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ARTEMIS

Accelerating the Restoration of Seagrass Meadows in the Mediterranean area through Innovative ecosystem-service based Solutions

Euro-MED0200867

Protecting, restoring and valorising the natural environment and heritage

Methodology for co-creating a Seagrass Credit System Cookbook. Part I

ecoacsa

UN environment programme | Mediterranean Action Plan Barcelona Convention | Plan Bleu | hcmr | ISPRA | MEDSEA | IME | obsam | Comune di Monfalcone | ecoacsa | EY denkstatt | bax | The Green Tank

Project acronym	ARTEMIS
Project title	Accelerating the Restoration of Seagrass Meadows in the Mediterranean area through Innovative ecosystem-service based Solutions
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TERMS & DEFINITIONS

The following terms carry specific meanings within the ARTEMIS Seagrass Credit Framework:

Accreditation area: The intersection between confirmed seagrass presence (*Posidonia oceanica* or *Cymodocea nodosa*, monitored via condition index protocols) and the legally or consensually secured project area. It is the spatial unit across which credits are quantified and issued.

Active restoration: The coordinated efforts by individuals, groups, or states to directly revive the structures and functions of degraded marine ecosystems through targeted interventions, including transplanting, substrate recovery, and genetic-assisted restoration (Telesetsky, 2019).

Additionality: The requirement that a project delivers ecological and financial benefits that would not have occurred in the absence of the project. Additionality must be demonstrated across three dimensions: financial (credit revenues are necessary for project viability), regulatory (the project exceeds legal minimum requirements), and technological or behavioural surplus (use of innovative techniques or community-led stewardship).

Baseline scenario: A qualitative narrative describing the most likely trajectory of ecosystem Extent and Condition in the absence of the project, established at project design and reassessed at least every monitoring period.

Buffer pool: A non-tradable reserve of 20 % of all generated Seagrass Credits, retained as a safeguard against verified reversals (≥ 1.5 % loss in seagrass Condition or Extent attributable to project failure, based on Telesca L., *et al.*, 2015).

Buyer / investor: finances the credit scheme through upfront investment or ex-post credit purchases, creating the financial demand that makes restoration economically viable. In the seagrass restoration context, primary buyer segments include <u>coastal tourism operators, port authorities, marine transport companies, and corporate sustainability departments</u> with CSRD reporting obligations.

Certifier independently verifies that monitoring data are accurate, methodologies have been applied correctly, NECO calculations are valid, and credits represent genuine, additional ecological improvement. In the long term, this role should be fulfilled by an independent third-party auditor registered with the Mediterranean Seagrass Credit Standard.

Condition: The ecological state of the seagrass ecosystem within the accreditation area, evaluated via ecosystem and ecological-based indices for

Posidonia oceanica and *Cymodocea nodosa* meadows, normalised to a 0–1 scale for credit calculation.

Crediting baseline: A dynamic, quantitative reference representing the projected trajectory of ecosystem Condition in the absence of the project, recalculated every monitoring period from data gathered in the negative control area.

EBQI: Ecosystem-Based Quality Index (Personnic *et al*., 2014). A composite ecosystem-based index evaluating the overall functioning of the *P. oceanica* ecosystem across twelve functional compartments, ranging from 0 (worst) to 10 (best ecological quality).

Ecosystem services: The contributions of ecosystems to the benefits used in economic and other human activity (SEEA EA, UN et al., 2021). Primary credited services in ARTEMIS: Global Climate Regulation (or Blue Carbon) and Biodiversity Preservation.

Evaluator: assesses the broader impact of the project — the full biodiversity and ecosystem service improvements — against a credible ex-post counterfactual (the negative control sites), providing the evidence base for long-term credit integrity and the adaptive management signals required at each 5-year crediting baseline update.

Extent: The physically monitored planar surface area (m^2) of the seagrass ecosystem within the accreditation area, disaggregated by ecosystem type.

Leakage: The displacement of anthropogenic pressures (e.g., anchoring, fishing) outside the project boundary due to project activities, resulting in negative impacts on adjacent areas. Quantified negative leakage is deducted from Net Ecosystem Condition Outcomes. Positive leakage is not deducted.

MediSkew: A rapid assessment index evaluating the ecological status of *Cymodocea nodosa* meadows, based on deviation of measured median leaf length from the reference and the skewness of the leaf-length frequency distribution (Orlando-Bonaca et al., 2015), ranging from 0 (best) to 1 (worst condition).

Monitoring period (t): Temporal framework in which the project proponent must track shifts related to ecological, financial and social issues.

Natural Capital Accounting (NCA): A framework for compiling ecosystem data and measuring changes in the stock (Extent and Condition) and flows (Ecosystem Services) of natural capital, which integrate ecosystem service values into accounting systems, aligned with the UN SEEA EA (UN et al., 2021). The ARTEMIS NCA is documented in Deliverable 2.3.1.

Net Ecosystem Condition Outcomes (NECO, eq.m²): The verified net positive change from the baseline in Area-adjusted Condition attributable to the project, for each monitoring period. It includes leakage consideration.

Passive or natural restoration: Protection and management of existing habitats to allow natural ecological recovery without active human intervention. It is also an essential pre-condition for active restoration.

***Posidonia oceanica* Multimetric Index (POMI**, Buia et al., 2004), integrates plant-level and community-level descriptors — including shoot density, percentage of necrotic rhizomes, lepidochronological leaf production, and epiphytic load — weighting each metric according to its sensitivity to the most common Mediterranean anthropogenic pressures (eutrophication, mechanical disturbance, thermal stress). The resulting composite score ranges from 0 to 1.

***Posidonia oceanica* Rapid Easy Index (PREI**, Gobert et al., 2009): The Italian national WFD assessment method, which integrates five descriptors of *P. oceanica* condition: shoot density, lepidochronological rhizome growth, leaf surface area index, non-structural carbohydrate content, and rhizome architecture. Each descriptor is standardised against reference values from minimally impacted meadows and combined into a composite score ranging from 0 to 1.

Pressure Index for Seagrass Meadows (PISM): A structured index quantifying the anthropogenic pressure context of the project site across six categories within a 1 km buffer, adjusted for coastal morphology.

Project developer: designs and implements restoration projects, manages the Project Management Plan, and is responsible for generating verifiable ecological outcomes.

Quality Square Meters (Qm²): The unit of area-adjusted ecosystem condition: $Qm^2 = Extent\ (m^2) \times Condition$ (normalised index value, 0–1).

Reference ecosystem: A real or modelled ecosystem in which natural ecological and evolutionary processes predominantly determine structure, composition, and function, representing the state of minimal human disturbance within the same ecosystem type and context.

Regulator: defines the legal space within which all other participants operate — setting the boundaries of what activities require authorisation, which ecosystems are protected, and what reporting obligations apply. Key regulatory instruments include the EU Nature Restoration Regulation (NRR), the Habitats Directive, the WFD, and national maritime and environmental codes.

Sea steward / local community: manages the restoration site on a day-to-day basis, implements active transplantation and maintenance activities, participates in co-monitoring, and serves as the primary holder of local ecological knowledge. Community co-ownership of this role is essential for FPIC compliance and long-term project legitimacy.

Seagrass Biodiversity Unit (SBU): The primary credit unit: 1 SBU = 1% of net positive change in Quality Square Meters (Qm²). 100 SBU = 1 complete Seagrass Credit (SC).

Seagrass Credit (SC): A tradable, verified unit representing a net positive change in Quality Square Meters in a defined accreditation area, confirmed by independent verification. SCs are not offsets and cannot be used to compensate for ongoing environmental damage.

Significance: contextual attributes that differentiate credits without entering the credit calculation, including key species supported (e.g., *Pinna nobilis*, *Sarpa salpa*), ecosystem service values quantified as per D.2.3.1 (Blue Carbon in t CO_2e; Biodiversity Preservation in €/m²), Natura 2000 designation, and IUCN habitat status.

Standard developer: provides the methodological and certification framework within which credits are defined, measured, and verified. This Cookbook constitutes the ARTEMIS standard developer contribution, designed to be framework-independent and compatible with SD VISta, the proposed EU Nature Credits standard, and IAPB guidance.

Technician / auditor: conducts technical monitoring activities — field ecological surveys, blue carbon sampling, PISM pressure assessments — that generate the primary data underlying credit calculations. Basic components for this role have been developed in the standardised protocols described on D.1.2.1. and D2.3.1. within the framework of ARTEMIS project.

Weighted *Posidonia oceanica* Index (**WePOSI,** Gerakaris and Panayotidis, HCMR, 2021): The Greek national WFD assessment method for the BQE 'Angiosperms', integrating seven descriptors across population, individual, and community biotic levels into an EQR (0–1), with five WFD-aligned status classes (Bad, Poor, Moderate, Good, High). Validated across 70 meadows in the Eastern Mediterranean.

COOKBOOK OVERVIEW

This Cookbook provides a **standardised, transnational framework for generating credible Seagrass Credits in the Mediterranean basin**, covering the full project lifecycle from feasibility assessment through ecological baseline characterisation, monitoring, independent verification, and credit issuance. It serves as a **ready-to-use guide for organisations** — including marine protected area authorities, research institutions, NGOs, municipalities, private companies, and blended-finance intermediaries — seeking to develop **nature credit schemes based on the restoration and conservation of Mediterranean seagrass meadows**, with a primary focus on *Posidonia oceanica* and *Cymodocea nodosa*.

The Cookbook is designed as an **independent methodological framework**, applicable in conjunction with existing and emerging international nature credit standards. This independence is deliberate: different pilot sites operate in different national regulatory contexts, and different credit buyers may have different certification requirements. The **ARTEMIS methodology provides the ecological core that can be adapted to multiple certification environments** without being dependent on any single one.

The document is structured in six substantive sections, followed by a Technical Appendix:

- **Section 1 (Introduction)** provides background, defines the Seagrass Credit unit, and describes the six-phase project cycle.
- **Section 2 (Seagrass Credit Framework)** sets scope, guiding principles, policy alignment, and expected benefits.
- **Section 3 (Applicability Conditions)** establishes eligibility, governance requirements, and credit ownership principles.
- **Section 4 (Seagrass Project Requirements)** defines timelines, spatial boundaries, baselines, additionality, durability, and adaptive management.
- **Section 5 (Seagrass Outcomes)** provides the 12-step quantification methodology from extent mapping to credit pricing.
- **Sections 6 (MRV)** specify monitoring, reporting, and verification principles.
- **Sections 7 (Risks)** introduce risk management requirements.
- **The Technical Appendix** provides detailed assessment protocols for ecosystem and ecological condition indices.

This structure provides a clear, **stepwise approach to the development of seagrass credits**, where each section builds on the previous ones to progressively integrate key concepts, methodologies, and practical applications required for robust and transparent credit generation.

The companion document, Cookbook Part II, addresses the **enabling conditions for the credit system to function in practice**: legal foundations, commercial design, financial planning, and risk management at the business-plan level.

1 Introduction

1.1 Background and Rationale

Seagrass meadows are among the most ecologically significant and economically valuable marine ecosystems in the Mediterranean Sea. *Posidonia oceanica*, as slow-growing, endemic seagrass species, forms structurally complex, three-dimensional habitats that **sustain extraordinary levels of biodiversity, regulate coastal hydrodynamics, stabilise sediments, and act as disproportionately large long-term carbon sinks** relative to their areal extent. Despite occupying less than 0.2% of the ocean floor globally, seagrass meadows may account for up to 18% of total oceanic carbon burial (Duarte *et al*., 2013; Fourqurean et al., 2012; Macreadie *et al.,* 2021). Their global economic value has been estimated at approximately US$6.4 trillion annually (Costanza *et al*., 2014).

The EU Nature Restoration Regulation (NRR, 2024) establishes **legally binding restoration targets** for *P. oceanica* and other marine habitats under Article 5, requiring Member States to put in place restoration measures sufficient **to progressively improve the condition of degraded marine ecosystems by 2030**. The EU Biodiversity Strategy 2030, the Marine Strategy Framework Directive (MSFD) Descriptors 1 and 6, the Water Framework Directive (WFD), and the EU Habitats Directive all reinforce the legal and policy mandate for seagrass conservation and restoration. Yet the financial resources currently mobilised through **public mechanisms fall far short of what is needed** to implement restoration at the scale required by these obligations.

The ARTEMIS project (Interreg Euro-MED Programme, Euro-MED0200867, January 2024 – September 2026) was developed precisely to address this financing gap, by **combining active and passive (or natural) seagrass restoration** at four Mediterranean pilot sites — Atzikiari Bay, Crete (Greece); Capo Testa-Punta Falcone, Sardinia (Italy); Cala Blanca, Menorca (Spain); and Bay of Panzano, Monfalcone (Italy) — **with the development of an innovative Seagrass Credit** system capable of mobilising private and blended finance. Deliverable 3.2.1 established the state of the art of market-based instruments applicable to seagrass restoration. The present Cookbook translates that state of the art into **an operational credit generation methodology, grounded in the ecological data, condition indices, and Natural Capital Accounting values** developed across the ARTEMIS scientific programme (D.1.2.1, D.1.3.1, D.2.3.1).

1.2 Seagrass Credit System

Nature credits are considered a more suitable approach than Payment for Ecosystem Services (PES) schemes in the context of the ARTEMIS project, due to the stronger environmental integrity they present. In credit systems, payments are strictly tied to **measurable and verified ecological outcomes**, rather than to actions alone. They require baseline definition, monitoring, and independent verification, ensuring that financial flows are directly linked to tangible gains in ecosystem conditions. Meanwhile, PES schemes may compensate for maintaining practices, they do not always guarantee that real ecological improvements will occur. Table 1 presents the main differences between PES and Nature Credits.

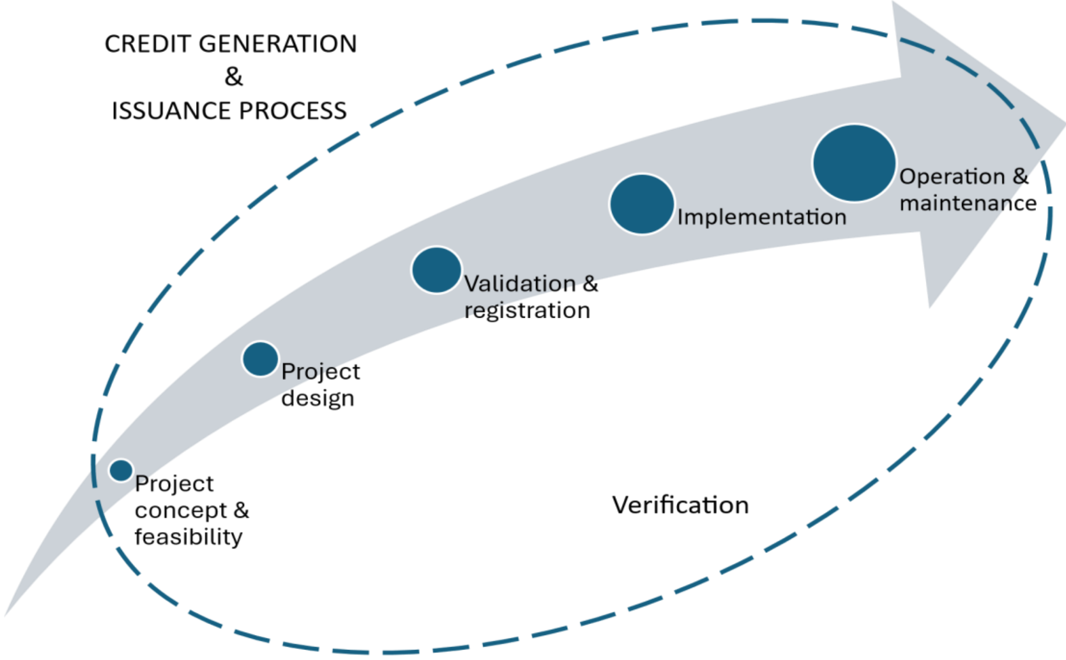
In addition, nature credits are more effective in **scaling private investment due to their standardization** (through the Natural Capital Accounting System, presented in D2.3.1) and tradability. By converting ecological improvements into comparable and trackable units, they create a clear value proposition for investors and companies. This improves transparency, reduces uncertainty, and enables participation in broader environmental markets, making them a more robust mechanism for financing large-scale nature restoration.

Table 1. PES VS Nature Credits

Aspect	Payment for Ecosystem Services (PES)	Nature Credits
Definition	Voluntary contract where beneficiaries pay providers for ecosystem services	Market-based instrument where measurable ecological improvements are quantified and converted into tradable credits
Payment logic	Payment for actions or practices (e.g., conservation, management)	Payment for verified outcomes (measurable ecological improvement)
Conditionality	Conditional on service provision, often ongoing	Conditional on demonstrated additional and measurable impact
Measurement	Often limited or indirect measurement of outcomes	Requires quantification, monitoring, and verification of ecological change
Standardization	Context-specific, less standardized	Increasingly standardized units (credits) enabling comparability
Market structure	Often local or public schemes	Emerging global market mechanisms with registries and certification

1.3 Project Process

The Seagrass Credit generation process consists of six phases, **from initial concept to credit issuance, designed to ensure additionality, durability, and verifiable ecological outcomes** (Figure 1). The process is explicitly iterative: findings at any phase may require revisiting earlier phases.



1. **Project concept and feasibility**: A preliminary site assessment identifies the target seagrass species and ecosystem type; establishes legal or consensual tenure arrangements; characterises vulnerability drivers (anchoring, eutrophication, warming); confirms minimum viable scale (≥100 m^2 recommended for commercial credit issuance); and maps the stakeholder landscape. Feasibility is confirmed once eligibility criteria are preliminarily met.
2. **Project design**: A Project Management Plan (PMP) is developed, integrating baseline assessments (extent mapping, condition indices, pressure assessment); description of active and passive restoration activities (further developed in D1.3.1); additionality demonstration; spatial boundary delimitation in GIS (reference, project, accreditation, and leakage areas); stakeholder engagement and Free, Prior and Informed Consent (FPIC) process; benefit-sharing mechanism; and monitoring plan.
3. **Validation and registration**: The PMP is submitted for peer review, confirming eligibility, additionality validation, monitoring design robustness, and stakeholder engagement. During 2026–2028, an ARTEMIS expert panel interim review process is applied. Upon approval, the project is registered and the crediting period begins (at least 30 years, in 10-year cycles).
4. **Implementation and monitoring**: After active and passive restoration commences, annual monitoring of Condition, Extent, leakage, and disturbance events are conducted per the PMP. Year 0 monitoring establishes the baseline.

5. **Operation and maintenance**: Ongoing activities, adaptive management, benefit-sharing disbursements, and credit-related reporting throughout the crediting period.
6. **Verification and credit issuance**: Independent verification every 10 years confirms ecological gains (NECO in eq.m^2). Verified gains are converted to Seagrass Credits, buffer pool applied, and net credits issued and registered. Ecosystem service values are reported as Significance attributes to estimate credit prices, due to the lack of a market-based price.

2 Seagrass Credit Framework

This chapter presents the scope, objective and limitations of the methodology applied for the development of a seagrass credit. It also describes basic elements of the credit system, the guiding principles in which the methodology lies on, a brief resume of the policy framework, and the social benefits derived from seagrass ecosystems.

2.1 Scope, Objective and Limitations

The methodology of the **Seagrass Credit System establishes a standardised framework for the quantification, generation, and valuation of Seagrass Credits in the Mediterranean basin**, focused on *Posidonia oceanica* and *Cymodocea nodosa* ecosystems, but also scalable to other marine ecosystems. It supports active and passive restoration initiatives and covers all project phases from feasibility to credit issuance. The methodology is explicitly independent of any single certification standard, applicable within multiple international frameworks — including the SD VISta Nature Framework (Verra, 2024), the EU Nature Credits Roadmap, and any future Mediterranean-specific standard — **ensuring flexibility as the nature credit market matures**.

The primary objective is to provide a scientifically rigorous, transparent, and market-ready system for **converting verified ecological improvements in seagrass extent and condition into tradable credit units**, enabling result-based private and blended financing for Mediterranean seagrass restoration. It also estimates the value of credit units compared to the value that restoration projects offer to society through the **monetary valuation of ecosystem services**. This approach provides a price estimation tool in the absence of a full-implemented nature credit market system.

Acknowledged limitations:

- **The methodology does not aim to deliver a comprehensive biodiversity assessment**. It provides a transparent, operationally representative ecological quality metric calibrated to the WFD/MSFD monitoring framework. Full biodiversity characterisation (fish assemblages, Shannon–Wiener diversity, benthic macrofauna — as documented in D.1.2.1) is reported as Significance context information, not as a credit calculation input.
- **The methodology is currently validated for Mediterranean seagrass species** (*P. oceanica, C. nodosa*). Adaptation for other European seagrass species (*Zostera noltei, Z. marina*) or ecosystems require documented methodological justification and appropriate reference values.
- **The values for credit issuance and prices presented in this report have been obtained by using several assumptions** that allow

establishing a robust Credit System, but that needs to be validated when further monitoring data is available. The same situation can be attributed to the passive restoration exercise here described.

- **The current Seagrass Credit System has been developed as an independent framework**, but flexible enough to be aligned with other international credit standards. This independent role or not should be validated in further steps.
- **The governance role** around the Seagrass Credit System lies over the ARTEMIS project during its lifecycle. Future decisions need to be taken to ensure the governance role linked to the system.

2.2 Seagrass Credit Description

A Seagrass Biodiversity Unit (SBU) is an area-based asset representing a verified improvement in the ecological state of seagrass meadows. It is defined as:

1 SBU = 1% of net positive change in Quality Square Meters (Qm^2)

where Qm^2 = Extent (m^2) × Condition (normalised ecosystem condition index, 0–1).

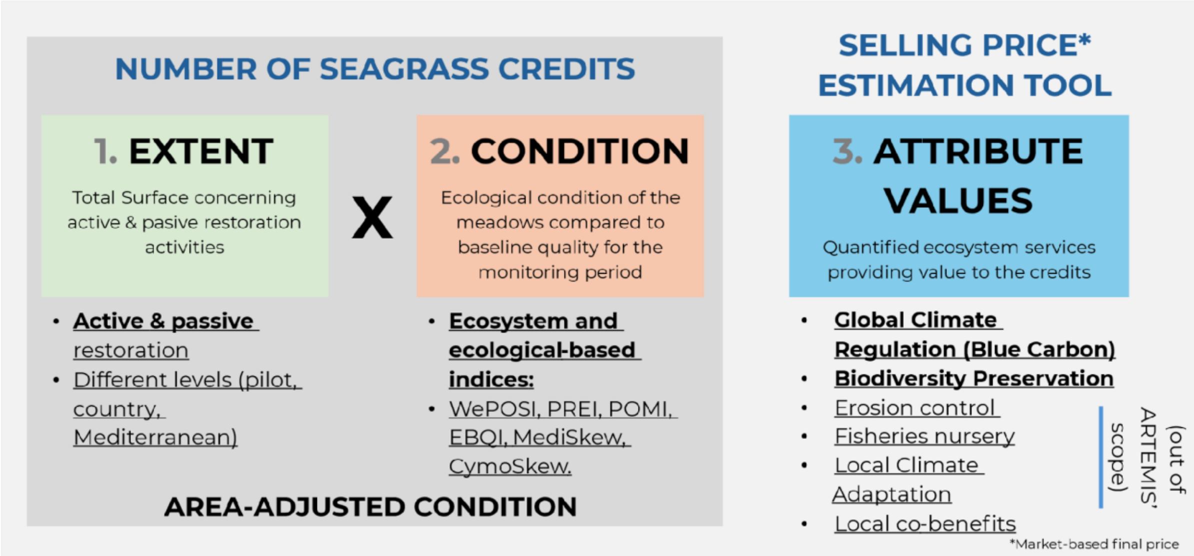
One complete Seagrass Credit (SC) = 100 SBU, representing a full net positive change in Qm^2. The credit is therefore jointly determined by the spatial scale of restoration (Extent) and the ecological improvement achieved (Condition change).

Three components characterise every Seagrass Credit:

- **Extent**: the physically monitored planar surface area (m^2) of the seagrass accreditation area, confirmed by geo-referenced cartographic survey.
- **Condition**: the ecological state of the seagrass ecosystem, evaluated using standardised WFD-compliant biological quality indices — EBQI and WePOSI for Posidonia oceanica; MediSkew for Cymodocea nodosa — normalised to a 0–1 scale.
- **Significance**: contextual attributes that differentiate credits without entering the credit calculation, including key species supported (e.g., *Pinna nobilis, Sarpa salpa*), ecosystem service values quantified as per D.2.3.1 (Blue Carbon in t CO_2e; Biodiversity Preservation in €/m^2), Natura 2000 designation, and IUCN habitat status.

Seagrass Credits are not offsets. They represent positive, additional, and durable investments in marine nature, issued only after independent, ex-post verification of ecological gains. They must not be used to compensate for ongoing environmental damage. **A 20% buffer pool is retained from all**

issued credits to cover verified reversals (≥10% loss in Extent or Condition attributable to project failure, based on Telesca L., *et al.,* 2015).



2.3 Guiding Principles

The ARTEMIS framework is structured around three high-level principles, adapted from the International Advisory Panel on Biodiversity Credits (IAPB, 2024) and aligned with SEEA EA (UN, 2021) and SD VISta (Verra, 2024), to the specific ecological and governance context of Mediterranean seagrass restoration:

Principle 1 — Verified positive outcomes for nature

Credits are issued only ex-post, after independent confirmation of ecological gains. Two baseline concepts apply: the Baseline scenario (qualitative narrative of the without-project trajectory) and the Crediting baseline (dynamic quantitative reference, recalculated every 5 years from the beginning of the reporting period, for the negative control area). Durability is ensured through governance, adaptive management, ecological safeguards, and a 20% buffer pool. A reversal (≥ 1.5 % annual loss in Extent or Condition attributable to project failure, based on Telesca L., *et al.*, 2015) triggers buffer credit consumption. MRV is multidimensional: annual monitoring, independent third-party verification every 10 years, and transparent reporting via the ARTEMIS consortia until at least 2028.

Principle 2 — Equity and fairness for people

Free, Prior and Informed Consent (FPIC) is mandatory for all local communities with customary rights in or adjacent to the project area. Benefit-sharing is a design requirement, considering local stakeholders and embedded in the PMP. Data sovereignty is upheld through FAIR + CARE principles[1], ensuring community oversight of project evidence and monitoring data. Ongoing or past disputes over land or resource rights must be disclosed at project design and managed through fair, equitable consultation.

Principle 3 — Good governance for high-integrity markets

Spatial boundaries are GIS-defined and ecologically grounded (Reference area, Project area, Accreditation area, Leakage area). Blue Carbon and Biodiversity Preservation Credits can be bundled into Seagrass Credits or separated based on the requirements of the projects, for instances when biodiversity activities demonstrably exceed those required for carbon outcomes. Governance is collaborative, transparent, and adapted to Mediterranean realities including MPA co-management frameworks and diverse national regulatory contexts.

2.4 Alignment with International Policies

The ARTEMIS Seagrass Credit methodology is aligned with the following key international and European policy frameworks (Table 2). For further information, a policy recommendations report has been developed within the framework of the ARTEMIS project (D4.2.1):

Table 2. Key policy frameworks and relevance to the ARTEMIS Seagrass Credit system

Framework	Mentions *P. oceanica* / restoration	Relevance to ARTEMIS Credits
Kunming-Montreal GBF (2022)	Restoration	Target 2 (restore ≥30% degraded ecosystems by 2030); Target 19 (mobilise $200bn/yr for biodiversity). Global mandate for seagrass credit systems.
EU Nature Restoration Regulation (2024)	Both	Article 5 mandates restoration of *P. oceanica*; Article 10 endorses result-based finance. Primary legal basis for EU seagrass credit demand.
EU Biodiversity Strategy 2030	Restoration	Calls for ≥30% restoration of degraded EU seas; supports EU Nature Credits Roadmap.
EU Habitats Directive (92/43/EEC)	Both	*P. oceanica* as Annex I priority habitat; active restoration supported under Articles 6 and 17.
Water Framework Directive	Implicitly	Five WFD ecological status classes underpin condition framework.
Marine Strategy Framework Directive	Implicitly	MSFD D1 (biodiversity) and D6 (seafloor integrity) require GES for seagrass; ARTEMIS monitoring contributes to national MSFD reporting.
Barcelona Convention / SPA-BD Protocol	Both	*P. oceanica* listed in Annex II; SPAs provide the primary legal protection framework at Mediterranean scale.

[1] https://ardc.edu.au/resource/the-care-principles/

Paris Agreement (Art. 6)	Both	Article 6.4 supports internationally transferred mitigation outcomes; Blue Carbon from seagrass may qualify under NDCs.
SEEA EA (UN, 2021)	Implicitly	NCA framework underlying D.2.3.1; provides the economic basis for credit generation and pricing
CSRD / TNFD / EU Taxonomy	Implicitly	Corporate sustainability reporting requirements create institutional demand for verified nature-positive data; ARTEMIS credits are designed to meet TNFD ocean metrics.

2.5 Social Benefits

Mediterranean seagrass meadows generate a diverse portfolio of ecosystem services quantified in ARTEMIS D.2.3.1. The primary expected benefits from the ARTEMIS credit system include:

- **Global Climate Regulation (Blue Carbon)**: *P. oceanica* accumulates carbon at 1.24–26 Mg CO_2 ha^{-1} yr^{-1} (ARTEMIS pilot range) with stocks of 79–2838 Mg CO_2 ha^{-1}. Restoration progressively recovers sequestration capacity. Blue Carbon values are reported as Significance attributes and can be separately monetised through compatible carbon credit mechanisms.
- **Biodiversity preservation**: Seagrass meadows support endemic species (*Pinna nobilis*), and rich benthic communities. Restoration improves ecological condition scores and associated fish assemblage metrics (abundance, biomass, Shannon diversity), generating the primary ecological signal underlying Seagrass Credits.

Future developments of the Credit System and its associated NCA system may include other expected benefits from seagrass conservation and restoration:

- **Coastal protection**: Seagrass canopies attenuate wave energy and stabilise sediments, reducing coastal erosion. Restoration of fragmented meadows progressively restores this hydrodynamic function.
- **Fisheries nursery**: Seagrass meadows function as nursery and feeding-habitat for commercially important fish. Recovery of meadow structure generates economic co-benefits for artisanal fisheries communities.
- **Local Climate change adaptation**: Healthy seagrass meadows increase coastal ecosystem resilience to marine heatwaves, sea-level rise, and storm surge — all intensifying in the Mediterranean under current climate trajectories.
- **Local economic co-benefits**: Credit revenues generate employment in ecological monitoring, restoration works, MPA management, environmental education, and sustainable tourism, contributing to the blue economy of coastal communities at pilot sites and beyond.

3 Applicability Conditions

This section presents the eligibility rules, governance requirements, and credit ownership principles.

3.1 Eligibility Criteria

To be eligible for Seagrass Credit generation, a project must satisfy all of the following:

- **Conservation and/or restoration activities**: The project must implement either active or passive seagrass restoration (transplantation, substrate recovery, eco-mooring installation) and/or conservation activities boosting existing Extent and Condition against identifiable threats.
- **Target species**: The current methodology is based on *Posidonia oceanica* or *Cymodocea nodosa* projects. Adaptation to *Zostera noltei* or *Z. marina*, or any other ecosystem type requires documented methodological justification.
- **Geographic location**: Mediterranean Sea basin. Projects in other biogeographic regions require a documented adaptation procedure including species-appropriate reference values and condition indices.
- **Implementing entity**: Any legally recognised entity with demonstrated legal or consensual rights over the project area and full accountability for all PMP commitments.
- **Land/sea rights**: Legal proof of ownership, management rights, or usage rights (including MPA co-management and customary fishing grounds agreements) covering the full crediting period.
- **Vulnerability**: The project area must be demonstrably at risk of biodiversity loss or degradation in the absence of the project, supported by ecological data, historical records, or scientific literature.
- **Project duration**: Minimum 30 years in 10-year accreditation cycles.
- **Project legality**: Full compliance with all applicable national, EU, and international environmental legislation.
- **Governance**: Inclusive and transparent, ensuring meaningful participation of local communities in project design, implementation, and benefit distribution.

Non-eligible activities:

- Projects where **seagrass loss is primarily driven by large-scale**, non-local pressures (e.g., basin-wide warming) with no feasible local intervention.

- Compensation schemes where **restoration is legally mandated** as a condition of development (no additionality).
- Projects involving conversion or replacement of native seagrass with **non-native species**.

3.2 Seagrass Credit Rights and Ownership

Credit ownership is established through the PMP and must reflect three complementary dimensions: **tenure** (legal or consensual rights over the project area), **action** (the entity generating measurable ecological outcomes), and **cost** (the entities bearing conservation costs). Final allocation must be co-defined in the PMP with FPIC documentation submitted at validation.

The implementing entity must hold an unconditional, undisputed, and unencumbered right to claim the benefits generated by the project. **Ongoing or past disputes over land or resource rights must be disclosed** at project design and managed through fair, equitable consultation. An accessible grievance mechanism is mandatory.

3.3 Seagrass Credit Roles, Relationships and Flows

Although presented as a step-by-step process for simplified understanding, **the Seagrass Credit system is in practice a more complex, dynamic network of actors, information flows, financial transactions, and management actions** with strong interrelations and feedback loops. Figure 3 maps these interconnections, illustrating how each participant in the Seagrass Credit ecosystem relates to the others and where the critical transitions — from ecological intervention to verified credit issuance — occur.

The framework distinguishes three types of flow connecting participants: cash flows (the financial transactions that make the system economically viable), management actions (the on-the-ground interventions that generate ecological outcomes), and process flows (the information, data, and governance interactions that ensure the system's integrity and accountability). Three numbered pathways structure the verification logic: outcome monitoring relative to the ex-ante baseline (①), impact evaluation relative to a credible ex-post counterfactual (②), and independent ex-post counterfactual evaluation by the Evaluator (③).

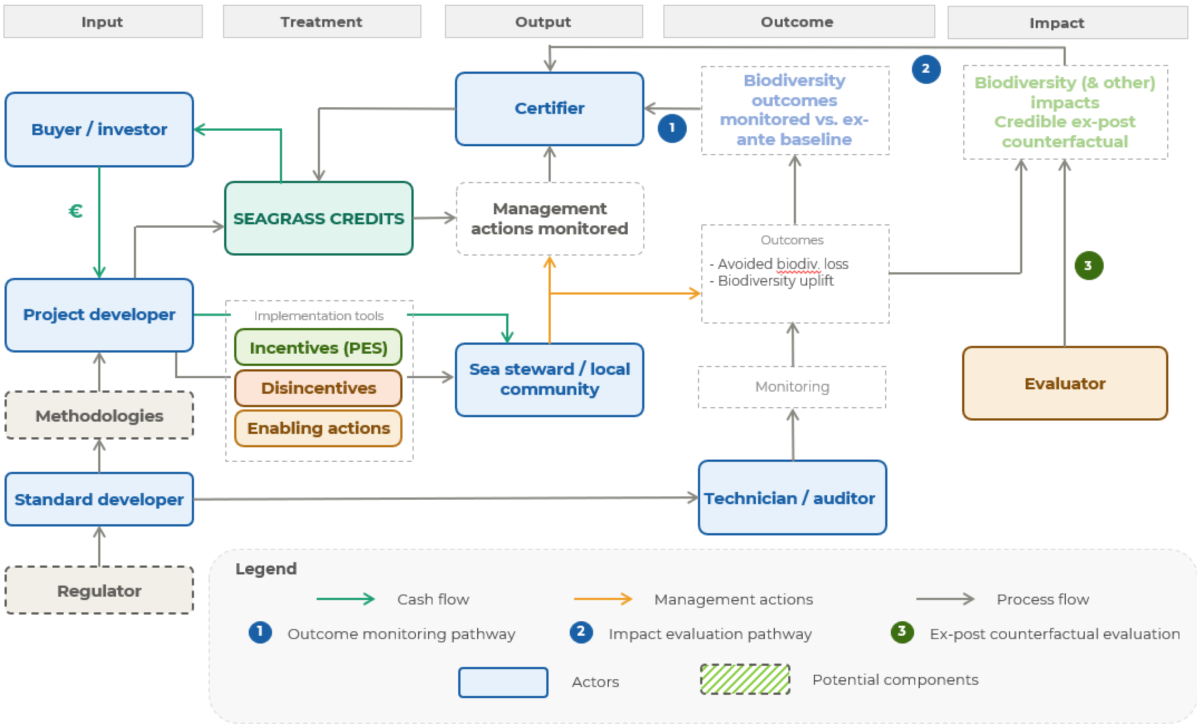


Figure 5. Theory of change for Mediterranean Seagrass Credits: participants, flows, and interactions. Numbered pathways indicate: ① outcomes monitored relative to the ex-ante baseline (condition indices trajectories); ② biodiversity and carbon impacts evaluated vis-à-vis a credible ex-post counterfactual (negative control sites); ③ full impact assessment by the Evaluator against the without-project scenario. Adapted from Wunder, S., C.Fraccaroli, J.Bull, et al. 2025.

The eight participants of the Seagrass Credit ecosystem each perform a distinct, non-interchangeable function:

The **Buyer or investor** is the financial engine of the Seagrass Credit system. By committing capital — either as upfront investment in project development or as ex-post purchase of verified credits — the buyer creates the economic demand that transforms ecologically motivated restoration into a financially sustainable enterprise. In the Mediterranean seagrass context, primary buyer segments may include coastal tourism operators, port authorities, marine transport companies, and corporate sustainability departments subject to CSRD reporting obligations, all of whom face growing institutional and reputational incentives to demonstrate verifiable, nature-positive impact. The cash flow from buyer to project developer (represented by the green arrow in Figure 3) is the foundational financial transaction of the entire system: without it, neither the implementation tools nor the long-term stewardship commitments required for credit integrity are financially viable.

The **project developer** is the operational centre of the credit system. It designs and implements the restoration project, prepares and manages the Project Management Plan, mobilises the implementation tools — incentives such as PES arrangements, disincentives such as anchoring restrictions and protected area enforcement, and enabling actions such as stakeholder engagement and environmental education — and bears ultimate responsibility for generating the verifiable ecological outcomes on which credit issuance depends. The project developer is the actor through whom all other participants are coordinated: it contracts with technicians and auditors, engages with sea stewards and local communities, submits to certifier review, and reports to the buyer. Its financial viability depends on the revenue generated by credit sales, creating a direct alignment between ecological performance and commercial sustainability.

The **standard developer** provides the methodological and certification framework within which credits are defined, quantified, and verified. This encompasses the ecological condition assessment protocols (EBQI, WePOSI, MediSkew), the credit quantification formula (NECO), the buffer pool and reversal management rules, and the governance requirements for project registration and credit issuance. In the ARTEMIS context, this Cookbook constitutes the standard developer's primary contribution — designed to be framework-independent and compatible with other credit standards, the proposed EU Nature Credits standard, and the IAPB core principles. The standard developer interacts with the project developer by providing the methodological toolkit, and with the regulator by ensuring that the methodology meets or exceeds the requirements of applicable EU and national legislative frameworks. Its role is foundational: the credibility, market acceptance, and long-term integrity of the credit system rest entirely on the robustness of the standards it establishes.

The **regulator** defines the legal space within which all other participants operate — determining which activities require authorisation, which ecosystems are protected and under what conditions, and what reporting and disclosure obligations apply to project developers, buyers, and certifiers. In the Mediterranean seagrass credit context, the regulatory framework is multilevel and multiactor: it encompasses the EU Nature Restoration Regulation (NRR), the Habitats Directive (HD), the Water Framework Directive (WFD), the Marine Strategy Framework Directive (MSFD), the Barcelona Convention and its SPA/BIO Protocol, and the national maritime and environmental codes of each Member State in which pilot projects operate. The regulator does not participate directly in the credit transaction but shapes its conditions profoundly — through the permitting requirements that determine the cost and timeline of project development, through the protected area designations that define the governance context of each pilot site, and through the mandatory reporting obligations (CSRD, TNFD) that drive corporate buyer demand. As described in Cookbook Part II, the current absence of explicit regulatory frameworks for marine restoration crediting in most Mediterranean Member States constitutes the primary legal barrier to market entry, making regulatory engagement a strategic priority for all other participants.

The **sea steward or local community** is the day-to-day custodian of the restoration site and the primary holder of the local ecological knowledge that underpins long-term project success. In practical terms, this role encompasses the implementation of active transplantation and maintenance activities, the management of eco-mooring infrastructure and visitor use, participation in co-monitoring programmes alongside the technician, and the translation of the project's ecological objectives into locally meaningful stewardship commitments. Community co-ownership of this role is not merely ethically desirable — it is a functional requirement for project durability. The Free, Prior and Informed Consent (FPIC) process formalises the community's entry into the project governance structure, and the benefit-sharing mechanism ensures that a meaningful portion of credit revenues flows back to local stakeholders, creating sustained incentives for long-term site stewardship. The sea steward receives management action signals from both the implementation tools (incentives, disincentives, enabling actions) and the management monitoring outputs, translating them into adaptive on-the-ground responses.

The **technician or auditor** is the primary generator of the ecological data on which the entire credit quantification system depends. This role encompasses the conduct of field ecological surveys (for instance, EBQI or WePOSI condition assessments for *Posidonia oceanica*, MediSkew assessments for *Cymodocea nodosa*), blue carbon sediment sampling, PISM pressure assessments, fish and benthic community censuses, and transplant survival monitoring. The standardised protocols for each of these activities have been developed within the ARTEMIS project framework and are described in full in Deliverables 1.2.1 and 2.3.1. The technician's outputs feed directly into the monitoring stream that provides both the outcome monitoring signal (against the ex-ante baseline, pathway ①) and the raw data from which the evaluator constructs the ex-post counterfactual assessment (pathway ③). The independence and methodological rigour of the technician is therefore a critical determinant of credit integrity: data collected by parties with a direct financial interest in the outcome of the credit calculation must be subject to independent audit.

The **certifier** independently verifies that the monitoring data are accurate, the methodologies have been applied correctly and consistently with the validated Project Management Plan, the NECO calculations are arithmetically and methodologically valid, and the credits to be issued represent genuine, additional ecological improvement attributable to the project and not to background regional trends or natural variability. The certifier operates at the junction between the Output phase (where management actions and monitoring data are compiled) and the Outcome phase (where biodiversity improvements relative to the ex-ante baseline are assessed), and is the gatekeeper through which credits must pass before issuance. During the ARTEMIS project period (2026–2028), this role is fulfilled by the ARTEMIS expert panel through a transitional peer-review certification process. In the long term, it must be fulfilled by an independent third-party auditor registered with a Mediterranean seagrass credit standard or an equivalent recognised certification body, with no financial relationship with the project developer and with demonstrated competence in Mediterranean marine ecology and natural capital accounting.

The **evaluator** operates at the outermost ring of the verification system, assessing the full biodiversity and ecosystem service improvements generated by the project against a credible ex-post counterfactual — the negative control sites monitored under identical protocols outside the project boundary. Where the certifier asks *are the monitoring data correct and the NECO calculation valid*?, the evaluator asks the deeper question: *has the project genuinely caused the observed improvements, or would they have occurred anyway*? This causal inference role is methodologically the most demanding in the system, requiring the evaluator to disentangle project-attributable changes from background regional trends, climate-driven variability, and the effects of other concurrent management interventions. The evaluator's outputs provide the evidence base for the ex-post counterfactual validation that underpins long-term credit integrity (pathway ③), feed into the 5-year crediting baseline update that keeps the NECO calculation aligned with current ecological reality, and generate the adaptive management signals that allow the project developer to adjust restoration strategies in response to emerging ecological or climatic conditions.

4 Seagrass Project Requirements

This section defines the main elements integrated in an accreditation project, such as timelines, spatial boundaries, baseline, additionality, durability, and adaptive management.

4.1 Project Schedule

Temporal boundaries of a seagrass restoration project are defined as follows. Also, an example of project schedule is presented in this section (Figure 4):

- **Start date**: The date of the first on-the-ground action leading to conservation outcomes (first seagrass transplant, first eco-mooring installation, first sediment remediation action).
- **Credit period duration**: Minimum 30 years, in three consecutive 10-year accreditation cycles. Credits accrue annually and are issued following independent verification at each cycle close.
- **Monitoring period**: The time range (in years) during which the project's activities and outcomes are monitored to ensure ecological improvement. Annual monitoring throughout the project lifetime is recommended for the ARTEMIS framework. Wider monitoring periods must be justified at PMP.
- **Verification period**: Independent third-party verification at least once every 10 years. Interim ARTEMIS peer review recommended every 5 years during early stages of restoration projects.

Years	0	1	2	3	4	5	6	7	8	9	10
	• Activities • Baseline & monitoring 0 • PMP	• Implementation • Monitoring • Risk				• NCA credis • MVR	• Implementation • Monitoring • Risk				• NCA credis • MVR • Benefit sharing

Years	11	12	13	14	15	16	17	18	19	20
	• Implementation • Monitoring • Risk				• NCA credis • MVR	• Implementation • Monitoring • Risk				• NCA credis • MVR • Benefit sharing

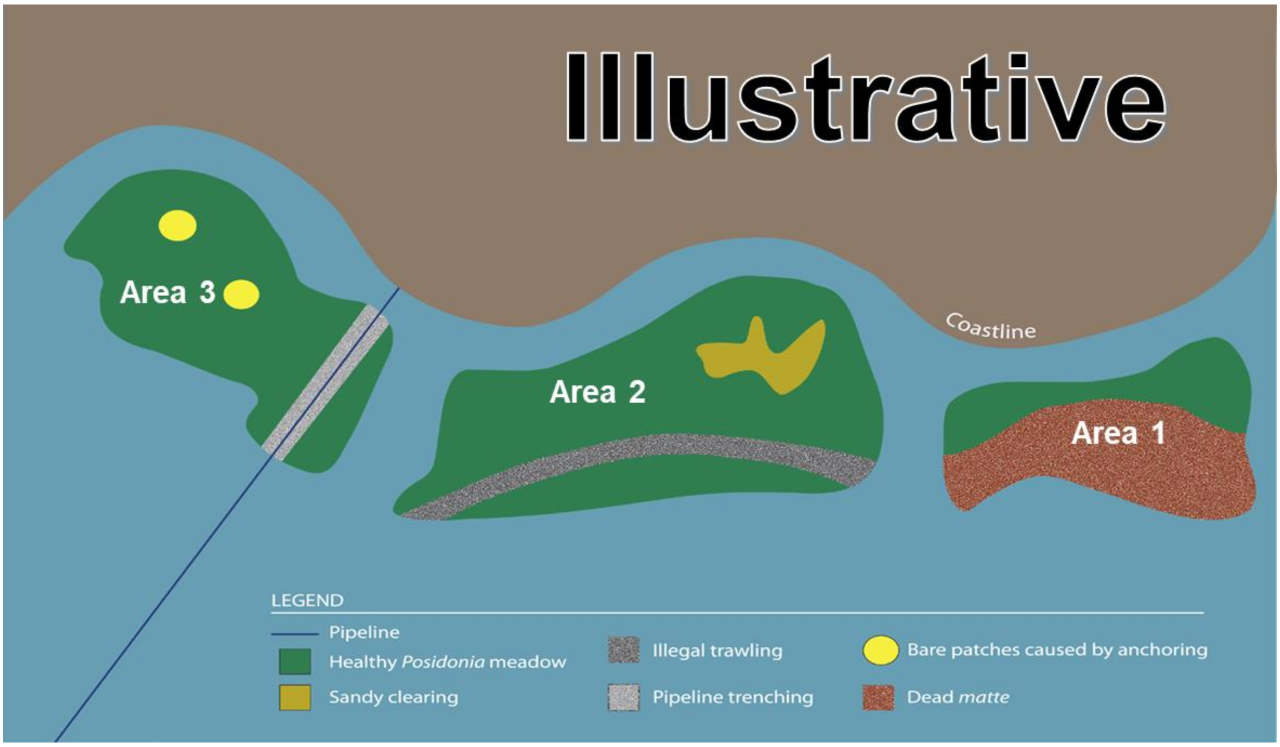
Years	21	22	23	24	25	26	27	28	29	30
	• Implementation • Monitoring • Risk				• NCA credis • MVR	• Implementation • Monitoring • Risk				• NCA credis • MVR • Benefit sharing • **Project closure**

4.2 Spatial Project Boundary

Four nested spatial units must be identified in a restoration project, when possible, GIS-defined with unique identification codes:

- **Reference area**: The broadest ecological context, encompassing WFD reference conditions, MSFD descriptors at Marine Reporting Unit scale, and Habitats Directive conservation status. Not subject to direct monitoring.

- **Project area**: The legally or consensually secured marine area where the project has permission to implement restoration and issue credits.
- **Accreditation area**: The intersection of confirmed seagrass presence and the project area. The units across which NECO and Seagrass Credits are calculated.
- **Potential leakage area**: The zone beyond the accreditation area where pressure displacement may affect adjacent seagrass. Monitored per the leakage assessment protocol (Step 7).



4.3 Baseline Scenario

The baseline scenario is a **qualitative narrative describing**: i) the sustainable development context at project start (socioeconomic and environmental conditions); and ii) the without-project scenario — the most likely trajectory of ecosystem Extent and Condition in the absence of the project. The narrative must be **supported by quantitative evidence where available**: condition indices time-series, satellite imagery, WFD/MSFD ecological status reports, and scientific literature on degradation dynamics.

The baseline scenario must **be established at project design and reassessed at minimum every five years** and whenever a triggering event occurs (marine heatwave, pollution incident, anchoring disturbance). **Reassessment must include independent expert review and stakeholder consultation**. Results feed directly into the update of the dynamic crediting baseline (Step 4).

4.4 Additionality

Seagrass Credits must demonstrate additionality across three dimensions, beyond ecological additionality:

- **Financial additionality**: Credit revenues are essential for project financial viability; the project would not proceed or be sustained without them.
- **Regulatory additionality**: Restoration outcomes exceed those required by applicable environmental legislation (e.g., restores beyond NRR Article 5 minimum compliance requirements).
- **Technological or behavioural surplus**: The project employs innovative techniques (genetic-assisted *P. oceanica* propagation, biodegradable restoration modules) or engages local communities in new stewardship roles (fisher-led EBQI monitoring, community anchoring management).

4.5 Durability

Long-term durability is ensured through: i) a minimum 30-year project horizon; ii) the maintenance of management rights throughout the crediting period; iii) a 20% buffer pool with defined reversal triggers (≥ 1.5 % annual loss in Extent or Condition) and recovery management protocols enabling rapid response to emerging risks (designed within the framework of ARTEMIS project in D1.3); and iv) independent verification every 10 years.

4.6 Adaptive Management

Projects must integrate **adaptive management as an ongoing, iterative process** — reflecting the slow growth rates and ecological vulnerability specially of *P. oceanica* — triggered by monitoring data deviating from expected ecological trajectory; stakeholder input identifying new pressures; external shocks (marine heatwaves, pollution events, regulatory changes); or verification findings. **All deviations** from the validated PMP **must be documented in the next monitoring report**. Significant deviations require an updated project description and, if affecting the crediting baseline, an updated baseline reassessment.

5 Seagrass Outcomes — The 12-Step Quantification Process

This section provides the **complete step-by-step methodology for converting ecological monitoring data into Seagrass Credits**. The 12 steps form an integrated analytical chain: spatial and ecological definition (Steps 1–2) establishes the physical and ecological reference frame; condition assessment (Step 3) and baseline definition (Step 4) provide quantitative additionality due to the restoration project; pressure analysis, attribution, and leakage (Steps 5–7) isolate the net project effect; NECO calculation and credit conversion (Steps 8–9) translate ecological gains into credit units; and buffer pool, net issuance, and pricing (Steps 10–12) complete the market-ready output (for see a theorical example, see the Technical Appendix — Credit system case study).

Table 3. Overview of the 12-step Seagrass Credit quantification process

Step	Name	Primary output
1	Seagrass Extent	Area (m²) of seagrass ecosystem within accreditation area, by ecosystem type
2	Reference ecosystems and values	Reference condition values from minimally disturbed control sites
3	Ecosystem Condition assessment	Ecological and ecosystem-based condition values for Seagrass Extent; normalised 0–1
4	Negative control scenario (crediting baseline)	Dynamic baseline trend rate B_t; recalculated every 5 years from control area monitoring
5	Pressure assessment (PISM)	PISM score documenting anthropogenic pressure context at site scale
6	Attribution of project impacts	Verified Area-adjusted Condition change attributable to project activities
7	Leakage	Leakage discount LD_t deducted from NECO
8	Net Ecosystem Condition Outcomes (NECO)	$NECO_t$ (eq.m²) = $((E_t \times C_t) - (E_0 \times C_0 \times (1+t \times B_t))) \times LD_t$
9	Conversion to Seagrass Credits (SC)	SC = $(NECO_t / UCE) \times 100$
10	Buffer Pool	20% of gross SC retained in non-tradable reserve
11	Net Seagrass Credit (NSC) issuance	Net SC available for trading after buffer deduction
12	Pricing Seagrass Credits	Credit price (€/NSC) derived from NCA ecosystem service values (D.2.3.1) and total project costs

5.1 Step 1 — Seagrass Extent

Extent is the **physically monitored planar surface area** (m²) of the seagrass ecosystem within the accreditation area, **disaggregated by ecosystem type**, following monitoring protocols detailed in D1.2.1. It must be quantified using robust, replicable cartographic methodologies integrating:

- Depth range delimitation: mapping of upper and lower meadow limits, including type and depth of lower limit (also a WePOSI population-level metric).
- Remote sensing: satellite imagery, aerial and underwater drone photogrammetry, acoustic mapping, and towed video transects.
- Ground-truthing: systematic SCUBA surveys with geo-referenced observation points.
- GIS-based area calculation: all output processed in a documented coordinate reference system with spatial resolution and accuracy assessment.

Extent is assessed at project start (Year 0) and at each verification event, with annual updates via remote sensing. Extent is consolidated as a stock into the NCA system through the Ecosystem extent accounts (D2.3.1).

5.2 Step 2 — Reference Ecosystems and Values

A reference ecosystem is a **real or modelled ecosystem** in which natural ecological and evolutionary processes predominantly determine structure, composition, and function, **representing the state of minimal human disturbance** within the same ecosystem type and context. In the ARTEMIS framework, reference values are derived primarily from the control station — a comparable, minimally impacted seagrass area within or adjacent to the project site, systematically monitored using identical protocols.

Where site-specific controls are unavailable, reference values may be derived from: regional WFD/MSFD monitoring datasets; peer-reviewed scientific literature for minimally disturbed meadows in the same biogeographic region; historical pre-disturbance monitoring data; or expert consultation with documented justification.

When multiple estimates or measurement methods are available for a given indicator, reference values must be defined using **precautionary and conservative assumptions**. Investors must demonstrate that the selected value does not overestimate ecosystem condition relative to the intended scoring framework.

Reference values must be updated if new measurement methods or data sources become available during the monitoring period and demonstrably improve the accuracy or reliability of previous estimates.

When a reference value cannot be robustly established for a given indicator, after a documented and exhaustive review of available information, the project developer must:

- Explicitly justify the absence of suitable data; and
- Apply a conservative proxy value consistent with the precautionary principle and the directionality of the Condition scoring system.

The rationale for such proxies must be transparent, reproducible, and subject to verification.

Reference values may be derived from one or more of the **following sources**:

- Direct field observations.
- Contemporary or historical monitoring datasets.
- Modelled ecological data.
- Peer-reviewed scientific literature.
- Assessments conducted for the IUCN or equivalent bodies.
- National or regional ecological datasets, including those related to WFD and MSFD.
- Structured expert consultation.

All sources must be cited, and their relevance and limitations clearly documented.

Reference ecosystems may be set by using the following approaches:

1. **Reference Site Approach**:

    - Use measurements from intact or minimally disturbed ecosystems within the same functional group and ecoregion as the project area.
    - Reference sites can be inside or outside the project extent and should represent stable ecological states.
    - Historical data from the past 50 years may be used if recent measurements are unavailable.
    - Sampling must avoid edge effects (≥200 m from habitat edges) and follow comparable methods to those used in the project.
    - Multiple reference sites are recommended to account for natural variability; use the most conservative value (maximum measured) for each indicator.

0. **Statistical Approach**:

    - Apply predictive empirical models or other statistical methods when suitable reference sites are unavailable.
    - Models should relate Condition indicators to causal factors (e.g., disturbance intensity) to estimate values for intact ecosystems.
    - Document all data sources, justify the approach, and quantify uncertainties.
    - Use conservative estimates, such as the upper bound of a 90% confidence interval.

0. **Historical Reference State Approach**:

    - When neither reference sites nor statistical models are feasible, use non-contemporary historical data (>50 years old).
    - Sources may include palaeoecological evidence, museum archives, or early scientific records.
    - Document search methods, justify data selection, and consult experts to interpret historical context accurately.
    - Incorporate techniques like ancient environmental DNA or fossil records where possible.

5.3 Step 3 — Ecosystem condition

Ecosystem Condition (hereafter, Condition) refers to **the state of an ecosystem** within a defined spatial unit (the Extent), **assessed through its abiotic and biotic characteristics**. Condition provides a standardized representation of ecosystem integrity and its capacity to sustain ecological processes and deliver ecosystem services.

Condition is described through four conceptual components:

- **Composition**: the relative abundance (or richness) of the species assemblage as a whole, rather than the number of individuals of a single species, that is present within an ecosystem.
- **Structure**: the aggregate biophysical properties of ecosystems, considering fragmentation and connectivity as well, i.e., how linked one ecosystem is to another.
- **Function**: the ability of the ecosystem to sustain natural processes and cycles, such as productivity, nutrient cycling, or regeneration.
- **Pressures**: anthropogenic drivers that alter ecosystem composition, structure, or function.

Condition gives insight into the **capacity of ecosystems to deliver ecosystem services** on which business and society depend. Furthermore, it reflects changes in the state of the ecosystems to be effectively valued.

These **changes must be monitored** with robust, relevant, and coherent indicators, which reduce uncertainty and allow an accurate definition of the ecosystems.

Pressure indicators may be used both to document restoration actions and to contextualize observed changes in Condition (See Step 5. Pressures over project ecosystems).

The following guiding principles should underpin any indicator selection process:

- **Relevance**: the most relevant indicators are considered including those impacts that are material for society and nature, being responsive to change within the monitoring period and over the project lifetime.
- **Replicability**: all assumptions, estimations, data, caveats, and methods used are transparent, traceable, fully documented, and repeatable. This allows for eventual verification or audit, as required.
- **Rigour**: the use of technically robust (from a scientific and economic perspective) information, data and methods that are up to date, accurate, and complete, reduce uncertainty.
- **Consistency**: all data and methods used for an assessment are compatible with each other and within the scope of the analysis, measuring distinct components of the Condition.
- **Independence**: all information included in the assessment of Condition indicators is unrelated to each other, which avoids double counting.

Investors must establish the **initial ecological condition** of the project area to serve as the **baseline for monitoring** the state of ecosystems.

At project start, investors must assess and report the value of Condition indicators for each ecosystem type within the project Extent. Condition indicators must then be combined using the ecosystem-specific indexes defined in the Restoration ToolBox (see D1.2.1.) and the NCA methodology (see D2.3.1.). Then, indexes values shall be standardized to a 0-1 scale by using the reference condition value for each ecosystem.

Area-adjusted Condition must be aggregated at project level, by multiplying the mean Condition by its ecosystem Extent, in square meters (m2). Area-adjusted Condition is measured in “equivalent square meters” (eq.m2).

When the project Extent encompasses multiple ecosystem types, investors must sum up the Area-adjusted Condition (eq.m2) values for all ecosystem types.

Investors must include a detailed monitoring plan in the project description. An exhaustive sampling protocol for the condition indicators is crucial for the monitoring plan, and must focus on locations, methods and frequency for indicator measurements at every stage of the project.

Ecosystem Condition must be assessed by using the same approach at any temporal scenario within the project lifetime, unless inevitable and justiciable changes in the quantification methods are performed.

Investors may add new indicators to the monitoring plan in concordance with the selection process but must not remove any previously selected indicator from the monitoring plan over the project lifetime.

This methodology directly defines the quantification of the state of the seagrass meadows ecosystems, specifically for the formations of the *Posidonia oceanica* and *Cymodocea nodosa* species. However, the recommendations contained here may be adapted to the monitoring of other marine ecosystems.

Disclaimer on condition index selection

The EBQI (*Posidonia oceanica* ecosystems) and MediSkew (*Cymodocea nodosa* ecosystems) are the **recommended primary condition indices within this methodology**, as they are the most comprehensive currently available for Mediterranean seagrass ecosystems: both integrate structural, compositional, and functional dimensions of ecosystem condition into a single index, and both have been validated against anthropogenic pressure gradients across the Mediterranean basin.

Official WFD-intercalibrated indices — including PREI, POMI, and WePOSI for *P. oceanica*, or CymoSkew for *C. nodosa* — **may be used as complementary or alternative indicators** where site-specific ecological, methodological, or regulatory considerations justify their selection. However, users should be aware that these indices vary in the breadth of ecosystem components they capture: indices focused primarily on plant-level structural descriptors (shoot density, rhizome architecture, leaf surface area) do not fully represent the compositional dimension of ecosystem condition — specifically, the diversity, abundance, and functional structure of the associated biological communities (fish assemblages, benthic macrofauna, epifauna). Where such indices are used as the primary condition metric, it is therefore mandatory to complement them with explicit biodiversity indicators — such as species richness, Shannon-Wiener diversity (H'), and abundance metrics for fish and benthic communities — incorporated through weighted values and averages following the corresponding assessment methodologies described in the Restoration ToolBox (D.1.2.1) and the NCA framework (D.2.3.1).

Regardless of the index selected, normalisation to a 0–1 scale must be performed using the **calibration against the site-specific reference condition** values established in Step 2 of this methodology. This ensures **comparability of condition scores across indices, sites, and monitoring periods**, and maintains the integrity of the area-adjusted Condition (Qm^2) calculations on which Seagrass Credit quantification is based.

Posidonia oceanica meadows Condition

Biotic indexes, which reflect the quality of the ecosystems, are widely used to evaluate the quality of marine ecosystems. Sometimes, key species or ecosystem engineers are selected for this purpose. This is the case of the Mediterranean seagrass *Posidonia oceanica*, widely used as a biological quality element in the context of the European Union Water Framework Directive (WFD).

However, the good quality of a water body or the apparent health of a species, whether it is an ecosystem engineer such as *P. oceanica* or not, is not always indicative of the good structure, composition and functioning of the whole ecosystem. For that reason, a key point of the Marine Strategy Framework Directive (MSFD) is the ecosystem-based approach. P. oceanica is also included in the Habitat Directive (HD).

Posidonia oceanica (L.) Delile is a seagrass species endemic to the Mediterranean Sea, which dwells in the sublittoral zone. Due to the length, up to 120 cm, and density of the leaves, the seagrass canopy decreases water movement and traps sediments. Rhizomes resist burial by vertical growth, so that the sea bottom slowly rises. Within the sediment, the deeper parts of the rhizomes, attached leaf sheaths and roots die, but their decay is extremely slow, so that they can persist for extraordinarily prolonged periods. *P. oceanica* is one of the most important engineers of an ecosystem in the Mediterranean Sea.

The ecological condition of ***P. oceanica*** **meadows is assessed through an ecosystem-based approach** that evaluates the state of the seagrass ecosystem by parametrizing, assessing, and quantifying each of its functional compartments through non-destructive methods. The resulting condition assessment is then calibrated to calculate the ecosystem status within a given area. This approach must capture the full complexity of the *P. oceanica* ecosystem — from primary producers to top predators — **ensuring that condition assessments reflect not only the structural state of the seagrass meadow but also the functional integrity** of the associated biological communities (see Technical Appendix for condition indices recommendations).

Cymodocea nodosa meadows Condition

In the Mediterranean region, *Cymodocea nodosa* is widely distributed throughout shallow sites. Therefore, a correct assessment of the status of its meadows is of great importance for the implementation of the WFD, the MSFD, and the HD, especially for areas where *P. oceanica* meadows (the most frequently used indicator in the Mediterranean Sea) are rare or not present.

C. nodosa forms meadows that are monospecific or mixed with *Zostera noltei* and can be found in deep waters (40 m). *C. nodosa* is considered a pioneer species which can quickly colonize bare areas of the sea floor. Its rhizome may grow several meters per year.

Seagrasses invest more into below-ground tissues under nutrient-limited conditions, and, in contrast, more biomass is produced in above-ground tissues when more nutrients are available. However, longer exposure to high nutrients would lead to meadow degradation, due mainly to the limitation of light induced by increased growth of phytoplankton and epiphytes.

The ecological condition of *C. nodosa* meadows is assessed through an approach that uses the species' **biomass growth cycle as the primary indicator of ecosystem state**, translating canopy structural characteristics into a quantified condition score. The resulting assessment is calibrated to calculate the ecosystem status within a given area. This approach is specifically designed for areas where *P. oceanica*-based assessment methods are not applicable, providing a robust **condition metric for *C. nodosa* habitats** across the Mediterranean (see Technical Appendix for condition indices recommendations).

5.4 Step 4 — Negative control scenario

The negative control scenario is a **quantitative and dynamic reference used to calculate creditable ecosystems gains**. It represents the projected changes in ecosystem extent and/or condition in the absence of project intervention.

Investors must select negative control areas **outside the project boundary**, which must be similar to the same type of ecosystem presented within the project boundary, allowing changes in the state of ecosystems to be monitored and tracked.

The negative control scenario attributes disturbances in the ecosystems to the project itself, **discarding changes related to external leakage**.

The negative control scenario must be evaluated at distinct monitoring periods using the same sampling methods (i.e., condition indices) as in the project boundary to produce a dynamic crediting baseline. This updated value becomes the reference for the next monitoring period, ensuring the baseline evolves with real evidence, instead of projections.

Investors must guarantee the capacity to monitor the required data throughout the project's crediting period.

Investors must secure the necessary permissions to collect data from both negative control areas and the project boundary.

5.5 Step 5 — Pressures over project ecosystems

Investors must also include a pressure index for seagrass meadows (PISM), which allows the **evaluation of pressure-impact relationships in these marine ecosystems**, according to the type of coastal morphology. The PISM index includes six (6) main **pressures in coastal areas in 1 km buffer area around the sampling site** (Table 3), and must be performed by using the Impact statement assessment introduced in the Natural Capital Accounting report (see D2.3.1). At least, the following pressures must be considered:

- Presence of artificial coastline.
- Direct leaching from the coast.
- Aquaculture.
- Rainwater discharge.
- Industrial wastewater discharge.
- Navigation routes.

Investors must calculate the PISM index for each temporal scenario of the project by using the following pressure values and multiplying the sum of pressures by the factors 0.75 for convex coastlines, 1 for straight coastlines, and 1.25 for concave coastlines.

The final PISM score must be reported separate from the Condition evaluation, which may allow investors to track ecosystem condition fluctuations related to pressure changes within the project extent.

Table 4. PISM pressure categories and scoring (0–3 scale)

Pressures/ Values	**Artificial coastline**	**Direct leaching**	**Aquaculture**	**Rainwater discharges**	**Industrial wastewater discharges**	**Navigation routes**
0	Natural coastline	Leaching from natural areas (overgrown meadow, forest)	No aquaculture	No rainwater discharges	No industrial discharges	Occasional navigation of small boats
1	Minor constructions (pier, platform, rubble), which do not significantly change hydro-morphology, mostly natural coastline	Leaching from areas with single houses, no villages and/or local roads and/or agricultural surfaces	Shellfish farms	Presence of rainwater discharges	Discharges with wastewater treatment plant	Dense navigation of tourist vessels
2	Partially modified coastline, with shorter natural segments, hydro-	Leaching from villages/towns or smaller	Fish farms	N/A	Discharges without wastewater	Navigation of large ships (with

	morphology slightly altered	agricultural surface			treatment plant	digging routes)
3	Completely modified co astline, with significantly altered hydro-morphology	Leaching from extensive agricultural surfaces (with plowing, fertilizing)	N/A	N/A	N/A	N/A

5.6 Step 6 — Attribution of Project Impacts

Changes in Area-adjusted Condition between Year 0 and Year t are attributed to project activities — rather than external drivers — **through comparison with the negative control scenario**. Project-attributable change is the difference between the observed trajectory in the accreditation area and the projected trajectory of the crediting baseline (B_t). Attribution must be assessed at least every five years, with supporting evidence from PISM trend data, restoration activity logs, and condition indices trajectories at impacted and control stations documented in the monitoring report.

5.7 Step 7 — Leakage

Leakage represents **negative ecological impacts generated outside the project boundary by pressure displacement** (anchoring, fishing displacement to adjacent meadows). Positive leakage (beneficial unintended effects on adjacent areas) is documented but not deducted. Quantified negative leakage is expressed as leakage discount LD_t (0–1) applied in the NECO formula. The implementing entity must identify all leakage pathways at project design and establish monitoring protocols for the leakage area. For small-scale pilots (<1 ha), leakage may be assessed qualitatively with documented justification, provided active pressure management measures are in place.

Leakage is accounted for through a Leakage Deduction Factor (LD), applied as a multiplier to the gross NECO value in Step 8. **LD is a function of two parameters**: the Leakage Determination Area (LDA) — the portion of seagrass habitat outside the accreditation area, within the project management boundary, that is not subject to legally binding protection of 25 years or more and is therefore potentially exposed to displaced pressure — and the Estimated Degradation Rate (EDR), the background rate of *P. oceanica* or *C. nodosa* meadow degradation in the bioregion in the absence of management intervention.

The Leakage Deduction Factor is calculated as:

$$LD = 1 - \frac{LDA}{A} xEDR$$

Where: LDA is the leakage determination area in m², A is the total project accreditation area in m², and EDR is the estimated degradation rate expressed as a proportion per monitoring period (≥ 1,5 % loss Telesca L., *et al*., 2015). An LD value of 1.0 indicates no leakage risk; values below 0.85 trigger a mandatory leakage management review and require the implementation of additional pressure mitigation measures in the LDA before credits can be issued for that monitoring period (for see a theorical example, see the Technical Appendix — Credit system case study).

The LDA must be assessed and documented in each Monitoring Report, using updated habitat cartography and pressure data. Areas outside the accreditation boundary that have been brought under enforceable anchoring prohibition during the project period may be reclassified as protected and excluded from the LDA, progressively reducing the leakage deduction as the project's management footprint expands. This dynamic design creates a direct financial incentive for project developers to extend passive restoration measures — eco-mooring networks, navigation restrictions, surveillance — beyond the minimum active restoration plot, aligning the commercial logic of the credit system with the broader ecosystem-scale conservation objectives of the ARTEMIS project.

5.8 Step 8 — Net Ecosystem Condition Outcomes

Net Ecosystem Condition Outcomes (NECO) must be determined for each monitoring period (Figure 2). Net outcomes represent the **quantified difference between the Area-adjusted condition project impact**, adjusted for leakage (LD), from any temporal scenario (year t) **and the baseline** (year 0), projected to year t using the negative control parameter (see Negative control section).

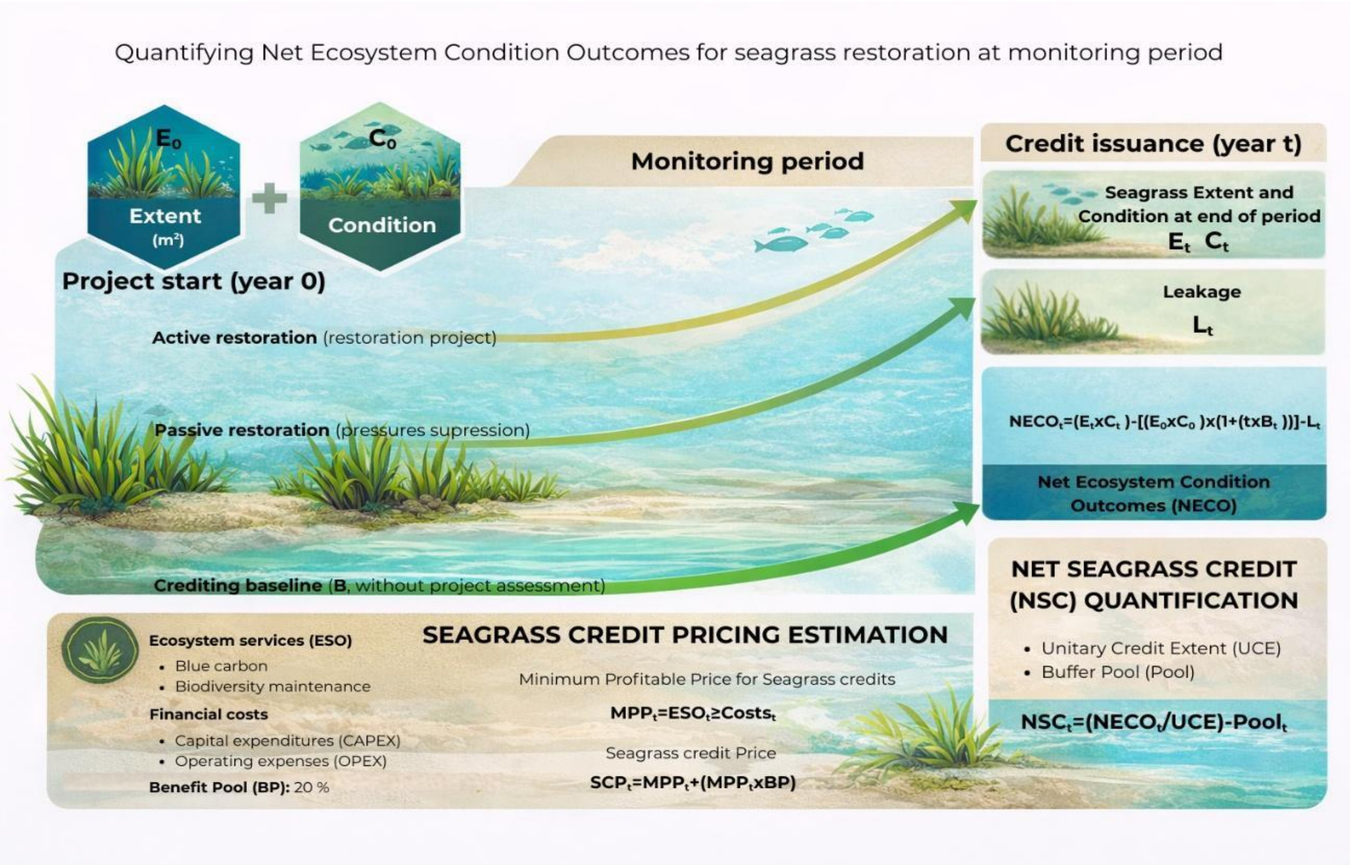
Investors must calculate the NECO (in eq.m2) in the project extent (for see a theorical example, see the Technical Appendix — Credit system case study):

$$NECO_t = \Big((E_t * C_t) - \big[(E_0 * C_0) * \big(1 + (t * B_t)\big)\big]\Big) * LD_t$$

Where: E_t = Extent at period t; C_t = normalised Condition at period t; E_0 = Extent at Year 0; C_0 = normalised Condition at Year 0; B_t = cumulative baseline trend rate; LD_t = leakage discount factor. NECO is calculated per ecosystem type and summed. If $NECO_t \leq 0$, no credits are issued for that period.

5.9 Step 9 — Conversion to Seagrass credits

The Figure 8 illustrates the **stepwise methodology for generating seagrass credits**. First, the ecosystem extent and condition are defined at project start (Step 1–3), followed by the establishment of a baseline scenario (Step 4). During the monitoring period, pressures are assessed and project impacts are isolated while accounting for leakage (Steps 5–7). The resulting ecological change is then quantified as Net Ecosystem Condition Outcomes (NECO) (Step 8), which are converted into standardized credit units using a unitary credit extent and supporting parameters (Step 9), and adjusted through a buffer pool to manage risks (Step 10). Finally, credits are issued (Step 11) and assigned an economic value based on ecosystem services and project costs (Step 12), completing the transformation of ecological improvements into tradable seagrass credits.



Unitary Credit Extent refers to **the minimum tile of an ecosystem where a Net positive Ecosystem Condition Outcome is obtained**. For this methodology, the Unitary Credit Extent is proposed to be 25 m². Investors must use the same Unitary Credit Extent for the whole project lifetime.

Seagrass Credits (SC) are calculated based on the project's Net Ecosystem Condition Outcome (NECO). The number of Seagrass Credits resulting from project activities in each monitoring period is calculated by dividing NECO and the Unitary Credit Extent (UCE).

Seagrass Credits (SC) are calculated based on the project's Net Ecosystem Condition Outcome (NECO). The number of Seagrass Credits resulting from project activities in each monitoring period is calculated by dividing NECO and the Unitary Credit Extent (UCE).

$$SC_t = \frac{NECO_t}{UCE}$$

Where: Where: SC_t is the number of Seagrass Credits generated at monitoring period (year t); and, UCE (Unitary Credit Extent) is the minimum ecologically coherent accreditation unit established at project design (25 m^2 recommended for commercial projects).

5.10 Step 10 — Buffer Pool

20% of gross SBU generated in each accreditation cycle are **retained in a non-tradable, project-specific buffer pool reserved exclusively against verified reversals**. Reversal trigger: ≥ 1.5 % verified annual loss in seagrass Extent or Condition attributable to project failure (not natural disturbance or force majeure, applying a precaution buffer to the decline rate adapted from Telesca L., et al., 2014), confirmed by independent verification. If the buffer is exhausted, unsold issued credits are cancelled until recovery is confirmed. Already sold and retired credits remain valid. For see a theorical example, see the Technical Appendix — Credit system case study.

5.11 Step 11 — Net Seagrass Credit Issuance

Investor must calculate the net number of Seagrass Credits that may be issuance for the monitoring period, deducting the buffer pool held from Seagrass Credits released by project activities.

Net credits are formally issued upon completion of independent verification and registered in the project registry. Each issued credit carries a unique identifier documenting: project ID, site, accreditation period, ecosystem type, Condition indices evaluation, and Significance attributes (key species, Blue Carbon value in t CO_2e, Biodiversity Preservation value in €/m^2).

5.12 Step 12 — Pricing Seagrass credits

The Seagrass Credits pricing process is grounded in the **economic valuation of ecosystem services generated through restoration activities** (based on the NCA system, in D2.3.1.), **balanced against the costs required to deliver and maintain these outcomes over time**. The process aims to create a transparent and consistent approach that reflects both the environmental value produced by seagrass ecosystems and the financial realities faced by investors. By linking credit pricing to measurable ecosystem service outcomes and restoration expenditures, the methodology seeks to ensure that Seagrass Credits are environmentally credible, economically viable, and attractive to investors, while supporting the long-term sustainability of marine ecosystem restoration initiatives.

Ecosystem services accountability

Ecosystem Condition gives insight into the capacity of ecosystems to deliver ecosystem services on which business and society depend.

Ecosystem services are broadly categorized into three different groups:

- **Provisioning services** are those ecosystem services representing the contributions to benefits that are extracted or harvested from ecosystems.
- **Regulating and maintenance services** are those ecosystem services resulting from the ability of ecosystems to regulate biological processes and to influence climate, hydrological and biochemical cycles, and thereby maintain environmental conditions beneficial to individuals and society.
- **Cultural services** are the experiential and intangible services related to the perceived or actual qualities of ecosystems whose existence and functioning contribute to a range of cultural benefits.

Seagrass Credit **price will be established by the own credit market**, which will vary based on how much investors will be interested in paying.

However, price estimations are extremely useful to ensure that Seagrass Credits investments are interesting for investors. To characterize the value of the restoration projects and, therefore, credit delivery, the developed framework includes the evaluation of ecosystem services and risk mitigations. At least, carbon absorption and biodiversity preservation services must be considered by investors at this stage.

For that purpose, investors must identify, evaluate and value ecosystem services during the same reporting periods of ecosystem Condition. Ecosystem services must be linked to their corresponding ecosystem assets, which must be found within the project Extent.

Ecosystem assets supply ecosystem services, either from a single ecosystem asset or by multiple ecosystem assets operating collectively. In this framing, ecosystem assets may be characterized as producing units. Ecosystem assets are measured by their extent and condition as well as the basket of ecosystem services flows that they generate.

Investors must quantify ecosystem services (following the NCA methodology, see D2.3.1. for further information) by the following steps:

- Identify, classify and report ecosystem assets, which are contiguous spaces of a specific ecosystem type characterized by a distinct set of biotic and abiotic components and their interactions. The definition of ecosystem assets is a statistical representation of the general definition of ecosystems from the Convention on Biological Diversity.
- Characterize physical and monetary stock accounts, which record the supply of ecosystem services by ecosystem assets and the use of those services by economic units.
- Assess physical and monetary flow accounts along different monitoring periods, by deducting changes in ecosystem service stocks quantified from the baseline. This assessment will allow investors to recognize which value is provided by the ecosystem services linked to seagrass restoration activities.
- Obtain total Ecosystem Services Outcomes (ESO) in monetary terms during the monitoring period (year *t*).

$$ESO_t = \sum_{1}^{t} \quad Ecosystem\ services_i$$

Where: ESO_t are the total Ecosystem Services Outcomes in monetary units at monitoring period (year *t*); and, $Ecosystem\ services_i$ every ecosystem service evaluated in monetary flow accounts within the project Extent at monitoring period (year *t*). For see a theorical example, see the Technical Appendix — Credit system case study.

Capital expenditures and operating expenses

Capital expenditures (CapEx) are the **funds that investors allocate to acquire, or develop long term assets directly enabling credit generation**, such as equipment, geospatial infrastructure, technical studies (e.g. condition mapping), maintenance and monitoring of activities, restoration works, third-party verification, permits, revenues from associated businesses, and commercial-related costs. To be capitalized, expenditures must demonstrably contribute to the project's ability to generate verified outcomes over multiple monitoring periods. By investing in fixed assets, investors aim to enhance their operations, ensuring sustained growth and competitive advantage. CapEx decisions reflect strategic intent, positioning businesses to leverage new opportunities and optimize their physical infrastructure.

Operating expenses (OpEx) are **essential costs that investors incur as a result of performing restoration operations** within the project Extent, including measures needed to accomplish the monitoring plan. Effective management of OpEx can lead to competitive advantages and increased profitability, which is crucial to balance cost reduction with operational quality.

Investor must capitalize expenses that meet the asset recognition criteria under recognized accounting standards (e.g., IFRS), such as physical equipment, acquired software, or durable restoration infrastructure. These assets must be systematically amortized (e.g., straight-line) over their useful life, which cannot exceed the duration of the loan period.

Design, community engagement, baseline, and validation expenses are recognized as operating expenses (OpEx) in the period in which they are incurred, unless it is reliably demonstrated that they meet the capitalization criteria (IAS 38).

Investor must identify and evaluate both CapEx and OpEx to quantify seagrass restoration associated costs over project lifetime. These costs must be assessed at each monitoring period.

$$Costs_t = Amortized\ CapEx_t + OpEx_t = Minimum\ Profitable\ value\ (MMP)$$

Where: $Costs_t$ are the total costs at the reporting period (year t); $Amortized\ CapEx_t$ total capital expenditure amortized at monitoring period (year t); and, $OpEx_t$ total operational expenses at monitoring period (year t). For see a theorical example, see the Technical Appendix — Credit system case study.

These costs include the following components, which are aligned with liabilities exposed in D2.3.1. needed to obtain the Natural Capital Balance Sheet:

- Consulting fees (for habitat delineations, physical or biological assessments, hydrologic analyses, impact assessments, etc.).
- Bank entity boundary and topographic surveying costs.
- Engineering drawing and specification production costs.
- Local, state, and federal application costs (including preparation and associated environmental assessments, endangered species consultations, etc.).
- Pre- and post-restoration costs.
- Long-term monitoring consultant fees.
- Legal fees (primarily for bank entity acquisition, business plan approval, negotiations with investors, and bank instrument review).
- Credit marketing costs may result from having to solicit customers, produce advertising tools, conduct analyses of credit market structure and demand, or legal fees associated with credit trades.
- Bank management may include extensive management of the resources for some bank types.

- Revenues from associated business (e.g., from the sale and/or development of extra parcels or appurtenant business products, etc.).

6 Monitoring, Reporting and Verification (MRV)

In this section, monitoring protocols are summarized (for further details, please see D1.2.1 and D2.3.1), and reporting and verification principles are introduced to ensure for a robust and credible crediting process.

6.1 Monitoring

Results-based payments are essential to promote effective conservation and restoration (Radoux, 2025). This methodology adopts a Monitoring, Reporting, and Verification (MRV) system grounded in the precautionary principle, which "*is an approach to risk management, where, if it is possible that a given policy or action might cause harm to the public or the environment and if there is still no scientific agreement on the issue, the policy or action in question should not be carried out. However, the policy or action may be reviewed when more scientific information becomes available*". It prioritizes safety and prevention under conditions of uncertainty. Accordingly, "*payments should be based on the most conservative evidence available*".

Periodic monitoring is mandatory throughout the crediting period. The monitoring plan, embedded in the PMP, specifies locations, methods, timing, and frequency for all indicator measurements. Minimum monitoring actions must cover the following information by applying the specific protocols detailed in D1.2.1:

- Seagrass Extent: remote sensing or visual survey update with ground-truthing at a subset of previously surveyed stations.
- Ecosystem Condition: full condition indices assessment at least every 5 years.
- Biodiversity metrics: fish assemblage surveys (species richness, abundance, biomass, Shannon–Wiener diversity) and benthic macrofauna characterisation at minimum every 5 years; key species occurrence records annually.
- Blue Carbon: annual above- and below-ground biomass assessment; sediment core analysis every 10 years (^{210}Pb and ^{14}C radiometric dating).
- Pressure monitoring: PISM recalculation annually using updated satellite, cartographic, and field data.
- Leakage monitoring: systematic visual survey of the potential leakage area for pressure displacement evidence.

- Disturbance events: documentation of all extraordinary events (marine heatwaves, pollution, illegal anchoring, storms) with ecological impact assessment.

All monitoring data must be geo-referenced, temporally labelled, and stored in secure formats **compatible with the ARTEMIS Natural Capital System** (D.2.3.1). Photo-vouchers from each monitoring event must be archived with full metadata. Community-based monitoring — trained fishers, divers, or MPA rangers contributing under scientific oversight — is explicitly encouraged as a cost-effective means of building local capacity and increasing stakeholder engagement. Where community-based data are used, quality control protocols and trainer certification must be documented in the PMP.

An unexpected annual decline in Condition or Extent of > 1.5% from the previous monitoring period (not attributable to known natural disturbance) triggers an adaptive management review within 90 days and notification of the project governance body.

6.2 Reporting

Annual monitoring reports must be submitted to the governance body within 3 months of the close of each monitoring year, covering: updated Extent map; condition indices scores (impacted and control stations); PISM score; NECO calculation; updated crediting baseline trend; biodiversity metrics; Blue Carbon update; and adaptive management actions taken.

A full Verification Report is prepared by an independent third-party verifier at each 10-year verification event, summarising Extent and Condition trajectories; cumulative NECO; gross and net credit issuance; buffer pool status; leakage assessment; and all adaptive management events. The Verification Report is the basis for credit issuance.

6.3 Verification

Independent third-party verification is required at minimum once every 10 years. Verifiers must be independent of the implementing entity and credit buyer. Verification confirms: PMP compliance; ecological data integrity; NECO calculation accuracy; crediting baseline adequacy; leakage assessment; buffer pool adequacy; and absence of double counting. During 2026–2028, the ARTEMIS expert panel interim review process applies to pilot sites.

7 Operation and Maintenance — Risks

Project risks are identified through the eligibility criteria (see section 2.1 Eligibility Criteria) and supported by secondary data on socio-economic variables of historical seagrass degradation processes. Risk analysis (see Cookbook part II) focuses on drivers that are either reversible through project activities (e.g. sustainable management, conservation incentives) or tied to local livelihoods, cultural practices, and ethnic identity.

Seagrass restoration projects operate in a complex risk environment (Table 5). The following categories must be assessed, documented in the PMP, and managed through ongoing adaptive management:

Table 5. Risk categories, key factors, and primary mitigation measures

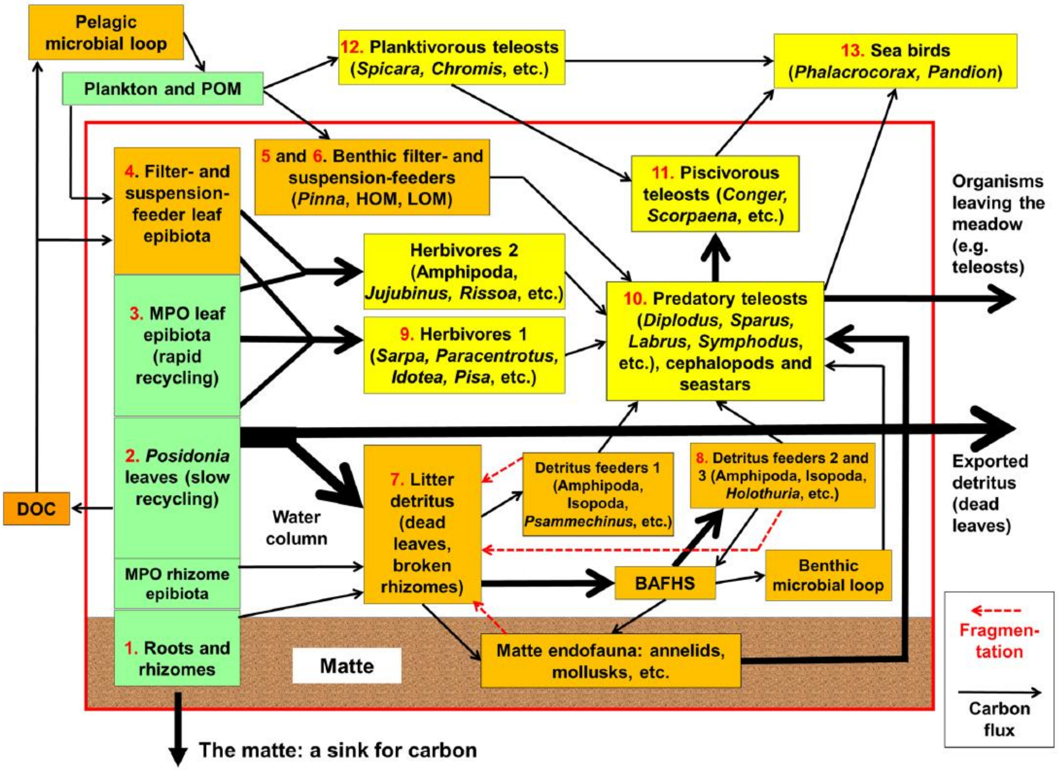
Risk category	Key risk factors	Primary mitigation measures
Environmental	Marine heatwaves and other Climate Change hazards; storm damage; eutrophication pulse; invasive species; low transplant survival; genetic diversity loss in transplanted stock	Site selection criteria; genetic diversity monitoring; 20 % buffer pool (25–30% in high-exposure areas); adaptive management triggers for anomalous mortality events
Technical	Inadequate restoration design; monitoring capacity gaps; methodological inconsistency across monitoring cycles	Pilot-validated protocols (D.1.3.1); standardised EBQI/WePOSI/MediSkew assessment (Technical Appendix); annual protocol review
Financial	Credit market volatility; buyer default; monitoring cost overruns; delayed revenues relative to upfront costs	Diversified revenue streams; multi-scenario cash flow projections (D.3.3.1 Part II); contingency reserves (≥10% annual budget); blended finance structures
Legal	Regulatory changes affecting permits; maritime space use conflicts; credit ownership ambiguity	Early engagement with competent authorities; lifecycle regulatory mapping (D.3.3.1 Part II); governance body with public authority representatives
Governance	Weak oversight; unclear roles; implementing entity–community conflict	Multi-stakeholder governance body; transparent PMP; FPIC; co-created benefit-sharing; grievance mechanism
Socio-economic	Conflicts with artisanal fisheries; 'privatisation of nature' perceptions; restriction of traditional activities	Community benefit-sharing with direct income; fisheries co-management agreements; environmental education; participatory monitoring

A critical systemic risk across all ARTEMIS pilot sites **is climate change**, specifically marine heatwaves — documented to cause acute *P. oceanica* mortality in Mediterranean events of 2015, 2018, 2019, and 2023 (Garrabou, J., 2022). The non-stationary nature of this risk, combined with the slow growth rates of *P. oceanica*, creates a genuinely challenging risk environment. The ARTEMIS framework addresses this through the 20 % buffer pool (sized for moderate reversal events; 25–30 % recommended in high-exposure areas), the dynamic crediting baseline (adjusting for background ecological deterioration), and the adaptive management protocol (enabling rapid response following heatwave events). Projects in areas of documented high heatwave frequency must include a site-specific climate risk assessment in the PMP.

A. Technical Appendix — Ecosystem Condition Assessment Protocols

Posidonia oceanica — EBQI Protocol

The EBQI assessment follows Personnic et al. (2014), as applied in ARTEMIS D.1.2.1. Sampling is conducted at fixed georeferenced stations in the impacted restoration zone and the control zone, at the standard monitoring depth (typically 15 m, consistent with the Greek WFD monitoring network):



The suggested parameters for the EBQI evaluation are shown in the following table[2].

[2] These recommendations are made by Personnic *et al.*, 2014, where deeper information about methodological methods and others can be found.

Indicator	Condition component	Weighting (W)	Parameter	Considerations	Quantification tips
1. *Posidonia* roots and rhizomes.	Structure	3	Growth rate of orthotropic rhizomes (mm/year).	High and low rhizome growth rates are indicative of over sediment input or of deficit in sediment, respectively.	The value obtained is multiplied by 1.5 to include the slow growth during the following two years.
2. *Posidonia* leaves.	Function	5	Density (shoots/m^2).	Shoot density is correlated with annual leaf primary production at local scale.	The final *P. oceanica leaf* index is the arithmetical mean between the density and the cover parameters.
	Structure		Cover (%).	Cover rate is estimated by visual observation. The cover rate of the meadow is rarely 100 %.	
3. Multicellular Photosynthetic Organisms (MPOs), filter- and suspension-feeder leaf epibiota.	Structure	4	Biomass (g DM/shoot).	Leaf epibiota provides information on water quality, especially nutrient concentration in seawater.	Only the two oldest (most external) leaves are considered.

4. Benthic filter feeders: *Pinna nobilis*.	Structure	2	Density (individuals/100 m^2).	*Pinna nobilis* individuals inhabit optimal seagrass meadows, linked to deep substrates.	Visual counting methods of individuals and statistical estimations of density.
5. Filter- and suspension-feeder epibiota on *P. oceanica* rhizomes[3].	Function	2	Density (individuals or colonies/m^2).	Species that require high level of organic matter (HOM) —such as *Sabella spallanzani, Phallusia mammillata, P. fumigata* —in the water are considered.	Visual counting methods. The final *filter- and suspension-feeder epibiota on rhizomes* index is the arithmetical mean between the HOM and LOM densities.
	Function			Species that require low level of organic matter (LOM) —such as *Halocynthia papillosa, Antedon mediterranea* —in the water are considered.	
6. Detritus feeders.	Function	2	Individuals/10 m^2	The macro-detritus feeders *Holothuria spp.* is considered as a proxy due to its facility to be counted.	Visual counting methods.
7. Herbivores	Function	5	Individuals/m^2	The macro-herbivore sea urchin *Paracentrotus lividus* is considered	The final *macro-herbivore* index is

[3] Other than *Pinna nobilis*.

				as the main consumer of *P. oceanica* leaves.	the arithmetical mean between the density of *P. lividus* and the grazing index.
	Function		Grazing index (% leaves)	The percentage of intermediate and adult leaves exhibiting bite scars due to *Sarpa salpa*. Bite scars must be carefully distinguished from broken leaves; the latter being related to hydro-dynamism.	
8. Predatory teleost, cephalopods, and sea stars.	Function	5	Kg teleost WM/100 m^2	Teleost fishes associated with seagrass beds occupy different positions in and above the canopy during the day and at night, spend more or less time in this habitat depending on their life cycle, and naturally fluctuate in abundance and biomass with depth, season and years.	Visual counting methods using common transects.
9. Piscivorous teleost.	Function				
10. Planktivorous teleost, zooplankton feeders.	Function	3			
11. Omnivores.	Function				
12. All teleosts.	Compisition	3	Specific Relative	SRDI enables calculation of:	SRDI is the mean number of species

			Diversity Index (SRDI).	• Predator biomass (other than piscivorous and planktivorous). • Top predator biomass (piscivorous). • Planktivorous biomass. • SRDI.	met with per transect.
13. Seabirds	Function	1	Distance to the nearest nesting site of *Phalacrocorax spp.* (km).	Shags can dive down to the benthic seagrass meadow; they mainly feed on pelagic planktivorous teleosts (e.g. *Spicara smaris, Chromis chromis*), but benthic teleosts (e.g. *Diplodus spp., Lithognathus mormyrus, Scorpaena notata, Serranus scriba and Symphodus mediterraneus*) account for 35% of the diet.	Estimations of the distance.
	Function		Distance to the nearest nesting site of *Pandion haliaetus* (km).	Osprey is an opportunistic fish-eating bird of prey.	

The grade of each considered indicator is given by multiplying its status (S), quantified from 0 (the worst status) to 4 (the best status), and weighting (W), from 1 to 5. Afterwards, for practical purposes, the EBQI is converted to a scale from 0 to 10:

$$EBQI = \left[\frac{\sum_{i=1}^{13} \quad (W_i * S_i)}{\sum_{i=1}^{13} \quad (W_i * S_{max.})}\right] * 10$$

Where: W_i is the weighting of the indicator i; S_i the status of the indicator i; $S_{max.}$ the highest possible grade of the status (4) for an indicator, and i is the number of the indicator.

Finally, investorsinvestor must classify the state of the ecosystems into five ecological classes, from bad to high:

Ecological class (Ecological value)	EBQI values
High (4)	EBQI ≥ 7.5
Good (3)	6 ≥ EBQI < 7.5
Moderate (2)	4.5 ≥ EBQI < 6
Poor (1)	3.5 ≥ EBQI < 4.5
Bad (0)	EBQI ≤ 3.5

The EBQI is also linked to a Confidence Index (CI) proposal, which identify data gaps for one or several indicators, differences in reliability between indicators and sites, and needs for further field studies to complete missing data.

InvestorsInvestor must classify the CI into five categories (0 to 4), according to the maturity of the data collected for each indicator, and multiply it by the indicator weighting (1 to 5). Therefore, the scale for the CI is obtained from 0 to 20. Afterwards, the CI must be converted to a scale from 0 to 4 for practical purposes:

CI categories	Criteria
4	Field data available, recent and suitable with the recommended methods
3	Field data recent, partially completed with expert judgment
2	No quantitative field data but recent expert judgment

1	No quantitative field data, but ancient expert judgment
0	Neither quantitative field data nor suitable expert judgment

$$CI_{EBQI} = \left[\frac{\sum_{i=1}^{13} \quad (W_i * CI_i)}{\sum_{i=1}^{13} \quad (W_i * CI_{max.})}\right] * 4$$

Where: W_i is the weighting of the indicator i; CI_i the Confidence Index of the indicator i; $S_{max.}$ the highest possible grade of the status (4) for an indicator, and i is the number of the indicator.

Finally, investors must multiply the ecological class value by the extent of the project and divide it to the maximum value (4) to obtain the condition (or state) of the *P. oceanica* ecosystems, which is expressed in condition-adjusted extent units, or equivalent m^2 ($eq.m^2$).

$$Ecosystem\ condition\ (eq.m^2) = \frac{extent * condition_{project}}{condition_{max.}}$$

Posidonia oceanica — WePOSI Protocol

The WePOSI (Weighted Posidonia oceanica Index) was developed by Gerakaris and Panayotidis (HCMR, 2021) as the national Greek method for the assessment of ecological status of coastal waters under the Water Framework Directive BQE "Angiosperms", designed to overcome the limitations of the previously applied PREI in capturing the full range of anthropogenic pressures on Greek P. oceanica meadows.

Selected from a candidate pool of 28 metrics through ANOVA and PCA screening, WePOSI integrates seven descriptors organised across three biotic levels — population level (type and depth of lower limit, meadow cover, dead matte cover, shoot density, and percentage of plagiotropic rhizomes), individual level (shoot length), and community level (epiphytic biomass) — combined into a final Ecological Quality Ratio (EQR) through a weighted equation:

$$EQR' = (EQR'MEADOW \times 0.5 + EQR'PLANT \times 0.3 + EQR'COMMUNITY \times 0.2) / 3$$

The resulting EQR is expressed on a 0–1 scale, mapped to five WFD status classes (Bad, Poor, Moderate, Good, High), with class boundaries aligned to those of the intercalibrated indices POMI, PREI, and Valencian CS. Validated across 70 P. oceanica meadows in the Ionian and Aegean Seas, WePOSI shows a strong and statistically significant relationship with the LUSIsg anthropogenic pressure index ($R^2 = 0.702$, $p<0.05$) and excellent correlation with the intercalibration common metric ($r = 0.909$, slope = 0.970).

Cymodocea nodosa meadows Condition

The MediSkew index (Orlando-Bonaca et al., 2015) is applied at the Monfalcone pilot site as mentioned in D1.2.1. This index is based on a ln-transformation applied to row data of *C. nodosa* leaf lengths[4], which combines two metrics:

i. deviation from the reference median length (Md), and
ii. skewness of the length frequency distribution (G).

$$MediSkew = \frac{\frac{(Md_{area} - Md_{RC})}{20} + \frac{|G|}{2}}{2}$$

Where: Md_{area} is the median length of the photosynthetic part of adult and intermediate *C. nodosa* leaves in a certain area; Md_{RC} the median length of the photosynthetic part of adult and intermediate *C. nodosa* leaves in the reference area; and $|G|$ the absolute value of skewness of C. nodosa ln-transformed leaf lengths for a certain area, which is calculated using:

$$G = \frac{n}{(n-1)(n-2)} \sum_{i=1}^{n} \left(\frac{x_i - \underline{x}}{s}\right)^3$$

Where: n is the sample size; x_i the ln-transformed length of the single photosynthetic part of the seagrass leaf; $\underline{x}$ is the sample mean (arithmetic mean of ln-transformed lengths of photosynthetic parts of leaves); and s the sample standard deviation.

In this case, the skewness G of pristine meadows —calculated with ln-transformed leaf lengths— is close to zero, while that of disturbed meadows shows a different degree of deviation from zero.

InvestorsInvestor may classify the MediSkew Index values into five ecological categories, from bad to high, to align the results with international marine frameworks:

Ecological class (Ecological class value)	MediSkew values
High (4)	0 ≤ MediSkew < 0.2
Good (3)	0.2 ≤ MediSkew < 0.4
Moderate (2)	0.4 ≤ MediSkew < 0.6
Poor (1)	0.6 ≤ MediSkew < 0.8
Bad (0)	0.8 ≤ MediSkew ≤ 1

[4] For each leaf, suggested parameters are length of the sheath, length of the photosynthetic part, and width.

Finally, investors must multiply the ecological class value (condition) by the extent of the project and divide it to the maximum value (4) to obtain the condition (or state) of the *C. nodosa* ecosystems, which is expressed in condition-adjusted extent units, or equivalent m^2 ($eq.m^2$).

$$Ecosystem\ condition\ (eq.m^2) = \frac{extent * condition_{project}}{condition_{max.}}$$

B. Technical Appendix — Credit system case study

Overview and purpose

This section presents a **complete, end-to-end worked example of the twelve-step Seagrass Credit generation process** described in this Cookbook, applied to the Sardinia pilot site at the Capo Testa-Punta Falcone Marine Protected Area. The example covers both active restoration (200 m² transplantation plot) and passive restoration (7.08 ha dead matte area under anchoring pressure reduction), enabling direct comparison of the two restoration modalities in terms of credit volume, pricing, and financial performance. It is designed to serve as a practical reference for project developers applying the methodology for the first time, and as a verification aid for certifiers and auditors reviewing credit calculations at this or comparable Mediterranean pilot sites.

BOX 1: Active restoration is 200 m² transplantation plot and passive restoration is potentially linked to a 7.08 ha dead matte area under anchoring pressure reduction
NOTE that this is an example theorical to reference how to apply model.

Limitations of the Theoretical Case Application

To develop and illustrate the methodology, the following steps are presented as a theoretical exercise rather than as a direct pilot project application. It is important to clearly establish this distinction, as the data used are the combination of certain assumptions and data derived from a NCA pilot project. Consequently, this exercise is limited to baseline information (NCA), while essential future data from control, impacted, and negative reference points are still unavailable (assumptions). Therefore, the assumptions outlined in the following subsection ("Hypotheses") are considered necessary for the exercise.

As a result, several additional assumptions continue to be applied. Although these considerations aim to be reasonably valid, they inevitably increase the overall level of uncertainty. Accordingly, this exercise should be interpreted with caution and understood solely to operationalize and illustrate the steps proposed in the cookbook. The resulting values should not be considered exact, directly comparable, or suitable for use as reference values in future studies.

From a cost perspective, significant limitations also remain. The monetary ranges are highly dependent on input data quality and the methodologies used. In addition, many relevant cost components are still missing, preventing the establishment of even a minimum realistic pricing value for the model. Likewise, determining a maximum sale value would require greater methodological harmonization, particularly considering the challenges discussed in Deliverable 2.3.1.

BOX 2: This exercise is a <u>theoretical</u> illustration of the methodology based on pilot data and future assumptions, so results should <u>be interpreted cautiously due to remaining uncertainties, incomplete data, and significant cost limitations</u>

Study area and initial configuration

The Capo Testa-Punta Falcone Marine Protected Area (Sardinia, Italy) encompasses approximately 5160 ha of coastal marine habitat in northern Sardinia, including 294.47 ha of *Posidonia oceanica* meadow (Figure 7). Three confirmed areas of dead-matte resulting from chronic recreational boat anchoring total 7.08 ha, with the two largest located in La Marmorata Bay. The selected active restoration site is a 200 m² dead matte patch at 20–25 m depth within La Marmorata Bay, transplanted during the ARTEMIS restoration campaign. The broader 7.08 ha impacted zone constitutes the potential passive restoration accreditation area.

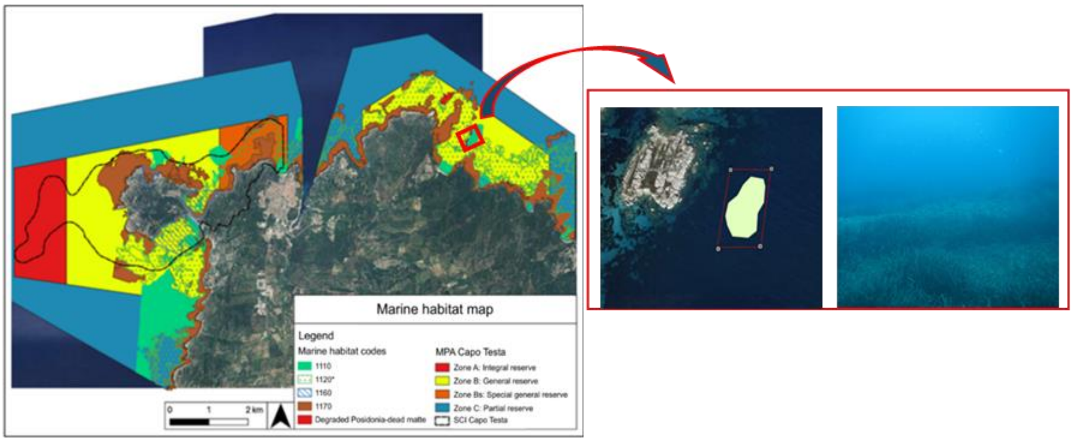


Figure 9. The Capo Testa-Punta Falcone Marine Protected Area (Sardinia, Italy). Source: D1.2.1

Two monitoring stations were established following the ecological survey protocols of Deliverable 1.2.1 (Figure 8):

- **ST1 (impacted station)**: located within the degraded dead matte area. Used as the baseline condition for both active and passive restoration calculations.
- **ST2 (control station)**: located in a healthy *P. oceanica* meadow at comparable depth and exposure. Used as the target condition representing the potential post-restoration ecosystem state.

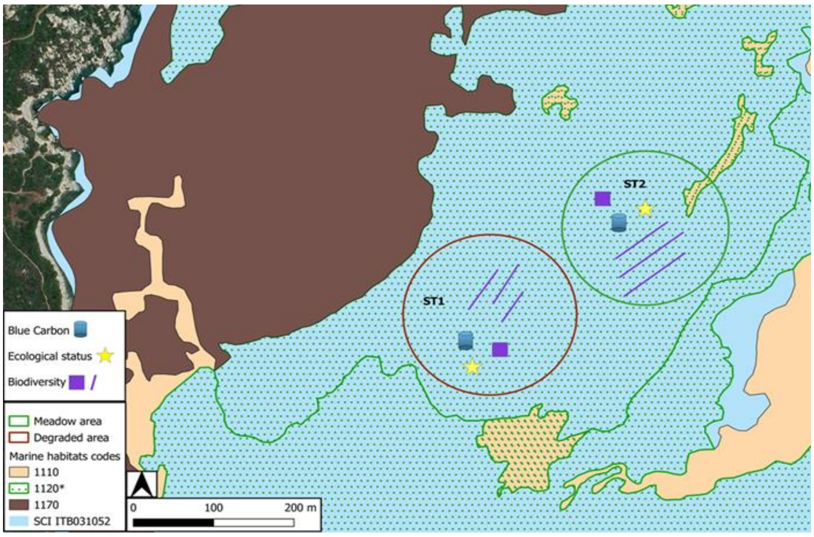


Figure 10. Monitoring stations at Capo Testa-Punta Falcone. Source: D1.2.1

The following tables summarize the initial configuration of the project area, which is divided into two main management zones: a very small Active Restoration Area (0.02 ha and EBQI 2.97) and a much larger Passive Restoration Area. Asset 2.1 (control) consists of Posidonia meadow (287.37 ha) monitored at station ST2, with an ecological quality index (EBQI) of 4.31. Asset 2.2 (passive area proposal) covers an area of 7.08 ha and is assumed to be monitored at station ST1, with an Ecological Quality Index (EBQI) of 2.97.

Table 6. Spatial configuration of the Sardinia pilot — extent by management zone

Pilot site	Active restoration zone area (m²) (ST1)	Passive restoration zone area (m²)	Posidonia – Control (ST2)
Sardinia (Capo Testa-Punta Falcone MPA)	200	70 800	287 370

Table 7. Ecological condition at project start (2025) in Sardinia pilot

Site	Ecosystem	Index	Year	ST1	ST2
Sardinia	Posidonia (marine)	EBQI	2025	2.97	4.31

BOX 3: ◦
ST1 (impacted station) IBQI (2.97)
ST2 (control station) IBQI (4.31)

Hypotheses and parameters

The following assumptions were adopted for this worked example. All parameters are explicitly documented to ensure full replicability, consistent with the Rigour and Replicability principles of the condition indicator selection framework (Section 4, Step 3).

- **Monitoring period (t)**: 5 years, consistent with the minimum monitoring cycle of the Seagrass Credit methodology and the first verification checkpoint defined in the Project Management Plan.
- **Unitary Credit Extent (UCE)**: 1 m², considered for a pilot experience, despite what has been developed for commercial projects in the Cookbook Part I.
- **Condition reference value**: 10 (maximum achievable EBQI score, which may differ from the real reference value achievable), used to normalise raw EBQI values to the 0–1 condition scale required for the Qm² calculation.
- **Baseline condition (C_0)**: EBQI of ST1 at project start = 2.97. Applied to both active and passive restoration scenarios.
- **Post-restoration condition (C_t)**: EBQI of ST2 (control station) = 4.31. Applied as the projected ecosystem condition achievable after 5 years of restoration, assuming progressive recovery toward the reference meadow state.
- **Negative control scenario**: B_0 = 2.97 (initial condition of the control area); B_t adjusted by the Estimated Degradation Rate (CR) applied over the monitoring period.
- **Estimated Clearing Rate (CR)**: 1.5% yr^{-1}, derived from Telesca *et al* (2015), who reported that *P. oceanica* biomass decline rate across Mediterranean meadows. Applied as the background rate of meadow degradation in the absence of management intervention.
- **Leakage Determination Area (LDA)** (passive restoration only): estimated on 400 m², corresponding to twice the active restoration plot area, based on the spatial pressure analysis from Deliverable 1.2.1 maps.
- **Passive restoration costs**: Only visitor reception and mooring maintenance costs (EUR 220/m²/yr) and environmental education activities (EUR 110/m²/yr) are included, as these are the cost categories directly attributable to passive restoration measures at this site.
- **Carbon accounting**: Values from the control area (ST2) are used as Deliverable 2.3.1.
- **Social price:** Based on social price values used in D2.3.1.
- **Minimum Profitable Price & Biodiversity preservation total:** Not enough information and exactly, so assumed that is right for theoretical example.

BOX 4: The following assumptions were adopted of the methodology, include: t, UCE, reference, Co, Ct, Bo, CR, LDA, costs and other

Active restoration — Credit calculation

NECO calculation

The Net Ecosystem Condition Outcomes (NECO) for the active restoration scenario are calculated following the formula defined in Step 8 (in complement to before steps) of the Cookbook:

$$NECO_t = \left((E_t * C_t) - \left[(E_0 * C_0) * \left(1 + (t * B_t)\right)\right]\right)$$

Where: E_t = Extent at period t; C_t = normalized Condition at period t; E_0 = Extent at Year 0; C_0 = normalized Condition at Year 0; B_t = cumulative baseline trend rate.

Applying the methodology before explaining and hypotheses or parameters, the formula is:

$$NECO_{active\ 5} = \left(\left(200\ m^2 * \frac{4.31}{10}\right) - \left[\left(200\ m^2 * \frac{2.97}{10}\right) * \left(1 + \left(\frac{2.75-2.97}{2.97}\right)\right)\right]\right) = 31.12 \approx 31$$

Buffer pool & Net Seagrass Credit- calculation

Then, SC_5 is 31, is necessary to calculate buffer pool of 20% SC (step 10) and the Net Seagrass Credit – NSC (Step 11) are:

$$BP_5 = 31 * 0.2 = 7 \text{ (Step 10)}$$

$$NSC_5 = 31 - 7 = 24 \text{ (Step 11)}$$

BOX 5. Summary of result active restoration: •

Total credits are 31, buffer pool 7 and net seagrass credit 24 (0.12 credit/m²)

For further and more disaggregated information, see Table 8.

Table 8. Active restoration credit calculations

	Pilots Index	Theorical EBQI	Reference or calculate
Data	Reporting period (t)	5.00	See chaper of hypotheses
	Unitary Credit Extent (UCE)	1.00	Cookbook I (fixed parameter)
	Extent (m2)	200.00	Area
Condition	Reference	10.00	Maximum of the methodology IBQI
	Baseline	2.97	ST1 Condition
	Negative_bas: B0	2.97	See chaper of hypotheses
	Condition t	4.31	ST2 Condition

	Pilots Index	Theorical EBQI	Reference or calculate
	Negative_t: Bt	2.75	See chaper of hypotheses
# credits	Variation Bt	-0.07	1 + ((Bt-B0)/B0)
	F = 1+ Variation Bt	0.93	
	C0: Ecosystem condition of the asset at the baseline	0.30	2.97/10= 0.29
	Ct: Ecosystem condition of the asset at the end of the RP.	0.43	4.31/10= 0.43
	E0*C0	59.40	0.29*200
	Et*Ct	86.20	0.43*200
	E0*C0*F	55.08	59.40*1
	NECOt_ sin lD (Net Ecosystem Condition Outcomes without leakage)	31.12	86.20-59.40
	SCt (Seagrass Credits)	31.00	Approximate 26.8/1
	BP (buffer pool)	7.00	26*0.2=6
	NSCt (net Seagrass Credits)	24.00	**26-6=20**

Passive restoration — Credit calculation

NECO calculation & leakage

The Net Ecosystem Condition Outcomes (NECO) for the active restoration scenario are calculated following the formula defined in Step 8 (in complement to before steps) of the Cookbook:

$$NECO_t = \Big((E_t * C_t) - \big[(E_0 * C_0) * \big(1 + (t * B_t)\big)\big]\Big) * LD_t$$

Where: E_t = Extent at period t; C_t = normalized Condition at period t; E_0 = Extent at Year 0; C_0 = normalized Condition at Year 0; B_t = cumulative baseline trend rate; LD_t = leakage discount factor.

Applying the methodology before explaining and hypotheses or parameters, the formula is:

$$NECO_{passive\ 5} =$$

$$\left(\left(70\,800\, m^2 * \frac{4.31}{10}\right) - \left[\left(70\,800\, m^2 * \frac{2.97}{10}\right) * \left(1 + \left(\frac{2.75 - 2.97}{2.97}\right)\right)\right]\right) * \left(1 - \frac{400\, m^2}{70\,800\, m^2} * (0{,}015 * 5)\right) =$$

$$11{,}012.99 \approx 11{,}012$$

Buffer pool & Net Seagrass Credit- calculation

Then, SC_5 is 11,012, is necessary to calculate buffer pool of 20% SC (step 10) and the Net Seagrass Credit – NSC (Step 11) are:

$$BP_5 = 11\,012 * 0.2 = 2203 \text{ (Step 10)}$$

$$NSC_5 = 11\,012 - 2203 = 8809 \text{ (Step 11)}$$

BOX 6. Summary of result passive restoration: •
Total credits are 11 012, buffer pool 2203 and net seagrass credit 8809 (0.12 credit/m²)

For further and more disaggregated information, see Table 9.

Table 9. Passive restoration credit calculations

Pilots		Theorical	Reference or calculate
Index		EBQI	
Data	**Reporting period (t)**	5.00	See chapter of hypotheses
	Unitary Credit Extent (UCE)	1.00	Cookbook I (fixed parameter)
	Extent (m2)	70 800.00	Area
Condition	**Reference**	10.00	Maximum of the methodology IBQI
	Baseline	2.97	ST1 Condition
	Negative_bas: B0	2.97	See chapter of hypotheses
	Condition t	4.31	ST2 Condition
	Negative_t: Bt	2.75	See chapter of hypotheses
# credits	**Variation Bt**	-0.07	1 + ((Bt-B0)/B0)
	F = 1+ Variation Bt	0.93	
	C0: Ecosystem condition of the asset at the baseline	0.29	2.97/10= 0.29
	Ct: Ecosystem condition of the asset at the end of the RP.	0.43	4.31/10= 0.43
	LDA (Leakage determination area)	400.00	See chapter of hypotheses
	CR: Annual rate of change in seagrass biomass (Estimated Clearing Rate)	0.08	See chapter of hypotheses* period
	LD: Leakage Deduction Factor	0.9996	1-(400/70 800) * 0.075
	E0*C0	21 027.60	70 800*0.29
	Et*Ct	30 514.80	70 800*0,43
	E0*C0*F	19 497.14	21 027.60*0.93
	NECOt (Net Ecosystem Condition Outcomes with leakage)	11 012.99	(30 514.80-19 497.14) * 0.9981
	SCt (Seagrass Credits)	11 012.00	Approximate 11 012.99/1
	BP (buffer pool)	2203.00	11 012.00*0.2
	NSCt (net Seagrass Credits)	8809.00	11 012.00-2203.00

Figure 9 compares three possible condition trajectories over a five-year period in the theoretical Case Application: improvement (C+), maintenance (C=), and deterioration (C−). All scenarios start from the same initial condition value of 2.97 (3.0) in Year 0. The improvement scenario shows a steady increase, reaching 4.3 by Year 5, representing positive ecological or environmental recovery. The maintenance scenario remains constant at 3.0 throughout the entire period, indicating stable conditions with no significant change. In contrast, the deterioration scenario gradually declines to 2.8 by Year 5, reflecting worsening conditions over time. Overall, the figure illustrates how environmental conditions can evolve positively, remain stable, or degrade depending on management effectiveness and external pressures.

When applying the assumptions for both seagrass declining despite restoration actions (simulating restoration effort failure scenario) or high natural recovery in the negative control (the without-project scenario), the designed issuance process of the generation of seagrass credits is cancelled by showing a negative number of credits.

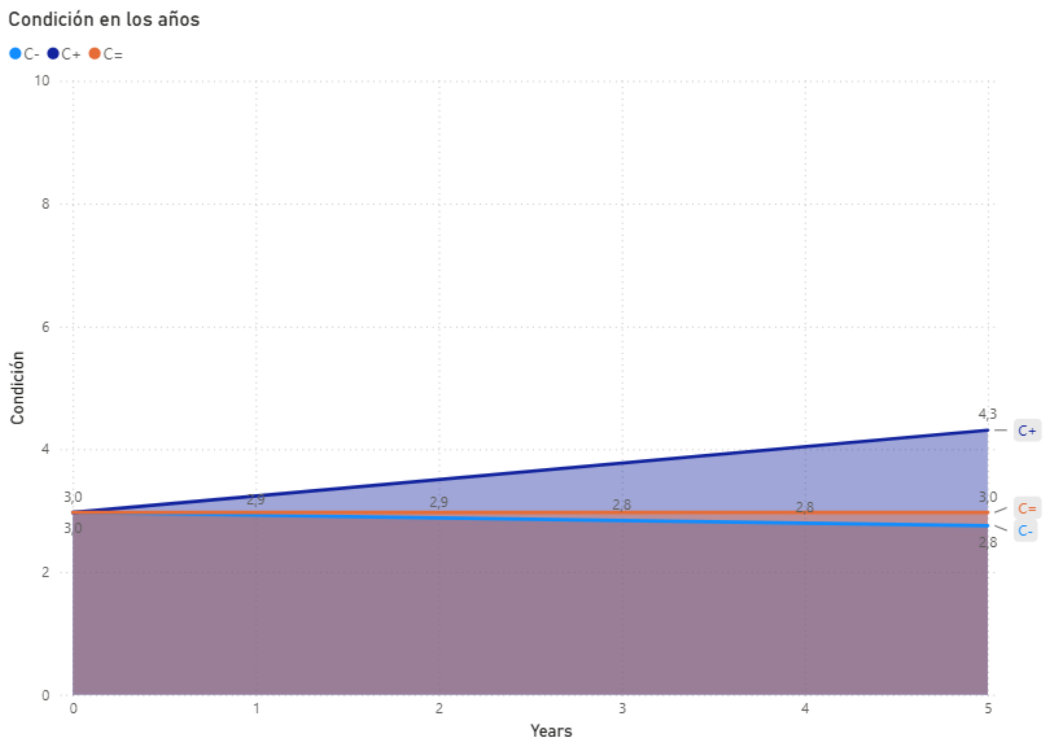


Figure 11. Condition negative, control and restoration of Theoretical Case Application

BOX 7

The number of credits largely depends on the area.

Step 12. Pricing Seagrass credits applicate to active restoration- theoretical

As stated in Step 12, the price of Seagrass Credits will ultimately depend on market demand and investors' willingness to pay. Nevertheless, estimating ecosystem services is essential to ensure financial viability, while allowing all values to be standardized into the same monetary units across the project area and monitoring period. Especially in cases where a reference market-price is unavailable, such as in the current situation where the market is still incipient. For that purpose, the following formula needs to be applied:

$$ESO_t = \sum_{1}^{t} \quad Ecosystem\ services_{(biodiversity\ \&\ blue\ carbon)}$$

Where: ESO_t are the total Ecosystem Services Outcomes in monetary units at monitoring period (year t); and, $Ecosystem\ services_i$ every ecosystem service evaluated in monetary flow accounts within the project Extent at monitoring period (year t).

$$\sum_{1}^{5} Ecosystem\ services_{(biodiversity*\ \&\ blue\ carbon**)} = \left(2390.88\frac{EUR}{m^2} + 50.11\frac{EUR}{m^2}\right) * 200\ m^2 = 488\ 197.10\ EUR$$

Notes:

***Biodiversity cost; all costs are normalized to EUR/m² and then summed up.**

****Blue carbon cost; costs are normalized from ton/m² yr to ton/m², and then transformed into monetary terms.**

It is now essential to relate these values to the number of credits to determine both the potential value per credit and the total potential value for each type of credit:

Table 10. Summary of unitary price credits and total value – active restoration

Type of credit	Unitary price	Total value	Number of credits
Pool credits	15 748.29 EUR / credit	110 238.06 EUR	7
Tradable credits		377 959.05 EUR	24
Total		488 197.10 EUR	31

These prices should be considered as the maximum achievable value for credits, being aligned to the societal value of nature.

The minimum price estimation should also achieve at least the value of the costs incurred for the restoration project implementation, following the formula:

$$Costs_t = Amortized\ CapEx_t + OpEx_t = Minimum\ Profitable\ value\ (MMP)$$

Where: $Costs_t$ are the total costs at the reporting period (year t); $Amortized\ CapEx_t$ total capital expenditure amortized at monitoring period (year t); and, $OpEx_t$ total operational expenses at monitoring period (year t).

In addition to these implementation costs, an industrial benefit rate must be considered for commercial transactions.

In this example, the MMP value for the 5-year reporting period, considering scientific monitoring, educational and public activities costs, visitor reception and maintenance costs and restoration actions costs, **is 11 876.61 EUR per credit, with a total value of 368 175.00 EUR.**

BOX 8. The theoretical credit price for the active restoration area ranges from EUR 11 876.61 to EUR 15 748.29 per credit, where the lower range represents the MMP and the upper range corresponds to ESO.

For more disaggregated information, see Table 10, also for MMP or potential value.

Table 10. ESO, costs, price and MMP- Active restoration.

Pilot	Theorical Period Extent	Value 5.00 200	Metric yr m2	Reference or calculate Parameter active area
Global Climate Regulation	Blue carbon retention	0.28	Tn CO2 m-2	Tn CO2 ha-1/10 000
	Blue carbon sequestration	0.01	Tn CO2 m-2	Tn CO2 ha-1/10 000*period
	Market value	70.00	EUR / Tn CO2	70 EUR Tn-1
	Social value	168.84	EUR / Tn CO2	168.84 EUR Tn-1
	Social price	50.1105	EUR m-2	Social value* (sum of carbon)
Biodiversity preservation	Administrative / Management costs	0	EUR/ m2	Defensive cost
	Scientific monitoring costs	108.6	EUR/ m2	Defensive cost
	Educational and Public activities costs	110	EUR/ m2	Defensive cost
	Visitor reception and maintenance costs	220	EUR/ m2	Defensive cost
	Use and operational costs	0	EUR/ m2	Defensive cost
	Conservation projects costs	0	EUR/ m2	Defensive cost
	Restoration actions costs	197.875	EUR/ m2	Defensive cost
	Biodiversity preservation total	2390.88	EUR m-2	(sum of biodiversity cost active[5]* period) + Restoration actions costs
Price	Subtotal	488 197.10	EUR	(sum of biodiversity preservation + social price) * extent
	# credits	31.00	credits	NECO
	Unitary Price	15 748.29	EUR / credit	subtotal/#credit
	# pool credits	7.00	credits	BP
	Pool Price	110 238.06	EUR	#pool credits* unitary price
	# tradable credits	24.00	credits	NSC
	Tradable credits Price	377 959.05	EUR	NSC* unitary price
Minimum Profitable Price	MMP	368 175.00	EUR	(((Administrative cost + Scientific monitoring costs+ Use and operational costs) *period) + (Restoration actions costs)) *extent
	MMP/ credit	11 876.61	EUR / credit	MMP/#Credits

Step 12. Pricing Seagrass credits applicate to passive restoration- theorical

[5] Except Restoration actions, because this cost was once in first year

The same process described above was applied to passive restoration; however, there was a lack of restoration activities costs available, which include the same categories: scientific monitoring, educational and public activities costs, visitor reception and maintenance costs and passive restoration actions costs.

$$\sum_{1}^{5} Ecosystem\ services_{(biodiversity*\ \ carbon\ blue**)}$$

$$= \left(1650\frac{EUR}{m^2} + 50.11\frac{EUR}{m^2}\right) * 70\ 800\ m^2 = 120\ 367\ 824.34\ EUR$$

Notes:

Biodiversity cost; Each defensive cost adjusts EUR/m² and then all of them are added

Carbon blue cost; For normalized was necessary adjust the unit's ton/m² yr to ton/m² for period, then for the price euro

It is now essential to relate these values to the number of credits to determine both the potential value per credit and the total potential value for each type of credit:

Table 11. Summary of unitary price credits and total value – passive restoration

Type of credit	Unitary price	Total value	Number of credits
Pool credits		24 080 123.23 EUR	2203
Tradable credits		96 287 701.11 EUR	8809
	10 930.61 EUR / credit		
Total		120 367 824.34EUR	11 012

BOX 9. The theoretical credit price for the passive restoration area ranges from EUR 7072.28 to EUR 10 930.61 per credit, where the lower range represents the MMP and the upper range corresponds to ESO.

In this case MMP of the total is adjusted to reporting period and area for project management costs, hypothetically included only visitor reception cost (mooring areas). **The result is 7072.28 EUR per credit with a total price of 77 880 000.00 EUR.**

BOX 10. The active restoration scenario shows consistently higher theoretical credit prices (EUR 11 876.61–15 748.29 per credit) than passive restoration (EUR 7072.28–10 930.61 per credit), with both cases defined by MMP as the lower bound and ESO as the upper bound.

For further disaggregated information passive restoration cost and price, see Table 12.

Table 12. ESO, costs, price and MMP- Passive restoration.

Pilot	Theorical	Value	Metric	Reference or calculate
	Period	5.00	yr	Parameter
	Extent	70 800.00	m2	active area
Global Climate Regulation	Blue carbon retention	0.28	Tn CO2 m-2	Tn CO2 ha-1/10000
	Blue carbon sequestration	0.01	Tn CO2 m-2	Tn CO2 ha-1/10000*period
	Market value	70.00	EUR / Tn CO2	70 EUR Tn-1
	Social value	168.84	EUR / Tn CO2	168.84 EUR Tn-1
	Social price	50.1105	EUR m-2	Social value* (sum of carbon)
Biodiversity preservation	Administrative / Management costs	0.00	EUR/ m2 per year	Defensive cost
	Scientific monitoring costs	0.00	EUR/ m2 per year	Defensive cost
	Educational and Public activities costs	110.00	EUR/ m2 per year	Defensive cost
	Visitor reception and maintenance costs	220.00	EUR/ m2 per year	Defensive cost
	Use management costs	0.00	EUR/ m2 per year	Defensive cost
	Relocation of aquaculture facilities located over or near seagrass meadows.	0.00	EUR/ m2 per year	Defensive cost
	Prohibition of trawling and all towed gear.	0.00	EUR/ m2 per year	Defensive cost
	Use of anti-trawling devices to prevent illegal fishing	0.00	EUR/ m2 per year	Defensive cost
	Regulation of coastal construction activities with explicit Posidonia avoidance criteria.	0.00	EUR/ m2 per year	Defensive cost
	Reduction of nutrient and pollutant inputs through improved wastewater and stormwater treatment.	0.00	EUR/ m2 per year	Defensive cost
	Minimisation and control of brine discharges from desalination plants, especially in shallow or semi-enclosed areas.	0.00	EUR/ m2 per year	Defensive cost
	Establishment of temporary or permanent exclusion zones	0.00	EUR/ m2 per year	Defensive cost
	Biodiversity preservation	1650.00	EUR/ m2	Sum all of them EUR / m2 passive* period

Price	**Subtotal**	120 367 824.34	EUR	(sum of biodiversity preservation + social price) * extent
	# credits	11 012.00	credits	NECO
	Unitary Price	10 930.61	EUR / credit	subtotal/#credit
	# pool credits	2203.00	credits	BP
	Pool Price	24 080,123.23	EUR	#pool credits* unitary price
	# tradable credits	8809.00	credits	NSC
	Tradable credits Price	96 287 701.11	EUR	NSC* unitary price
Minimum Profitable Price	MMP	77 880 000.00	EUR	(Administrative cost + Scientific monitoring costs+ Use and operational costs + Visitor reception and maintenance costs) *period*extent
	MMP/ credit	7072.28	EUR / credit	MMP/#Credits

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