

## **CIESM Congress Panel P2 – Restoration of the Venice Lagoon**

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summary by Alberto Giulio Bernstein and Roberto Zonta

The Integrated Coastal Zone Management is an important goal for modern societies. Coastal zones are essential for the equilibrium of the whole sea-life, since the large amount of organic matter that is produced in their waters is fundamental for the maintenance of the food chain. Despite accounting for no more than 15% of the surface and 0.5% of the total volume of the ocean, about 90% of marine living resources comes from the coastal water. On the other hand, more than 60% of the world's population lives within 60 km of the sea, and human activities are changing rapidly the fluxes of matter and related pollutants from the continent to the coastal zones. These issues are particularly evident for the Mediterranean Sea. In this framework, the Panel discussed some topics related to the ICZM of the Venice Lagoon.

The Venice Lagoon has long been managed by human societies starting well before the industrial revolution. Any modification of the lagoon-coastal system, therefore, is impacting a coastal stretch that is not pristine. In the Venice Lagoon, a complex infrastructure (called MOSE), including mobile flood barriers, is being constructed in the three inlets by Magistrato alle Acque, the local water Authority of the Italian Ministry of Infrastructures. The MOSE will protect the lagoon during the events of high water level; the progress of work is 63% and it will be completed in 2014. The MOSE System also includes morphological interventions of restoration and safeguard, in both the lagoon and the coastal zone.

Giovanni CECCONI outlined the MOSE System of interventions currently implemented, describing the integrated activities of morphological restoration and flood control, in a lagoon which has a negative sediment budget and an increasing risk of extreme flooding due to the RSLR. Fourteen millions m<sup>3</sup> of maintenance dredging sediments have been reused in 94 salt marsh fills for starting-up a naturalization processes. Forty-five kms of littoral have been protected by beach nourishment and dune construction with 9 million m<sup>3</sup> of sand dredged at sea. The availability of muddy and sandy sediments is fundamental for environmental restoration of places affected by RSLR and erosion. After more than 20 years of experiments and studies in the lagoon environment dynamics, there is quite a wide range of tools available for creating COOS (Confined Ontic Open Systems, able to maintain their identity while changing morphology) using large volumes of sediments from maintenance dredging. MOSE mobile flood barriers, the most effective way for controlling storm surge, are also an effective tool for sensitive management of environmental issues like oil spills or summer anoxic situations by increasing tidal flushing, thus complementing long term environmental restoration and management.

Andrea RISMONDO discussed marine seagrass transplanting methods applied to both lagoon and the littoral since early 1990s. Seagrass decreases turbidity and resuspension, enhancing water clarity and stabilizing sediment, and plays a nursing role resulting in a valuable community for benthic species, vagile forms, fish fauna. The sod method is well promising, in particular if the integration between morphological and environmental recovery is realized, by evaluating the opportunity to raise the original lagoon floor level before carrying out seagrass transplantation, looking for the most suitable depth. Moreover, a variable and heterogenous structure should be preferred when carrying out hydromorphologic interventions, as variation of floor levels results in a quicker and better colonization dynamics.

Francesco SCARTON described the effects of the large program carried out the last 20 years in the lagoon to create and/or restore salt marshes, reed beds and beaches. Most of these man made habitats have reached structure and functions comparable to natural habitats, and thus become important for bird communities, in particular waterbirds, of local, national and EC interest. Birds heavily use the new sites throughout the year, and breeding populations of several species nowadays exceed thresholds of natural importance. Management of new sites is needed in the next years, to maintain their value for wildlife and to allow the existence of a range of diverse sites, suitable for species with different habitat preferences.

Daniele CASSIN summarized the results of the analyses 50 cm-long sediment cores from 380 sites of the lagoon, performed in the framework of the QSEV project (*Quality of the Sediment in the Venice Lagoon*), aimed to supplement and detail the existing large knowledge base on sediments, a widely discussed issue in lagoon environmental management. Pollutant concentration shows a wide variability both spatially and along the vertical profile, but no evident situation of acute contamination are observed. However, the contamination level of Hg deserves attention, its value resulting quite often above internationally recognized standards such as the NOAA-ERM limit. Main issues to be further investigated should focus on Hg and PAHs. For mercury, direct and secondary sources should be identified, transformation processes in the sediment (specifically, methylation) should be studied, and its presence and the behavior in the food web should be analyzed, by considering valuable species. The latter topic is fundamental also for PAHs, as well as the biotic and abiotic quantification of degradation and weathering processes.

Pierpaolo CAMPOSTRINI described the complex interdisciplinary monitoring plan (in place since 2004) runs by independent public scientific Institutions to side the MOSE construction. The program is mainly oriented to provide: i) a fast feedback for any alarm situation, ii) the elements to know the actual impact of site work, taking in due account to the variability of environmental conditions, also for asking mitigation and compensation measures when needed, iii) along with the work realization, useful elements for lagoon management and nature conservation. Initial status has been defined, pressures coming from the work sites have been characterized, thresholds have been stated, environmental effects have been cross-checked. Both “acute” and cumulated effects are under control. A number of mitigation/compensations were suggested and applied, no major problems occurred. Relevant and detailed information on the ecosystem behavior has been accumulated, to be used in the future management of the system, which should integrate an “intelligent” monitoring, where also the scientific community should help in selecting indicators and updated techniques.

Luca ZAGGIA showed the results of a study based on the use of Acoustic Doppler Current Profilers (ADCPs) to estimate water discharge and solid transport through the three inlets of the Venice Lagoon. In the long term, the average solid flux is positive, indicating a tendency for the loss of sediments from the lagoon ( $0.57 \times 10^6$  t/y). The results seems to indicate a marked reduction in the rates of sediment loss in the more recent period. The northern lagoon (Lido inlet) is driving the export of sediments while the yield of the central lagoon (Malamocco inlet) is only a minor proportion of the budget. The observed differences highlight the need to better investigate the fate of sediments in the central lagoon and the interactions between longshore transport and tidal exchange. The effects of anthropic activities as commercial shipping can significantly contribute to sediment loss from shallow water areas, whereas the effects of other activities, as clam harvesting, on the sediment distribution must be investigated. The outcomes of the experimental studies on sediment transport are a reference for the management of the lagoon system and a prosecution of the monitoring (discharge, solid flux) should be considered as a priority by public Institutions. Very interesting data were shown suggesting a possible significant ground water input that should be investigated to close the mass balances.

In the coastline of the Venice Lagoon (up to three miles offshore) there are many activities in relationship with the fishery production, which is living a particularly difficult moment. Describing a special monitoring of *Chamelea gallina*, Thomas GALVAN underlined the necessity of a management plan, in order to coordinate and resolve the conflicts among the fishery activities and between fishery and others fields (tourism, port activities, etc.), adapting to new UE legislation (Reg. CE 1967/2006) and creating protected marine environment. For near-shore fishery resources is important i) to prepare a management plan for the coast, ii) to supervise the quality of other areas to keep them as good as possible, iii) to check the fishing pressure between lagoon and near-shore.

Sandro CARNIEL focused his presentation on the integrated wave-current-sediment numerical models, whose capability to account for all the relevant physical processes of nearshore water environments has been remarkably increasing in the last decade. They are now reliable tools to support decision makers on a variety of applications in the coastal zone, such as beach protection, “search and rescue” as well maritime engineering operations. In this field, the cutting-edge science themes are i) 2-way coupling of atmosphere-ocean interactions (wave-driven circulation), nearshore turbulence, bottom boundary layer, coastal morphodynamics, climate change and related scenarios, ii) availability of last generation detailed bathymetry opens unprecedented possibilities for supporting nearshore operations and coastal structures design, starting from the Adriatic region.

Storm surge forecast is a difficult task. Georg UMGIESSER described the SSF system which was set up at the Centre for sea level forecasting and flood warnings of the Venice Municipality (ICPSM). The model runs on a computational grid of the Mediterranean Sea and uses a 2-dimensional formulation of the shallow water equations. A routine based on an Artificial Neural Network (ANN) strongly improves SSF. A new high resolution finite element tide-wave-surge model has been recently developed to study the interactions between tide, wave and surge in determining the total water level in the Mediterranean Sea. The hind cast results of this new model framework along the Italian coast show that the run with tide and with wave is more accurate than the conventional method (surge plus tide independently). New techniques should be tried out (neural networks, ensemble forecasts, assimilation) to improve the water level forecast skills in the Venice Lagoon. A coordinated effort is needed for the reliable operation of the MOSE mobile barriers. An operational model for the Venice Lagoon is still needed, able to deal with emergencies, accidental pollution, and assistance for monitoring tasks.

## **Conclusions**

The Panel had not, of course, the ambition to discuss in few hours all the aspects related to the MOSE Project, and from all the different points of view. But the Panel assembled a variety of stake holders and research teams who presented some interesting aspects of the main general topic, showing opportunities to further integration of available data and interpretation.

For nearly 15 years, as the discussion was focused on whether or not to construct the MOSE system, the intense debate was driven by socio-economic interests and political positions. This marginalized the discussion on technical scientific aspects and almost paralyzed the discussion on strategic decisions concerning the environment of Venice, its lagoon and the coastal zone. Nowadays, the construction of the MOSE system prompts a number of new interesting issues to the discussion of which science shall contribute. On a large scale and long term perspective, such as *how to put in a proper general prospective of integrated management of the lagoon, of its draining basin and of the coastal zone the MOSE closure and habitat restoration activities*. Or on a specific scale, such as *how*

*to improve the model-based prediction of high-water levels, .... how to monitoring the impact of the MOSE on biota and biodiversity ... how to decide whether to close the barriers or not under contrasting environmental and economic pressures.*

Research institutions and other actors involved in environmental activities, have gained significant scientific and technical knowledge, operational and investigative skills and built solid and rich databases of environmental variables. As the MOSE approaches completion (already reached 63% progress), is now essential to bring together and exploit this “diffuse” know-how in order to assist at the best level the present and future management of the MOSE system.

Integration and updating of existing data is getting more and more important and shall involve all. This will permit to achieve the maximum possible positive effects for Venice and its community, such as environmental quality, know-how and know-why exportation, best management practices, sustainable development, and growing of new productive activities.