



Ninth International Symposium



Monitoring of Mediterranean Coastal Areas: Problems and Measurement Techniques

Livorno (Italy) 14th - 16th June 2022

edited by

Laura Bonora, Donatella Carboni,
Matteo De Vincenzi, Giorgio Matteucci



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MONITORING OF MEDITERRANEAN COASTAL AREAS:
PROBLEMS AND MEASUREMENT TECHNIQUES

- 1 -

MONITORING OF MEDITERRANEAN COASTAL AREAS: PROBLEMS AND MEASUREMENT TECHNIQUES

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Preface

The Ninth edition of the Symposium *Mediterranean Coastal Monitoring: problems and measurement techniques*, held in Livorno from 14th to 16th June 2022, addresses scholars of the coastal areas of this Mediterranean basin, as it happens once every two years. The event, organized by the Institute of BioEconomy (IBE) of the National Council Research (CNR) in collaboration with the Italian Society of Silviculture and Forest Ecology (SISEF), is divided into the following Sessions: Flora and fauna of the coastal system: dynamics and protection; Morphology and evolution of coasts and sea beds; Coastal environmental engineering: pollution, energy production, economic-environmental monitoring and evaluation, regulatory context; Coastal and underwater cultural heritage; Geography and coastal landscape: dynamics of the territory and integrated protection.

During the consolidated three days, following the tradition, The Symposium with its interdisciplinarity intends to demonstrate the importance of multidisciplinary studies, underlining the need for integrated investigation approaches. Since the coastal system represents a complex and delicate natural structure, whose evolution is the result of delicate physical, chemical and biological balances, strongly conditioned by anthropic interventions, the aim of the Symposium is to contribute to the spread of knowledge, providing notions and information on dynamics and / or on the variations of marine-coastal ecosystems, in the hope that this can be useful to increase man's respect towards the land that hosts him.

Despite the COVID 19 pandemic, the success of this edition is attested by the 170 contributions selected by the Scientific Committee from among those received. Participation involved all the thematic lines envisaged by the sessions, involving many countries bordering the shores of the Mediterranean Sea. The importance of the event is also attested by the publishing house's request to turn the Proceedings of the Symposium into a Series, of which this volume is the first issue.

A personal thank you goes, first of all, to all those, colleagues and friends, who have invested time and energy in the organization. The same gratitude goes to all the participants, who, with their presence, have shown that they believe in our initiative.

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Presentation of Proceedings

As described in the Preface of this Proceedings Volume, the Symposium has been confirmed as a place to present the research carried out in recent years on the monitoring of the Mediterranean Coastal Areas and therefore as a space to present new proposals and promote actions for the protection of the marine and coastal environment.

The interdisciplinary of the Symposium has been the occasion for consolidating the scientific exchanges of scholars from Mediterranean countries and also for promoting a greater diffusion of the research and related results.

It is relevant that the Symposium is considering the Mediterranean Coastal Areas in all their aspects: from morphology and evolution of coastlines and seabeds to the landscape dynamics and integrated protection; from the dynamics and protection of coastal and underwater flora and fauna to cultural heritage, considering the challenges of pollution, energy production, environmental assessment and regulatory context of coastal areas.

In this 9th edition, in fact, we had more than 100 participants from 12 countries; this is a sign of great success and willingness of being in presence in Livorno to discuss problems and propose solution for the Mediterranean coastal areas. The international scientific committee supervising the Symposium, formed by 35 renowned scientists, did a great and hard work in selecting 42 oral and 100 poster presentation among the 170 contributions received.

It is important to underline since this year, the *Proceedings* will become a Series published by Firenze University Press: another step forward that underline the scientific and political relevance of studying and managing Mediterranean Coastal Areas.

For all selected works a *double peer review* has been carried out for the inclusion of the extended papers in this Volume.

This edition has been the occasion to establish a new collaboration between CNR-IBE and Italian Society of Silviculture and Forest Ecology (SISEF) in the organization of the Symposium.

The aim of CNR-IBE and SISEF is to continue in their collaboration to organize the next edition, the 10th, of the Symposium and to involve an increasingly wide audience of scholars, supporting in this way the dissemination of scientific results obtained in the field of protection of the Mediterranean coasts.

The Director of CNR-IBE
The Vice President of SISEF
Dr. Giorgio Matteucci

INTRODUCTION

Several agreements for the protection of the coastal and marine environment are currently effective in the Mediterranean region. However, from a historical point of view, the attention to the "health conditions" of the Mediterranean is a concept born only recently. If we wanted to indicate a precise moment, we should identify it in 1975, the year of birth of the *Mediterranean Action Plan*¹. The following year it was signed the Convention for the protection of the Mediterranean Sea against pollution (definitively entered into force in 1978), the so-called Barcelona Convention². This agreement was revised and supplemented in 1995 (Convention for the protection of the marine environment and the coastal region of the Mediterranean). The Barcelona Convention is managed by the United Nations Environment Program (UNEP) with the aim of preventing, reducing, combating, and eliminating, as far as possible, sea pollution in order to protect and improve the marine and coastal environment and thus contribute to its sustainable development. The Treaty identified seven action protocols³ concerning, for example, the protection of the sea from pollution of terrestrial or marine origin (including hazardous waste, exploration and use of the continental shelf), cooperation for the prevention and control of pollution from ships and Integrated Coastal Zone Management (ICZM).

Another important regulatory instrument for the Mediterranean, is the Framework Directive on the Strategy for the Marine Environment (2008/56/EC, Marine Strategy Framework Directive, MSFD).

Characterized by greater applicability than previous instruments, it provided that each State Member should develop a strategy for achieving or maintaining Good Environmental Status (GES) by 2020. In particular, it identifies marine monitoring as the first of the operational components in an appropriate governance system (Ferraro et al., 2017; Gianoli 2013).

¹ <https://www.unep.org/unepmap/>

² <https://eur-lex.europa.eu/legal-content/IT/TXT/?uri=LEGISSUM:l28084>

³ THE PROTOCOLS OF THE BARCELONA CONVENTION: 1. Dumping: Prevention of pollution due to diving operations of ships and aircrafts; 2. New Emergency Protocol: Cooperation to prevent pollution caused by ships and in emergency situations; 3. LBS (Land Based Sources): Protection from pollution of terrestrial origin; 4. SPA / BIO: Special Protection Areas and Biological Diversity; 5. Off Shore: Protection from pollution deriving from the exploration of the exploitation of the underwater continental shelf and of the subsoil (not yet entered into force); 6. Hazardous wastes: Cross-border handling of dangerous wastes and their disposal (not yet in force); 7. ICZM (Integrated Coastal Zone Management): Integrated Coastal Zone Management (defined by the Contracting Parties at the Conference of the Parties in Almeria and signed in Madrid, Spain, in January 2008).

However, today, when we talk about the Mediterranean Sea, we too often think about the millennia of history that saw it as a protagonist and about the many cultures that developed on its shores. We also consider that it was (and still is) a great source of sustenance and trade for many populations and, last but not least, we recognize the strategic role as a center of the world (at least of the western one) that this sea played for many centuries. Nevertheless, unfortunately, the Mediterranean is not always seen as an environmental entity that has been exposed, for a very long time, and particularly in recent decades, to enormous pressure on all the ecosystems that compose it: a pressure generated especially by the men who lived and still live along its coasts.

The coastline of the Mediterranean extends for a total of about 46000 km, with other 19000 km of the islands; of all coasts, almost half (46 %) is sandy and it includes important but fragile habitats and ecosystems such as beaches, dunes, lagoons, marshes, river deltas, estuaries, etc. (Gianoli 2013).

The main dangers for this complex and varied environment are represented by the fragmentation, the degradation and the loss of its habitats and landscapes. Among the various causes of degradation, population density plays a fundamental role, almost a third of the Mediterranean population (512 million in 2018, equal to 6.7 % of the world population) lives in the coastal areas and over 70 % in its cities. Nevertheless, the area demographic context is very different: Northern Mediterranean Countries (NMCs) are characterized by a low fertility rate, an aging population and a relatively low percentage of the workforce; Southern and Eastern Mediterranean Countries (SEMCs) are undergoing a demographic transition phase with a quite stronger growth, an overall younger population and therefore a larger active population (SoED 2020).

The population of the countries bordering the Mediterranean Sea was made up of about 450 million people in 1996 (EEA, 1999), it reached more than 525 million individuals in 2020 and, according to recent projections and estimates, it will reach 655 million of residents in 2050 (EEA, 2020). This steadily increasing population pressure is exacerbated by tourism. The mild climate and the natural and cultural heritage attract a large number of tourists, whose percentage, in fact, represents about one third of the world's international tourism. Moreover, tourism concentrates on a seasonal way in coastal areas, in particular on the coasts of the north-western basin (AEA, 2006). Furthermore, coastal tourism is one of the main factors associated with the production and management of waste, particularly marine litter. The strong spatial and temporal variations of tourism, mainly concentrated along the coast and with important peaks during the summer season, lead to an increase in waste production, untreated wastewater discharges and strong pressures on natural resources. Besides, the deterioration of the quality of the

environment, as well as that of water quality, can in turn have an impact on the environment and on the development of tourism, reducing the attractiveness of tourist destinations (EEA, 2020).

In addition, the intensification of urbanization (between 1965 and 2015 about three quarters of Mediterranean countries doubled or more than doubled the inhabited area in the coastal strip 1 kilometer from the coast) left less space for natural coastal ecosystems, reducing the contribution of ecosystem services and increasing the risks for biodiversity and for people living on the coast (SoED 2020).

The Mediterranean Sea is home to more than 17000 marine species (between 4 and 18 % of the known marine species in the world), but it represents only about 1 % of the global volume of the oceans. Furthermore, the Mediterranean Sea has the highest rate of endemics on a global level (from 20 to 30 % of species), for this reason it is considered a biodiversity hotspot.

Another serious threat is the chemical contamination of marine sediments and aquatic, animal, and plant bio-communities, as a result of the pollution produced by urban areas, industrial settlements, petroleum refining and air transport. Often these are substances that deplete oxygen, or heavy metals, persistent organic pollutants (POPs), hydrocarbons and nutrients in the water. Although in recent years some of these factors have seen, on average, an improvement in the situation linked to greater controls carried out on land-based activities, the risks of contamination associated with hazardous substances still remain a significant problem in many areas of the Mediterranean. Moreover, the release of nutrients into marine waters as a result of human activities is at the origin of the problem of the increase in induced eutrophication, especially in coastal areas in close proximity to large rivers and cities. Clearly, these phenomena also lead to immediate socio-economic implications, since they affect the quality and quantity of the catch, the conditions and landscape value of the coastal ecosystem, the deterioration of water quality and, consequently, also on tourism.

Another threat for the Mediterranean ecosystems, often linked to the change of the water conditions (such as temperature, excessive presence of nutrients, etc.), is the invasion of non-indigenous species. In recent years this is a worryingly increasing phenomenon, especially in the easternmost part of the Mediterranean where its impact on biodiversity, on predation habits, on alteration of the chain and, in general, on habitat modification, has been documented. All that has had repercussions on fishing, aquaculture, tourism, and human health. Furthermore, the problem of over-exploitation of fish resources is very widespread, often well beyond the limits of sustainability. The macroscopic result is the change in biodiversity between species, especially in terms of endangered or threatened species due to intensive and indiscriminate fishing techniques.

Paradoxically, even the development of fish farming (recorded especially since the 1990s) has not alleviated the problem of overfishing but, on the contrary, has ended up adding further pressures to the marine ecosystem due to the release of nutrients, organic pollutants and sometimes antibiotics for livestock into the sea. There is also a conflict with the tourism industry over the use of small natural bays and a degradation of the habitats near the cages (AEA, 2006). Other problems relate to the impact of noise caused by marine biological communities from intense maritime traffic (especially in the western Mediterranean basin) and from industrial installations or offshore military activities in specific areas. Underwater noise is a problem of growing concern in important cetacean habitats such as the Pelagos Sanctuary (the sanctuary is between France, Côte d'Azur and Corsica), the Principality of Monaco and Italy (Liguria, Tuscany and northern Sardinia) or the Strait of Sicily. Besides, it is important to point out the integrity of the seabed, threatened by deep fishing, dredging or other drilling and excavation activities, which have the effect of increasing the suspended particulate matter, together with sediments. Consequently, this modifies the habitats of numerous species in the medium / long term. But above all, it remains the key problem: the risks for biodiversity. As a matter of fact, this is the element on which all the other pressure factors affecting the Mediterranean (Gianoli 2013) group together. The Mediterranean Sea is also one of the areas in the world most affected by marine litter. More than 730 tons of plastic enter the Mediterranean Sea every day; these represent 95 to 100 % of floating marine litter and more than 50 % of seabed litter. Single-use plastic accounts for over 60 % of the total marine litter found on Mediterranean beaches, waste normally produced by recreational beach activities. The main causes of plastic pollution include: an increase in its use, unsustainable consumption patterns and inefficient waste management practices. In fact, less than a third of the plastic produced each year in the Mediterranean countries is recycled. Even wastewater represents an important way of entry of waste into the sea of waste hitherto, less than 8 % of wastewater is subjected to tertiary treatment. Other important sources of marine litter are fishing, tourism, and shipping. Litter affects marine organisms primarily through strangulation and ingestion, but also through colonization and buoyancy. They also have important socio-economic effects through the costs of decontamination, as well as the potential loss of income and tourism jobs, and reduction in the value of land and recreational and fishing activities (SoED 2020).

Therefore, in order to "*prevent, reduce, fight and, as far as possible, eliminate sea pollution and in order to protect and improve the marine and coastal environment and thus contribute to its sustainable development*", as stated by the Convention of Barcelona, it is indispensable an integrated approach based on the knowledge about the different ecosystems and landscapes of the Mediterranean Sea.

Furthermore, in order to better protect the environment, it would be appropriate: to fill the gaps in terms of knowledge; to perfect management practices; to increase the socio-economic capacity for environmental management; to strengthen Integrated Coastal Zone Management (ICZM); to decentralize actions, so as to take into account the specific contexts as well as the specific pressures, impacts and particular needs of each country or area that persists in its waters; to improve monitoring and evaluation plans, in order to ensure informed and adequate policies. And the environmental monitoring is precisely the key theme of this 9th Symposium.

Environmental monitoring defined by the European Environment Agency (EEA) as "*Periodic and/or continued measuring, evaluating, and determining environmental parameters and/or pollution levels in order to prevent negative and damaging effects to the environment*" becomes the fil rouge of the Symposium with the aim of considering both the environmental quality and the effectiveness of the management of the *Mare Nostrum*, with an Integrated and multidisciplinary Ecosystem Approach given the complexity and the dimensions of the phenomenon to be examined.

With these premises, it is possible to achieve a resilient and sustainable future of the Mediterranean Sea only through a holistic and integrated approach and this new edition of the Symposium will be able to provide new knowledge, new tools, new case studies useful for good governance processes and for stakeholders, contributing to identify those cause-effect phenomena that link particular human activities to documented environmental effects and, consequently, to provide information that allows policy makers to adopt policies and strategies able to avoid, or at least reduce, negative effects on the environment.

The Symposiarch

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SESSION

**MORPHOLOGY AND EVOLUTION
OF COASTLINES AND SEABEDS**

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MORPHOLOGY AND EVOLUTION OF COASTLINES AND SEABEDS

Coastal areas are the most inhabited zone around the world where social and economic interests are increasingly concentrated. During the last tens of years, the construction of river dams and the dredging of riverbeds have prompted, along the coast, a strong decrement of sediment supplies resulting in intense erosive processes. Moreover, in the framework of the greenhouse effect and sea-level rise, coastal zones are strongly subject to drastic and fast changes. These changes are especially evident, because of their low-slope degree, in sandy coasts where the danger of coastal submersion is increasingly close. Finally, warming of temperatures have serious impact on ecosystems.

Within this worrying scenario the session "Morphology and evolution of coastlines and sea-beds" collect nine research articles. Eight are case studies coming from Italy, Spain Greece and Croatia while one is a research-review within the Mediterranean area.

The review in the Mediterranean area (*E. Anthony*) consists of the analysis of the continuity of flux sediment along the coast and river and how this has been interrupted, or strongly modified, by human activity. The intense fragmentation of flux, even more so in the context of climate change and sea-level rise, needs, according to the author, in an urgent effort to be re-established.

D'Ascola et al., along the coast of Castiglione della Pescaia, provide an example of the application of a method based on the utilization of the geo-database "Linea di Costa" performed by ISPRA. The authors underline how this procedure represents a simple and easy method for specialists and stakeholders to obtain both a quick framework of the current stage of the coastline along with its evolutionary trend in terms of erosion and accretion.

Lupicchini et al., proposed an innovative method to obtain shoreline identification using the topography, achieved from unmanned aerial vehicle (UAV) images. The authors have utilized the new approach along the strand-plain north of the Arno River that is currently affected by strong erosive processes. The comparison with the results obtained for the same stretch of coast through the classical methods of shoreline identification, based on topography, has allowed to evidence of the advantages of the new method.

The erosion process affecting the highly anthropized area of Porto Cesareo, located in a Marine Protected Area of the Gulf of Taranto (Puglia), is analyzed by means of an interdisciplinary approach by *Picciolo et al.*. Besides the typical approach based on the analysis of the aerial photogrammetry and satellite images,

they also utilized underwater archaeological markers to identify and date the ancient paleo-shoreline.

Three study cases are from Spain. *Arriola Velasquez et al.* propose a study based on the use of radionuclides as tracers of marine sediment movement along the beach La Canteras located in Las Palmas de Gran Canaria. The data acquired, developed using statistical methods, show the influence of wave action in their concentration. The authors point out the effectiveness of this methodological approach and its reproducibility for other coastal zones.

Pagan et al., apply the Remotely Piloted Aircraft System (RPSA) and the Structure for Motion (SfM) image base computing techniques, to study both the dynamics of coastal dune systems and the coastal erosion process occurred along the Guardamar beach (Guardamar del Segura). The result shows how this low-cost approach is adequate for monitoring the evolution of the coastal zones characterized by the beach ridge systems.

Lopez and Pagan present a study on textural sediment analysis of the coarse sand feeding performed at Los Locos Beach (Torrevieja). This beach is instead naturally characterized by fine sand. The study shows how after a short period (15 months) the dumped coarse sands, as a result of wave movement work, became increasingly similar to those natural.

Finally, *Vandrakis et al.*, present a geomorphological approach to study, along the coast of Schinias - Marathon National Park (Attiki Greece), *Posidonia* Banquetts and their influence on coastal evolution and morphodynamics. The acquired data have demonstrated how the accumulation of *Posidonia* plays a significant role in the partial contrast to the erosive processes.

Also the study of *Pikely et al.* focuses on the theme of *Posidonia*. The authors analyze the effects of the continuous removal of *Posidonia* accumulations on the beach of Sakarun (Croatia), highlighting how this can determine a sedimentary deficit on the beach.

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NATURE PROTECTION AND LOCAL DEVELOPMENT: A STUDY CONCERNING A NATURAL PARK LOCATED IN SARDINIA (ITALY)

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Abstract – As per Italian National law on natural protected areas (Law no. 394/1991), Regional natural parks can include inner land areas, rivers, lakes, and coastal areas having high natural and environmental values. Within a park, such areas define a homogeneous system based on natural characteristics and aspects of sites and on high-value views and landscapes, having also regards to cultural traditions of local communities.

Defining appropriate spatial planning tools for these areas is therefore of outmost importance. On the one hand, plans must guarantee protection and preservation of local natural values and of the ecological balance; on the other hand, plans should also promote social and economic development, by implementing planning processes aimed at valorizing the local identity. This problematic dichotomy deserves serious consideration because protected areas can border, or even include, agricultural plains, urban settlements, as well as tourism hotspots, subject to high anthropic pressures.

The eastern part of the Tepilora Regional Park, located in Sardinia (Italy), represent a relevant case study as a paragon of the question at stake.

It develops near the attractive village of Posada and includes the Rio Posada's (Posada River) environmental system, the River's estuary and the adjacent beach, an extended, flourishing and characteristic agricultural plain.

This study implements a knowledge-based planning methodology that starting from an in-depth study of the context, identifies a territorial system, consistent with the governance tools in force, characterized by sub-areas of a significant degree of internal homogeneity and, therefore, from a specific level of protection, which constitute the spatial reference for the definition of the constraints, of the permitted uses, of the intended public or private use, by virtue of the needs of protection and conservation of the resources present, in the Park.

The aim of the proposed methodology is to being effective in recognizing both expressed and unexpressed potentials of the Park spatial context, and it makes it possible to protect and enhance the Park's attitudes and identity through the definition of place-based planning strategies.

Introduction

The growing awareness about the importance of protecting the environment to ensure the ecological balance for present and future generations has led to a progressive expansion of the system of protected areas, on a national and international scale [3], which nowadays consists of heterogeneous landscapes, from those characterized by a high degree of naturalness to those most marked by anthropic action. This complexity is at the core of several

multidisciplinary studies oriented to define integrated approaches to landscape planning and management, capable of combining nature conservation and local development needs [5,11].

According to the Italian Constitution and international agreements, Law no. 394/1991 (National law on natural protected areas) defines and classifies the protected natural areas. The Law represents the first comprehensive legislation which introduces a special protection and management regime for territories worthy of protection by virtue of their significant naturalistic and environmental values [4].

According to the VI update of the Official List of Protected Areas (2010), there are over 870 Protected Natural Areas in Italy [6]. More precisely, the terrestrial ones cover a surface of over 3 million hectares, that is about 10.5 % of the national territory [7].

The amount of recorded protected areas represents a significant result in ethical and moral point of view [2] and reveals a shared understanding of the environmental protection as a prerequisite to prevent loss of the soil resource and the ecosystem stability/balance, especially when involved in more effective green infrastructure projects [10], thus safeguarding primary values such as health, life, and biodiversity. At the same time, the data testifies an important economic and social goal as conservation policies, in the broader sense of protection and enhancement of natural and anthropic capital, actively contribute to increasing the country's levels of wealth and economic well-being [9]. In this regard, protected areas may represent an essential condition to promote endogenous model of sustainable development of the territories, also from the point of view of tourism, in line with the growing demand for slow tourism [1].

Regional natural parks constitute an important component of the nation's natural heritage, in qualitative and quantitative terms. Among the 871 Protected Natural Areas recorded in the Official List, 134 Protected Natural Areas fall into the category of Regional Natural Parks. The law establishes three main cognitive, planning, regulatory and management tools through which to ensure the protection of their natural and environmental values: the regulation, which governs the activities permitted within the protected area; the planning scheme, which divides and regulates the territory according to the different degree of protection; the multi-year economic and social plan which promotes the sustainable development of local populations through compatible initiatives and activities.

In the Sardinia Region (Italy), Regional Law no. 31/1989 introduces the principles for the establishment and management of the protected areas, including natural parks. The four parks established to date differ in terms of geographical location, environmental and landscape characteristics, degrees of naturalness and anthropization, total surface, number of municipalities involved, presence of protected areas, including those of international level [8]. Nowadays, none of the four parks has yet adopted the main planning tool, i.e. the plan of the park, and, as a consequence, the regulation and the multiannual program of economic and social development, determining a general condition of delay in the definition of a regulatory framework for the natural heritage protection and in the proposal of development strategies aimed at ensuring the protection of natural and anthropic values and of their long-standing interrelations, according to the principles of integrated conservation.

Within this framework, the Tepilora Natural Park, located in north-eastern Sardinia, represents a relevant paragon to deal with the issue at stake [13].

The present study proposes a knowledge-based planning methodology that supports plan-making processes concerning natural parks for an effective conservation of the specific territorial reference units (homogeneous areas). The latter identify areas characterized by

different degrees of naturalness, to which to assign different degrees of conservation. In this sense, the planning scheme of the Tepilora natural park is the result of the complex cognitive framework matured through specialized studies, field investigations and critical interpretations of the territory.

After a first introduction on the state of planning of natural parks in the Sardinian Region (paragraph 1), the paper analyzes the case study (paragraph 2) and proposes a planning methodology that supports plan-making processes concerning natural parks (paragraph 3). Finally, the authors discuss the expected results of the ongoing planning experience.

Area of study

The Tepilora Regional Natural Park, located in north-eastern Sardinia, can be considered a relevant case study for the definition of planning approaches and methods aimed at ensuring the protection of a territorial system characterized by different degrees of naturalness and heterogeneous values. These unique features, together with the geographical context, have also been stressed by the recent establishment of the Tepilora, Rio Posada and Montalbo Biosphere Reserve by UNESCO (June 2017), as part of the "Man and Biosphere (MAB)" program. The Biosphere Reserve brings together 17 municipalities of north-eastern Sardinia around the Tepilora park, which appears as its beating heart (Core zone MaB).

The Park covers an area of about 7877 ha, from the granite plateau of the Municipality of Bitti, to about 500 m above sea level, passing through the hilly area of the Municipality of Lodé, up to the plain of the Municipality of Torpé and the Coastal Municipality of Posada. For this reason, during the elaboration of the plan and according to the context analysis, three macro-areas have been recognized within the Park, which are characterized by a landscape and management homogeneity fully recognizable in relation to the territorial planning scheme drawn up (Fig. 1), which see in the Rio Posada (Posada River) the precious element of connection between sea and mountains.

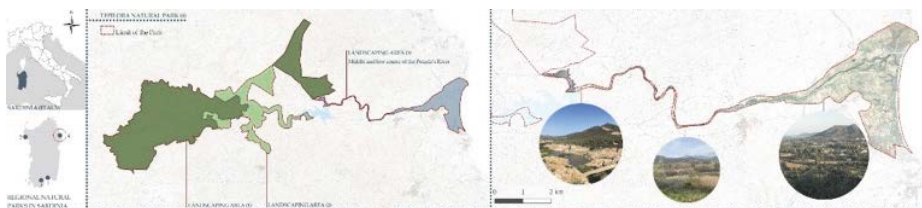


Figure 1 – The Tepilora regional natural Park and its landscaping areas. Author: Mara Ladu.

The first macro-area is identified with the mountain-forest landscape, where the character of the forest landscape prevails characterized by a high degree of naturalness, consisting of the state forests of Crastazza - Tepilora and Sos Littos - Sas Tumbas in the territory of Bitti and the state forest of Usinavà in Torpè.

The second macro-area is identified with the landscape of two enclaves located in the territory of Bitti and the hilly-forest landscape of the territory of Lodé.

The third macro-area takes the name of Medio e Basso Corso del Rio Posada (Middle and Lower Course of the Posada River) and is identified with the fluvial-agricultural and coastal landscape of the wetlands and the beach. The context is that of the alluvial agricultural plains of Torpè and Posada, served by a capillary irrigation network infrastructure that has allowed until now the development of intensive agricultural activity, where the artificial reservoir of Torpè represents an element of discontinuity between mountain areas and intermediate areas of the plains. It includes, in Torpè, the middle course of the Rio Posada and, in Posada, where it develops around the fortress of the ancient village, the flourishing agricultural plain, the beach, its dune system, where a mainly seasonal type of tourism has been consolidated, and finally the Ramsar area Foce del Rio Posada (Mouth of Posada River), recently established. This is an area of great landscape and naturalistic value, and represents the place where the Rio ends its path by rejoining the sea.

The diversity of landscapes of the park translates into a rich ecosystem variety (in terms of habitat and species), geomorphological, microclimatic and vegetational, also determined by historical and cultural factors. The downstream part of the park is characterized by an evident process of anthropization characterized by an important coexistence between natural habitats and agricultural areas and is also equipped with a recent and punctual planning tool, the Municipal Urban Plan (MUP). As will be illustrated in the next paragraph, the latter is the area of study assumed for the development and application of the proposed territorial planning methodology that is based on the reading and interpretation of the environmental context of the territory, in coherence, when possible, with the transformation processes in progress, and aimed at protecting and enhancing the complexity, identity and peculiarities of the territory.

Materials and Methods

The plan of the Tepilora Park consists in the conception of a territorial system divided into three macro-areas, each of which is divided into similar areas, characterized by the same degree of naturalness and protection, and further divided into Spatial reference units (SRU) that introduce further specific requirements. The methodological approach, developed and applied in the Middle and Lower Course of the Rio Posada is based on five main phases.

The first phase consists of the analysis of the territory and the identification of the structural components of the landscape. This phase is divided into: visits on site, diachronic reading of orthophotos, elaboration of environmental analysis, study of cartography and specialized plan reports. The last three define the Cognitive Framework (CF) of the Plan.

Visits on site are fundamental to investigate, from a qualitative point of view, the dynamics of the context, to build a visual idea of the study area and the consequences that design choices can have on it, on a human scale. The diachronic study of orthophotos shows the evolution of the study area, at a landscape scale. The structure of the CF was defined during the setting up of the Strategic Environmental Assessment (SEA). The SEA, in the case of the Tepilora Plan, plays a key role: it is integrated into the planning process [14] in the elaboration of the CF and of the Interpretative and Strategic Design Framework (IF-SD). In the definition of the latter, integration takes place by objectives and actions that are deduced in the drafting of the Environmental Report (ER). While with regard to the CF, the environmental analysis of the ER constitutes the complete cognitive basis of the state of the

environment that allows to highlight the potential strengths, weaknesses, opportunities and risks that, summarized and collected in the SWOT analysis, represent the reference point of a sustainable planning rooted in the context to which it refers in strategic and spatial terms¹.

The analysis phase allows to identify the Rio Posada and the mouth system, the agricultural alluvial plain, the beach and the relief of Orville, as structural components of the landscape. For each of these, a degree of anthropogenic transformation (low, medium and high) was assigned and at the same time, spatial correlation with the landscape systems highlighted by the specialized analyzes (phase I) was evaluated. The correlation assessment was then carried out, in terms of zoning and regulations, with the planning tools in force on the area of study: the MUP of Torpé and Posada (phase II) (table 1).

Table 1 – Excerpt referring the assessment of correlation between the structural components, the landscape systems, the level of anthropic transformation undergone by them and the planning tools in force on the study area.

Structural components of landscape	Landscape systems	Level of anthropogenic transformation	MUP of Posada	Correlation assessment
Rio Posada and mouth system of Rio Posada	- Artificial basins and rivers of the Thermo-Meso-Mediterraneo Secco - Holocene lake sediments of the Dry Mediterranean Thermo-Meso	Low	H: safeguard zones	Yes
Agricultural Alluvial Plain (Posada)	- Thermo-Meso-Mediterranean Dry Alluvial Deposits - Intrusive and metamorphic substrates of the Dry Thermo-Meso-Mediterranean	High	- E: agricultural area - F: tourist-receptive area - G: areas for public services - S: services of general interest	Yes

The next step is to assign, for each type of urban area identified by the UP, a preliminary degree of protection (phase III), in line with the provisions of Law 394/1991: zone A, integral reserve; zone B, general reserve; zone C, protection areas; zone D, areas of economic and social promotion. The process of awarding the preliminary degree of protection took place following an assessment of consistency between the objectives, the intended uses, the prevailing categories of intervention identified by the MUP, and the level of protection provided by the protection zones referred to in the legislation on parks. Zones

¹ For further information, please refer to the SEA of the Tepilora Plan. The integration of the SEA into the planning process is also specifically the subject of Marras M.'s doctoral research, under the supervision of Prof. Zoppi C. and the co-supervision of Proff. Colavitti A.M. and Lai S.

A, B, C, D were then further divided into SRU (phase IV). The articulation in SRU represents a further degree of deepening, developed through the analysis of specialized studies, context and, in particular, carrying out a critical overlay mapping between cartography related to landscape systems, land cover, geology, vegetation and fauna. The perimeters of the areas identified in advance have therefore been subject to verification and, in some cases, redefinition of their degree of protection. In this way, although the zoning of MUP finds significant correspondence with the classification reported by the study on land cover, and highlights the invariants, the zoning of the Park Plan often does not coincide with that defined by the current MUP, as it implements a project that recognizes and reinforces the continuous and unitary character of systems that currently appear fragmented (Fig. 2).

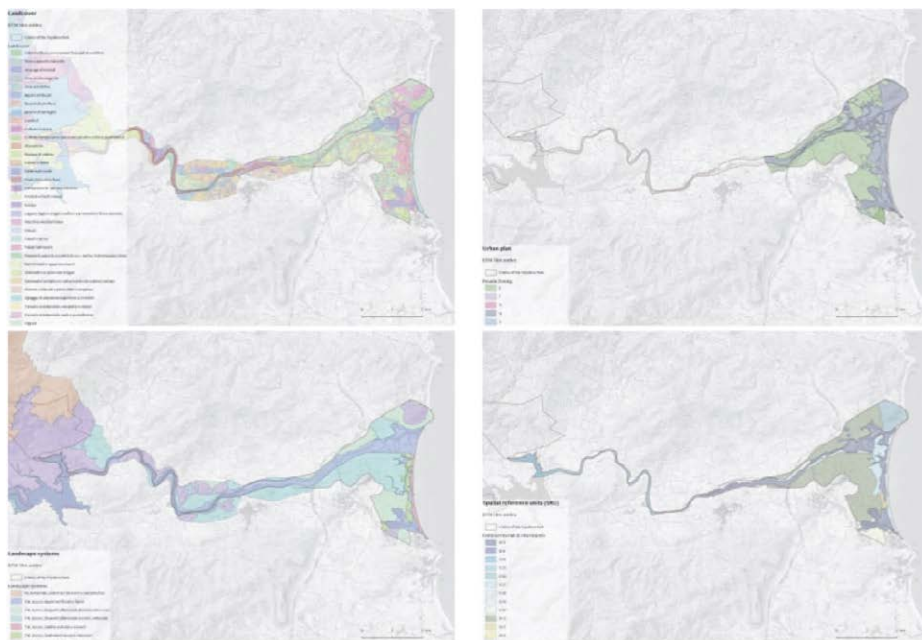


Figure 2 – Representation of the maps related to land use, the zoning of the urban planning tools in force in the area of study, the landscape systems, the SRU system introduced by the Tepilora Park Plan. Author: Martina Marras, based on the cartography drafted by the Planning Office.

The spatial taxonomy is accompanied by regulatory requirements defined in the Implementing Technical Standards (ITS). In the ITS, a more detailed definition of the general requirements relating to zones A, B, C, D is reported integrated for each SRU by further specifications that take into account the protection needs of species, animals and plants, and of the habitats present.

Phase V relates the system of actions that address the strategic framework of the plan objectives identified during the elaboration of the SEA, with the spatial system of the SRU highlighting the integration between the strategic plan and the regulatory device (Table 2).

Table 2 – Excerpt referring to some SRU about the correlation between the zoning introduced by the territorial planning of the Park of Tepilora, its strategic framework and the urban planning tool in force in the study area.

MUP zoning of Posada	Level of protection	SRU	Action of the plan
H - Water system and wetlands H - Habitat 43	B. General reserves	B15 Water system and wetlands of the Rio Posada	Interventions to improve the use of the environmental context of the Rio Posada Integrated conservation of the landscapes of coastal wetlands, river mouths and agricultural alluvial plains aimed at ensuring the balance between environmental protection needs and settlement development requirements Restoration and maintenance of riverbeds and sediment management (...)
...			
H - Beaches and dunes H - Area of tourist-environmental redevelopment	C. Conservation areas	C28-Beaches and dunes	Interventions to contain massive seaside tourism and to promote itinerant tourism in the various areas of the Park Actions to prevent the degradation and fragmentation of dune habitats Interventions aimed at the sustainable management of the coasts (...)
...			
E1 - Posada Gardens E1 - Area with sclerophyll vegetation, meadows and pasture E2 - Agricultural land E5 - Wooded areas and deciduous forests S2 - Services G - Services	D. Areas of economic and social promotion	UTR-D12-Posada Gardens	Launch of projects for the economic exploitation of products and services, direct and indirect, of agricultural and forestry systems Definition of measures for the reintroduction of traditional agricultural production on the territory Interventions in support of extensive and organic agriculture, favoring traditional cultivation methods and techniques Interventions to adapt and strengthen the irrigation network in the agricultural plain of the municipalities of Torpè and Posada (...)
...			

Results

The Plan of the Tepilora Park, in the macro-area of the Middle and Lower Course of the Rio Posada, which extends for about 955 hectares, that is 12 % of the entire Park, provides for the establishment of: n. 2 UTR of general oriented reserve (B), for an area of 217 hectares approx.; n. 7 UTR of protection areas, for an area of about 271 hectares; n. 4 UTR of economic and social promotion (D), for an area of 467 hectares approx. 48.9 % of the macro-area under study is represented by areas of economic and social promotion characterized by a considerable level of anthropogenic transformation deriving from agro-silvo-pastoral activity. The oriented reserve and conservation areas occupy an area equal to about 30 % of the entire extension of the macro-area and no integral reserve areas (A) are identified. The Plan assigns a high level of protection to the wet element of the Rio Posada water system, including it in zone B of general oriented reserve. Here the scientific and educational uses related to the dissemination of knowledge of the Park are allowed, as well as the activities of tourist, recreational and cultural fruition. These are allowed in compliance with the species and habitats present and with specific limitations relating to the means of use. The construction of new buildings and infrastructures is not allowed, with the exception of small buildings for the introduction of naturalistic observation activities. Protection zones (C) define a buffer zone between the wet element (B) and the agricultural plain (D). In the latter, the Plan identifies the area of economic and social promotion as the small urbanized portions present and the alluvial agricultural plain, recognizing a value that is also identity to the agricultural plot of cultivated fields and rural roads typical of the context. In these territories, the Plan allows sustainable anthropic activity aimed at enhancing pre-existing economic activities, also through the construction of new buildings related to the activities of running the fund and tourist-accommodation. At the same time, it introduces specific protection provisions for the most sensitive elements present in widespread form, including small streams and woodland formations.

Discussion and conclusions

The present study proposed a knowledge-based planning methodology which, starting from an identification of three similar macro-areas in the Park, allowed to define a further division of the territorial system into Spatial reference units (SRU) and to introduce different levels of protection according to the specific degree of naturalness recognized.

The study highlights how important it is for the planning process to develop in successive levels of plan design and in stages. The stages involve knowledge, interpretation and choices of plan. It is important to emphasize that the process of defining the Plan contains a subjective component, through which the planner projects into the plan his technical skills, his experience [12], but also his vision of the world. As explained in the previous paragraphs, the draft plan is developed starting from a general context, following a progressive degree of detail in the definition of a spatial articulation, in UTR, which is compared from a zoning and regulatory point of view with the pre-existing planning tools at an urban scale, in a gradual transition of scale that takes shape both in terms of planning and analysis. In the transition of scale, the study of the dynamics of the context is confirmed as fundamental, but also a subsequent skimming aimed at identifying the aspects considered fundamental so that the

plan choices can be targeted and consistent with the objectives. In this macro-area, four main aspects have been identified, among the more than ten present: landscape systems, land cover, urban planning tools in force, flora and fauna. These have been chosen according to the area of study, that is a protected area, and according to the type of plan. In this way the planning process aimed at maintaining those natural elements which are specific to the landscape, protecting the species present, and their habitats, and evaluating the transformations already regulated by the local planning tools in force. The results also describe how the strategic vision, and the regulatory system can effectively contribute to the implementation of a virtuous local development, inside or outside the limit of the Park, identifying specific actions in favor of the integrated conservation of the coastal environment and, more in general, of the agricultural-fluvial landscape typical of the macro-area here examined.

In conclusion, the plan of the park becomes the planning tool capable of defining a regulatory framework based on the recognition of the place identity and its values, as well as of the expressed and unexpressed potential of the territorial context of the Park within a comprehensive conservation and enhancement strategy. Finally, the methodology is readily exportable to other spatial contexts, at different spatial scales, where conservation and development pressures should be adequately balanced as regards areas characterized by relevant values of nature and natural resources.

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Marras M. and Ladu M. collaboratively designed this study and jointly wrote Section 2, Section 4 and Section 5. Individual contributions are as follows: M.L. wrote Section 1; M.M. wrote Section 3. All authors have read and agreed to the published version of the manuscript.

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MONITORING OF MEDITERRANEAN COASTAL AREAS:
PROBLEMS AND MEASUREMENT TECHNIQUES

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