



## **D6.4 Restoration Demo at Ebro Delta**

29/03/2024

### **WP6**

Lead beneficiary: EURECAT, LIM/UPC

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## **REST-COAST**

**Large Scale RESToration of COASTal Ecosystems through Rivers to Sea Connectivity**



This project receives funding from the European Union's Horizon 2020 research and innovation programme, under Grant Agreement 101037097

**Prepared under contract from the European Commission**

Grant agreement No. 101037097

EU Horizon 2020 Coordination and Support Action

Project acronym: **REST-COAST**  
Project full title: **Large Scale RESToration of COASTal Ecosystems through Rivers to Sea Connectivity**  
Start of the project: 01.10.2021  
Duration: 54 months  
Project coordinator: Prof. Agustín Sánchez-Arcilla, Universitat Politècnica De Catalunya (UPC)  
  
Type: Restoring biodiversity and ecosystem services  
Call: H2020-LC-GD-2020-3  
  
Deliverable title: Restoration Demo at Ebro Delta  
Deliverable n°: D6.4  
Nature of the deliverable: Demonstrator  
Dissemination level: Public  
  
WP responsible: WP6  
Lead beneficiary: EURECAT, LIM/UPC  
  
Citation: Frías, S., Molero, J., Mestres, M., Puértolas, L., Caiola, N., Sánchez-Arcilla, A. & C. Ibáñez (2024). *Restoration demo at Ebro Delta*. Deliverable D6.4. EU Horizon 2020 REST-COAST Project, Grant agreement No 101037097  
  
Due date of deliverable: Month 30  
Actual submission date: Month 30

Deliverable status:

Version	Status	Date	Author(s)
1.0	Final	29 March 2024	Various EURECAT, LIM-UPC, ALBIREM

The content of this deliverable does not necessarily reflect the official opinions of the European Commission or other institutions of the European Union.

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## Preface

Within the WP6 of REST-COAST, task 6.1.2 is devoted to fostering the proactive transfer of the project's results to ensure that the coastal restoration message reaches and permeates stakeholders and society at each pilot site. The planned communication strategy includes the elaboration of demonstrative material on the benefits of restoration, information on ongoing restoration activities, and the making of promotional videos aimed at civil society, policy makers, stakeholders and educational community at all levels. It also involves an active presence in social and mass media, from local to international scales, to reach general society and all governance levels, as well as specific activities targeting the scientific and technological communities via the publication of high impact papers, presentations at national and international conferences, and the organization and/or participation in workshops and seminars. The current document summarizes the work done for the Ebro Delta pilot site by the REST-COAST local partners to fulfill the requirements of this task 6.1.2.

## Summary

The Ebro Delta, one of the largest wetlands in the western Mediterranean, is an important economic and ecological pole, although very vulnerable to climate change. Its low-laying configuration and anthropic decoupling from the Ebro river sediment source due to the construction of dams and reservoirs, make it highly sensitive to erosion and flooding, putting at risk both its economic and ecological values in the future, particularly under projected climate change conditions.

With this in mind, different restoration activities are being carried out at this pilot site within the framework of the REST-COAST project. On the one hand, artificial embryonic dune systems are being created along the most vulnerable coastal spots, with the aim of reducing the risk of erosion and, eventually, of flooding by taking advantage of the natural processes of sediment distribution due to coastal currents. On the other hand, the connectivity between different habitats is promoted by removing a coastal dike that separated a coastal lagoon and wetlands from the beach, and also by recovering a historical buffer zone, eliminated during the transformation of marshes for rice production, in an attempt to reduce erosions rates in this area.

These restoration actions are developed in cooperation with the most important local, regional and national stakeholders, as illustrated by their participation in the project's Core Platform (CORE-PLAT), and the direct involvement of some of these actors in the restoration activities themselves. In addition, an intensive communication and dissemination strategy has been followed to increase the awareness of national, regional and local policy-makers, the scientific and technical communities, and the general public to the challenges faced by the Ebro Delta, and foster their understanding of the different restoration actions that have been undertaken.

## List of abbreviations

EU	European Union
BDV	Biodiversity
ESS	Ecosystem Services
CORE-PLAT	Coastal Restoration Platform

## 1. Introduction to the Pilot Site

The Ebro Delta is located in the Western Mediterranean (Catalonia, NE Spain). It is one of the largest wetland areas (320 km<sup>2</sup>) in the western Mediterranean region and one of the three Core Pilots of the REST-COAST project. It is characterized by being a low-lying area, heavily anthropized, without coastal engineering structures and with land-use dominated by agriculture (70% of the surface area is agricultural land), mainly for rice production (95% of agriculture is rice production). Natural areas cover about 80 km<sup>2</sup> (25% of the delta surface area). These areas include salt marshes, reed-type marshes, sand dunes, coastal lagoons, natural springs, bays and sandy beaches. (Fig. 1).



**Figure 1. Land uses of the Ebro Delta. Yellow for agriculture uses, purple for other artificial areas, blue for natural areas, green for forest areas, beige for beaches and red for urban areas.**

The evolution of the Ebro Delta is conditioned by the balance between the sediment contribution from the Ebro river and wave (storm)-induced erosion. In the last century, the sediment contribution from the river to the delta has decreased significantly (estimated at 99% reduction) due to the construction of numerous dams and weirs in the river basin, leading to an effective decoupling of the land-estuary-sea dynamics. At the same time, natural erosion has been enhanced by increased storminess, with erosion rates exceeding 15 m/yr locally (Fig. 2), particularly at the delta apex, more exposed to wave incidence. A significant fraction of the eroded sediment accumulates at the northern spit which separates the Fangar bay from the sea. The spit growth reduces the bay's inlet, leading to longer water residence times and more frequent episodes of high water temperature and anoxia in the summer, thus affecting aquaculture activities. The present level of conflicting uses (associated with the scarcity of water and sediment) is being aggravated by climate change and economic trends, resulting in loss of territory and support for socio-economic activities. For instance, future changes in precipitation and river flow patterns may induce complex changes of the watermanagement plan, sea level rise, combined with deltaic subsidence, can lead to the permanent flooding of a relevant percentage of the Ebro Delta, changes in wave direction may alter the coastal fringe shape; heatwaves and droughts may require further control of the water uses.



**Figure 2. Example of shoreline retreat due to erosion, and hard engineering solution to protect a coastal asset (Vascos restaurant), at the northern end of La Marquesa beach (credit Taula de Consens - Aguaita.cat).**

The coastal ecosystem of the Ebro Delta area is under stress in both present and future climates due to sediment shortages caused by river regulation, delta subsidence and acceleration of relative sea level rise. Therefore, coastal restoration will have a shorter life than in other more stable coasts. For the implementation of hands-on coastal restoration measures, two “must” are considered: the river-delta-coast connectivity and coastal dynamics. Thus, the Ebro Delta faces several challenges of river restoration that should be distinguished from those of coastal restoration. On the one hand, the river context is limited by the historical lack of solid and liquid phases of ecological flow, which has notorious consequences on the sedimentary dynamics of the Delta. As a result, there is an enormous sediment retention along the reservoirs of the Ebro basin, which causes the regression and subsidence that endangers the region in a context of climate emergency. On the other hand, the lack of sediments affects at the same time to the coast, increasing the beach surface losses year by year. In addition, the coastal restoration actions have to face challenges such as the erosion and flooding by wave action, flooding and land loss related to sea level rise, and accretion by longitudinal sediment transport (Fig. 3).



**Figure 3. Flooding scenario predictions for the Ebro Delta without sediment contributions. On the left, the evolution with the current contribution of sediments. On the right, the evolution with the contribution of sediments. The land areas shown in red in the simulation correspond to areas already below sea level due to subsidence, but not yet flooded because they are not directly connected to the sea.**



With this in mind, the restoration activities that are being carried out at this pilot site within the framework of the REST-COAST project are of two types. On the one hand, the creation of artificial embryonic dunes along the most vulnerable coastal spots (Fig. 4), with the aim of reducing the risk of erosion by taking advantage of the natural processes of sediment distribution. This will also decrease the risk associated with flooding, particularly in stronger wave conditions.



**Figure 4. Creation of artificial dunes at La Marquesa beach (top) and state of the dunes after a storm (bottom).**

On the other hand, the removal of a coastal dike (Fig. 5), that has historically separated the beach from the Alfacada coastal lagoon area and wetlands, aims to reconnect these habitats, recovering their natural dynamics and enhancing biodiversity by reestablishing the natural salinity gradient. In addition, connectivity by realignment will be tested in the Bombita Natural Reserve (in the northern hemi delta), in an area owned by the Government of Spain, creating a buffer area to reduce erosion rates. This area was part of a large dune system that disappeared due to coastal retreat and the transformation of the marshes for rice production (Fig. 6).





**Figure 5. Alfacada Lagoon before (left) and after (right) the removal of the dike.**



**Figure 6. Various levels of plant succession and types of habitats in the old rice fields closest to the sea in the Bombita Natural Reserve: flooded, semi-flooded and drier areas, with visible development of tamarisks.**

### 1.1 Demonstrative material of restoration benefits

Coastal adaptation plans based on restoration can provide an excellent demonstration of how to control flooding and erosion risks, while contributing to natural capital stocks and climate mitigation through

coastal blue carbon. However, coastal restoration is often distrusted or implemented at a local scale, hampering its potential for coastal adaptation. Restricted restoration outcomes, commonly due to insufficient up- and out-scaling embedded in complex social-ecological systems, make the building of such trust a complicated effort (Sánchez-Arcilla et al. 2022).

The REST-COAST project aims to demonstrate the feasibility and benefits of coastal restoration at the European level both for biodiversity (BDV) and ecosystem services (ESS) and produce a scalable plan for coastal adaptation through large scale restoration, based on functional (coastal water/sediment/ecological fluxes) and spatial (restored habitats at landscape level) connectivity. Restoration interventions will increase the resilience of both the deltaic plain and its coastal fringe, reducing risk levels and enhancing BDV. To maximize the social benefits of restoration, it is being co-designed by relevant stakeholders to transform current coastal/risk management and restoration techniques/investment/governance to an enlarged and long-term socioeconomic commitment.

The advances in technology, finance and management schemes, integrated in the restoration plans, should lead to a transformation of governance/policies and societal perception/engagement, so that coastal restoration is backed by a socioeconomic transformation.

##### 1.1.1 Benefits of restoration (perceived, achieved, not achievable, expected)

The presence of technical barriers, and specially governance and financial barriers, created problems in the past, with governance traditionally perceived as the most relevant and frequent barrier in this pilot site. Local stakeholders highlight the focus on short-term policies, the limitations in coordinated decision making and the lack of integrated approach (i.e., interdisciplinary and coordinated action among stakeholders). The bureaucratic issues are highlighted by stakeholders such as issues between Catalan and central governments in terms of land ownership and management as well as the lack of agreement and investments in the area. However, today different initiatives are being promoted at different levels to address, adapt and mitigate them. The local CORE-PLAT (see section 3.1), created in the framework of the REST-COAST project, has proven to be a relevant forum to discuss, anticipate problems and boost restoration activities. Thus, governance is also considered by local stakeholders as the main potential enabler for coastal restoration upscaling. The most relevant and frequent technical barrier are the difficulties related to management plans, which should be addressed as a priority in the Ebro Delta Pilot and its CORE-PLAT, as it may become a strong impediment to coastal restoration at this pilot site.

The urgent need for tackling restoration by the growing willingness of social inertia in the territory and the international directives is a powerful technical enabler in the Ebro Delta Pilot. At the governance and financial level, new governance models based on participation and co-creation and the international interest in investing in low cost and effective policies for coastal restoration are relevant and frequent enablers in this pilot site to be reinforced for coastal restoration. For this reason, promoting restoration among stakeholders through innovative co-creation processes is a valuable opportunity to facilitate coastal restoration upscaling in the Ebro Delta.

The perceived benefits of local restoration practice, which are the benefits that stakeholders expect or anticipate from coastal restoration efforts, include enhanced BDV and ESS delivery which will reduce flooding risks, increase protection against erosion and storm surges, improve water quality and enhance food provision (aquaculture and fisheries), while promoting coastal blue carbon and recreational opportunities.

The hands-on restoration actions were initiated and the monitoring campaigns for BDV and ESS are being carried out to determine the success of the restoration and the achieved benefits in the Ebro Delta Pilot.

Connectivity and natural dynamics at landscape level restoration efforts are expected to enhance coastal resilience, climate risks reduction, as well as improving BDV status and ESS delivery associated with healthy wetlands and coastal environments. At the ecosystem level, restoration actions are expected to improve biodiversity, restore river-delta-coast connectivity and enhance ecosystem resilience. From a socioeconomic perspective, restoration is expected to benefit local communities by leading to reduced storm damage, coastal protection and resilience, enhanced coastal areas to develop socio-economic activities (deltaic agriculture, aquaculture, coastal eco-tourism, etc.), improved recreational opportunities, and job creation through restoration projects.

As for expected benefits in the future as the restored ecosystem continues to evolve, long-term benefits are expected such as increased carbon sequestration, continued habitat enhancement, and sustained ESS for coastal communities. Healthy ecosystems resulting from large-scale interventions, together with their ESS, should enable more resilient coastal trajectories under accelerated climatic pressures, promoting the values of out-scaling restoration as a key element in worldwide coastal adaptation. Recognising the key role of restoration scale, the REST-COAST project incorporates the development of innovative finance and governance instruments in the restoration plans for a long term socio-economic commitment to ESS that deliver acceptable risk reduction and biodiversity gains within a decarbonised coastal adaptation.

To understand the effects of restoration on the Ebro Delta Pilot, monitoring BDV and ESS evolution is needed as well as some metrics development. For this purpose, several methodologies have been designed for the study and monitoring of the effects of restoration, in cooperation with other pilots, as part of the goal of Task 1.3 of the WP1. The results of the hands-on restoration actions obtained from the scientific monitoring will promote the inclusion of ESS into decision-making for coastal and river stakeholders and citizens, generating a collective demand for a transformation of relevant governance and policies to overcome restoration barriers.

## 2. Ebro Delta Pilot video

The Ebro Delta Pilot video that has been produced (link to video: [REST-COAST Pilots: Ebro Delta \(youtube.com\)](https://www.youtube.com/watch?v=REST-COAST_Pilots_Ebro_Delta)) lays special emphasis on the REST-COAST project's goal to reconnect society with nature to increase support when developing large-scale coastal restoration. It aims to explain in a comprehensive and effective way the restoration actions that are being carried out in the Ebro Delta within the REST-COAST project, as well as the impact and benefits of restoration for ecosystems and local community. The video includes explanations from scientists and experts from different research centers and non-governmental organizations to emphasize the importance and impact of coastal restoration efforts and to raise awareness, among civil society, policy makers, stakeholders and education community at all levels. In particular, this visual production focuses on explaining the hands-on restoration that is being carried out in the Alfacada lagoon which aims to increase the connectivity between the sea and the wetlands by removing more than 1 Km coastal dike. This artificial dike has historically modified the hydrology of the area, causing this coastal wetland to have a level of salinity lower than that which would correspond naturally.

The combined effects of deltaic subsidence, the lack of sediment supply, the sea level rise and the greater recurrence of storms (the latter related to climate change), caused numerous alterations in the coastline, with sectors where the coastline suffers active erosion and flooding during marine storms such as the Gloria storm occurred in January 2020. Removing the coastal dike (with the previous reinforcement of the innermost dike) will let the coastal lagoon and marshes to recover a more natural dynamics enhancing biodiversity, associated to the recovery of the natural salinity gradient and more dynamic hydrological regime, as well as ecosystem services such as fisheries and coastal protection, given the buffer capacity of salt marshes. This will lead to a more resilient system under a climate change scenario, more capable of

absorbing marine storms and sea level rise. This coastal protection system based on nature-based solutions could be a model for upscaling coastal restoration in Ebro Delta Pilot and beyond.

The production of demonstration material such as this video aims to establish a social commitment to coastal restoration, engaging citizens, stakeholders (management and finance) and policy makers (transformation in governance/policies) to further development and long-term maintenance of large-scale restoration, with transversal socio-ecological benefits. For this purpose, the video will be used to explain the REST-COAST project to the civil society, policy makers, stakeholders and education community at all levels and active dissemination will be carried out by utilizing a multi-channel and multi-level approach to connect society with nature and raise awareness for the need and benefits of large-scale coastal restoration.

The Ebro Delta Pilot video has been uploaded to the REST-COAST website ([Videos \(rest-coast.eu\)](https://rest-coast.eu/videos)). A communication plan of this material will be designed and carried out to disseminate the restoration activities in this pilot site to all relevant audience groups and stakeholders to increase social awareness, motivation and acceptance for restoration by public administration and civil society and training for co-evaluation and transformation. The transfer of restoration upscaling benefits for BDV and climate resilient ESS will promote a participatory engagement for a decarbonised coastal adaptation that reduces risk levels and increases coastal health and welfare. At the same time, the aim of this demo material is empowering individual/collective decisions supported by disseminated restoration hands-on results and the project transfer tools.

On the one hand, this video will be disseminated through the social media platforms through REST-COAST's channels and those of the different institutions that promote the hands-on restoration activities of this pilot site. On the other hand, the video will be presented in the communication and stakeholder engagement activities at Pilot site level such as the next CORE-PLAT meeting.

### 3. Demo activities

#### 3.1 Hands-on restoration actions

Hands-on restoration actions in the Ebro Delta pilot site aim to reduce the risk of erosion such as the implementation of embryo dunes and sand dikes along the most vulnerable spots of the delta coast to enhance coastal energy dissipation (additional adaptation) by local coastal geodiversity. This solution takes advantage of the natural processes of sediment distribution and also decreases the flooding risk particularly in strong wave conditions. Other restoration efforts in this pilot site have the goal of increasing the sea-delta connectivity such as the removal of an artificial coastal dike in the Alfacada lagoon (Fig. 7) to recover the connection between the coastal lagoon and marshes habitats to enhance biodiversity and ecosystem services such as water quality, fisheries and coastal protection, given the buffer capacity of salt marshes. In addition, connectivity by realignment has also been designed and will be tested in the Bombita Natural Reserve (in the northern hemi delta), in an area owned by the Government of Spain, creating a buffer area to reduce erosion rates. This area was part of a large dune system that disappeared due to coastal retreat and the transformation of the marshes for rice production. In this area, the project aims to eliminate artificial barriers (roads, canals, small dikes) to enhance the natural capacity of the coastal system (beach, dunes and marshes) to recover.





**Figure 7. Restoration works in the Alfacada Lagoon consisting of the removal of the dike.**

### 3.1.1 Communication and dissemination activities

From the beginning of the project, the Ebro Delta partners have undertaken a very proactive stance to involve the national, regional and local actors in the design and execution of the different restoration actions. At the same time, numerous communication and educational activities have been carried out to inform the scientific community, policy makers and general public on the need for REST-COAST, its restoration actions, and the expected outcome.

In addition to the establishment of the Ebro Delta CORE-PLAT in January 2023, as described below, several meetings have been held with authorities and other significant actors in the Ebro Delta. These include, for instance, different meetings with the Ebro Delta Consensus Board (a local instrument created to fight against the regression of the Delta and its effects, searching for solutions and acting as interlocutor with the public administrations) to inform of the project, harmonize approaches and analyze the restoration measures, and with relevant members of the Catalan government (e.g., the Secretary of Territory and Mobility or the General Director of Mountain and Littoral Policy, amongst others) to present the project, its application to the Ebro coast, and the possible extension of its results to other vulnerable sites in the Catalan coast. Along the same line, Prof. Agustín Sánchez-Arcilla presented REST-COAST in the Commission on the Protection of the Ebro Delta of the Catalan regional Parliament in June, 2022, and also in the Committee on Environment, Public Health and Food Safety of the European Parliament during the same month. More recently, in March 2024, representatives of the REST-COAST participated in a meeting with the Spanish Minister for Ecological Transition and Demographic Challenge (MITECO), the Catalan Minister for Climate Action, Food and Rural Agenda, and other high-level administrative officers, together with the Consensus Board, to inform about and discuss the actual state of the project and its implementation in the Delta.

On the other hand, the Ebro Delta partners have generated a large number of mass media pieces, including press releases, interviews and articles, to convey the importance of REST-COAST to the general public, particularly in the Delta area. For this, participation in local and regional media has been prioritized, without neglecting national- and wider-scope interventions. The focus in these has generally been placed on highlighting the vulnerability to the effects of climate change of the Catalan coast in general, and the Ebro Delta in particular, and on the need to increase coastal resilience in these areas through the adoption of new (experimental) nature-based measures, including retreat, that allow climate adaptation in the long

run. This approach promotes the social acceptance of large-scale restoration works that are not always understood by the local population. In addition, several videos related to REST-COAST activities, such as the construction of sand dunes along La Marquesa beach in 2022-2023 or the controlled flood from the Mequinensa dam in January 2024, have been made public by the MITECO or the Confederación Hidrográfica del Ebro (Ebro River Authority), for instance. A list of these dissemination activities, which includes newspaper, magazine and TV pieces, plus online interventions, is provided in the annex to this document.

Another important demo activity is the organization of, or participation in, workshops. These range from the local to a national scale, and attract all kinds of public, from the layperson to coastal managers, policy makers and scientists, allowing the exchange of information between all levels. Some of the workshops related to REST-COAST and the Ebro Delta pilot are the one on “Protection Strategies for the Ebro Delta”, held in Amposta on March, 2022; the “River-delta-coast connectivity” workshop in Madrid and the workshop “Challenges and future of the coastal zone. Climate change and littoral dynamics”, held in El Masnou (Barcelona) in May, 2022; or the “Conference on climate change adaptation of ports, beaches and promenades along the Catalan coast”, held at the UPC in March, 2024 (Fig. 8). The full list of workshops and symposia can be found in the annex.



**Figure 8. Conference on climate change adaptation of ports, beaches and promenades along the Catalan coast, held at UPC on March 7th, 2024.**

Finally, regarding the scientific community, the main demo activities are related to the publication of scientific papers, to the presentation of the REST-COAST project itself and its results in different scientific conferences and meetings related to climate change, wetlands, adaptation measures and other topics, and in meetings of other projects that show synergies with REST-COAST. Again, the full list of scientific communications is provided in the annex.

### 3.1.2 The Ebro Delta CORE-PLAT activities

The presence of technical barriers, as well as governance and financial barriers, created problems in the past, with governance traditionally perceived as the most relevant and frequent barrier in this pilot site. However, today different initiatives are being promoted at different levels to address, adapt and mitigate them. One of the main restoration enablers that Ebro Delta Pilot is using to support coastal restoration activities as well as gathering different priorities and needs of stakeholders to overcome current technical/social/financial barriers to restoration is the Ebro Delta CORE-PLAT, which is a governance instrument to engage stakeholders on co-designing and co-implementing hands-on coastal restoration (Living Lab methodology) for its long-term maintenance and upscaling.



The Ebro Delta CORE-PLAT was designed by a multi-level approach of collaborating and decision-making. On the one hand, the CORE-PLAT fostered a small institutional decision-making group to discuss at the executive level and reach operational consensus in the Pilot. On the other hand, the executive CORE-PLAT in this Pilot was constituted by different key local stakeholders, including the pre-existing Consensus Board (*Taula de Consens*) that involves various actors from the territory (e.g., municipalities, irrigation communities, rice farmers, and citizens of the Ebro Delta). The technical proposals resulting from the executive level of the CORE-PLAT are then shared with a territorialized group, a broad forum connected to the region to discuss, integrate the expectations and inputs from the locals and co-create the proposed actions.



**Figure 9. First workshop of the CORE-PLAT of the Ebro Delta Pilot, held at Eurecat in January 2023.**

The first workshop of the CORE-PLAT of the Ebro Delta Pilot was held in January 2023, with key stakeholders invited on a regional scale as public administrations, economic and citizen associations, altogether with environmental NGOs (Fig. 9). Some of the invited stakeholders were also present in the workshop agenda, with public administrations that have competencies in coastal and water management sharing some relevant updates on regional planning development. Thus, Mr. Antoni Espanya from the Tarragona Coastal Service of the Spanish Ministry for Ecological Transition and Mr. Jesús Gómez from the Department of Climate Action Food and Rural Agenda of the Catalan Government preliminarily presented, respectively, the Delta Plan and the Delta Strategy. These are two strategic official roadmaps that include actions of coastal restoration and sediment management and are close to receiving final approval. The Catalan Water Agency (ACA), the Spanish Ornithological Society (SEO BirdLife), the Ebro Delta Consensus Board and the Ebro Delta Natural Park also engaged in the discussion, highlighting the relevance of participation in decision-making and introducing some of the Ebro area specific challenges around it. In addition, participants informally discussed how to deal with barriers and enablers for coastal restoration projects and they stated that more efforts should be invested to co-design and create projects aimed at addressing restoration barriers, while fostering enablers. The second workshop of the CORE-PLAT of the Ebro Delta took place in July 2023, the same stakeholders of the previous workshop were invited and the restoration actions of the REST-COAST project were addressed. Furthermore, potential upscaling opportunities and financial arrangements under the WP3 perspective were discussed too. As a result of both workshops, the essential need to continue promoting a new governance model stands out to converge on priorities among local community agents and co-determine strategies to make restoration, conservation and management efforts effective.

### 3.1.3 Educational activities with university students

An education activity on coastal restoration has been designed by Albirem to engage university students of the Mediterranean Environment course, conducted by Dr. Laura Puértolas, Associated Professor at IES Abroad Barcelona and Director of Albirem. The students of this center center came from a variety of public and private US universities to study a semester abroad. The Mediterranean Environment course offers an interesting framework to disseminate the REST-COAST project, as it looks closely into the effects of human activities on a variety of ecosystems, including marine and coastal areas, the efforts to reverse its impacts and to reach sustainable development. The first activity has been launched in March 2024, with the support of Eurecat. An applied assignment to the hands-on restoration activities that are being carried out in the Alfacada lagoon has been proposed to the students and it will evolve through Spring and Fall semesters in the next few years, together with on-site visits to the Alfacada lagoon, in the Ebro Delta. Thus, the results from one semester will be used as a starting point for the students enrolled in the course in the next semester, in order to keep track of the Alfacada lagoon restoration project.

The group assignment will include 3 types of activities, in a sequential approach, and is expected to be conducted by 15 students in this semester. The activities will be the following:

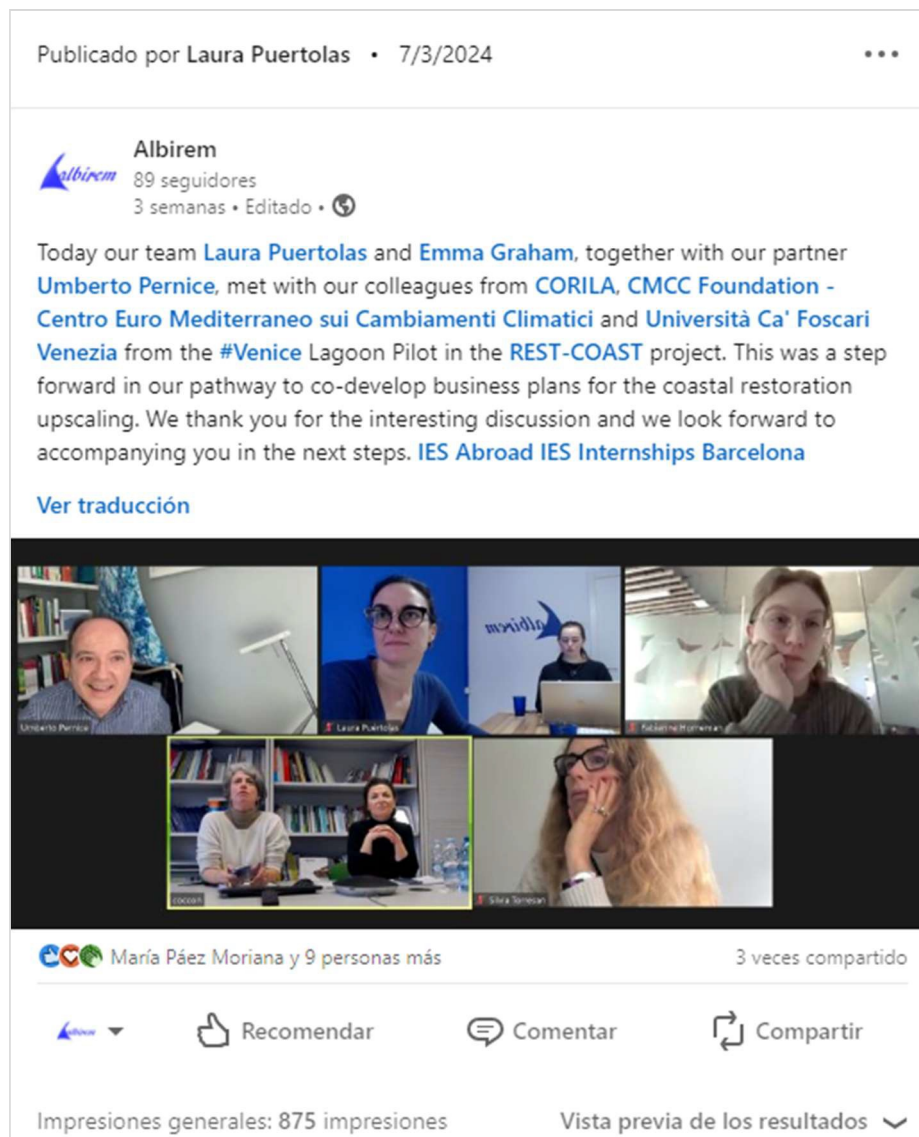
1. Analyzing the REST-COAST project and the Alfacada lagoon intervention, and preparing some dissemination materials, as a post for the REST-COAST project website addressed to university students.
2. Analyzing some past environmental data from the Alfacada lagoon physicochemical parameters (e.g. salinity) and its potential correlation with habitats (vegetation). The main point will be to explore which vegetation communities are more adapted to salinity and that students are able to match salinity numbers with related habitats.
3. Make some hypotheses about possible future restoration pathways with the dike removal, so how do they expect the salinity to change and the habitat composition to be in the next year? This hypothesis will then be checked by students from the next semester.

This type of educational activities will allow not only to disseminate the restoration activities and results of the REST-COAST project but also to co-create a part of the restoration analysis and scientific discussion between researchers of the project and educational community. Thus, this will also contribute to raising awareness about nature-based solutions as a coastal adaptation and restoration solution, and the importance of enhancing ecosystem services and biodiversity among students.

This activity also aims to increase and expand the dissemination of the REST-COAST project in a relevant international academic institution such as the IES Abroad Centre, who will share some press releases, publications on social media or related activities in research meetings, expanding the target audience.

In parallel with this, Albirem also collaborates with the IES Abroad Foundation and allows students of their programs to carry out internships in their offices, in order to guarantee students the implementation of the knowledge acquired in their university studies. These internships, facilitated by Albirem, are regulated by the internship program agreed with each home university. Since Fall 2023, in the frame of internship programs, Albirem also engages interns in training and dissemination activities from the REST-COAST project. In a first stage, students are informed about the project activities by sharing with them dissemination materials from the project (e.g. REST-COAST website, Ebro Delta and other pilot cases factsheets) and an internal meeting is conducted to explain the main goals of the project, the activities carried out by Albirem from WP1, WP3, WP4, WP5, WP6 and WP7. Then, a planning with some potential dissemination activities is discussed with the student, to find common interests that may enhance his/her participation in activities related to the REST-COAST project during the internship. This activities may

include learning about some research topics conducted by the team of Albirem and other partners in the project, taking part in meetings and taking part in the preparation of some dissemination materials. As an example of this, during the Spring 2024 semester, Albirem's internship student took part in the discussion about environmental economics for the elaboration of business plans within WP3 activities in the project pilots, also attending to a meeting for applying this to the Venice Lagoon Pilot Site, with the collaboration of Pernice. This activity was also disseminated in LinkedIn through a post in Albirem's page (see Fig. 10) and achieved 875 impressions.



**Figure 10. Post in LinkedIn to disseminate the IES Abroad internship training activities in Albirem about the REST-COAST project.**

### 3.2 Demonstration value and replication

The environmental problems addressed in the Ebro Delta Pilot within the REST-COAST project are not specific to the selected study sites (Marquesa beach, Alfacada coastal lagoon and Fangar Bay), but are

common throughout the whole Delta. Erosion/flooding risks and coastal retreat are also hot topics at the southern hemi-delta, where the narrow Trabucador barrier beach separating the Alfacs Bay from the open sea is subject to constant breaching linked to storm occurrence. As in Fangar Bay, the Alfacs lagoon also presents water quality problems that impact ecosystem services such as fishing, aquaculture and tourism. Thus, the solutions developed for the REST-COAST Ebro Delta Pilot are clearly out- and up-scalable to other sites within the Delta.

In addition, the reconnection of the beach with the Alfacada's coastal lagoon and the wetlands aims to demonstrate the viability and benefits of coastal restoration. A monitoring programme has been designed and implemented to measure biological variables and physico-chemical parameters of soil and water to assess biodiversity and multiple ecosystem services such as flooding and erosion protection, water quality, food provisioning (e.g. fish stocks), and blue carbon (through CO<sub>2</sub> and CH<sub>4</sub> fluxes monitoring) (Fig. 11). All of this data will be useful to assess hands-on restoration performance and the results obtained will prove how hands-on actions may trigger upscaling to similar systems in the Ebro Delta.



**Figure 11. Sampling soil and plant GHG fluxes in the Alfacada lagoon.**

At a larger scale, some of the restoration solutions proposed for the Ebro Delta may be applicable or adaptable to other deltaic systems with similar problems. For instance, the artificial dunes experiments with different mound configurations provide valuable information on the mechanisms that drive the natural redistribution of sediment by waves and currents that can be useful for other European deltas affected by erosion. An example of this could be the Po Delta, which combines progradation of its northern half (Ninfo et al., 2018) with an increasing vulnerability to flooding in its central and southern portion (Taramelli et al., 2020), or the Rhône Delta (Dufois et al., 2014). Furthermore, it is expected that all coasts that are affected by rigidization and dependent on the input of severely regulated rivers, particularly (but not only) in the Mediterranean Sea, can benefit from the nature-based solutions developed and tested within REST-COAST, and the experience acquired during the project.

The REST-COAST project will combine technical, financial and governance innovation and outcomes of the project to upscale hands-on restoration actions within the coastal Pilots and beyond for worldwide coasts. This upscaling will demonstrate to what extent large-scale coastal restoration can: a) reduce erosion/flooding and environmental degradation risks; b) decarbonise coastal adaptation through connectivity and natural resilience; c) contribute to climate mitigation with enhanced capture of coastal blue carbon. Therefore, based on the results of the REST-COAST project, a systematic restoration approach that delivers ESS and BDV gains will result in large scale projects that incorporate new techniques (WP1-2)

and financial management innovation (WP3-4) for risk reduction (WP2), coastal adaptation (WP4) and governance transition (WP5), with and increase in social awareness, acceptance and capacities (WP6).

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## 2. Acknowledgements

The work undertaken at the Ebro Delta pilot site relies heavily on the involvement of all the relevant actors, gathered under the umbrella of the Ebro Delta CORE-PLAT, the REST-COAST partners (EURECAT, LIM-UPC, Albirem, CIIRC; UPM, SEO-Birdlife, MITECO and ACA) and other institutions such as the Ebro River Authority (CHE). The Ebro Delta REST-COAST consortium also acknowledges the cooperation of the IES Abroad Foundation in the training activities related to the Ebro Delta pilot are within the Mediterranean Environment course.

## Annex

### A.1 Scientific publications

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- Sánchez-Artús et al., (2023). *Present and future flooding and erosion along the NW Spanish Mediterranean Coast*. Frontiers in Marine Sciences, DOI: 10.3389/fmars.2023.1125138.

## A.2 Presentations at conferences and scientific meetings

- Cáceres et al., (2022). *La restauración costera como una combinación de intervenciones de ingeniería convencional y verde. Aplicación al caso del Delta del Ebro*. XVI Jornadas Españolas de Ingeniería de Costas y Puertos. Vigo, Spain.
- Mestres et al., (2022). *Modelado hidromorfodinámico de alta resolución como herramienta de apoyo a la restauración costera. Ejemplos de aplicación a zonas vulnerables*. XVI Jornadas Españolas de Ingeniería de Costas y Puertos. Vigo, Spain.
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- Sánchez-Arcilla et al., (2023). *Nature based solutions for sediment starved deltas: the Ebro case in the Spanish Mediterranean coast*. Coastal Sediments 2023, New Orleans, US.
- Grossmann et al., (2023). *Measurements and modeling of sediment transport during offshore and onshore bar migration*. Coastal Sediments 2023, New Orleans, US.
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### A.3 General dissemination activities

- *Restaurarán las costas europeas para prevenir efectos del cambio climático* - <https://www.lavanguardia.com/vida/20211018/7798124/restauraran-costas-europeas-prevenir-efectos-cambio-climatico.html> (18/10/2021)
- *Restaurarán las costas europeas para prevenir efectos del cambio climático* - <https://www.themartcityjournal.com/es/green-new-deal/en-marcha-un-proyecto-liderado-por-la-upc-para-restaurar-la-costa-europea-con-soluciones-naturales-y-carbono-azul> (18/10/2021)
- *El projecte REST-COAST, liderat per la UPC, vol restaurar la costa europea amb solucions naturals i carboni blau* - [https://exteriors.gencat.cat/ca/ambitsdactuacio/afers\\_exteriors/ue/fons\\_europeus/detalls/noticia/20211019\\_rest-coast](https://exteriors.gencat.cat/ca/ambitsdactuacio/afers_exteriors/ue/fons_europeus/detalls/noticia/20211019_rest-coast) (19/10/2021)
- *D. González-Marco interviewed in 2 nation-wide radio stations - Interviews in the Spanish National Radio and in Cadena Ser, to inform about REST-COAST* (21/10/2021)
- *A. Sánchez-Arcilla and I. Cáceres interviewed for a Catalan newspaper - Interview in Diari ARA to inform about REST-COAST* (22/10/2021)
- *Pla europeu per salvar el delta de l'Ebre* - [https://www.ara.cat/societat/canvi-climatic/cimera/delta-ebre-laboratori-crisi-climatica-europa-projecte-ue-sediments\\_130\\_4167428.html](https://www.ara.cat/societat/canvi-climatic/cimera/delta-ebre-laboratori-crisi-climatica-europa-projecte-ue-sediments_130_4167428.html) (31/10/2021)
- *El projecte europeu REST-COAST permetrà fer una prova pilot per mobilitzar sediments del pantà de Riba-Roja* - <https://setmanarilebre.cat/el-projecte-europeu-rest-coast-permetra-fer-una-prova-pilot-per-mobilitzar-sediments-del-panta-de-riba-roja/> (03/11/2021)
- *Project underway to restore the European coastline with nature-based solutions* - <https://eurecat.org/en/project-underway-to-restore-the-european-coastline-with-nature-based-solutions/> (04/11/2021)
- *Un projecte europeu assajarà al Delta solucions naturals de restauració costanera* - <https://setmanarilebre.cat/un-projecte-europeu-assajara-al-delta-solucions-naturals-de-restauracio-costanera/> (06/11/2021)
- *V. Gràcia interviewed on the Spanish National TV - Interview to inform about REST-COAST* (09/11/2021)
- *V. Gràcia interviewed on nation-wide TV and Radio stations* (17-28/11/2021)
- *En marcha un proyecto per restaurar la costa europea amb solucions basades en la natura* - <https://eu.mittum.com/creativities/showit/c/508134/u/737/md5/59732de1a735d2d6719c599ae72828d5> (30/11/2021)
- *REST-COAST, un projecte per salvar el Delta* - [https://rdi.dtes.scipedia.com/s/Draft\\_Gil\\_Riba\\_580961349](https://rdi.dtes.scipedia.com/s/Draft_Gil_Riba_580961349) (15/12/2021)
- *A UPC-led project to restore European coasts with natural solutions and blue carbon underway* - <https://www.upc.edu/en/press-room/news/a-upc-led-project-to-restore-european-coasts-with-natural-solutions-and-blue-carbon-underway> (20/12/2021)
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  - Costas resilientes: la transformación innovadora del litoral para protegerlo del cambio climático - <https://piernext.portdebarcelona.cat/entorno/costas-resilientes-cambio-climatico/> (26/05/2022)
  - AÑO 2100: LA ESPAÑA BAJO LAS AGUAS QUE PODRÍAN VER NUESTROS HIJOS - <https://www.abc.es/sociedad/2100-espana-bajo-aguas-hijos-20220705045705-nt.html> (06/07/2022)
  - El deshielo sigue en aumento y el nivel del mar subirá en las próximas décadas - [https://www.cope.es/actualidad/sociedad/noticias/deshielo-sigue-aumento-nivel-del-mar-subira-las-proximas-decadas-20220707\\_2184603](https://www.cope.es/actualidad/sociedad/noticias/deshielo-sigue-aumento-nivel-del-mar-subira-las-proximas-decadas-20220707_2184603) (07/07/2022)
  - Catalogue of innovative and green technical solutions - <https://catalonia.com/documents/176177/179357/the-greentech-catalogue.pdf> (07/07/2022)
  - Interview with Prof. Sánchez-Arcilla on RTVC - <https://youtu.be/n6usCSnUqso> (07/07/2022)
  - El impacto medioambiental en el litoral español: cómo frenar los próximos temporales - [https://www.cope.es/actualidad/sociedad/noticias/impacto-medioambiental-litoral-espanol-como-frenar-los-proximos-temporales-20220710\\_2187121](https://www.cope.es/actualidad/sociedad/noticias/impacto-medioambiental-litoral-espanol-como-frenar-los-proximos-temporales-20220710_2187121) (10/07/2022)
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  - A. Sánchez-Arcilla interviewed by Catalunya Ràdio (19/01/2023)
  - Tres anys després, un altre temporal Gloria provocaria destrosses iguals o pitjors - <https://www.ccma.cat/catràdio/catalunya-al-dia/tres-anys-despres-un-altre-temporal-gloria-provocaria-destrosses-iguals-o-pitjors/noticia/3207770/> (20/01/2023)
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  - REST-COAST – Large Scale RESToration of COASTal Ecosystems through Rivers to Sea Connectivity - <https://eurecat.org/en/portfolio-items/rest-coast/> (01/03/2023)
  - Agustín Sánchez-Arcilla interviewed by Nathan Siegel for Mongabay news platform (07/03/2023)
  - Inaugurat el Living Lab Ebre Bioterritori a Amposta, el primer de la xarxa del Centre en Resiliència Climàtica per fer front a l'emergència pel canvi climàtic - <https://eurecat.org/inaugurat-el-living-lab-ebre-bioterritori-a-amposta-el-primer-de-la-xarxa-del-centre-en-resiliencia-climatica-per-fer-front-a-lemergencia-pel-canvi-climatic/> (17/03/2023)
  - Amposta posa en marxa el primer de la xarxa del Centre en Resiliència Climàtica per fer front a l'emergència pel canvi climàtic - <https://ebredigital.cat/2023/03/17/amposta-posa-en-marxa-el-primer-de-la-xarxa-del-centre-en-resiliencia-climatica-per-fer-front-a-lemergencia-pel-canvi-climatic/> (17/03/2023)
  - Inaugurat el Living Lab Ebre Bioterritori a Amposta, el primer de la xarxa del Centre en Resiliència

*Climàtica per fer front a l'emergència pel canvi climàtic -*

<https://eu.mittum.com/creativities/showit/c/525684/u/201/md5/74ab350d55d4979f96dd2b2cdb0e47d7> (30/03/2023)

- Agustín Sánchez-Arcilla interviewed on REST-COAST by Dalia Haidar for BBC News Arabic (31/03/2023)
- Using Nature based solution in restoration projects - Cooperation between Nahal Dalia pilot and Ebro Delta <https://www.youtube.com/watch?v=PQ3UZJHaaw0> (18/04/2023)
- Article and interview with V. Gràcia in the Catalan network of local televisions - <https://www.laxarxa.cat/programa/fet-a-mida/capitol/capitol-550-26-01-2024> (26/01/2024)
- Interview with V. Gràcia on local TV network - <https://www.tac12.tv/programes/connecta-10comarques/item/32914-connecta-10comarques-capitol-560> (12/03/2024)

#### A.4 Workshops, seminars and symposia

The goals and actions of REST-COAST related to the Ebro Delta have been present at the following events.

- iGenium (online, 21/10/2021) - *The Ebro delta and REST-COAST (Green Deal EU project)*
- MPA-Forum of Marine Protected Areas in the Mediterranean (29/11/2021) - *Coastal adaptation-through-restoration. The REST-COAST project and implications for MPAS*
- MedECC (online, 11/01/2022) - Presentation of the project and Special Report on Coastal Risks
- Catalan Parliament (Barcelona, 16/02/2022) - Presentation of the project and report on the state of the littoral
- Catalan Government (Barcelona, 07/03/2022) - Presentation of the project to members of the regional government
- CIIRC-UPC workshop (Barcelona, 05/05/2022) - *Restoration of the catalan coast under a changing climate*
- Environmental workshop (El Masnou, 21/05/2022) - *Challenges and future of the littoral zone. Session 1. Climate change and coastal dynamics.*
- REST-COAST workshop (Madrid and online, 31/05/2022) - *River-delta-coast connectivity*
- Delta Strategy (Amposta, 28/10/2022) - Presentation of the Delta Strategy, action plan to protect the Ebro Delta
- Workshop (Madrid and online, 17/11/2022) - *Towards an integrated management of dams and sediment*
- Workshop (Madrid, 27/02/2023) - *Climate change in the marine environment*
- Workshop on the strategy for the protection of the Ebro Delta (11/03/2023) - *Coastal dynamics and sediment transport projects. The dutch model in the Ebro Delta?*
- Technical workshop (Barcelona, 13/06/2023) - *NBS and urban marine ecosystems*
- Workshop (Barcelona, 04/07/2023) - *Ebre: river-delta connectivity. Challenges and present and future solutions*
- Workshop on the management of sediment in urban beaches (Sitges, 15/09/2023)
- VII workshop on the Garraf Coastal Management (Vilanova i la Geltrú, 22/11/2023) - *Resilient beaches and fisheries*
- IHÉDATE workshop (Ebro Delta, 14/03/2024) - Meeting and field trip for the IHÉDATE members
- Workshop (Barcelona, 07/03/2024) - *Conference on climate change adaptation of ports, beaches and promenades along the Catalan coast*