. 1426-1435.

facility) for stabilization. Good water circulation will be ensured, and sluices installed to permit water height regulation, essential for this subtidal species.

LIFE SeagrassRIAwild proposes not only a paradigm change in seagrass restoration, but also a societal innovation process to a new socio-ecological reality. Salt pans, once a profitable occupation, have been neglected for decades, abandoned or converted into aquaculture facilities. The same way agricultural fields are planted and harvested by farmers, former salt pans can easily be repurposed for mariculture, and seagrass crops may in the future represent an income for sea farmers.

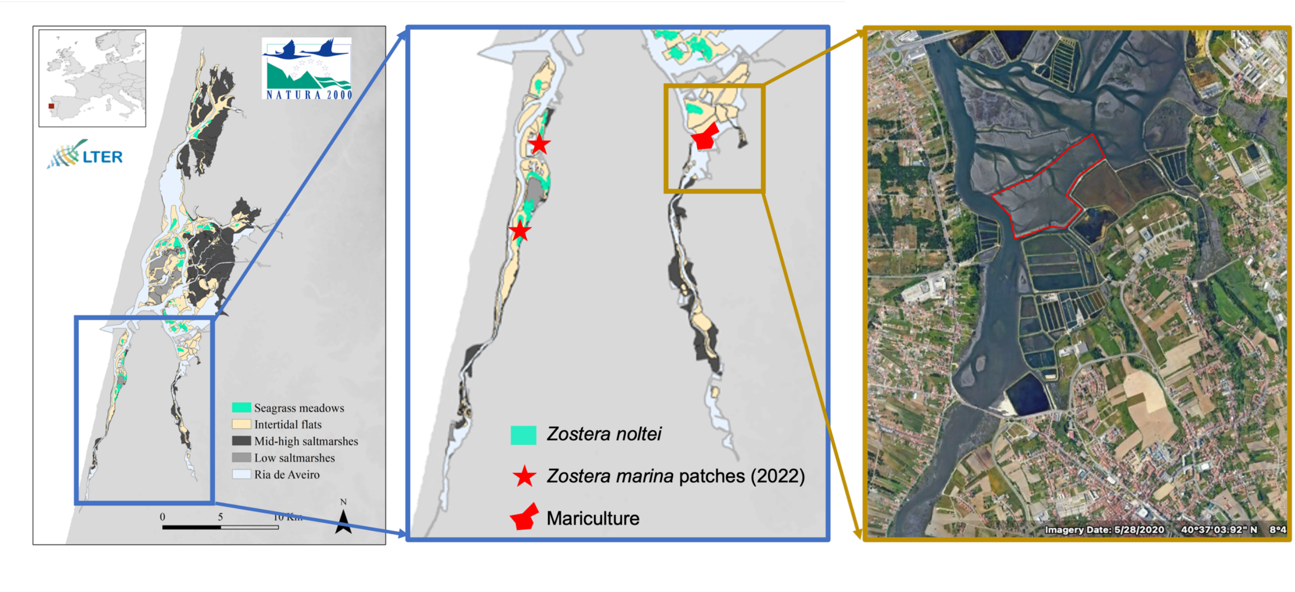

Figure 3 – Ria de Aveiro lagoon (Portugal) and Zostera *sp. seagrass meadows; Location of the current* Zostera marina *patches; and Location of the future seagrass mariculture.*

Once the infrastructure is finalized, the seagrass mariculture will be implemented. Plants will be sourced from the nearest healthy and robust populations north and south from the Ria de Aveiro, namely from the Rias de Vigo (UVIGO, Figure 4) and the Óbidos Lagoon or the Sado Estuary (authorization granted for Spain, authorization from ICNF pending on donor meadow evaluation for Portugal). Potential donor meadows will be thoroughly characterized (area, shoot density, biomass, coverage area), associated microbiome, photosynthetic efficiency (PAM fluorometry) and genetic diversity, to assure its conservation status and viability as donors. While no genetic comparison of *Z. marina* populations from the three systems exists, a study on *Z. noltei* reported differentiation between northern (Vigo and Aveiro and Mondego) and Southern populations (e.g., Sado and Ria Formosa), attributing it to dominant currents[10]. Genetic factors have long been invoked to be crucially important for local seagrass resilience and hence, transplant success. Genetic diversity, in particular, was shown to positively affect productivity and recovery after stress in experimental and natural settings [11]. To ensure that donor beds are genetically diverse, prior assessments on the clonal and genetic diversity are planned. Although few data is available, it is also likely that seagrass plants are locally adapted to their

[10] Diekmann, O.E., et al., *Popoulation genetics of Zostera noltii along the west Iberian coast: consequences of small population size, habitat discontinuity and near-shore currents.* Marine Ecology Progress Series, 2005. **290**: p. 89-96

[11] Reusch, T.B.H., et al., *Ecosystem recovery after climatic extremes enhanced by genotypic diversity.* Proceedings of the National Academy of Sciences of the United States of America, 2005. **102**(8): p. 2826-2831.

environment[12] hence the genetic characterization of putative donor beds along with matching their phenotypic traits prior to large scale transplantation is important. For genetic characterization, a large number of custom-made genetic markers (SNPs, gene linked microsatellites) tailored for specific genes such as light harvesting genes /heat shock protein encoding genes and transcription factors can be rapidly developed, owing to the availability of the full *Z. marina* genome[13]. PCR-based methods use a tiny bit of leaf and can hence non-destructively follow transplants over several years and possibly, link transplant success or failure to genetic factors. At the same time, plants from the nurseries that perform well might share attributes that make them particularly stress resilient and / or suitable for transplantation. In order to identify whether such traits have a genetic basis, genome scans can be used. The use of multiple donor populations will also minimize the risk of any possible miss adaptation of plants from a specific donor site.

Z. marina restoration methods have evolved from more destructive methods (sods, requiring a 1:2 proportion of donor area) to current successful transplanting densities of around 5 shoots/m2 or lower. **LIFE SeagrassRIAwild** will take advantage of the associated partner's (SDU) optimized transplanting methods[3] to maximize gain from minimum donor meadow impact. We propose to colonize 1 Ha of mariculture with as little as 10 m2 of donor meadow area, which through vegetative growth will increase density, expecting to reach natural eelgrass patch shoot density within 24 months[3]. The expected 1000-fold increase within two years will support the incremental expansion of mariculture populations, the onset of system-wide restoration efforts and the optimization of nursery processes.

Figure 4 – Donor Z. marina meadow at San Simon, Vigo.

[12] Hammerli, A. and T.B.H. Reusch, *Local adaptation and transplant dominance in genets of the marine clonal plant Zostera marina.* Marine Ecology Progress Series, 2002. **242**: p. 111-118.

[13] Olsen, J.L., et al., *The genome of the seagrass Zostera marina reveals angiosperm adaptation to the sea.* Nature, 2016. **530**(7590): p. 331-+.

Seagrass Nursery

After successful colonization of the mariculture, **LIFE SeagrassRIAwild** will optimize processes for maximization of mariculture exploitation. Traditional restoration involves the harvesting of donor seeds or plants and subsequent seeding or planting. Plant-based restoration involves translocation and planting; seed-based restoration requires an additional processing step of seed harvest, maturation and storage. This latter processing step allows for treatments like disinfection (sterilisation), removing invasive species, dormancy breakage, and seed coating[8]. In WP4, a nursery facility will be built in ECOMARE UAveiro, with flowthrough water circulation, aeration and controlled temperature to allow mid-term seed maturation and storage. Seed harvest, maturation, storage and germination processes will be optimized under controlled conditions (ECOMARE UAveiro nursery facility), aiming to attain a seasonal seed supply for transplanting purposes. State of the art methodologies for the maturation and storage will be implemented and optimized, acknowledging the expertise shared within the Global Seagrass Nursery Network (GSNN).

Seagrass rewilding

The goal of rewilding the Ria de Aveiro with *Z. marina* will rely on the combination of technology, scientific knowledge and social engagement. To minimize the risk of significant impacts for the mariculture population, in each transplanting season (spring/summer) starting from year 4, a maximum of 1% of the mariculture colonized area will be available for transplantation. Harvested shoots will support two distinct purposes, the first being the expansion of the mariculture colonization (WP3). This will occur both passively, through vegetative growth and seed dispersion, and actively through yearly self-feeding transplantation measures. The other, and main purpose will be the Ria de Aveiro rewilding efforts with *Z. marina* (WP5). Rewilding efforts will encompass two distinct, parallel approaches, one more conservation oriented (Citizen Science transplantation events) and one combining conservation and management (NbS deployment). For both purposes, a hydrodynamic modelling task will precede the operational phase. For this purpose, we will use Delft3D open-source model. This is a three-dimensional (3D) hydrodynamic, sediment transport and bottom evolution model[14]. The hydrodynamic implementation, calibration and verification of Delft3D in Ria de Aveiro has been previously performed by the UAveiro team[15], and will evaluate the best possible locations for the transplant activities. A set of objective risk evaluation criteria will be defined (currents, water depth, turbidity), and potential locations serialized, with restoration efforts prioritized in sites with the highest success probability. These previous studies support the use of Delft3D as an adequate numerical model to be used also to evaluate vegetation-induced momentum loss and the vegetation influence on turbulence generation and dissipation[16]. The Delft3D implementation will assess different layouts for NbS deployment (e.g., width and length) and characteristics of the vegetation patch (e.g., density, diameter, height) on the sediment deposition processes for green infrastructure deployment purposes (HAEDES).

Conservation oriented restoration activities will rely on validated methods for *Z. marina* transplantation[3], for which team members will receive and update training at SDU. Depending on potential transplant site conditions, transplant methodology (planting, seeding or a combination of both methods) will be optimized. Transplant sites with low-tide water column heights below 50 cm will be prioritized, to allow for pedestrian transplantation. Actions will be co-implemented with local communities, citizen science and capacity building activities for the local population, assuring seagrass awareness and contributing to restoration actions sustainability along the project and beyond.

In parallel, **LIFE SeagrassRIAwild** will explore innovative nature-based solutions to potentiate synergistic effects of seagrass conservation efforts and system management needs. **LIFE SeagrassRIAwild** will evaluate

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[14] Lesser, G.R., et al., *Development and validation of a three-dimensional morphological model.* Coastal Engineering, 2004. **51**(8-9): p. 883-915

[15] Lopes, C., Sousa, M., Ribeiro, A., Pereira, H., Pinheiro, J., Vaz, L., and Dias, J. (2022). Evaluation of future estuarine floods in a sea level rise context. Scientific Reports, 12, 8083.

[16] Baptist, M.J. (2005). Modelling floodplain biogeomorphology. *PhD Thesis*, TU Delft, 195 pp

the possible use of seagrass vegetation as a Nature-Based Solution (NbS) to reduce sediment accumulation within navigation channels located inside coastal lagoons. This idea (*VEgetation for sedimentation contROl in NavIgation ChAnnels – VERONICA*) has already been developed by HAEDES at the proof-of-concept level. Operational management of these channels includes regular maintenance dredging operations to allow safe navigation. These operations have an associated cost, significant impact on local fauna and flora, and also increase CO2 emissions. The proposed NbS aims to minimize the need for dredging activities to maintain navigability, while contributing to the overall project objective – restoration of *Zostera marina* in Ria de Aveiro. It is expected that seagrass vegetation at a mature state, implanted along navigation channels margins, will have a sediment accretion effect which will reduce sedimentation within the channels, while increasing biodiversity and restoring seagrass habitat areas, responding to Q2 (How to foster a win-win between seagrass restoration and socio-economic activities?).

Cais da Bestida navigation channel was selected as a case study for this pilot installation, due to known sediment accumulation issues that compromise its access. Also, the channel is in a suitable environment for *Zostera marina* growth and development. Moreover, this NbS will be designed to be scalable and reproducible in other navigation channels with similar environmental characteristics (in Ria de Aveiro and other systems)

Monitoring and Ecosystem Functions and Services recovery

Traditional monitoring (e.g., in-water based surveys) of eelgrass meadows in coastal areas is time and labour intensive, requires extensive equipment, and has low temporal resolution[17]. In the last decade, the utilization of Unmanned Aerial Vehicles (UAVs) has gained popularity in ecological sciences due to their ability to rapidly collect large amounts of area-based and georeferenced data, coupled with Object Based Image Analysis for gaining an improved understanding of eelgrass recover by estimating both cover and biomass[17]. Monitoring of transplant success will rely on this novel monitoring tool, combining remote sensing (using UAV), and innovative automated approaches for seagrass coverage estimation (supervised machine learning), for which dedicated training secondments for UAveiro team members will occur at SDU. Complementarily to remote monitoring methods, seasonal characterization (area, shoot density, biomass, coverage area), associated microbiome, photosynthetic efficiency (PAM fluorimetry) and genetic diversity will occur to evaluate the evolution of transplanted population, by comparison with the donor mariculture meadow.

Evaluation of ecosystem functions and services recovery in restored areas will be four-fold, relying on benthic and ichthyofauna biodiversity and production, blue carbon storage and sediment accretion, for a holistic overview of the impact of seagrass rewilding.

We will evaluate the benthic responses to the restoration measures through analyses of the macrobenthos (metazoans >1mm) community dynamics by measuring biodiversity, community composition changes and associated productivity as a measure of the functioning. We will follow a BACI design, including surveys before-implementation and after-implementation in the following years. Considering the somewhat invasive nature of the sampling procedures and the time needed for the recovery of the benthic communities (2 to 7 years[18], the after-implementation sampling will only occur after the first year of the successful transplant/restoration, i.e., once the seagrass has reached natural shoot density. This evaluation will also include the unvegetated sediments at both time periods to set reference conditions spatially and temporally. The benthic communities

[17] Svane, N., et al., *Unoccupied aerial vehicle-assisted monitoring of benthic vegetation in the coastal zone enhances the quality of ecological data.* Progress in Physical Geography: Earth and Environment, 2022. **46**(2): p. 232-249

[18] Borja, A., et al., *Medium- and Long-term Recovery of Estuarine and Coastal Ecosystems: Patterns, Rates and Restoration Effectiveness.* Estuaries and Coasts, 2010. **33**(6): p. 1249-1260

evaluation will consist of 1) biodiversity patterns assessment, including functional indicators (i.e., functional complementary and identity indicators[19]; 2) community composition and structure changes; 3) trend analyses on key species and 4) production measurements, including turnover rates[20]. These structural and functional data on the communities will provide information on the relevant ecological functions that can be linked to ecosystem services[21]. Examples of such functions and links to services are the benthic productivity itself as food availability for other trophic levels (including fish nurseries) and proxy of food provisioning services of the system, contribution to nutrients and other materials cycling, bioturbation as a path for cycling but also on the potential interactions with seagrass establishment itself, among others[21]. We will also tackle the effects of the environmental constraints on these benthic community indicators to identify key drivers and state-pressure relationships. Altogether, the collected information will support the quantification of the role of the Seagrass Restoration as Nature-Based Solution, using habitat restoration, itself with several associated services (e.g., coastal protection, blue carbon, habitat provisioning) while promoting biodiversity locally as natural capital for several other benefits.

Coincidently, seagrass meadows provide adequate habitats for a high number of marine and estuarine fish species[22], some with high conservation importance such as the European eel *Anguilla Anguilla* (IUCN, Critically Endangered), and the syngnathids short-snouted seahorse *Hippocampus hippocampus* (IUCN, Data Deficient, Near Threatened in the Mediterranean) and long-snouted seahorse *Hippocampus guttulatus* (IUCN, Data Deficient, Near Threatened in the Mediterranean). Structured habitats such as seagrass meadows and biogenic reefs often present higher species densities, especially when compared with more homogenous estuarine intertidal areas[23]. In addition, estuaries also provide a key nursery role for several marine fish species, most with high commercial and ecological value. To evaluate the impact of seagrass presence in fish fauna, two sites with unvegetated bottom and two restoration sites will be monitored. A high temporal resolution (3 years), including sampling at all sites before seagrass transplants (first year), will ensure that the expected increase in ecological complexity in transplanted sites will be consistently measured (2 years). Sampling will be performed seasonally to encompass the natural variability in species abundance and population dynamics typical of temperate estuarine ecosystems, using a combination of fyke nets and video sampling. Data analyses at the fish assemblage level will include standard measures of diversity: Species richness, Shannon-Wiener diversity, and Pielou's Evenness, and community composition (species individually and grouped by habitat use guilds) between sites, seasons and years.

Sediment accretion capacity of NbS solutions will be evaluated by monitoring of the Sediment/Bathymetry component through bathymetric surveys which will be performed by a subcontract to AtlanticLand company. A first bathymetric survey will be carried before the implementation of the project (reference situation); a second bathymetric survey will be performed immediately after the field experiment implementation (post-implementation); regular bathymetric surveys will be performed every six months until the end of the project. The monitoring of the Hydrodynamic component will be performed through the deployment of current meters and water level sensors. The instruments will be positioned in two characteristic locations along the channel cross-section: one measuring point after and one before the NbS solution. This setup will be repeated for the

[19] Dolbeth, M., S. Doledec, and M.A. Pardal, *Relationship between functional diversity and benthic secondary production in a disturbed estuary.* Marine Ecology Progress Series, 2015. **539**: p. 33-46

[20] Dolbeth, M., et al., *Secondary production as a tool for better understanding of aquatic ecosystems.* Canadian Journal of Fisheries and Aquatic Sciences, 2012. **69**(7): p. 1230-1253

[21] Daam, M.A., et al., *Establishing causal links between aquatic biodiversity and ecosystem functioning: Status and research needs.* Science of the Total Environment, 2019. **656**: p. 1145-1156

[22] Orfanidis, G.A., et al., *Fish Assemblages in Seagrass (Zostera marina L.) Meadows and Mussel Reefs (Mytilus edulis): Implications for Coastal Fisheries, Restoration and Marine Spatial Planning.* Water, 2021. **13**(22)

[23] Franca, S., M.J. Costa, and H.N. Cabral, *Assessing habitat specific fish assemblages in estuaries along the Portuguese coast.* Estuarine Coastal and Shelf Science, 2009. **83**(1): p. 1-12.

reference situation. A real-time monitoring of the Hydrodynamic component is expected to last until the end of the project. The assessment of the NbS compared to the reference situation will enable the design of a success evaluation matrix. This matrix considers the following parameters: transplant success, implementation cost, complexity of the implementation (e.g., divers, ship vessel) and sedimentation rate in the navigation channel. We will also assess the optimization of plant transplant disposal to both consider the cost/effort of the NbS implementation and the capacity of the donor meadows. The overall field monitoring plan will be continuous, starting 18 months before the implementation of the project and it will continue until the end of the project.

Coastal wetlands, including seagrasses, salt marshes and mangroves are among the most relevant carbon sinks (blue carbon ecosystems), with a large contribution to global carbon sequestration[24]. Therefore, management and restoration of blue carbon ecosystems have great potential to contribute to sequester carbon. Blue Carbon storage will be assessed at restored areas at Ria de Aveiro, both in the mariculture and in the lagoon, and the climate mitigation capacity and potential of the restored meadows will be estimated. Blue carbon stocks in restored meadows will be compared with bare bottom areas, allowing to highlight the restoration contribution and global potential to mitigate climate change.

A socio-economic assessment of the restoration program will be performed, through a Cost-Benefit analysis involving the Community of Practice (CoP), ensuring the engagement of the local communities to improve the coastal area environmental performance, for replication and scaling up.

Environmental education, training and capacity building towards project legacy

The extent of recolonized area will depend on available donor transplant units (which will tend to be in surplus through the incremental colonization of the mariculture area) and on volunteers' effort available. Particularly where resources are lacking and/or long-term and large-scale restoration efforts are required, the value of citizens to assist with implementation of co-designed measures is crucial for the success of conservation measures. For that purpose, **LIFE SeagrassRIAwild** will invest in environmental literacy (WP7), through pedagogic visits to the mariculture engaging local schools, cultural and sports associations. These actions will support the legacy of the project, by supplying the necessary social engagement to continue restoration efforts beyond the project duration. The involvement of the NGO Ocean Alive, Portugal's first co-operative dedicated to ocean protection through marine education, awareness-raising campaigns for the protection of the seagrass meadows of Sado Estuary, will be of paramount importance for **LIFE SeagrassRIAwild,** aiming to replicate their successful strategy in the Ria de Aveiro and responding to Q3 (What are best practices to promote public endorsement and involvement in the restoration program?). In addition, a capacity building program inspired in the innovative and successful one ongoing in Sado Estuary by Ocean Alive, "Keepers of the Sea", will be developed and implemented at Ria de Aveiro. A local community leader (fishing women or bait diggers) will be recruited and trained, will recruit five more "Sea guardians", building a **Guardians of the Ria** network which will have three different roles: 1) seagrass monitors, contributing to the mapping of seagrasses (using a GPS); 2) awareness agents to their peers; and 3) marine guides, participating in education and training activities of **LIFE SeagrassRIAwild**. These activities will provide a multiplier effect on seagrass awareness in the local communities, while being a crucial part of the project legacy and After-LIFE sustainability plan.

LIFE SeagrassRIAwild will also foster the project legacy through the organization of training courses for researchers, technicians and restoration practitioners, which will substantiate the replication of activities at a regional, national or international level, supported by the seagrass mariculture infrastructure, a legacy of the project, which will perdure in time and be made available for potential restoration efforts.

Gender dimension

[24] Nellemann (2009). ISBN: 8277010605

LIFE SeagrassRIAwild aims to be consistent with the European Gender Equality Strategy 2020-2025 and specific aspects of the project where the gender dimension will be incorporated into the projects R&I content include: i) the work which will be performed will include consideration of gender balance and gender equality in each of the main activities and sectors identified. The proposed restoration efforts will acknowledge the gender differences and will include adjustments aimed at equal opportunities; ii) the representative and gender-balanced stakeholder groups will play a role in developing the Stakeholder Forum

Ethics & security

LIFE SeagrassRIAwild methodology, following a transdisciplinary approach, involves the engagement of human participants as volunteers for events (e.g., workshops, training activities), restoration efforts and personal data (e.g. questionnaires). All participants in co-development activities are volunteers and Informed Consent will be provided, to be signed by each participant. The anonymisation of the respondents to the questionnaires is assured, in line with national and EU regulations on data protection, and the access to this data is restricted, in line with Directive 95/46/EC, which specifies that personal data must be processed according to certain principles and conditions that aim to limit the impact on the persons concerned and ensure data quality and confidentiality (data security). The field work will not raise ethical concerns related to Environment safety and the consortium will involve and engage the relevant governmental authorities regarding water and nature management and conservation. The use of Artificial Intelligence (e.g., machine learning approaches) will not raise ethical concerns, as humans or personal data will not be involved in artificial intelligence procedures.

LIFE SeagrassRIAwild will follow closely the Open Science practices enabling (i) research output management; measures to ensure reproducibility of research outputs in both experimental and desktop studies; (ii) providing open access to research outputs – all scientific outputs of the project will be published in open access journals and project report and recommendation will be freely accessible online; (iii) open peer-review process will be mandatory for the project publication and dissemination strategies; (iv) involving all relevant knowledge actors such as direct beneficiaries of the project, local and national environmental, planning and innovation agencies and public at large through targeted dissemination strategies. The training component of the project will focus on direct beneficiaries engaging also local communities.

Exploitation measures during the implementation of **LIFE SeagrassRIAwild**, and the exploitation of results and sustainability beyond the project will follow the European Code of Conduct for **Research Integrity principles** of *Reliability, Honesty, Respect and Accountability* and the **FAIR principles** of *Findability, Accessibility, Interoperability, and Reusability* for knowledge and data sharing. Intellectual property rights will follow the guidelines on EU trade policy and intellectual property by the European Commission. This will ensure coherence of practices and a legacy towards the sustainability of **LIFE SeagrassRIAwild** results, products, and services.

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1.5 Upscaling results of other EU funded projects

Upscaling results of other EU funded projects

Explain if and how the proposal builds on or up-scales results of other EU funded projects.

LIFE SeagrassRIAwild will build upon previous UAveiro team projects, namely **EU FP7 LAGOONS** which developed a Science-Policy-Stakeholders interface which facilitated participatory governance of the system based on public mobilization and engagement. Furthermore, the numerical modelling developed for habitat suitability in its scope will assist on the planning of restoration efforts.

LIFE SeagrassRIAwild will also build up on the ecosystem-based management approach to support EU efforts to protect aquatic biodiversity and ensure the provision of aquatic ecosystem services, developed under the scope of project **EU H2020 AQUACROSS**.

Moreover, **LIFE SeagrassRIAwild** will build upon and scale up the findings from **LIFE BIOMARES** (LIFE 06 NAT/P/ 0000192) that successfully performed the preparatory actions for habitat restoration of *Z. marina* meadows to enhance biodiversity at Luiz Saldanha Marine Park, located south from Ria; While specific goals, challenges and conditions are distinct, the lessons learned in LIFE BIOMARES will be of invaluable assistance for the successful accomplishment of project objectives.

LIFE SeagrassRIAwild may also have a positive spill-over effect on Project ***LIFE* ÁGUEDA** – Conservation and Management Actions for Migratory Fish in the Vouga River Basin (LIFE16 ENV/PT/000411), aiming to **re-naturalize river morphology (and restoring/re-creating its associated aquatic/terrestrial habitats)** with special aim on the **European eel,** listed as listed as Critically Endangered in the IUCN Red List of Threatened Species**.** Considering the importance of seagrass meadows for this species, acting as refuge and feeding ground for glass eels, the restoration of this habitat will potentially have a positive effect on the local European eel population, within the same river catchment as Project ***LIFE* ÁGUEDA**.

LIFE SeagrassRIAwild will also build upon and scale up the processes from **Better BirdLIFE** (LIFE17 NAT/DK/000498), in which SDU (Prof. Mogens Flindt) has the responsibility for the development of drone-based bird registrations and creation of new eelgrass meadows in the vicinity of new stone reefs. Methodologies developed within **Better BirdLIFE** may be replicable within **LIFE SeagrassRIAwild,** namely the eelgrass meadow transplantation methods and drone-based monitoring, first developed in previous **NOVAGRASS** project, which aimed to design innovative eelgrass restoration techniques specific for estuaries and coastal waters in Europe.

LIFE SeagrassRiawild will strive to build upon the lessons learned by previous LIFE project aiming at seagrass restoration efforts (**LIFE SeResto,** LIFE12 NAT/IT/000331), dealing with Blue carbon ecosystems (**LIFE Blue Natura**, LIFE14 CCM/ES/000957) while looking to establish synergistic efforts with ongoing ones, namely **LIFE Recreation ReMEDIES** (LIFE18 NAT/UK/000039) and **LIFE ADAPTA BLUES** (LIFE18 CCA/ES/001160).

1.6 Complementarity with other actions

Complementarity with other actions

Explain how the project is complementary to other regional, national or international initiatives/activities/projects. How will it integrate the results from these other actions?

LIFE SeagrassRIAwild will benefit from the knowledge and experience gathered in ongoing seagrass *Z. noltei* and *Z. marina* restoration projects at Ria de Aveiro:

BioPradaRia- Restoration, management and conservation of biodiversity and biological resources associated with Ria de Aveiro seagrass;

RemediGrass-Seagrass beds as green and blue infrastructures for ecosystem restoration;

FITA-Fighting towards restoration actions for *Zostera marina* (Linnaeus, 1753) through baseline characterization of local populations historical spatial distribution and population genetics; as well as passive restoration measures applying citizen science;

LIFE SeagrassRIAwild will benefit from and contribute to ongoing or foreseen to start until the 1st of January 2023, related **H2020** and **H Europe** projects coordinated by UAveiro team members, in a synergistic and potentiator effect to maximize impact and scale-up results, while enabling efficient knowledge transfer from established networks to the proposed work:

BESIDE ERA Chair (2021-2026) – aim to reinforce and consolidate at UAveiro research expertise in Environmental Economics and Natural Resources. It is an ERA-Chair on Innovation strategies for institutional, behavioural, critical and adaptive economics towards sustainable development, management of natural capital and circular economy**.**

RESTORE4Cs (2023-2025) aims to provide tools and methodologies to assess pressures and impacts on the status of wetland ecosystems, while maintaining functional biodiversity through conservation and/or