REST-COAST

LARGE SCALE RESTORATION OF COASTAL ECOSYSTEMS THROUGH RIVERS TO SEA CONNECTIVITY

VENICE LAGOON

RESULTS & ACHIEVEMENTS REPORT

SUMMARY

The Venice Lagoon pilot site focuses on the restoration of saltmarshes – one of the lagoon's most ecologically distinctive and threatened habitats. Restoration activities were implemented across 138 hectares of man-made salt marshes in the central lagoon, targeting 11 marshes and restoring 21,008 linear metres of marsh edge reinforcement (contermination).

Implementation levels range from 0% to 100% across the ten challenge categories. Full implementation was achieved for direct marsh edge restoration and for the removal of invasive alien species, the *Baccharis halimifolia*. The second phase – nourishment of the marshes with dredged sediment – was halted by regulatory constraints, limiting bird habitat benefits to roosting in the marhes' boundary poles rather than breeding and feeding. Several pressures, including reduced river sediment inputs, subsidence, and tourism, fall outside the scope of the pilot interventions.

Monitoring results are encouraging: restored marshes support a substantial share of Venice Lagoon's breeding populations of several Annex I bird species, in some cases exceeding 10% of the entire Italian breeding population. Hydrodynamic modelling confirmed average wave height reductions of -15% (exceeding -30% in some areas). Governance was strengthened through the establishment of a permanent CORE-PLAT stakeholder platform, culminating in a signed restoration agreement among key institutional actors.

Funded by the European Union

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THREATS AND PRESSURES TACKLED

- Progressive erosion and disappearance of natural salt marshes.
- Submerging of tidal flats and mudflats.
- Reduced sediment inputs into the lagoon from rivers.
- Loss of suitable bird nesting habitat.
- Increased wave erosion from motor boats and maritime traffic.
- Chemical contamination of water, soils and sediments.
- Hydromorphological disruption from lagoon inlet modifications and excavation of artificial channels.
- Colonisation of invasive alien species (IAS), particularly *Baccharis halimifolia*.
- Lowering of land elevation (subsidence).
- Pressure from anthropic activities including tourism, ports, fisheries and aquaculture.

BASELINE CONDITION

Saltmarshes are among the Venice Lagoon's most ecologically valuable habitats, yet they have been subject to sustained erosion and degradation for decades. Progressive loss of marsh edges accelerates sediment export from the system, deepens adjacent tidal flats, and reduces the biological connectivity and ecosystem service capacity of the lagoon.

Since 1992, the Venice Water Authority (Ministry of Infrastructures) has created and restored artificial saltmarshes to counteract this trend. However, by the time of the REST-COAST project, many of these marshes had reached an advanced stage of degradation requiring renewed intervention. Simultaneously, the lagoon's natural capacity to receive sediment from rivers has decreased, and subsidence continues to lower marsh elevations – pressures that the pilot interventions address only partially.

Invasive alien species, principally *Baccharis halimifolia*, had colonised some marsh surfaces, further altering habitat quality. Bird nesting habitat had contracted, but long-term monitoring had already established that artificial salt marshes – when in good condition – can support high proportions of the lagoon's bird community. Restoring those conditions was therefore a primary ecological objective.

RESTORATION STRATEGY SELECTED AND WHY

The project adopted a two-phase restoration methodology developed and refined by the Venice Water Authority since 1992. Phase 1 restores degraded marsh edges through contermination works, stabilising the marsh perimeter and preparing the site for phase 2. Phase 2, executed by the Venice Port Authority as part of routine port maintenance, nourishes the marsh surface with sediments in good chemical and ecological status dredged from navigational channels – converting a waste product of infrastructure operations into an ecological resource.

This dual-phase approach was selected because it links infrastructure maintenance directly to ecological restoration, spreading costs across existing operational budgets and avoiding the need for standalone sediment procurement.

Contermination type is calibrated to local wave exposure: Type P1 (single boundary) for moderately protected areas; Type 2 (double boundary) for highly exposed locations with high wave fetch.

IAS (and waste) removal was integrated into the physical works, using mechanical excavation followed by surface levelling to restore correct marsh elevation and reinstate regular tidal flooding – the condition that naturally inhibits colonisation of terrestrial invasives. The approach was supported by hydrodynamic modelling and biodiversity monitoring to quantify outcomes and inform spatial prioritisation, and by the CORE-PLAT governance platform to coordinate among institutions and build shared commitment to and decision on implementation.

HOW THE CHALLENGES WERE ADDRESSED AND KEY RESULTS ACHIEVED

Progressive Erosion and Disappearance of Salt Marshes

21,008 linear metres of salt marsh contermination were restored across 11 marshes (138 hectares in total) through three executive projects: P1061 (3 marshes), P1073 (5 marshes) and P1079 (3 marshes). Works are fully implemented as planned, arresting ongoing erosion and sediment loss from these salt marshes.

Deepening of Tidal Flats and Mudflats

Restored salt marshes reduce wave motion from motorboats and wind, lowering erosion of morphological structures and slowing the deepening of adjacent canals. Full resolution requires broader interventions beyond the pilot scope.

Reduced Sediment Inputs into the Lagoon

Restoration does not affect riverine sediment supply to the lagoon. However, restored marshes trap and retain sediments already present in the system, reducing net sediment loss. River-sourced sediment deficits fall outside the scope of the pilot, but have a system-level impact.

Loss of Bird Nesting Sites

Contermination works (phase 1) were completed, providing new roosting habitat for birds. Phase 2 sediment nourishment – required to create conditions suitable for breeding and feeding – was halted by regulatory constraints. Lagoon-wide monitoring recorded a net increase of +86 nesting pairs in 2024 compared to 2023, across Avocet, Black-winged Stilt, Common Tern, Little Tern, Mallard, Oystercatcher, Redshank, Shelduck and Yellow-legged Gull. Long-term data show that artificial salt marshes now host 50–70% of total breeding pairs for several species recorded in the Venice Lagoon, and in several cases support more than 10% of the entire Italian breeding population of certain Annex I species (this is the case of *Sterna sandvicensis*).

Increased Wave Disturbance from Boats and Maritime Traffic

Restored salt marshes attenuate wave energy from boats and maritime traffic, reducing erosion of lagoon habitats. The protective effect is proportional to the extent of completed work.

Chemical Contamination

Chemical contamination was not directly targeted. Ongoing monitoring and modelling efforts are working to quantify the potential contribution of restored salt marshes to water quality purification.

Hydromorphological Disruption

Inlet-scale hydromorphological changes were not addressed by the pilot. Hydrodynamic modelling at the pilot area scale demonstrated measurable local effects: average wave height reduction of -15% (exceeding -30% in some areas), water level reduction of up to 5% in vegetated zones, and reduced bottom water velocity in vegetated areas. A noted side effect is that wetlands can increase water levels near main inlet mouths during flood phases and increase bottom currents in adjacent unvegetated channels – relevant for future spatial planning.

100% Implemented — Invasive Alien Species

Baccharis halimifolia was fully removed from all targeted marshes by mechanical excavation, followed by surface levelling to restore correct tidal flooding regimes and prevent re-establishment.

0% Implemented — Subsidence

Land elevation lowering due to subsidence is not addressed by the restoration interventions implemented under the pilot.

0% Implemented — Tourism, Ports, Fisheries and Aquaculture

These pressures were not directly targeted. Future suggestions address how ecotourism could be leveraged to redirect and reframe tourism demand in ways that support rather than undermine lagoon restoration.

PERCENTAGE OF TARGET ACHIEVED

100% Salt marsh edge restoration (contermination) completed across all 11 target marshes (138 ha); IAS removed from all targeted sites.

40% Bird nesting habitat – phase 1 (contermination) complete; phase 2 (sediment nourishment) halted by regulatory constraints.

25% Tidal flat deepening and wave disturbance – partially addressed through completed restoration works (phase 1).

0% Riverine sediment deficit, chemical contamination, inlet-scale hydromorphology, subsidence, and tourism pressure – outside the direct scope of pilot interventions.

SPECIFIC SOLUTIONS IMPLEMENTED

Salt marsh contermination

Restoration of 21,008 linear metres of marsh edges across 11 marshes (138 ha) using calibrated boundary types (Type P1 for moderate exposure; Type 2 for high-exposure areas), arresting erosion and preparing sites for phase 2 nourishment.

IAS removal

Mechanical removal of *Baccharis halimifolia* from all targeted marshes, followed by surface levelling to restore correct elevation and reinstate natural tidal flooding regimes.

Hydrodynamic modelling

Numerical modelling comparing lagoon configurations with and without wetlands and seagrass, quantifying wave attenuation, water level and bottom velocity effects to inform spatial planning of future restoration.

Biodiversity monitoring

Lagoon-wide bird monitoring programme tracking nesting pairs across Annex I and other species, providing long-term data on successional dynamics and habitat performance across marsh stages.

CORE-PLAT governance platform

Establishment of a permanent participatory platform bringing together the Venice Water Authority, Venice Port Authority, Veneto Region, Venice Municipality, research partners and other stakeholders to co-design restoration strategies and build shared institutional commitment and decision.

Restoration agreement

Formal signed agreement among key lagoon actors committing to adopt REST-COAST operational guidelines, maintain the participatory platform, and share restoration plans transparently.

Operational guidelines

Development of best-practice guidelines for less environmentally impactful works in the Venice lagoon, available for adoption by all institutional actors.

KEY STAKEHOLDERS INVOLVED AND HOW

The Venice Water Authority is the primary body responsible for implementing restoration works in the lagoon, with a continuous programme of marsh creation and restoration dating back to 1992. It led the three executive projects and is the principal signatory of the restoration agreement.

The Venice Port Authority (VPA) is responsible for phase 2 sediment nourishment, supplying dredged material from channel maintenance operations to restore marsh elevation. Coordination between the Water Authority and VPA is central to the dual-phase restoration model.

The Veneto Region and Venice Municipality are key decision-makers engaged through the CORE-PLAT, whose participation in the platform indicates regional and local political commitment to the restoration programme.

REST-COAST research partners provide scientific data, hydrodynamic modelling, operational guidelines and biodiversity monitoring results that inform management and operational decisions and underpin the evidence base for scaling and policy influence.

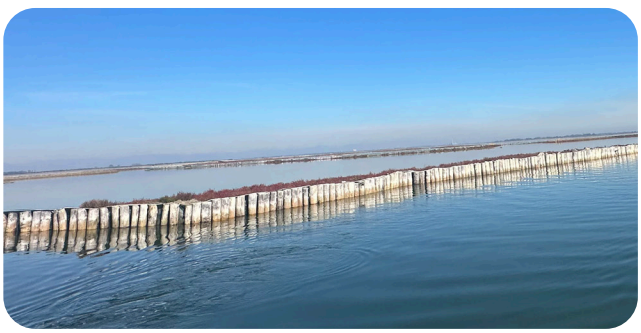
The CORE-PLAT is explicitly recognised as a tool for fostering shared, transparent and inclusive decision-making. Its formalisation through the signed restoration agreement marks a significant step in institutionalising collaborative governance for one of Europe's most complex lagoonal systems.

INFLUENCE ON DECISION-MAKING

The most concrete policy outcome of the pilot is the signed restoration agreement among key lagoon actors. Participants committed to promoting, supporting and implementing environmental restoration projects in the Venice Lagoon using REST-COAST best practices and operational guidelines; applying guidelines for less environmentally impactful works; maintaining and consulting the participatory platform; and periodically sharing plans and projects within the CORE-PLAT. This agreement embeds REST-COAST outputs directly into the ongoing institutional governance of the lagoon.

At the national scale, restoration in Venice operates within the framework of the Special Law for Venice, which provides dedicated public funding for lagoon interventions. REST-COAST contributes to shaping how these resources are deployed through its operational guidelines and restoration prioritisation frameworks.

No specific EU-level policy change is reported, though the lagoon including Natura 2000 sites, and hosting Annex I bird species, means that restoration outcomes have direct relevance to EU Habitats and Birds Directive obligations.



RECOMMENDATIONS FOR FUTURE DEVELOPMENT

Complete phase 2 sediment nourishment works by resolving outstanding regulatory constraints; this is the single most critical step for unlocking full benefits to breeding birds and their feeding habitats.

Maintain and strengthen the Venice CORE-PLAT, inviting additional stakeholders to expand the co-design community and deepen knowledge exchange.

Prioritise future restoration in areas most degraded or at highest risk of erosion, guided by CORE-PLAT inputs and REST-COAST modelling results.

Continue and expand the monitoring programme at both pilot area and lagoon-wide scales to assess medium- to long-term restoration effects and manage marsh successional dynamics.

Maintain a mosaic of marshes of different ages across the lagoon to sustain avian biodiversity: bird species richness and breeding abundance peak at approximately 8–20 years after marsh creation and decline thereafter, making age-diversity across the marsh network essential.

Promote adoption of sustainable materials and techniques in line with REST-COAST operational guidelines, continuously integrating emerging green technologies and new scientific knowledge.

Develop ecotourism and birdwatching as a revenue-generating mechanism: a REST-COAST study found these activities were cited as the most valued economic benefit by 82% of respondents, followed by educational activities (79%) and CSR/NbS opportunities (64%). Redirecting mass tourism toward dispersed, nature-based experiences can generate revenues channelled back into conservation.

FINANCIAL MECHANISMS USED AND PROPOSED

Restoration interventions in the Venice Lagoon have been financed primarily through national public funds allocated under the Special Law for Venice, which provides a dedicated legal and budgetary framework for lagoon conservation and management.

A significant embedded financial mechanism is the repurposing of sediments dredged from navigational channels as nourishment material for salt marsh restoration. This converts a routine waste product of port maintenance into a valuable ecological resource, capturing value that would otherwise be lost with additional costs. Realising this mechanism requires coordination among Port Authority and dredging contractors, underpinned by negotiated agreements and precise logistical planning to match sediment supply with restoration demand in terms of timing, quantity and quality.

Future mechanisms under development include ecotourism and birdwatching revenues channelled back into restoration funding; Corporate Social Responsibility and circular economy activities linked to Nature-based Solutions; and user fees and green finance instruments that can complement national funding as the quantified evidence base for ecosystem services – hydrodynamic modelling results, biodiversity data – continues to grow.