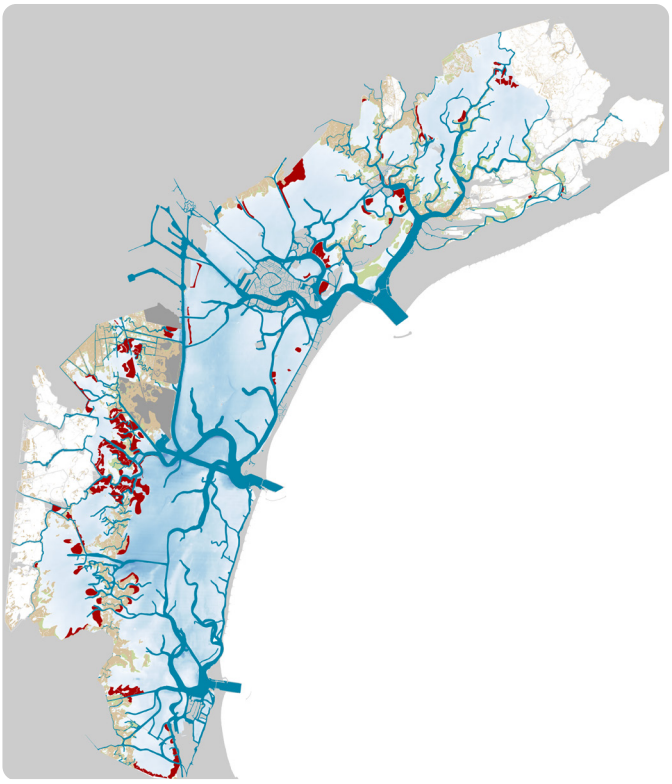
REST-COAST

Venice Lagoon
Pilot Fact Sheet

Pierpaolo Campostrini, Caterina Dabalà, Francesca Coccon (CORILA), Silvia Torresan, Elisa Furlan, Fabienne Horneman (CMCC), Andrea Critto, Fabio Pranovi, Silvia Rova (Ca' Foscari University of Venice), Alberto Barausse, Paolo Comandini (University of Padova), Valerio Volpe, Giovanni Assalone, Marianna Cianci (Provveditorato Interregionale per le Opere Pubbliche per il Veneto, Trentino-Alto Adige e Friuli-Venezia Giulia)

Country: Italy
Area: Drainage basin: ±2.068 km^2
Lagoon: ±550 km^2
Geographic coordinates of the site centroid point: Long: 12.319794, Lat: 45.418696
Reference system: WGS84 EPSG:4326



Ecosystem type

The Venice lagoon, spanning ±550 km^2 (Janowski et al., 2020), is a complex ecosystem, showing features of transitional waters in the inner brackish areas, while presenting the characteristics of a coastal marine bay elsewhere, either in terms of salinity regime and of habitat types. The complexity of the lagoon results in a mosaic of coastal habitats including salt marshes, seagrasses, wetlands, mudflats, islands, and eutrophic lakes (Carniello et al., 2009; Ravera, 2000; Rova et al., 2019; Solidoro et al., 2010).

Key habitats

Target Habitats: 1140 - Mudflats and sandflats not covered by seawater at low tide, 1150* Coastal lagoons, 1310 - *Salicornia* and other annuals colonising mud and sand, 1320 - Spartina swards (*Spartinion maritimae*), 1410 - Mediterranean salt meadows (*Juncetalia maritimi*), 1420 – Mediterranean and thermo-Atlantic halophilous scrubs (*Sarcocornetea fruticosi*), 1510* Mediterranean salt steppes (*Limonietalia*), 3150 - Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*.

This project receives funding from the European Union's Horizon 2020 Innovation Action under grant agreement No 101037097.

Key species

Marine seagrasses: *Cymodocea nodosa*, *Zostera marina*, *Zostera noltei*.

Fishes: The fish assemblage of the Venice lagoon is made up of 94 species of which marine stragglers is the most abundant category (55 species), followed by marine migrants (16 species), and lagoon residents (15 species) (Scapin et. al., 2019). Of these, four species are of EU importance included in the Habitat Directive: *Alosa fallax*, *Aphanius fasciatus*, *Knipowitschia panizzae*, *Pomatoschistus canestrinii*. Other species, for instance *Sparus aurata*, *Dicentrarchus labrax*, *Platichthys flesus*, *Solea solea*, *Chelon ramada*, *C. auratus*, *C. saliens*, *C. labrosus e Mugil cephalus*, which are concentrated in the Venice lagoon at the juvenile stages, represent important stocks exploited for fishing purposes (Cavraro et al., 2017).

Birds: The lagoon of Venice is the largest Important Bird Area (IBA) on a national scale, counting the highest number of species of Community importance to be preserved (Coccon et al., 2016). A total of 140 breeding species have been recorded in the lagoon, representing around 55% of the known species for Italy, moreover, many of the breeding aquatic species have a restricted areal distribution linked to wetlands, or small populations, whose survival is threatened (Campostrini and Dabalà, 2017).

Among the species of conservation interest, included in the Birds Directive (Annex I), are *Charadrius alexandrinus*, *Sternula albifrons*, *Sterna hirundo*, *Sterna sandvicensis*, *Circus aeruginosus*, *Circus pygargus*, *Circus cyaneus*, *Recurvirostra avosetta*, *Himantopus himantopus*, *Botaurus stellaris*, *Ixobrychus minutus*, *Egretta garzetta*, *Ardea alba*, *Ardea purpurea*. Other species characterizing the lagoon ecosystem in the wintering period are *Calidris alpina*, *Pluvialis squatarola*, *Numenius arquata*, *Tringa totanus*, *Tadorna tadorna*.

Organisation responsible for the pilot

CORILA, CMCC, University Ca' Foscari of Venice, University of Padova, Provveditorato Interregionale per le Opere Pubbliche per il Veneto, Trentino-Alto Adige e Friuli-Venezia Giulia.

Glasswort plant *Salicornia veneta*

Seagrass *Zostera marina*

Dunlin *Calidris alpina*

Sandwitch tern *Sterna sandwicensis*

Kentish plover *Charadrius alexandrinus*

Eurasian oystercatcher *Haematopus ostralegus*

Little tern *Sternula albifrons*

Eurasian curlew *Numenius arquata*

Pressures, threats and issues

The ecological functionality, the "dynamic balance", as well as the biodiversity of the Venice lagoon are threatened by a number of factors, both natural (as climate change, subsidence and sea level rise) and anthropogenic processes (i.e. the lagoon alterations caused by the modifications at the lagoon inlets and the excavation of deep channels that contribute to the erosion of the natural lagoon habitats, the low amount of sediments entering the lagoon, the chemical pollution of water, the waves generated by motor boats associated to wind, marine litters and Invasive Alien Species IAS).

Biodiversity loss

Within the lagoon of Venice, there are unique valuable habitats of conservation importance (e.g., natural salt marshes, mudflats and seagrasses) that play a fundamental role both as regulators of the lagoon hydrodynamics and as habitat for many wildlife species, also providing a huge number of ecosystem services. However, such habitats are currently threatened by the aforementioned factors leading to habitat degradation/disappearance and biodiversity and ecosystem services loss. As an example, several bird species of conservation interest that are characteristic of the lagoon of Venice (for instance kentish plover, little tern and sandwich tern) are facing a population decline due to the loss of the nesting habitat because of the increase in mean sea level and the enhanced frequency of high tide events in the summer period with consequent loss of their brood.

Natural impacts

Combined with eustatic Sea Level Rise SLR, between 1972 and 2002 subsidence has further increased relative sea level rise by ±1.5 mm yr-1 (Solidoro et al., 2010). In the past century the combination between natural and induced (groundwater withdrawal) processes, together with eustasy, have caused 23 cm of land subsidence (Carbognin et al., 2004). The city of Venice is also periodically subjected to sudden and frequent high tides, the so called "acqua alta", leading to significant damages to residential structure, economic activities, cultural heritage and transport facilities (Bonato et al., 2022).

Future projections for multiple hazards indicate that at least 75% of the North Adriatic region could be affected by one or more climate hazards, with highest concentrations near the

coastline (Gallina et al., 2020). Depending on the climatic projections, sea level rise will range between 32 and 100 cm by 2100, temperature is expected to increase with 2 - 2.5 degrees Celsius by the middle of the century, while the intensity of storm surges is expected to decrease. Moreover, in the future, a variety of activities taking place in the Venice lagoon will be adversely impacted by climate change. For instance, increasing occurrence of heat waves and low primary productivity is expected to increase mortality and thereby negatively impact fishery resources.

Anthropogenic impacts

The Venice lagoon is a complex, heterogeneous, and dynamic system that continuously evolves in response to modifications from stressors (Solidoro et al., 2010). During the last century, the lagoon has experienced general degradation including the deepening of tidal flats and the reduction of salt marshes (Carniello et al., 2009). Many changes are deeply rooted in human interventions, such as the diversion of rivers, construction of sea defenses, development of industrial areas and dredging artificial channels (Rova et al., 2019).

Main historic anthropogenic factors include (Solidoro et al., 2010):

- Land-based interventions (such as agriculture, industrial activity, and sewage inputs) loading nutrients in the lagoon,
- Industrial activities producing heavy metals and chemical pollutants,
- Maritime traffic,
- Fishing and aquaculture,
- Alterations to physical and morphological features of the lagoon forcing driving exchanges with the sea and warming climatic conditions due to climate change.

Population & Tourism

Many tourism-related activities are concentrated in the city center of Venice. The city records over 10 million tourist presences every year to which are added the "visitor" tourists (i.e., people who do not spend the night in the city), whose number is greater than 12 million/year (Campostrini and Dabalà, 2017). Other important activities are the touristic and industrial-commercial harbors (among the most important in Italy), being the Venetian port one of the most important in Italy (25 million tons of goods per year and 1.6 million passengers on cruise ships, Port of Venice – throughput statistics, 2019 final report). Livelihood industry (fish farms, aquaculture, traditional fishing) and local handcraft (glasses, crochets) are other relevant anthropic activities carried out in the lagoon. This wide range of activities and the high human pressure on the lagoon bring to the need of finding a trade-off between economy and sustainability.

Expected impact of the project

Within REST-COAST, the Venice pilot targets all five Ecosystem Services ESS: food provisioning, water quality purification, climate change mitigation, reduction of coastal erosion risk and reduction of coastal flooding risk. Each of these is addressed in a variety of projects and adaptation plans within the Venice lagoon.

The safeguarding of Venice and its lagoon is indeed of "primary national interest" according to a law issued in 1973 ("Special Law of Venice"). Huge efforts have been spent at all levels (national, regional, and local) by Public Administrations. Specific and severe limits for pollutant emissions (both in water and air) have been introduced since the '90s, but the pollution effects are still present in the soil and sediments.

Since 1992, in application of the Morphological Plan, the Venice Water Authority implemented several interventions to contrast the erosion

Maritime traffic


View of a natural saltmarsh

trends occurring in the lagoon. Morphological structures (i.e. artificial salt marshes and mudflats) for a total surface of 16 km^2 have been created, and other interventions for contrasting the loss of sediments and protecting the edges of the existing salt marshes and eroded mudflats have been done for an extension of about 40 km.

To contrast the flooding in the city (due to SLR) a mobile barrier system ("MOSE") has been built in the three lagoon inlets. This system can separate the lagoon from the sea in case of extreme high tide events. First activated in October 2020, the barriers have been raised 30 times in the first 2 years.

Finally, the municipality of Venice is currently working on the "Climate Adaptation Plan".

Stakeholders

The main stakeholders for the Venice pilot are represented by:

- Public Administrators (State, Regions, and Municipalities), including the North Adriatic Sea Port Authority, which is directly involved in safeguarding activities;
- Universities and Research Centers;
- Other Academic and Cultural Institutions;
- Private owners of cultural heritage assets (including the Catholic Church);
- Economic operators in different sectors (though trade associations), in particular
  - Industrial operators
  - Fishing and agricultural operators
  - Tourism and Services operators
  - Professional orders
- Civil Society Organizations and NGOs.

Part of the stakeholders above mentioned recently signed the "Wetland area contract for the northern lagoon of Venice". As the objectives and actions pursued by this body are in line with those to be pursued within the REST-COAST project, our aim is to engage them, together with all the other relevant stakeholder of the whole lagoon, to plan a negotiated restoration strategy to be discussed and shared by all the administrators of the territory.

Big clods to protect saltmarsh edges

Piling technique to protect salt marsh edges

Key variables of relevance to REST-COAST

The REST-COAST project aims to help restore the Venice lagoon through Nature Based Solutions (NBS). To reach this aim both environmental and socio-economic aspects are of great importance. Throughout the project the following biological, geophysical, hydrological variables will be monitored to evaluate the provisioning of ecosystem services (ESS):

- Attenuation of waves/energy at the break zone;
- Wetlands erosion and sedimentation patterns;
- Water turbidity and quality (temperature, salinity, chlorophyll-a, nutrients);
- Carbon storage within the salt marshes;
- Vegetation land cover;
- Bird species presence, occurrence, and distribution;
- Seagrass meadows coverage and distribution.

References

Bonato, M., Sambo, B., Sperotto, A., Lambert, J. H., Linkov, I., Critto, A., Torresan, S. and Marcomini, A. (2022). Prioritization of Resilience Initiatives for Climate-Related Disasters in the Metropolitan City of Venice. Risk Analysis, 42(5), 931-952

Campostrini, P., Dabalà, C. (2017). Una visione olistica, multidisciplinare ed integrata per il Piano di monitoraggio della costruzione del MOSE. In: Campostrini P., Dabalà C., Del Negro P., Tosi L. (eds), Il controllo ambientale della costruzione del MOSE. 10 anni di monitoraggi tra mare e laguna di Venezia. CORILA, Venezia, p 13–35

Carbognin, L., Teatini, P., and Tosi, L. (2004). Eustacy and land subsidence in the Venice Lagoon at the beginning of the new millennium. Journal of Marine Systems, 51(1-4), 345-353

Carniello, L., Defina, A., & D'Alpaos, L. (2009). Morphological evolution of the Venice lagoon: Evidence from the past and trend for the future. Journal of Geophysical Research: Earth Surface, 114(F4), 4002. https://doi.org/10.1029/2008JF001157

Cavraro, F., Redolfi Bristol S., Georgalas, V., Torricelli, P., Zucchetta, M. & Franzoi, P., (2017). Ingresso e distribuzione di uova, larve e giovanili di teleostei marini in laguna di Venezia: connettività mare-laguna e funzione di nursery. In "Il controllo ambientale della costruzione del MOSE. 10 anni di monitoraggi tra mare e laguna di Venezia", P. Campostrini, C. Dabalà, P. Del Negro, L. Tosi (editors), CORILA.

Coccon, F., Dabalà, C., Baldaccini, N.E. Analysis of temporal evolution of bird communities to
evaluate the impacts of the MOSE construction yards in Venice lagoon, Italy. VI International
Symposium "Il Monitoraggio Costiero Mediterraneo: problematiche e tecniche di misura", 28-29 Settembre 2016, Livorno, Italy

Franzoi, P., Franco, A., & Torricelli, P. (2010). Fish assemblage diversity and dynamics in the Venice lagoon. Rendiconti Lincei, 21(3), 269-281.

Gallina, V., Torresan, S., Zabeo, A., Critto, A., Glade, T., & Marcomini, A. (2020). A multi-risk methodology for the assessment of climate change impacts in coastal zones. Sustainability, 12(9), 3697.

Janowski, L., Madricardo, F., Fogarin, S., Kruss, A., Molinaroli, E., Kubowicz-Grajewska, A., & Tegowski, J. (2020). Spatial and temporal changes of tidal inlet using object-based image analysis of multibeam echosounder measurements: A case from the Lagoon of Venice, Italy. Remote Sensing, 12(13), 2117.

Ravera, O. (2000). The Lagoon of Venice: the result of both natural factors and human influence. In J. Limnol (Vol. 59, Issue 1).

Rova, S., Müller, F., Meire, P., & Pranovi, F. (2019). Sustainability perspectives and spatial patterns of multiple ecosystem services in the Venice lagoon: Possible roles in the implementation of the EU Water Framework Directive. Ecological Indicators, 98, 556–567. https://doi.org/10.1016/j.ecolind.2018.11.045

Rova, S., Pranovi, F., & Müller, F. (2015). Provision of ecosystem services in the lagoon of Venice (Italy): An initial spatial assessment. Ecohydrology and Hydrobiology, 15(1), 13–25. https://doi.org/10.1016/j.ecohyd.2014.12.001

Scapin, L., Bristol, S. R., Cavraro, F., Zucchetta, M., & Franzoi, P. (2019). Fish fauna in the Venice lagoon: Updating the species list and reviewing the functional classification. Italian Journal of Freshwater Ichthyology, 1(5), 271-277.

Solidoro, C., Bandelj, V., Bernardi, F., Camatti, E., Ciavatta, S., Cossarini, G., Facca, C., Franzoi, P., Libralato, S., Canu, D., Pastres, R., Pranovi, F., Raicevich, S., Socal, G., Sfriso, A., Sigovini, M., Tagliapietra, D., & Torricelli, P. (2010). Response of the Venice Lagoon Ecosystem to Natural and Anthropogenic Pressures over the Last 50 Years (pp. 483–511). https://doi.org/10.1201/ebk1420088304-c19