

QUADERNI CA'VENDRAMIN

LABORATORIO INTERNAZIONALE DELTA E LAGUNE JOURNAL

ACTS OF THE
INTERNATIONAL
CONFERENCE
ON THE LAGOONS

VIVIFICATION
INTERVENTIONS
AND CONSERVATION
OF THE LAGOONS: THE
ITALIAN EXPERIENCE

THE DELTA AND FOREIGN
LAGOONS: THE
SITUATION, PROBLEMS
AND SOLUTIONS

RESULTS OF THE PO
DELTA SUMMER SCHOOL

WORKSHOP SYNTHESIS
AND RESULTS

1

NOVEMBER - 2010

ISSUE

3	PREFACE by Fabrizio Ferro	<i>Presentation</i>
4	THE FONDAZIONE CA' VENDRAMIN by Lino Tosini	
6	INTERNATIONAL CONFERENCE ON THE LAGOONS edited by the Scientific Committee	
8	MAP OF THE LAGOONS PRESENTED AT THE CONFERENCE	<i>Studies & Research</i>
10	VIVIFICATION INTERVENTIONS AND CONSERVATION OF THE LAGOONS: THE ITALIAN EXPERIENCE INTRODUCTION by Anna Maria Martucelli	
14	THE PO DELTA LAGOONS by Bruno Matticchio and Giancarlo Mantovani	
24	CAORLE LAGOON by Sergio Grego and Graziano Paulon	
28	VENICE LAGOON by Giovanni Cecconi	
34	THE SACCA DI GORO by Silvano Bencivelli	
40	LESINA LAGOON by Paolo Breber, Lucrezia Cilenti, Tommaso Scirocco and Antonietta Specchiulli	
46	CABRAS AND S'ENA ARRUBIA PONDS by Oliviero Uras	
52	GRADO-MARANO LAGOON by Michele Cicuttini	
60	EVOLUTION AND CRITICALITY OF THE NATION'S COASTLINES by Umberto Simeoni	

64	THE DELTA AND FOREIGN LAGOONS: THE SITUATION, PROBLEMS AND SOLUTIONS INTRODUCTION by Luis Berga	<i>Studies & Research</i>
66	THE EBRO DELTA LAGOONS by Inma Juan Franch	
70	NORFOLK BROADS by Henry Cator	
76	THE CURRENT SITUATION AND PROBLEMS OF THE PARANÁ DELTA by Andrea Behar	
86	THE IMOLA PROJECT: A TENTATIVE INTEGRATED LAGOON MANAGEMENT PLAN FOR TAM GIANG-CAU HAI by Massimo Sarti	
94	THE WORKGROUP SEMINARS INTRODUCTION by Pippo Gianoni	
96	CONSTRUCTING SCENARIOS FOR FRAGILE TERRITORIES: RESULTS OF THE SECOND EDITION OF THE PO DELTA SUMMER SCHOOL by Matelda Reho and Maria Chiara Tosi	
106	CONSERVATION AND PRODUCTIVE ACTIVITIES IN THE PO DELTA by Remigio Rossi	
108	SYNTHESIS AND RESULTS by Pippo Gianoni and Remigio Rossi	

110	THE FISHERMAN TRAINING PROJECT by Remigio Rossi	<i>Laboratory activities</i>
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PREFACE

FABRIZIO FERRO
Fondazione Ca' Vendramin President

After the 'trial' publication of Issue 0 of the *Quaderni Ca' Vendramin*, which revealed numerous certified positive findings, it is with particular satisfaction that I present Issue 1 of what I hope will become a series of cultural-scientific publications by the *Fondazione Ca' Vendramin* and in particular, its *Laboratorio internazionale delta e lagune*. I consider this an extremely important editorial activity because it represents the opportunity to exchange experiences for the development of scientific knowledge of the management of the lagoons and deltas at a national and international level.

It is a further possibility of technical and cultural enrichment for the personnel of the Veneto reclamation *Consortia*, *Delta del Po* and *Veneto Orientale*, to whom the Veneto Region has entrusted the management of the lagoon valley basins, an activity that is considered to be essential to the maintaining of their environmental hydraulic balance and to the socio-economic aspects of the territory, also from the recent regional law for the reclamation no. 12/2009.

This issue includes the contributions made by the speakers at the *1st International Conference on the Lagoons* held at the *Museo Ca' Vendramin* on the 2nd and 3rd October last year. It is made up, in substance, of the "acts of the Conference", reports presented on the aforementioned days and shared between Italian and foreign experiences in lagoon and coastal wetland management as well as the issues affecting deltas in general.

I would also like to take this occasion to thank the speakers for their highly qualified contributions to this, Issue 1 of the *Quaderni Ca' Vendramin*, a cognitive and scientific collection, indispensable for the vastness of the themes dealt with and the large geographic horizon covered.

THE FONDAZIONE CA' VENDRAMIN

LINO TOSINI

Fondazione Ca' Vendramin Director

On 30 October 2009, upon the initiative of the *Consorzio di bonifica Delta Po Adige* and between the Veneto Region, the Province of Rovigo, the *Ente Parco Regionale Veneto del Delta del Po*, and the *Consorzio di bonifica Delta Po Adige* (now Delta del Po) itself, the *Fondazione Ca' Vendramin* was founded. The aim of the Foundation is to promote advanced research, at national and international level, of themes pertaining to deltas and coastal wetlands, favoring the acquisition of knowledge and the development of historical and cultural aspects linked to the hydraulics and reclamation of the Po delta and the Veneto Region. In particular the following two principal objectives. The first objective regards the promotion, management and coordination, in collaboration with the territories universities, of interdisciplinary scientific research on the deltas, lagoons and coastal wetlands through the *Laboratorio internazionale delta e lagune*. The laboratory will develop interdisciplinary research aimed at enabling the coexistence and harmonization of the various and diverse issues affecting deltas, lagoons and coastal wetland areas all over the world, making this techno-scientific as well as socio economic legacy of knowledge available to all parties involved in order to improve and develop these territories.

The second objective regards the promotion, management, valorization and development of the "Po Delta museum system" and in particular, the *Museo Regionale della Bonifica Ca' Vendramin*, as well as the complex of historical hydraulic works and antique water towers. The museum will develop and manage the use of trails aimed at allowing one to visit the hydraulic works, rural environments and landscapes of the Po Delta, Province of Rovigo and the Veneto Region, promoting collaboration with national and international bodies in order to develop the history, tradition and tipicity of the delta, lagoon and reclamation environments. Therefore, the Foundation essentially has two objectives: that of advanced research linked to the deltas and lagoons and that which is historical-cultural, referring to the *Museo Regionale della Bonifica Ca' Vendramin*. Art. 4 of the Statute reports in detail the Foundation objectives contained in the previous two principal aims, for the accomplishing of which a Scientific Committee was nominated, acting as a point of reference for proposals and the activation of the Foundation's cultural and scientific activities. The aforementioned activities have only recently been launched, although certain extremely important initiatives are in their final planning stages. Above all, the Hue lagoon project in Vietnam should be defined within 2010 through the signing of an apposite agreement between the FAO and the *Fondazione Ca' Vendramin*.

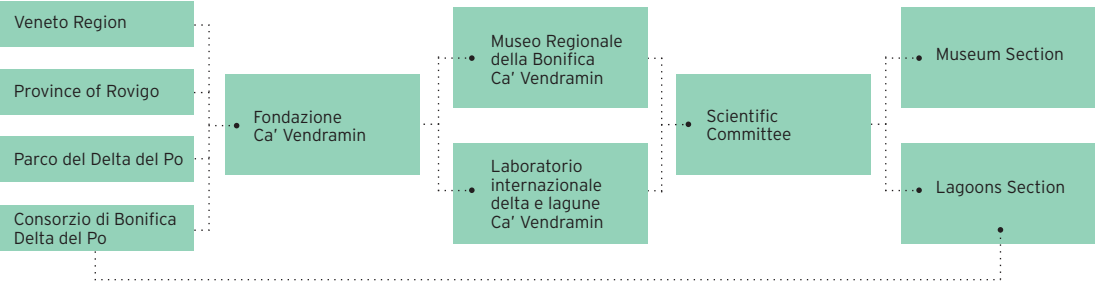
The project, to be developed over three years, was initiated following the Veneto Region's mission to Thua Thien Hue in Vietnam and is to be developed by the Ministry of the Environment and Territory, representatives of the *Consorzio di Bonifica Delta Po Adige* and Delta Med¹ association. On this occasion, the Regional minister, Giancarlo Conta, the FAO representative Mr. A. Speedy and the Regional Vice President Mr. Nguyen Van Cao shared the intention of launching collaboration under the auspices of the decentralized Italy-FAO Cooperation Program through the signing of a "declaration of intent". The decentralized cooperation project, thanks to the FAO's three-year financing (Euro 155,000,00) and that of the Veneto Region through the *Consorzio Delta del Po* and the *Fondazione Ca' Vendramin* (totaling Euro 210,000,00 for the 2010-2012 period), proposes, as a general development objective, a series of research

¹ Delta Med is an association based on the initiative of the *Comunidad General de Regantes del Canal della Derecha del Ebro* (Spain) and the *Consorzio di bonifica Delta Po Adige* of Taglio di Po (Italy). It brings together legal persons representing the deltas and coastal wetland areas of the Mediterranean with the objective of sharing experience and knowledge regarding the issues of territory, the environment and sustainable agriculture. For more information on Delta Med please see page 104 of Issue 0 of the *Quaderni Ca' Vendramin*.

and monitoring activities in order to identify, via preliminary projections, innovative-trial interventions aimed at environmental protection and the improving of the Hue Lagoon's management, that could also be of use in the conservation and management of the Venetian lagoons and the Po delta. Even if the total financing does not appear to be sufficient to reach the projects objectives, we retain however that the proposed first part is of a functional value and represents the concrete launch of international collaboration on the issues related to coastal wetland areas.

Other activities that are in the final preparation stages are training courses that will enable, in the medium term, the clear and synergetic positioning of the Foundation in the field of training both in Veneto and nationally. One course regards the Po delta lagoons' fishing profession and aims to impart basic and in-depth knowledge about breeding environments, the biology of the organisms that are bred, the sectors potential as well as sustainability concepts and economic aspects. The course is of particular relevance to the Po delta's young shellfish farmers. The other course, which is open to students, researchers, workers and members of the public administration and or private organizations, aims at deepening the knowledge about ecosystems and the dynamics of lagoon areas in order to develop the necessary skills to face the impact and risks that these environments are subject to and to support the economic activities there. This enables the broadening of the researchers', administrators' and workers' skills, which are indispensable in the real and proactive integrated management of the lagoons with regards to the environment and economies associated with them.

Other activities connected to the valorization and development of the Po Delta museum system, consisting of the *Museo Regionale della Bonifica Ca' Vendramin* and the Delta's complex of historical hydraulic works. The Po basin Authority has also been contacted in order to draw up an agreement on the so called "*contratti di fiume*" regarding the Delta area. These planning instruments will have direct input on the Delta and in the management of the lagoons, which is why, as the local body of reference, the *Fondazione Ca' Vendramin's*, involvement, as well as that of the Po Basin Authority and the Veneto Region, is extremely important. The Foundation, resolved of bureaucratic inertia of the constitution has therefore been launched with the fundamental support of Scientific Committee in defining its own path for the accomplishing of statutory objectives.



The *Fondazione Ca' Vendramin*.

**INTERNATIONAL CONFERENCE
ON THE LAGOONS**

edited by the Scientific Committee

The Veneto Region, through the *Consorzio di Bonifica Delta del Po*, performs the hydraulic and environmental management of the Po delta and its lagoon systems. It has also started research in collaboration with the Universities within the region to guarantee balanced interventions that meet the various needs of a complex and constantly changing environment.

14 years from the first meeting in Ca' Vendramin in 1995, in the presence of representatives and operators from all the Italian lagoons, the conference's goal is to check the state-of-art relevant to the management of lagoon environments, which represent ecosystems with great environmental and productive values. Another goal is the opportunity to know the situation in other lagoons and European delta environments as well as other continents with which collaboration projects are already in progress. The idea is to realize an operational network about the lagoons based on the *Laboratorio internazionale delta e lagune Ca' Vendramin*.

**Group photo of the
Vietnamese, Spanish
and Argentine
delegations.**



**Speakers and
participants at the
conference.**



CONFERENCE PROGRAM



Convention poster.



Ca' Vendramin.

Thursday 1st October:

Vivification interventions and conservation of the Lagoons: the Italian Experience *by Anna Maria Martuccelli*
The Veneto region's experience in managing the lagoons *by Riccardo De Gobbi*
The Po Delta Lagoons *by Giancarlo Mantovani and Bruno Matticchio*
Lagoon of Caorle *by Sergio Grego*
Lagoon of Venezia *by Giovanni Cecconi*
The Sacca di Goro *by Silvano Bencivelli*
Lesina lagoon *by Paolo Breber*
Cabras and S'Ena Arrubia Ponds *by Oliviero Uras*
Grado-Marano Lagoon *by Michele Cicutini*

Friday 2nd October:

The delta and foreign lagoons: the situation, problems and solutions *by Luis Berga*
The Delta Med Association *by Manel Masià Marsà and Lino Tosini*
Adaptive, real time, self learning lagoon living *by Jörg Imberger*
Lagoons of the Ebro Delta *by Inma Juan Franch*
Norfolk Broads *by Henry Cator*
Paranà Delta *by Andrea Behar*
Hue Lagoon *by Massimo Sarti, Nguyen Van Cao and Do Nam*

Workshop dei gruppi di lavoro:

Planning and naturalness in lagoon environment *by Emanuela Finesso, Matelda Reho and Pippo Gianoni*
Compatible uses in lagoon environment *by Remigio Rossi and Luigi D'Alpaos*
Summary of the work group results

Saturday 3rd October:

Welcome from the representative of the institutions:

Charmain of the Province of Rovigo
Charmain of the Parco Regionale Veneto del Delta del Po
Mayors of the Municipalities of the Delta

Delta and Lagoons: meeting with the institutions *by Roberto Casarin*
Presentation of the results of the work groups *by Pippo Gianoni*
Presentation of the "Charter of naturalness of the Po Delta" *by Remigio Rossi*
Presentation of the *Laboratorio internazionale delta e lagune Ca' Vendramin* *by Roberto Tovo and Chancellors of Universities*

Conclusions of the Regional and Ministerial Administrators:

Giancarlo Conta
(Councillor for the Environment Policies)
Marialuisa Coppola
(Councillor for the Budget Policies)
Antonio Buonfiglio
(Deputy-Minister of the Ministry for Agriculture, Food and Forestry)

Laguna di Venezia
Italia (Veneto)
50.000 ha



Norfolk Broads
England
30.000 ha



**Lagunas del delta
de l'Ebre**
España
1.500 ha



**Stagni di S'Ena
Arrubia e Cabras**
Italia (Sardegna)
2.000 ha



Delta del Paraná
Argentina
1.700.000 ha





Laguna di Caorle
Italia (Veneto)
3.000 ha



Laguna di Marano e Grado
Italia (Friuli Venezia Giulia)
3.000 ha



Laguna di Lesina
Italia (Puglia)
5.300 ha



Sacca di Goro
Italia (Emilia-Romagna)
3.000 ha



Hue Lagoon
Vietnam
22.000 ha



Lagune del delta del Po
Italia (Veneto)
16.500 ha

MAP OF THE LAGOONS PRESENTED AT THE CONFERENCE

(Approximate area of lagoons and wetlands)

_INTRODUCTION VIVIFICATION INTERVENTIONS AND CONSERVATION OF THE LAGOONS: THE ITALIAN EXPERIENCE

ANNA MARIA MARTUCELLI
ANBI Director-general

Today's encounter, as programmed, is dedicated to the theme of lagoon vivification and conservation, that of the Italian lagoons in particular. Tomorrow, as you may well know, will be dedicated to the problems facing the lagoons of other countries. The significance of the encounter has its roots in the fact that the lagoons constitute an extraordinary and precious resource not only due to their environmental value, but also because of their economic and productive values. Therefore, actions aimed at the safeguarding, protection and restoration of the lagoons regard the general public. Deltas, natural systems of extreme environmental significance characterized by wetland areas that constitute a precious habitat for fauna and flora, merit similar consideration.

Deltas are systems that are dominated by rivers. Lagoons are systems dominated by the sea, and are in fact modeled by the action of the sea via the forces of wave motion and tidal currents, in this way the sea constitutes, in this case, the primary sedimentary source. Deltas are characterized by vast expanses of wetlands almost at sea level, while lagoons are mainly systems characterized by open, shallow bodies of water. There is nevertheless, a type of lagoon that is much more similar in nature to deltas: the delta lagoon. Delta lagoons are situated on the margins of deltas or between the main branches of rivers. Actions for the restoration and conservation of these natural systems are therefore extremely significant in the field of environmental protection. Moreover they are actions that to start with, require knowledge of realities specific to lagoons and deltas, be it regarding hydraulic, geomorphologic or mareographic aspects.

In order to correctly evaluate the actions necessary to guarantee the vivification and conservation of the lagoons, long periods of study, detailed experimentation, monitoring, construction of considerable mathematic models and widespread measuring and observation campaigns are undertaken. As it was recently revealed, identifying intervention strategies and effective operative methodology constitutes a laborious elaboration process. However, it is not only a case of determining how and when to carry out the intervention, but also to be able to guarantee its management.

Lagoon management certainly takes on a strategic, central role, that over time requires a long, continuous and patient procession of maintenance and conservation activities, and has two aspects: hydraulic management and environmental management. The close link and the integration of the two aspects determined the need to consider the role that the reclamation *Consortium* could take on in this sector, bearing in mind its knowledge and professionalism, and the evolutionary process recognized by the reclamation actions on the territory ahead of the functional versatility it assumed in reference to the objectives of territorial, environmental and health safety.

When, in 1984, the book titled "*Le bonifiche in Italia dal '700 ad oggi*" was published, it bore testimony of the fundamental role that reclamation activities have played in the construction and defense of plains in Italy that over the centuries have been recovered by hydraulic reclamation. In fact, it is only through the act of recla-

mation, carried out using the untiring work of man and the investment of enormous capital that our plains have been salvaged, rendered productive and inhabitable, that we have been able to create, with the improvement of environmental conditions and the containing of the power and disorder of the waters, more civil forms of life.

In this general picture the *Polesine*, because of the geographic origins of its terrain and the power and disorder of the large Po and Adige Rivers that longitudinally border the territory, is a shining example of a reclamation action that was completed in order to restore submerged terrain, contain the flooding of the waters, guarantee soil stability and hydraulic safety, allow for civilian settlement and economic development, as well as to protect the *Polesine* territory. The *Polesine* hydrographic complex and the complicated hydraulic network cutting through the territory is testament to the age-old and imposing reclamation works that allowed for the construction of the *Polesine*. More recently, reclamations in our country and in the *Polesine*, have undergone a particular process of adaptation to the changeable needs of the territory and society, diversifying the intervention itself and enriching the targeted actions as well as defense and hydraulic regulation, economic development, the extension of irrigation and environmental safeguarding through actions for the protection of natural resources.

It is not to be forgotten that a political organism for the correct governing of the territory today calls for the fundamental action of defense from the water and of the waters, an action for the constant hydraulic risk prevention and reduction, but at the same time that calls for active protective actions and safeguarding of the soil and other environmental resources through the ordered and proper use of the territory, the ongoing organization and regulation of the waterways, the rational use of water resources and the widespread restoration of surface water and groundwater. Only in this way is one able to also realize the hoped for environmental safeguarding. Reclamation as a whole, specifically aimed at the conservation and defense of the land, the rational use of water and the protection of these environmental resources, is rightfully concurrent with modern policies regarding the territory of which it represents a fundamental and strategic phase. On the other hand, as one can see, over the centuries the role of reclamations has constantly adapted itself to the needs of the territory. One only has to recall the extensive drainage actions that the reclamation *Consortium* carried out through the management and maintenance of an important and interconnected hydraulic systems in all the plains of our country, the widespread irrigation system made up of diversion canals, adduction and distribution as well as dam walls and traverses.

The reclamation activities to which our country owes its conservation and maintaining of the physical conditions necessary for civilian life are spread over more than 50% of the territory, as well as productive activities which guarantee the ongoing organization, regulation and protection of the waterways, with the continuous supply and rational use of water through collective irrigation systems. This is also testimony to the evolution of the national legislation and organic regional legislation regarding reclamations. Regarding the former, one only has to recall that the two most recent national framework laws on the natural resources sector, the framework

law for land defense (law 183/1989) and that for the management of water resources (law 36/1994), include reclamation and irrigation actions in the field of fundamental actions for the conservation and defense of the land and the continuous supply and rational use of water, and they indicate the reclamation *Consortia* and irrigation *Consortia* as entities having their own functions and specific institutional competencies in the two respective sectors. What's more, the framework law for the protection of water, approved with legislative decree 11 May 1999 no. 152 recognizes the contribution that the Consortiums can make to the environmental protection sector.

It is to be underlined that the reclamation *Consortia* have already for some time been working on certain initiatives contemplated in the 1999 legislation. Amongst these initiatives are those that are the subject of the present debate, falling under environmental protection actions carried out by the *Consortia* that bear witness to the evolutionary process of reclamations in the territory. As you will see, the interventions carried out on the Venice Lagoon drainage basin and those of the delta lagoons, the monitoring of water and the protection of the springs and water sources are of particular importance. Reclamation actions have been of decisive importance to the country through the illustrated evolutionary process in virtue of the fact that today it includes a series of actions and interventions aimed at land conservation and defense, the rational use of water mainly for irrigation and the safeguarding of the environment. The *Consortia*'s interest in the lagoon and delta systems stems from this evolution of the reclamation action, and hence the vivification, restoration and conservation of the lagoons that are dealt with in this encounter.

Moreover, it is clear that the strategic role and fundamental contribution of the entire reclamation to territorial, environmental and health safety is certainly not exhaustive, but should be coordinated and integrated by the other institutions' actions, to which the state and regional organizations entitle functions and power that is wider reaching and more general, aimed at achieving the same objectives, in order to guarantee sustainable development. In comparison, the planning and collaboration with these institutions should be for the main entities of the realization and management of the entire reclamation - the reclamation *Consortia* and irrigation *Consortia* - a general rule. The environmental and economic value of the lagoons should lead to an orientation of the territories' policies that bears in mind the delta lagoons' problems identifying intervention strategies and effective operative methods as well as the identification of competent management subjects. There are certainly studies and research, as to which the experiences illustrated today bear witness, but also proposed solutions and experimentation.

There is certainly, as the work carried out up to this point proves, a scientific and interdisciplinary approach to the problems. In previous encounters and debates conclusions oriented towards the need for a scientific interdisciplinary approach had already emerged and the constitution of an international conference on deltas and lagoons, capable of deepening the interdisciplinary research and exporting the approach developed in the Po delta to the rest of the Mediterranean as well as other parts of the world, was hypothesized. It is also necessary to institute a research centre with the objective of promoting, managing and coordinating advanced research

on deltas, lagoons, and wetlands with reference to their connecting territories. President Ferro briefly spoke of this in his introduction. I maintain that, at national level, the lagoon and delta system's problems cannot go unappreciated. In the context of environmental policy that should not overshadow the need to protect natural resources and environmental and economic value that will be subject to dangerous degradation if one does not intervene promptly.

The Veneto regional legislator recognized the functional versatility of reclamation actions in the territory and it is because of this that in the field of reclamation functions, environmental protection, with specific reference to the valley and lagoon landscapes as well as the conservation and development of the water heritage, have been clearly indicated. Referring to the reclamation *Consortium* as the management body is not only due to the solid integration of the hydraulic regulation actions and vivification and restoration of the lagoons, but also the constant presence of the *Consortium* in the territory, its specific professionalism and circumstances in which in substance, the legislator intervened in order to recognize the efficiency and competence which the *Consortium* had already demonstrated. At a national level, two important provisions were added to the previously cited laws, in particular, the conclusive investigation document on the *Consortia* approved by Parliament in January 1996 as well as the State-Region Agreement on the 18th of September 2008. Both recognize the value of the territory that is, today represented by public works and the effective manner in which they are managed by the Consortiums, as well as the validity of the *Consortium* institution, and its management of natural land and water resources, including the protection thereof.

One hopes therefore, that taking into account the special natural resources constituted by the lagoons, and in the sense that the national legislator, having been made aware of the need, would positively consider the formulation of a provision dedicated to protecting the lagoons, a field in which the interventions and actions required for their safeguarding, the necessity to work through the activity of focused research and specific experiments, thereby recognizing the need for a highly specialized and multidisciplinary laboratory are individualized. Obviously, the necessary financial resources are required and suitable management entities need to be identified, and there is also the need for the organization of and cooperation between the local territorial entities and the reclamation *Consortium*.

**_ACTS OF THE CONFERENCE
THE PO DELTA LAGOONS**

BRUNO MATTICCHIO
Ipros Ingegneria Ambientale Srl

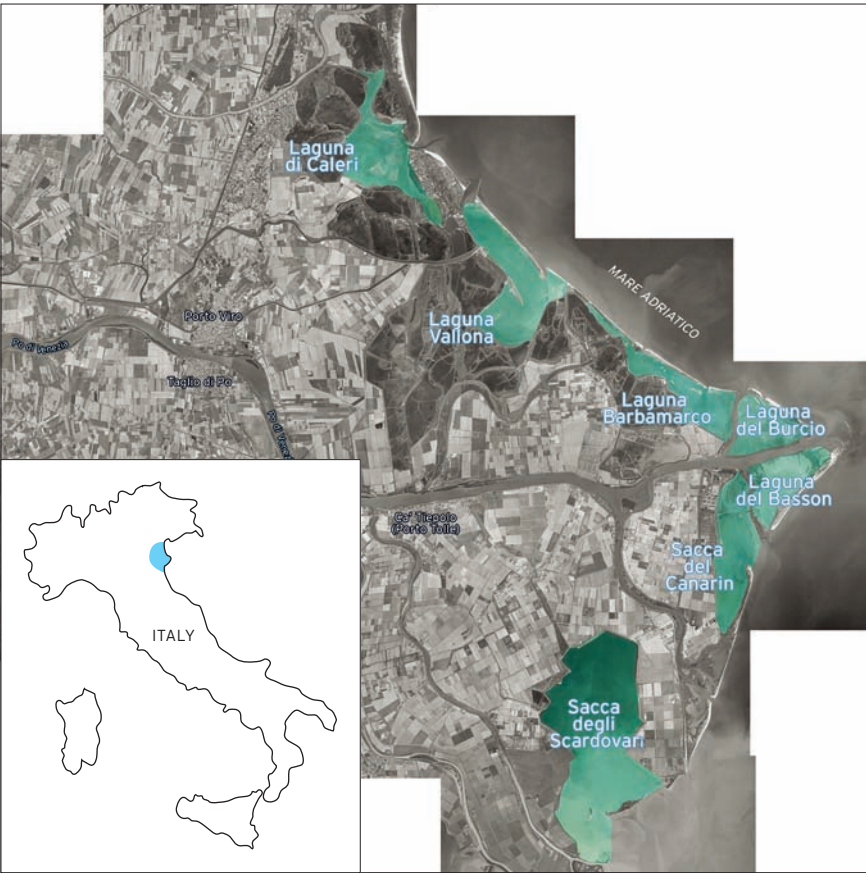
GIANCARLO MANTOVANI
Consorzio di Bonifica Delta del Po Director

The Po Delta lagoon system comprises 18000 ha of water surface areas, 8150 ha of which are occupied by lagoons, 8600 ha by banked *valli da pesca*, and over 1250 ha by wetlands. There are 7 main lagoons, of which the biggest, the *Sacca di Scardovari*, covers an area of 3300 ha, and the smallest, the *Burcio*, 100 ha. (Figure 1)

This is a particularly delicate and unstable environment, subject to intense dynamics typical of transition zones. At the same time its hydrological and morphological safeguarding constitutes an undeniable objective due to its high ecological value and multiple anthropologic activities that take place there (fishing, shell fishing, tourism etc.). At the end of the last century, the delta lagoons were

subject to progressive hydro-morphological and environmental degradation, for which there are various motives, the most important being subsidence, mainly due to the extraction of methane water from deep stratum and its negative effects on the basins' morphology.

Originally characterized by deep canals flanked by shallow depths and salt marshes that only emerged at high tide, the lagoon bottoms underwent a progressive "flattening" that had a negative effect on tidal current circulation, hampering the mixing and exchange of water especially in the bodies of water situated further away from the mouths, and having serious repercussions on the environmental quality and ichthyic production. (Figure 2).



**Figure 1: the Po
Delta Lagoons.**

The aforementioned degradation was principally evident in the formation of large areas of stagnant water, often with low salt levels, in which serious eutrophication and algae proliferation phenomena systematically originated, especially during the summer months. Therefore, since the early 1990s, the *Consorzio Delta Po Adige*, under the mandate of the Veneto Region, has enacted a series of provisions in order to improve the lagoons' hydraulic system and stabilize their hydrodynamic balance.

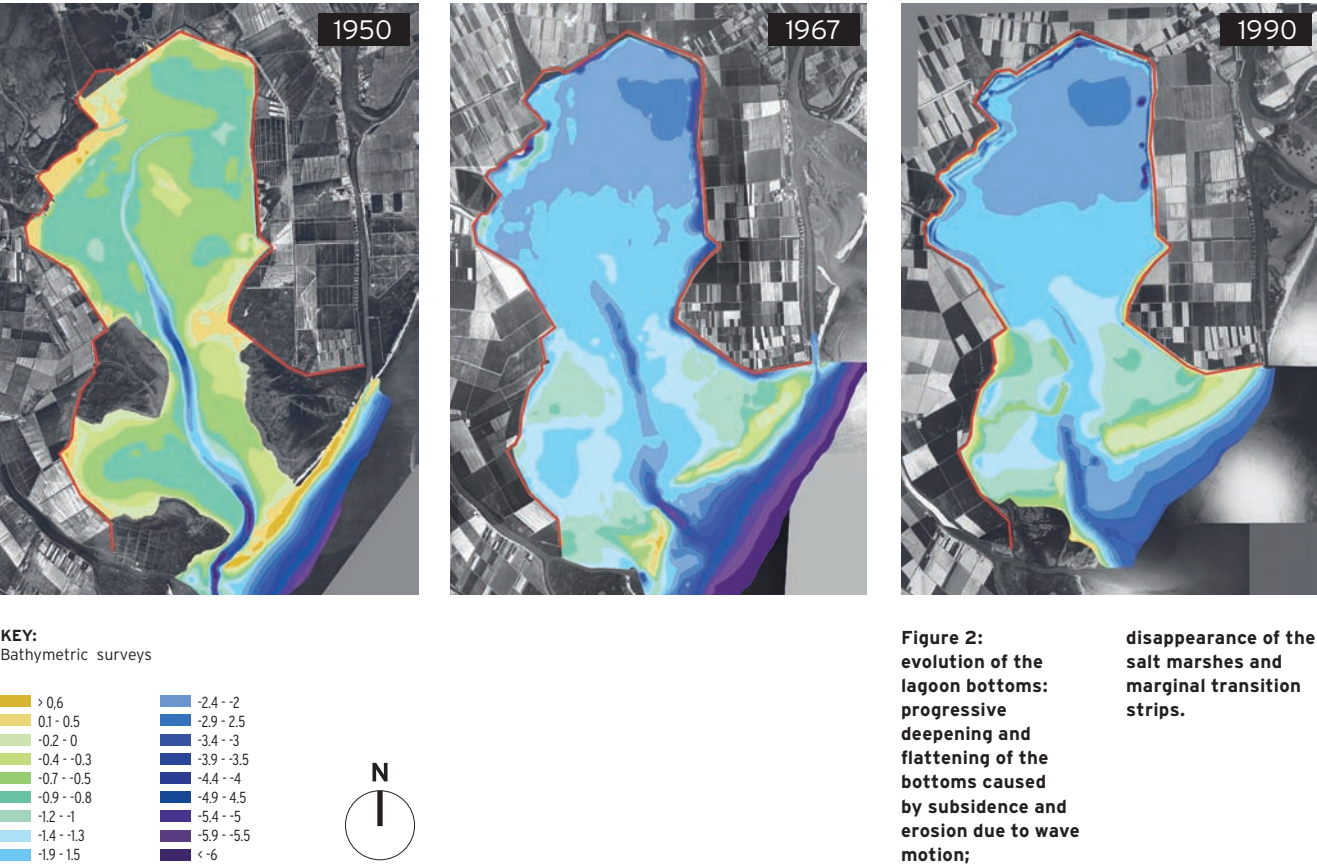
In particular, these include lagoon "vivification" interventions, mainly based on the dredging of canals and the forming of "salt marshes" from the resulting materials. These interventions, reconstituting at least part of the origi-

nal "diversity" of the lagoon bottoms, enable the tidal currents to reach the internal bodies of water and favor the mixing phenomena linked to both the circulation of the said currents and the effects of the wind.

Consolidation works were carried out on the lagoon mouths and sandbars in order to, as much as possible, increase and maintain the lagoon-sea exchange. Systems to control tidal flux in particular sections, aimed at increasing the natural exchange of water in the bodies of water that had been most affected were also introduced. An essential requirement for the identification of the interventions required, as when evaluating their effectiveness, was the range of experimental investigations and models. Put

to use right from the outset, their objective was, on one hand, to improve our knowledge of the lagoon system and, on the other, to follow their evolutionary dynamics over time, be they natural or triggered by the interventions themselves, in this way measuring and guiding the realization of the works.

These investigations provide support to the *Consortium's* current activities, which regard, on one hand, the completion of projects and the maintenance and management of completed works, and on the other, the realization of ulterior interventions to deal with particular critical situations, above all those linked to the effects of sea storms on the sandbars and lagoon mouths. Amongst the monitoring activities, topographical and



bathymetric surveys that were used to define the physical geometrics of the system and to support planning played an important role. (Figure 3).

The surveys, coupled with the aerial photographs and broadened to include the different grades of detail of the bottoms of the lagoon and the stretch of sea opposing it, must be carried out at regular intervals in order to record the morphological variations that characterize these types of environment. Further to collaborating in the management of the continuous network for the monitoring of physiochemical parameters and water quality, the *Consortium* heads up the authorized regional agency (AR-PAV), periodically conducting surveys to measure the hydrodynamic parameters of the lagoons (Figure 4).

Typically, the carrying out of these investigations covers a wider range, simultaneously revealing tidal levels and in flowing water during spring tides. The levels are recorded in more points in the lagoon basin in order to define phase displacements and size variations of the tidal swell, which gives one an idea of the tidal propagation towards the lagoon margins. The in flowing quantities are generally surveyed at the mouths to the sea and in some internal sections. This is done in order to quantify both the sea-lagoon water exchange and therefore the effectiveness of the mouths, and the lagoon canal flux, and therefore tidal current activity in different parts of the body of water.

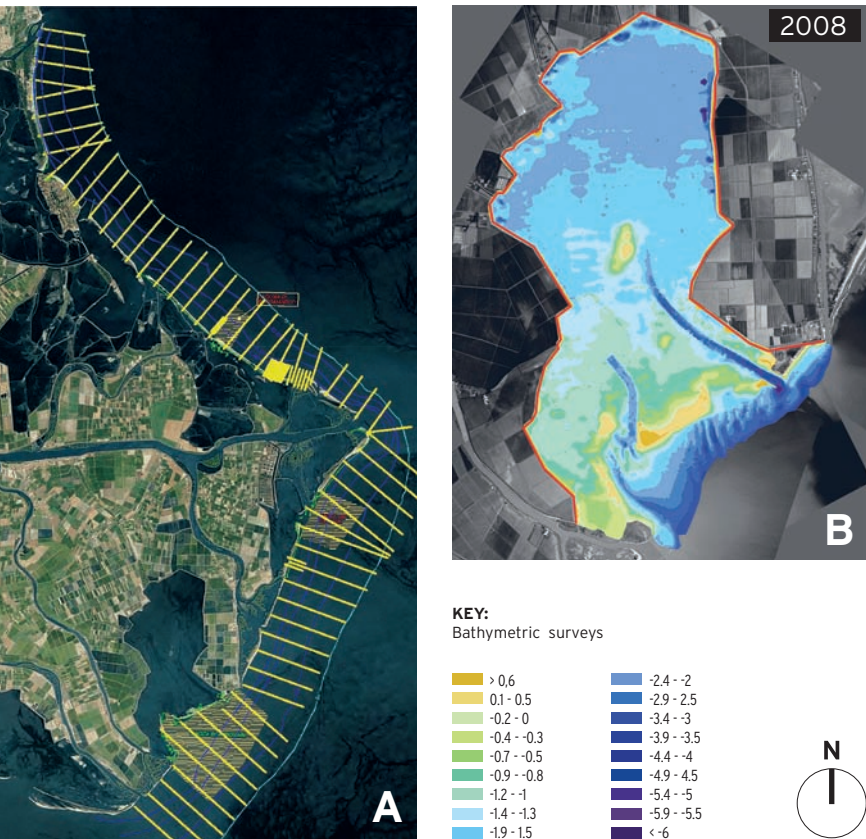
The hydrodynamic measurements are flanked by distribution surveys and

surveys on the main physiochemical variations, salinity in particular.

In lagoon environments, the wide and sudden variations in salinity caused by fresh water of fluvial origins coming into contact with sea water not only influence the quality of the water and aspects linked to productivity, but also their hydrodynamics. In fact, the grades of density due to the variations in salinity in turn affect water movement and favor, especially in the deeper, less hydraulically active areas, damaging stratification phenomena of the column of water.

The recorded, formatted and geo-referenced data was inserted in a geographic database (GIS) so that those planning interventions in the lagoons

Figure 3:
A. bathymetric survey of the coast:
- profiles every 1km;
maximum depth -15m; - detailed bathymetric surveys of the lagoon mouths; - shoreline survey;
B. bathymetric survey of the lagoon.



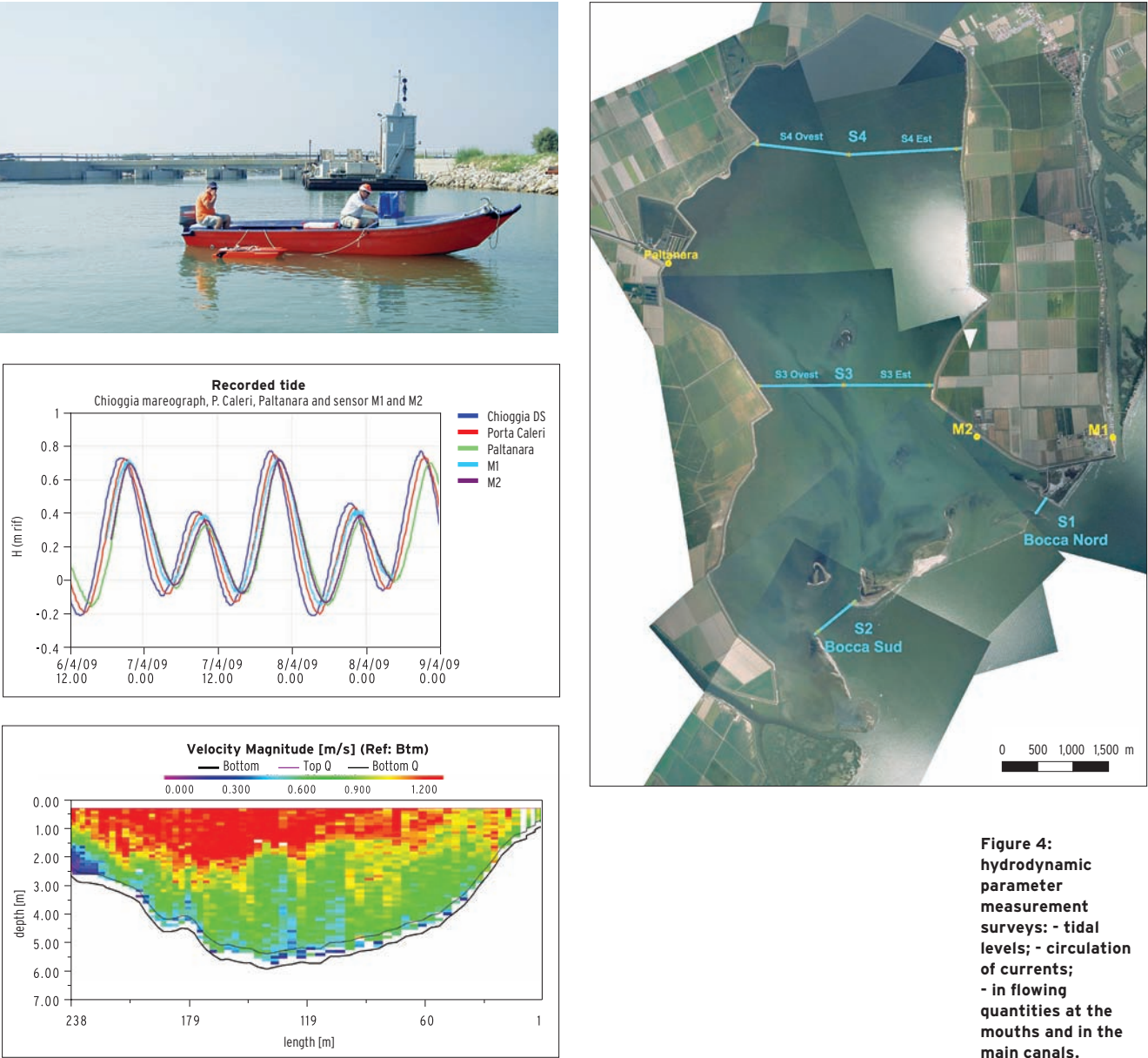
could easily access it. The *Archivio Geografico del Delta del Po* is organized into a series of thematic levels, which with the exception of the cartographic overview logically expanded to include the whole of the Delta territory, specifically refers to the different components of the physical system of the lagoon environments, but also provides levels dedicated to socio-economic and plan-

ning interventions carried out by the *Consortium*. Despite the current potential of field investigations, in order to clearly define the complex dynamic of the lagoons' hydrodynamic processes, it is necessary to refer back to investigations with mathematic models.

In fact, once adequately validated based on experimental data, these cal-

culatation instruments can on one hand, be reliable in representing the hydrodynamics of the whole basin and on the other, simulate the effects of different planning scenarios. (Figure 5).

In the first stage of planning lagoon vivification interventions, their configuration was mainly identified on the basis of calculations carried out using



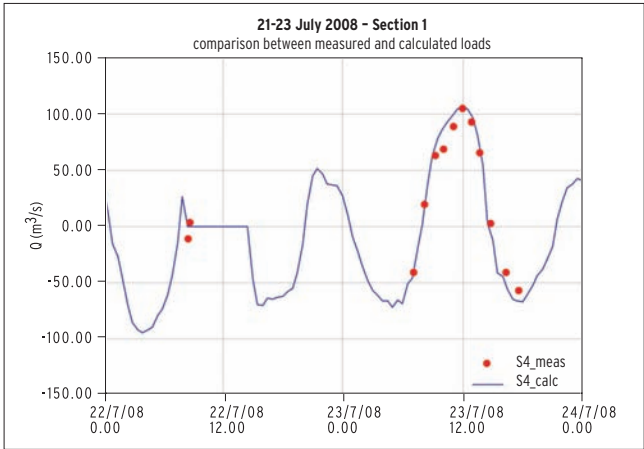
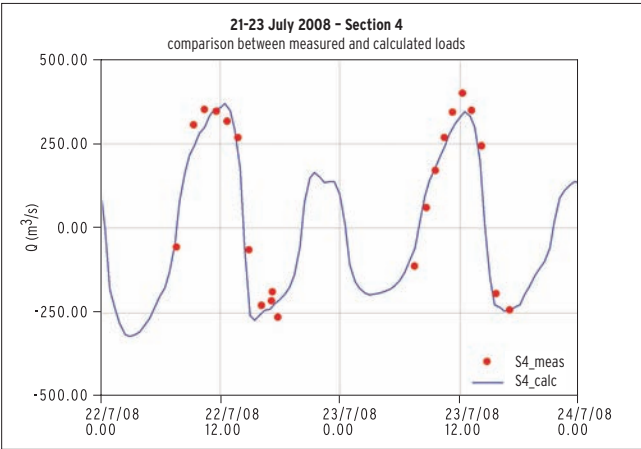
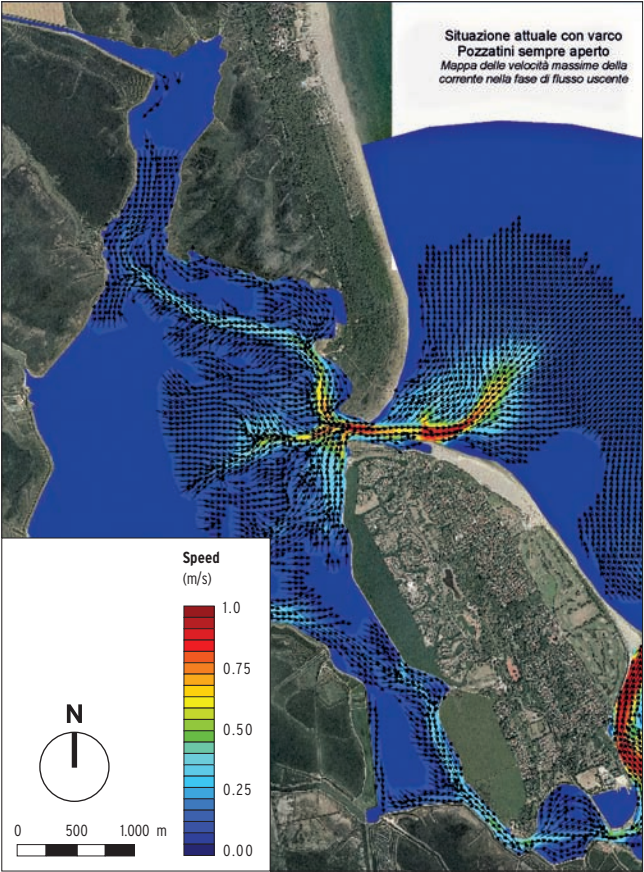


Figure 5: 2D hydrodynamic model for the study of tidal current circulation analysis of condition; identification and verification of the project solutions.

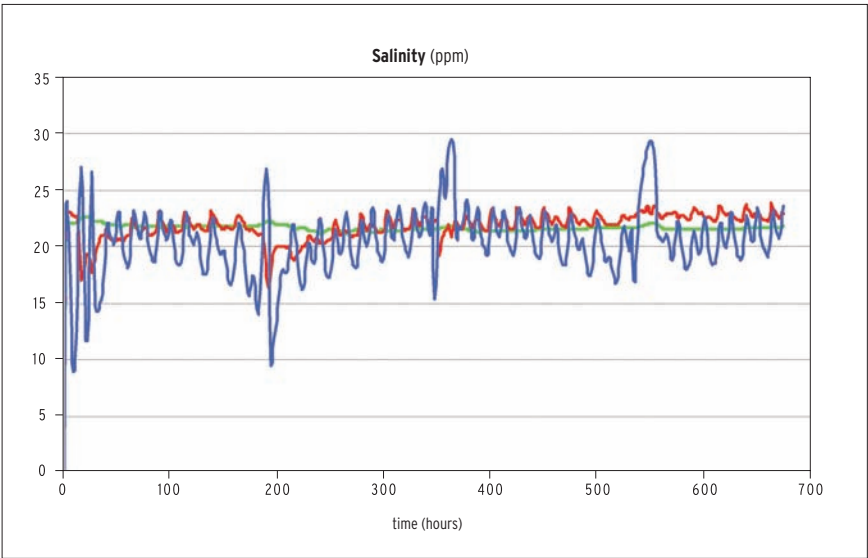
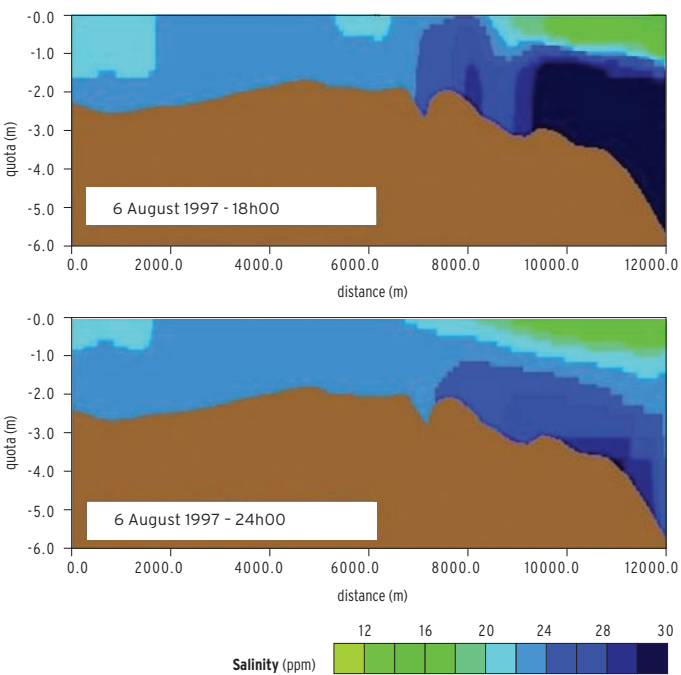
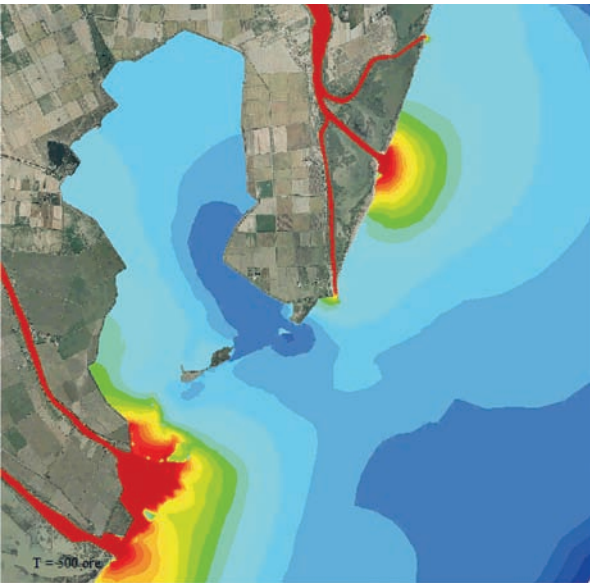


Figure 6: 3D hydrodynamic model for the study of stratified currents: fresh fluvial water entry; mixing and stratification; wind action.

two-dimensional mathematic models. The positive results achieved implicitly confirmed the validity of this approach. In the current management phase, the *Consortium* still makes use of simulations using two-dimensional models in order to verify the current circulation situation in the lagoons and evaluate eventual alternative planning.

More sophisticated hydrodynamic models are also used to investigate the evolution of the lagoon bottoms due to the combined effects of the tidal currents and the sea storms, in analysis relating to the stabilization of the lagoon mouths and sandbars. Lastly, three-dimensional models are used to study lagoon hydrodynamics in investigations regarding the in flow of fresh water of fluvial origin, mixing and stratification phenomena and circulation caused by the wind (Figure 6).

In summary, the preliminary studies and monitoring carried out on the lagoon areas showed the hydrodynamics to be the predominant factor to be worked on, on one hand in order to achieve the environmental restoration of the lagoons and on the other, to recuperate their productive resources and develop the economic activities linked to them.

Moreover, these studies enabled the identification of the instruments to be used in the vivification of the lagoons, that is the carrying out of works on the lagoons' morphology and restoring, within limits, the characteristics that the lagoons possessed prior the occurring of subsidence phenomena, breaking down the range of possible solutions into two main intervention categories:

- the digging of new sub-lagoon canals or the re-digging and adapting of those already existing in deeper areas;



Figure 7: artificial salt marshes: wire fencing.



Figure 8: artificial salt marshes: wooden poles placed side by side.



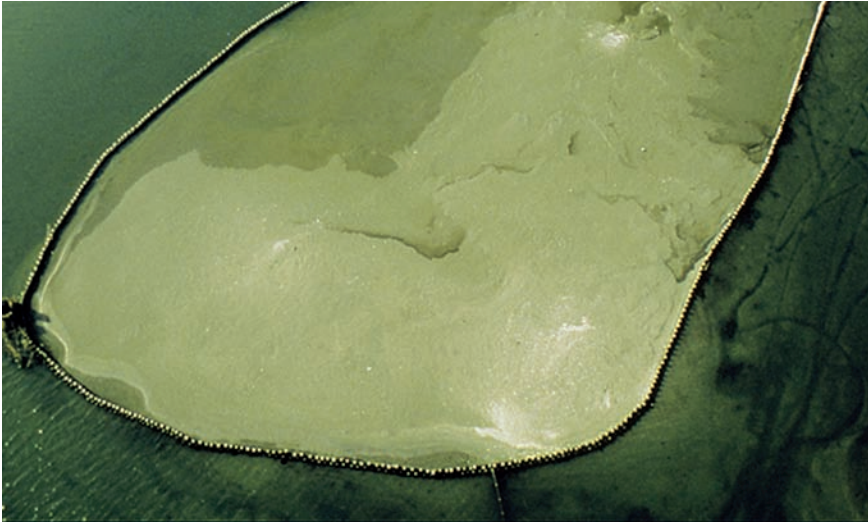


Figure 9: artificial salt marsh: cordoned off area filled with materials resulting from diggings.

- the forming of artificial salt marshes made up of materials originating from digging and placed in peripheral shallow areas.

It was in this way that vivification projects realized with financing provided by I.M.P (Integrated Mediterranean Program) under Reg. EEC No 2088/85 were carried out in the *Caleri*, *Vallona*, *Barbamarco* and *Scardovari* lagoons. The digging of new canals was realized with special vacuum pump dredgers and in some cases with boat mounted excavators. The artificial salt marshes were

realized by cordoning off the identified areas with wire fencing (Figure 7) or wooden poles placed side by side (Figure 8).

Once the areas had been cordoned off they were then filled, up to 30÷50 cm above sea level, with the material originating from dredging, in this way creating salt marshes (Figure 9). Moreover, environmental restoration works were realized, in order to compare wind erosion, via the planting of pioneer species that led to the activation of the natural “vegetization” of the salt marshes (Figure 10).

Furthermore, sluice or flap gate systems were realized in the *Caleri*, *Vallona* and *Barbamarco* lagoons in order to optimize hydrodynamic flow via the regulation of tidal flux (Figure 11 and 12). This induces residual circulation and increases the exchange of lagoon water with a ‘pumping’ effect. The positive results of the interventions were immediate and they helped in recovering lagoon productivity, productivity that was the litmus paper by which the validity of the interventions would be tested. (Figure 13).

The lagoons are coastal areas with



Figure 10: pioneer species plantations.

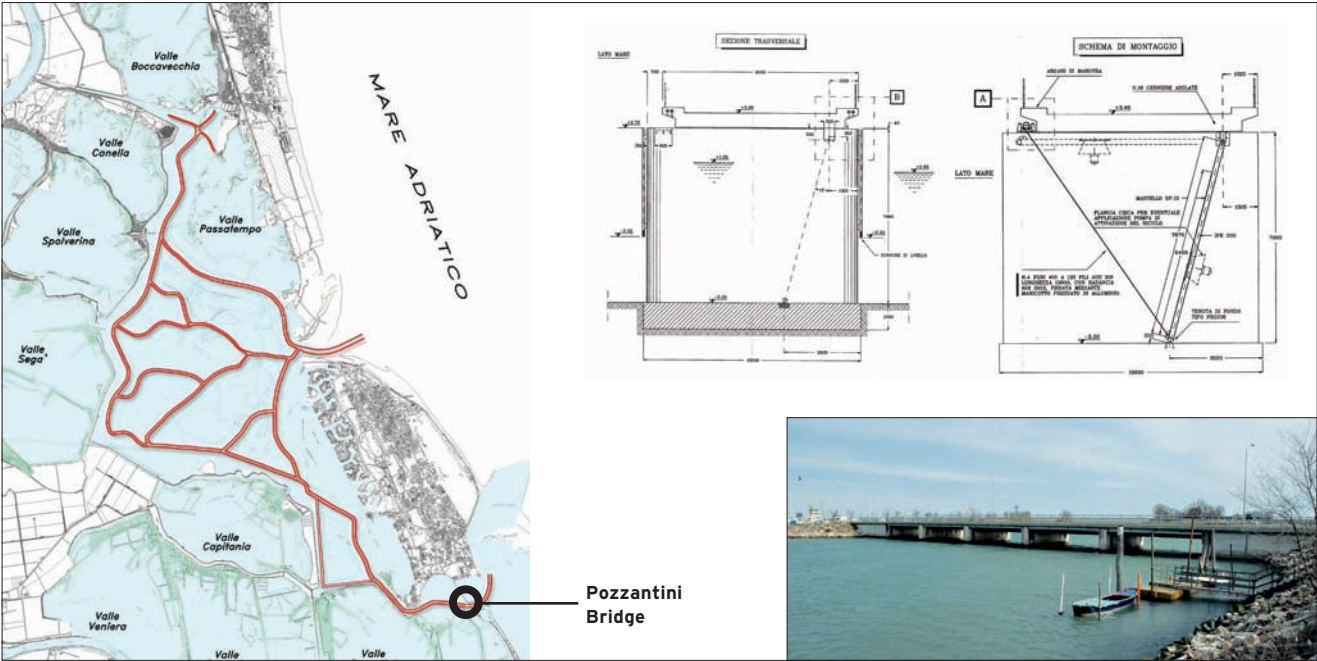


Figure 11: realization of systems on the Caleri lagoon.

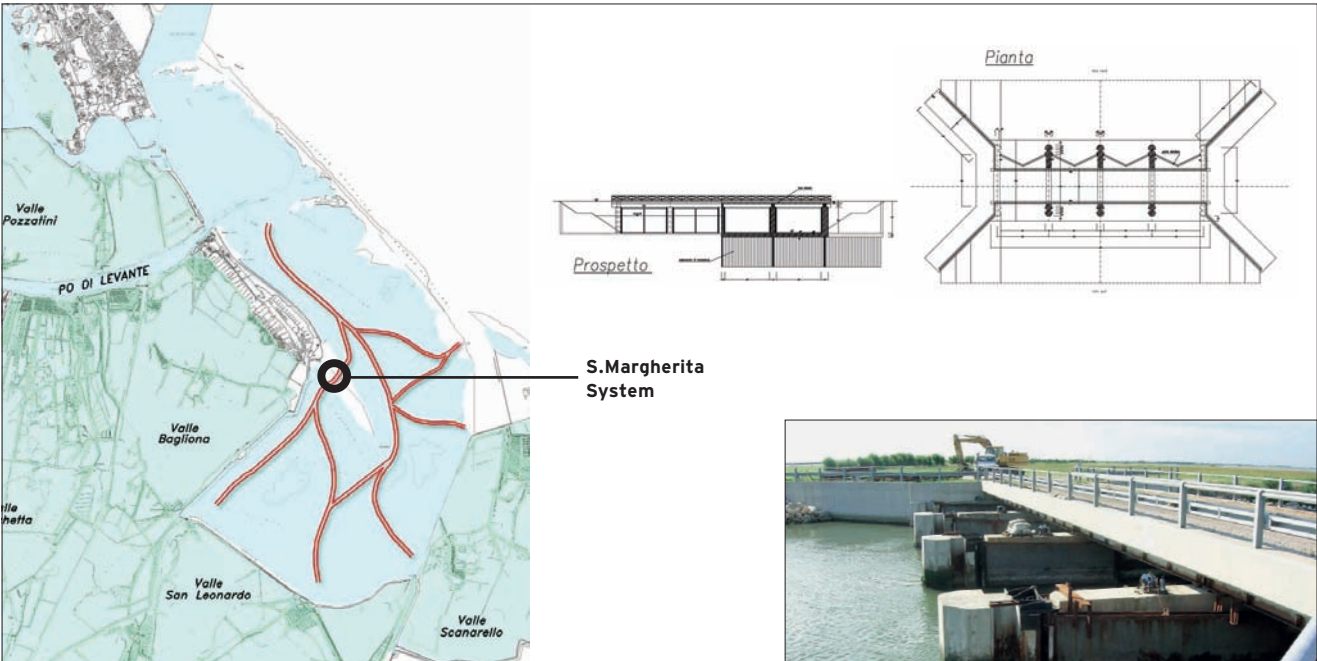


Figure 12: realization of systems in the Vallona lagoon.

a precarious balance between land and sea, and are subject to continuous and rapid variations.

That is, they are dynamic environments that change from day to day and it's these changes that have repercussions, usually negative, on lagoon hydrodynamics and hence the environment. The need to continue the monitoring of these changes, rectifying them as much as possible and where not rectifiable, to adapt to them was immediately highlighted. Hence, one moves on to the concept of the management of the lagoons.

Right from the beginning, with art.29 of the Regional Law 22.02.99 no.7, the Veneto Region acknowledged the importance of the management of the lagoons. With this law it authorized the Regional Council to entrust the management of and carrying out of works in the lagoons of the Po delta and Caorle to the reclamation *Consortia Delta del Po* and *Pianura Veneta tra Livenza e Tagliamento*. The same law also authorized the Regional Council to finance specific maintenance projects in the lagoons.

The basic guidelines for the management of the lagoons are as follows:

- the maintaining of the correct hydrodynamics of the lagoons, the maintenance of the lagoon mouths and existing canals as well as restoration interventions of lagoon morphology;
- the depositing of dredged material in the salt marshes and sandbars;
- stabilization interventions in the lagoon mouths;
- reinforcement and nourishment of coastal sandbars;
- the planting of vegetation;
- the functional management of systems connecting the sea and lagoons as well as those connecting the lagoons

and rivers;

- monitoring of lagoon water quantities;
- monitoring of lagoon fish and shellfish production;
- bathymetric checks and hydraulic measuring campaigns;
- the completion of interventions.



Figure 13: the resuming of productivity after the interventions.

_ACTS OF THE CONFERENCE CAORLE LAGOON

SERGIO GREGO

Consorzio di Bonifica Pianura Veneta tra
Livenza e Tagliamento Director

GRAZIANO PAULON

Consorzio di Bonifica Pianura Veneta tra
Livenza e Tagliamento

Of all the ecosystems in the area, from a naturalistic and environmental point of view, the Caorle Lagoon is certainly the most important. However, its importance goes beyond strictly ecological aspects: the condition of the lagoon environment is in fact linked to its economic activities, which range from agriculture and fishing to tourism (Figure 1).

Caorle Lagoon represents the remains of the large expansion basin of the flooding of the *Livenza* and *Tagliamento* Rivers. As a consequence of various reclamation interventions carried out between the beginning of the 1900s and the early 1960s, its original configuration has been significantly modified: mudflats and salt marshes are now confined to very restricted spaces, while the areas between the large lagoon canals have been transformed into banked *valli da pesca* or even, after reclamation, cultivated land. The lagoon hydraulic system is based on two main branches, the *Canale Nicesolo* into which, via the *Canale Saetta* and *Maranghetto*, part of the Livenza and the Lemene Rivers' loads flow, and the *Canale Lovi*, a level spillway of the Tagliamento River, into which the *Canale Cavrato* flows. Moreover, drainage networks of the opposing reclaimed territories flow into the entire lagoon system, incorporating the *Canale Sindacale*, *Taglio* and other minor canals.

From a hydraulic point of view, the system appears to be extremely efficient thanks to the expansiveness of the liquid areas of the main channels. The system, however, shows poor water exchange capacities with the sea: this is due to the closure at the top, the point where the rivers forming the network connect, creating an almost closed at the bottom funnel-shape; under these conditions, it is capable of gathering scarce amounts of ebb-tide during the tidal cycle.

In the past the lagoon canal complex was joined to large liquid surfaces (*valli*), making up an alternate flow system guaranteeing water exchange and its full working capacity. Currently, the free *valli* have almost completely disappeared; the lagoon's detritic system is no longer able to perform its primary function, the alternating transportation of water loads as high as the lagoon *valli* were large.

Today Caorle's lagoon hydrographic system is essentially a network of waterways. The residual *valli* (*Valle Zignano*, *Perera*, *Valgrande*, *Valnova* and other smaller ones) have a limited contribution to the hydrographic system's flow due to the reduced dimensions of the watersheds or the system's open canals. The system receives freshwater from the Lemene and Loncon Rivers and partly from the overflow of the Tagliamento and Livenza, as well as from the outflow of the reclamation system to the rear (Figure 2).

The seawater enters the system at high tide, penetrating it as much as the opposite flowing freshwater consents. At low tide both the freshwater and the seawater that entered at high tide flow out to sea. The mixing however, is only significantly noticeable further downstream, the part of the system which is affected by the ebb tide. In terms of quality, this characteristic strongly affects the overall situation and in certain situations organic substances, suspended solid substances; microbiological pollution and nutrients associated with eutrophic phenomena and the reduction of dissolved oxygen are found in the water in the system.

The salinity, however, is extremely variable, only reaching sea water values (35 g/l) at the outlets and being reduced to hyper-saline values (1-2 g/l) over a large part of the area.



Figure 1: the city of Caorle and its lagoon.

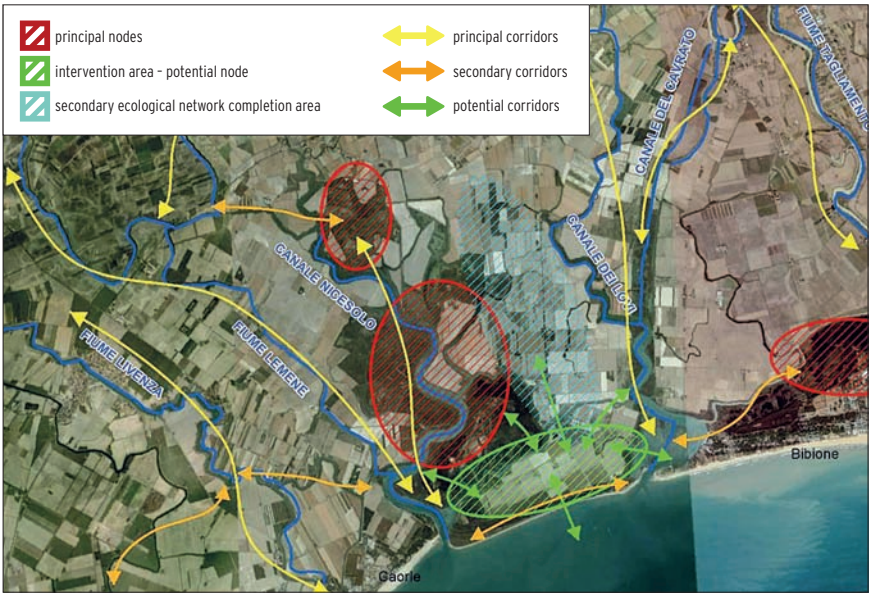


Figure 2: interventions carried out in the lagoon environments.

Overall, the survey of lagoon flow highlights the strong tidal out flow at the mouths, the reversal of the swell occurring only a few kilometers away; this explains the prevalence of freshwater in the eutrophic parts of the lagoon system. Faced with this situation, since 1990, the *Consorzio di bonifica Pianura Veneta*, at first with the *Integrated Mediterranean Programs* and later the *Programma Regionale di manutenzioni lagunari* in accordance with Regional Law no. 7/1999, carried out a series of interventions (Figure 2) in order to restore the functionality of the Caorle Lagoon ecosystem, jeopardized by the gradual loss of water salubrity, the progressive sinking of the lagoon canals and valli areas due to the insufficient exchange of water between the lagoon and sea, and the presence of emissions into the lagoon via the main river branches, purified however by the urban system to the rear and the agricultural land.

The operative hypothesis, translated into various interventions could be summarized as follows:

- the reopening of the parts of the valli or of areas connected to the lagoon system (*Vallevecchia*), connecting to the canal system via arteries with low hydraulic resistance, in order to vivify these areas be it the channeling canals or tidal flow;
- diversion of the major river flow of low water and of more consistent out flow from the reclamations via mobile barricades, with secondary effects contrasting the moving up of the salt-wedge and the reduction of the mixing of lagoon waters with those channeling the outflow originating from urban settlements;
- enlargement of canal sections that vivify the lagoon system, in particular the *Canale Nicesolo* and *Canale Lovi* and the contextual and environmental restoration of mudflat and salt-marsh areas in the neighboring areas.

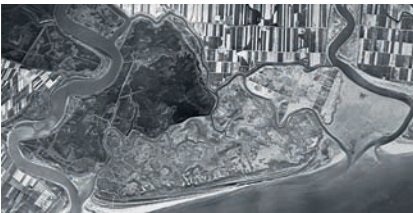


Figure 3: the Valevecchia environmental restoration and renaturalization project. (Image: Studio Tepco).

In concrete terms, the excavation of *Canale Nicesolo* has been realized first, therefore a large part of the internal lagoon canals, and in this period there are works underway on the mouth of *Canale Lovi*. In any intervention, as highlighted above, there are specific complimentary environmental systemization interventions and reconstruction of mudflats and salt marshes associated with excavation works.

One can affirm that the first functional cycle of interventions is about to be completed. This should be immediately followed by the launch of systematic monitoring campaign in order to vivify, via direct measures, the exact consistency of the consequential benefits in qualitative terms as perceived by experts in the field. This involves going ahead with this action, as the conditions of improvement created show reversible characteristics for now. The most recent analysis has drawn atten-

tion to a specific environment of the Caorle lagoon system. *Vallevecchia*, an area of about 900 hectares, underwent hydraulic reclamation in the 1960s, in which, almost contextually with the aforementioned processes, accompanied by planning experience, certain observations were made with the objective of environmental recuperation also via the large-scale reintroduction of wetland environments.

Since 1994, the Veneto Region (the owner of the area) and the *Comune di Caorle* have carried out certain experimental environmental requalification interventions with the reintroduction of wetland environments over an area of almost 80 ha. With the conclusion of the initial experimental phase, a feasibility study was carried out including the definitive planning of certain interventions (Figure 3) aimed at obtaining the following strategic objectives:

- to show *Vallevecchia's* full environmental and landscape potential, and hence that of the entire Caorle Lagoon via the restitution of large spaces to the lagoon, the creation of wetland environments, the augmentation of biodiversity and the recalling of priority species;
- to give a significant push to lagoon flow dynamics, largely devitalized by the complexes of reduction interventions in the open spaces of the free expansion of the tide;
- to recuperate the cultural and historical value of the lagoon by developing its relationship with the population of Caorle, which is still strongly connected with the large open waters and salt marshes and still intensely affected by the conflicts that have, from the confiscation of the property of Caorle in 1642 to the draining of the area in the 1900s, left their mark on the history of the community;
- to take advantage of the economic



Figure 4: the mouth of the *Baseleghe*.

potential of the lagoon and its surrounding areas, enriching and diversifying its tourist appeal, improving on the seasonal opportunities and consolidating the prospects of integrating the agricultural activities of the areas behind the lagoon with the environmental and tourist use of the rural territory, incorporating Vallevecchia.

The feasibility study highlighted three possible scenarios resulting from the re-naturalization interventions, identifying three overall hypotheses that could be summarized as follows:

1. the reopening of the *Canale Baseleghe* (Figure 4) and the extension of restoration and environmental requalification work to include almost the whole of *Vallevecchia*, according to a scheme based on the prevalence of wetlands realized via the expanded opening of the lagoon waters;
2. the integration of the reopening of

the *Canale Baseleghe* and its bordering areas to the tide, the realization of a reversible seasonal wetland environment in the rear western areas via the controlling and monitoring of meteoric outflow, aimed at realizing the first functionality test of the systems opening to the tides, the evolution of environments constituted under conditions of different saline degrees and at the same time, the possibility of analyzing the eventual definitive expansion of the interventions;

3. the limiting of interventions to the opening of the *Canale Baseleghe* in the area to the east, and the maintenance of the current agricultural destination to the rear of the district.

The Veneto Regional Council recently opted for the second scenario, regarding which subsequent decisions were made regarding the initiation of planning and identification of financial resources.

**_ACTS OF THE CONFERENCE
VENICE LAGOON**

GIOVANNI CECCONI
Consorzio Venezia Nuova

The safeguarding of the City of Venice from flooding and erosion is closely linked to the restoration of the hydro-morphological structure of the lagoon and its waterfront. Beaches, dunes, salt marshes, mudflats, bottoms and canals have been considerably transformed by the effects of subsidence, the raising of the sea level, the drastic reduction of sedimentary deposits, excessive wave motion, navigation and mechanized fishing (Figure 1). Without complete hydro-morphological and biological organization the sediments remain suspended and are transported from the bottoms and salt marshes to the canals where they are deposited, or from where they are dispelled into the sea: this results in a general flattening as well as the loss of form also of the multiplicity of habitats and the systems hydro-morphological functions and biological complexes. This reminds one of the results obtained by the *Magistrato alle Acque* and its reclamation activities in the lagoon's hydro-morphological structure through the re-use of dredged sediments in maintaining canals (Figure 2).

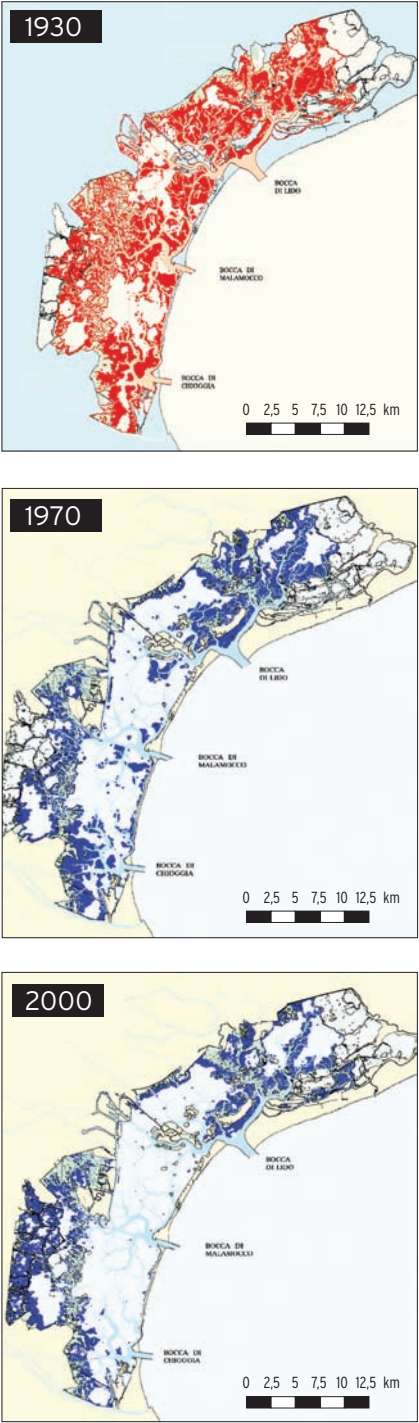


Figure 1: shallow bottoms from 0 to -60cm m.s.l. have been reduced by 2/3; from 168 km² in 1930, to 105 km² in 1970, to 60 km² in 2000.

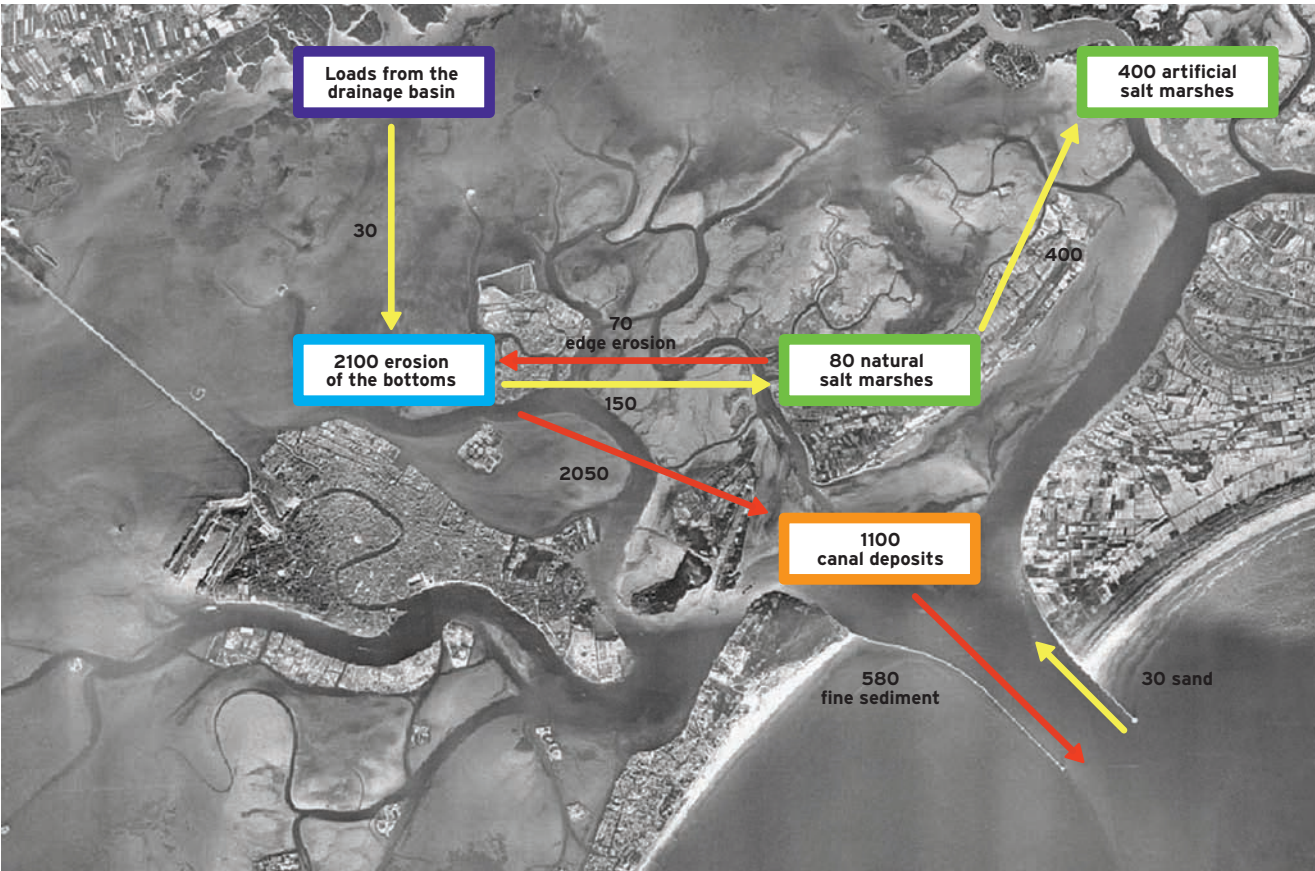


Figure 2: sediment balance in thousands of km².

Protection from wave motion

The fragile morphological structures of the lagoon, like its mudflats and salt marshes, are exposed to serious erosion of its deepest bottoms caused by an excess of energy in the wave motion caused by wind and the augmentation of the quantity and speed of passing watercraft, be they for transportation or pleasure. Today, traditional Venetian rowing along the lagoon canals is seldom practiced and people no longer risk crossing the *Canale della Giudecca* by rowboat (Figure 3).

For some time now, The *Magistrato alle Acque* has been involved in both preempting wave motion problems (by enforcing speed limits and intensifying surveillance), with structural interventions

for the protection and reinforcement of the urban fringes and on the borders of salt marshes and by experimenting with new devices to control the energetic flow of wave motion that propagates from the borders of the navigation canals.

While intervention techniques have been acquired and applied for some time now in the case of adherent interventions (piled structures, geo-grids with stones as high as the salt marshes in places), the detached defenses near the area in which there is excessive wave motion should be perfected by looking for solutions that do not alter the value of the landscape, or are at least perceived as a necessary but harmonious transition between highly anthropologized environments with excessive energy (the anthropological system), and environments that have auto-



Figure 3: wave motion caused by water traffic: its effect on the bottoms, salt marshes and traditional Venetian rowing.

conservation characteristics (the natural system).

In June 2008, a *demonstrative experiment* was undertaken using a series of possible techniques for the interception of waves in the shallow depths beside the canals. The aim was to quantify and make an inverse connection between the interception capacities of the wave motion and visual alteration: in fact, although the structures should emerge very little in order to reduce the impact on the landscape, for them to be effective their size and cost had to be exponentially augmented. The experiment served as a point of comparison, the *arena* in which the institutions, together with the other stakeholders could find an informed solution to the way in which artificial defenses are realized, in order to conserve and protect the territory which is home to the mudflats, salt marshes and traditional Venetian rowing from the effects of necessary navigation.

Mudflat and salt marsh reconstruction

In 1986, the *Magistrato alle Acque di Venezia* readopted the age-old practice of reusing sediment resulting from maintenance dredging of the canals in forming deposits that over time, as a result of tidal energy and wave motion, have been naturalized and have become mudflat and salt marsh habitats. Today, more than 20 years later, reconstructed mudflats and salt marshes cover a surface area of 11.5 km²: double that of the natural areas that have undergone erosion in the same period (84 completed salt marshes covering 8.5 km², 14 completed mudflats and raised areas, as well as 11 incomplete salt marshes covering an area of 1.5km² (Table 1).

Coastline protection	Total volume
Sand for beach nourishment	8.500.000 m ³
Beaches	45 km
Recovered dunes	8 km
Lagoon canal management	Total volume of dredging
Chioggia port authority Aspo	2.000.000 m ³
MAV Genio Civile Opere maritime	4.300.000 m ³
Venice port authority	7.400.000 m ³
Comune di Venezia canals INSULA	420.000 m ³
MAV (Law 366/63)	10.000.000 m ³ for 176 km of canals
Protection of natural salt marshes and mudflats: 34 km	
Salt marshes and mudflats made of reused sediments: 18.000.000 m ³ , in 109 units, covering a surface area of 11,5 km ²	

Table 1: Sediment quantities used for hydro-morphological recuperation and beach protection.

Over and above their aesthetic, landscape and natural value, not to mention their precious habitats, biotypes and species that are protected by European directives - like its wetland avifauna, ichthyofauna, entomofauna and rare species of halophylic vegetation - the salt marshes and mudflats ensure hydro-morphological stability; in fact they limit the formation and propagation of waves across the bottoms, guiding the flow along the canals, and above all, within certain limits, they are able to adapt to the rising of the average sea level or the energy of the waves in virtue of the of vegetation and benthic species that provide bio-stabilization and regulate the size of the surface area around the normal high tides. In recent years through various studies, experiments and especially surveys and monitoring, the knowledge necessary to manage the naturalization of sedimentary deposits has been selected in order to improve the evolution of newly formed habitats into highly complex hydro-morphological and biological assets. The de-

velopment of the method regarded:

- the updating of the most suitable techniques in forming initial mudflat and salt marsh deposits;
- the materials and structures which would have the least impact in order to protect their borders;
- the way in which salt marsh areas are refilled, devices to reduce the generation and propagation of waves and to contain the erosive effects of fishing and navigation (Figure 4).

Results

The principal hydro-morphological and environmental functions carried out by the 100 morphological structures realized between 1986 and 2007 were evaluated: monitoring highlighted that, in general, the progressive evolution from a sedimentary deposit to a tidal habitat takes 5-10 years, over 5 different stages to build up a hydro-morphological network, vegetation structure and a number of nesting species (Figure 5 and 6).



Figure 4: examples of salt marsh and mudflat border protection through experimentation with sedimentation screens, surface beach nourishment, vivification canals and vegetation transplants.

Vegetation structure

The salt marshes are sites of community interest to be protected by European law. In most cases, the artificial structures evolve, becoming salt marsh habitats and hence, sites of community interest. In December 2007, through the monitoring of these artificial salt marshes, it appeared that they had a density of precious habitats similar to that of natural salt marshes: in fact, with natural salt marshes, the extension of habitats with species of community interest make up 60% of the total surface area (24 km² of 40 km²) and with artificial salt marshes 42% (2.7 km² of 6.3 km² surveyed). When the structures reach the advanced stage, the development of the vegetation species is accompanied by a peculiar process in which the structures adapt to the average sea level in order to capture sediment and organic materials in exactly the same way as the natural salt marshes' typical self-conservation process.

Nesting avifauna

Over the course of their evolution, the artificial salt marshes serve as ideal stop off, feeding and nesting areas for diverse species of wetland birds: particularly valuable species like the Shelduck, Oystercatcher, Black Winged Stilt, Avocet, Kentish Plover, Redshank, Herring Gull and Little Tern nest in the Venice lagoon's artificial salt marshes in such large quantities of couples that they contribute significantly to the national total. While in the natural salt marshes 4-6 species, which are particularly interesting from a nature point of view, nest in an area of some km²: the Redshank, Mallard, Fan-tailed Warbler, Black Winged Stilt as well as the Kentish plover and Little tern, the introduction of artificial salt marshes has revealed another 3 species: the Wood-

cock, Shelduck and Little Ringed Plover, thereby substantially increasing this specific richness (Figure 5 and 6).

In both the natural and artificial salt marshes, but above all in the artificial ones, there is a notable density of Redshank, a particularly important species, with as many as 40-couples/ km².

Final conclusions and future developments

The interventions carried out up to this point, using 18 million m³ of sediment, have guaranteed the quantitative and functional conservation of the salt marsh habitats of the Venice Lagoon. The reconstructed salt marsh habitats show vegetation structures that in 60% of the cases have an adequate naturalness level for their age, while in 27% of the cases small corrective interventions are required, and only in 13% of the cases, the increasing or reducing of sediment volume is required in order to counteract excessive or insufficient sediment levels (Figure 7). In the future, in order to contain the erosive processes of the lagoon bottoms owed to the waves' and cross currents' excess energy, it will be necessary to devise new landscape structures that permit the realization of adequate interception and channeling structures on mudflats or raised areas of the lagoon bottoms. The effectiveness of the interventions depends on the surpassing of the formal constraints of "where it was, how it was" in favor of "function conservation", it is along these lines that, in the area of *Canale dei Petroli in Fusina* and *Canale dei Marini*, north of Venice, two important interventions using sandy sediments originating from the diggings carried out in order to construct the mobile barriers at the port mouths, are already underway.

¹ According to EEC directive 92/43 regarding the conservation of natural and seminatural habitats and wild fauna and flora: *Salicornietum venetae* (*Salicornia* is not a priority natural habitat cod.1310), *Puccinellio festuciformis-Sarcocornietum fruticosae* (*Sarcocornia* is not a priority natural habitat cod.1420), *Spartina* swards (*Spartinion maritimae* are not priority natural habitats cod.1320); Mediterranean salt steppes (*Limnethalia* are not priority natural habitats cod. 510).

² In particular, the nesting of 13 aquatic bird species, of which 5 are of community interest (marked with the symbol *), was revealed: Shelduck, Mallard, Shoveler, Northern Lapwing, Oystercatcher, Black Winged Stilt*, Avocet*, Little Ringed Plover, Kentish Plover*, Redshank, Herring Gull, Common Tern*, Little Tern*.



Figure 5: the realization of artificial morphological structures. STAGE 0: mixtures of sediment and water flowing into the delimitations. Even in this first phase these areas are suitable feeding and nesting sites for avifauna.



Figure 6: STAGE 1 from 2 months to 1 year after realization (left) and STAGE 5 more than 10 years after realization (right).

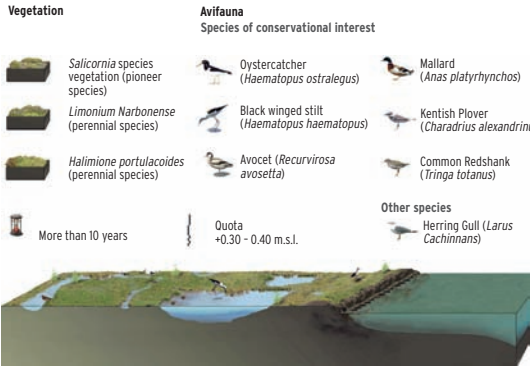
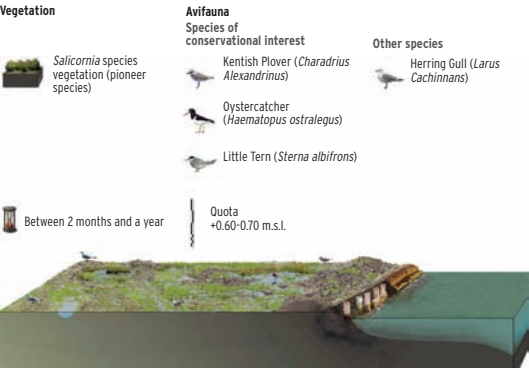


Figure 7: the diversity of vegetation that progressively begins to populate the salt marshes provides ideal nesting habitats for many avifauna species.

**_ACTS OF THE CONFERENCE
THE SACCA DI GORO**

SILVANO BENCIVELLI
Province of Ferrara
Coastal Waters and Ichthyic Economy

The *Sacca di Goro* is the southernmost lagoon of the Po delta and is strongly influenced by nutrients contributed by the Po Basin. It is a highly productive environment and for this reason, there has been a substantial development of shellfish, but at the same time it is an environmental high-risk area due to the systematic proliferation of macro algae, often resulting in dystrophic crisis. Its rehabilitation focuses mainly on monitoring the inflow and increased exchange of fresh water with the sea. The system relies on a network of sub-lagoon canals and different hydraulic structures principally consisting of floodgates that control the flow of water that consume very little energy and incur very little economic cost.

The *Sacca di Goro* is a classic example of a coastal lagoon that is strongly conditioned by the inflow of fresh water. In the western part, it receives the *Po di Volano* and the *Canal Bianco*, shown by the light blue arrows in the image (Figure 1), tributaries of the northernmost part of the territory of the Province of

Ferrara. The connecting basin is about 650km², with 70,000 inhabitants and is characterized by intense agricultural development. In the east the Sacca is connected to the *Po Di Goro* by hydraulic systems that allow for the quantity of water flowing into the Sacca to be controlled, also indicated by light blue arrows. Furthermore, some of the inflowing water from the *Po di Goro* passes through a basin of about 80ha that has a phytopurification effect, even if it has diminished somewhat in recent years due to reclamation interventions along the embankments.

The *Sacca* is connected to the sea by two mouths opening along the lines of sandbars separating the *Sacca* from the open sea, shown above by the dark blue arrows. This is an extremely fragile territory, subject to subsidence on one side, and the interaction of marine and fluvial dynamics on the other. Due to its shallow bottoms (1,5m on average), the water quality inside the Sacca is guaranteed by a network of sub-lagoon canals that transport water exchanged with the

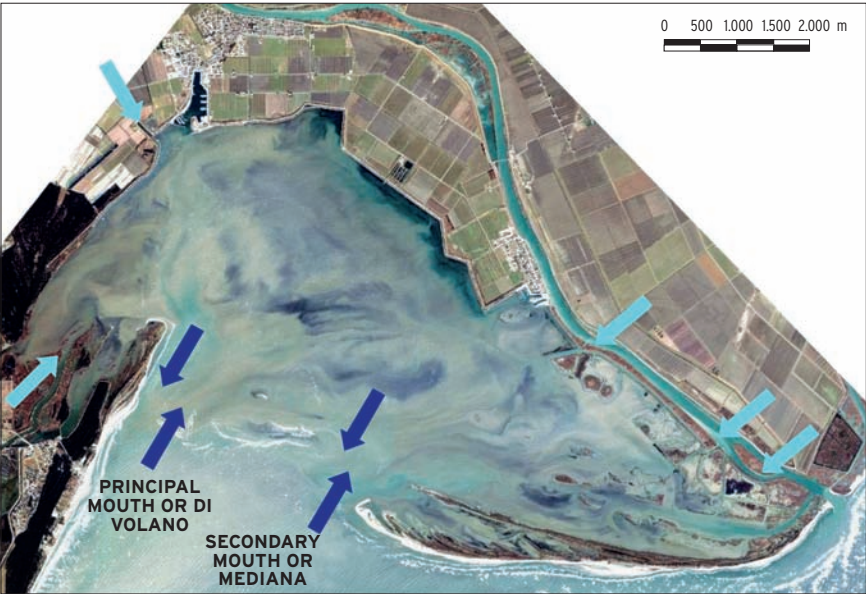


Figure 1: analysis of a Quickbird satellite image of the *Sacca*, taken on 23 January 2006.

sea through the two connecting mouths (Figure 2).

Like all lagoons, the *Sacca* is an environment for the transition of internal (fresh) and external (sea) water and is in a constant state of morphological evolution. Over the last few years in particular, there has been a continuous and worrying westward growth of the sandbar, to the detriment of the secondary mouth opening which has progressively been reduced in size and constricted, as a result of the stress caused by this growth process, into a westward rotation also causing the deepest section of the tidal canal to move towards the sea. Furthermore, the excess of sedimentation at the terminal part of the sandbar caused problems with the island barrier system situated on the other side of the mouth in that, in this particular area there were no longer deposits and due to subsidence and erosion produced by the waves, the area underwent continuous lowering.

Currently, the secondary mouth could be considered the beating heart of the lagoon's circulatory system in that it is from here that the three canals distribute water to the northern part, northeastern part towards *Gorino* and eastern part towards *Faro*. It is this last canal, realized by the Region in 1999, that connects the secondary mouth to the most internal area of the *Sacca*, and is then connected to the outlet of the *Po di Goro* by means of an automatic flood-gate (*porte vinciane*) to control water levels, allowing only unidirectional outflow from the lagoon thus enabling the vivification and protection of the entire eastern part of the lagoon. The natural evolution of the closure of the *Sacca* to the sea causes a progressive lengthening of the sandbar, which in time results

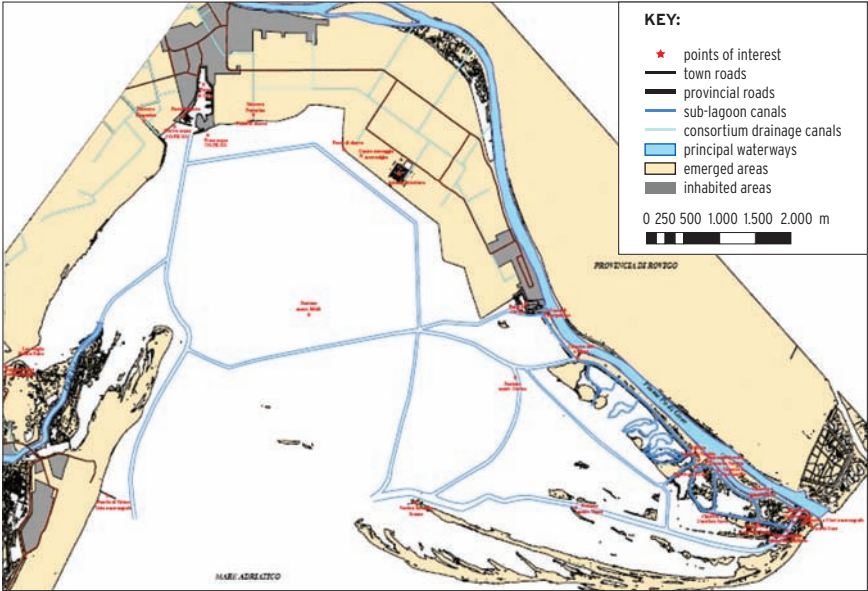


Figure 2: general map of the *Sacca di Goro*.

in a growing reduction in the hydraulic exchange of internal and external water. This evolutionary process not only causes a reduction in water exchange, but also a reduction in hydrodynamic circulation of the tidal currents inside the *Sacca* resulting in the consequent reduction in hydrodynamic mixing capacity and therefore, the transport capacity and dispersion and convection of dissolved substances or substances carried in the water.

The lack of movement in the water gives life, in warmer periods, to the proliferation of the algae population, having a notable negative effect on the hydraulic environment of the lagoon and causing a marked reduction in shellfish production, the primary economic source of the area and obviously, causing enormous environmental damage to an area which is not only included in the Parco del delta del Po, but is also considered to be a SCI (Site of Community Interest) and SPA (Special Protection

Area). In order to counteract the effects of morpho-dynamic evolution, different interventions have already been carried out in order to improve the hydraulic exchange of the internal and external environments, essentially consisting of the dredging of the lagoon canals capable of more dynamically channeling seawater into the *Sacca*, and the re-dredging of the tidal canals near the mouths. In this context, the mouths connecting to the sea and the sub-lagoon canals should guarantee a continuous exchange of water of different salinity levels and a better diffusion of this water inside the lagoon, in this way vivifying the environment and guaranteeing a balanced ecosystem.

The mouths and their canals are both "sediment traps" in that on the completely flat lagoon bottom, they represent depressions towards which that which is brought by tidal currents and waves caused by passing boats, tends to be deposited. Accordingly, this phe-

nomenon has to be periodically counter-acted by the removal of that which has been deposited: it is only in this way that the canal and mouths can maintain their efficiency.

The primary difficulty in the management of the *Sacca's* internal water is in identifying the correct amount of water exchanged between the lagoon and the sea, so that exchange is so limited that it compromises the quality of the internal water, while on the other hand not so consistent that it upsets the correct balance between temperature, salinity, dissolved oxygen and stratification of internal water that determines the elevated productivity of the *Sacca*.

The interventions carried out in the *Sacca* in recent years were aimed at re-establishing the correct circulation of water in the area facing the *Po di Goro*, restoring the hydraulic systems and phytopurification basin to full working order and improving hydraulic circulation in the central part of the lagoon with a connecting canal to the secondary mouth. The tidal canal of the secondary mouth and sub-lagoon canal

connecting the secondary canal to the unidirectional system at the back of the *Faro di Goro* was resectioned. Furthermore, a wave set-up at the summit of the embankment between the *Dorino* basin and the *Lanterna Vecchia* was realized in order to once again block the overflow of water from the *Po di Goro* at times when it is particularly full.

All in all, over the last five years the Province of Ferrara has resynthesized about 25 km of the sub-lagoon canal network removing 500,000 mc of sediment through regional (*Protezione Civile*) and state (*CIPE* funds) financing amounting to a total of almost Euro 3,000,000.

The material resulting from the various interventions has always been used internally in the lagoon based on its granulometric size. In particular that which is predominantly clayey or lime clayey, is used for reconstructing salt marshes raising the bottoms in order to promote the re-growth of reeds, or if it is sandy or limey sandy, for the nourishment of the bottoms of the shell fishing concessions in order to augment productivity. In both cases the results

have always been satisfactory. An important parameter in evaluating the effectiveness of interventions carried out is certainly shellfish productivity, which is of particular importance to the local economy. In 1985 the Philippine clam was introduced to the *Sacca di Goro*, an ideal environment for growth and above all, reproduction after the first phase of acclimatization, which was accompanied and followed by the previously mentioned massive environmental reconditioning interventions.

The following diagram (Table 1) is of particular importance in that it clearly shows how, after the completion of the most important environmental reconditioning work between 1999 and 2001, namely the removal of the point of the sandbar towards the west and the re-digging of the canal behind the sandbar towards the east and activation of the unidirectional system, there was a definite increase in the quantity of clams produced, in fact double that of the preceding period.

Evidently, for 2009 an estimate has been made based on the data available

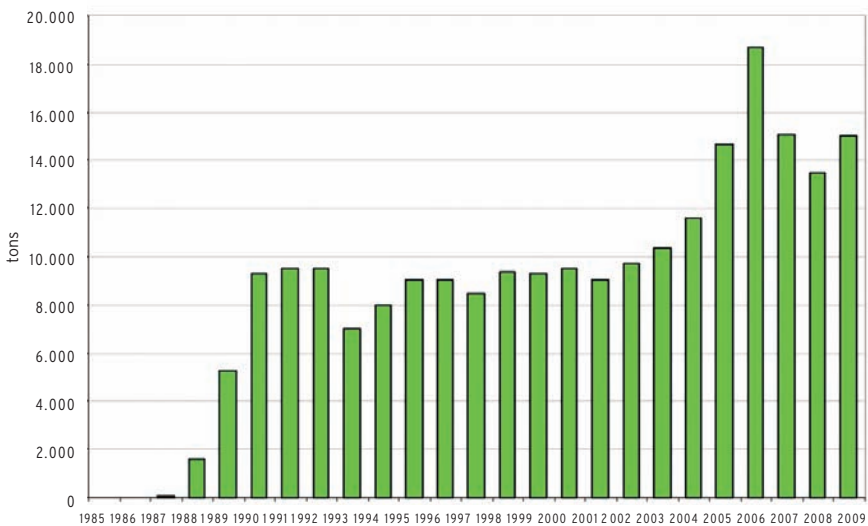
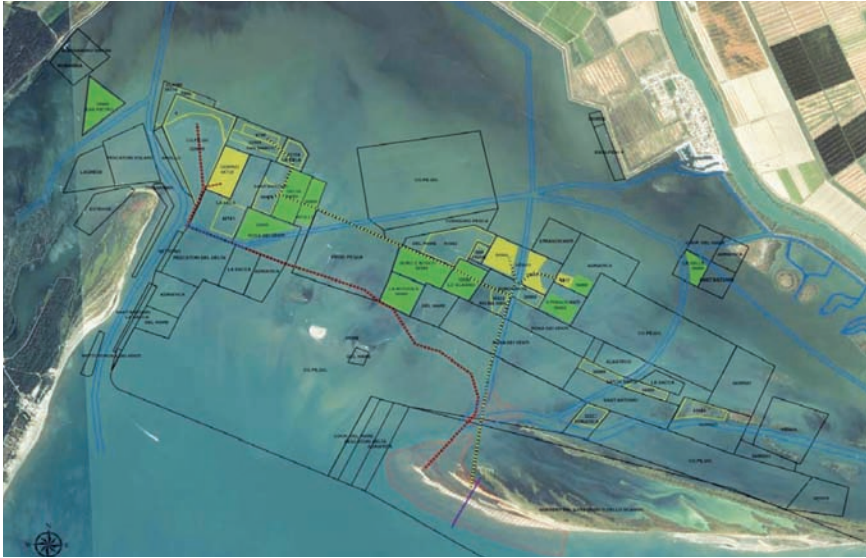


Table 1: clam production in the *Sacca di Goro* (source: E. Turolla).



KEY:

- digging area
- pipelines
- state-owned concessions

Figure 3: the project for the reconditioning of hydraulic circulation.

to date. In recent years production has been certified as being around 15,000 tons per annum making the *Sacca di Goro* one of the principal producers of clams in Europe, certainly the leader if one takes its size into consideration. The environmental improvement is also largely evident in the water quality controls that are continuously carried out. In 1988, the Province set up an automatic water-quality monitoring network, which having been implemented over the years, has resulted in its current configuration of four fixed stations with multi-parametric probes, and two stations with currentmeters and two mareographs.

Moreover, it is to be pointed out how closely shellfish production is linked to environmental quality, and how they both share the same purpose. Further to the environmental characteristics and the works carried out, the management bodies' and producers' capacity to come up with a shared plan for the management of the lagoon has been decisive, and was made concrete in a protocol agreement established between the Emilia Romagna Region, the Province of

Ferrara, the *Comune di Goro* and the Associations representing the fishermen, agreeing to establish the *Comitato di Coordinamento* in order to draw up a set of management rules and identify the Province as the point of reference for activities in the lagoon. It is to be pointed out that it is the only lagoon that is part of the maritime domain in the Po delta. As previously stated, the *Sacca di Goro*, like all lagoons, is an environment in continuous morphological evolution, and this is the motive for the continual carrying out of interventions.

The westward growth of the sandbar has progressively reduced the section of the secondary mouth and in 2007 caused an opening of about 200 m, and due to the thrust produced by the point of the sandbar, turned the tidal canal in a clockwise direction from its original orthogonal position, to a more inclined position. The eventual closure of the secondary mouth would have resulted in grave consequences for the environmental quality of the internal area and its economic activities. By means of a mathematic model representing the lagoon's hydraulic circulation, the Prov-

ince simulated three possible scenarios: 1) the complete closure of the secondary mouth caused by the growth of the sandbar; 2) the situation as it stands; 3) the situation after the possible realization of a project to re-open the mouth. The results obtained show that the eventual closure of the secondary mouth would have grave consequences for the entire lagoon's hydraulic circulation, dramatically increasing the speed of the incoming currents from the principal mouth (which does not allow clam cultivation in the area and that could trigger probable erosive phenomena) and slowing it down in internal areas with high risks for the quality of the internal water, incompatible with shellfish production.

There was a strong feeling of imminent danger to the environment and the production activities associated with the probable rapid closure of the secondary mouth. Faced with the impossibility of gathering adequate public finance in order to carry out a substantial intervention, which would buy at least 3-4 years of time, the Province turned to the *Sacca di Goro*s' shell fishermen pointing out that the hypothesized closure of

the sandbar would not only cause enormous environmental damage, but would also have strong repercussions on the productive capacity of the lagoon, essentially asking the fishermen's cooperatives to finance a substantial project aimed at reconditioning hydraulic circulation (Figure 3).

Support for the project was strong (including 24 cooperatives representing 90% of the fishermen working in the lagoon) allowing the Province to plan a substantial intervention, totaling € 7,500,000 for the removal of about 1.200,000 cubic meters of sand in order to improve the bottoms within the land grants. We are therefore dealing with a project that is relevant from an economic point of view, complex in terms of the environmental value and the fragility of the area and that represents a historic turn around in the continuous carrying out of exclusively public interventions in order to protect the lagoon over the last 20 years. Whilst drawing up the project, the numerous issues regarding the intervention area and connecting areas were taken into consideration:

- defense of sea storm territories;
- availability of materials for replenishment of beaches;
- maintenance of the ecological balance and biodiversity safeguard;
- the presence of avifauna of European interest;
- the economic importance of shell fishing to the *Goro* and *Gorino* communities;

The project is compromise between the different needs of the area and could therefore be seen as a concrete application of the guidelines for Integrated Coastal Zone Management, as approved by the Emilia Romagna Region and acknowledged by the Province of

Ferrara. The work is currently undergoing completion and the first indications seem to be particularly positive: water circulation has increased, many cooperatives have already been able to start cultivating in replenished areas and the lagoons overall production seems to be higher than last year.

As already mentioned, the *Sacca di Goro* owes its heightened productivity to the deposits of nutrients brought by fresh water and the Po Basin. This situation generally leads to a hypertrophic situation if the exchange with the sea is reduced and the circulation of water inside the lagoon is limited due to the silting of sub-lagoon canals. The most evident characteristic of these situations of degrade is the enormous development of macro-algae largely consisting of *Ulva*. While the algae is alive they do not pose any particular problems, in fact there is a high amount of oxygen in the water due to the notable photosynthetic production, and the presence of the biomass constitutes the beginnings of a rich trophic chain.

However, the over-population of *Ulva* leads to rapid degradation due to shading, the complete segregation of nutrients and very often, increased temperature. The high level of consumption of oxygen required for the degradation of thousands of tons of biomass results in an anoxic crisis and the production of substances that are toxic to many of the living creatures in the lagoon. In the past and to a lesser extent more recently, we have assisted many times in situations of enormous damage to the environment and likewise with economic damage due to disease in large quantities of clams. Obviously, these situations are prevented where possible by structural and management interventions, but



Figure 4: the mechanical gathering of macro-algae.

faced with such a situation; the only defense is the mechanical gathering of as much macro-algae as possible. In this way, the decomposing of the biomass in the water is avoided as is the possible damage caused by dystrophic crisis. The carrying out of this activity since 1990 has resulted in consolidated experience, honed over many years of gathering, especially over the last few years with the participation of the fishermen (Figure 4).

Different cooperatives have equipped themselves with gathering machines that deposit the gathered material, along with that which is gathered manually with the help of fishing boats, in large baskets measuring 5 by 10 meters or more, specifically constructed for and positioned in the lagoon. A watercraft belonging to a company appointed by the Province periodically oversees the emptying of the baskets and the transportation of the biomass to land via an opportunely equipped storage centre. After a stabilization period of over one year, the biomasses are reused in the farming of newly claimed land in the areas immediately adjacent to the Sacca. In the past, positive results have also been achieved in the drying of *Ulva* and its application in paper production. In the coming months, depending on the EU's concession of the requested finance, an experimental project for the production of biogas will be initiated.

Conclusions

Today, the *Sacca di Goro* is an environment that is in good environmental condition thanks to the numerous interventions carried out over the years. It is a well known fact that it is part of a precarious balance, destined to rapidly modify itself in context to the charac-

teristic morphological evolution of lagoons, which for the *Sacca di Goro* is particularly speeded up by a costal dynamic characterized by a high rate of sediment transport. Therefore, ulterior financed interventions are to be scheduled, aimed at maintaining the functionality of the sub-lagoon canals and the mouths connecting to the sea. The way ahead is to avoid inflexible interventions that provide only temporary results and often have grave negative effects. There is a need to go along with the natural evolution.

The *Sacca di Goro* plays an important economic role related to shell fishing activities, employing about 1300 fishermen and more than 300 people. It is an economic activity that is compatible with the environmental and natural characteristics of the area. The impact on the environment of an industrial activity capable of providing employment for 1300 people would be far greater. Although one should not forget that shell fishing activities do have an effect on the environment linked to the contemporaneous presence of millions of animals in restricted spaces and their metabolism, therefore: one should not surpass the limits of environmental sustainability. In the *Sacca di Goro* there is currently data permitting the fishing of about 1300 hectares: a limit not to be surpassed.

The *Sacca di Goro* is an area of multiple aspects: together with a high environmental value, it is also highly important economically. It's a case of pervading diffused interests, typically those of the public with the private sector, who earn an income from fishing. The fishermen, in modern terms, are stakeholders, interest holders in this environment. They consequently have an

interest in decisions relating to the management and new interventions planned for the lagoon. The signing of an agreement protocol between the Region, the Province, the Municipality, the Associations representing the fishermen and the resulting coordination committee proved to be the decisive element in the sharing of actions carried out in recent years. Many shell fishermen, in particular the older ones, had moved from fishing in the sea, where their income was steadily becoming more ephemeral, to the lagoon, attracted by higher and more steady earnings. This situation continued until last year, when falling clam prices rendered this situation less truthful. The shell fishermen have nonetheless maintained the spirit of the fisherman in fishing as much as possible today, because tomorrow one doesn't know if it will be even possible to set sail, and even then, the yield might not be of any significant quantity.

Aquaculture is very similar to agriculture in that there is not only the need to sow, but also the need to look after the produce. In fact, it is necessary to detect clam sperm in the areas where it is naturally deposited, take it to the concession, clear any macro-algae from the concession and periodically verify clam development until the required levels are reached, it is only then that the harvesting cycle can be concluded.

Working in order to give the fish farmers the sense of being entrepreneurs is fundamental and could be initiated by the public bodies by involving them in the management of the environment in which they work.

_ACTS OF THE CONFERENCE LESINA LAGOON

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TOMMASO SCIROCCO
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CNR - ISMAR (Lesina - Foggia)

An account is given of the man-made alterations in the ecology of Lesina, a large (5328 ha) shallow lagoon on the south Adriatic coast of Italy, alterations motivated by the necessities of fish production, reclaiming land for agriculture, and eliminating malarial marshland. Up to 1851 the ecosystem was ruled by entirely natural forces. In that year an artificial outlet to the sea was dug in addition to the existing natural one. In 1903 a second artificial sea channel was opened.

By the 1950s all the surrounding fresh-water fens (ca 1500 ha) had been drained and a dike built around the perimeter of the basin. Underwater trenches in the lagoon have been dug to facilitate water circulation. Pollution has become evident in the last fifty years. Three years ago a small harbour for sea-going fishing vessels was constructed at the entrance of one of the sea channels.

Introduction

Lesina Lagoon lies on the south Adriatic coast of Italy (Figure 1). It has an oblong shape, extending parallel to the coast for 22.4 km, with a width varying between 3.8 and 1.4 km. The mean depth of the waters is 0.7 m with a maximum of 1.15 m. The waters are brackish showing a permanent gradient from east to west. In the eastern part, where freshwater flows

in, values always stay lower than that of the sea (36 ‰ S), whereas in the western part salinity often exceeds marine values in summertime when evaporation is high.

When the lagoon is at mean sea level its surface area is 5328 ha but, before being diked in the 1950s (Figure 2), it used to expand an extra 1500 ha (a total of 6673 ha under water) during the rainy season in autumn and winter. Two artificial canals (*Acquarotta*, *Schiapparo*) connect the lagoon with the sea.

These channels were dug in 1903 and 1853 respectively; before that there was one main channel, *S. Andrea*, and several minor ones (*Acquarotta*, *Zappino*, *S. Maria*, *S. Placido*, *Caùto*, *Morella*, *Gravaglione*, *S. Focato*) which, however, were simple ditches dug by hand across the sand spit to the sea as the season required.

The mean annual rainfall in the area is 455 cm and the evaporation rate from the water surface is 10 mm in summer, 6 mm in spring and autumn, and 2 mm in winter. Its catchment basin extends to 604 km², more than ten times the water basin. At the eastern extremity three large karst springs of freshwater (*S. Nazario*, *Lauro*, *Fiume Longo*), flowing from the foot of the *Gargano* massif about 2 km

Figure 1: satellite image of Lesina Lagoon. The white sulfurous patches in the west attest to the recent dystrophic crisis. At the eastern end one can see the green patches of reeds.



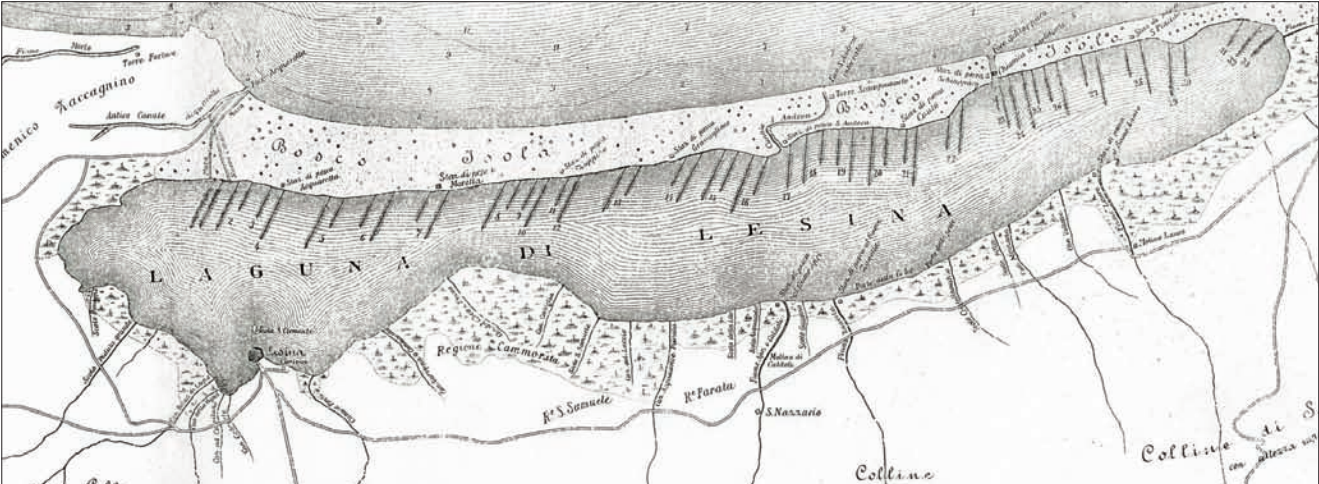


Figure 2: Lesina Lagoon in the early 1900s, before the reclamations. Note the flood marshes in the east, south and west. “Paranze”, trawlers for winter eel fishing, depart from the northern bank. The S. Andrea mouth has been silted up, substituted by the Acquarotta and Schiapparo channels.

away, contribute ca 2000 l/sec. Before the reclamation works of the first half of the 20th century, these springs conferred a freshwater character to the eastern fens. Within the catchment basin are the towns of San Nicandro, Poggio Imperiale, and Lesina with a total of 30,000 inhabitants. The wastewater treatment plants of these towns contribute 60 l/sec of freshwater to the lagoon (Breber 1999).

The Fishery

Since remote times Mediterranean lagoons have attracted men for reason of their rich fish catch. A good lagoon can yearly yield 100 kg/ha and more of commercial fish. The catch is usually composed of eel (*Anguilla anguilla*), seabass (*Dicentrarchus labrax*), gilthead seabream (*Sparus aurata*), grey mullet (*Mugil cephalus*, *Liza aurata*, *Liza saliens*, *Liza ramada*, *Chelon labrosus*), and silverside (*Atherina boyeri*), but the list can be quite longer, including molluscs and crustaceans, in the case of a particular lagoon.

The critical aspect of a lagoon fishery is that nearly all of the commercial species spend only part of their life cycle in lagoons. These bodies of water provide

rich feeding grounds but are not suitable for reproduction, so in order to breed the fish are obliged to return to the sea. Fish like to enter lagoons especially at the end of winter as newborn fry, whereas for the sexually mature the urge to migrate back to the sea comes in autumn at the onset of the breeding season. The years between the stage of fry and that of sexual maturity may be spent in the lagoon.

The connection between lagoon and sea is obviously of strategic importance for the stocking of a lagoon. In winter the sea-mouths are kept closed in order to raise the level of the lagoons during the winter rains. Then in March the water-gates are opened so that the out-going current of brackish water may lure the swarms of newborn fry to swim in to stock the lagoon. In May at the end of the spring fry migration the watergates are closed. During the summer the water level of the lagoon decreases because of evaporation so that when the sea-mouth is opened again in October this time there is an incoming current from the sea. Feeling the call of the seawater, the sexually mature fish in the lagoon become restless, rush for the channel and thus are caught in the nets waiting for them (Bullo 1902).

Problems Before 1811

Before the elimination of the feudal system of land tenure in 1811, the fishing rights in Lesina lagoon were shared in common by the lord and by the local citizens. The townsfolk of Lesina could fish for home consumption or for sale within the community, while the right to export the produce abroad belonged exclusively to the holder of the fief. There was much poaching, of course, on the part of the locals running their own underhand business with outsiders, which recurrently lead to open clashes with the lord's agents. There were also disturbances coming from outside.

A quarrel broke out in 1539 when men from the neighbouring town of *S. Nicandro* were caught placing nets in the lagoon. According to the law *De Salario Eorum* by king Ferdinand I (1482-83), the common right to fishing belonged to those inhabitants whose territory bordered on the body of water concerned (Colozzi 1932). The border between Lesina and *S. Nicandro* is the public road which links Lesina to the towns of Rodi and Vico to the east (Figure 2). Before the lagoon was diked in the 1950s, this road also coincided with the high-water limit during the season of flood. However, during the period of low water the edge of the lagoon would recede at least 1,100 m from the road leaving bare 1,581 ha of marshy land.

The lesinesi considered this summer condition as valid for establishing the lagoon boundary when the road was far away from the water's edge while the sannicandresi upheld their fishing rights on the basis of the winter condition when their territory did, in fact, border with the water. The lesinesi of course could not resign themselves to this aggressive policy of their neighbour and so legal actions

and violent clashes went on through the centuries. Up to this time the problems that affected Lesina lagoon were purely of social and economic nature, and the ecosystem was still largely unaffected although. Heavy tampering with natural forces came as a consequence of the abolition of the feudal system in 1810 (Colozzi 1932).

Problems After 1811

The abolition of the feudal system brought by the Napoleonic period meant a radical change in land tenure. In the case of Lesina this meant that the rights of the lord and of the local citizens could no longer be exercised promiscuously. The Royal Commissary on the 8th June 1811 proceeded to split the lagoon between the former lord and the townsfolk. The eastern two thirds of the lagoon became the private property of the one-time feudal holder and the western one third was given to the citizens for their own fishing (Figure 3).

The prohibition for the locals to sell fish outside their township was lifted so that they now too, if they wanted, could go abroad to trade. The Commissary gave permission to the lesinesi for digging a new sea channel to serve their own part of the lagoon but this project would be put into effect many years later. At this point the owner of the two thirds made a deft and rather high-handed move. In 1823 he obtained from the mayor of Lesina the perpetual lease (emphyteusis) over the one third of the lagoon belonging to the township. In this way the lesinesi lost all vestige of the right to fish. The contract did recognise, however, the other common rights of less consequence such as the snaring of coot, the gathering of dry wood on the spit separating the lagoon from the sea, and the gathering of

reeds and rushes in the marsh. This deal gave the private owner the possibility of finally exploiting the rich eel fishery all for himself while the township received a rent which would, on the face of it, ease the tax load on the citizens.

The owners who had held the lagoon as a fief from 1753 to 1810, and then as private property from 1810 onwards, put it up for sale in 1836. But now the spirit of the times had changed and the new owners found that the locals were not so docile as heretofore and not at all reconciled with how the situation had evolved. The new attitude of the populace was heralded by the illicit opening in 1851 of a new sea channel (*Schiappare*) at the eastern end of the lagoon (Figure 2). This was almost certainly done by the sannicandresi (Rosano *et al.* 1903).

The town council of Lesina now began a long war and by means of captious legal means started to sabotage the management of the fishery in order to demoral-

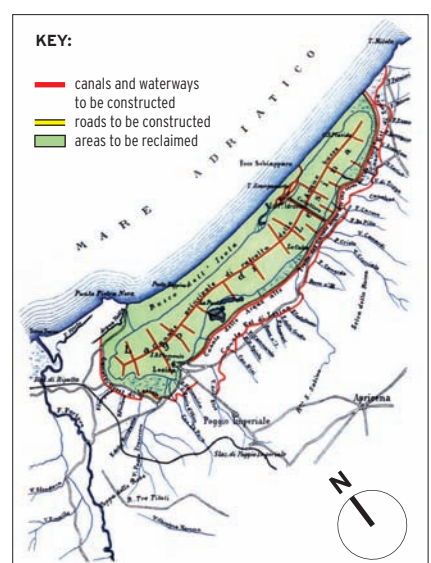
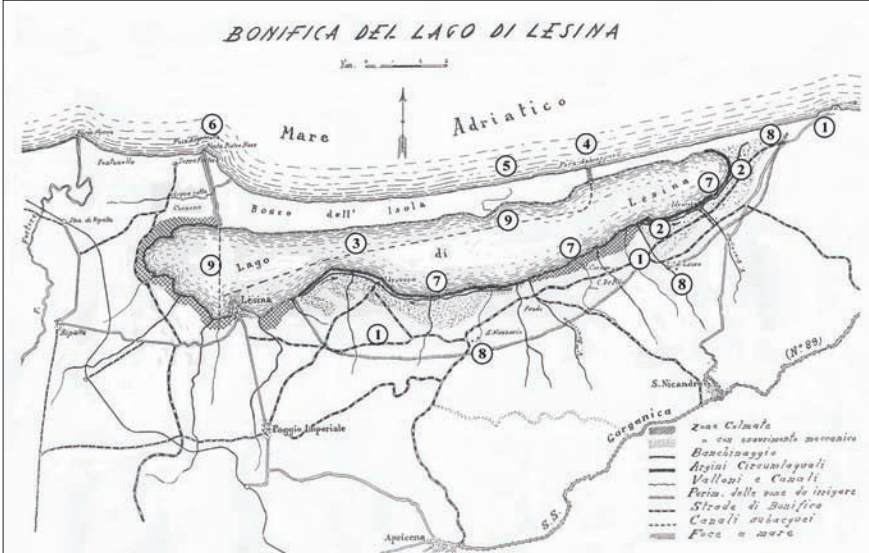


Figure 3: the draining of the Lesina Lagoon (Camera dei Deputati 1915) was supported by its owners in order to resolve their dispute with the Lesina town council.

ise the owners and, in the long run, make them relinquish their rights. The legal device used by the mayor was the following: conceded that the lagoon was undisputed private property, the one or more channels which linked it to the sea were, however, classified as public waters and thus did not come under the authority of the owners.

The mayor of Lesina now declared that on the grounds of public health these outlets to the sea should be kept permanently open. The incidence of malaria was very heavy locally and the exhalations of the marshes were in those days thought to be the cause. By keeping the outlets to the sea open and the level of the lagoon as low as possible, the fringing marshes would not flood and thus less prone to form gases from the decomposing vegetation. For the owners this was a dirty trick. As explained at the beginning, the opening and closing of these channels during definite periods of the year is fundamental in managing and sustaining the fishery. The owners, therefore, refused to comply but the mayor did not relent and in 1873 convinced the Ministry of the Interior to order the opening of *Schiappare* channel (Figure 2). The mayor managed for several years to have his way, letting the fish escape to the sea in winter, hindering the ascent of fry in spring, and so causing heavy losses to the owners.

The owners in the meantime managed to bring the Ministry round to their point of view and in 1882 obtained a new decree which permitted the closing of *Schiappare* channel in winter in order to raise the water 0.9 m above mean sea level. *Schiappare* channel had by now superseded the ancient channel of *S. Andrea* which was allowed to silt up (see Map). The mayor retaliated and, on his own authority, ordered the floodgates to be left open and



KEY:

1. Lesina-Rodi Road	7. Dikes
2. Eastern wetlands	8. S. Nazario Springs and Longo River (left to right)
3. 1811 division	9. Sub-alluvial canal.
4. Schiappare Channel	
5. S. Andrea Channel	
6. Acquarotta Channel	

Figure 4: the reclamation of the Lesina ecosystem (Colacicco, 1955).

seals put on them, he also prohibited the placing of fish weirs in the channel as these too were considered an obstacle to the discharge of water, and he even went so far as to forbid the fishing for eels in the lagoon with dragnets since this practice, by tearing up the bottom vegetation and thus making it die and rot, was the indirect cause of the smells which were then thought to be the origin of malaria.

In 1902 the central government, tired of this quarrel, appointed a committee of experts to investigate the whole business and to possibly come up with a definitive solution. The resulting reports (Bullo 1902; Nazzani 1904) showed some sympathy for the owners' point of view and did make clear to the central authority the necessity of raising the level of the lagoon during winter. It is in these very years the discovery was made that it was not the marsh gases (methane, H₂S), as heretofore universally believed, the cause of malaria but the protozoan *Plasmodium*

transmitted by the females of the *Anopheles* mosquito. The idea that the draining of marshes would solve the problem lost nearly all of its original motive since any puddle, the same drainage ditches of the reclamation works were quite sufficient for spreading the agent. In 1905 a yet another decree from the Ministry of the Interior swung the situation back in favour of the mayor of Lesina. The increase in level of the lagoon during the autumn and winter months was reduced from 0.9 to 0.3 m, the fish weirs in Schiappare channel could stay but the prohibition of fishing for eels with dragnets was left.

The owners of Lesina lagoon, who had by now become very discouraged of their chance of ever seriously controlling the fishery and were also aware that the government was about to declare the lagoon public waters, changed their strategy completely and started to promote the draining and reclamation of the entire complex (Figure 3). By turning the lagoon

into fields this would certainly settle the matter once and for all: the area would remain private property, there would be no more poaching of fish, no more common rights to respect, and all the legal grounds of the town council for heckling with the excuse of public health would vanish forever. But such a drastic project was destined not to be.

In 1903 the *Acquarotta* channel at the western end was finally accomplished nearly a hundred years after it had been originally proposed. Initially, the artificial channel was led up to an abandoned branch of the *Fortore* river which was supposed to serve as the sea outlet (Fig. 2). This solution immediately proved inadequate so that the artificial channel was subsequently prolonged northwards, opening into the sea at the rocky spur called "*Pietre Nere*" where it has since then functioned efficiently (Colacicco, 1955) (Figure 4).

In 1924 the lawcourt of Bari passed a judicial determination recognising the common right of the townsfolk of *S. Nicandro* to fish in the lagoon (Colozzi 1931). This was considered preposterous by the lesinesi. They, who had lived off the lagoon for centuries and identified with it, were now the only party excluded from this resource: the owners had their commercial fishing rights, the sannicandresi had had their common right to fish finally accepted, while the emphyteusis contract of 1823 with which the lesinesi had forfeited their right to one third of the lagoon was still considered valid.

In 1925 the mayor of Lesina tried another move. He declared that, according to his reckoning, the owners had not paid the full amount of the dues for the emphyteusis for the last three years and for this reason, according to the terms of



Figure 5: the Eastern Sacca. The modifying of freshwater emissions resulted in about 500ha at the eastern end of the basin being invaded by reeds.



Figure 6: view of the southern bank. The dike upon which the road runs was initially part of reclamation works carried out to prevent flooding of the bordering land.

the contract, the third part of the lagoon should now revert back ipso facto to the township of Lesina. But all this manoeuvring on the part of the various parties was preempted by the government who in the meantime had been drawing up a comprehensive plan intended to solve all aspects of this business. To begin with, the waters of Lesina lagoon were definitely decreed to be public (1934), without possibility of reclaim, so that the question of the emphyteusis contract of 1823 between the township of Lesina and the owners was once and for all settled. The onetime owners were furthermore "asked" to cede 60% of their commercial fishing rights to the communities of Lesina (30%) and of *S. Nicandro* (30%).

The conflict arising from the winter flooding of the now largely cultivated fens of the eastern portion of the ecosystem was going to be settled by building a dike around the lagoon at the low-water perimeter so that the level of the lagoon could be raised for the purpose of the fishing industry without expanding its surface. These works (Figure 4), planned in 1925, were terminated in the 1950s. The springs of *S. Nazario*, *Lauro* and *Fiume Longo* proceeded to be canalized and conveyed straight into the lagoon. At the same, 25 km of underwater trenches within the lagoon basin were dug in order to increase the penetration of seawater (Colacicco 1955). The virtual conclusion

of the 134 years war between the private owners and the local community arrived in 1943 during the Allied Occupation following World War II when the military authorities, petitioned insistently by the township, gave over 99% of fishing rights to the locals (Colacicco 1955).

When the lagoon came completely under the control of the local communities a period of decadence in the fishery management began. A lagoon fishery requires centralised management but when the organisation is bottom-up involving several fishermen's cooperatives the tendency is towards every-man-for-himself, leading to overfishing and to the neglect of the spring stocking operation. The mayor of Lesina did manage for a certain while, on his authority, to coordinate the fishing organisation, but by the 1980s the situation had become anarchical. The fishermen have now dwindled to about 40 units most of whom are pensioners rounding off their income.

One initiative in the 1970s was the digging of long and wide underwater trenches which were supposed to help water circulation and offer refuge of deeper water to the fish during cold and hot spells of weather. New fish weirs have also recently been installed in the sea channels. In 1981 the eastern portion (970 ha) of Lesina lagoon became a bird sanctuary by decree of the Minister of Agriculture and in 1991 Lesina lagoon was included in the newly instituted *Gargano National Park*, leaving out, however, the central portion for the benefit of the wildfowlers.

Discussion

What have been the long term ecological and economical results of all the changes in the ecosystem brought by man? If the engineering works ensured

the draining of the freshwater marshes and fens enabling the land to be cultivated, it also had the effect of modifying the salinity of the eastern basin to the point that about 500 ha of once brackish waters have since become freshwater invaded by reed growth (Figure 5) which is unsuitable for fish production. Considering that 1500 ha of reclaimed fens had once been frequented by eels and that 500 ha of congested reed brake once yielded eels plus other fish, the drainage works have subtracted about a third of the fishery yield.

The new agricultural land which took the place of the marsh around the perimeter of Lesina lagoon may be distinguished in two parts. The part along the western and southern shore today yields industrial crops such as wheat, sugar beet, tomatoes, and sunflower. This type of agriculture would not survive today without EU subsidies. The new land at the eastern extremity has instead produced lucrative market gardens. Thus only about a third of the reclaimed land has in the long term given rise to self-supporting agriculture.

Surrounding the lagoon with a dike (Figure 6) has eliminated the once very wide ecotone of shallow water which was the habitat of numerous wader birds. Today the conservation of this type of territory would be given top priority. The digging of underwater trenches has adversely affected the benthic environment which is where most of the biotic production takes place in lagoons. The trenches which were dug in 1970s have in the meantime mostly filled up and are nearly even with the rest of the lagoon bottom but have yet to be re-colonised by eel grass (*Zostera*, *Cymodocea*, *Ruppia*) although this plant, which is a very important component of the ecosystem, is present in luxuriant growths on both sides of the track.

The last decades have seen sewage pollution come to the fore as a prime ecological factor. Most of the pollution reaching the lagoon comes from the badly-functioning sewage-treatment plants of Lesina, *Poggio Imperiale* and *San Nicandro*, and from the intensive fish culture which uses the waters from *S. Nazario* spring. Taking 60 g to be the daily B.O.D. for every inhabitant, it may be calculated that the lagoon every day receives about 1800 kg of B.O.D. from the towns, with an addition of 750 kg/day in summertime because of the holiday residents. Localised heavy macroalgal growth and anareobic conditions are the result (Figure 1). Here too one feels the loss of the freshwater ecotone of reeds and bulrushes with its high depurating capacity: one hectare of shallow freshwater wetland is capable of removing 21.7 kg of BOD per day (Breber 1999).

In 1994 the fishermen of Lesina decided to use the seaward entrance of *Acquarotta* canal as a harbour for their sea-going fishing vessels. This has had a negative influence on the spring migration of fry because the resulting noise, soiled water, lights, movement and unnatural obstacles at the very point of entry to the lagoon constitute a strong deterrent. Another negative factor are the long moles into the sea that were built on both sides of the sea channels. Considering the way fry swims in the shallow water along the shore, these moles at angles to the coast are an obvious obstacle along their course into the lagoon.

Bibliography on page 112.

_ACTS OF THE CONFERENCE
CABRAS AND S'ENA ARRUBIA
PONDS

OLIVIERO URAS
Consorzio di Bonifica dell'Oristanese

Description of the water synopsis
and surrounding system

The consortium district covers a surface area of 854 sqkm, falling under twenty-five municipalities in the province of Oristano. From a hydrologic point of view, the *Piana dell'Oristanese*, bordered in the south by the *Fluminimannu di Pabillonis* River, is influenced by the banked valley flow of two principal water bodies: the Tirso and Mogoro; by the valley water bodies channeled by the Marefoghe/Cispiri/Cabras pond system with the rivers that flow into them; by the valley flow defined by small trickles running into the Cabras, Santa Giusta, Pauli Maiori, S'Ena Arrubia, Corru S'Ittiri and Marceddì ponds and by the more capillaceous connecting reclamation network.

The District covers a territory comprising the Tirso lowland valley in the north, and the plain to the right of the *Fluminimannu* River in the south, situated between the two elevated areas of the Ferru and Arci mountains. The hydrologic network, although dense, is made up of waterways with modest inflow and a torrential rate of flow that is typical of the Mediterranean island climate. The Tirso River, crossing the territory in a North East/ South West direction, is banked and therefore has very few interconnections with the minor hydrographic networks and reclamation

networks. The numerous wetland areas constituting ponds of various sizes, of which only some have been reclaimed and that because of their particular beauty, richness and the particularity of the vegetation and animal species present, constitute a natural heritage of notable value that is today safeguarded by regional national and international plans, protections and conventions are particular to the territory. The *Oristanese* wetlands are therefore primarily a source of beauty to be conserved. The reclamation activities initiated in these territories in the 1920s were principally aimed at managing the river processes of the stretches of valley water bodies, the draining of certain marshy areas and the construction of a notable viable rural network.

Subsequently the 1950s saw the initiation of the realization of collective public irrigation systems. Time has proven the functionality and the intrinsic consistency of these types of works. If the *Oristanese* has not been in the news from a hydrologic disaster point of view, it is owed above all to the soundness of the hydraulic reclamation operations carried out in the past and synthetically described here. Turning our attention to the wetlands that, as mentioned above, with the exception of the Mogoro River and the marginal areas behind the banks of the Tirso constitute the natural location of the Oristanese hydrologic di-

Table 1: characteristics of the Ponds interconnected with the defined areas of the district.

Water body	Basin (sqkm)	area falling in the district (sqkm)	defined area (sqkm)	Average Volume (mmc)	Average surface area (ha)
Cabras Pond	459	256	146	38	2.300
Pauli Maiori and S.Giusta Ponds	167	105	75	4	900
S'Ena Arrubia pond	121	121	72	1	210
Corru S'Ittiri Lagoon	35	35	35	3	350
S. Giovanni e Marceddì Ponds	974	148	81	16	1.600
TOTAL	1.756	665	409	62	5.360

strict, let us examine the following table summarizing the salient characteristics of the ponds interconnecting with the defined areas of the district.

From the Table 1 one can formulate the following explicative observations:

- the total catch basin of the *Oristanese* ponds connected to the hydrographic and reclamation networks equates to about 7.3% of Sardinia's surface area and 58% of Oristano Province's surface area;
- these wetlands are therefore receivers of consistent portions of fresh water in the regional territory. The area quota of the catch basin falling within the Consortium District equates to about 80% while the hydraulically organized zones flowing into it equate to 100% of the surface area of these self same zones; one can therefore affirm that in the *Oristanese*, the whole reclamation is tributary to the ponds.

Moreover, when examining the Table 1, one is able to divide the lagoon water bodies into two distinct categories: those of the lagoons themselves and those of the ponds. Bearing in mind that between these two types there are no clearly demarcated borders, one can assign the water bodies with minor catch basins, those of smaller dimensions and those in direct contact with the sea (Santa Giusta, S'Ena Arrubia and Corru S'Ittiri) to the first group, while those with bigger catch basins, larger dimensions and proportionately further away from the sea can be assigned to the second group.

All the abovementioned wetland areas have contact with the sea and are therefore potential *valli da pesca* suitable for saltwater fish breeding and above all, mullets. This allows not



Figure 1: grey mullet Bottarga.

only for fishing and the selling of fish, but also the traditional production of precious *bottarga* (Figure 1) made from the mullet's salty roe pouch and dried eggs. The ponds therefore constitute a precious economic resource to be safeguarded and managed prudently. Today they are part of the Regional Property, the ichthyic capitalization of which has been entrusted to the Fishing Cooperatives. The current asset substitutes, for some of them, private ownership and semi feudal management systems dating back to a not too distant past (about 80 years).The Consortium collaborates with the Region in managing the ponds, delegating the realization of works and serving as consultants for study and research in the hydraulic and hydrology fields.

Principal problems/conflicts emerging in recent years regarding above all, the multiuse of the area

The *Oristanese* territory is, to a larger extent than other areas in Italy, dedicated to amongst various production activities, agriculture and breeding, even if this has declined in the last few decades. Industry in the area is limited to small enterprises that do not produce particularly large amounts of pollution

(transformation of agricultural produce and similar activities), concentrated in dedicated zones in inhabited areas, and for the large part in the *Porto Industriale di Oristano* downstream from the wetlands, hydraulic and reclamation grid and ponds.

The agriculture and breeding workers, despite being inferior in numbers to those of the industrial activities (20% of the active population), are more widespread throughout the territory and, above all in the part in which the plains and wetlands are situated. The present population is not large: about 170,000 inhabitants in the entire Oristano Province of which there are less than 100,000 in the Hydrologic District being studied. It is understandable how the conflicts that have emerged in recent years regard, on the one hand, the simple conservation of the wetlands or their use for principally fishing, and amongst human activities, the conflict between the fishing activities and the other uses of the territory which include agriculture and breeding, inhabitation and finally, those relating to industrial activities. All of the abovementioned activities could in fact result in the discharge of pollutants or hyper-nutrients into the ponds via the hydrologic network.

It is evident that, in the studied district, the principal origins of discharges that are dangerous to the ponds and to the fishing activities principally originate from the farmers and breeders, followed by the inhabitants and lastly, the factories. Other "internal" conflicts, until now overlooked, can be derived from the practice of fishing activities using improper or out dated methods. Sporadically the Consortium activity also influenced this, above all in the limited and controlled use of herbicides to clean the canals. The most extraordinary



Figure 2: the perishing of fish in the S'Ena Arrubia pond.

problem to emerge in recent years, probably linked to the multiple uses of the district, is most certainly the perishing of fish (Figure 2) which occurs above all in late spring/summer and more frequently (at least for some years) in the smaller ponds and those subject to high levels of anthropic pressure, while causing more damage in those with higher capacities. In reality the smaller water bodies, especially those which are shallower and less voluminous and with reduced inflow of fresh water, are more sensitive in that they lack the hydraulic inertia that allows them to react to eventual external negative or sudden stimuli. The causes of the aforementioned disasters have not yet been unequivocally established due to the complexity of the interdisciplinary problems under which they are buried and the crossing of the numerous possible contributing and interfering factors. Drawing upon the studies and investigations carried out, it is possible to define certain plausible, if not certain scenarios.

For the *Oristanese* ponds, spring is the most prosperous season while its end is the period that poses the highest risk. The inflow of fresh water in the winter and spring allows for the lowering of salinity levels and the entry of juvenile fish from the sea. At the beginning of the next summer season the

salinity levels suddenly rise, a floating algae population develops, the ichthyic population is at a maximum while, due to high temperatures, the capacity to absorb oxygen from the pond surface is at a minimum. Moreover, it is also to be remembered how algae, even if essential, produces oxygen during the day via chlorophyllian photosynthesis, but in the absence of light, it simply absorbs it overnight.

In this situation, eventual localized deaths, also for contingent motives and not widespread, (masses of fish in restricted areas and consequently traumas, predator attacks etc.) can result in further removal of oxygen as a result of the decomposing carcasses and threaten to trigger a chain reaction which could spread to the whole, or a most of the body of water. It is evident how the eventual inflow of nutrient substances or pollution into the ponds can be extremely dangerous, especially if it occurs suddenly, because in the above mentioned situations, it could trigger the aforementioned auto-degenerative mechanism. Therefore, downstream of the incumbent purification systems to be realized in correspondence with the hydrologic and reclamation network discharges, there is the need to protect the pond water bodies with adequate works before the emissions flow into them via the waterways, allowing for the improvement and characteristic homogenization of the emitted water.

Solutions adopted in overcoming problems/conflicts and those related to effectiveness

Following the initiative principally by the Sardinia Region, the owner of the wetlands and hence the subject most interested in the overcoming of the above

mentioned problems/conflicts, different actions were undertaken in order to overcome the above criticalities. Above all, the Region financed a study and research campaign aimed at investigating the hydrological and biological dynamics that influence the different realities in the ponds and the causes of dystrophism. From the results of the said studies, the previously hypothesized degenerative mechanism was noted.

The *Consortium* and its technicians, in the role of expert consultants looking into its hydrologic aspects, collaborated in the studies related to the Cabras Pond. The analysis conducted by the Consortium allowed for the overcoming of certain mistaken beliefs regarding the saline dynamics of ponds with larger catch basins and limited contact with the sea (Cabras and Marceddi), which were principally thought to be caused, as with lagoons in a strict sense, by tidal motion and the consequent exchange with the sea. The study however, showed a higher dependence on the inflow of fresh water from the afferent catch basin and evaporation from the lake surface. In the Sardinian climate, this results in the desalinification of water in the winter and spring periods, reaching a minimum in the April/May period and salinification in the summer with minimums in the September/October period.

The study therefore highlighted the consequences of recent climatic changes which, with hotter and drier annual averages, has resulted in a higher average salinification of the pond water and as of the 1990s, the improving of the irrigation management which, reducing the amount of supplied and unused water, contracted the relative unnatural summer inflow of fresh water to the ponds, consequently reducing the desli-

nification of the previous years' higher irrigational waste.

The improvement of agricultural effluent was useful to, other than the regional and provincial institutions' incumbent monitoring of the discharges, the improving of production technology that made herbicide and pesticide that do not require specific discharges readily available. In order to improve effluent resulting from livestock farming, which is intensive and widespread in the district especially in the *Arborea* area, amounting to 30,000 heads of cattle over 8000ha, the Region has for some time been active in counteracting nitrates originating from agriculture. In order to improve urban effluent, the Region has provided for the financing of purification systems for each municipality, and as for the District, a network between different municipalities consisting of a few bigger, simpler and more economically manageable systems. In order to improve industrial effluent, the Provincial administration has for some time been monitoring discharges following the realization of single and consortium purification systems.

The initiatives described above were aimed at protecting the ponds from what they receive from inland. One would think however, that a more direct connection with the sea would be positive for the oxygenization of the water as well as the breeding of precious species, more typically marine species like sea bass, sea bream and sole etc. In many water bodies the shortening and widening of the mouths to the sea is provided for. This has caused the water bodies with smaller basins of fresh water to have a higher salinification and unfortunately, the abnormal development of *Mercierella enigmatica*: infesta-

tions of colonies of worms which create at times quite large, masses of calcium carbonate in the form of intertwined tubules. This animal, not typical of our lagoon environments, is unfortunately perfectly suited to them, especially prospering in water that is mostly saline with the sporadic inflow of fresh water, such as those from the canals connection to the sea, or lagoons themselves when they are shallower with less fresh water inflow.

Technical interventions put in place over the last few years in order to protect and improve pond habitats and their level of innovation

Here follows a description of the principal interventions fundamentally carried out by the Sardinia Region in order to protect and improve the pond habitats. The said interventions are divided into water bodies and listed in approximate chronological order.

Santa Giusta

This is the most vulnerable pond because of its notable anthropic pressure on the hydrologic basin and proportionately, because of its limited water volume. The Sardinia Region has carried out consistent works in this pond by enlarging its mouths to the sea, excavating internal arteries, realizing protective external surrounding canals and the connection of these with the basin of the neighboring industrial port.

Marceddi/San Giovanni pond complex

Over the years, the *Consortium* has realized, on behalf and at the expense of the Region, consistent works relative to the Marceddi ponds including:

- the realization of an internal embankment to the pond dividing it into two areas of which the first, upstream and on the left is destined to receive the fresh water from the vast catch basin, and the second, further downstream and on the right is of higher salinity and more specifically dedicated to fishing. The two zones are connected to each other via embankment overflow during flooding or via sluice gates in low water or calm conditions.
- the reconstruction of fish farms with more durable materials and more manageable methodology corresponding with the mouth to the sea.

It is difficult to express definite opinions regarding the appropriateness of the realized works, although one cannot doubt that of all the *Oristanese* ponds, the Marceddi ponds currently appear to be the least problematic and they allow for wider management options without noticeably upsetting the environment in which they exist.

S'Ena Arrubia

Over the years, the *Consortium* has realized, in conjunction with the European program Life Natura, an intervention for the protection and revitalization of the S'Ena Arrubia pond. The said works consist of: the realization, upstream of the water body and corresponding with the external emissary canal named *Diversivo S.Anna*, of a phytodepuration and lagooning zone in which the low water is deviated from the canal servicing the basin area (previously the reclaimed Sassu pond) in which there is intensive livestock farming. In order to obtain the hoped for biological filtration along the Diversion border, thresholds have been realized with the aid of barriers, allowing for small watersheds.



Figure 3: S'Ena Arrubia pond Inlet and fish farm.

The water in the reclaimed area is pumped upstream from the said barriers in a way that allows for the emission of water from the most intensive area into the pond only after the hoped for biological filtration action in the Diversion. The intervention also included the cleaning and organizing of the mouths to the sea.

Cabras

Of all the *Oristanese* water bodies, the Cabras is the largest and that least directly linked to the sea, hence that which is less vulnerable, be it upstream or downstream. It is perhaps for this reason or due to the onerous nature of the relative eventual interventions that it has not been concerned by particularly consistent interventions. Modest works were carried out in the 1990s to enclose the ichthyic district and limit the increase of salinity in the tributaries.

More recently, upon the initiative of the Sardinia Region and in collaboration with the *Consortium*, in addition to the research described in the previous paragraph, aeration works were put in place that should serve as refuge areas for fish in cases of dystrophia as well as mo-

nitory works allowing for the acquisition of data and orientation for further more specific interventions. The later works, having been recently realized, have not yet been able to produce results because of the lack of dystrophia and continuity in the availability of data. In the short term, maintenance/management problems have been highlighted, which appear to be arduous and not always defined.

Proposals for the future and principal risks to the water bodies over a period of ten years

The experiences in carrying out the interventions of recent years have shown that the *Oristanese's* lagoon water bodies are environments that are hostile to the maintenance of works that are realized in them. The creation and proliferation of the above described calcareous concretizations is disastrous for the operation and conservation of moving regulatory organs (barriers and similar) and in fact threatens the survival of the shallower lagoons and those with a higher average salinity in which, in creating aggregations on the bottoms further reduces levels and water volumes.

The situation described above elicits, if not imposes, in shallow brackish water environments, the of realization of works in the future without moving organs, or at least works that are reliable and simple to operate, permitting their predetermined ease of use. Similar considerations involving past experiences elicit the suggestion that the management of the works, if upstream of the water body, can only be entrusted to the managing body of the hydrologic network and if downstream or in the water body, to its managing entity that should be opportunistically given the responsibility through necessary adaptations of the self same land grant, and should be equally simple and predetermined.

The abovementioned considerations put the realization of semi-natural basins for lagooning and/ or phytodepuration, that could possibly be created using at most natural and minimal height differences and not very sophisticated artificial equipment, in good light.

Where one establishes without a doubt that the increase in salinity in summer above a certain threshold can be damaging to the water body and its animal and vegetation populations,



Figure 4: S'Ena Arrubia pond.

the close connection in the Oristanese between the hydrographic & reclamation networks and the ponds could lead to the limiting of the said salinity through the programmed release from the irrigation network and then draining. Moreover one hopes that the actions described in point 2 will be completed in the future and the quality of the introduced water will improve. A lot has been done, but there is still a lot to do in terms of further purification interventions and maintenance and management.

From this point of view, considering the not too dense population in the district, the consequent proportional limitation of pollutants, the actions that have already been carried out and those regarding the improvement of effluents still under evaluation, one foresees a possible positive or at least non-degenerative evolution of risk, above all to the larger water bodies in which the situation still appears to be irreparably

compromised. Along with the aforementioned actions to be undertaken and consolidated in order to avoid problems and conflicts, an administrative simplification is desired that would avoid the overlapping of different uncoordinated subjects in the management and study of the lagoon water bodies. This said coordination could perhaps be easily obtained by giving wider jurisdiction and qualification to the concessionaires, for fishing, of the wetlands that should internally organize their interdisciplinary technical staff that are capable of contributing to the granting Region in a highly qualified way and to provide for the management of sophisticated works and instrumentation.

_ACTS OF THE CONFERENCE
GRADO-MARANO LAGOON

MICHELE CICUTTINI
Consorzio di Bonifica Bassa Friulana

The general picture

This area in the terminal zone of the Friuli low-lying flatland (*Bassa Friulana*) is formed by the submersion of a coastal area, deltas, separated from the sea by a network of dunes and sandbars determined by the interplay of river sedimentation and sea currents as well as wave action. Such limitations provide a certain dynamism and are in continuous evolution. The lagoon is closely linked to the surrounding land, given that it is from here that the river water arrives, with maximum amounts varying between about ten and 100 mc/s of groundwater. Due to the presence of internationally protected migratory avifauna (in the Ramsar area named *Marano Lagunare - Foci dello Stella*), according to the Birds Directive this area constitutes a SPZ and is defined as a SCI in the Habitats Directive.

The lagoon is located in Friuli Venezia Giulia (Figure 1), a region that constitutes an important biogeographical crossroads and is one of the most interesting areas of study in Europe; due to its position, its physical and geo-

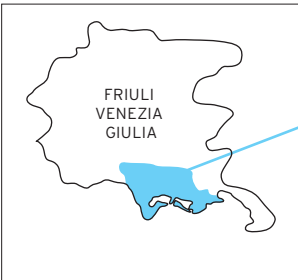
morphological aspect and climate, the region represents a wide variety of environments and biotypes as well as an exceptionally rich flora consisting of 2780 species, more than the entire patrimony of Germany (2400 species) and more than half of that of Italy.

The border between the lagoon and open sea is made up of a number of small coastal islands, in some cases connected by artificial seawalls; in spite of the occlusion of some mouths, the lagoon and sea interact via the principal remaining mouths. Seawall delimitations are present on the internal islands and on the lagoons internal (northern) border, protecting the reclaimed lowlands from the high water. The most important inhabited areas are Grado and Lignano, which are mainly tourism areas, and Marano Lagunare, predominantly linked to fishing and aquaculture.

Land Reclamation

The internal costal strip is a result of land reclamation. Along the internal limits of the lagoon, the reclaimed strip extends over an average of 2 km in the

Figure 1:
Grado-Marano
Lagoon.



Lagoon area (average submersion): 160 km²
Beach development: 12,00 km
Sea wall development: 78,60 km



Figure 2:
potential
dispensability map
of the Grado-Marano
Lagoon.

western and central part and over 5 km in the east. The principal stages were:

- early 1900s: over 50 thousand hectares of wetlands, with agricultural activities taking up 20 thousand hectares;
- the first land reclamations: the 1904 intervention directed by the State on the basis of the 1900 Consolidating Act: construction of perimeter embankments, internal canals, streets and sewers for the disposal of water (technical solutions based on natural intermittent drainage); the final results of these first interventions proved modest as over time, there proved to be higher land compaction than expected, resulting in insufficient cultivation.
- first World War: the *Bassa Friulana* was still largely conditioned by the waters;
- post-war years: the beginnings of modern land reclamation with mechanical exhaustion of the waters.

Hydraulic Circulation in the Lagoon

The lagoon bottom still has branched, meandering river furrows, the remains of the ancient hydrographics of the emerged area which has been modified in part by lagoon circulation, and in part by human intervention. The nature of the bottom, where there are not ar-

tificial stone deposits, is sandy/clayey or clayey and peaty, making it practically impermeable. These furrows, correlating with the tidal oscillations, are immensely important for lagoon circulation, the exchange of water and definitively, the vitalization of the water. They have a distinctive role, constituting a distinctive characteristic of the Grado-Marano Lagoon; in fact in the bigger, adjacent Venice lagoon for example, the role of the tides in the exchange of water is notably smaller (Figure 2).

The Issues Embankment Delimitation

Due to the astronomical and meteorological effects on the tides, the lagoon's water level may rise up to one meter above the maximum spring tide, (or a total of 1,5 m above the mean level) and subside by almost as much. Because of the continual overall rising of the mean sea level (currently 1,6mm per year) and progressive subsidence of the lagoon coasts, the high water phenomenon in the lagoon occurs more frequently, insomuch as every year, on at least one occasion, abnormally high levels are noted. Such circumstances call for the constant maintenance of the effectiveness of the defensive bar

of embankments protecting the inland areas and islands. In a recent study the *Protezione Civile* of the Friuli Venezia Giulia Region, with relation to various valuation parameters, were able to identify and classify critical points of the embankment with regard to the danger that they posed (Figure 3).

Environment Quality

The central part of the lagoon and the central part of the *Bassa Friulana* territory were registered as reclamation sites of national interest with Ministerial Decree no. 468 on 18 September 2001 on account of serious pollution found in the lagoon sediment. It was estimated that in order to carry out reclamations in the Marano Lagunare and Grado Lagoon and its neighboring waterways, a total amount of about 54,8 billion lire was required, 28,6 billion lire of which was required for urgent interventions. As reported in the decree, "*pollution in the area can be attributed to mercury deposits originating from a cellulose production plant in Torviscosa*".

The pollution level of 20 kg per day as recorded in 1949 dropped in 1970 (about 6-7 kg per day), before being reduced to zero with the adoption of effective recu-

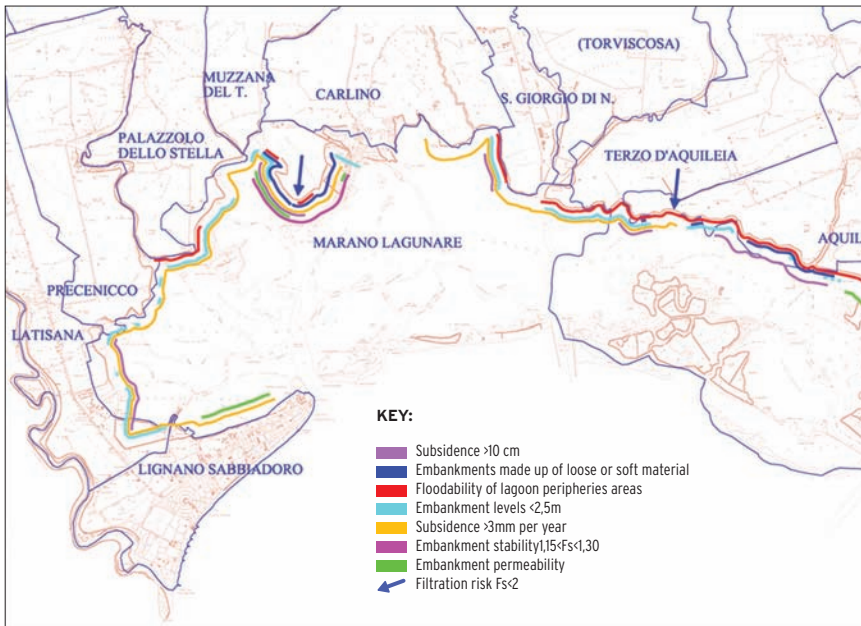


Figure 3: critical points of the embankment (western part).

peration systems. The overall deposits in the area amount to about 186,000 kg, about 11,5 g/m² of which is sediment pollution. [...] Bearing the sediments high mercury concentration in mind and its neurotoxicity to the food chain, even in small doses, and the presence of fishing and shell fishing activities in the lagoon, it could be said that the Grado-Marano Lagoon is a high health and environmental risk area”.

Lagoon Fish Breeding

Over the last decade this sector has been put to the test; there are multiple reasons for this:

1. the mixing of meteoric water and seawater resulted in a deterioration of water quality in the *valli da pesca*;
2. the shallow bottoms and eutrophication are responsible for the de-oxygenation of the lagoon;
3. the differences in water salinity result in the presence of parasites;

4. the absence of dredging interventions results in the progressive silting of the lagoon canals, causing poor lagoon circulation;

5. the simple 1 or 2 mouth conformation of the canals connected to the lagoon results in the absence of water exchange and the consequential deterioration of water quality.

For these reasons, the quality of the lagoon water is not good and, according to the law, shell fishing is precluded in large parts of the lagoon. This issue was made official and dealt with via the use of the following extraordinary legal instruments, used in such cases:

- Presidential Decree, 3 May 2002: an environmental socio-economic state of emergency was declared in the lagoon;
- Ministerial Ordinance No. 3217, 03/06/2002: the appointment of a Commission to manage and resolve the emergency;
- Ordinance No. 3556, 21/12/2006:

redefined and increased the Commission's operative responsibilities;

- Presidential Decree 12/12/2007: extended the state of emergency.

In carrying out the necessary measures to resolve the emergency, one of these being dredging, some difficulties were encountered:

- identification/realization of final sediment storage/deposit sites showed physiochemical characteristics in excess of the limits shown on Table 1 column B, attachment 5, Title V, Part IV of Decree no.152/2006.
- the identification of sediment processing methods aimed at maximizing their reuse in the lagoon.

Agriculture

Unfortunately, the agricultural sector also plays an active part in the environmental degradation process underway in the Lagoon. The introduction of monoculture, the complete mechanization, chemicalization of farming processes and the expansion of cultivated surface areas have resulted in a series of serious effects on the territory, from the impoverishment of the soil, the decline and polluting of the territory as well as its surface and groundwater, the adoption of intensive non-sustainable production, to the nitrate pollution of the water, not to mention the progressive elimination of its shrubbery, bushes and grassy areas.

It is really in relation to nitrate pollution that one is reminded of Regional Council Deliberation no. 1246 dated 26 June 2008, which brought about the identification of the Grado-Marano Lagoon drainage basin as an area vulnerable to nitrates originating from agriculture, in accordance with the Council of

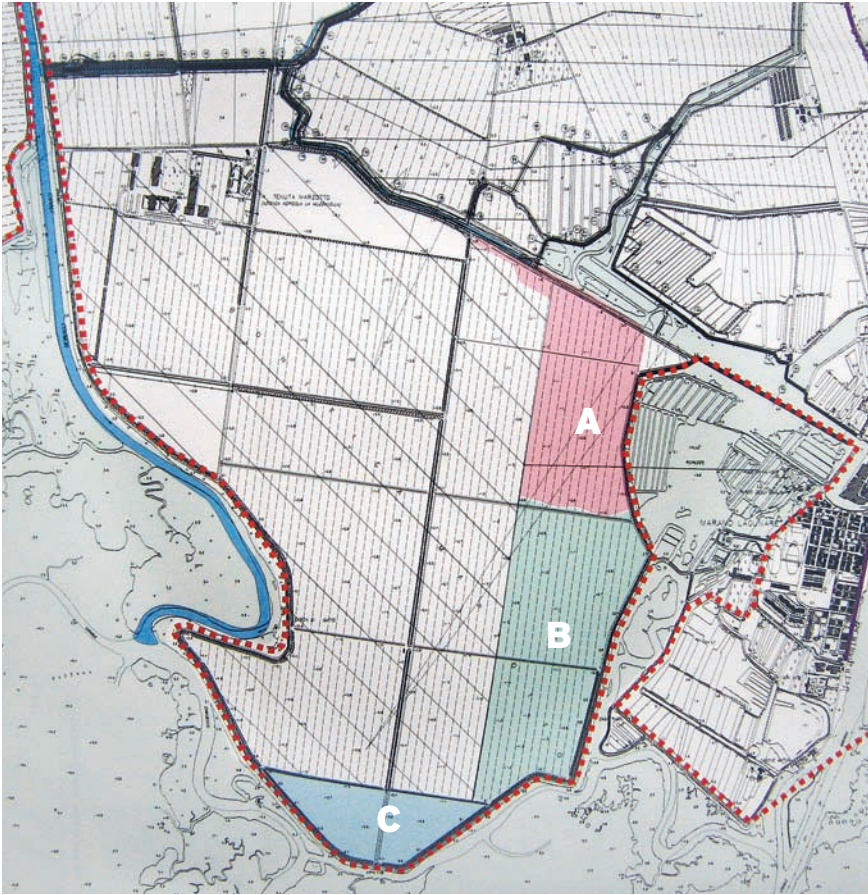


Figure 4:
Renaturalization
intervention
plan, the so-
called Muzzanella
reclamation.
A. Freshwater
wetlands.
B. Lagoon area with
controlled tidal
systems.
C. Lagoon areas with
free tidal systems.
D. Perimeter of the
National Interest
Site.

the European Union Directive 91/676/CEE, 12 December 1991. One is witness to a general ecological fragmentation of the landscape, with a reduction of interstitial fauna specimens and a decline in biodiversity and regional genetic heritage with the creation of isolated habitats that are too small to "network" with each other.

Solutions and Interventions

The example project is called *Environmental restoration and protection of coastal areas and lagoons through reclamation works, water vivification and canal hydraulic circulation system improvement*. The project was financed by the Council of the European Union with the Consolidated Program Document 2000-2006 - Objective 2, by means of the *Regione Autonoma Friuli Venezia Giulia* and the *Direzione Regionale dell'Ambiente*.

Intervention Objectives

The objectives of the interventions are essentially summarized as follows:

1. the restructuring of the meteoric water collection and the discharge system through the realization of drainage canals and a dewatering pump in order to remove agricultural water from the peripheral areas of the lagoon, discharging it in the Cormor canal that, although flowing into the lagoon, is not related to the area from which the water is drawn in order to supply the valleys;

2. environmental restoration and renaturalization by reconstructing typical lagoon habitats;

To be achieved in conjunction with:

3. the identification of a location in which, through appropriate precautions, predicted either in the intervention in question or in successive phases

of completion and in the dredging programs of navigable lagoon canals, to implement the sediments originating from the dredging of the lagoon canals in order to resolve the issues for which the above Ordinances were drawn up.

The Renaturalization Intervention

Covering a vast area (Figure 4) of about 72 hectares in the Marano Lagunare (UD) municipality currently used for agriculture (Muzzanella reclamation), the intervention regards the creation of the following habitats:

- lagoon renaturalization areas of freshwater environments with a hydraulic management system (19,4 ha);
- lagoon restoration areas with controlled tidal systems (33,2 ha);
- lagoon restoration areas with free tidal systems (15,9 ha).

Freshwater wetlands (Figure 4-A): situated in the northern part. Following the realization of a conduit to regulate the carrying capacity, the following will be realized:

- a 135 cm deep "comb-like" basin to facilitate the first natural phytodepuration;
- a much higher table (an average height of 10 cm) where the phytodepuration transformation process will take place;
- two freshwater surfaces, in the centre of the area with variable depths (10, 60 and 135 cm) in order to favor some certain avifauna species that require special conditions;
- water circulation: via a winding flow canal and another conduit, situated next to the entrance conduit, it can be re-introduced to the reclamation network;
- a third water surface of controlled saline water: fed via a third connecting conduit.

Lagoon areas with controlled tidal systems (Figure 4-B): made up of three water surfaces of differing depths compared to the average sea level:

- supply: entrance conduit situated in the south;
- discharge: sewer situated in the north (in and out-flowing tide quotas between 9,50 and 10,50).

Particular attention is paid to the planning and creation of three small islands in this area (one in the brackish water area and two in the salt water area) in order to create those particular conditions that allow aquatic birds to stop, make nests and feed in a safe place, far from predators and protected from adverse atmospheric conditions.

Lagoon areas with free tidal systems (Figure 4-C): these areas are found in the south. The lagoon system is restored following the historical morphology of the lagoon, after careful analysis of the landscape characteristics on the I.G.M. plans as far back as 1891.

Renaturalization Works

Regulation works: works regulated by apparatus limiting the exchange of water between the division of the peripheral lagoon reclamation and the renaturalization and vivification area.

Tidal current regulation works: works placed on the banks with more waterways (6 at the entrance and exit, respectively) and equipped with canal lock gates:

1. with the in-coming tide, water only enters the internal basin from the lagoon via the works in the south while those in the north remain closed;

2. with out-going tide, the water only exits from the internal basin to the lagoon via the works in the north while



Figure 6: *Consorzio di Bonifica Bassa Friulana* analysis campaign (2007): elements with concentration superior to the value limits of column "A" Ministerial decree 471/99.

those in the south remain closed. A sensor system and automation allows for the closing of the waterways with vertical apparatus should the tidal level exceed 10,50; a safety valve is also installed to ensure extra security.

Vivification works: allows the salinity controlled basin to exchange saltwater with the tidal current controlled basin:

1. via Electro-pump: water discharge in the tidal system controlled division;
2. via the apparatus controlled waterway: inflow of water from the lagoon;
3. with the use of other regulation works: inflow of freshwater from the reclamation.

Mud Classification and Use

The Venice Protocol, applied to the Grado-Marano Lagoon canals, classifies the mud into 3 categories based on the contents of the elements and polluting compounds such as metals, total hydrocarbon, PAH, PCB and pesticides.

- category A: extensive use in the reconstruction of salt-marshes or other works (banks, trenches etc.); mud result-

ing from the project excavations which falls into this category will be placed in the western area at the outflow of the free tide;

- higher categories (B & C) redefined in the light of Table 1 of the Ministerial Decree no. 471/1999 and further amendments;

- category B: the formation of islands in areas of high natural value or reinforcement of lagoon beaches through the use of naturally or artificially surveys assuring coefficient permeability $k \leq 1 \cdot 10^{-7}$ cm/s; mud resulting from the project excavations which falls into this category will be placed in the central area at the outflow of the free tide: in this area of the lagoon, apart from the water surface areas, emerged land originating from lagoon dredging operations and classifiable as category B, mud that in order to avoid being subjected to the sea level requires notable quantities of material to be taken from the sediment aliquot, will be appropriately remodeled. It is with this aim that near the *Canale Corniolo*, three areas with embankments covered in muddy material with an appropriate permeability and thickness of 1 m; and a quota of 11,8 thereby guaranteeing the impossibility of submersion will be created.

- category C: formation of reclaimed areas (*Casse di colmata*) or the reinforcement of existing ones, with the recommendation that the water from the pumping operations remaining in the lagoon should not be murky, but should be preventatively filtered within the legal limits of waste matter; moreover the eclamed areas (*Casse di colmata*) should be impermeable, be it at the bottom or along the sides, according to an analogous permeability coefficient predicted for the formation of the islands (Figure 6).

Environmental Characterization of the Lagoon

The environmental and socio-economic state of emergency in the Lagoon is made up of the following stages:

- Ministerial Decree no. 468, 18 September 2001: the entrustment of the Environmental Characterization regarding the reclamation of marine and brackish water areas included in the perimeters of sites of national interest to ICRAM;
- Ordinance no. 3217/2003: appointment of the Commission delegated with managing and resolving the state of emergency in the Grado-Marano Lagoon. ICRAM is entrusted by the self same Commission with the environmental characterization of the entire lagoon area regarding the resolving of the state of emergency.

Conclusions

From the conclusive preliminary Characterization Plan report: “taking into account the distribution of sampling points and pollution, without a risk analysis and the inability to identify the extent and distribution of pollution, one proposes the removal of material by dredging”. It is with this in consideration and the low levels of contamination identified in the areas inside the lagoon perimeter that, in the preliminary characterization, an *ex situ* reclamation process was proposed, allowing for the recuperation and reuse of the dredged material in environmental engineering works connected to the re-profiling of the banks, the nourishing of salt marshes and the remodeling of coastal environments and stretches of sand.

Possible sediment regeneration technique: electro-chemical geo-oxidization processes and induced complexation applied directly *in situ* or *ex situ*. The material resulting from the canal dredging activities running along the perimeter of the Marano territory, originally of no danger, in terms of mercury concentration values, which does not exceed the value limits of Table B of 471/99, could be placed inside the *Casse di colmata* in collection tanks, with the authorization of the region, or in collection areas in coastal environments.

These areas should have a natural or artificial impermeability system at the perimeters and on the bottoms, capable of providing the required impermeability equivalent to at least: K minimum or equal to $1,0 \times 10^{-9}$ m/s maximum width or equal to 1 m.

Regarding, however, the investigations carried out in the national inter-

est site (Figure 4-D) inside the lagoon, one sees that after the carrying out of scheduled activities in the characterization plan, the environment concerned does not show signs of being polluted. The resulting parameters are in fact generally a lot lower than the legal limits for industrial areas stated in Attachment 1 of Ministerial Decree 147/99, be it for the soil (Table 1/A) or for groundwater.

Characteristics of the Current Situation

1. Area concerning the Ministry (solid ground within the perimeters of the National Interest Site): waiting for a decision from the Ministry;
2. Area concerning the Commission: (lagoon area within the perimeters of the National Interest Site): waiting for a decision from the Commission;
3. Area not falling into the above categories (solid ground outside the perimeters of the National Interest Site): any future intervention must be in accordance with Legislative Decree no. 152/2006.

Apart from the allocation of the necessary finance, the realization of interventions of Objective 2 currently depends on the conclusions of the characterization procedure and eventual reclamation.

_ACTS OF THE CONFERENCE EVOLUTION AND CRITICALITY OF THE NATION'S COASTLINES

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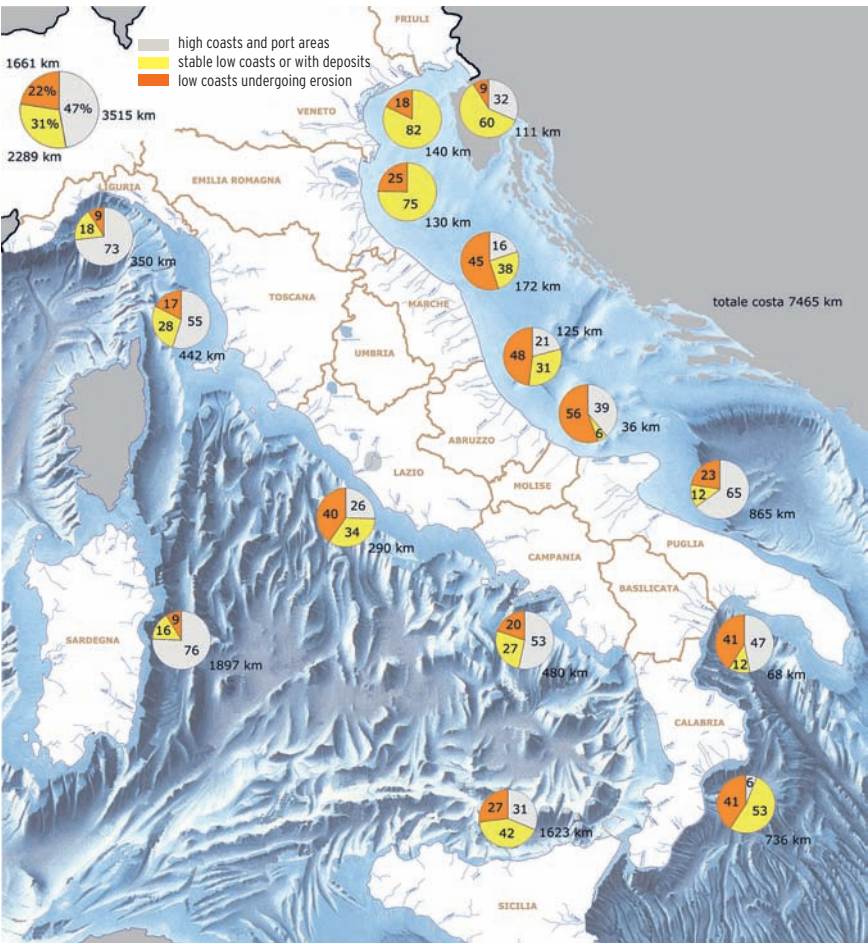
The occupation of our coastline began after the Unification of Italy with the construction of harbors, roads and railways. In the 1900s a further push was provided by the development of industry, namely the petrochemical and seaside tourism industries, which, after an initial gradual growth, showed an evermore-exponential trend following the Second World War. The low coasts were the preferred locations for these settlements, destroying numerous highly valuable coastal ecosystems, without taking the long and short-term environmental impact into consideration. Their introduction, often into fragile social structures like those of the south, did not favor the conservation of landscape value or the establishing of these enterprises in the local economy. This occupation, borne of the distorted conviction that urban development would bring inevitable economic wellbeing is often rooted in conflicting interests. In fact, the urban development and the serious overlapping of uses of the coastline not only has geological equilibriums, but also ecological that are extremely sensitive to changes to the *habitat*.

A big boost to demographic expansion can be attributed to the highway network which, connecting the city with the sea, favored the expansion of coastal settlements. It is estimated that today, 58% of the coastline is completely urbanized with a further 29% showing significant urban development. Therefore, it is over the last 100 years that the progressive urbanization of the coastline has produced the most significant modifications to the equilibrium of coastal areas. If on the one hand, the high coasts present notable problems especially regarding the instability of cliff faces and retraction, the beaches are the areas that are most sensitive to even the slightest variation in the coastal equilibrium and sedimentary

balance. Construction's growing need for inert substances, the organization of watersheds, creation of reservoirs and extraction of liquids from the subsoil (water/gas) together with the construction of maritime portals and projects for settlement defense, have produced a notable sedimentary deficit, progressively aggravating the coastal erosion phenomenon (Simeoni & Bondesan, 1997).

Different strategies and types of intervention will be put forward as a remedy for the growing erosion of the beaches. The 1907 law defending the settlements was the first official response to the coastal erosion: public resources were made available for settlement protection, but unfortunately the reconstruction of the beaches, or the safeguarding of sensitive areas and areas of noticeable natural value, was never contemplated. It was in this way sundry types of works were put in place in order to protect settlements or slow down erosion. It has only been in the last few decades through beach nourishment interventions, or where necessary beach reconstruction via the depositing of suitable materials, that the defense of the coasts has been worked on.

Between 1800 and 1900, the Italian scientific community, in carrying out the first studies on coastal geomorphology and coastal dynamics, created the base for the raising of consciousness about the problem of evolution and the conservation of its coastlines. Later in the 1930s, sporadic studies that resulted in the publication of important monographs of Italian beaches were conducted. This research, coordinated in part by the *Consiglio Nazionale delle Ricerche* (C.N.R.), represent the first attempt at coordinating the various groups, working on the coastline in their various capacities.



Region	High-lying coast and port areas (km)	Low-lying coast	
		total km	km of area undergoing erosion
Friuli Venezia Giulia	35	76	10
Veneto	0	140	25
Emilia Romagna	0	130	32
Marche	28	114	78
Abruzzo	26	99	60
Molise	14	22	20
Puglia	563	302	195
Basilicata	32	36	28
Calabria	44	692	300
Sicilia	506	1117	438
Sardegna	1428	459	165
Campania	256	224	95
Lazio	74	216	117
Toscana	243	199	77
Liguria	256	94	31
Italia	3515	3950	1661

Figure 1: regional scale representation of high-lying and/or rocky coastal areas as well as low-lying areas subdivided into those undergoing stable progression and erosion. The data, expressed in km and percent in comparison to the total length of the regional coastline, are taken from the G.N.R.A.C study conducted on 7,465 km of coast.

In the 1960s the C.N.R. promoted a series of interventions that provided the basis for the launching of interdisciplinary studies in order to safeguard the beaches. Different Special Programs were launched, one of them being on "Soil Conservation" which covered the specific theme of "Coastal Standards and Conservation". It was in this side project that three sampling areas were identified (the Upper Adriatic, Upper Tyrrhenian and Ionian Seas) that interdisciplinary studies focused on.

In this way, it was possible for the first time in Italy, to integrate geological, sedimentological, morphological, hydrofluvial and hydro-maritime research and presentations identifying the evolu-

tionary history of coastal areas and the dynamics of its coastal assets. These "applied geographical" studies highlighted the more important aspects of the environmental degradation caused by the intense 'anthropologization' of the coastal areas, often triggering important erosive phenomena.

The significance of the scientific production and the high level of knowledge reached were the stimuli for the compilation of the first edition of the Atlante delle Spagge Italiane by the C.N.R, which summarized the results of research on about 40% of the Italian coastal territory. This atlas, the first of its kind covering the Mediterranean, was mainly aimed at urban planners, users of the coastal terri-

tory, and above all, the public administration. It was accompanied by the publication of "Raccomandazioni tecniche per la Protezione delle coste" (Technical advice for the protection of coasts), which in 1983, preceded the publication of the atlas charts.

In the years following, research was carried out in the field of coordinated projects of national interest by M.U.R.S.T., which at that time represented the Ministries of Education, Universities, and Research (M.I.U.R). The studies primarily focused on the relationships between natural processes and the changes undergone as a result of 'anthropologization' and subsequently, the identification of the beaches' sedimentary equilibrium

and changes resulting from coastal defense works. The gathered data allowed for the completion of the editing of the *Atlante delle Spiagge Italiane* (AA.VV., 1999) and the drawing up of a comprehensive evolutionary picture of the national coastline. The atlas is made up of 108 pages in 1:100.000 scale in which three themes are graphically condensed into a ready-reference: made-made works, natural works and hydrological & sedimentary dynamics. In 1998, a 1:750.000 map showing the risks to the national coastline was produced based on research carried out by the *Gruppo Nazionale per la Difesa dalle Catastrofi Idrogeologiche* (G.N.D.C.I.) of the C.N.R. Starting from the updating and revision of knowledge acquired in order to compile the *Atlante delle Spiagge*, various risk categories were attributed, based on ten-year evolutionary tendencies, the morphology of the hinterland and the presence and effectiveness of defense works.

In 2006 the *Gruppo Nazionale per la Ricerca sull'Ambiente Costiero*, from which the acronym G.N.R.A.C. is derived, presented a report on the Italian coastlines (AA.VV., 2006) at the *Consiglio Nazionale delle Ricerche*. Although the Association is still fairly young, it has brought together about 200 experts with research experience and experience in the management of coastal environments gained over a period of more than thirty years of activity. The report, published in a special edition of the scientific journal *Studi costieri* constituted the first summary on the evolution and criticality of coastlines in a regional sphere that was not exclusively cartographic. The report showed a grave situation, with 42,5% of all Italy's beaches undergoing erosion, many of which were stable however, due to defense works (Figure 1). The individual regional cases show extremely diverse

situations, resulting from both physical conditions and the specific land use of the coastline.

Entirely natural stretches alternate with intensely urbanized coastlines with beaches where erosion is progressing at a rate of some ten meters per year, as well as those where, over the last century, the shorelines has advanced some hundreds of meters. In all the regions erosion is principally caused by a sedimentary deficit due to the construction of weirs in the waterways, the dredging of sand and gravel from the riverbeds, and the construction of ports and projecting structures that prevent sedimentary flow along the shorelines.

From this overall picture, one can see how the solutions adopted in combating erosion have not been entirely effective, and how their diffusion has transformed stretches of sandy coastline into rocky coasts. In some places, different types of structures have been put to work (groynes, artificial islands and submerged or emerged adherent cliffs) in order to protect the coast and often associated with one or the other in various combinations. What's more, in some sectors, as in the case of the Tuscan coast, the diffusion of these works is such that they have a 2:1 protection ratio (2km of cliffs per kilometer of coastline). All of the aforementioned is well documented in almost 1400 publications on the topic between 1982 and 2005, listed in the appendix of the publication "*Lo stato dei litorali italiani*", added to the 350 publications produced by the C.N.R.'s *Progetto Finalizzato* in the 1980s.

Any analysis on the evolutionary tendencies of the coasts is therefore rendered more difficult by the high frequency of defensive works, of which one must

evaluate their effectiveness and impact on the adjacent coastline. Many stretches of coast considered to be stable are only so due to serious defensive interventions, and other advancing stretches owe this tendency to the barricading of sediments by gate structures that trigger important erosive processes. It is on these premises that the regional, and even more so, the national situations should be carefully considered, and only in-depth and up dated knowledge of the processes at work and the territorial specifications can provide reliable indicators for the management decisions to be effected.

Fortunately over the last few years, things are changing and the old rigid defenses are being substituted with 'soft' defenses, essentially based on the depositing of sand on beaches affected by erosion. This technique, known as artificial beach nourishment is being applied more and more often in the western world, with deposited material at times being protected by traditional defensive works. In some cases, containment works are not constructed, in favor of protection of the landscape and further beach nourishment. Many Italian regions are currently at work on projects of this kind and important research has allowed for the identification of sand deposits on the continental shelf opposite Italy's coastline.

Thanks to the Po territory, up until the middle of the 20th century there was, due to abundance of sediment discharge, an accentuated expansion of the delta area out to sea (Dal Cin & Simeoni, 1984). The decades following saw the establishment of a regressive crisis determined by the river's diminished solid transport by the construction of dykes and weirs and the excessive removal of inert materials directly from the riverbeds.

The strong subsidence in the area which, compared to gently sloping beaches not only determines the regression of the shoreline (meters for drops of only a few centimeters) , but also the steepening of the bottoms and the reduction of the coastal sand body also contributed to this regressive coastal crisis. The mouths of the river branches were also of grave concern, often being obstructed by sandy bars that limit the outflow of quotas to the sea and hamper navigation. Other criticalities in the delta area are related to the tendency, which has become more noticeable over the last few decades, of the lagoon mouths to restrict (Simeoni *et al.*, 2007), which slows down internal hydraulic circulation, favoring the depositing of light materials, the depopulation of benthic life forms and an increase of anoxic events in the water.

Undoubtedly, the delta's altimetric structure (Figure 2) is not protected (Bondesan *et al.*, 1995) because the larger part of the territory presents quotas that are below sea level and is dominated, by some meters, by the flooding of the waterways. The exaggerated lengthening of the delta branches, the rigidifying of the hydrografic network and subsidence has resulted in the delta assuming a basin shape, rising at the edges facing the sea and with a vast depression in the middle (Simeoni *et al.*, 2000).

Although there are clues indicating that at least some of the causes (for example the lowering of the territory due to the extraction of methane water) have to some extent minimized their negative effects, the management of this territory remains complex and intricate. Naturally in this situation, the primary problem is that associated with the identification of the territory's physical response to predicted climatic changes. If, nationally, the

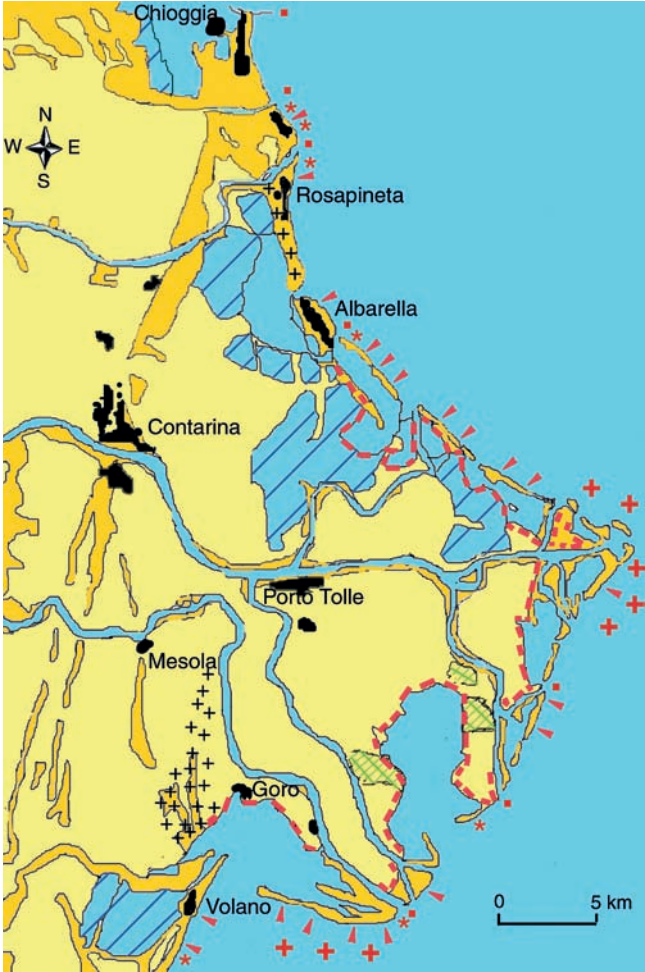


Figure 2: altimetric structure of the Po delta territory. Areas below sea level are indicated as well as the coast's evolutionary tendencies, the presence of defenses and elements pertaining to land use.

- KEY:**
- territory >0 m
 - territory <0 m
 - coastal retraction tendency
 - coastal defense works
 - mouth defense works
 - raised ground and dikes
 - urban areas
 - valli da pesca
 - rice fields
 - forest
 - rising bottoms

interest in the coastal environment and the economic value of the beaches brings forth the search to find new solutions for the defense thereof, it is also with the knowledge that not all coastlines are defendable, and also, in many cases, it is the erosion of these coastlines that guarantees the influx of sand to the neighboring areas. The fact that a large part of the world's beaches are undergoing erosion demonstrates that this tendency has its origins in global factors, principally the rising of the sea level.

It has been estimated that within 2020 about half of the world's population will settle in territories within 60km of the sea. Should this be the case, it is evident

that all plans to develop coastal areas should be carefully evaluated (Simeoni, 2005) in order to avoid having to intervene in order to protect newly constructed settlements in the near future.

Bibliography on page 112.

_INTRODUCTION
THE DELTA AND FOREIGN LAGOONS: THE SITUATION, PROBLEMS AND SOLUTIONS

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Deltas are strategic points on the borders between coasts and the sea. In general, they are rich in water resources and have fertile terrain, and are therefore important areas for food production. Consequently, civilizations throughout history have inhabited these areas, and today they are a source of richness to many nations due to their agriculture, fishing and the development of tourism.

Moreover, the particular enclave typical of these areas represents a rich environment and lagoons and deltas are the most emblematic manifestation of its biodiversity. The paper presented at the conference describes the situation, problems and alternative solutions for the lagoons of the Mediterranean partners of Delta Med (the Po, Nile, Evros, Danube, Rhone and Ebro).

These Deltas' characteristics are described, as is their evolution over the years. The considerable differences between them are noted, and certain typical issues that they have in common are also summed up including: the management and quality of water resources, subsidence and flooding, saline environments and salt-wedge intrusion, coastal regression, subsidence and eustatism, wetlands and lagoons, environmental agriculture, as well as environmental conservation and sustainable development. Furthermore, the potential impact of climate change on the vulnerability of the deltas is evaluated, with particular attention being paid to the effects of rising sea levels.

Threats to the deltas are also analyzed, that is: the upstream development of water basins, anthropic pressure, the impact that the population has, economic and tourism development, the fragility of the deltas' natural systems, the pressure on water resources and risks to which they are exposed, water quality, capacity, infrastructures,



The Thames barrier.



Flooding of the Po.

flow, environmental impact, salinization, regression, subsidence, threats to the wetlands and lagoons, the loss of biodiversity and the effects of climate change.

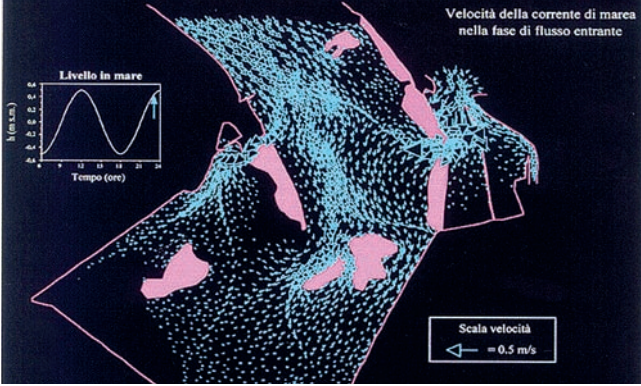
All in all, a wide range of solutions and alternatives for addressing the threats and challenges facing the deltas are presented. These solutions could be structural measures such as the maintenance and restoration of water infrastructure and coastal areas, the improving of water quality and the efficiency modernization of irrigation, water reuse, implementation and retention of the network of freshwater canals, construction of salt water barriers, sea walls, polders, pumping stations, as well as the supply and redistribution of coastal sand, dune protection and climate change adaptation measures.

The importance of implementing non-structural management measures, such as the management of the basin's water resources and sediments, the overall assessment of environmental flow in the delta (rivers, wetlands and lagoons), the protection and restoration of the wetlands and lagoons, water management in general, environmental conservation measures and the development of environmentally sustainable agriculture are underlined.

One can conclude that in order to achieve sustainable development, it is necessary to confront the current and future threats and challenges caused by progress and global social changes, be it those that have already occurred or those that are emerging, as well as the dangerous effects of climate change on the deltas' existence and survival. In order to do this, it is necessary to implement an integrated, structured management plan and develop civil administrative processes and structures, in this way improving the governance of the deltas.



Defense embankments to protect against erosion in the Sacca degli Scardovari.



Mathematic model for a hypothesized regeneration project in the Vallona lagoon (Po Delta).

ACTS OF THE CONFERENCE
THE EBRO DELTA LAGOONS

INMA JUAN FRANCH
Parc Natural del Delta de l'Ebre

The Ebro Delta Lagoons

Located in the south of Catalonia, The Ebro delta is characterized by a landscape that is, from a biological point of view, extremely rich, bringing together a priceless diversity of fauna and flora. Covering 320 km², it is the largest aquatic habitat in the Catalonia territory and is of vital importance to the Mediterranean wetlands. Its biological richness is contrary to its high levels of anthropization and the agricultural transformation of large parts of its surface area.

In order to create a certain harmony between the natural values of the area, its use by man and the requirements of its inhabitants, in 1983 the *Generalitat de Catalunya* established the *Parque Natural del Delta de l'Ebre* (the Ebro Delta Nature Park), the importance of which is internationally recognised by specialized bodies of the highest level. The Delta's landscape is extremely particular. Its entirely flat terrain, through which the Ebro River flows, makes it quite unusual.

The large rice cultivations, changing from season to season (earthy in winter, flooded with water in spring and green in summer), dominate the Delta's physiognomy. The coastal area is considered to be one of the Mediterranean's most beautiful landscapes with its large reed surrounded lagoon. The peripheral areas are made up of large areas of land rich in salt deposits, with wide desert like beaches and dunes bordered by *Ammo-*

philae and other plants well suited to this environment.

The lagoons are the most important aquatic environments of the Delta. They possess all the characteristics of Mediterranean coastal lagoons and currently make up part of the Ebro Delta Nature Park. Unlike the inland and mountain lakes, their nearness to the sea and the influence of sea and fresh water define these ecosystem. They are also considered to be priority habitats according to the *Habitats Directive* 92/43 of the European Union code 1150: lagoons, *albuferas*, and coastal ponds (*Ruppietea maritima*e, *Potametea*, *Zosteretea*). Their importance is derived as much from their natural value as from the socio-economic activities developed in them. Even if the deltas could be considered to be highly productive ecosystems, this is contradicted by their extreme fragility, in fact they are areas that can often be threatened: their worst enemies are, among others, eutrophication, contaminants and the over use of their resources.

The lagoons' origins are a direct consequence of the Delta's evolutionary dynamics. Some lagoons are formed through the isolation of large masses of seawater that are progressively surrounded by barriers and cordons of sand. Others originate from the overflow of water from rivers as they flow towards the sea. Currently there are eight coastal lagoons in the Delta: the *Olles*, *Canal Vell*, *Garxal*, *Calaixos de Buda*, *Alfacada*, *Platjola*, *Tancada* and *Encanyissa*. These lagoons, directly connected to the sea and surrounded by rice fields, which make up the borders between the sea and continental aquatic environments, are extremely different to Mediterranean coastal lagoons in terms of their hydrologic function. This is due to the artificiality of the water sys-

Total Delta plain surface area	330,31 km²
Alluvial plain	83,4%
Rivers	2,4%
Lagoons	4,3%
Lobes	10,0%
Bays	68,46 km²

Table 1: Ebro Delta surface areas.



tem. Used predominantly for rice cultivation (22, 000 ha), the system consists of an immense network of canals and fresh water gullies spread throughout the Delta.

A hydraulic network of over 800 km

The excess freshwater resulting from irrigation, and above all, drainage of the rice fields flows into the lagoons from April to December, while from July to April, the period in which the canals are closed for rice field irrigation, salty sea-water invades the lagoons. The interaction of these two types of water defines the ecosystem in different areas, not only in the Delta lagoons, but also in the bays. The only lagoon in which this singular hydrologic cycle is not produced is the *Garxal*, into which fresh river water flows. This agricultural system marks the hydrological cycle of many of the Park's protected areas.

The vegetation

The inflow of large quantities of fresh water results in the development of intense vegetation within the lagoons. The submerged vegetation is made up of macrophytes, rooted plants that grow underwater. There are wide prairies, principally made up of species like *Potamogeton*, *Ruppia* and *Najas*, which serve as food and shelter for many species of the food chain. On the perimeters of the lagoons, a fairly large cordon of emerging vegetation mainly composed of *Phragmites australis* and reeds, grows in brackish marshes.

Ebro Delta:
fisherman
with *Tresmall*;
flamingoes, hunters
in the Canal Vell
lagoon.



Figure 2: brackish water and *Salicornia*.

The fauna

Throughout the year, the birds of the Delta are attracted to the Lagoons. In winter, the lagoons are complemented by large concentrations of ducks, coots (*Fulica atra*), cormorants (*Phalacrocorax carbo*) and Flamingos (*Phoenicopterus ruber*) with nesting colonies of herons and terns in spring and summer. It is one of the most variable environments under the ichthyological profile due to its direct relationship with the physico-chemical conditions of the water.

Species like the grey mullet (*Chelon labrosus*), European sea bass (*Dicentrarchus labrax*), Gilthead sea bream (*Sparus aurata*), European eel (*Anguilla anguilla*), Common sole (*Solea vulgaris*) and the Common carp (*Cyprinus carpio*) populate its waters and are fished by fishermen of the Cofradia de San Pedro, that has a fishing concession in the ponds between October and March.

Human activities

The biological productivity in the lagoon has become an economic resource for the Delta population. The first colonies took advantage of its inestimable vegetation and fauna resources that favored subsistence activities such as hunting and fishing which are now deeply rooted practices in the territory.

- **Hunting:** the presence of a large amount of aquatic birds attracts local and international hunters. Currently there are 11 hunting associations with more than 4,000 members. Hunting activities are administered by the *Departament de Medi Ambient* (environmental management) of *Generalitat de Catalunya*, which regulates activities with hunting use plans, distributed by the Nature Park management, the monitoring and application of which is subsequently guaranteed by custodians (*agents rurals*).

- **Fishing:** the lagoons are protected by the Nature Park and the laws provide

that all the activities carried out must follow traditional methods, a limitation that is also applied to fishing. The *Cofradia di San Pere* has always had the right to fish in all the lagoons. It consists of about 900 members to whom only 40 per year are given licenses to fish between October and March.

- **Tourism:** the richness of the landscape and ichthyic population attracts many visitors wanting to discover and enjoy its beauty. The law prohibits recreational activities in the lagoons, and it is for this reason that it has been made possible to visit the Park through various structures, viewing points, interpretive walks, etc. that allow visitors to get to experience the appeal of this natural environment.

Management of the lagoons

Ecologically speaking, lagoons are among the most valuable of environments and require on going and complete management. Managing the lagoons means bringing all of the hydrologic events that occur within them to have a finality that is productive and that conserves these ecosystems. For example, the correct management of the water allows for the development of beds of macrophytes, which in turn serve as food and offer refuge to many species in the food chain. In the past, the management of the water in the basins was carried out by their users. The fishermen, hunters, the *comunidad de regantes* (public corporations responsible for the organization and the general use of public surface and ground water that is considered to be communal) and guardians have acquired knowledge and experience that they currently share with the Park management that is in charge of the lagoons' administration.



Figure 3: (clockwise from left to right) cyclist at Garxal lagoon. Seabird migration. Lighthouse at Punta del Fangar. Rice field in November. Fisherman with Rall.

Park objectives in relation to the lagoons

1. The conservation and improvement of biological, anthropic values and their diversity. 2. To establish a safeguarding and sustainable development strategy with all of the users.

Nature Park actions aimed at the complete management of the lagoons

1. The close, coordinated collaboration with the *comunidad de regantes*, the bodies that hold concessions of water from irrigation canals and that can therefore collaborate in supplying water to the lagoons and the implementation of management that guarantees the conservation and improvement of the lagoons. 2. To execute the approved management plans for each of the Delta lagoons. 3. The sustainable management, together with the fishing and hunting associations, of fishing and hunting activities. 4. To coordinate the different public administration bodies that have jurisdiction in the Park area. 5. To improve the water

system in order to facilitate the perfection of management and monitoring. 6. To favor the maintaining of rice cultivation and the implementing of agri-environmental measures, in this way guaranteeing the environmental maintenance of the current Delta ecosystem and its lagoons. 7. To carry out the monthly monitoring of biological and physicochemical parameters of the lagoon waters as well as that of the macrophyte beds, as indicators for managing conservation criteria of the lagoons' environmental conditions, and at the same time monitoring anoxia, eutrophication and compaction levels. 8. The carrying out of controlled fires in the reeds. (*Phragmites australis*). 9. The carrying out of periodic clearing of interconnecting canals in the lagoon. 10. Monitoring and checking of activities. 11. Interpretive and computer signposting of the norms and notions relating to the lagoons.

All of these actions contribute to the improvement of lagoon management, but it is also clear that there are still some threats that render these areas ex-

tremely fragile, for example:

- the presence of water: managing the Ebro River; flooding of the rice fields;
- water quality: issues related to chemical and anthropic pollution;
- eutrophication, hypersalinity and anoxia;
- compaction of internal basins and canals connecting to the sea;
- regression and subsidence;
- anthropic pressure;
- colonization by allocthonous species.

The conservation of these natural areas is not only the Park administration's responsibility, but also that of society in general, and it is our duty to preserve this natural heritage for future generations.

_ACTS OF THE CONFERENCE
NORFOLK BROADS

HENRY CATOR
Officer of the Order of the British Empire (OBE)
Fellow of the Royal Institution of Chartered
Surveyors (FRICS)

What we in England call The Norfolk Broads. These are situated in Eastern England where we have some of the lowest lying land and the most fertile agricultural land (Figure 9). This map (Figure 1) shows the extent of the low lying land managed in Eastern England by the Internal Drainage Boards under the management of the consortium named the *Water Management Alliance*. The river catchment of the Broads all flows out into the North Sea at Great Yarmouth. The environmental importance of the Broads is huge. A huge freshwater habitat which is now challenged by climate change and rising sea levels. The Broads is the largest fresh water habitat in England. The Broads and Rivers are closely allied to the management of the surrounding land.

The origin of the Norfolk and Suffolk Broads goes back in history to the medieval times when peat was dug for fuel. These diggings then flooded and channels were cut to link them to the adjacent river system.



Figure 2: in the past, the Broads river system made up an integral part of the transport network.

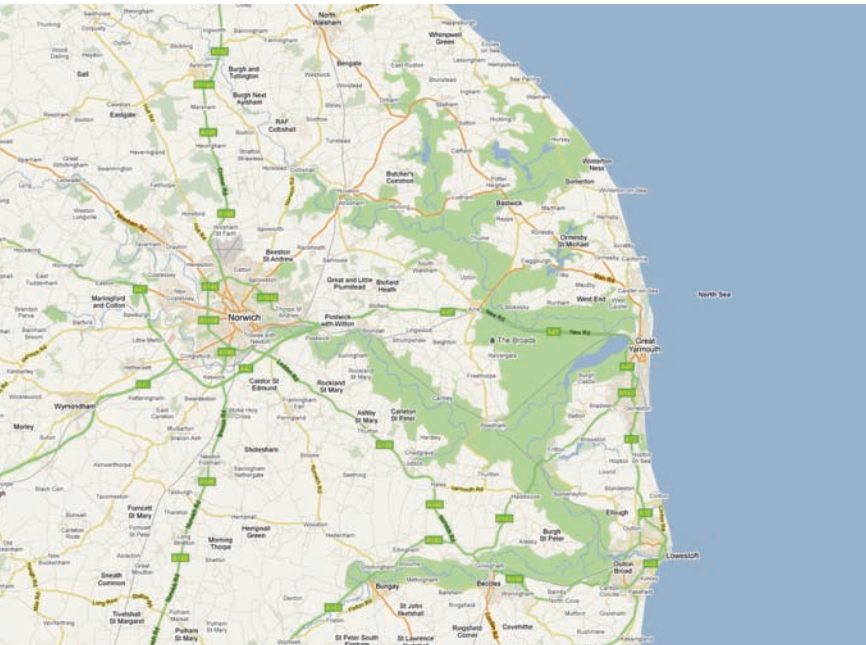


Figure 1: map showing the size of the Norfolk Broads.



Figure 3: In terms of specific and habitat biodiversity, the management of the open spaces in these marsh environments produces enormous benefits.

The surrounding land is predominantly flat so the rivers and Broads soon became a vibrant water transport network. Norwich was for many years the second largest city in England after London, its wealth coming from wool and trade with nations within the Hanseatic League in northern Europe. The marshes and land along the rivers was productive for grazing and the harvesting of reed and sedge used for thatching of roofs on the buildings. The surrounding higher land was and continues to this day to be productive arable farming land.

In the early 1900's the Broads became a popular destination for wildfowling in the winter and sailing in the summer. Rural Britain was becoming accessible following the introduction of the railways. By the 1920's local boat builders had started producing boats for hire. With the development of the internal combustion engine motor boats soon increased and at the peak in the 1970's there were over 5,000 motor vessels registered on the Broads network, most discharging

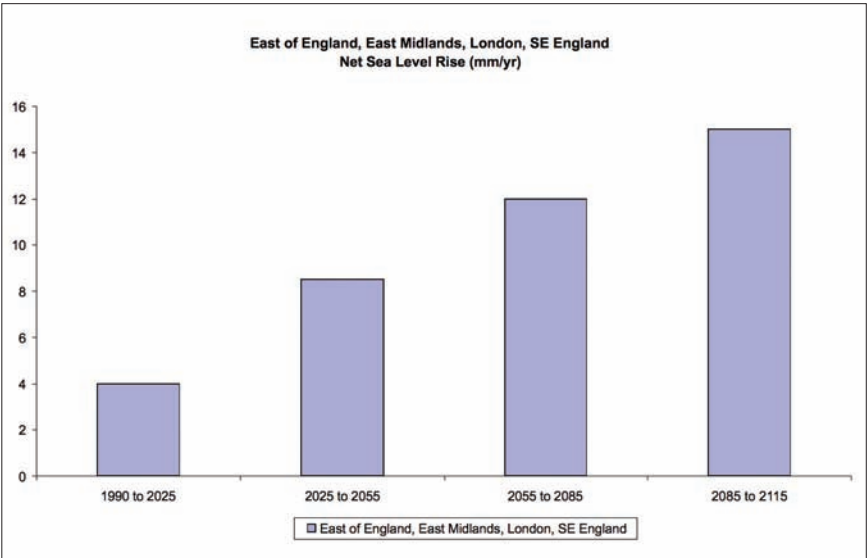
their toilets directly into the river.

The legislation controlling sewerage treatment works was weak. The Broads were becoming nutrient enriched and the algae that flourished soon cut out the sunlight causing the plants to die and the water became turbid and polluted (Figure 10). Water quality is now improving again with boats having to have sealed tanks for sewerage. The local villages are connected to main sewers so there is no diffuse pollution from septic tanks. A lesson that was learnt is how sensitive a balance there is within nature before a tipping point is reached.

The holiday industry grew until the 1980's when cheap flights and holidays abroad provided an alternative to holidays on the Broads. The increased commercial pressure placed on the fragile eco-system resulted in the formation of a National Park Authority in 1989.

Following the Broads Act 1989 the *Broads Authority* was formed. This body

Figure 4: net sea level rise forecast, a phenomenon that has its origins in salt wedge growth.



was for the first time to bring together the interests of conservation and navigation within the Broads area. Throughout the 1990's conservation came to the fore and agriculture and tourism were increasingly challenged to change their management. "Green" tourism and electric boats are now common in the Broads area (Figure 7). Most of the marshes which were ploughed and drained during and after World War II have now been returned to grazing marshes where high water tables for birds and plant bio-diversity can be maintained.

A system that is reliant upon fresh water. The farming systems have changed as well. In the early 1990's the Broads Grazing Marsh Scheme became the pilot for the whole of the national programme for *Environmentally Sensitive Areas* (ESA's). Under this project farmers were given grant aid to return arable land to grazing. The effect of pastoral management in these marsh areas is very beneficial for wildlife, flora and fauna (Figure 3).

As the Broads are man-made water bodies from peat diggings, they require intervention and management to reduce

the sediment build up and this is done by dredging. As a result of sediment accumulating rapidly in the last sixty years and the rising dredging costs since the early 1980s, there has been a significant decrease in the volume of material routinely removed (Figure 5). The knock-on effects of sediment build up in the waterways are failure to achieve water quality improvements which are required to meet the UK Government's targets for an SSSI condition and boats running aground in some areas.

Whilst dredging can now be carried out at a reduced cost following the purchase of equipment by the *Broads Authority*, the navigation authority, the continuing issue is the disposal of dredged material. This has been a particular issue in an area of water known as Heigham Sound where navigation has been affected due to the increased sediment. The Broads Authority is currently trialling a method where metal baskets lined with plastic are filled with sediment and placed into the water to rest on the mud. A circle of baskets will be formed and sediment will be deposited in the centre to form an island, which in time will become a habitat

for wild fowl (Figure 5). This will not only solve the problem of sediment deposits but will have a beneficial impact on conservation.

The increased demands for fresh water from a growing population and new housing coupled with agricultural demand for irrigation have put increased pressure on the fresh water resources in these catchments. As a result in times of low rainfall there is less fresh water within the river system flowing to the sea.

With sea levels rising at a rate of about 6mm per year the result is salt creeping back up the river system (Figure 4). When there is not a sufficient flow of fresh water coming down the river the heavy salt water wedge heads further up stream leading to an increasing risk of saline intrusion to the surrounding freshwater system.

The grazing marshes rely on fresh water within the surrounding dykes. These provide drinking water for the livestock as well as serving as 'wet fences' to keep cattle and stock on parcels of land in separate ownership or occupation.



Figure 5: canal dredging works and embankment maintenance, also useful in creating new extensive secondary habitats.



Figure 6: incentives for Agriculture and extensive grazing are constantly evolving, in line with the Broads Authority's planning of the area.



Figure 7: eco-tourism in the Broads.

The dykes are the drainage channels by which this land is drained. Much of it relying upon pumped drainage as it is beneath sea level.

One of the main challenges facing the Broads is how to protect a fresh water site of international importance from saline intrusion. A Tidal Barrage at the mouth of the rivers at Great Yarmouth was first talked about in the early 1950's but discounted following opposition from the Port of Yarmouth and the effect that it would have on shipping. With the recent construction of a new Outer Harbour at Great Yarmouth there is now a possibility to look again at water control structures.

and wildlife and protect the businesses of those who live and work in the area. At what point and at what level do we invest today in order to protect tomorrow? Perhaps we all need to work closer together!

The questions that face the Government Agencies, local stakeholders and the local community is how important is it to maintain a freshwater system or should we accept natural processes and surrender back to the sea the land which has been reclaimed over the last 1000 years? How important is this fertile agricultural land to feed a small island nation with a growing population?

How important are the fresh water species that have colonized the Ramsar Sites, the Special Areas for Conservation (SAC), the Sites of Special Scientific Interest (SSSI) and the National Nature Reserves (NNR), all these designations with statutory protection under the EU Habitats Directive? Who should be involved in the debate? How can works be financed? Is it a national or local responsibility to preserve this area?

It is apparent that, given the money, there are technical and engineering solutions which can be made to protect this area from saline intrusion and so preserve its unique and special bio-diversity

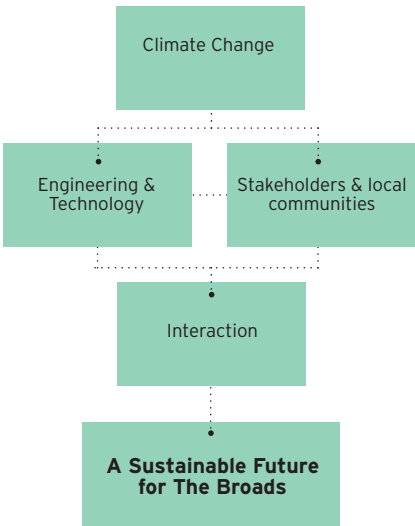


Figure 8: actions indispensable in obtaining a sustainable future for the Broads.



Figure 9: aerial view of the Broads.



Figure 10: through the various activities established in the *Broads Act*, an effort has been made to improve water quality, eliminating excessive algae and minimizing discharges into the basin.

_ACTS OF THE CONFERENCE THE CURRENT SITUATION AND PROBLEMS OF THE PARANÁ DELTA

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This work forms part of the project titled *Urban-environmental risk map of the Delta Territories. Case Study: the Paraná Delta*. Changes in land use together with the expansion of human settlements, resource consumption, the transformation of the landscape and incompetence on the half of real estate developers and politicians, or those who are responsible for making decisions, all have an affect on natural ecosystems on different territorial scales, and this is precisely what has happened in one of the country's most important wetlands: the Paraná delta.

Urban-environmental risk is a concept that implies the existence of two factors: danger¹ and vulnerability², and it is the interplay between these two factors that gives rise to the risk, the characteristics and specificity of which are extremely diverse. This document describes the general characteristics of the area and its problems.

General Characteristics

The Paraná River delta is one of the most important wetlands in Argentina (Figure 2). It stretches out over 300km and covering an area of 17,000 km², it is 320 km long, varying in width from 18 km outside the city of Baradero to over 60 km between the rivers Luján (Buenos Aires) and Gutierrez (Entre Ríos).

From the town of Diamante to its estuary, it is divided into three main areas:

- the *Upper Delta* (from Diamante, Entre Ríos to Villa Constitución, Santa Fe).
- the *Middle Delta* (from Villa Constitución to Ibicuy, Entre Ríos).
- the *Lower Delta* (from Ibicuy to the mouth).

The scale of the analysis is closely related to the amount of information available, which facilitates the understanding of the complex structure of the ecosystem.

Landscape type

The Paraná delta is a vast wetland that is home to a rich biodiversity and has the functions of, among other things, charging and discharging groundwater, flood control, the retention of sediments and nutrients, the stabilization of the shoreline and protection against erosion and climate changes. This is a complex and dynamic ecosystem. The hydrological regime is also the main deciding factor in the structure of its communities and ecological functions.

This type of ecosystem plays a crucial role in many natural processes, thus presenting unique and recognizable characteristics and attributes (Canevari *et al.*, 1999). Its main functions include: flood control, the recharging and discharging of aquifers, sediment retention, accumulation of nutrients and toxic substances as well as acting as a carbon reservoir.

Colonization

Being the gateway to the metropolitan area of Buenos Aires (AMBA), the Paraná delta region has always been a relatively important area from an economic and social point of view. The Delta region's

¹ Danger refers to the probability of the occurrence of a physical event that could be damaging to society.

² Vulnerability refers to a society's tendency or an element of society to be subject to damage.



Figure 1: the second phase of colonization: the establishing of the first permanent settlements.



Figure 2: the Paraná Delta.

history can be divided into three main phases, from the period of its “conquest” to that of its occupation by native peoples. It is noted that the first inhabitants of that area were the ancestors of the Guarani, in the southeast and Chanàs in the northwest.

The Creole and European occupation of these lands (between the eighteenth century and the first half of the nineteenth century) marked the beginning of the construction of the territory. The main activities were the direct extraction of natural resources and this did not lead to the creation of major settlements.

A second period (from the second half of the nineteenth century to the early twentieth century) is marked by the beginning of a major transformation process of the natural environment, mainly due to the formation of the first permanent settlements and the intensive cultivation of fruit trees by small family units. This period was characterized by the im-

migrants’ need for land to work, and the existence of cheap land in the Delta, as well as its proximity to the urban market of Buenos Aires, which drew many people to this area (Figure 1).

All produce was destined for the domestic market, Greater Buenos Aires in particular. The annual fruit harvest was sold at the Port of Tigre, also known as “*Puerto de Frutos*” (Port of Fruit). For some years the Delta was the only supplier of fruit to the metropolitan area, as well as being a tourist destination and an area mainly dedicated to recreation. This phase coincided with the region’s heyday.

The third and final period began in the mid-twentieth century, that is, when the three factors that previously had allowed for the development of the area ceased to exist together, as evident in the crisis which small production underwent.

The three conditions can be summarized as follows: the cessation of agri-

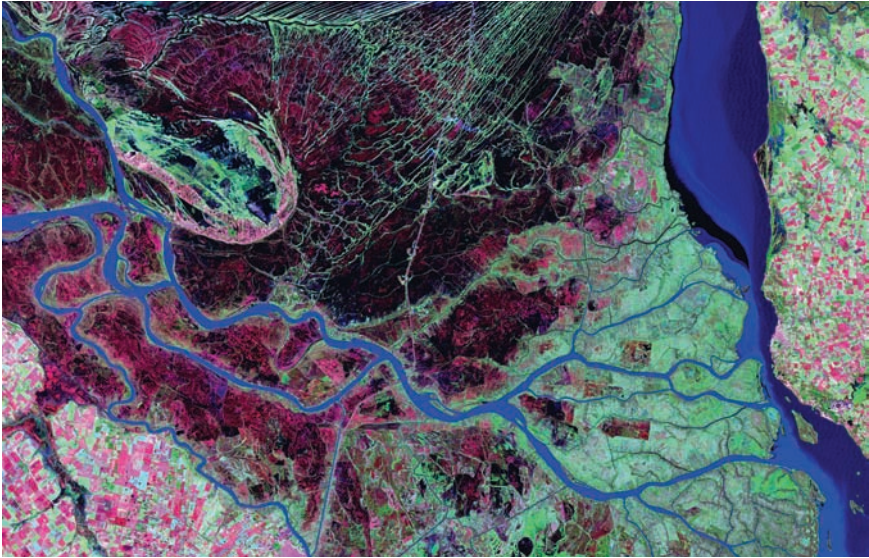


Figure 3: the advancing of the urban frontier in the Paraná Delta (Image LandSat satellite).

Figure 4: spread of the often very large "closed residential complexes": Colony Park.

Figure 5: widespread urbanization.



cultural production (mainly fruit production), increased demand for wood and its derivatives, profit from deforestation; the impossibility for small producers to invest in this market due to their limited capitalization capacity.

Small producers responded by abandoning and selling their farms and migrating to the city. Those who remained diversified their production and sources of income (reforestation, the basket market, subsistence farming, working for companies or in public offices, etc.). It must be said that this decision was more likely a subsistence strategy than one aimed at economic development.

Current issues

Due to its location adjacent to the highly anthropized and most firmly established development corridor in the country, this is an area of particular interest, consistent with land use transformation processes. The territory is divided into three main groups extending from the capital city of Buenos Aires.

The advancing of the urban frontier

Since the mid-twentieth century, the urban area has grown in size and changed considerably in the 1990s (Figure 3). Thirty one percent of the national population lives in the relatively small (less than 0.15% of the surface area of the country) Greater Buenos Aires (AMBA) area, which produces 53% of total GDP.

In the 90s the development of the municipalities of the first and second groups making up the territory was promoted. This development was characterized by a profound reforming of the property, the passing of new urban laws, falling inflation, rising direct foreign investment (due to the lowering of international interest), the construction of transport infrastructures (motorways) and the transformation from an industrial economy to a service economy, yet it was also saw the fragmentation of social classes closely related to territorial segmentation.

The housing market wielded its power over any attempt at planning. In this context, the private stakeholders reaped certain benefits in relation to the governance and management of the city regarding institutional spaces. Thus, the metropolitan city and territory influenced by it favored the construction of more than four hundred closed residential complexes, characterized by different types of urban planning, covering a radius of between 30 and 70 km from the city centre.

About 75% were occupied from 1991 onwards (Koppmann Sonia Vidal, 2002, 2005, 2006, 2008, Pablo Ciccolella, 2004; Guillermo Tella, 2001), the highest percentage concentrated along the north and north-western corridors of the region, close to the North exit of the *Pan-American Highway*. According to P. Cic-

colella, the area delegated for the expansion of private housing is 500 km² (even larger than that of the city of Buenos Aires which is around 300 km²).

The Delta is an interesting case study not only because of its biodiversity, but also because of the different modes of appropriation and transformation of the territory on the basis of its productive and residential processes.

Different territorial realities can be found along the Delta: urbanized areas (medium density) (Figure 5), natural territories, industrial centers, farms, mixed-use areas, ports, private urbanization and spread out urbanization (on the islands).

The increasing private urbanization of the *Lower Delta* islands has led to certain environmental consequences:

- the physical changes to the zone with embankments, reclamations and/or works involving the diversion of water-courses, the construction of embankments or the flooding of parts of the Delta;
- the lack of environmental impact assessment of the projects. The lack of adequate monitoring of projects and works;
- the violation of towpath regulations, defined in the Civil Code as 35-meter wide areas stretching inland from the shoreline that should be free entry public areas. The private sector does not comply with these provisions, in violation of national law and the Civil Code.

Geological evolution

The advancing of the Delta frontier

The Delta river carries 160 million tons of sediment per year from the highest part of the river and deposits it at the mouth.

The *Bajo Delta Bonaerense* (which belongs to the province of Buenos Aires) can be defined as the estuary. In the eastern part, at the mouth, is subject to continuous sedimentation causing the formation of banks and islands in what is called an “advancing front” (Kandus, 1997). These islands form a growing delta at the mouth of the Plata (Iriondo and Scott, 1979, Parker and Marcolini, 1992).

A study by the *Instituto Nacional de Agua (INA)* showed that in the last 200 years, the surface area of the Delta has increased to 200 km², and if we do not proceed with the reclamation of the *Río de la Plata*, the front will reach the city of Buenos Aires’ coast within 110 years.

The following issues are to be resolved:

- the administrative fragmentation of the island territory due to the lack of delegation of responsibilities in the area;
- the lack of a definition of the areas, in order of priority, to which production and preservation is to be dedicated. In general, this is problematic in the broadening of productive horizons;
- illegal land occupation and depopulation due to the implementation of laws, which today has resulted in some producers being involved in land ownership disputes;
- the phenomenon of newly formed territories (alluvial or embanked), which are acquired and developed without the intervention of the government, creating further conflict.

The expansion of agricultural boundaries

Natural ecosystem: Flora

Generally speaking, the Paraná delta,

being subject to tidal freshwater, constitutes a wetland area that is influenced by lunar tides and characterized by the effects of the wind in the vicinity of the *Río de la Plata*.

Without a doubt, as one moves further away from the river, the wetlands decrease in size, thereby establishing a hydrological gradient between downstream and upstream water sediment (Kandus, 2002). And it is the latter, also influenced by the rising seasonal peaks of the Paraná River, which gives the area its typical alluvial plain characteristics.

The plant communities initially appear on banks and coasts, where the flow of the sediment-laden waters is weak.

LOWER DELTA		
Laurel	Monte Blanco Forest	
Guama (<i>Inga edulis</i>)		
Higueron (<i>Ficus costaricana</i>)		
Myrsine (<i>Myrsine laetevirens</i>)	Moderate height	
Geiger Tree (<i>Cordia sebestena</i>)		
Palm		
Abundance of Epiphytes and Liana		

UPPER AND MIDDLE DELTAS		
Willow	Woodland trees	
Aliso del río (<i>Tessaria integrifolia</i>)		
Curupí (<i>Sapium haematospermum</i>)		
Laurel	Fast growing	
Timbo Blanco (<i>Albizia inundata</i>)		
Cockspur Coral Tree (<i>Erythrina crista-galli</i>)		
Scarce Epiphytes and Liana		

Table 1: vegetation species of the Lower, Upper and Middle Deltas.

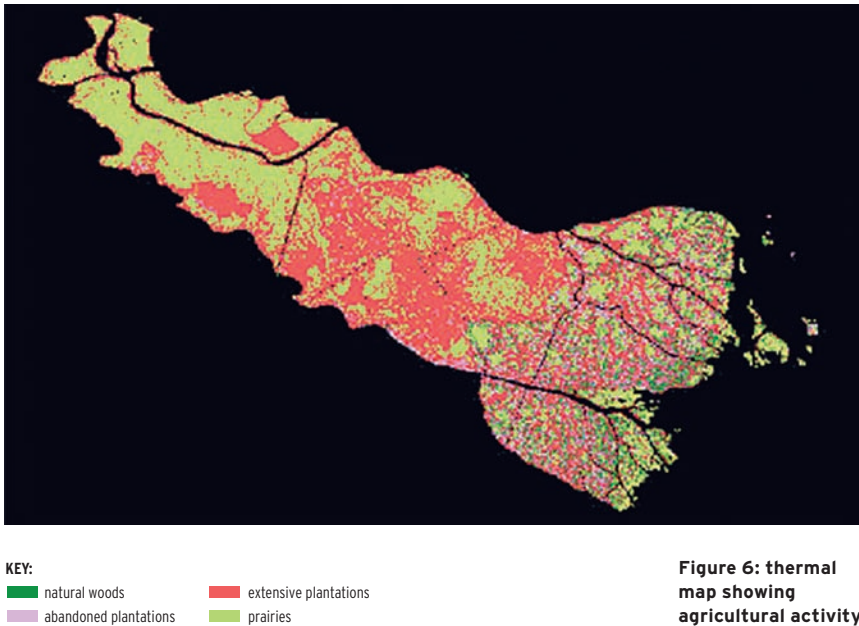


Figure 6: thermal map showing agricultural activity.

The succession process begins with pioneer species such as rushes, which gradually contribute to the elevation of the terrain, eventually forming an island. The higher part, the bank, is occupied by rainforest. In the *Upper Delta* there is a greater presence of elements in the Chaco region, mainly growing on the rocks that surround the island system. A bona fide jungle called "*Monte Blanco*" characterizes the *Lower Delta*.

The flora that has been re-introduced, either by intention or not, poses a serious problem for the Delta ecosystem, causing the displacement of native flora and colonization of natural environments (Table 1).

Agricultural activities

The Paraná delta represents one of the most important poplar and willow cultivation frameworks in the country (Figure 6). The prevalence of these crops is due to the fact that the climatic and soil conditions of the area are more favorable for large-scale production of timber and

especially fast-growing soft wood. On the other hand, *Salicaceae* are extremely ecologically adaptable, grow rapidly and produce high quality materials suitable for various types of commercial activities.

The entire region's forest surface area currently occupied by *Salicaceae* is estimated to be about 58,000 ha, 38,500 ha of which are in Entre Ros and 19,500 in Buenos Aires (Borodowski, 2006). One of the major problems preventing the Delta from expanding its production horizons is that of land ownership. The first settlement plans permitted those who moved there to request that they be given a sufficient amount of land on which to live and start up a productive activity.

The Paraná delta region is a structure made up of a series of small establishments. According to the SAGPyA, 92% of establishments have less than 200 ha of land, medium size producers that have between 200 and 1,000 ha account for 6%, while the large producers with more than 1,000 ha account for only 2%.

Traditional agro-pastoral activities have also contributed to the destruction of natural vegetation along the basin, leading to deterioration and soil erosion, as well as the elimination or fragmentation of habitats of the wetlands' typical tetrapod species. Rain forests like *Monte Blanco* have been, and continue to be affected by this problem to the point that not only their role as biodiversity corridors has been compromised, but also their existence (Bucher, 1999, Quintana *et al.*, 2002), especially the subtropical species, since many of them are exclusive or optional to these forests (Giraud *et al.*, 2004).

Agricultural and pastoral activities developed on land or with techniques that are inappropriate, as well as the increased advancing of the agro-pastoral border contribute to intensifying the problems mentioned above. All of this amounts to water resource (large dams, canals and drainage works) management practices that affect the structure and especially the functioning of wetland systems (Bo and Quintana, 1999).

As a confluence area for the La Plata River basin's reclamations, the Delta is not only suffering from the impact of unsustainable practices developed upstream, but also those outside the country.

The La Plata basin

La Cuenca del Plata (the La Plata Basin) is the surface area into which the waters of the La Plata River and its tributaries flow. It covers a vast territory that extends beyond the national borders and encompasses an area with enormous potential. It covers an area of 3.1 million km², of which 49% belongs to the Paraná River basin.

The basin territory extends into five different countries of which its main rivers (the Paraguay, Paraná, Uruguay and Plata) form the borders. Given its size, morphological diversity and climate, it generates a wealth of water resources that have not yet been exploited to their full potential. If one adds its human resources and the economic activities that are developed here to this physical reality, one can get a general idea of the area of study's size and potential.

The Paraná River is the second most important river in South America and fourth in the world in terms of size, scale and biodiversity, as well as being a source of life and culture to communities that occupy its banks. The river has been altered and damaged, mainly due to the construction of dams in the upper section. Forty-one dams in total have been built in its basin covering nearly 1.8 million ha of terrain.

The quantity and distribution of the population is related to its natural conditions and historical-economic structure, which for the large part, has been developed in the eastern part of the Paraguay-Paraná Axis, headed up by its two metropolises (Sao Paulo and Buenos Aires). The percentage of population living in Brazil (67%) added to those resident in Argentina (24%), amounts to a total of 91% of the total population of the Basin.

Hydroelectric dams

The large dams were mostly developed over the course of the twentieth century. Large hydroelectric plants were built, for which large areas of territory were flooded. This was not done for the benefit of the local population, but in order to provide cheap electricity to large electro-intensive companies, a fact that

has left a legacy of pollution, poverty and even higher debt. Along the Paraná River, there are four hydroelectric plants (the Ilha Solteira and Jupiá in Brazil, the Itaipu between Brazil and Paraguay and the Yaciretá between Paraguay and Argentina). These hydroelectric dams have certain negative effects on the territory, which can be classified as:

- first level effects: producing chemical, physical and geomorphologic consequences, resulting in the blocking of the river and affecting its distribution and natural frequency of its flow;
- second level effects: producing changes in the primary biological productivity of the ecosystem, including effects on river and riparian plant life and downstream river habitats, wetlands for example;
- third level effects: altering the fauna (e.g. fish) as a result of first level effects (that inhibit migration) or second level effects (such as the reduced availability of plankton).

The Guarani aquifer system

The so-called Guarani Aquifer (Figure 7) is one of the largest underground water reservoirs in the world and lies below the Paraná River basin. It covers an underground area of about 1.19 million square kilometers (equal to that of Spain, France and Portugal put together) of which 850,000 km² (71.4% of total) falls in Brazil, 225,000 km² (18.9%) in Argentina, 70,000 km² (5.9%) in Paraguay and 45,000 km² (3, 8%) in Uruguay.

In Argentina it is less than 900m below the surface, while in the other countries the depths vary (between 50m and 1,500 m). Generally, the water pressure is so high that, when drilling is carried out and groundwater is reached, the water rises naturally, often emerging above

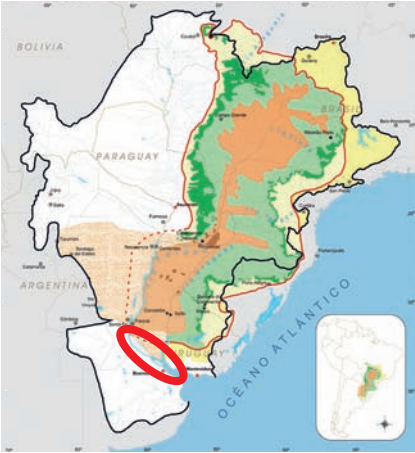


Figure 7: the Guarani aquifer system.

ground level with temperatures, in accordance with the depth reached (due to the geothermal gradient), that vary between 33°C and 65°C.

Despite the fact that the total volume of water stored is extremely large (50,000 km², of which 1 km² is equal to 1 billion liters), in reality that which is actually usable, currently considered to be a renewable or reserve supply, is 40 - 80 km² / year.

The Guarani groundwater system rests upon on ancient geological formations, which can be traced back to the Triassic, Jurassic and Early Cretaceous. These rocks are between 200 and 132 million years old.

National and Regional Economy Mercosur

The Delta is located in the main commercial corridor of the Mercosur (the economic and political agreement between Brazil, Paraguay, Uruguay and Argentina). Chile, Bolivia and Venezuela were not included in the original constitution, but have signed political and economic agreements.

The Mercosur's most important trade route is the Mercosur-Chile corridor, which runs from Sao Paulo to Santiago, Chile via Argentina. In addition, the Paraguay-Paraná waterway is an important place for commercial trade and the commercial ports of the La Plata River provide a connection with other continents for international trade.

Because 49% of Argentina's import and 33% of its export trade is with the Mercosur countries, this regional agreement is important to the Argentine economy, as are its connections with other Latin American countries which account for 8% of its imports and 25% of its exports. The Mercosur-Chile corridor is mainly concentrated along the internal routes of each country, from Sao Paulo to Santiago, Chile, via the two Argentine cities of Rosario and Mendoza.

C.O.P.R.O.N.E.

This is a local development agreement between the Northeastern municipalities of greater Buenos Aires (AMBA) that consists of 15 municipalities, 6 of which are members of the Consorcio de Conin-delta.

Port activity

Port activity is very important to the Paraná river, and the Delta in particular. Over 51% of all Argentine ports are located on the Paraná River, of which 34% are located in the Delta. The products moving through these ports consist primarily of soybeans, cereals, oleaginous seeds, citrus fruits and fuel. The Paraná's ports handle 70% of the transport of grain and those of the Delta handle 8%.

The Paraná - Paraguay Waterway

Dredging works have been planned, as well as the short term realization of passages on the rocky bottoms and signal systems in 23 traits, considered essential in the creation of a navigable canal (10-foot deep) for barges of 320m long and 60m wide, which will operate 24 hours a day, 365 days a year between Corumbà in Mato Grosso do Sul and Canal Tamengo in Bolivia and Santa Fe in Argentina.

The dredging is changing the river's course and water quality while eroding coastlines, which are also affected by the wave motion as a result of passing boats. Sediment removal and large-scale river traffic also causes water pollution. Naturally, the magnitude and duration of which depends on the volume and characteristics of the site.

Air, water and land pollution

Farming

Because of its high profitability, there has been an increase in the quantity of land devoted to the cultivation of transgenic soybean crops on the mainland. This has resulted in the conversion of millions of hectares of grassland, making the Delta a coveted area for cattle breeding and fattening. The INTA (2008) notes that over the past three years, livestock has increased from 60,000 to 1,000,000 heads, well above the recommended amount for the area.

In December 2004, for example, the Entre Rios approved the *Ley de Arrendamientos* (leasing law) and as of August 2007, about 109 contractors have already leased approximately 128,350 hectares of public land in the *Departimento di Victoria*. 99% of this land is used for farming.

There has also been an increase in abusive levees and dams in order to convert the wetlands into territory appropriate for the landholders' needs.

Cattle produce 21 times more waste (feces and urine) than human beings. A piece of land with 10,000 head of cattle produces the same amount of waste as a city with a population of 210,000 (Beloso, 2008). Generally, in areas dedicated to livestock production, no residual waste treatment technology of any kind is required; therefore it is not handled properly, resulting in soil and water contamination (Figure 8).

This translates to a significant threat



Figure 8: some of the territories of the main sources of pollution.

to the environment, which not only results in the death of aquatic organisms but also the likelihood of health problems among region's population.

Although cattle manure is rich in nutrients, the amount required in agriculture is well below the amount of waste produced. This excess of nutrients can affect both the groundwater and surface water, causing severe damage to the natural environment. When this excess of nutrients (nitrogen and phosphorus) comes into contact with surface water, it encourages algae growth.

This phenomenon, known as "eutrophication", creates two problems: firstly, the algae increases the turbidity of the water and blocks out sunlight, killing aquatic plants that provide food and shelter for fish; secondly, the algae dies and is decomposed by bacteria, a process that uses the oxygen dissolved by the water, thus reducing the amount of oxygen available for fish and other aquatic organisms.

Ultimately this phenomenon results in the death of fish and aquatic organisms, the reduction of biodiversity and in extreme cases, so-called "dead zones" like those found in Riachuelo in Buenos Aires.

Reforestation
"Atrazine" and "glyphosate" Pollution

The *Salicaceae* reforestation sites in the Paranà delta are characterized by extremely diverse plant communities composed mainly of subtropical species of the Pampeana Steppe and some naturalized exotic plants (Burkart, 1957).

Because of their density and their tendency to colonize, many of these species

are invasive, as much so in plantations as in drains and sewers (Toscani, 1978, 1994).

Qualitative changes in the wetlands: as a result of the new economic stakeholders' interests, the changes to the territory do not take into account the possibility of fires, alteration of the waterways and infestation control.

What is planted? Reforestation is principally carried out through the planting of native willows, pecan nuts and to a lesser extent, wheat, sorghum and soy.

Production techniques: the ecosystem has been denied. The same techniques that are used on the mainland are applied and embankments constructed to regulate water and adapt the soil to agro-pastoral activities border it.

Agrochemical products used to fumigate the fields end up in the Paranà's streams, the poisons mixing with the river's water. It has to be said that these agrichemicals are harmful to man.

Industry

In the Paranà delta there are a variety of industrial zones strategically situated close to the principal ports and along the *Mercosur* corridor. All the Delta municipalities have industrial areas, but the most important are to be found at San Nicolàs, Ramallo, Zàrate and Campana. On one hand, industrial activities are an important resource for the local and national communities, they generate employment, benefit the cities through investment and improve the living standards of inhabitants, but on the other hand, they have a negative impact due to the pollution they produce (Figure 7).

The factories produce gas emissions, liquid and solid waste as well as noise pollution. Often waste is collected without being adequately treated and in this way contaminate, along with the soil, ground and surface water resources affecting the quality of fishing and agro-pastoral products.

Some of the more problematic activities:

- frozen products: poisonous substances (detergents);
- tanneries: chrome, acids and sulphide;
- paper production; Mercaptans, acids and resin;
- cereal and vegetable oil factories: caustic soda;
- soap factories: detergents, acids, caustic soda;
- mosaic factories: aniline;
- boat fuel deposits: accidental hydrocarbon spillage.

This consumable product contamination not only affects those that live in the area, but also the whole region in which they are produced.

Fires

The land destined for forestation and cultivation of soy needs to be free of weeds and rodents. As in the past, the land is burned in order to remove redundant elements (Figure 7). In less than ten years the land value on the islands has increased 20 fold and the number of cattle by over 400%.

Traditionally, farmers burn their pastures in order to speed up forage germination their for livestock. In 2008 a conflict triggered by the burning of pastures on the Paranà delta islands brought this issue to the attention of the media and political world.

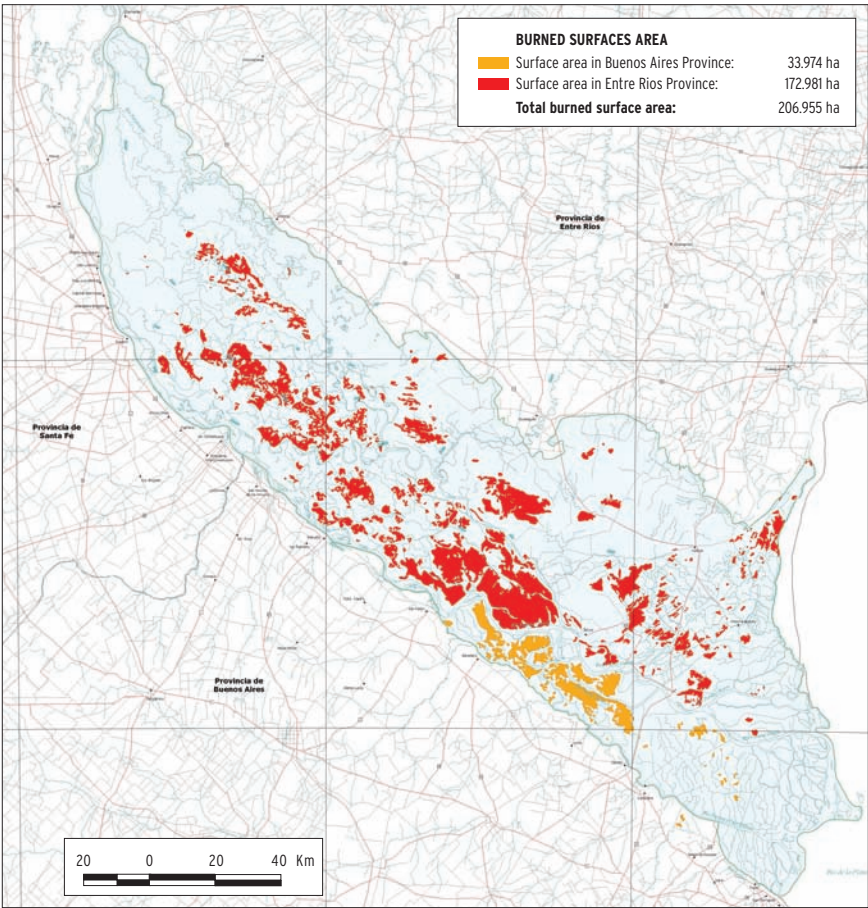


Figure 9: map showing the areas that were burned in 2008.

In April 2008 (Figure 9), when Buenos Aires was covered in smoke generated by the burning Delta grasslands, this practice began to be seen as a structural problem.

Once the occupation process of the islands was triggered, the fires spread on an unprecedented scale and frequency. The fires became a road safety problem, a public health issue in the city and caused severe environmental damage to the wetlands.

What effects do the fires have? The ashes are deposited in the cities and roads, endangering the environment and inhabitants. They are difficult to control and easily spread over large areas. The smoke is harmful and damages the hu-

man respiratory tract. Wildlife and native plant species are also endangered, altering the biodiversity of the Delta. The fires have scorched more than 700 species of flora and of the 580 vertebrate species that inhabit the area of the islands 37 are currently nationally or globally at risk of extinction. The burning also produces carbon dioxide, which aggravates the greenhouse effect.

Tourism

Tourism activities can be classified as shown in the Table 2. It should be noted that some of them are carried out in or are shared by more than one sector. Tourism has an impact on the environment. The speed of passing vessels creates wakes that not only endanger rowers but also increase coastal erosion (Figure 10).

The noise of these boats' engines and horns raise levels of acoustic pollution, and the pollution caused by the cleaning of their bilges is discharged into rivers and streams. The docks are disintegrating due to wave motion. The boat service is poor, the boats themselves are in poor condition and solid waste produced by their activities is thrown into the rivers and streams, buried or burned.

The lack of nautical maps covering the area leads to boats crossing areas demarcated for other activities like rowing leading to an increase in the possibility of accidents. There is also a lack of service infrastructures to cater for the growing numbers of tourists, especially during high season.

Sanitation services are not provided by the public sector and there is a lack of adequate monitoring of wastewater treatment. Sand is also extracted and placed elsewhere in order to simulate beaches.

Conclusions

Through its natural dynamism, the Delta territory is faced with changes in both the flow and capacity of the water, as well as decreases or increases in the quantity of debris. One should also consider the direct influence of manmade works and various kinds of speculation.

The latter may cause an increase in ecological risks that have not yet been evaluated, such as those that have changed the destiny of the *Lower Delta* (heavily oriented towards tourism), and that threaten other delta regions.

Public policy, intended as a set of State actions for the promotion and development of the Delta Bonaerense, is to leave it be, or simply omit it (Tamayo Sáez, 1997). This inefficiency or lack of control has also promoted the development of irregular land and private tax speculation outside of the law. There are examples of situations that have created the conditions for the proliferation of these practices, and are the prerequisites for the establishment of an “informal land market”.

The growth of the real estate market in areas that are naturally low-lying and hence susceptible to flooding through the creation of landfills and embankments, prevents the normal development of the wetlands, and directly and negatively affects the land in that it is unable to absorb water and loses nutrients, contributing to the hydrodynamic compromising of the ecosystem as well as interfering with one of its principal services, namely the regulation of water.

It also has a negative impact on the water in its pollution of ground and surface water as a result of solid waste,

Place	Activity
Mainland	<ul style="list-style-type: none">- Tours: of the center, the Tigris River banks, the <i>Paseo Victorica</i>, the Real path and the <i>Puerto de Frutos</i> path- Equipment museum- La Costa Park- Casinos- The La Costa Train- The Rowing Club- Cycling- Picnic areas- Gastronomy
Waterways	<ul style="list-style-type: none">- Rowing- Fishing- Boat trips- Water Skiing- Wakeboarding- Powerboating- Kayaking- Beaches and Bathing
Islands	<ul style="list-style-type: none">- Walking- Bird watching- Photographic expeditions- Picnic areas- Gastronomy- Entertainment- Camping- Beaches and Bathing

Table 2: the main tourism activities.

sewage and gray water discharges. Construction work debris, the introduction of exotic plant species for landscaping, the removal of natural vegetation and the migration of wildlife due to noise have negative effects on vegetation. This altering of the landscape’s natural state results in it being all the more heterogeneous.

The project will provide information on the state of the environment, the principal altering factors, their impact on the environment, as well as responses and future prospects.

The result will be a final summary of the environmental risk map, on which the zones will be divided into levels of risk associated with one or more threats. This will enable the creation of an analysis tool for the formulation of policies and environmentally sustainable urban projects.



Figure 10: sport-tourism activities in the Delta.

_ACTS OF THE CONFERENCE THE IMOLA PROJECT: A TENTATIVE INTEGRATED LAGOON MANAGEMENT PLAN FOR TAM GIANG-CAU HAI

MASSIMO SARTI

Capo Consulente Tecnico per il Progetto IMOLA

The "Integrated Management of Lagoon Activities in Tam Giang Cau Hai Lagoon (IMOLA)" project started in August 2005 and will complete its first phase in December 2008. Its rationale is based on the increasing pressure the lagoon's aquatic resources are subject to, and the resulting environmental degradation. Together with the typhoons, floods and droughts, which frequently strike the Thua Thien Hue Province and the Tam Giang-Cau Hai lagoon, this has created a situation of increasing vulnerability for the population and, in cascade, effects of environmental degradation, social disruption and poverty.

The immediate objective of the project is "to develop and implement an integrated lagoon management plan, built through stakeholder consensus, which balances the sustainable use of the lagoon resources with the livelihoods and needs of the resource users". In modern terms and more appropriately so because the Tam Giang-Cau Hai is a vast natural wetland (the largest in South East Asia), an "ecosystem management" approach is embodied in this formulation that harmonizes the imperative of natural landscape and resources conservation with the need of economic development and food security for human communities. To achieve this immediate objective, six outputs were defined and activities to achieve the outputs were formulated.

The project was structured in three phases: a pre-planning survey phase; a planning phase, consisting of management plan formulation; an implementation phase during which management plan is piloted preparation phase. The pre-planning phase was initiated at the time of project conception and formulation (feasibility, preliminary assessment, budgeting, GoV formalities etc.), then

carried out during early stage of project implementation (2005-2007), including institutional analysis, assessment of legal framework, stakeholder's analysis, training need assessments and evaluation of necessary datasets to be acquired. During the project pre-planning, surveys were designed and budgeted and, through appropriate contracts with the identified partners, conducted until the finalization of a comprehensive lagoon GIS-based database that constitutes the informative platform onto which the *ILMP* is built. Ecosystem definition - a conceptual background for ecosystem management - is the outcome of the survey phase.

A characteristic of the Tam Giang-Cau Hai is its compartmented physiography, resulting in complex and fluctuating hydrology, depending on balance of water masses and river discharge (Figure 1). Hindered circulation of the water masses and complexity of environment is a consequence.

The following zoning based on ecological features has been drawn:

- the *O'Lau ecozone* (Upper Tam Giang), proximal (near to the river mouth) an distal (away from it), respectively characterized by riverine freshwater from the O' Lao river and transitional brackish waters;
- the *Lower Tam Giang ecozone*, characterized by riverine predominance, with stronger seasonal marine influence and restricted circulation, hindered by narrow passageways;
- the *Huong river delta ecozone*, where fluvial and marine water mix, enhanced by the complexities of the deltaic physiography;
- the *Sam Chuon ecozone*, isolated from both riverine and marine influx, with restricted to strongly inhibited circulation;

¹ Ecosystem management as "a process that integrates ecological, socio-economic, and institutional factors into comprehensive analysis and action in order to sustain and enhance the quality of the ecosystem to meet current and future needs." The core objective of ecosystem management is the sustainable, efficient and equitable use of natural resources. Ecosystem management recognizes that the inter-connectivity of ecological, socio-cultural, economic and institutional systems is fundamental to our understanding of the factors, which influence environmental objectives and outcomes. It is a holistic, multi-disciplinary and integrated approach, which requires a substantial shift in the way we perceive and approach the management of both our natural and modified environments (*IUCN's Commission for Ecosystem Management*; IUCN-CEM).



Figure 1: pictorial view from DEM of the Thua Thien Hue Province and the Tam Giang-Cau Hai lagoon.

Figure 2: aerial view of the Thuy Tu channel, southern lagoon.



- the *Upper Thuy Tu ecozone* characterized by reverting flows, depending on seasonality and ponds of stagnant waters at times.
- the *Lower Thuy Tu ecozone* (Figure 2), somehow influenced by Cau Hai water masses flowing upstream;
- the *Cau Hai ecozone*, divided in two parts: a low-energy one, fluvial-dominated and a higher energy one, more prominently marine. An intermittent clockwise circulation is driven by both outward flowing river waters and incoming tides.

There is a clear need for management for the lagoon and a latent need for management of the coastal and in-shore marine fisheries of the Thua Thien Hue Province. According to existing data and feedback from fishers, Fishery Associations and commune leaders and local knowledge, the main reasons for the need to manage the lagoon are the continuing degradation of the lagoon ecology and environment and a significant decrease in stock abundance and diversity.

Based on these premises, the IMOLA

project conceived its implementation strategy, foreseeing two concurrent and complementary goals, that of an assessment of natural resources state and environmental remediation and that of fishery sector rationalization, through the development of professional organization of fishers and aquaculture operators, bridged by a sound program of capacity building and technological enhancement instrumental for planning.

The core of the IMOLA Project implementation strategy: the build of co-management

The concept of co-management is nowadays widely accepted for small-scale fishery in developing countries worldwide, but how it is practiced and how devolution of power is locally realized follows a diversity of models and is still a matter of concern. Resistance is understandably higher in those situations where communities lack sufficient degree of organizations for the dialogue. The IMOLA Project located itself into this scenario, with the awareness of having to fill this organizational gap first, to build a co-management partnership, and then develop a process of resources management and territorial planning from the grassroots: this is where most of project investment went.

Outputs were scoped to deliver knowledge to the fishers and aquaculture farmers, to raise their awareness and capability to intervene in the decision formulation, but also to endow them of the necessary technical knowledge and environmental concern necessary to invert negative trends of the past decades. To maximize the impact, the majority of the lagoon basins/ecosystems (Figure 3) (Cau Hai, Thuy Tu, Tam Giang) were considered and a range of social situations, from the

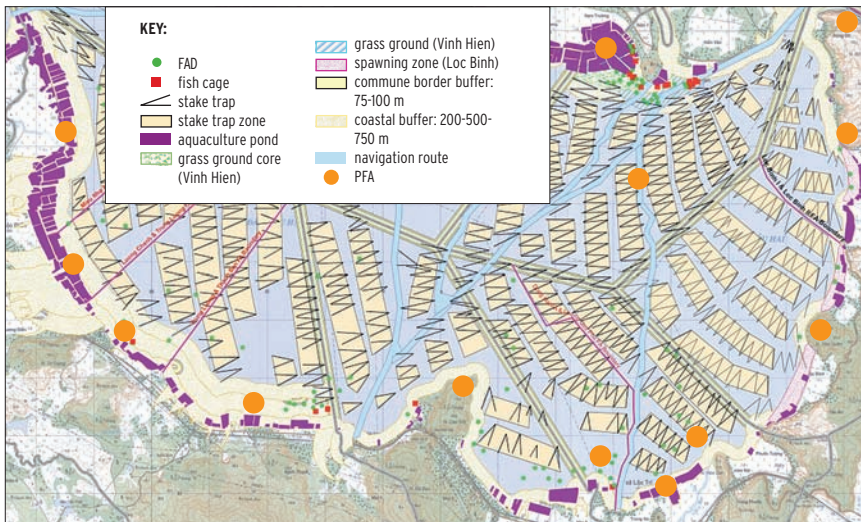
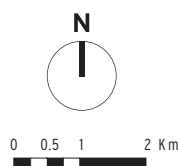


Figure 3: map showing agricultural and fishing activity.



Integrated Lagoon Management Plan: key policy issues

The IMOLA project identified six main policy issues as elements of importance in driving the Provincial economy and, more specifically, that component hinged on the community of fishers of the Tam Giang-Cau Hai lagoon. Subject to the subtleties of an endangered environment, the subsistence of artisanal fishers must relying on the sustainable use of natural resources, in the lack of which loss of livelihood and social disruption, along with further environment degradation, would derive.

Reversal of negative trends of the past decades is achievable though the implementation if an integrated management plan that should include with priority:

- adoption of measures to mitigate the effects of intensive aquaculture (chiefly shrimps). Promotion of "safe aquaculture" through rationalization of culture practices, *BMPs* and *GAP*;
- adjustment and amendment of fishery activities;
- development of an economically successful and responsible lagoon artisanal

fishery community, through awareness raising and construction of a co-management partnership;

- streamlining and adaptation of provincial policies, institutional and regulatory framework for fishery management;
- remediation and restoration the environment and promotion of biodiversity conservation;
- building of capacity and development of technological tools for territorial planning.

Policy issues related to environmental sustainability were scrutinized during the pre-planning phase, and recommended measures are herewith presented. These are proposed for validation in the forthcoming implementation biennium of the IMOLA II Phase, in the prospect of more substantial investments. The biennium 2009-2010 is proposed for *ILMP* validation and adaptation, for enactment in the subsequent quinquennium 2010-2015, with orientations towards 2020.

In the following sections policy issues will be reviewed, the problems stated and the hazards evaluated in terms of seriousness and likelihood to generate an emergency, including a time frame for each emergency to manifest. A set of recommendations will be provided to guide decision makers in setting up priorities and introduce plan adaptation whenever appropriate.

most disadvantaged to the better-off were included among the targets sites: all five districts were touched by IMOLA, with three of them selected for specific interventions (total 22 communes corresponding to the 75% of the water surface and 63% of the lagoon population).

Types of interventions ranged from "first-aid" remedies wherever emergency situations revealed (as in the case of shrimp aquaculture fish epidemics), to extensive planning exercises, to build a conceptual basis for the integrated management, with prospects of implementing the plan, at least at the experimentation level, in the two forthcoming years of the IMOLA II Phase. In harmony with FAO mandate, the project maintained its orientation towards the poorest, as disadvantaged bear the heaviest burden from reforms and changes, without losing focus on the imperative of environment improvements and regulatory streamlining.

Mitigation of the effects of intensive aquaculture

Since 1986 (time of the earliest aquaculture ventures in the Tam Giang-Cau Hai), the production has steadily increased to nearly 7,000 tons in 2005, a value approximately one order of magnitude higher than it initially was. As a consequence, water quality increasingly deteriorated, chiefly from untreated effluents, whilst severe damage to the environment was produced by pond encroaching onto the shallow subtidal coastal zone. Water pollution and over-fishing has determined a steady decline in capture and in vast parts of the Tam Giang-Cau Hai lagoon. The following interventions are proposed, in order to:

- 1. scale down shrimp aquaculture, to bring it in line with the lagoon carrying capacity;
- 2. mitigate the impact of effluents on the aquatic environment;
- 3. diversify the production and livelihood opportunities;
- 4. improve product quality, market value and increase profitability;
- 5. optimize the production of aquatic commodities based on market demand and ecosystem productivity.

Reduce the acreage of the earthen shrimp ponds. The acreage of the total shrimp ponds in the Tam Giang-Cau Hai (Figure 4) lagoon should be reduced by 20% by 2010, corresponding to half the contribution calculated to meet the current carrying capacity.

Re-landscape and re-naturalize the reclaimed land. The process of re-naturalization of the degraded/converted pond acreage should foresee the following four stages implementation:

- restoration of the “low-tide”, shallow-subtidal ramp;
- expansion of spawning/nursing grounds from re-naturalized pond areas;



Figure 4: shores of Thuy Tu are sites of intensive farming (shrimp).

- rebuilding of a supratidal terrace, for protection of the high-tide pond systems, pollution prevention and service provision;
- improve pond hydraulics and maintenance of “high-tide” pond system. To prevent uncontrolled release of wastewaters, the following is recommended:
 - wastewater control and treatment of effluents prior to the emission in the lagoon;
 - experimentation of low-cost, environmentally compatible, physical, chemical and biologic treatments systems;
 - reconditioning of canals and circulation network in “high-tide” pond systems, to prevent undetectable contamination.

Promote and incentive alternative aquaculture (including bivalve culture). The following livelihood options are recommended:

- experiment and promote alternative fish and aquatic species culture (based on biological and habitat requirements and market demand);
- promote the adoption of *BMPs* and *GAPs*, in line with the code of conduct foreseen by the “safe aquaculture zone” protocol;
- experiment and promote the farming

of low-impact, low-cost species such as sediment- and filter-feeders bivalves, in appropriate habitats.

Explore opportunities to develop mariculture. Mariculture development is often seen as an important strategy to contribute to poverty alleviation of rural coastal communities. In Thua Thien Hue, the practice may contribute to alleviate the pressure on internal coastal waters through:

- implementation of experimental pilots, to culture a range of marine products including groupers, seaweeds, lobsters, abalones, sea cucumber etc.;
- provision of specific training on mariculture techniques, disease prevention, etc.;
- investments in support of the sub-sector.

Market chain, industry development and branding. The adoption of measures to rationalize the sector, industrialize the

production and develop a market chain should proceed though:

- improvement of aquatic-product safety and quality control;
- application of the aquatic-animal health protocol, for disease control and prevention;
- application of "safe aquaculture zone" protocol to small-scale farms, *BMPs* and *GAPs*;
- enhancement of post-harvest processing technology and distribution strategies;
- branding of aquatic products (the production of higher value products provides the opportunity to adopt a effective and distinctive market brand for the Province);
- development of international market opportunities.

Adjustment and amendment of fishery activities

Capture fisheries is a traditional occupation for lagoon communities in Hue, where it can be defined as a small-scale and subsistence artisanal fisheries: it is a multi-species multi-gears fishery, practiced in the lagoon, but also in rivers and, for some littoral communes facing the ocean, on-shore. Stake traps are one of the most popular, effective and widely distributed gear over a range of 35 types (both fixed and mobile) used by fishers for capture in inland waters: its non-selective character and large size makes it the most impacting device in enclosed sea tracts (Figure 7).

Thus, and beyond the need to manage fishing capacity *senso largo*, priority measures to stop and possibly reverse the trend of environmental degradation and over fishing have to focus on the lagoon ecosystem as a whole, in particular by:

- reducing the effort of fixed gears;
- eliminating "low-tide" aquaculture, in at least all formerly known and/or potential nursing and breeding grounds.

Reflecting the situation of lagoon and marine fisheries in Thua Thien Hue Province and the needs for management, some of the possible management options (as relevant to the fisheries and following *FAO*, 2001) are presented. Provided that the "Individual Quota" (IQ) system is hardly feasible for neither the lagoon nor the marine fisheries, only output restrictions such as "exclusive fishing zones" and "closed fishing seasons", and input restriction such as licensing systems and fishery co-management mechanisms will be discussed.

Exclusive zones. Zoning according to type of effort (e.g. fixed-fishing-gear zone, mobile-fishing-gear zone, waterways etc.) and ecological sensitivity are criteria that have been put forward earlier by the provincial authorities and followed by the project in what has been the first policy-enforcement exercise undertaken by the nascent Fishery Associations. Communal zoning is part of this exercise as a contribution to participatory planning and lagoon zoning. The Fishery Associations boundaries were demarcated first, to define the area of competencies. The participatory drafting of management regulation, to control the use of each zone, complemented the zoning exercise.

Closed seasons. Closed seasons are based on the same rationale but include a time dimension. They are an option, provided that both locations of critical habitats and spawning, breeding and nursery periods or migration of breeders are known. At present, information and data are still scant to define when and

how temporary closures would benefit stock protection and recovery. However, the concept of time restrictions is in place and measures are being undertaken.

Input restrictions. The chosen approach to limit inputs at national and, consequently, provincial level is co-management through enforcement of co-management bodies that are, in the specific case of the Tam Giang-Cau Hai community, the Fishery Associations and issuance of fishing rights.

Reduction of IUU fishing. The reduction of *IUU*, in particular of destructive fishing practices, is not only a management option but, in the lagoon as well as in the coastal fishing grounds, a priority measure to arrest further resource depletion.

Fishery co-management through Fishery Associations

As the financial burden of monitoring, surveillance and control measures required to implement management measures through top-down control is too high, provincial authorities increasingly view participation of resource users as a necessary element of the fisheries management system. To limit access, the chosen approach envisions the issuance of territorial user rights to co-management partners, i.e. the Fishery Association, and notwithstanding the delegation of power is still a matter of concern, the process has begun. Fishery Associations are functioning and, although in a preliminary state of development, have been actively involved in participatory planning exercises.

Problems in the process of being resolved are the following:

- the drafting of guidelines on how the

Figure 5: net enclosures for fishing in Sam Chuon.



Figure 6: racks for oyster culture in Cau Hai.



- district will allocate fishing rights;
- planning of allocated areas of competence;
 - the capacity at the commune level to manage and enforce management and to deal with destructive activities;
 - the coordination and networking between province, district, commune and Fishery Associations;
 - the need to have alternative livelihoods for those impacted by the fishing rights.

- Uncertainties still persist in the following issues:
- how to improve a conflict-management mechanism able to address conflicts;
 - how to control access;
 - how to deal with mobile fishers from other areas of the lagoon and whether

and how to restrict their access to the area.

The immediate objective of empowering Fishery Associations is to adjust the reduction of efforts in terms of space and time and through limiting access, according to data and information available and to be developed, in order minimize negative impacts on livelihoods and to maximize long-term conservation and stock recovery effects.

- Focus of the Fishery Associations should be primarily committed on:
- improving the lagoon environment;
 - decreasing fish mortality;
 - progressively eliminate/replan low-tide aquaculture, as stipulates at policy level, considering that this type of exploitation is economically wasteful and oc-

- cupies, most probably, potential nursing and breeding areas;
- reduce drastically fixed gear and net enclosures (Figure 5) for the same reason and because of their non-selectivity and negative impact on fish migration;
 - enable right-based effective self-management/co-management and assist in combating *IUU*.

Environmental conservation

- As a consequence of fishery activities, agriculture and infrastructure building, the following environmental changes have progressively affected the Tam Giang-Cau Hai lagoon and surrounding wetland, which might enhance their negative effect in the mid-terms, if a conservation policy is not enforced:
- enhanced coastal erosion in the central Thuan An tract;
 - alteration of the original distributaries pattern of the Huong river delta;
 - reverted flows in some of the lagoon tracts and circulation changes due to tide prevalence;
 - reduction/degradation of breeding/nursery grounds, because of excessive low-tide aquaculture development;
 - loss of natural habitats;
 - loss of biodiversity.

The result of these changes have resulted into a fragmentation of ecosystems and habitats, inducing in cascade alterations in the wildlife, both aquatic and terrestrial, behaviour, migration patterns and the biological cycle of species that migrate from the sea into the lagoon for reproduction.

There are no documented records of the impact of such ecological changes but traditional wisdom reports of disappearance of aquatic species, loss of natural biotopes (e.g. the endemic mangrove

forest), impoverishment of avian fauna (so common in most wetlands of the world), along with an overall loss of catch because of overfishing.

The result is a net loss of public patrimony to the advantage of private mismanagement that if calculated at the rate of current economic values may total figure of millions of dollars.

A natural wildlife and environmental conservation policy should envision the following interventions aimed to revert the trends and trigger a cycle of positive feedbacks that will ultimately pay back in terms of profit for fishers and improvement for collateral economic activities eventually being promoted (e.g. ecological tourism) or gain in non-use (environmental, heritage, aesthetic) values:

- re-naturalization of the reclaimed low-tide aquaculture areas;
- establishment of ecological island (wildlife sanctuaries) and ecological corridors;
- establish the concept of coastal zone maintenance as a trade-off of coastal waters resource use;
- establish practices of internal waters and ground-water management;
- adopt measures to limit water pollution (ban of selected POPs);
- rehabilitate the natural lagoon hydrology, by i) reactivating the natural distributaries' system of the Huong river delta, and ii) reactivating the natural tides through inlet stabilization;
- regulate the intake of sediment from active floodplain.

The incorporation of these measures along with technical specification into a "*Natural Wildlife and Environmental Conservation Act*" will contribute:

- to promote the sustainable development³ of natural and physical resources

and the maintenance of ecological processes and genetic diversity;

- to provide for the fair, orderly and sustainable use and development of air, land and water;
- to encourage public involvement in resource management and planning;
- to facilitate economic development in accordance with the objectives set out in the preceding paragraphs;
- to promote the sharing of responsibility for resource management and planning between the different spheres of Government, the community and industry in the State;
- a planning scheme is binding on all members of the public, State Government agencies, public authorities and planning authorities.

Adjustment of legal and institutional framework

The Vietnamese Constitution provides the overall legal framework for aquatic resource utilization and the Fishery Law delegates the management of fishing grounds at large to the Province. The objective is to decentralize the management of coastal routes to District- and Commune-levels People's Committees and to develop models of co-management.

The lagoon fisheries falls under this legislative perimeter: at Provincial level and largely following the national legal framework, there is a plethora of plans, decrees and decisions addressing specific issues on marine and lagoon management.

Specifically, Decision 3677 contains an extensive list of rules and regulations directed at managing fishing capacity, e.g. conditions and limits to self-management by Fishery Associations, such as forbidden gear, spatial limitations for fixed

gear, minimal mesh sizes etc. It further postulates to reduce present capacity by 30% towards 2010, by:

- reducing 40% the number and density of fishing tools, equivalent to 40% of capacity;
- reducing 25% of exploitation timing due to the ban on exploitation for 3 months in a year, equivalent to 15% of capacity;
- reducing 25% of small individuals to be tapped due to the regulation on the increasing of the minimal mesh size, equivalent to 15% capacity.

According to IMOLA findings, there is a certain vertical overlap of competences on Province level, at least with respect to competences of the former *DOFI* on Province level and towards District/Commune administrations that has led to vertical policy inconsistency and which could provide obstacles for the decentralization of fisheries management functions as discussed above. For example, it is not clear at which autonomy *DPCs* will have to issue specific regulations guidelines on allocation of fishing rights.

Vertical and horizontal overlaps are also demonstrated by the inconsistencies in data collection and management that cannot be explained by the noted scarcity of staff capacities only.

From the legal standpoint, recommendations are:

- to eliminate policy inconsistencies;
- to provide clear-cut definitions of prerogatives and competences of agencies delegated to administer fishing rights;
- to provide technical specification of authorized capture gears and define listing of banned destructive;
- delegate power to Fishery Associations to enforce *MSC* in the areas of their



**Figure 7: fish corrals
otherwise named
stake traps (no sao)
in Cau Hai.**

competence;

- envision legal instruments to financially support institutionalized co-management partners (i.e. the Fishery Associations).

The goal of the *ILMP* design is to develop and promote practical policy options to support sustainable fishery, rural livelihoods along with environment conservation measures through a range of research, development and advocacy activities. The area covered by the coastal zone, as it is legally defined, is comparatively small. It is to this area that Provincial policies and integrated management requirements apply.

However, as unanimously recognized, this definition is inadequate as a starting point for a truly integrated resource management strategy. Ideally, the full catchment of rivers discharging into the sea should be included to allow proper accommodation between activities and processes linked by hydrology. Therefore, from the institutional standpoint, recom-

mendations are:

- to promote the establishment of a Basin Authority, with jurisdiction over the whole catchment area, including coastal lagoon and wetlands and/or;
- to promote the establishment of a Coastal Basins Authority, with jurisdiction over the coastal physiographic unit under the influence of a specific basin, neighbouring coastal physiographic units and the continental shelf;
- to Provincially institutionalize fishery, environmental, biological and epidemiological data collection and management;
- to promote networking with agencies at National and international level.

_INTRODUCTION THE WORKGROUP SEMINARS

PIPPO GIANONI

IUAV Venezia e Dionea SA Locarno

The construction of a complex territorial process implicates the involvement of, and exchange of ideas between, various stakeholders that not only work and live in the territory, but that are also involved in its construction. It is with this in mind that Cà Vendramin serves as a point of exchange between different sources of knowledge.

It was decided that two lines of work were to be followed, in concordance with Marina Bertoncin's consideration that in the "*delta territory laboratory* recent motions have been applied in the activation of territorial principles that are ultimately self-serving, internally re-establishing the process of reconstructing the territory. The self-generating dynamics, (*omissis*) move within those activities (principally fishing and activities linked to the Park), capable of assuming important roles and that could also drive other sectors".

An expanded initial observation regards planning via the exchange of ideas between the various stakeholders working in the Delta, as referred to in the Park Plan and the presentation of the results of the *Università IUAV* Delta Summer School, titled *Constructing Scenarios for Fragile Territories*.

A second theme is linked to the Delta's productive activities and their compatibility with the protection and conservation of natural values.

The workgroup seminars enabled the exchange and definition of a series of operative proposals that could serve as a stimulus for the future be it at the planning or organizational and management level.

_ACTS OF THE CONFERENCE CONSTRUCTING SCENARIOS FOR FRAGILE TERRITORIES: RESULTS OF THE SECOND EDITION OF THE PO DELTA SUMMER SCHOOL

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In this paper we present the results of the second edition of the Po Delta Summer School, an activity carried out at the Po delta territory Observatory that this year, was set up as an Erasmus Intensive Program, in this way also benefiting from the financing of the European Community. The Po Delta Summer School covers some important themes and questions that in recent years have affected the territory; and in doing so promotes multi faceted consideration via its involvement of transversal work groups with differing abilities, be they planners, landscapers, or communication designers. This foresaw the involvement of students and professors from different European Universities: *Universitat Autònoma de Barcelona* (geography and territorial planning); *Delft University of Technology* (landscape architecture and urban planning); *Universitatea de Arhitectura si Urbanism "Ion Mincu" Bucuresti* (landscape architecture and urban planning); as well as the *Università IUAV di Venezia* (landscape architecture, urban planning, territorial planning, product and communication design).

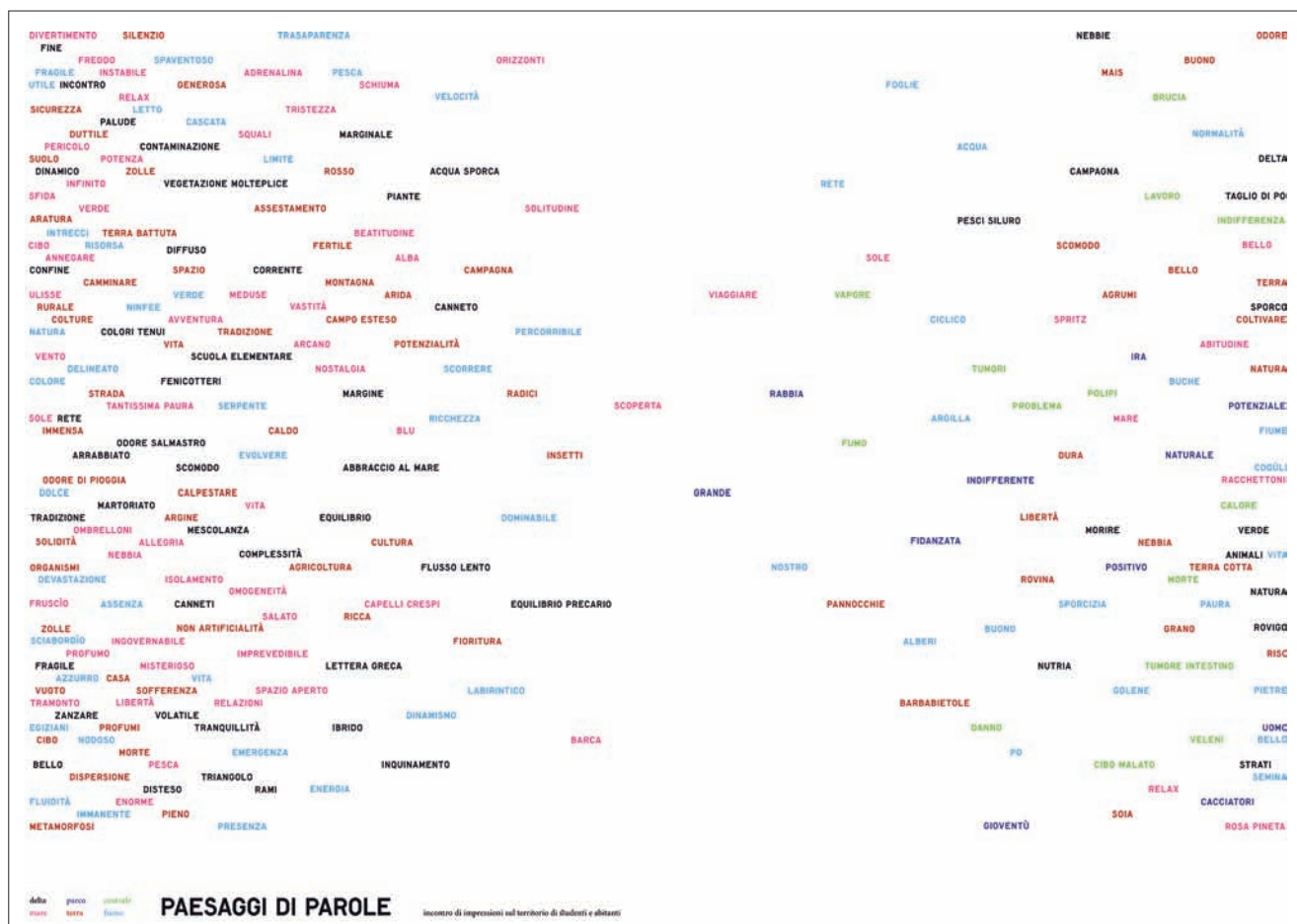
The Summer School makes up part of a bigger research-action project defined by the *Osservatorio sul territorio del delta del Po*, borne from collaboration between the *Fondazione della Cassa di Risparmio di Padova e Rovigo* and the *Università IUAV di Venezia*, with the objective of deepening and widening society's knowledge of their own territory in order to orientate changes with the ambition of having a fly-wheel effect on the processes of cultural, social, economic renewal and the valorization of the landscape. The work carried out within the Summer School records considerations, investigations, comparisons and scenarios in the Po Delta, a fragile territory with characteristics, paradoxes

and dilemmas that are to be found in and shared by other delta territories. It is for this reason that the work is presented as an interpretation and projection that ultimately, other fragile territories will be able to draw upon.

The work carried out is based on two hypotheses. The first hypothesis is that the Po delta cannot be considered as a territory, a settled, static object, but rather an animated and dynamic phenomenon, a mass of composite materials undergoing continual change. Therefore one is confronted by an extremely important question: it is difficult to experience the changes if not under extreme conditions, that is when the magnificence of the water is confronted by the tragedy of devastation. It is this that has created the basis for the gradual formation of a notional collective in which instability, insecurity and depression make up the main issues through which the territory and its population defines itself, while at the same time being insistently and inexorably urged towards conditions of stability, security and prosperity.

The dialog with the inhabitants, as is always the case, proved to be an important instrument without which it would have been impossible to appropriate local knowledge, but at the same time it also provided the opportunity for them to get to know our activity, the presence of the University in the territory, an organization that is looking after this territory.

The second hypothesis recognizes the Po delta as a territory in which, through long term successive stratification, there has been a forced distinction between different principles: land and water, nature and culture, rivers and settlements.



This distinction has often manifested itself in a division between the protagonists, specific organizational strategies, financing, development, cultural and social processes as well as the anthropization and infrastructure of the territory. A tension between opposites that, only with difficulty, is able to come together and perhaps is still today, one of the main areas of conflict and difficulty coagulating around certain non contrasting strategies and certain directions of development which have the same aims. Through comparing the fragility that extends across certain European delta territories and the elaboration of scenarios that suggest the linking together of at times untried actions and assuming the complementary nature and integration

of different development strategies, use of resources, activation of the local and external bodies as a final goal, we tried to introduce a different point of view to the local debate in the hope of providing a basis for discussion that was capable of confronting a perspective, that while rooted in the territory, was still open to external influence.

The research carried out by the Summer School covered three main themes.

1. Comparing European delta territories

The comparing of delta territories was considered to be the first step in realizing a European delta atlas. It is

for this reason, in order to highlight themes, questions and already existing projects, that technicians of the government institutions in the compared delta territories were directly involved. The collected material and information was processed with the aim of rendering synthesis maps, diagrams and descriptive schemes for each delta that was analyzed, but above all, to focus on that nucleus of themes capable of outlining specific characteristics that differentiate these territories (Figure 2).

The atlas presents an analytical look at the principal characteristics of each delta territory in Europe. The comparison of the Po delta and the Ebro, Rhine and Danube Rivers is aimed at identifying not only specific and particular problems, but also those that each territory might have in common. The analysis criteria were selected from those capable of highlighting certain important questions regarding ecological characteristics (mainly linked to hydrological risks and climate change) and specific economic and social problems in the said territories. The data was collected starting with the synthesis studies and information mainly supplied by researchers and professors from the various countries in which the analyzed deltas are found.

On one hand, the work disposed by the students underlines the vast differences between the territories: the Reno delta's high levels of urbanization, the predominantly agricultural use or uses linked to the hydraulic resources of The Po and Ebro Deltas, and the relative isolation and natural character prevalent in the Danube delta. On the other hand, the work concentrated on identifying the common problems of fragile territories such as those analyzed. The

principles regard hydrographic network management; potential economic losses linked to the risk of flooding, the process of progressive salinification, the disappearance of natural habitats and the loss of biodiversity, risks that in turn are linked to the rising of global average temperatures.

The result provides a panorama of the problems, be they general or more specific, and offers several cues prompting a wider debate on the future development of the Po delta. The putting together of the atlas has its origins in the hypothesis that the intrinsically instable nature of the delta territories exposes them to bigger environmental and anthropic risks. Their geographic position, specific morphology, the confluence of antithetical processes as well as their evolution and continuous dynamism, renders them complex, singular and delicate, allowing them to be easily compromised and constantly seeking a balance: at times more exposed than other territories threatened by progressive demographic, economic and civil degradation.

Considering fragility to be a condition that is specific to these areas, an attempt was made to trace back the relationship between the territorial structures of certain European deltas and the complex dynamics determined by this condition. Hydraulic transformations, the phenomenon of subsidence, the process of progressive salinification, flooding/drying up, the infrastructure and organization of settlements, protection of natural areas, population distribution and its dynamics and the organization of human activities are the principal themes of the atlas, the aim of which was to put together a cross referenced reading that could be used to come up with new sus-

tainable development strategies which, in turn could be used to manage the intrinsic fragility, with a stronger link to the territories' own values.

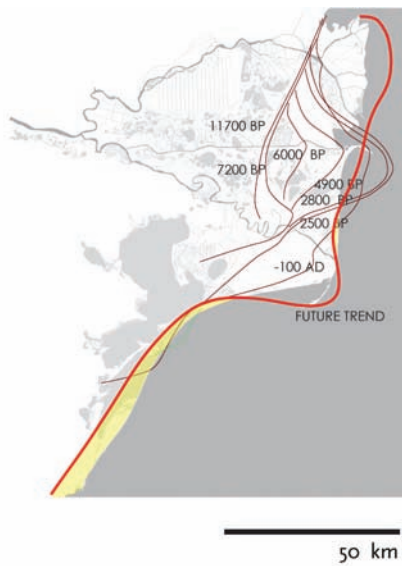
Each of the delta territories that were used in putting together the atlas presents specificity and differences. The Danube delta is characterized by a strong natural vocation in which a weak settlement system, although showing much potential, is poorly connected to the principal attraction poles of the region, and is overpowered by weak socio-economic development processes. Starting from the idea that as a whole, these aspects are closely connected, the lack of accessibility could be interpreted in different ways: it could be considered a problem for human activity and the needs of society, but also as a favorable condition for biodiversity. This is especially true if one considers that it is the only delta in the world to be declared a protected biosphere. In this context, the human and environmental aspects should relate and adapt to each other through strategic management programs, as with the restitution of the land to the sea, re-qualification of rivers and re-naturalization, paying particular attention to landscape values.

The Ebro delta, as opposed to the Danube delta, is an area that has been taken over by a more consistent anthropization process, aimed at improving its agricultural production capacity, but at the same time bearing in mind the natural dynamics of biodiversity.

Figure 2: atlas: coastal erosion.

EROSION COAST LINE

DANUBE

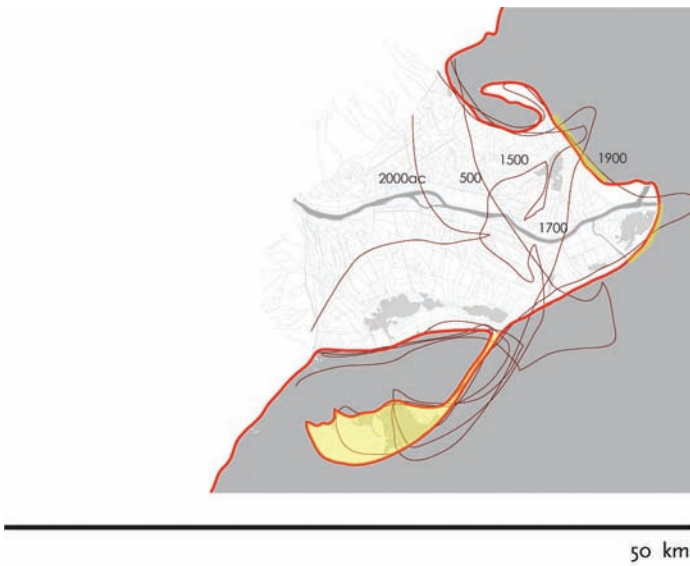


coast line trend tendenza della linea costiera
erosion erosione
evolution lines linea d'evoluzione

Sediments accumulation from Kilia branch and erosion in the southern coasts. The Sulina jetty construction has increased this dynamic.

Accumulo di sedimenti dal braccio di Kilia e erosione nelle coste meridionali. La costruzione del molo di Sulina ha accentuato la dinamica.

EBRO

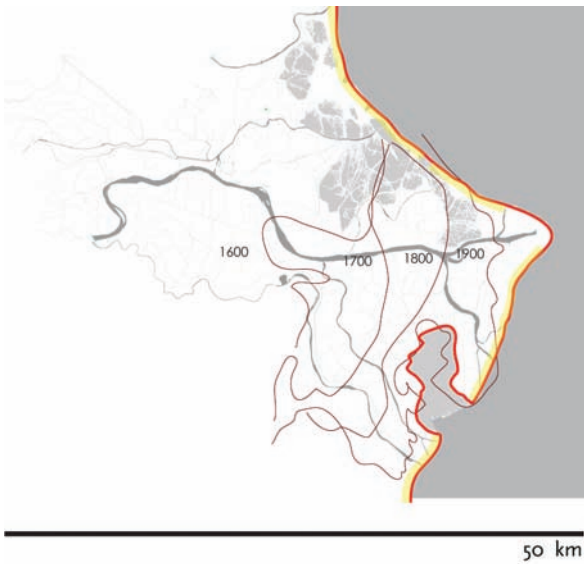


coast line trend tendenza della linea costiera
erosion erosione
evolution lines linea d'evoluzione

Due to decrease in water flow, upstream sediment trapping and wind, the Ebro delta is not growing.

A causa della riduzione della portata, del trattenimento dei sedimenti a monte e del vento, il Delta dell'Ebro non cresce.

PO



coast line trend tendenza della linea costiera
erosion erosione
evolution lines linea d'evoluzione

Due to decrease in water flow, upstream sediment trapping and wind, the Po delta is not growing.

A causa della riduzione della portata, del trattenimento dei sedimenti a monte e del vento, il delta del Po non cresce.

RHINE



coast line trend tendenza della linea costiera
erosion erosione
evolution lines linea d'evoluzione

Erosion along the coast because of the sea current and the deficit of sediments discharged by the Rhine.

Erosione lungo la costa a causa delle correnti marine e del deficit di sedimenti portati dal Reno.

The main stretch of the river running across the delta has been modified in order to guarantee a higher level of economic production. To maintain the balance between nature, human settlements and recreational activities, a regional management program capable of incorporating all the principal activities of the delta has been developed. It is important to highlight the fact that, of the four studied deltas, this is the only case in which there is active cooperation between the territorial bodies involved.

The Po delta is presented as a large agricultural region supported by a capillary hydraulic infrastructure. The existing water systems are the result of a long important process of anthropization of the territory. Today, phenomena like subsidence, the return of salt wedges, the lack of water and the rising of sea levels has rendered the territories economy all the more uncertain. Aquaculture and activities related to the water seem to be promising alternatives that are able to adapt to the emergence of new instability. The *Polesine Camerini Station* represents another threat to the delta environment, but could also be seen as an opportunity. The hypothesis of converting the existing station using innovative environmentally friendly technology could lead to the restoration of the entire territory. Finally, the Reno delta is characterized by consistent population levels, living in close relation to their own territory and who have over time, equipped themselves to counteract its intrinsic fragility and take advantage of its natural resources.

Today, the Reno delta is one of the most urbanized areas in Europe. Recent issues related to the quality, quantity and accessibility of its waters have been regarded as challenges of utmost

importance, having been highlighted by the risks induced by climate change. In this specific territory, a new balance between human activities and natural processes is indispensable to the sustainable development of the territory.

2. Community maps

The principal aim of the community maps was to elicitate the Po delta's inhabitants' perception of their own territory. The maps show the way in which the local community sees, perceives, and attributes value to their own territory, or landscape, together with activities that have been carried out, a place of memories and future transformations. The putting together of the maps was done over three principal phases.

First, it was necessary to identify and define the territorial environment that was to be investigated. Next, the instruments most suited to collecting the inhabitants' opinions and stories were identified. Lastly, the representation techniques most suited to the graphic restitution of the collected data was discussed. In fact, the way in which the collected information was represented was itself the object of research and experimentation. For this reason there are notable differences between each elaborated map. The necessary information for the realization of the maps was collected through numerous interviews and then refined into a questionnaire, the compilation of which was often accompanied by more in-depth conversations in order to clarify the interviewed person's point of view.

Considering the Summer School's limited time period, it was decided to base the investigations on a numerically restricted, sufficiently heterogenic sam-

pling of the Taglio di Po and Porto Viro municipalities as a departure point in the elaboration of a batch of "perception maps" showing the relationship between the inhabitants and their territory. Despite the carrying out of the sampling, it seems as though the results of the investigation report a significantly generalized perception of certain territorial phenomena by a large part of the local community (Figure 1).

3. Scenarios

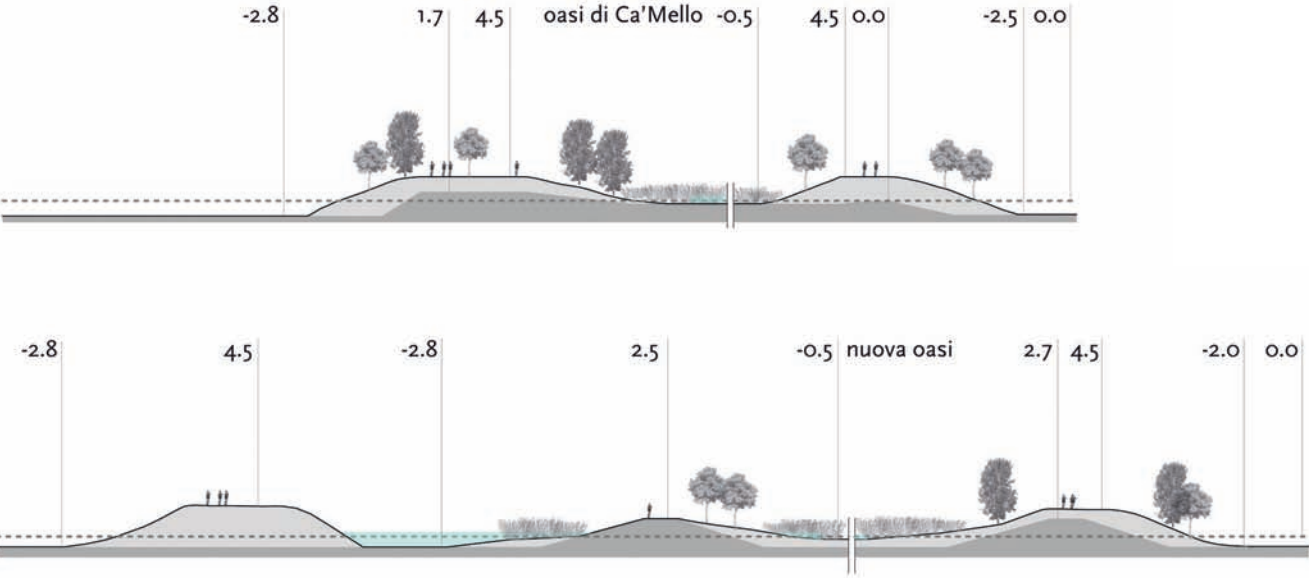
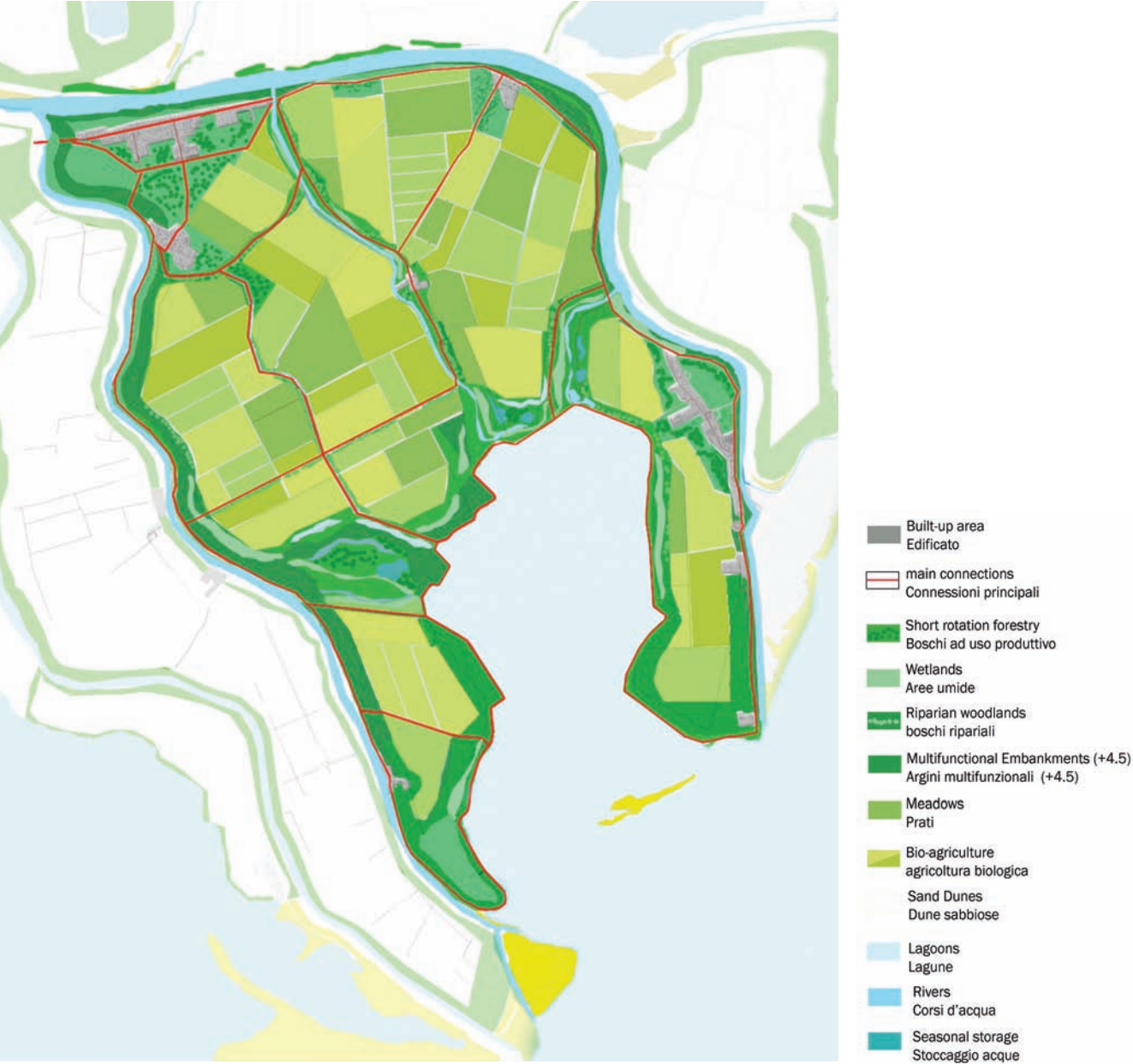
One of the Summer School's tasks was to deal with the identification of resources and criticalities in the Po delta territory and the predisposition of scenarios for their effective use. The activities carried out were compared above all with the "principles of land and water", elements of this fragile territory affected by important climatic changes. Considering that these elements are producing significant effects on locations and the inhabitation of the Delta, they made up the basis for the creation of the scenarios.

The implicit issue is the Delta's possible future development and to which types of landscapes it will give form. This issue is based on three presuppositions:

1. a growing knowledge of the workings of climate change;
2. the reinforcement of the link between landscape (ecological and economic aspects) and quality of life of the inhabitants (social, cultural and eco-

Figure 3: scenario: foreseen land use.

MASTERPLAN



conomic aspects);

3. shared planning and programming of the transformations and intervention strategies based on involving and communicating with the local population.

The students worked on constructing scenarios for the sustainable development of the *Isola di Polesine Camerini* and *Isola della Donzella*. On the basis of a so-called S.W.O.T. Analysis, the strengths, weaknesses, opportunities and risks to be found in the investigated area were identified. The information was collected from excursions, maps, texts and data; as well as from lessons and discussions carried out with inhabitants, experts and stakeholders (including trade union representatives and local administrators.) The scenarios propose a future prospective based on the specific characteristics of the investigated places.

The intension was to lever upon the strengths, opportunities, and endogenous characteristics of each area; to effectively put to use the current and future fragilities of the territory (weaknesses and threats, the raising of the sea level, the advancing of salt wedges or the results of climate change.) The constant discussion and exchanges, also with other work groups within the Summer School contributed to the critical observation of the construction of the scenarios, like wise with their refining, regarding social, economic and ecological aspects. Overall, the scenarios constructed appear to be very different. They offer different solutions for future sustainable development, applicable to other similarly fragile areas of the Delta.

The conclusive works could provoke disagreement amongst the local popula-

tion, the administrators and stakeholders. They could be judged to be drastic or unrealistic. They could go against the established image of the territory as represented by the present administrative, institutional and management structures. Nevertheless, we would like to suggest to those in charge of the transformations to react quickly to the effects of the rising sea level as well as climatic and economic changes.

One of the two scenarios titled *Corridoi Verdi*, (Green Corridors) which relates to the *Isola della Donzella*. The *Isola della Donzella* has a reversed 'U' shape and is surrounded by water bodies on three sides, two of which are made up of branches of the Po River. The *Sacca degli Scardovari*, lies to the south making up a biologically highly diverse area ideal for shell fishing while the emerged areas of the island are entirely cultivated.

The use of the land, the water cycle as well as its relative infrastructures, roads and areas with high levels of naturalness (the later falling within the *Parco Regionale del Delta del Po*), constitute the elements upon which the critical observation on the island's sustainable future was developed.

Observation of the following systems was carried out:

- the water system and ecological structure;
- the various infrastructures and settlement system.

The investigation highlighted that, like its neighbor the *Isola di Polesine Camerini*, the effects of climate change, in particular the re-emergence of salt wedges and insufficient irrigation, are a threat to the agricultural activities that are carried out on a large part of the island.

A portion of the territory has recently

been the object of a pilot project called *Oasi di Ca' Mello* carried out on the ancient sediments of a branch of the River Po, in which the *Consorzio di Bonifica Delta del Po* collaborated with the regional agricultural entity Veneto Agricoltura. A series of devices allow for the purification of the water drained from nutritionally rich cultivations. The exiting drained water flows through the humid areas of the island's ecological corridor and after purification is partially stored with the aim of being re-used for irrigation.

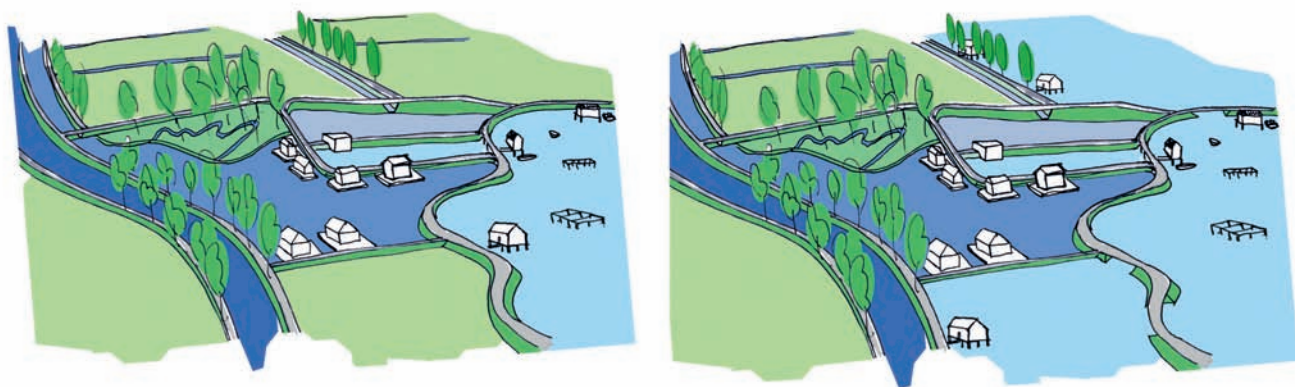
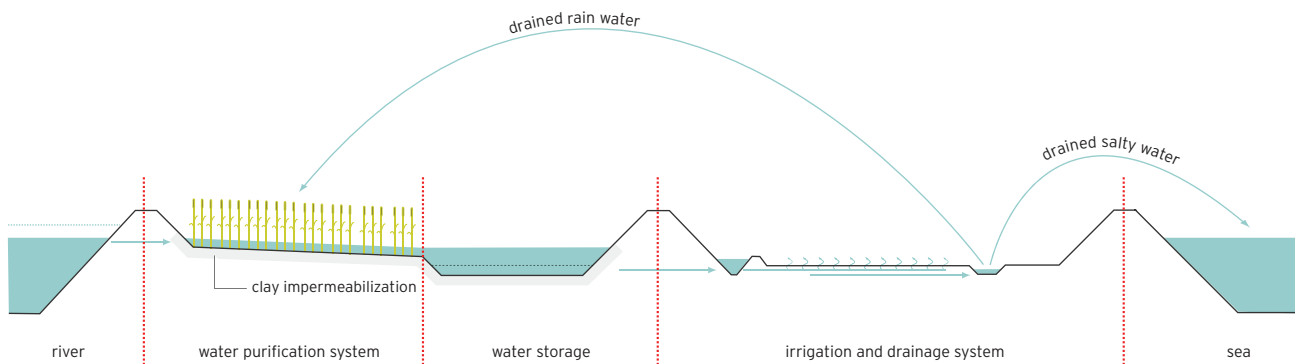
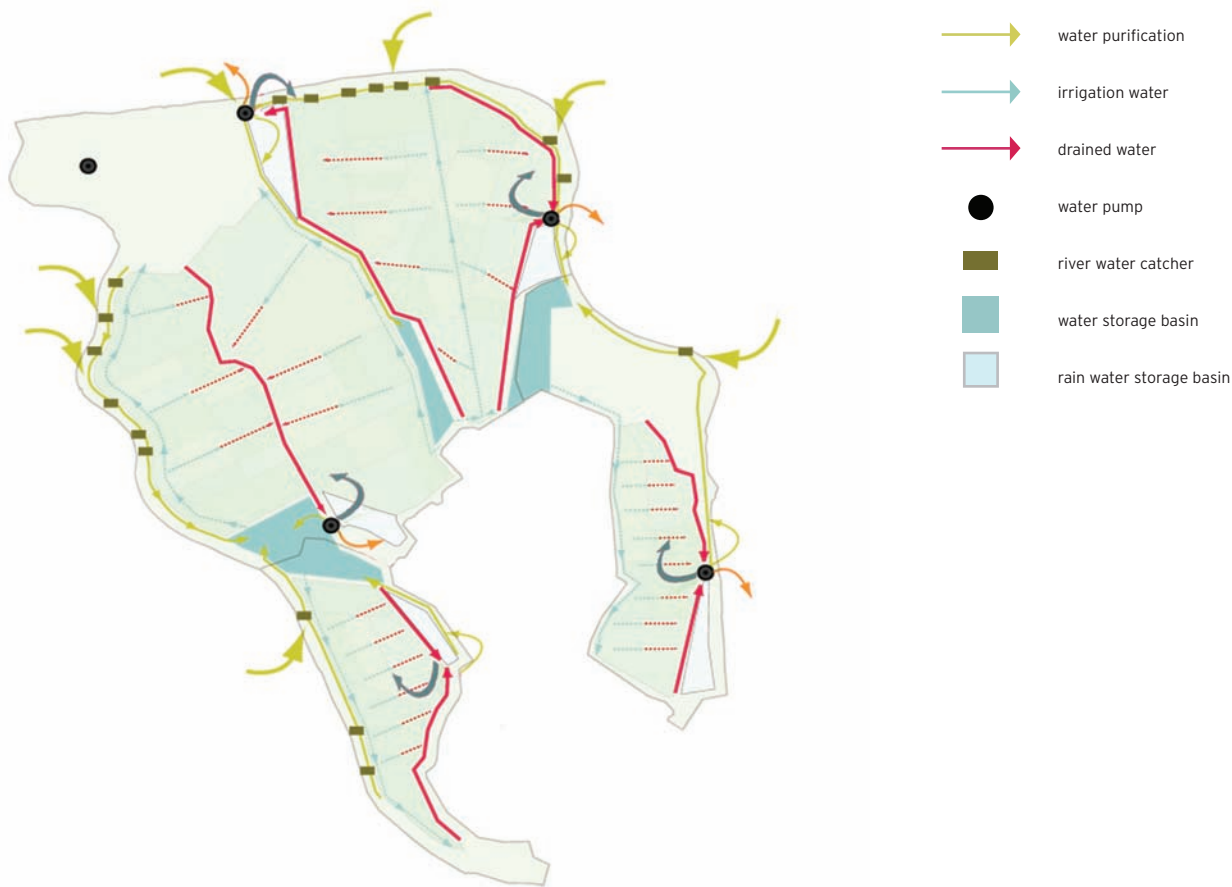
The potentiality and main possibilities for the elaboration of a long-term strategy were also identified via the characteristics of the agricultural landscape, different sites of social and historical value and physical and strategic characteristics of the *Oasi di Ca' Mello* pilot project.

The underlying physical and strategic structures of the *Oasi di Ca' Mello* pilot project, together with the characteristics of the agricultural landscape and different sites of social and historical value, are the principal elements upon which an attempt was made to construct a solid, long-term strategy.

The design concept inspired by these characteristics proposes the reiteration of the *Ca' Mello* territory's ecological infrastructure in order to reinforce the physical and social infrastructures and direct the development of the area towards a sustainable territorial configuration.

Figure 4: scenario: water management system.

WATER SYSTEM



The strategy is a response to the following issues:

- salinification of the soil and surface water;
- marine eustacy;
- insufficient competitiveness of tourism and agriculture.

The hypothesized territorial transformation process foresees certain possible interventions, in order to reduce the salinification phenomena occurring in fresh water and its effects on the area's activities. This new system can support economic activities, providing an alternative to extensive agriculture.

The principal actions foreseen are as follows:

1. At the moment, the territory is undergoing salinification. In the *Oasi di Ca' Mello* pilot project, the retained, purified and stored water puts pressure on the salt water reducing the amount to which it rises back up. The purified water is partially re-used for irrigation. The oasis system could be replicated on a larger scale and it is for this reason that this prototype was used in developing the scenario.

2. Other wetlands similar to *Ca' Mello* could be replicated on the island. A wetlands system using already existing embankments and canals to form new green corridors is put forward. During the year the rainwater drained from the fields and the fresh water from the water bodies upstream is retained, purified and stored. In the case of the *Oasi di Ca' Mello* the intrusion of salt water is notable reduced. The stored water is capable of catering to the irrigation needs of the island's activities. The wetland areas forming new fauna and flora habitats increase its biodiversity. The new

ecological corridors are multifunctional infrastructures of the landscape upon which territorial development and fruition depends.

3. The new environment allows for more sustainable water management and re-qualification of the territory. The green corridors are platforms from which new ecotourism and bio-agricultural activities can be launched. As an alternative to the current extensive agriculture, biological agriculture introduces production that is compatible with soil conditions, at the same time diminishing the nutrient content of the soil.

4. In cases of considerable rising of the sea level and augmentation of the intrusion of salt water, the southern most parts of the *Isola della Donzella* are flooded, removing the embankments to the sea. The low-lying ground, engulfed by salt water become suited to clam and mussel cultivation, today considered to be one of the most profitable agricultural activities. The formation of new lagoons suited to shell fishing, the agricultural activity first requires the soil to be purified. Organic agriculture as proposed in the previous phase contributes to this objective.

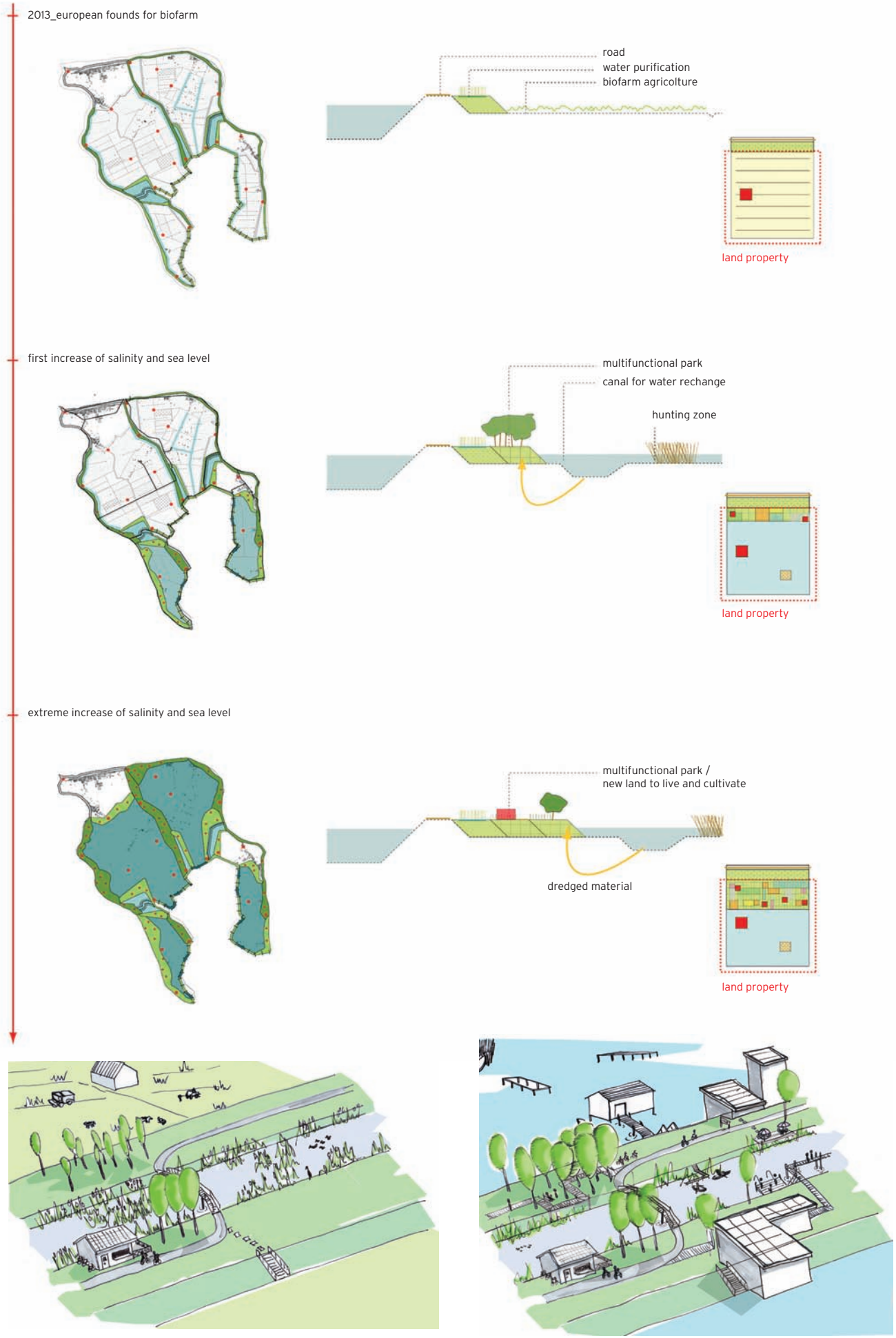
As we have tried to demonstrate, the favorable condition that is in some way intellectually protected, within which the Summer School's activities have been carried out, has made it possible to imagine the re-composition and cogitation of apparently indomitable principles. It seems legitimate, at this point to ask oneself what the prospects for research and experimentation projects closely carried out with specific territories are as well as for those activities in which Universities work side by side with the territory in contributing to the reorien-

tation of construction and transformation processes.

A year and a half after the start of activities in the Po delta territory, one could say that the University's presence in this territory has taken on a more structured and continuous role. Right from the start the aim was to effectively integrate, converge and exchange knowledge of various subjects with the involvement with the local population, to present a vision, specific points of view, and evaluation criteria, contributing to making instruments favoring territorial interventions of the observers, instruments that can, with good reason, participate in the collective effort to undertake, like in other territories, a different development path. The interest and curiosity in the activities in which we have up to now been involved, clearly show the support that the local community are giving us, and will continue to give us in the future, allowing this experience to continue in its work and contribute to envisioning the future of this territory.

Figure 5: scenario: phases.

TIMELINE



_ACTS OF THE CONFERENCE CONSERVATION AND PRODUCTIVE ACTIVITIES IN THE PO DELTA

REMIGIO ROSSI
Università di Ferrara

Introduction

This document is a summary of and conclusion to the "Compatible uses in Lagoon Environments" workshop presented at the 1st International Conference on the Lagoons, from 01 to 03 October 2009, coordinated by Remigio Rossi and Luigi D'Alpaos. Contributions were also made by The President of the *Consorzio Pescatori di Scardovari* Giovanni Colacicco, Lorenzo Carnacina representing the hunting world, Pierfrancesco Macola representing tourism, the fish breeder Giuseppe Penzo and Marco Gottardi of the *Parco Regionale del Veneto*.

The document suggests strategies for reaching objectives and if agreed to by the Administration, should be the basis for criteria selection, intervention priority, and the predisposition of specific operative projects.

Basic document guidelines

In the past, the main activity that has enabled the conservation of Italian brackish water environments, and those of the Mediterranean area in general, has been the fishing activity: over the years, the fishing managers have contributed to the vivification and then to the conservation of the coastal lagoons through maintenance interventions on tributaries, tidal canals, bottoms and overall internal circulation, even if their final objective was to optimize fishing production.

Recent European Community conservation policies have brought about the creation of protected areas within many lagoon environments. The protected areas and the simultaneous presence of activities like fishing, aquaculture and hunting in the lagoons could be seen as a

contradiction that could lead to conflicts over their use. The best solution, however, is to guarantee the survival of environments and resources through their multiple uses. The creation of sustainable development models requires new ways of using environmental resources based on a new relationship between enterprise and the environment.

A balance should be struck between first generation environmentalists and the economic stakeholders who are exclusively oriented towards the profit of their enterprises without considering the "outside world". This means abandoning past scenarios as exclusive reference models, capitalizing on what remains of the past, and in short, inventing the future, like certain community programs hope to do.

A new environmental and production concept

New European Community policies imply a new notion of the environment. The production sector should embrace the concepts of total quality and take up the fight against the intensive misuse of natural resources. The culture of the environment inhabitants, their productive capacity as well as the quality of the territory are also local resources that must provide the local economy with a competitive advantage and help to build a niche in the markets.

Production should not only keep an eye on the product, but also on its production processes (company type, the human and environmental factors of which it is made up, quality control systems, etc.). New companies should look after the environment, taking care of the landscape through renaturalization e.g the realization of plantations

and lagooning areas. In so doing, the companies offer “environmental services” of recognizable collective interest, thereby legitimizing public support for the enterprise. The quality of the territorial context can allow for the creation of “brands” that can be used for marketing purposes. There should be no difference between defending the territory and promoting its productivity. The enterprises and the territories activities should instead take on a broader and more strategic role in guaranteeing its conservation, overall qualification and economy.

Strategic guidelines for identifying Delta environment policies:

- the enterprises’ active participation in the leadership of environmental policies, while promoting an entrepreneurial mentality that is disposed to follow ecologically compatible production principles;

the assigning of parts of the territory to lagooning, seen as an instrument for improving water quality;

- the increasing of the vegetation covering, for ecological, productive, recreational functions;

- the realization of hydraulic interventions and eco-compatible agricultural activities integrated with urban and territorial interventions. Cooperation with the Land Reclamation *Consortia* is essential in managing the terrain and reclamations, the surface water system (canals and mouths) and reclamation infrastructures;

- the offering of quality products (e.g. the “*Parco del Delta*” trademark) through advertising campaigns and food

education in order to guarantee a recognizable, widespread and profitable presence in the marketplace.

- the recognition of the close relationship between aquatic and terrestrial environments when considering each intervention proposal. The borders of interventions often involve different Municipalities and accordingly it is the hydraulically connected basins that should undergo interventions.

General projects

General hydraulic management project

The main problem facing the lagoons is hydraulic circulation. The reclamation *Consortium* is in charge of a general project aimed at the hydraulic reorganization of the mouths, all canals, embankments and service infrastructures (conduits, siphons and eventual thrust points), be it for freshwater or seawater.

General water and sediment quality restoration project

As referred to in the *Water Framework Directive*, the natural purification system is capable of removing thinly dispersed pollutants. Once the necessary standards are reached, the lagooning of water could involve the purification of significant amounts of water destined and certified for production, consumption and eco-tourism.

General Environmental quality restoration project: vegetation

The degradation of many of the basins is due to the lack or limited presence of vegetation, an element that is useful in maintaining high levels of biodiver-

sity. The following projects have yet to be developed:

- general Conservation Project entrusted to the Private sector;
- the Delta and its lagoons Governance Project.

Compatible Productivity Initiative
(here follows a simple list)

- Income from traditional *Vallicoltura*.
- Income from fishing.
- Income from clam farming.
- Income from Tourism and Eco-tourism.
- Income from hunting activities.

The *Laboratorio internazionale delta e lagune Ca’ Vendramin* could be the instrument through which the study of the above-mentioned themes is broadened.

SYNTHESIS AND RESULTS

PIPPO GIANONI
IUAV Venezia e Dionea SA Locarno

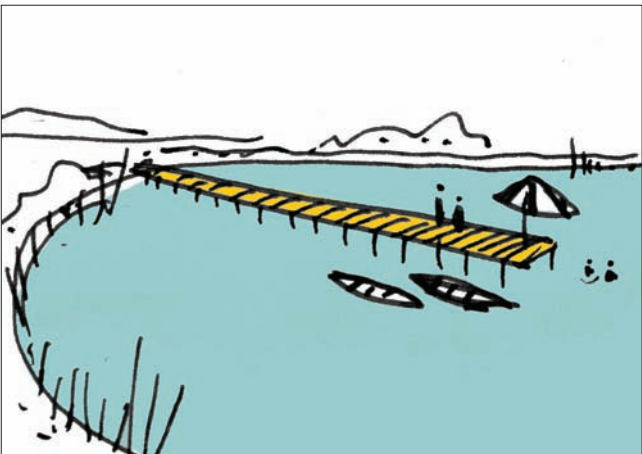
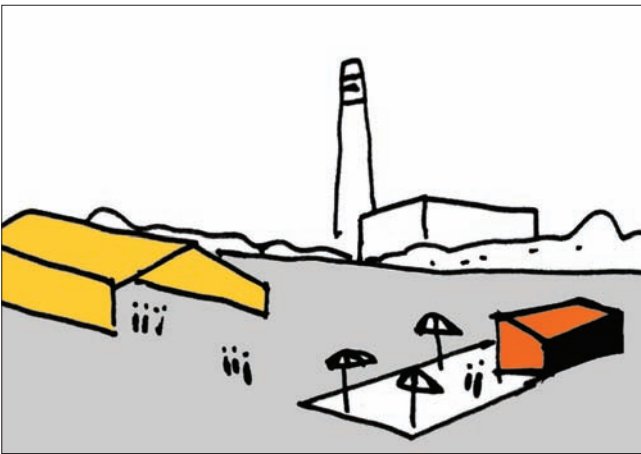
REMIGIO ROSSI
Università di Ferrara

Over the last 15 years, Lagoon management has had a predominantly technical focus, favoring vivification interventions aimed at resolving production and environmental problems. The work carried out over this period has produced positive results, leading to an improvement in the situation, both from an environmental and production point of view.

Bearing in mind that a well-conserved lagoon is able to respond better to the different ecological, economic and social demands, the environment conservation is of utmost importance in intervention planning. Being fragile, dynamic and continuously evolving systems, new ideas and instruments are therefore necessary in the management of the lagoons and the valorization of transitional waters.

Creating a shared vision between territorial planning and active lagoon management, the protection of the environment and economic development, while capitalizing on production and tourism/recreation, seems indispensable. The evolutionary processes need to be accompanied by new paradigms, like:

- flexible planning and management, capable of adapting to the continuous climatic, ecosystem, economic and social changes;
- multidisciplinary studies and programs, that bring together engineering, natural sciences, social and economic aspects to generate integrated, multidisciplinary concepts for water body management. New development models could be achieved inte-



Hypothesis for Po Delta recreational activities, as proposed at the "Constructing Scenarios for Fragile Territories" workshop.

grating scientific and local inhabitant skill;

- scientific research as a growth factor, giving the universities a primary role in the territory, identifying sectors in which to be involved in the European and world delta networks through culture, experience and know-how;

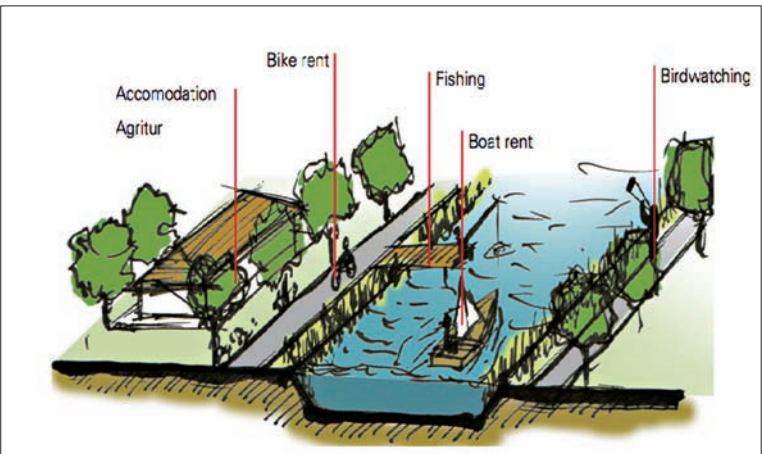
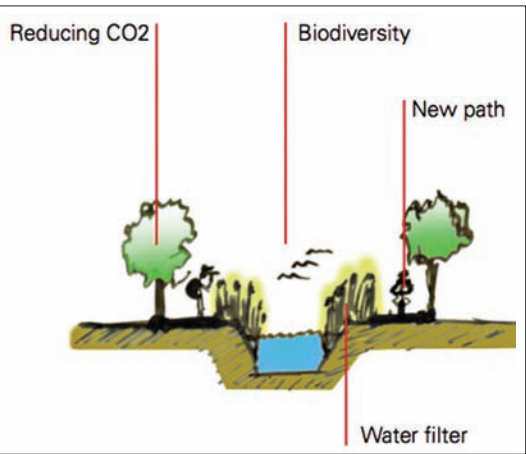
- reducing planning and management fragmentation, through a discussion forum consisting of the various local planning entities and area management, as well as new instruments e.g. the *Contratti di fiume* (River Contracts);

- capitalizing on public/private sector partnership through the development of common initiatives and the on-going training of the Delta's workers;

- active participation in the delta and lagoon network in order to share experiences and knowledge;

- seeing the territory as a laboratory where innovation and experimentation takes place in support of qualitative growth.

The *Fondazione Cà Vendramin* can help in achieving these objectives by following the example of other European models and acting as a meeting-point, helping to create an open *forum* for discussion and proposals.



Analysis regarding environmental sustainability and the development of integrated tourism, as proposed at the "Constructing Scenarios for Fragile Territories" workshop.

THE FISHERMAN TRAINING PROJECT

REMIGIO ROSSI
Università di Ferrara

Every production sector is invariably subject to the updating of knowledge regarding technological innovation, market trends and legislative changes. In the Po delta, for the shellfish culture this means that the shell fisherman have to keep hygienic-sanitary requirements in check while paying particular attention to the conservation of the environment.

The world of shellfish production is continually confronted with difficulties and emergencies that the “simple clam collector” of the past is no longer capable of solving. Therefore, in order to capitalize on quality production, a new figure has to be created, “the real clam farmer”. Today, being a good farmer is no longer sufficient: apart from a growing commitment to the environment, new abilities for marketing and product promotion as well as legislative knowledge are needed to confront with other farmers, the institutions and the public administration.

Originally aimed at the Po delta shellfish farmers, the *Fondazione Cà Vendramin's* professional training course is intended to supply the fisherman with the specific knowledge and continuous multidisciplinary updating necessary for a modern shell farmer.

The course, titled “Integrated shell fishing management”, covers a wide range of topics from biological, ecological, and zootechnic to economic, social, legal and food



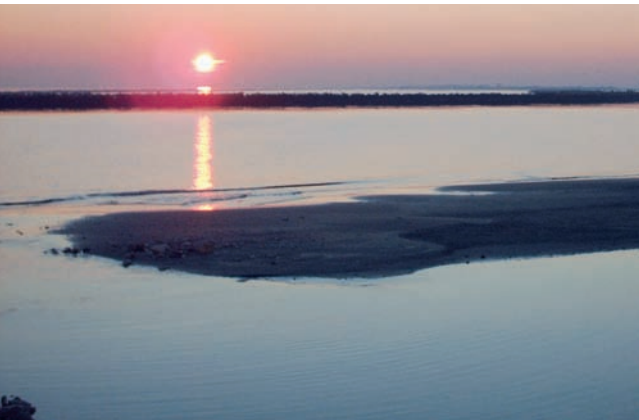
Clam fishermen in boats with “rasca corta” and “rasche lungha”, fishing

equipment which today is considered outdated.

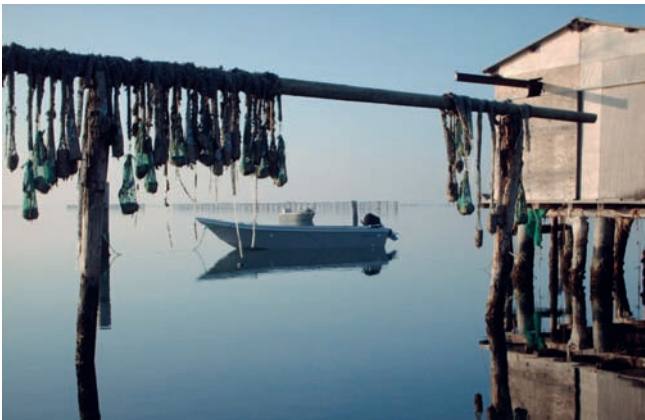
safety aspects, and was designed to be an organic “collage” of contributions that future elaborations could be based on. The common thread linking all of the different topics is that of the development of responsible and ecologically sustainable shell farming; specifically in the peculiar case of the *Polesine*, connected to the heart of the *Po Delta Park*.

The course is made up of ten three-hour monothematic training sessions, planned so as not to interfere with the work commitments of the participants, 20-25 per course. After an introductory encounter explaining the aims and methods of the course and the issuing of course materials, the following themes will be dealt with: delta geomorphology and the Po delta's formation and territorial evolution; lagoon ecology; bivalve biology in relation to shell culture; hydraulic interventions in the Po delta lagoons; the economic importance of the shellfish; marketing and modernization in the commercialization of ichthyic products; the main sanitary aspects pertaining to shell culture; problems pertaining to concessions in the delta areas, and last but not least, the new prospects for the diversification of shell culture.

The themes of each encounter will be entrusted to nationally recognized experts, who put together the teaching materials specifically produced for this course. The encounters will take place in the evening at the *Fondazione Ca' Vendramin* offices.



The sun sets over
Barbamarco lagoon.



Mussel processing
shed in the Sacca
degli Scardovari.

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QUADERNI CA' VENDRAMIN

Laboratorio internazionale delta e lagune Ca' Vendramin journal
Issue 1 - November 2010



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Production of the edition and project series:

Deltaplanning Srl

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Graphic design and layout:

Dasler comunicazione

Editorial assistant and project coordination:

Maria Saccon

Translations:

Stephen Trollip (except pages 6-7, 40-45, 70-75, 86-93)

Printing:

Tipografia Papergraf Spa

Contributing editors:

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Photographs:

Archivio TE.MA Progetti
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