Governing Future Challenges in Mediterranean Protected Areas

Edited by
Loredana Teresa Alfarè - Istituto di Scienze Marine (CNR-ISMAR)
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FOREWORD

The National Research Council (CNR) founded in 1923 is the largest Italian research institution which includes 102 institutes. Among these, the Institute of Marine Sciences (ISMAR) conducts multidisciplinary studies in all fields of marine science comprising geological, biological and oceanographic research. The CNR-ISMAR includes 204 permanent staff members distributed over 6 geographical sites: Venice (headquarter), Trieste, La Spezia, Bologna, Roma and Naples.

The Università della Svizzera italiana (USI) and its UNESCO Chair, a competent partner in ICT, communication, tourism and UNESCO designated sites, has joined our endeavour to investigate the state-of-the-art, the necessities and prospective of governance and management of Protected Areas (PAs) in the Mediterranean.

The Mediterranean Sea provides one of the most extensive and diverse coastal environments in the world. The drive for resource exploitation and sea-related economy, together with intense coastal and industrial urban development, are increasing pressures, resulting in habitat degradation and threat to the productivity and health of the oceans with negative effects on the coastal and marine PAs.

CNR-ISMAR investigates the driving processes and the response of coastal systems to the impacts of climatic fluctuations, long-term climate change and man-related activities as well as the impacts of marine litter and alien species in sensitive environments. Coastal tourism is one of the main topics studied by the Institute related to its strong impact on coastal and marine environment. In addition, the Institute cooperates with the Intergovernmental Oceanographic Commission (IOC-UNESCO) in consolidating the Mediterranean blue identity as a hotspot of innovation for environmental protection and sustainable development.

The articles included in this volume outline new approaches, methods, techniques, and tools to deal with the management of sensitive environments, such as the PAs, in a sustainable and effective manner. My first objective, as director, is to qualify CNR-ISMAR for responding to the international scientific challenge that requires interdisciplinary expertise and approaches. The Institute is involved in numerous international and national projects dealing with anthropic impacts in PAs. The disciplines tackled in the volume are encompassed in its strategic main lines. These articles are the results of interdisciplinary teamwork among research teams of the Institute as well as external institutions engaged in these scientific topics.

The volume is directed to practitioners and scientists active in PAs and gives numerous recommendations how to transform and improve existing governance and management systems of Marine and Coastal PAs. I have supported this initiative with pleasure and endorse the proposals for new paradigms related to the protection of the marine environment.

Rosalia Santoleri, Director CNR-ISMAR

Table of Content

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- ECOlogical observing System in the Adriatic Sea: oceanographic observations for biodiversity (ECOSS): *Challenges for Marine Ecological Observatories to Promote Effective GMS of Natura 2000 Network - The Case Study of ECOAdS in the Adriatic Sea*
- Climate cHallenges on coastal and traNsitional chanGing arEas: WEaving a Cross-Adriatic Response (CHANGE WE CARE). *Response to Climate Change in Coastal and Marine Protected Areas: Threats and Opportunities*

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Introduction

The intention of the book on "Governing Future Challenges in Mediterranean Protected Areas" is to examine current Governance and Management Systems (GMS) of Protected Areas (PA) and to assess their appropriateness to face future challenges, providing reciprocal benefits to local communities and environment.

The argument is well known and discussed, nevertheless in reality the approach of the governance models still shows their roots in the traditional top-down approaches with a management system focused on coordination. Commonly they have not yet adopted integrated evidence-based approaches with inclusive participation and decision-making processes.

The idea to elaborate this book was born during a meeting between researchers and editors, who realized the need to explore new models of GMS and to apply them to their research fields. The chance to establish working groups to write the chapters, to provide tailored solutions, brought enthusiasm to reflect current and future challenges affecting the Protected Areas. Joining different expertise and points of view was one of the most exciting aspects of this publication. The cooperation between CNR-ISMAR and the UNESCO Chair in ICT to develop and promote sustainable tourism in World Heritage sites at USI – Università della Svizzera italiana, with IUAV University of Venice, Venice Lagoon Plastic Free, Legambiente, Worcester Polytechnic Institute has resulted in a variety of considerations and recommendations for the governing and managing bodies of the Mediterranean PAs.

The book contains eight articles, addressing different types of PAs: Biosphere Reserves, World Natural and Cultural Heritage sites, Marine and Terrestrial Protected Areas, Natura 2000 Areas, National and Regional Parks. They are increasingly facing challenges such as marine litter, invasive alien species, climate change, loss of biodiversity etc. Challenges that cannot be overcome without an appropriate GMS based on a real participatory approach and balance between conservation and development strategies.

The authors have been asked to answer the following guiding questions:

- What are the current evidences of PAs?
- How are the GMS facing these evidences?
- What procedures are established to support the change processes (e.g. stakeholder involvement, participatory processes, local governance or delegated authority)?
- What will be the future evidences and challenges of the PAs? What is the estimated time frame of the changes expected?
- What GMS approaches and adaptation mechanisms will be needed to overcome future obstacles?
- What is needed to launch the GMS transformation processes?
- Which instruments and incentives could support bottom-up decision making?

The first three articles introduce the main essentials and constraints to establish new territorial Governance and Management Systems and to adapt them to national and international institutional frameworks. The three dimensions of the integrated concept,

Top-down, Bottom-up and Outside-in could improve existing or establish innovative and effective tools to involve local communities and the multiple stakeholders in the decision-making processes. In the case of marine Natura 2000 network, a key conservation instrument in Europe, the ecological observatory of the Adriatic Sea (ECOAdS) illustrates a conceptual design of a common knowledge and monitoring framework and shared data management practices at transnational level overcoming the site fragmentation. The UNESCO Biosphere Reserve Programme is tailored particularly to experience and establish holistic GMS, balancing conservation and sustainable development. The delegation of authority and accountability to the single Biosphere Reserves could enable them to be prepared and to promptly react to emergencies related to current and future challenges.

Five articles deal with gaps in the GMS hindering the fight against the main threats accelerating negative impacts to PAs: climate change (CC), invasive alien species (IAS), marine litter (ML) and tourism.

Appropriate adaptation and mitigation measures to CC effects are necessary to overcome constraints for action, hence strategies for a sound management of Marine and Coastal Protected Areas have to be established urgently. The IAS is associated with CC effects and represent a serious and growing threat to biodiversity, and occasionally also to human well-being. The concept of circular economy offers new opportunities, reconsidering IAS as a resource, to transform something unwanted into advantageous raw materials.

Marine litter challenge is treated in different geographic dimensions. The composition and sources of marine litter in the Mediterranean MPAs point to the threat to different environmental compartments, including peculiarities of MPAs which might increase ML impacts. Management measures able to effectively reduce marine litter in MPAs and governance frameworks necessary are proposed to achieve biodiversity conservation objectives and social and economic development of MPAs. A very particular problem is the ML issue in the UNESCO World Heritage property “Venice and its Lagoon”. It is multifaceted, linked to its heterogeneity in terms of size and items, source and fate, including the unsettled issues of its removal and treatment. The testing of low thermal pyrolysis treatment of marine litter bonds the gap between monitoring and remediation. The findings will contribute to combine more robust and coordinated prevention and remediation measures by the site’s management authorities.

The analysis of the social media platforms such as Instagram, TripAdvisor and Airbnb of the Tuscan Island Biosphere Reserve as well as the Aeolian Islands World Heritage site show tourism attractions and offers from the user’s and visitor’s perspective. The interactions on the platforms reflect the attractiveness of natural and cultural heritage, the accessibility of the heritage, the visitor perception, the quantity and quality of hospitality businesses and services, visitor’s distribution and flows in the area. The results reflect the effectiveness of the GMS of the destinations, especially with regard to the conservation and protection of cultural and natural assets, and allow to define visitor management strategies.

By the editors, September 2020

Linking Governance and Management of Conservation Sites to Local Evidences

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Abstract

The "evidence-based governance and management system" is considered an integrated approach adequately involving the three dimensions top-down, bottom-up, and outside-in. It is an instrument to improve effectiveness of management and to engage local communities and stakeholders in the decision processes in territorial management. These new approaches are particularly significant for protected areas and internationally designated sites. The concept is based on local realities or evidences, which help to manage current and in particular, future challenges and to balance conservation and development. The territorial governance and management is confronted with accelerated adaptation needs to global threats such as climate change, invasive species, marine litter, socio-economic development, migration, tourism. The article discusses frameworks and transformation processes to adapt new governance and management systems, helping to prevent negative impacts to nature and society and to create new opportunities for local communities.

Keywords: Governance and Management Systems, protected areas, participatory processes, deliberative democracy, local evidences, threats and challenges, community involvement.

1 International Legal Frameworks related to Protected Areas

Protected area governance and management systems (GMS), whether state-run, private, or mixed, are dealing with "public goods". In recent years, there has been a shift from the traditional focus on conservation, research and education towards a mission to balance conservation and socioeconomic development [1]. Increasingly the protected area management responsible receive a stewardship function in taking care for natural assets on behalf of future generations supplementary to their guardian role [2]. The new challenge of protected areas (PAs) is to establish GMS improving efficiency and quality of the management, involving all relevant governance levels, civil society and stakeholders. The strategies envisage the mobilization of the local resources to stimulate the economic development and community interactions and generate benefit through innovation and inclusive growth [3] [4].

The legal foundations and related GMS are frequently incomplete, insufficiently established and inefficient. The political decision processes are often delayed and unnecessarily lengthy and do not respond to the increasing pressure on the ecosystems [5]. Varying governance strategies, different legal, institutional and financial conditions, badly established public and stakeholder's participation lead to incongruities. New deliberative governance and management approaches for protected areas with a strong focus on sustainable development is key to overcome obstacles related to accelerated change processes.

The complexity and inconsistency of multilevel governance systems, from international agreements to local realities, frequently hinders the implementation of sustainable development and conservation strategies. Multilateral environmental agreements (MEA) and bilateral agreements are the uppermost frameworks agreed among state parties. ECOLEX lists all the environmental laws, including in April 2020, a total of 2,179 international treaties and 13,052 treaty decisions at global and regional level [6]. The UN, through its Agencies' programmes and other international Organizations are in charge of major multilateral agreements related to protected areas, heritage conservation and environmental risks. Examples of MEAs highly relevant for the Mediterranean area:

- UN: Convention to Combat Desertification (UNCCD), Framework Convention on Climate Change (UNFCCC), Convention on the Law of the Sea (UNCLOS)
- UNEP: Agreements on the Conservation of African-Eurasian Migratory Water birds (AEWA), on the Conservation of the Black Seas, Mediterranean and Contiguous Atlantic Area (ACCOBAMS), Bonn Convention on Migratory Species, Convention on Biological Diversity, Cartagena Protocol on Biosafety, Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, Stockholm Convention on Persistent Organic Pollutants 2001
- UNESCO: Man and the Biosphere Program MAB, World Heritage Convention
- UNECE: Convention on Long-range Transboundary Air Pollution, Convention on Environmental Impact Assessment in a Transboundary Context, Convention on the Protection and Use of Transboundary Watercourses and International Lakes
- FAO: International Plant Protection Convention, International Treaty on Plant Genetic Resources for Food and Agriculture, Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade
- IUCN: Convention on Wetlands (Ramsar)
- EU: The Birds and Habitats Directives are the pillars of the nature legislation and the latest established the EU-wide Natura 2000 network of protected areas. The IAS Regulation fulfills the Action 16 of Target 5 of the EU 2020 Biodiversity Strategy. The Water Framework Directive is closely linked to the Marine Strategy Framework Directive which is the first EU legislative instrument related to the protection of marine biodiversity.

UNESCO designated protected areas such as Biosphere Reserves, World Heritage sites or Ramsar sites follow such international frameworks and represent multilevel governance systems. The implementation of the MEAs on national territories is a duty of the national authorities. Internationally recognized PAs are requested to establish management systems and plans, which are suitable pre-conditions to introduce and test new approaches.

In the internationally recognized PAs state government retains ownership and/or control and oversight, but increasingly delegates the daily management tasks to a local governmental level or to non-governmental organizations, private operator, or

community. State-governed sites often lack the legal obligation to inform or consult stakeholders or to involve them in decision making prior to establish PAs, meanwhile local bodies automatically consider bottom-up approaches in their decision and implementation processes. A basic distinction among governance types can be based on who holds authority, responsibility, and accountability for key relevant decisions regarding a protected area. Accordingly, four main protected areas governance "types" were identified: government, shared or private governance, and local community governance [7] [8].

The GMS of Marine Protected Areas MPAs is even more complex, since national and international territorial governance are overlapping. They are also highly variable due to an institutional diversity participating in the governance of challenges such as biodiversity, pollution, climate change [9]. The UN Convention on the Law of the Sea [10] is widely recognized as the overarching framework for marine governance. Coastal waters and their resources are in most countries considered as "commons". This means they are common property available equally to all citizens and not owned by any person or agency, and with the government as "trustee." A primary aim of conservation of MPAs is to provide sustainable resource use of the commons, a responsibility that should be shared by all people and all levels of government. As "trustee," the government is empowered to make rules for the commons that all must obey for the public good [11].

The main differences of MPAs versus terrestrial PAs are the multi-dimensionality and connectivity, the "open systems, the currents and tides, the uncertainty and the higher complexity, as well as different property rights, enforcement and management" [12]. The Governance and Management Systems of MPAs need therefore special attention since the "commons" are public goods with a high degree of delegation of authority and accountability to national governments and open for use to high numbers of stakeholders and people. Furthermore, the multiple interactions between the marine and the terrestrial part of PAs request special attention regarding negative impacts and the need of targeted research and assessment of changes.

2 New Approaches of Deliberative Governance Processes

Integrated governance approaches of protected areas including sustainable development strategies aim at knowledge-based development involving local society, adapted to available resources and an area's social, cultural and environmental specificities. All the governance models still show their roots in the traditional top-down approaches with a management system focused on coordination without adopting integrated, evidence based approaches with holistic participation and decision processes. To maintain the balance between conservation and local development, clarification of the strategic orientation, the holistic planning processes, the establishment of tools to measure the development, the involvement of local people and stakeholders in decision-making processes, and the fair sharing of benefits among all involved persons and institutions are essential. The exceptional assets and high community-development potential of PAs require innovative deliberative 'evidence-based governance' which are trans-border, multilevel, pluralistic, dynamic, respecting ecological and social limits, adaptive and open to changing constraints [13].

In the recent years different new approaches have been launched to improve deliberative democratic processes and to introduce new governance and management frameworks and methodologies. At the European level, the Territorial Agenda 2020, argues that the place-based approach to policy-making "implements the subsidiarity principle through a multilevel governance approach", based on the principles of "horizontal coordination, evidence informed policy-making and integrated functional area development" [14].

Fig. 1: Community involvement and participatory processes are needed to define strategies and objectives based on local place-based evidences such as resources, needs and challenges.

The Outcome-Oriented Public Management [15] introduced new forms of delegation of authority and accountability to local or institutional levels adequate to the level of action and to enhance performance and efficiency through active participation of actors of all hierarchical levels.

The Social Ecological Systems (SES) established by Elinor Ostrom is closely linked to complex-systems theories for human-environmental interfaces. The SES is a "framework, namely, to develop diagnostic tools for use by scholars or practitioners concerned with understanding the determinants of sustainability in complex SESs" [16]. The SES framework provides a coherent guide for the analysis of collective action and self-organization and proposes a set of variables such as actors, governance systems, resources systems and units.

The conceptual framework of adaptive cycle and resilience presents an explanatory model of development, crisis, and collapse in social and ecological systems. This approach could help to understand the emergence and development of actions towards governing sustainability [17].

Models of governance for sustainability depend from the competencies of the actors and their interactions between the different hierarchical levels of decision-making and actions. For a successful transformation process it is necessary to surpass system rigidities and achieve new shared and socially accepted rules. Crisis factor may activate transformations introducing new practices and define new rules agreed-upon by the authorities, communities and stakeholders. The identification of the environmental common goods and local resources supports building collective knowledge about social and ecological interactions. Active listening and moderated communication processes generate shared community values and facilitate multilevel governance and management processes. Governance of sustainability depends from good decision-making based on quality information. Actions carried out in Spanish BRs demonstrated how actors can provoke new processes, transforming governance and induce changes in policies and regulations [18].

With regard to territorial development processes, the SDI method [19], the NEXUS methodology or the Sustainability Profile Matrix [14], have paved the way to adopt new integrated territorial participatory processes towards approaches in areas with focus on rich natural and cultural heritage. Creating deliberative governance systems involving stakeholders and civil society in and around protected areas, could significantly create new job opportunities, benefits and income for indigenous people and will increase knowledge, awareness and responsibility of the actors, thus decrease pressure on the ecosystems. PAs particularly should seek to achieve good governance and management, and should focus on responsible leadership respecting seven principles: legitimacy, transparency, accountability, inclusiveness, fairness, connectivity and resilience [20].

3 Governance Systems in the Mediterranean MPAs

The Mediterranean Protected Area Network [21] listed 1,231 MPAs and Other Effective area-based Conservation Measures (OECMs) in the Mediterranean covering 179,798 km^2, which places a surface of 7.14% under a legal designation. For most sites, little is known about the management measures in place and if they are effective at maintaining or restoring the biodiversity, they aim to protect [22].

Marine Protected Area's higher complexity is even more challenging regarding the effective governance and management systems. Impacts from human activities, such as shipping, transport, energy production, trade, fishing, port activities, or tourism have increased in recent years and have created instability and augmented risks to ecosystems. Some of the impacts are the decline of fish stocks; reduced water quality due to exceeding supply or insufficient waste water treatment capacity; sediment contamination from inland or marine pollution; and harming of coastal ecosystems especially coastal wetlands. Increasing vulnerability due to climate change, such as coastal flooding from rising sea levels; coastal erosion; water scarcity and droughts; saltwater infiltration of aquifers; habitat destruction; or loss of biodiversity are causing unprecedented challenges. These new facts result in economic decline, unemployment and social instability, destruction of heritage and competition for resources [23].

The institutional diversity of the GMS of PAs is linked to the particularities of the areas and the varying legal frameworks. A harmonization among the PAs, an enlargement of

the areas or improved connectivity would pave the way to a reasonable GMS of the MPAs [24]. In the National Parks located in the Mediterranean Basin four different governance types with different level of involvement of local people and actors have been described [25]:

- Centralized management by the state: Albania, Cyprus, Morocco
- Centralized management by the state with consultation of local actors and population: Algeria, Jordan, Montenegro, Turkey, Tunisia
- Management with participation of local actors in decision making: Croatia, Greece
- Management with participation of local actors and consultation with local population: Spain, Italy, France, Slovenia

The participatory decision-making and planning processes are considered decisive for success of Marine Protected Areas (MPA) management according the International Union for Conservation of Nature (IUCN). "Local people must be deeply involved from the earliest possible stage in any MPA that is to succeed. This involvement should extend to them receiving clearly identifiable benefits from the MPA" [26]. These recommendations are basic conditions of the UNESCO strategies for WH and BR adopted in 2015. Studies show that the community involvement is still in a preliminary state and frequently solved with representation instead of active participation in decision making and implementation [27].

Mediterranean PAs have adopted sound strategic frameworks and are committed to advance towards new paradigms. Hence, the current and even more the future evidences in the PAs are completely different and require solutions corresponding to the local realities and obstacles. Balancing conservation and development, sustainable use of natural and cultural resources and protecting the endangered ecosystems require adequate actions to prevent and minimize potential impacts.

4 The Three Dimensions of Participation and Cooperation

The "Evidence Based GMS" [1] is an integrated approach characterized by the adequate involvement of the three dimensions top-down, bottom-up and outside-in (Fig.1). The three dimensions are connected among them interdependently and follow the principle of reciprocity, guaranteeing the mutual exchange of data, information, and resources through the territorial GMS.

International and national bodies define in a *top-down* process the overarching standards, norms, legal frameworks and financial contributions, facilitate the elaboration of evidence frameworks, and delegate authority and accountability to the local, operative level. The multilateral organizations may facilitate standard setting, knowledge dissemination and transfer, and transnational harmonization and global/regional assessments. The national authorities are required to provide legal and evidence frameworks, deliberative policy instruments and coherent funding as basis for efficient territorial governance.

Fig. 1: The holistic approach of territorial governance is based on local evidences engaging the three dimensions Top-down, Bottom-up, Outside-in (Grafic: FelderVogel Communication, Luzern).

Bottom-up processes define strategies and objectives based on local place-based evidences such as resources, needs and challenges. The local communities will not only actively participate in decision making and area management, they will benefit as a return of their investments and partnerships and increasingly exchange and cooperate internationally.

Public and private institutional partners from science, technology and communication as well as funding bodies have a key role in the *outside-in* processes. They provide knowledge, data, funding, access to external networks, and facilitate research, innovation and interconnectivity. Especially ICT tools and social media platforms provide new opportunities for interactions and community building, and open source databases for knowledge sharing.

5 Adaptation of GMS processes to Local Evidences in PAs

The evidence based Governance Management System (GMS) could be a way forward to improve or establish effective tools and to involve the local communities, especially the multiple stakeholders, in the decision processes. Commitment of the authorities, clear purpose and priorities, coordination of the transformation processes, awareness of the vulnerable natural and socio-economic equilibrium as well as open and transparent communication will be needed on the way forward. It will not be enough to delegate authority and accountability to the local level. People and stakeholders have to develop an ownership for the future conservation and development of the sites and will need knowledge, information, funding as well as decision and monitoring tools to act accordingly.

In PAs in many European countries, such as in Austria, Germany, Switzerland, France, Spain the delegation of authority and accountability to lower governance levels is progressing. Regional and municipal government bodies get in charge of site governance and management [4] [28]. The evidence-based governance relates to local realities such as natural and cultural resources as well as local communities. Territories rich in diversity are characterized by varied social, economic, and physical features, and issues like ecological fragility, economic development challenges, and exposure to natural hazards are rarely reflected in mainstream datasets. PA policies need to build adaptive capacities by responding to local and regional specificities and by encouraging a diversity of strategies [14]. An evidence-based and holistic governance depends on processes of deliberative democracy or deliberative decision-making [29]. Deliberative approaches adopt consensus decision making as well as majority regulations and therefore represent both representative and direct democracy.

The evidence-based GMS with a holistic three-dimensional approach could be a way forward to improve or establish effective tools and to involve the local communities, especially the multiple stakeholders, in the decision processes. It will not be enough to delegate authority and accountability to the local level. People and stakeholders have to develop an ownership for the future conservation and development of the sites and will need knowledge, information, funding as well as decision and monitoring tools to act accordingly.

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Challenges for Marine Ecological Observatories to Promote Effective GMS of Natura 2000 Network

The Case Study of ECOAdS in the Adriatic Sea

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Abstract

The Natura 2000 (N2K) network is a key conservation instrument in Europe, despite its many limitations concerning the efficacy in covering and adequately safeguarding the marine environment, mainly due to missing coordinated Governance and Management Systems (GMS). In this study, we present and discuss the main benefits, which could be provided by Marine Ecological Observatories (MEOs) to support N2K marine network implementation and related GMS. The conceptual design of the ecological observatory ECOAdS, under development in the framework of the Interreg Italy-Croatia project ECOSS, is described. ECOAdS, which focuses on marine N2K sites under jurisdiction of Italy and Croatia, is a first operative pilot proposal of MEO for the Adriatic Sea. It represents an opportunity to build a common knowledge and monitoring framework and shared data management practices at the transnational level, overcoming the N2K site fragmentation. The main challenges that ECOAdS should face in its implementation are discussed, with emphasis on the integration of the marine connectivity aspects and on the adoption of adaptive and participative GMS to address the main conservation issues in the area.

Keywords: Adriatic Sea, Natura 2000 network, GMS, marine ecological observatories

1 Natura 2000 for Marine Conservation: How far are we from a Real Network?

The Natura 2000 (N2K) network of protected areas, both at land and at sea, is the main biodiversity conservation instrument in Europe, at the foundation of the EU commitment to the international Convention on Biological Diversity (CBD) and its Aichi Targets, and of the EU Biodiversity Strategy. The CBD Aichi Target 11 calls for the designation of a number of areas for marine conservation able to cover at least 10% of the marine waters by 2020. The N2K network represents the main driving forces contributing to the achievement of such a target in Europe. The network's legally binding basis are the Habitats [1] and Birds [2] directives, which set the same rules and obligations for all EU, even though the application of the legislation varies by countries, which are left with a considerable degree of freedom to set up their own conservation strategy. The Birds Directive (BD) defines Special Protection Areas (SPAs) for major migratory and threatened bird species and in its annexes lists 60 birds' species linked

to marine sites protection; the Habitats Directive (HD) defines Special Areas of Conservation (SACs) and lists 9 marine habitats and 16 marine species in need of protection. The network encompasses a multiplicity of protection levels, from strictly protected reserves to others where human activities are allowed and regulated and the protection of species or of habitats is combined with the management of the natural resources [1] [3].

The total number of marine protected areas in EU seas has more than doubled in the last six years, primarily due to the expansion of the N2K network. Based on the last N2K barometer (December 2019), more than 3150 marine N2K sites have been designated, covering almost 10% of the total EU marine area, corresponding to over 550,000 km^2 [4] [5].

Despite the contribution of the marine N2K network, the CBD conservation goals are still far from being fully achieved, while the worldwide marine conservation target has been proposed to increase up to 30% by 2030 [6]. To achieve this target, Europe must enlarge the number of marine areas devoted to conservation, also in the N2K network. However, numerous are the present limitations concerning the marine N2K sites' efficacy in covering and safeguarding adequately the marine environment [7] [8], preventing the establishment of an effective protection network. The selection of marine N2K sites lacks a systematic procedure, which could clearly and effectively address marine conservation needs. Most frequently, marine sites are the results of an extension of the terrestrial ones to the adjacent marine environments, often without assessing whether the priority marine species and habitats are the ones to be protected. N2K marine sites cover mainly coastal and shallow waters [9], leaving offshore and deep habitats almost completely under-represented. The prevalent small size of the sites limits their capacity of covering effectively habitats and areal dispersion of species or their populations, as well as the efficacy of sufficiently managing possible threats affecting protection targets, as these threats sources can be located in adjacent areas. For all the above reasons, N2K sites deliver limited protection to many threatened species. Moreover, many of these species are not even listed in the annexes of the HD and BD directives, which need to be updated [10]. On top, factors affecting N2K conservation efficiency are also: the rarefaction and fragmentation of ecological research and data availability mainly due to the different approaches adopted for their collection; the lack of transnational strategies, especially for the protection of highly mobile marine species that cross the geopolitical boundaries during their life; the limited attention to socio-economic and socio-ecological issues. About 40% of the N2K sites having a marine coverage higher than 10%, lack management plans and related conservation measures.

Ecological connectivity, which is one of the most relevant conservation issues, has been largely ignored during the design phase of the N2K network, even though it is one of the main objectives of HD (mentioned in Articles 3 and 10). Ecological connectivity is defined by UNEP [11] as "the degree to which landscapes and seascapes allow species to move freely and ecological processes to function unimpeded". This concept derived from the fact that, during their life-cycle, most animals and plants are largely dependent on more than one habitat and might need to freely move from land to sea and vice versa, as well as in the entire marine environment to accomplish their vital functions (e.g. feeding and breeding), in synergy with all the natural ecological processes (e.g.

production and consumption of food and oxygen) (Fig. 1). Connectivity becomes even more important in the marine environment where processes are highly interlinked, the complex life histories of most species have evolved adapting to the marine habitats, and many species are widespread [11]. Since single protected areas cannot conserve marine ecological connectivity, a network of ecologically coherent marine protected areas is a promising alternative. An effective network should be structured in a way to choose the right sites to protect, able to really preserve ecological connectivity [12] [13].

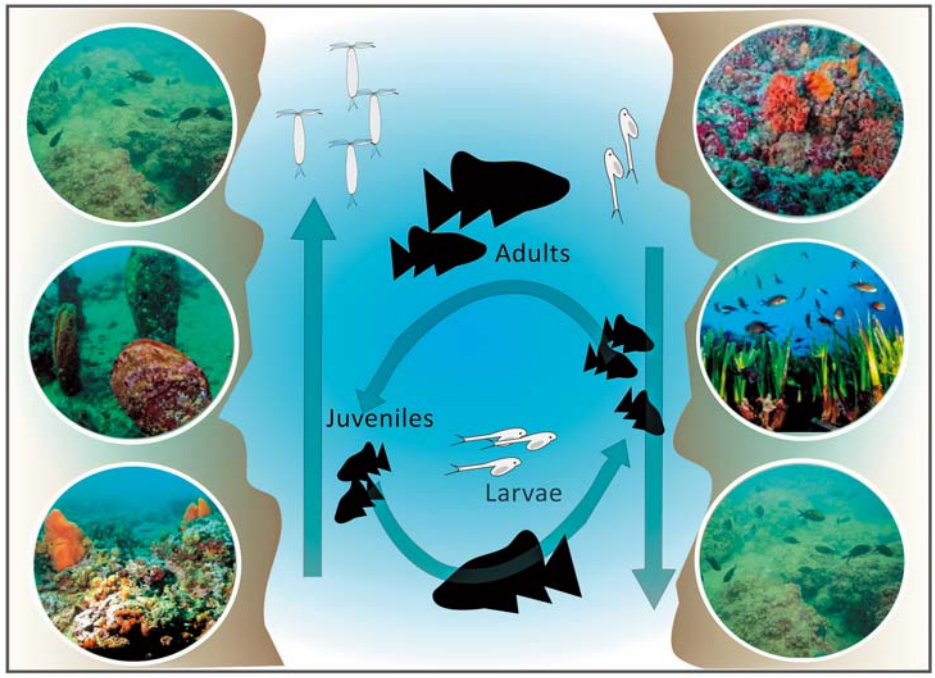

Fig. 1. Sketch showing species connectivity with the seascape.

The lack of a coordinated governance of N2K network, at both European and national levels, has so far strongly limited the capacity of N2K to foster each of the above listed limitations and to achieve ecosystem wide conservation measures through the establishment of management plans [14]. Governance systems can be defined as "the interactions among structures, processes and traditions that determine how power and responsibilities are exercised, how decisions are taken, and how citizens or other stakeholders have their say" [15]. N2K governance model, as for most protected areas, has still a marked traditional top-down approach, where national authorities are committed to the implementation of the conservation sites and to the coordination of their goals and may delegate the responsibilities to lower level hierarchies (e.g. regions, parks, municipalities). The actors involved in such a model should engage a wide variety of stakeholders to find solutions to possible conflicts of interest and to build strong collaboration to pursue effectively conservation goals [16].

The direct participation of citizens and stakeholders to N2K governance systems are fundamental to support decision-making processes, from the early stages of the N2K

sites establishment through their implementation, creating a stable partnership among all involved parties, and conquering their willingness to act collaboratively. In reality, the governance and management systems (GMS) of sites under protection rarely involve the local stakeholders and people in decision making and taking through participatory processes [17] [18]. The transformation of N2K into a real network requires an effective and robust GMS, based on the best ecological knowledge of the marine environment and on the local realities, in order to be able to deal with the fast ecological and socio-economic changes. GMS should rely on the ecosystem-based approach, which has being promoted by institutions worldwide as the best way to assess and harmonize science-based knowledge, environmental-related policies, stakeholder needs and the wider societal aspects [19] [20]. Most N2K sites are local realities that aim at finding a balance between the presence of humans and their uses and nature protection needs. The adoption of an ecosystem-based approach underpins connectivity among ecosystems, as well as among humans and nature, thus becoming a necessary approach to be incorporated into N2K GMS.

The successful implementation of the N2K network as well as their GMS requires being adaptive, founded on well-designed and dynamic research and monitoring strategies, able to assess the effectiveness of protection network. This implies that agencies and managers should hold the institutional capability and tools to carry out suitable monitoring, evaluate and report the derived results, and adapt properly their conservation strategy to respond to changes both within and outside the network.

This study explores the potential of Marine Ecological Observatories (MEOs) in favoring the overcoming of the above-described issues. MEOs, by promoting harmonization mechanisms, transnational information flow, and knowledge co-production at regional level to inform N2K GMS, can support N2K network implementation and the application of an ecosystem-based approach to its management. In the following sections, we identify and address the main challenges MEOs might face to deliver their benefits to N2K GMS. Moreover, we detail and scale up these concepts in the context of the Adriatic Sea, where an ecological observing system is under design and development in the framework of the Interreg Italy-Croatia project ECOSS (Observing System in the Adriatic Sea: oceanographic observations for biodiversity) [21].

2 GMS and the Fragmentation of Marine Conservation: the Role of Marine Ecological Observatories

Marine Observatories (MOs) are globally widespread: they consist mainly of observing, monitoring and experimenting infrastructures conceived to monitor oceanographic variables and to assess the state and modifications of coastal and offshore sea in response to anthropogenic alterations and to the changing global climate [22]. Oceanographic processes, which are mostly addressed in the MOs, are obviously entangled with the ecological ones, across a range of spatial and temporal scales. Therefore, a proper integration between oceanographic and ecological research and monitoring is key to build the knowledge needed to assess the performance of protected areas and the impact of on-going environmental and human-induced changes on conservation strategies [13]. This holistic view should be incorporated into MOs,

leading to the development of Marine Ecological Observatories (MEOs), able to arrange and maintain harmonized and coherent long-term observations linking oceanographic and ecological monitoring with the effectiveness of the protected areas [23]. In order to achieve long-term operational sustainability, MEOs should develop a proper governance structure, which includes, e.g., an advisory board, the establishment of shared regulations among the different players (e.g., managers, researchers and users), and an established framework of research activities oriented to answer and inform conservation management issues and hypotheses. In addition to playing a primary role in monitoring and coordinating different observers and existing or new data streams, MEOs should be designed to generate knowledge related to the dynamics between the human dimension and the natural systems. This typology of observatories should be able to involve researchers, policy makers and members of the civil society, and to collect a variety of knowledge and viewpoints to favor innovation and development in information planning and management at a proper spatial scale. Only in this way, MEOs can offer real support for conservation strategic planning, setting goals, performance standards and monitoring [24]. Although several examples of potential partnerships among marine protected areas monitoring activities and MOs are known worldwide [13], coherent and operative MEOs do not exist yet nowadays. We propose here essential attributes that MEOs should incorporate in their own governance systems and observation framework, to tackle the main issues evidenced in Chapter 1 for an effective N2K network implementation (Fig. 2).

(i) *An agreed conceptual framework* for the harmonization of monitoring schemes, data acquisition and analysis at trans-regional and national levels. At the core of MEOs are environmental observations, which are gathered with various instruments and strategies at different spatial and temporal scales, and which should be integrated into the N2K monitoring schemes in order to properly assess the effectiveness of conservation [13]. The framework should be based on assessed criteria and selected environmental monitoring indicators, recognized for being adequate to describe globally the state of the marine environment, also coherently with the EU legislative requirements.

(ii) *Data platforms to deliver oceanographic and ecological information and knowledge, fully adopting the open science approach.* Central to the development of MEOs, to inform properly GMS of N2K, is the adoption of the open science approach, which creates the conditions for the exchange of knowledge among scientists, decision-makers and citizens. Open science practices in ecology has become increasingly necessary for responding to conservation issues and for addressing environmental changes, by removing the cultural, institutional and technological barriers through the establishment of open information flows. MEOs should provide ways of making knowledge more readily available and comprehensible to different types of users, enhancing the transformation of a typical top-down flow of information into a multi-players dialogue [25].

(iii) *Tight cooperation among the fragmented multi-level governance systems and responsible managing authorities of N2K sites*. The present EU status still reflects a fragmented approach in the conservation and management of N2K sites within the wider context of marine environment. Data and information gathered and made available through MEOs should inform different policies and strategies, dealing with marine conservation, planning and management at both EU and global level. MEOs

should represent platforms to harmonize and create synergies among all these different jurisdictional instruments in particular the Habitats Directive HD [1], the Birds Directive BD [2], the Marine strategy Framework Directive MSFD [26], the and the Maritime Spatial Planning Directive MSPD [27]. In addition, all EU countries, driven by legal commitment (MSPD), are now developing their own marine spatial plans, and, never like today, it is important to inform this process in order to properly find space for new areas devoted to marine conservation. MEOs should support a systematic conservation planning to individuate coherently marine areas of priority for conservation, N2K sites included, to be integrated within the broader MSPD framework [28], and to favor ecosystem-based approach implementation. MEOs could also help to reach the United Nations Sustainable Development Goals (SDGs), in particular the UN SDG 14 "Life below water" that specifically requires strategies, infrastructures and investments for observing and monitoring the marine environment [29].

(iv) *Local ecological knowledge and priorities for the effective involvement of stakeholders and the civil society within the mechanism of knowledge co-production*. In the context of the marine N2K network, MEOs should function as knowledge cogeneration platforms from which different users could take advantage and effectively contribute to inform N2K GMS. MEOs would recognize the role of multiple knowledge sources to deal with uncertainties derived by knowledge gaps, by entailing local and traditional knowledge and directly engaging local communities that should become part of the observatory system itself and support the GMS [25] [30]. Contemporarily, MEOs should help GMS of N2K sites to apply concretely an ecosystem-based approach to pose people in the condition both to be able to recognize their deep interconnection with nature, and to approach the existing knowledge related to the marine environment.

3 MEOs Potential to Enhance GMS and N2000 Strategy in the Long-term: the Pilot Study of ECOAdS in the Adriatic Sea

The Adriatic Sea is a significant geographical zone for the establishment of a MEO, due to the concomitant presence of high degree of biodiversity, sensitive habitats and ecosystems, numerous ongoing monitoring and research activities, as well as heavy and diversified human pressures and economic interests, based on the marine resources of the area.

The design and implementation of such an observatory, named ECOAdS (ECOlogical observing system in the Adriatic Sea), is one of the main goals of the Interreg Italy-Croatia project ECOSS, a collaboration between 10 organizations from Italy and Croatia which will run from January 2019 to June 2021. The ECOSS project aims at integrating in ECOAdS the existing ecological and oceanographic research monitoring with N2K conservation strategies in the Adriatic Sea, focusing on the area under the jurisdiction of Italy and Croatia, thus providing a contribution to improve the conservation status of habitats and species of the N2K marine sites. This contribution will be of benefit especially for those sites that lack management and monitoring plans, therefore not being operationally implemented with respect to their conservation objectives.

ECOSS project foresees a design phase of ECOAdS, where the four main challenges evidenced for MEOs (Fig. 2) will be addressed, taking into account the specific features

of the area of the Adriatic Sea on which the project activities are focused. The design will be followed by an implementation phase where six specific N2K sites (Fig. 3), currently managed by the ECOSS partners, will be taken as case studies to pragmatically test the establishment of ECOAdS. Finally, a roadmap outlining the long-term strategy for the governance and maintenance of the ECOAdS will be produced, extrapolating the lessons learned also to other N2K sites in the Adriatic.

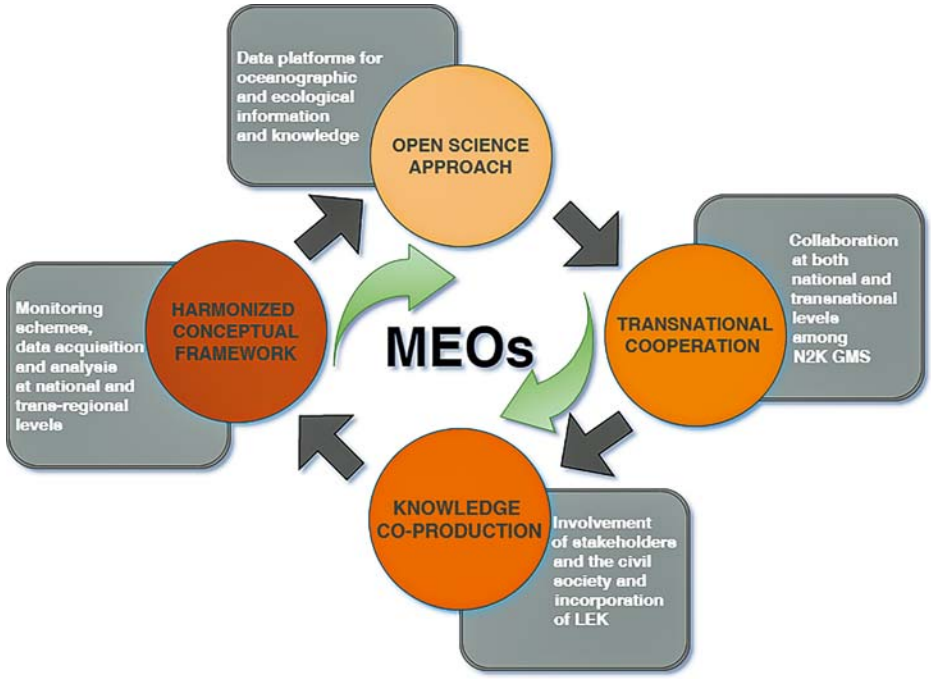

Fig. 2. The essential attributes of MEOs to tackle the main issues for an effective N2K network implementation. N2K = Natura 2000; GMS = governance and management systems; LEK = local ecological knowledge.

3.1 ECOAdS: the MEO Case Study in the Adriatic Sea, shared between Italy and Croatia

The Adriatic Sea region, as defined by the MSFD, comprises 368 marine N2K sites mainly covering the nearshore zone (0-1 Nautical Miles) and without offshore sites beyond the 12 NM [31]. On the base of the spatial measurement assessed through the use of data from November 2017 of MAPAMED dataset, the Adriatic counts 44 Italian and 245 Croatian sites wholly or partially marine, which cover respectively ca. 1694 km^2 (ca. 1.2%) and 5998 km^2 (ca. 4%) of the basin.

As reported in Chapter 1, the EC does not provide systematic guidelines on the management of N2K, but only general indications. In Italy, the Decree of the President of the Republic No. 1997/357 states that the regions must identify and establish conservation measures, and that they can also define and implement management plans.

In Croatia, the administration of protected areas and of the corresponding N2K sites is in general a responsibility of the managing authorities of counties and municipalities. However, many sites in both countries are not managed and monitored by established plans and strategies [32]. For instance, management plans are missing for five out of the six N2K sites considered in ECOSS: only the Po River Delta has produced its own management plan, which, however, is not yet in force.

Nonetheless, the Adriatic Sea hosts a number of well-established monitoring programs, acting at different spatial scales, from national to county/region level, and fixed-point observing systems (i.e. pylons, buoys, tide gauges, oceanographic platforms). These latter provide multidisciplinary and automated monitoring of coastal and offshore marine environments, with high temporal resolution, for a series of marine and atmospheric variables [33] [34] [35]. In general, ongoing monitoring observations are mainly linked to the fulfilment of the obligations established by the various EU Directives (mainly WFD and MSFD) or to specific programs and initiatives, such as the Italian Long-Term Ecological Research network, LTER-Italy. They address a wide variety of environmental issues, spanning from the assessment of the quality of transitional, coastal and marine waters to the monitoring of target species (e.g. dolphins and sea turtles) and other biotic components (e.g. plankton, macroalgae, coralligenous assemblages). It must be mentioned that neither of these initiatives are shared between the two countries, nor their focus is on N2K sites. In the case of ECOAdS, we considered the fixed-point observing systems, located in the pilot study area and of which ECOSS partners are managers and/or direct scientific advisors (Fig. 3).

As part of the design of ECOAdS, which aims at entailing all these monitoring initiatives, ECOSS recognizes that these existing observing platforms and monitoring schemes operate at various scales, with different aims and maturity levels, lacking an adequate coordination among them, which should connect the local, the regional, up to the whole Adriatic basin scale, in an integrated and coherent observatory.

In the design of a long-term sustainable and successful observatory, ECOAdS needs to be harmonized and incorporated into a suitable and clear governance structure, which could effectively support a shared understanding of the state of the marine environment and the connections among oceanographic and ecological observations with conservation issues.

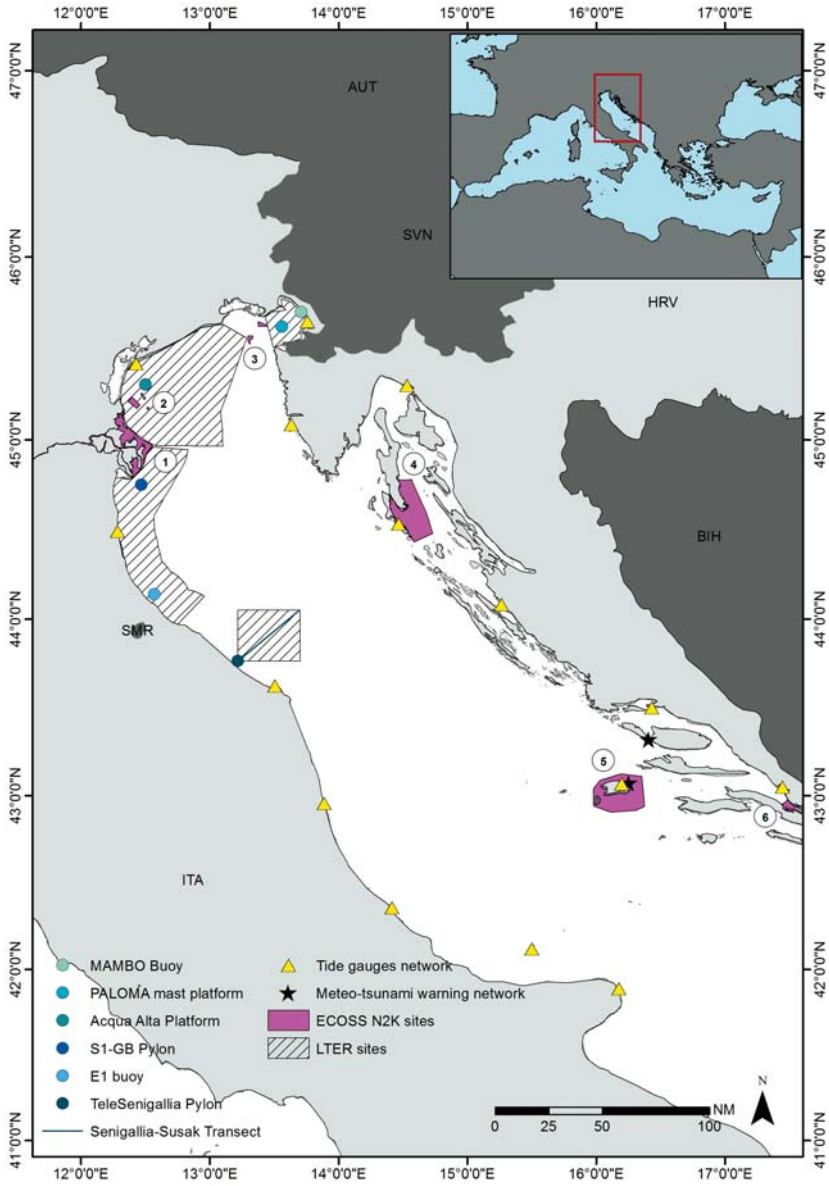

Fig. 3. ECOAdS N2K sites and fixed point observing systems managed by ECOSS project's partners. N2K sites: 1. Po river delta (IT3270017 and IT3270023), 2. Tegnùe di Chioggia (IT3250047), 3. Trezze San Pietro e Bardelli (IT3330009), 4. Cres-Lošinj (HR3000161), 5. Vis (HR3000469), 6. Mali Ston (HR4000015). Data Sources: ECOSS N2K sites [21], RITMARE [33], MAPAMED [36], Meteo-tsunami network [37], Tide gauges network [38], LTER-Italy sites [39].

The four main challenges faced by MEOs to support effectively GMS of N2K network, individuated in Chapter 2, will be addressed for ECOAdS, drafting a roadmap for its implementation. Figure 4 resumes the four essential attributes that will be incorporated by ECOAdS.

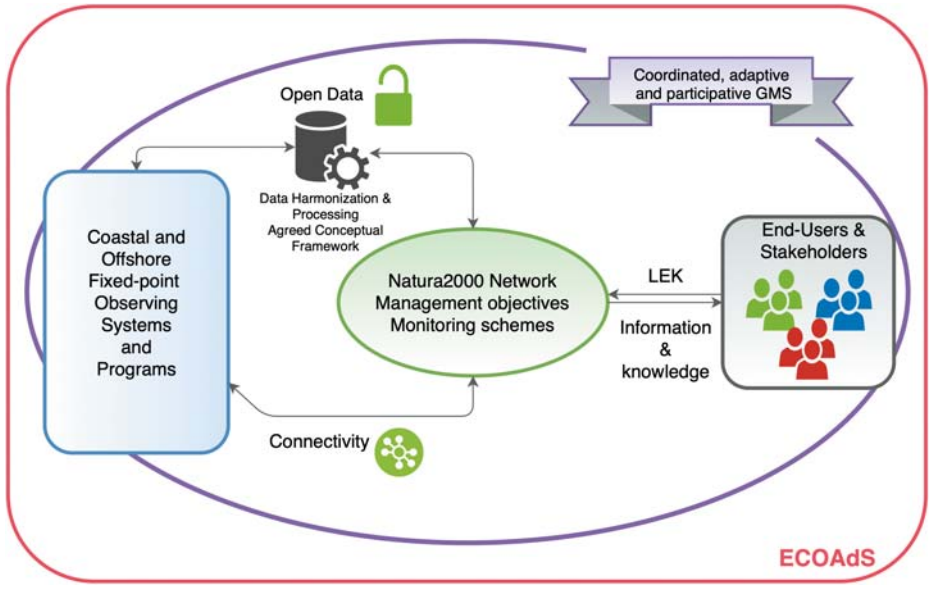

Fig. 4. Schematic view of the essential attributes of ECOAdS to support effective GMS of Natura 2000 in adopting an ecosystem-based approach and in implementing the network. (LEK=Local Ecological Knowledge).

3.1.1 Adoption of an agreed conceptual framework

Firstly, ECOAdS will develop and adopt a conceptual framework for the harmonization of existing oceanographic and ecological observations, monitoring schemes, data acquisition and analysis at national and trans-regional levels, in order to allow answering to the main N2K management issues. This will be mainly achieved through the selection of suitable performance indicators, recognized for being adequate to describe globally the state of the marine environment coherently with the EU legislative requirements, and to be monitored at adequate temporal and spatial scales. Besides, it will integrate different but complementary conceptual schemes of environmental variables, for identifying drivers of biodiversity changes, such as the Ecosystem Integrity framework, adopted by the LTER communities [40], the Essential Biodiversity Variables (EBVs) [41], developed by the Group on Earth Observations-Biodiversity Observation Network GEO-BON, and the Essential Ocean Variables (EOVs) [42], implemented by the Global Ocean Observing System GOOS. The obtained harmonized monitoring scheme entailed in ECOAdS will be shared at both national and trans-regional level in order to support common approaches of data

acquisition and data management practices, which has to be compliant with both the Essential Variables frameworks and the EU legislations [43].

3.1.2 Adoption of the open science approach

Observations have no meaning without open data policies and effective data management, which make information and knowledge accessible for different kinds of users. Data management procedures based on the "FAIR" principles, which states that data must be "Findable, Accessible, Interoperable, and Reusable", are indeed the base of open access to data and represent a crucial step towards open science [44]. In the present complex data management landscape, it is required to develop streamlined and modern data management, which could simplify, automate, and make the flow of data more efficient. Taking into account the experiences already available in the area [45] [46] [47] and the different level of maturity in respect to open science, ECOAdS will develop further techniques to better disseminate the results to the potential end-users (e.g. local, regional and national public authorities, managers of protected areas and N2K sites, education and research organizations). The aim is the implementation of an easily accessible data portal giving, whenever possible, open access to the observations collected by fixed-points systems and monitoring programs.

3.1.3 Cooperation among the fragmented multi-level governance systems

By embracing existing and coming observatory systems and monitoring programs in the Adriatic region, which cover different spatial scales, from the most limited sites scale to the largest basin scale, ECOAdS will require a nested structure. This will enable the collection of all relevant environmental data and information representatives of each N2K site, simultaneously capturing the wide regional ecological dimension that drives connectivity aspects related to networks of protected sites. Such structures will be the key to support conservation objectives, which need to be achieved at the country and regional level, although conservation measures need to be implemented at the N2K site level [48]. In this way, ECOAdS will concretely support and guide the GMS of N2K sites in establishing, if absent, or in implementing, if already present, coherent management and monitoring plans of both existing and future N2K sites.

ECOAdS top-down strategy foresees the acquisition of relevance in the environmental governance arena as fundamental decision-support tool for conservation, by engaging governance representatives and management authorities at the level of the N2K sites in the co-production of knowledge to support N2K GMS at both local and basin scales. ECOAdS will be addressed to favor an informational governance of N2K sites, where the information represents the key to boost adaptation strategies and ecosystem-based approaches in GMS [25] [49]. It will function as a cooperation bridge between Italy and Croatia, overcoming local and national boundaries, representing the opportunity of removing geopolitical limitations to build a regional-based marine knowledge framework.

By serving both these countries, ECOAdS may potentially benefit from regional financial mechanisms to ensure long-lasting activities. In this context, the EU Strategy for the Adriatic and Ionian Region (EUSAIR), acting at macro-regional level to promote economic and social prosperity and growth in the region [50], might play a decisive role. In particular "Environmental quality", which is one of the four pillars of

EUSAIR, addresses the environmental and conservation needs in the area with a special focus on the marine environment, to answer to both EU directives and Biodiversity Strategy.

Besides, ECOAdS could rely on, contribute to, and benefit from various Environmental Research Infrastructures (RIs), EU and global networks, supported by EU and national funds. Actually most of the ongoing research and monitoring activities in the Adriatic area are already connected to many environmental RIs (e.g. eLTER RI, Danubius RI, LifeWatch ERIC, EMBRC ERIC, ICOS ERIC, JERICO), and to other EU and global observatory networks (e.g. Copernicus, FixO3 and EMODnet). These initiatives could become relevant for the long-term maintenance and financial sustainability of ECOAdS. A joint collaboration is required and is arising among the different marine RIs [51], and ECOAdS could represent the opportunity to boost such collaboration in the Adriatic Sea, by representing and developing a co-located system with shared research and monitoring tasks allowing modular and multi-purpose uses. Long-term financial sustainability is actually a crucial issue for ECOAdS as well as for other MEOs. Although this issue is not addressed by ECOSS, it should be taken into account in the construction of the ECOAdS roadmap, aiming to achieve its full effectiveness and long-term maintenance. Financial sustainability should be facilitated also by the creation of efficient collaborations, transparent data sharing, and the maximum effort to minimize the duplication of activities [52].

3.1.4 Knowledge co-production

Human presence plays an important role and influence in the success of the N2K network, thus making it necessary to combine the social and ecological dimension and to integrate the priorities in the political agenda [53].

ECOAdS will entail a bottom-up approach by posing itself in the interface between scientists and non-experts, engaging the civil society benefiting from N2K sites to incorporate local ecological knowledge (LEK), as well as involving the younger generation of scientists through participatory processes. In this way, ECOAdS will collect local needs and support the adoption of its proposed holistic approach into future research and monitoring practices. The transfer of environmental knowledge will not be unidirectional, from scientists to non-experts, but rather it will turn in a multi-actors dialogue including different competencies. End-users and stakeholders engagement is at the heart of building and sustaining an observatory: it stimulates the increase in the ocean observing capacities, facilitates sharing of infrastructure, promotes best practices, builds capacity, fosters diversity, and develops innovative technologies and approaches [49]. Several experiences coming from both terrestrial and marine sites highlighted the added value gathered when citizen science mechanisms are set up in monitoring approaches, through the adoption of voluntary sighting activities, questionnaires, interviews and interactive open access portals [54] [55] [56]. Although the citizen science approach is not yet a common practice in the implementation of the N2K network, there is empirical evidence of their usefulness for the enrichment of environmental monitoring databases and information frameworks [57].

ECOAdS, in this context of sharing knowledge and information, will favor the meeting among individuals, organizations, and agencies at multiple governance levels, as well as between these actors and the marine environment, thus supporting the

operationalization of an ecosystem-based approach. The synergy between experts, the civil society and N2K GMS, would support governance and management authorities in taking responsibility and right actions, and in reinforcing their willingness toward effective implementation of N2K sites and networks in the Adriatic at multiple spatial scales and governance levels, willingness that has been observed to be often scarce [58].

4 Conclusions

This study reports the main limitations that curtail the efficacy of Natura 2000 (N2K) network, the main biodiversity conservation instrument in Europe. Missing systematic procedures to identify priority sites for conservation including offshore and deep habitats, inappropriate size of N2K to protect highly mobile species and to manage human pressures with large footprint, paucity of available ecological research and data, lack of coordinated transnational strategies, and limited attention to socio-economic and socio-ecological issues emerged as key constrains for N2K network implementation. Most of all, the lack of management plans and related conservation measures put in place in N2K sites strengthen these limitations.

Despite the recognized role that ecological connectivity plays in the marine environment, supporting all ecological processes that enable marine life to exist, related aspects have been largely ignored in the N2K network design until today. This weakens even more the conservation efficiency of the network, which is undermined also by the absence of a coordinated governance, at both national and regional scales.

The N2K governance model, presenting a marked traditional top-down approach, fails to involve citizens and stakeholders in its governance and management systems (GMS), leaving behind a key component to build a successful partnership for N2K conservation and sustainable management.

In this study we highlight the need of incorporating an ecosystem-based approach within the GMS of N2K to concretely include connectivity among ecosystems, as well as among humans and nature. A GMS of N2K network needs to be adaptive, founded on well-designed and dynamic research and monitoring strategies. Moreover, agencies and managers need the institutional capability and tools to carry out suitable monitoring, evaluate and report the derived results, and act to adapt properly their conservation strategy.

This paper reports the main benefits that the design and establishment of Marine Ecological Observatories (MEOs) can deliver, to support N2K marine network implementation and related GMS, coping with existing issues and favoring priorities' achievement. Moreover, the essential attributes that MEOs should include and support to become decision-support tools for the responsible authorities and agencies and to favor the overcoming of the identified issues that hinder N2K implementation and efficacy are outlined. These are: (i) an agreed conceptual framework for the harmonization of monitoring schemes, data acquisition and analysis at trans-regional and national levels; (ii) data platforms to deliver oceanographic and ecological information and knowledge, fully adopting the open science approach; (iii) tight cooperation among the fragmented multi-level GMS and responsible managing

authorities of N2K sites; (iv) local ecological knowledge and priorities integration for the effective involvement of stakeholders and the civil society within the mechanism of knowledge co-production.

The ecological observatory ECOAdS, which is the main outcome of the Interreg Italy-Croatia project ECOSS, is here presented as a first proposal of MEO acting in the Adriatic Sea. Supported by the transnational collaboration of Italy and Croatia, ECOAdS can function as a decision-support instrument useful to help the setting up of adequate N2K monitoring strategies able to entail marine connectivity aspects and to inform adaptive GMS at the Adriatic scale.

To bridge the dialogue between multi-level GMS at cross-border scale, ECOAdS foresees a harmonized set of ecological monitoring indicators by adopting a nested approach to depict the state of the Adriatic Sea, coherent with the FAIR principles: "Findable, Accessible, Interoperable, and Reusable". ECOAdS, by triggering participatory processes with multiple actors and in a multidisciplinary context, poses itself at the interface between authorities, experts, and the local communities inhabiting N2K sites, favoring a co-production of knowledge to implement the network and making the partnership of GMS with the civil society integral part of the observatory. Overall, ECOAdS can represent an opportunity to build a common knowledge and monitoring framework at a transnational level to overcome the N2K sites fragmentation, incorporating marine connectivity aspects and supporting transnational cooperation for planning and managing the Adriatic Sea conservation and the sustainable use of its resources. In the hope that the role of ECOAdS in supporting the transnational sharing of knowledge and in informing N2K Adriatic network and conservation strategies will be recognized, we suggest that regional collaboration scheme at the Adriatic level, such as EUSAIR, become starting platforms to support ECOAdS long-lasting activities.

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Mediterranean Coastal/Marine Biosphere Reserves: Governance and Management Challenges

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Abstract

Coastal Mediterranean Biosphere Reserves present different types of governance and management systems and are excellent laboratories for experimenting new strategies facing environmental, socio-economic and political challenges. The study carried out on 20 selected Biosphere Reserves evaluated the existing governance and management system as well as opportunities and ways to transform and adapt them to the changing evidences in the Mediterranean Basin. Protected areas, in particular Biosphere Reserves contribute to reduce environmental and anthropogenic negative impacts. They offer excellent opportunities to experience new approaches and to learn from models how to change and accelerate transformation processes driven by local realities and challenges sustained by local population and stakeholders. A strong commitment by national authorities to establish an inclusive good governance, with strong local actor's participation and collaboration, as well as adequate funding and human resource allocation is essential for success. The delegation of authority and accountability to the single Biosphere Reserve could enable them to prepare and to promptly react to emergencies concerning current and future challenges.

Keywords: governance; management; biosphere reserves; protected areas, coastal areas, participation, future challenges

1 Introduction

The Mediterranean Sea region is one of the most populated coastal regions with 21 countries overlooking its banks. Every year millions of tourists visit its beaches and Protected Areas (PAs), among them Biosphere Reserves (BRs), where sustainable tourism approaches are increasingly relevant. In particular, impacts of climate change are exposing the ecosystems to high risks due to the absence of adaptation and mitigation measures. Tools such as the Maritime Spatial Planning and Management Plans are deliberated and applied gradually, and the governance systems are still far from being effective. In addition, the implementation of international obligations at the national level are occurring at different phases in the single states.

In the last decade the protected spaces and particularly BRs, have progressively changed their scope from their primary objectives: conservation, education and scientific research. Today BRs are considered as driving forces for the local socio-economic development, safeguarding the inherent natural and cultural heritage and functioning as a laboratory for experimenting new management approaches and environmental measures [1].

The adoption of inclusive perspectives has allowed the introduction of new approaches for the participation of local bodies, private sector, organizations and civil society. Although mostly not involved directly in the decision taking processes, they are indirectly represented at the different governance levels, mostly by members of local and regional authorities [2].

Recent studies have been aimed at understanding the Governance and Management Systems (GMS), the actions undertaken regarding present and future challenges as well as the various degrees of stakeholders' involvement in the governance processes [3]. The main target of the CNR-ISMAR research realized by the authors, was the evaluation of existing GMS as well as opportunities and ways to transform and adapt them to the changing evidences in the Mediterranean Area.

The Mediterranean Sea is considered one of the world`s biodiversity hotspots, where the impact of climate change together with other anthropogenic pressures could be most devastating [4]. Studies analyzed marine and coastal BRs and the severe problems connected to climate change, sea level rise, coastal erosion, biodiversity decline, marine litter, invasive alien species, pressure from tourism, and scarce stakeholder involvement they encounter [5]. Furthermore, the Northern African BRs furthermore are threatened by political instability, social transformations, financial constraints, and sluggish economic development. However environmental risks and over exploitation of marine resources will increasingly threaten the marine and coastal biodiversity and habitats.

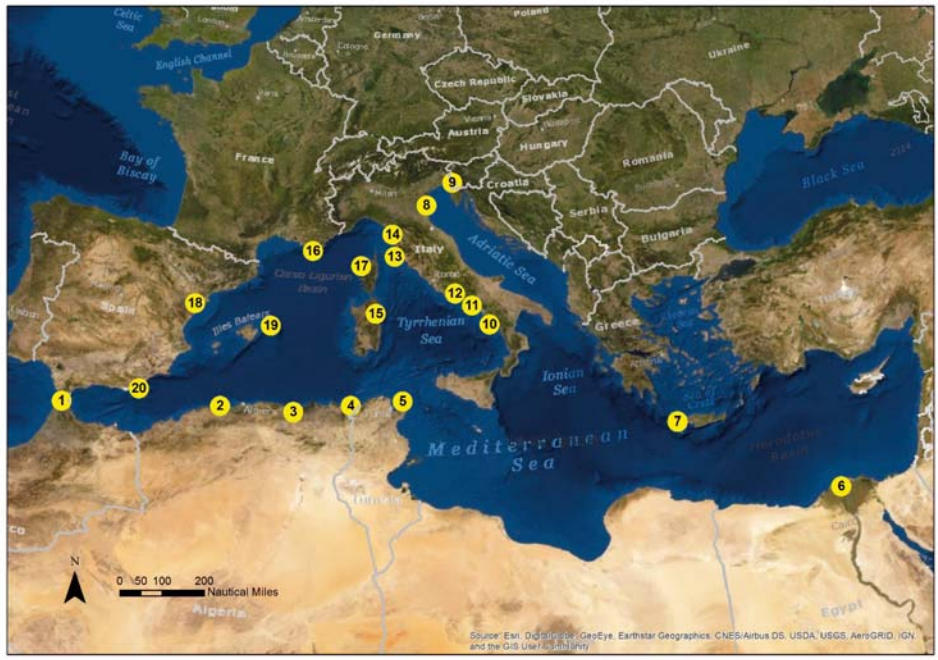
2 Survey and Data Collection

The study focused on the current UNESCO Biosphere Reserves located in the Mediterranean coastal area (Figure 1).

The selected sites include the following coastal or marine Biosphere Reserves:

- **Algeria**: Gouraya, El Kala and Taza
- **Egypt:** El Omayed
- **Tunisia**: Zembra and Zembretta
- **Morocco-Spain**: Intercontinental Biosphere Reserve of the Mediterranean
- **Spain:** Terres de l'Ebre, Menorca and Cabo de Gata-Nijar
- **France:** Camargue Delta du Rhone and Fangu Valley
- **Greece**: Gorge of Samaria
- **Italy:** Miramare; Circeo, Po Delta; Cilento and Vallo di Diano; Tuscan Islands; Tepilora, Rio Posada and Montalbo; Somma Vesuvio and Miglio d'Oro; Selve Costiere di Toscana.

The investigation was based on information and available materials (books, documents, articles, reports, internet sources and other grey literature). For each BR selected, the general description of the area (location, size, year of establishment, legal foundations, funding, zoning, governance and management systems, involved bodies etc.) were retained. Despite all the bibliographic data collected, often specific BR information was missing (i.e. present staff number, current budget). Data not publically available so far, were collected through interviews with the directors and/or managers of the BRs. The main questions concentrated on the actual management systems and challenges.



1. Intercontinental Biosphere Reserve of the Mediterranean
2. Gouraya
3. Taza
4. El Kala
5. Zembra and Zembretta
6. El Omayed
7. Gorge of Samaria
8. Delta del Po
9. Miramare
10. Cilento and Vallo di Diano
11. Somma Vesuvio and Miglio d'Oro
12. Circeo
13. Tuscan Islands
14. Selve Costiere di Toscana
15. Tepilora, Rio Posada and Montalbo
16. Camargue Delta du Rhone
17. Fangu Valley
18. Terres de l'Ebre
19. Menorca
20. Cabo de Gata-Nijar

Fig. 1. Coastal/Marine Biosphere Reserves in the coastal Mediterranean area.

3 The "Man and the Biosphere" Programme (MaB)

The "Man and Biosphere" Programme (MaB) - was created in 1971 and endorsed by the 16th UNESCO General Conference as an intergovernmental program aimed at providing scientific foundations for the actions related to a sustainable use of natural resources promoting a balanced relationship between people and their environment. Its aims include the promotion of scientific cooperation, interdisciplinary research for the protection of natural resources, the management of natural and urban ecosystems, and the establishment of a World Network of BRs [6].

After the Rio de Janeiro UN Conference on Sustainable Development in 1992, the objectives of the program have been continuously redefined:

- Identification and assessment of changes in the biosphere determined by anthropic activities and natural events especially in the context of climate change;
- Study and comparison of the dynamic interrelations between natural ecosystems and socio-economic processes;
- Improvement of the exchange and dissemination of knowledge on environmental problems and possible solutions;

- Promotion of environmental education in the field of management and sustainable development.

The MaB Programme includes the Biosphere Reserves, which encompass terrestrial, marine/coastal ecosystems or a combination of them. The BRs prioritize the balance of biodiversity and socio-economic development, promoting the possibility of carrying out multiple territorial functions. These protected areas are suitable for sustainable experimentations and guidance for a sustainable development aimed at improving the benefit of local communities. They promote the involvement of local communities, and are therefore considered best practices for the interaction between social and ecological systems.

The MaB International Co-ordinating Council (MaB-ICC) is the main governing body of the MaB Program, composed by 34 Member States elected by UNESCO's biennial General Conference. The International Advisory Committee for Biosphere Reserves advices the MaB-ICC and the Director-General about the World Network of Biosphere Reserves (WNBR) while the International Support Group (ISG) provides advices to the MaB Secretariat for the implementation of the Madrid Action Plan and other aspects of the MAB program.

The MaB National Committees ensure national participation in the program and support the governing bodies. At present there are 158 National Committees established among the 195 Members States and 9 Associate Members States of UNESCO.

3.1 Evolution of the Biosphere Reserve Strategy

The BR concept was created in 1974 and then significantly revised in 1995 with the adoption of the Statutory Framework and the Seville Strategy, further specifying the modern BRs visions and missions [7]. Before the Seville Strategy, the BRs concept based on the management model and functions of the PAs focused on conservation of natural resources. The management approach was top-down with little involvement of stakeholders or civil society. This kind of BR is called the "1st generation Biosphere Reserve".

Seville Strategy and the Statutory Framework introduced the “2nd generation Biosphere Reserve” combining the three interconnected functions conservation, development and logistical support and appropriate zoning, comprising core areas, adjacent buffer zones; and a transition area where sustainable development is promoted and developed by local actors. The strategy recognized the link between biodiversity conservation and development needs of the local communities [8].

With the Madrid Declaration and the Madrid Action Plan (MAP) adopted in 2008, the BR concept was further developed [9]. The BRs concept introduced participatory processes with a strong cooperation among the different bodies interested in its management. Biosphere Reserves are seen as learning sites for global, national and local sustainability where challenges such as climate change, stresses on ecosystems and landscapes, and urbanization as principle drivers are addressed. Sustainable development takes into consideration the biodiversity conservation and socio-economic growth.

A new vision was established with the "New Roadmap for the MAB Program and its World Network of Biosphere Reserves" [1]: MAB Strategy (2015-2025), Lima Action Plan (2016-2025), Lima Declaration. The 4th World Congress of Biosphere Reserves 2016 in Lima, Peru focused on the implementation of the MAB Strategy according to the 2030 Agenda for Sustainable Development, the Sustainable Development Goals (SDGs) and the Paris Climate Agreement. The related Lima Action Plan includes not only targeted outcomes and actions for implementing the strategic objectives of the MaB Strategy but also specifies the entities responsible for the implementation, the timeline and performance indicators.

3.2 The Biosphere Reserves

The MaB Programme encompasses 701 Biosphere Reserves, including 21 transboundary sites (by end 2019) representing all major ecosystem types and diverse development contexts. MaB and its network support the implementation of the 2030 UN Agenda for Sustainable Development, in particular Sustainable Development Goals number 15 related to life on land, number 13 on climate, number 6 on water, number 14 on sea and oceans, number 11 on cities, number 2 on food, and number 1 on poverty alleviation.

The Biosphere Reserves are characterized by three functions of equal importance and interdependency (Figure 2):

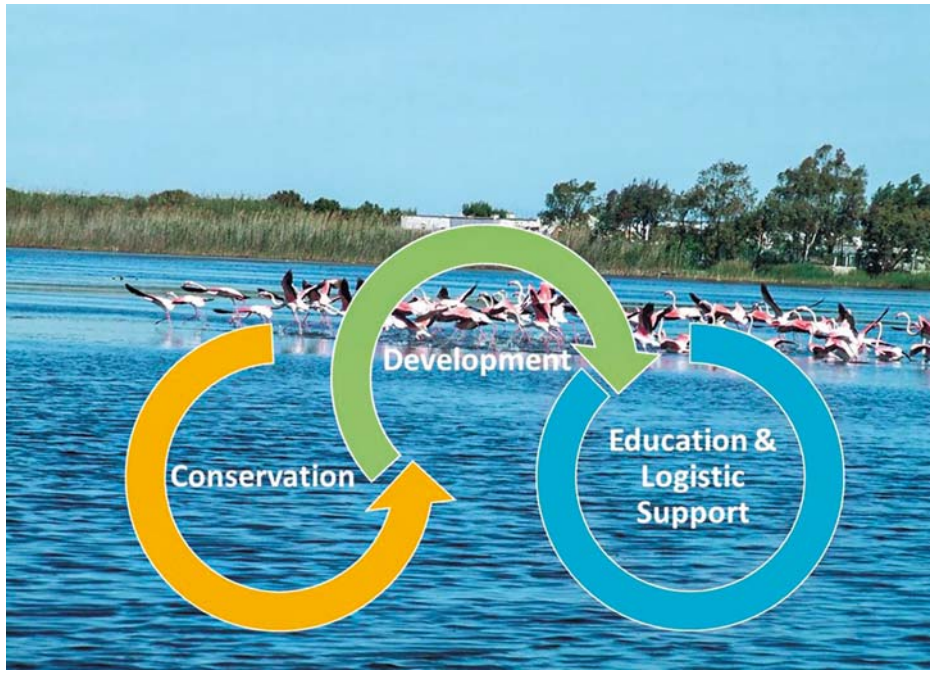


Fig. 2. The three functions of Biosphere Reserves (Photo: Lucrezia Cilenti).

Conservation: the BRs must ensure the conservation of selected ecosystems, variety of landscapes, biological diversity and genetic resources;

Development: to foster sustainable economic and human development, which are socio-culturally and ecologically sustainable and which could be realized locally taking the traditions into consideration;

Education and logistic support: to support demonstration projects, environmental education, training, research and monitoring related to local, national and global issues of conservation and sustainable development.

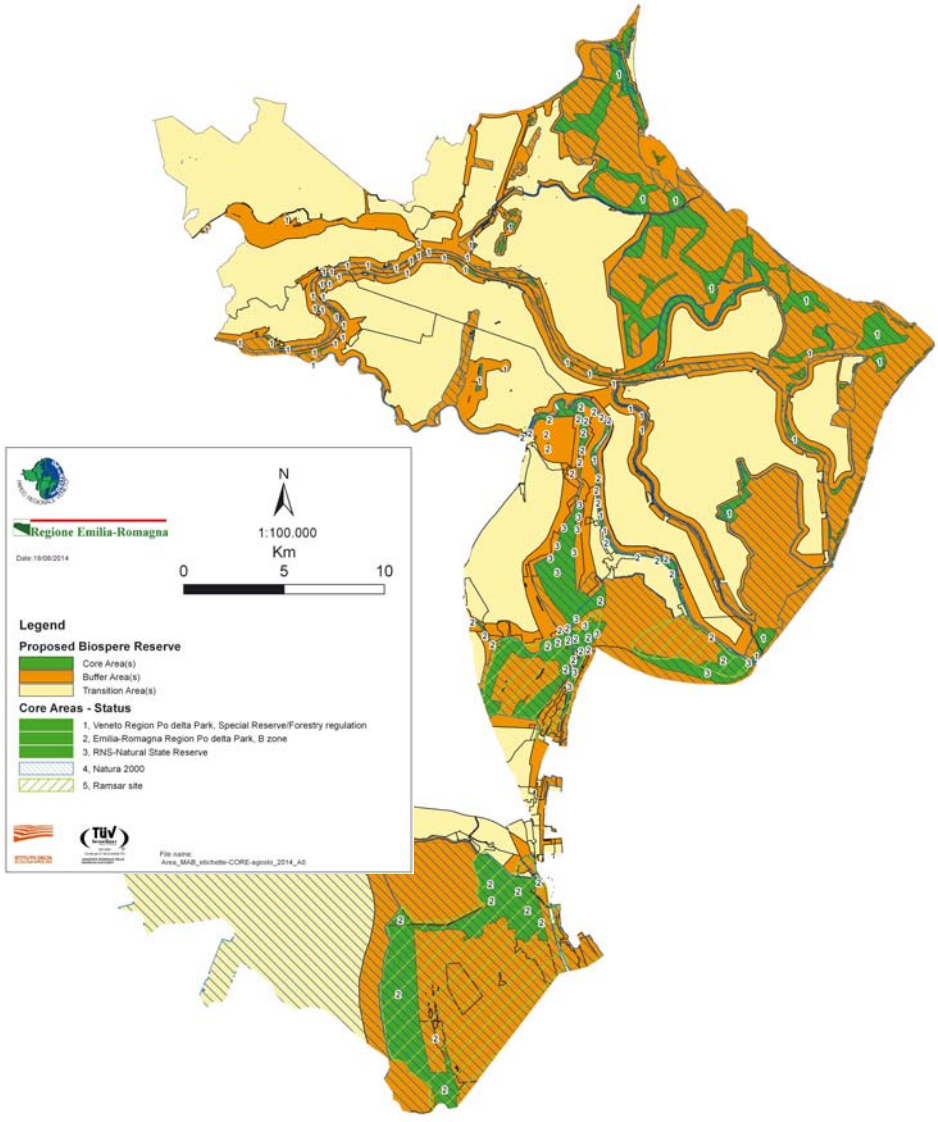


Fig. 3. Zonation system of the Delta Po Biosphere Reserve
(source: Ente parco del Po, www.biosferadeltapo.it)

These functions are in line with the three zones designated within each Biosphere Reserve and are interrelated (Figure 3).

- Core areas are protected sites for conserving nature.
- Buffer zones surround the core areas, can be used only for conservation, and restricted sustainable activities such as environmental education, ecotourism and recreation.
- Transition zones are used for sustainable agriculture, business and tourism. They may contain towns, farms and fisheries, as it is here where most of the inhabitants of the biosphere reserve live.

3.3 The World Network of Biosphere Reserves

The World Network of Biosphere Reserves (WNBR) was created with the objectives to increase the effectiveness of single Biosphere Reserves enhancing common understanding and co-operation at regional and international levels. The WNBR promotes North-South and South-South collaboration and represents a unique tool for international cooperation through the exchange of experiences and know-how, capacity-building and the promotion of best practices [6].

The 701 BRs located in 124 countries are distributed as follows [10]:

79 in 29 countries in Africa
33 in 12 countries in the Arab States
157 in 24 countries in Asia and the Pacific
302 in 38 countries in Europe and North America
130 in 21 countries in Latin America and the Caribbean

Different regional, sub-regional or thematic networks support the cooperation within the WNBR.

3.4 Benefits created by Biosphere Reserves

The Biosphere Reserves are places where new approaches to manage social and ecological systems, to avoid or reduce conflicts, to protect biodiversity and share solutions with the local population, are tested. They are learning laboratories where conservation and development are balanced and where it is possible to apply sustainability tools, take actions combating climate change, revitalize the local economy and become learning sites to explore and demonstrate strategies combining conservation and sustainable development, exportable to other contexts. Through educational programs organized on the site, the BRs can raise awareness of the local people and authorities on how to improve their quality of life reducing the negative environmental impacts, increase the exchange of information between researchers and citizens, and enhancing the cooperation among stakeholders [1].

The UNESCO's label increases the visibility of the site and if accompanied with an appropriate marketing strategy can become a new source of income. Tourism favored by the label can help to raise environmental awareness and appreciation of an "intact" site and in this way. Hence it is in the interest of BR's managers to ensure the site's protection for increasing the number of tourists and consequently its income. But it is well known that tourism has two faces and the negative impacts (consumption of water, waste, noise, pollution etc.) in some of the studied sites are higher than the positive

ones (e.g. economic growth, revitalization of the site). The results depend on the management of the area that must be based on a long-term strategy, involve in a concrete way the local population into the decision-making process, and the availability of natural resources and funding.

4 GMS in the Investigated Biosphere Reserves

The analysis related to the 20 coastal/marine BRs shows that the major part of them overlap with other PA categories and have adopted the existing GMS of the respective National or Regional Parks. In the last decade, Biosphere Reserves have elaborated biodiversity and sustainable development strategies, but they are rarely implemented at PA level and most sites still lack action plans, adapted management plans and funding to fulfill their supplementary tasks [2].

Table 1: Governance and Management Systems in the 20 selected Mediterranean BRs.

Legal Foundations	15 National Law, 6 National and Regional Laws*
Governance systems	11 Central governing bodies, 10 Regional governing bodies**
Management bodies	9 National Parks, 4 Regional Parks, 1 NGO, 1 Consortium, 1 Transboundary Management body, 1 National body, 1 Agency, 2 PNR + Syndicat Mixte,
Planning tools	10 Park Management Plans, 2 BR Management Plans (1 not yet approved), 5 Action Plans, 1 other plans, 1 any plan, 1 n.a.
Funding:	11 mainly National funds, 6 mainly Region, 1 mainly own funds, 1 Municipalities, 2 mixt

* The Intercontinental Biosphere of the Mediterranean (IBRM), having 2 different legal foundations and governance systems have been counted as 2 separate BRs.

** The IBRM has national legal Frameworks (Morocco, Spain), but Morocco has national and Spain regional governing bodies: Andalusia in the case of IBRM.

Most of the BRs are managed by national or regional park authorities, based on PA management plans. Spain is the only Mediterranean country that through the Law 33/2015 (ex 42/2007) on natural heritage and biodiversity, integrates norms regarding protected areas established in international contexts such as UNESCO BRs [11]. The North-African, Italian, French and Greek BRs have no specific legal status. There, the development functions have only been partially introduced, and the GSM follows the legislation of National or Regional Parks.

The studied Coastal/Marine Mediterranean BRs show a considerable variability in their legal foundations, governance and management systems, planning and management tools and funding sources (Table 1). The participation process is generally ensured by

representatives of the institutions but there is little legal provisions for direct citizen involvement, especially in decision-making processes.

4.1 Management Systems in the Southern Mediterranean BRs

The structures in charge of the BR management in the Northern African countries correspond to the structures in charge of the protected areas. Several public institutions share the management of BRs, most of them are trusteeship bodies rather than management bodies.

The management of protected areas in the Mediterranean is essentially state-owned, centralized and are marked by the preponderance of technical departments. The involvement of multiple administrations in the management system, the limited involvement of the civil society in the decision process, the lack of budgetary autonomy and skilled personnel, the use of police measures instead of incentives, make the management of protected areas particularly difficult. Nonetheless, the recent efforts aimed at improving the involvement of the citizens in project activities introduced by international projects, is showing positive effects. Some countries have recently enacted new legislations on protected areas that strengthen the involvement of relevant stakeholders in their management.

In **Morocco** the main responsible for the management of Protected Areas is the Haut-Commissariat aux Eaux et Forêts et à la Lutte Contre la Désertification (Office of the High Commissioner for Waters, Forests and Fight against Desertification) (HCEFLCD). The Law 1-10-123 from 2010 introduced the concept of management delegation to non-state actors for protected areas, explicitly providing the modalities for the establishment of public-private partnerships. Morocco has a unique BR overlooking the Mediterranean Sea, the Intercontinental Biosphere of the Mediterranean (IBRM) shared with Spain. Thanks to the cooperation with the Regional Government of Andalusia, Morocco is making significant efforts for an efficient management.

The Intercontinental Biosphere Reserve of the Mediterranean (IBRM) - The management structures of this BR consist in a *Transboundary Management Board* responsible for planning and cooperation program of the Reserve with the participation of Government Regional Offices and MaB Committees. The *Transboundary Coordination Committee* is headed by the Director of the IBRM (function occupied by rotation every 2 years of a representative of Spain and Morocco), the 2 coordinators of IBRM country and executive leaders of Regional Governments. The *Cooperation Advisory Board* formed by scientists, NGOs, local associations etc. establish working groups on specific issues. Finally there is the *Administrative and Management Committee* from each country, composed by the Director, National Coordinators of the IBRM, and Directors of the protected areas concerned, local associations of territories not protected by the Reserve.

Algeria adopted a new legislation on protected areas in February 2011 (Law 11-02). The new Act has established a national Commission on Protected Areas, which brings together representatives of all the sectors concerned, experts and representatives of NGOs which provide advice and opinions on new designations [12]. In Algeria the three main authorities in charge of the management of PAs are:

- Ministère de l'Agricolture, Développement Rural et de la Peche (Ministry of Agriculture, Rural Development and Fisheries) through the Direction General des Forêts (Forest General Directorate) (DGF)
- Commissariat National du Littoral (National Coastal Council) (CNL) in charge of controlling the coastal areas
- Ministère de la Culture (Ministry of Culture), responsable for cultural parks.

The BRs of *El Kala*, *Gouraya* and *Taza* are included in the national parks of the same name, consequently they have the same administrative organization. These areas are entrusted to a public administrative body including a *Scientific Council* and a *Guidance Council*. The latter is composed of representatives of different ministries, local elected representatives, scientists and an environmental protection association. It is responsible for deliberating on the development and implementation of the park management plan, and the activities carried out in matters related to the missions, organizations and operations of the National Parks [2].

Tunisia, after the political events of 2011, calls for institutional reforms aimed at establishing a clearer distribution of responsibilities between conservation organisms [13]. It also seeks a better coordination to find regular and adequate financial sources to support the National Parks (also through private investments). At present the management of the PAs is carried out by two bodies:

- Ministère de l'Agricolture, des Ressources Hydrauliques et de la Pêche (Ministry of Agriculture, Hydraulic Resources and Fisheries) through the Direction General des Forêts (Forest General Directorate) (DGF) and the Commissariat Regionaux de Développement Agricole (Regional Commission for Agricultural Development) (CRDA)
- L'Agence de Protection et d'Aménagement du Littoral (Coastal Protection and Development Agency) (APAL) subordinated to the Tunisian Ministry of Environment and Sustainable Development, responsible for coastal and marine protected areas.

Zembra and Zembretta BR is included in the namesake National Park. The park is managed by the Coastal Protection and Development Agency (APAL). A management plan of the marine part of the BR has been elaborated within the "MedMPA network" project of MedPAN but not yet applied [14]. The Islands are inhabited and the park has no personnel for the daily management.

In **Egypt** the Ministry of Environment through its executive arm, the Egyptian Environmental Affairs Agency (EEAA) is responsible for the management of the PAs. Each protected area has a board which is responsible for managing the site. The members of the board are made up of representatives from the EEAA, Governorate and other officials. The physical management of a protected area is undertaken by the Nature Conservation Authority, by the Area Manager and his staff with broad supervision from the Director General. The management is supported by a grant in aid from the government or a donor, augmented by revenues of the area, generated from entry fees, concessions, licenses fees or the like. The target is to use free market forces to first make the area financially self-supporting and later profitable.

El Omayed - The Omayed BR is situated within the jurisdiction of El Hammam which is affiliated to the Governorate of Matrouh in the El Omayed Protected Area (OPA). There are totally 10 institutions involved in the management of the OPA/BR with different roles and levels of responsibility.

4.2 Management Systems in the Northern Mediterranean BRs

The BR strategies introduced with the new MaB Roadmap [1] regarding conservation and sustainable development as well as GMS for core, transition, and development zones, including the vast marine area, are often not yet approved or implemented. However, the establishment of new GMS of BRs in European countries is well advancing. Managing bodies are composed by representatives of all administrative levels and the authority and accountability is delegated frequently to the Regions. In some countries Regions are governing authorities (Spain, France, Italy), and in almost all countries, the Regions, Provinces and Municipalities are part of the managing bodies. In France the BR bodies are joint committees, called Syndicate Mixte, in Spain regional authorities or consortium, in Italy park authorities or independent institutions as separate legal entities.

The governance and management bodies usually establish instruments regarding involvement of the local people and stakeholders. The participation process is required by national laws and ensured by the local authorities or institutions. Hence, there are rarely legal provisions for direct citizen involvement and the members of managing bodies are representatives of the local authorities or NGOs and not delegates of the local communities. A study of the Italian legal framework shows, that it is very specific and rigid regarding who can legally participate [15]. Generally the local communities are rarely involved in decision-making and taking processes, but have an important role in project activities.

In **Spain** each Autonomous Region is in charge of the establishment and management of protected areas on its own territory. National Parks are established by the central government upon proposal of the relevant Autonomous Region, which will be in charge for the management. At state level, the Ministry of Agriculture, Food and Environment is the main regulatory body. The local Autonomous Regions (Comunidad Autónomas) can develop and enforce their own environmental legislation. In September 2017, the Spanish MaB Committee approved the Ordesa-Viñamala Action Plan 2017-2025 and adopted the Ordesa-Viñamala Declaration to implement the Action Plan in the country's 48 Biosphere Reserves. This document is a guide that serves as a basis for initiatives, actions and projects that will be carried out by the Spanish network in accordance with the Sustainable Development Goals (SDGs) [16]. The three BRs analyzed represent different GMS types:

Terre de l'Ebre – The Regional Government (Generalitat de Cataluña) is the responsible body that has delegated to COPATE (Consorzi de Politiques Ambientals a las Terres de l'Ebre) for the management tasks. The Consortium is composed by different actors of the Government of Catalonia, supra-municipal administrations and other organizations.

Menorca – The Conseil Insular de Menorca (island government) is the responsible governing body of the BR, while the Agencia Menorca Reserva de Biosfera, is the

management body which works under the Conseil Insular and is associated with the Department of Economy, Environment and Game.

Cabo de Gata-Nijar – The BR is included in the Cabo de Gata-Nijiar Natural Park managed by the Consejeria de Medio Ambiente y Ordenación del Territorio de la Junta de Andalucia. The BR surface area coincides with that of the Natural Park, the status which was granted earlier.

In **France** the Ministry of Ecological and Inclusive Transition (MTES) is the main driver of the establishment of protected areas. The State has set up specific organizations of management of the various types of protected areas under its jurisdiction. The Regional Parks (NRP) are proposed by the regional authorities themselves. There is a 10 year trial period until they become permanent. Their funding is shared among municipal, prefectural, regional, state and other sources. They have ensured budgets on a 3-5 year basis grounding on management plans agreed upon and adopted by the stakeholders. Each one has a charter of principles for their management, based on hierarchically ordered values to be preserved. There is a central coordination and support mechanism, and a backing up by the state services to each NRP administration scheme [17]. The BRs are partially or completely overlapping with protected areas recognized by national law. The responsibility for BRs is entrusted to a public institution or an association. The majority of BRs are managed by public institutions (national parks, regional parks, mixed associations).The two BRs analyzed have the following GMS:

Camargue - Its governance is ensured by the Camargue Regional Natural Park (PNRC) and the Syndicate Mixte (Joint Committee) for the management and protection of the Camargue in the Gard Department (SMCG). The Syndicate Mixte is an association of municipalities and other local authorities that pool financial resources and work together in common projects. Operational decisions are made by the Management Committee, the Technical Committee (made up of partners and stakeholders of the site) and the Scientific Council (involving local researchers).

Fango Valley - The BR is managed by the Parc Naturel Régional de Corse and the Comité d'Aide a la gestion (composed by three municipalities, Office National des Forêts (ONF) and the Association APEEM).

In **Italy** the framework law on protected areas (Law 394/1991) outlines the fundamental principles for the institution and management of protected areas regarding their mission, classification and governance. It also sets out the legislation for national and regional protected natural areas. National Parks and marine areas are under the auspices of the Ministry for Environment, Land and Sea Protection (MATTM). Regional Parks are run by various regional administrations. However, once a park has been created, it is managed by an independent institution as a separate legal entity. The Regions and the autonomous provinces adopt their own legal frameworks for protected areas. These regulations are adopted within the national framework on protected areas. BRs have no specific legal status, some of them are partially or completely overlapping protected areas recognized by national or regional law.

Miramare BR - The Marine Reserve of Miramare was established with a decree of the Ministry of the Environment that has entrusted its management to the Italian

Association WWF ONLUS. In 2006, as part of a reorganization of the management of the protected areas of the WWF Italia, some services of the MPA Miramare were transferred to the company WWF Oasi srl with the authorization of the Ministry for Environment, Land and Sea Protection. The Miramare BR is managed by different actors, which have enforced different management tools: the WWF Italy for both the core area and the marine buffer zone, the Superintendence for the historical and artistic heritage of the Friuli Venezia Giulia Region, in collaboration with the WWF Italy, for the terrestrial buffer zone; the Ministry of Agriculture and Forestry, for the marine transition area; the Friuli Venezia Giulia Region, for the terrestrial transition area.

Po Delta – From the administrative point of view, the BR area is shared between two Italian regions (Veneto and Emilia Romagna) and their respective Regional Natural Parks. The Po Delta Regional Park of Veneto Region (Ente Parco Regionale Veneto del Delta del Po) is acting as coordinator and secretariat of the Reserve and supports the Institutional Coordination Board, the main decision taking body for all the issues regarding its management. This body is composed by institutional authorities which have a fundamental role in BR issues.

Tepilora, Rio Posada and Montalbo – This BR is included into the Regional Park of Tepilora established with Regional Law n. 21 in 2014. The management body is composed by a Permanent Consultative Assembly, the Coordinator (Regional Park and CEAS), the Management Committee, the Scientific Committee and the Participatory Tables for thematic issues.

Selve Costiere di Toscana – The BR is included in the Regional Park of Migliarino, San Rossore, Massacciucoli located in Tuscany Region and is administered by the park authority according to the Regional Law n. 61/11979.

The BRs *Cilento and Vallo di Diano, Tuscan Islands, Somma Vesuvio Miglio d'Oro and Circeo* are part of respective parks, National Park of Cilento, Archipelago Toscano National Park, Vallo di Diano and Alburni, National Vesuvius Park, Circeo National Park and for this reason they have the same GMS. The National Park Authority is the management body supervised by the MATTM. The managing bodies are those established by the framework Law 394/91 (President, Board of Directors, Executive Committee, Board of Auditors and the Community of the Park).

In **Greece -** After a long process of consultation and debate between the competent authorities, the environmental NGOs, the Ministry of Environment and Energy (the main governing body for protected areas in Greece) and citizens, the Greek Parliament voted on 8 February 2018 the Law 4519 "Management Bodies of protected areas and other provisions". This law regulates all issues concerning the organization and operation of the Protected Areas Management Bodies. Following the provisions of Law 4519/2018, the Management Bodies now receive finance from the regular budget of the Ministry of Environment and Energy. This is a new source of income, until 2017 Management Bodies received financing only from co-financed European programs and the Green Fund of Ministry of Environment & Energy [18].

Samaria Gorge - The Forest Directorate of Chania – Department of Forest Protection and Management, and Public Prosecutor and the Management Body of Samaria National Park-Western Crete have the responsibility for the management of the Samaria

National Park which includes the BR. The administrative body of the park is governed by the Board of Directors composed by 7 members and is currently in the process of appointment [18].

5 Prospects of Mediterranean Biosphere Reserves

5.1 Southern and Northern Mediterranean BRs perspectives

The Northern African BRs face the following problems: insufficient public funds designated to PAs, and not specifically to BRs. Management plans are developed for PAs and do not reflect the provisions of the MaB framework. In most cases they are not implemented. Frequent problems also concern conflicts of competences between the responsible management bodies; underqualified staff, scarce involvement of citizens in the decision processes [19].

Nevertheless, the countries have considerable opportunities for a consistent improvement of the performance of the BRs. Algeria shows a strong commitment to develop the BRs through several programs and has established a good coordination among partners involved in the BR management. The IBRM management in Morocco/Spain has a great opportunity to be considered a best practice for transnational BRs. In Egypt the potential of the BRs is very high due to the tourist interest even if the unstable political situation reduced the number of visitors in the last decade.

All countries are supported by international donors (e.g. GEF, World Bank) and Foundations (e.g. MAVA, WWF) with projects focused on conservation and development of the PAs. National strategies and responses to address climate change effects have been prepared in the North African countries. A Climate Change Adaptation Program has been recently started in Morocco with the support of the GIZ, which aims to increase capacities and develop adaptation approaches to afford the risks caused by climate change [9].

In Northern Mediterranean BRs, similarly to Southern ones, most of the Management Plans are grounded mainly on conservation and elaborated primarily for National Parks and not for the BRs, thus ignoring the principles of the MaB strategy. Therefore, the conservation function of the PA is usually well established. Awareness raising, capacity building, education and formation, communication and site promotion is mainly carried out by the Park Management. The Tuscan Island BR can be considered a good example of citizen's involvement through its website and the use of different Social Media. The online tools are permanently updated and the activities of the Biosphere Reserve promoted [20]. The targets to foster sustainable economic and human development and the logistic function to support research, monitoring, environmental education and training are only partially task of the PA Management. The main reasons are the lack of delegation of duties and financial resources, skilled personnel or missing professional competences. In this way the mission of the BRs is often downgraded to the use of an international brand and its prestige and fame as promotional tools.

International programs, especially EU projects offer excellent instruments to implement those operations traditionally not foreseen in the PA management plans (e.g. stakeholder involvement, mitigation and adaptation measures, disaster prevention and reduction, destination and heritage management, economic use of local resources).

Numerous European Projects involve PAs/BRs (e.g. LIFE EBRO-ADMICLIM, ADAPTAMED, LIFE-CLINOMICS, CLIMAPARKS, CHANGE WE CARE, ECOSS etc.) for exploring and testing new ideas needed to face present and future challenges. Such projects offer good opportunities to promote and create visibility for the BR's image and brand through media, education, training, and other dissemination activities. The BRs can be instrumentalized as laboratories to test innovative concepts and processes as well as multilevel governance and management approaches. Hence, long term incentives and follow-up projects could foster a continuous upgrading of BRs as future integrated frameworks for sustainable territorial development.

5.2 Adaptation of BRs Governance and Management to Changing Evidences

The study of the Mediterranean BRs shows a considerable diversity of governance and management strategies and participatory mechanisms. The institutional diversity of the GMS of protected areas, especially Marine and Coastal Protected Areas has already been observed by other investigations [21]. There is no one solution for all the PAs. The adaption of GMS to changing evidences and enhanced efficacy demand might be the key for the success of the conservation and development strategies in the coming decades (Table 2).

The BR Framework offers excellent opportunities to experience new concepts and to learn from models showing how to change, accelerate transformation processes driven by local realities and challenges, and sustained by local population and stakeholders. BRs have the potential to contribute to reduce climate change and biodiversity loss as well as to boost sustainability of socio-economic development through mitigation and adaptation measures included in their management plans. Technological solutions are essential drivers in the transition towards a green economy. Environmentally sound technologies include a variety of cleaner production process and pollution prevention technologies as well as end-of-pipe and monitoring technologies [22].

A study in five Spanish Biosphere Reserves successfully realizing innovative sustainability actions, emphasized the importance of knowledge co-creation among all the actors under the leadership of the BR manager. The study concluded that governance models must adhere to multilevel stakeholder participation and facilitate interactions among the different levels. Science is considered a key driver in knowledge acquisition and structuring, whereas BR managers are fundamental for transition on a local scale when sufficient institutional support, adequate skills, and positive attitudes are existing [23].

The WNBR has furthermore the chance to foster awareness raising and exchange of ideas and experiences worldwide. The Initiative "BiosphereSmart" is a global observatory "based on the idea to maximize the use of new information technologies to build a covenant for a sustainable future and a transition to green societies based on knowledge. It focuses on: sharing knowledge on climate change, green economies, and sustainable development [24].

Table 2. Challenges of Biosphere Reserves related to governance, management and operations.

CHALLENGES	
ISSUES	**SOLUTIONS**
GOVERNANCE	
Good Governance	• Link conservation goals to sustainable development • Promote interactive and inclusive governing mechanisms • Define capacities to direct impact and control • Foresee and prevent conflicts and disasters
Site Management Organization	• Develop a management structure appropriate to the size and scale of the BR • Define responsibilities for the management of environmental, economic, social and cultural issues
Deliberative processes	• Delegate the responsibilities for decisions and actions to the adequate level • Define the decision and participation processes
Funding	• Define regular funding in performance agreements • Participate to EU/international and national projects • Explore opportunities of co-funding e.g. donors, sponsors, ecosystem services
MANAGEMENT	
Partnership	• Establish relationships with relevant bodies through networking and platform creation • Define cooperation mechanisms • Establish public-private partnerships
Public and Stakeholder involvement	• Increase the role of local people in management decisions and day-to-day management of BRs • Develop a feeling of ownership, pride and 'stewardship' among residents
Evidence base	• Establish site knowledge and data base • Assure appropriate priority setting and decisions taking through result based, bottom-up and outside-in mechanisms
Assessment/Monitoring	• Strengthen research and impact assessment efforts • Establish effective monitoring with adequate indicators • use citizen sciences and change mechanisms jointly with academic partners
Human Resources	• Engage professionals with adequate competences • Encourage proper training, equipping, remuneration of managers, staff and rangers in line with required standards
Communication	• Integrate ICT and social media in communication strategies, encouraging rangers and guides to share stories, discoveries, challenges and threats with visitors • Establish online community platforms

OPERATIONS	
Target planning	• Establish foresight and adaptation mechanism • Identify opportunities offered by EU/national programs to cooperate and fund targeted projects
Action Plans	• Action Plans must include detailed recommendations for the implementation (including roles of actors, timing, responsibilities, costs, source of funding) to improve efficiency of BR functions and processes
Innovative tools and technologies	• Adopt new ICT products, services, and innovative marketing tools • Promote the use of new sustainable technologies

BiosphereSmart provides a web-based platform linked to UNESCO-MaB for Biosphere Reserves and similar territories, with the aim of:

- Sharing experience and lessons in using BRs in green economic development;
- Sharing ideas and best practices on issues related to sustainable development and climate change;
- Promoting sustainable urban futures issues within BRs and their surroundings;
- Providing an educational tool with mapping and advanced communication services;
- Empowering sustainable communities to improve their access to information and decision-making capacity;
- Improving information and response capacity for managers and scientific community in BRs;
- Strengthen partnerships within the World Network of BRs (WNBR).

6 Conclusions

Several studies related to PA management effectiveness have been carried out recently, pointing to the increasing importance of GMS. Most of the studies were based on interviews with managers or government representatives who expressed their point of view based on their own perceptions, "addressed" to present good results. Perhaps it would be better to assign assessment tasks to external and independent experts.

As emerged by the survey [8], Protected Areas can really contribute to reduce environmental and anthropogenic negative impacts. The results confirm conclusions of studies emphasizing that governance authorities have to dedicate a strong commitment to establish an inclusive good governance, with strong participation and collaboration, as well as a management with adequate funding and human resource allocation [25]. To improve the efficiency of the operations, it is necessary to foster capacity building for BR managers and staff, increase financial support and tools, enhance cooperation among the different governing and managing bodies, and strengthen public awareness and communication.

The Protected Areas, and consequently the BRs which are part or equivalent to their territory, are generally established and governed by the States (central governments). Only recently, restricted bottom-up approaches are established in some PA. This does not mean that a governance community model is more efficient than a top-down

governance. But the involvement of local people with their know-how and sense of ownership can increase the acceptance of the measures and reduce conflicts. Biosphere Reserves could become ideal places to launch innovative projects towards sustainability and adaptation to changing environment, due to their tasks to co-create knowledge involving all the actors. The leadership of the BR managers is fundamental for processes based on local evidences. It is imperative to foresee incentives and funding for follow-up actions in a long term to launch the transformation towards sustainable territorial development.

Seven principles are key to achieve good governance and management, and responsible leadership: legitimacy, transparency, accountability, inclusiveness, fairness, connectivity and resilience [26]. Only few of them have been found in the BRs analyzed. There is much work to do for reaching an adequate Governance and Management System, and there is not much time for preserving and developing in a sustainable way these areas for the next generations. The authorities should be committed to delegate authority and accountability to the single Biosphere Reserve, enabling them to be prepared and to promptly react in emergencies regarding present and future challenges.

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Response to Climate Change in Coastal and Marine Protected Areas: Threats and Opportunities

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Abstract

Climate change, with its effects, is deeply threatening marine and coastal systems, endangering the correct functioning of their processes and in consequence negatively affecting citizens and communities residing the coastal territories. Their protection can be carried out and consolidated through Marine Protected Areas (MPAs), identified since a long time as an efficient instrument, if appropriately managed, to safeguard the health of ecosystems. The correct implementation of protection measures requires dedicated planning and must answer to a plurality of needs, achieve purposes in a short and long time perspective and involve actively the local communities and the stakeholders. This publication aims to identify constraints and strategies for a sound management of MPAs, with particular focus to coastal areas, in order to develop appropriate adaptation and mitigation measures in contrast to climate change effects.

Keywords: Marine Protected Areas, coastal management, mitigation, adaptation, climate change

1 Present and Future Drivers of Coastal Processes

Coastal and marine environments are complex systems governed by the interplay of geological, biological and meteo-oceanographic processes. For this reason, their evolution is subject to the interactions of biotic and abiotic factors acting over different time scales, from shorter than one day (e.g. in the case of tidal wetlands) up to millennia and even longer (as is the case of large estuaries and lagoons). The rapid modification of key mechanisms of the Earth System as an effect of climate change increased significantly during the industrial era. Consequently, it affects the natural variability of marine and coastal environments, with severe impacts on the ecosystems and their resilience.

A detailed mechanistic description of such impacts requires the comprehension and the capability to predict the dynamics governing the underlying ecological cycles. Due to the degree of complexity and the associated site-specificity, a full characterization of the functioning of the ecological cycles is only possible for single systems, and generalization is usually a tricky exercise. Instead, disentangling the physical and geological drivers of coastal and marine systems, and in some circumstances their feedbacks, is more affordable and provides a crucial element for understanding ongoing processes and planning suitable responses.

1.1 Climate Change Impacts at Global Scale

Climate change related threats to biodiversity and ecosystem quality in marine and coastal environments act over different scales. Global-scale climate related phenomena affecting extensive open sea areas, are mostly related to ocean water temperature (particularly in the upper layers), the alteration of the water column structure, the ocean circulation, the transport of nutrients and oxygen, as well as ocean acidification [1]. In turn, as an interface between land and sea, coastal areas are also subject to a number of

other processes such as relative sea level rise, alteration in the hydrological cycle, meteo-marine climate (particularly on the frequency and intensity of storms) and salt intrusion (Figure 1). All these processes, undergoing long-term trends at a global scale, exhibit local deviations associated with the effects of regional or smaller scale processes. This is particularly evident in coastal systems, where the spatial variability of the physical constraints (e.g. coastal topography and seabed morphology) and the sharp gradients in the hydrodynamic drivers (e.g. onshore wave propagation, freshwater plume dynamics) can lead to a complex pattern of small-scale landscapes and ecological features.

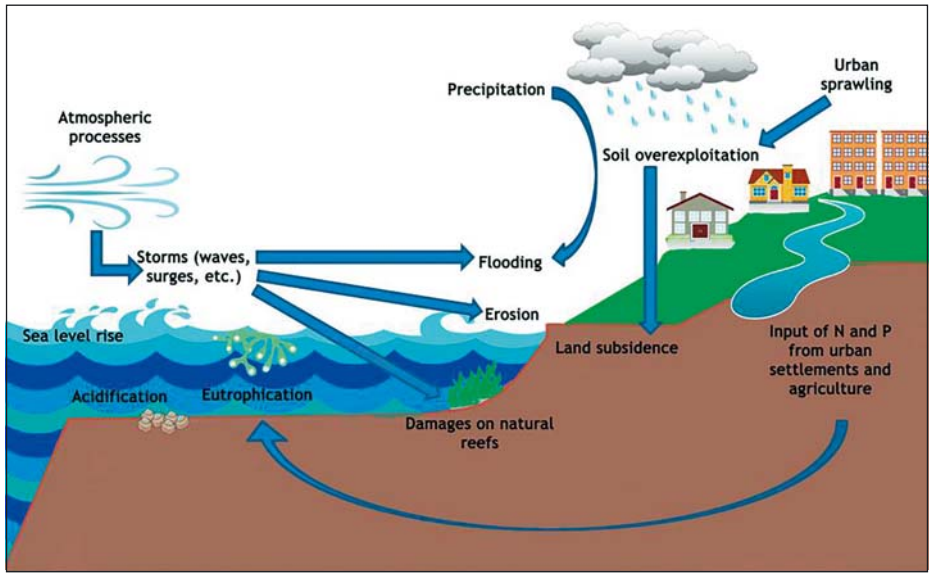

Fig. 1: Interactions between land and sea affecting the coastal system and its factors.

The complexity of marine and coastal systems reflects the multiplicity of impacts directly and indirectly, affecting ecosystem services and human well-being. Besides the global-scale role in climate regulation (through absorption/release and redistribution of heat and Carbon from the atmosphere), a number of interacting biotic and abiotic factors can produce socio-economic implications. For instance, changes in nutrient cycle and transport patterns can alter oxygen distribution, modulating the exposure to anoxia episodes and the environmental suitability for nursery, recruitment, breeding, and migration pathways for many species, with relevant impacts on fishery stocks.

The environment alteration can also produce severe drawbacks on the aesthetic, recreational and tourism services, as well as on the very safety and resilience of coastal areas. A typical example is provided by transitional environments, in which the morphological and habitat structures are the result of delicate interplays among current regimes, sediment supply and sea level rise, with biological communities playing an active role in the maintenance and evolution of the ecosystems. This is in particular the case of salt marshes where halophyte vegetation encroachments, acting as sediment traps, actively contribute in shaping the intertidal zone morphology with impacts on the

current and wave dynamics within the water body, as well as on the overall sediment budget of the system [2]. Due to their peculiar behavior and to the spatially variable conditions established throughout their surface, these eco-morphological features represent a biodiversity spot and a major element of morphological resilience for lagoons, estuaries and deltaic environments. Their possible failure as a consequence of changes in sea level rise, wave or current energy, or sediment supply, can thus lead to irreversible morphological and ecological degradation and to the transition towards a different type of coastal landscape. On open coasts a similar role is played by sea grass meadows, dissipating a significant fraction of the wave energy impacting the shore and at the same time exposed to a number of climatic and non-climatic stress factors, such as overexploitation, physical modification, nutrient and sediment pollution, introduction of alien species, and sea temperature rise. At a global perspective, Waycott et al. report that 58% of the studied sites (215 in total) experienced a decrease of seagrass meadows surface area, 25% increased, while 17% show no detectable change, resulting in a mean decline of 1.5% per year (the observations cover a time period from 1879 to 2006), which accelerated during the last 8 decades [3].

The knowledge of the mechanisms governing marine and coastal ecosystems and the awareness about their exposure to climate-driven changes and their implications for human activities are increasing worldwide. The tendency toward a multi-disciplinary assessment of climate processes and the formulation of sound responses increase accordingly. In some areas, such as the Mediterranean basin, extensive efforts have been undertaken in order to characterize climate change and its effects, made particularly urgent by the anthropic pressure along their coastal zones, the ongoing socio-economic activities in the regions and their importance as a biodiversity hotspot.

1.2 Initiatives to Protect Habitats and Ecosystems

Alongside the analysis of coastal and marine environments and their vulnerability to natural and anthropogenic stress factors, several initiatives have been launched throughout the decades aiming at safeguarding and protecting habitats and ecosystems. Some of them specifically address habitat-forming species. This is, for instance, the case of the “Paris Agreement” (2015), entered in force in 2016 [4], and the “Protocol on Integrated Coastal Zone Management in the Mediterranean” [5], emphasizing the role of productive systems such as seagrass meadows. Among policy-making efforts spent on the identification of suitable instruments for the protection of natural areas, Marine Protected Areas (MPAs) have been identified and progressively consolidated as an efficient instrument suitable for safeguarding of ecosystems health. In general, PAs are defined by the International Union for Conservation of Nature (IUCN) as “*a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation and cultural values”* [6]. In Italy, the overarching legal framework for MPAs is given by Law n° 979 from 1982 and Law n° 394 from 1991, and each MPA is established by a decree of the Ministry for Environment, Land and Sea Protection containing their characteristics and description, with objectives as well as safeguarding and protection rules (e.g. no-take zones, marine reserves, etc.). Their administration is entrusted to public bodies, scientific institutions, recognized environmental associations, even as a consortium. At Mediterranean level, the Barcelona Convention established the List of Specially

Protected Area of Mediterranean Importance (SPAMI) [7], to promote cooperation in the management and conservation of natural areas [8].

Nowadays, several studies have been performed to assess how MPAs can actively mitigate the effects of climate change if proper adaptation and management plans are implemented.

2 Current Practices for Addressing Climate-related Risks in MPAs, Successes and Challenges

Many efforts have been carried out to develop accurate tools aiming at enhancing and supporting the benefits provided by MPAs. Examples are given by no-take zones, aimed to safeguard and protect ecosystems, restock fauna and prevent degradation, and Ecologically or Biologically Significant Areas (EBSAs), crucial for maintaining healthy functions of oceans together with their services. Both these tools are widespread at a global level. In recent decades, the number of protected areas increased alongside with the number of countries (also small countries played an important role in this process) involved in their implementation. As Maestro et al. point out, since 2000 the overall coverage of MPAs has increased by more than 14%, leading to the protection of 7.44% of the world ocean surface (totally 15,334 MPAs covering almost 27 million km^2), and 17.3% of areas are under national jurisdiction [9]. From 2012 the Mediterranean Sea countries have achieved the establishment of 161 marine protected areas, covering the 4.6% of the whole surface of the basin (Fig. 2) [10].

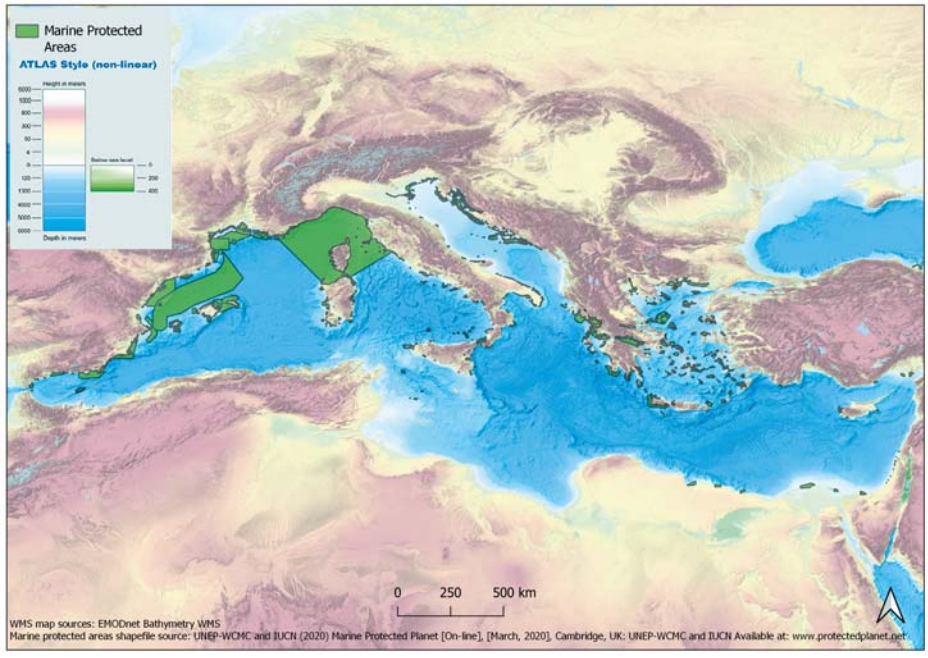

Fig. 2: Map of the Mediterranean Basin elaborated with QGIS [11] representing bathymetry [12] and MPAs established (in green) [13].

2.1 The Millennium Ecosystem Assessment as a Turning Point in the Definition of MPAs

An ideal turning point in the approach to MPAs designation, was defined in the Millennium Ecosystem Assessment (MEA) framework in 2005. MEA is an international initiative and network of scientists developed to identify the status of global ecosystem, evaluate consequences of ecosystem changes on human wellness and provide a scientific base to formulate the necessary actions aimed to conserve and to use ecosystems sustainably [14]. Indeed, prior to the MEA, the main interest in declaring protected areas was to protect biodiversity and fish resources together with the scientific need to increase knowledge about the marine environment, following an ecosystem-based approach. After 2005, the decision making process concerning ecosystem management has been integrated, aiming to amend human wellness and build capacity for scientific assessment, starting to give greater attention to these topics.

Among MPAs declared before 2005 in the Mediterranean, a good example is given by the Natural Park of the Strait (Spain, Strait of Gibraltar). In its declaration document, special emphasis is repeatedly put on concepts such as conservation of ecological processes, landscapes and biodiversity, protection from anthropogenic threats, enhancement of the sustainable use of resources, also taking into consideration socio-economic interests and guaranteeing educational, cultural and scientific services. This park is provided with two management plans that have not been modified so far: the National Resources Management Plan (PORN) and Use and Management Master Plan (PRUG) [9]. Since no reviews have been performed so far, it can be assumed that they do not consider the most recent conservation purposes.

From 2005, many countries showed their interest to explicitly tackle climate change effects through the commitment of the MPAs and their management plans. In the first two decades of the current century climate-related topics became increasingly prominent in National and International Protocols, Conventions and Practices. Still, MPAs declared after 2010 often do not have management plans, or these are only provided as draft versions [9].

2.2 Marine Spatial Planning and Integrated Coastal Zone Management

Among the planning and management processes widespread at a global scale and addressing the multiple uses (energy, industry, government, conservation, and recreation) of ocean and coastal regions, the Marine Spatial Planning (MSP) is one of the most diffused and studied.

MSP is an approach promoted by UNESCO and Intergovernmental Oceanographic Commission (IOC) based on planning and mapping techniques addressing anthropic and natural processes and how cumulative effects impact the seas through ecosystem-based, area-based, integrated, adaptive, strategic and participatory decision making [15]. Although climate change is not directly considered in MSP, some of its major effects such as modification of species distribution and habitats and ocean acidification are actually addressed. The aim is to preserve the value of marine biodiversity by allowing the sustainable use of the economic potential of the oceans. Considering MPAs as one of the possible measures, MSP aims to manage activities within the marine environment, taking into consideration multiple objectives, reduce conflicts and

estimate the cumulative effects and to study how that combination affects the marine environment.

In the face of the temporal and spatial shifts envisaged in marine and coastal systems, the debate on MSP has led to point out the limitations of prescribing rigid geographical boundaries when defining MPAs [16].

The European transposition is defined by the Directive 2014/89/EU [17]. Not all the Mediterranean Countries have applied, ratified, or implemented the MSP yet. In Italy no national plan is in development although it has been transferred from the EU directive into Italian legislation with decree n° 201, in 2016, appointing the Ministry of Infrastructure and Transport for the implementation of a marine spatial plan within 2021 [18].

Focusing on its specific natural and socio-economic dynamics, and possibly within a MSP, Integrated Coastal Zone Management is presently one of the main consolidated tools for a sustainable use of the coastal area. Globally adopted as a decision making process, its application in Europe is regulated since 2002 by the "Recommendation on Integrated Coastal Zone Management" [19].

The Mediterranean basin assumes huge relevance for manifold and sometimes competing uses of its area. Considering the strong pressure factors affecting its coasts, further complicated by the effects of climate change, a sound and integrated management of the coastal zone is a primary concern. To this aim, the "Protocol on Integrated Coastal Zone Management in the Mediterranean" has been signed in 2008 and entered in force in 2011, followed by an "Action Plan for the Implementation of the ICZM Protocol for the Mediterranean (2012-2019)" adopted in 2012 during the 17th Conference of the Parties (COP 17) [20]. This Protocol has the objective to facilitate the sustainable development of coastal zones in harmony with economic, social and cultural development, preserve coastal zones, ensure the sustainable use of resources, ensure the preservation of coastal ecosystem with landscapes and geomorphology, prevent and/or reduce the effects of natural hazards and in particular of climate change and finally achieve initiatives between public and private as well as decisions with public authorities at local, regional and national level affecting the coastal zone [5]. On this basis, the governance tools for the actual implementation of this practice are defined by the countries by issuing dedicated documents.

In Italy, the recommendations contained in the ICZM Protocol are implemented into governance indications by the "National Strategy for the Integrated Management of the Coastal Zones" (*Strategia Nazionale per la Gestione Integrata delle Zone Costiere*). On this ground, collaborations among the Ministry for Environment, Land and Sea Protection, regions and local bodies have been encouraged to undertake a prioritization of plans, programs or guidelines.

Among the priorities, processes are called up to enhance the efficiency of MPAs through the establishment of new ones, also to reinforce the connectivity of the Natura 2000 network. Furthermore, by constituting new ecologic protection zones and thus empowering the strategic role of MPAs, the objective of sustainable development along the coastal zone is easily brought within reach, considering the high vulnerability of these territories in a climate change view.

2.3 MPAs as Tools Addressing Climate Change Impacts: Strengths and Weaknesses

MPA concept is recalled also at a global level, as reported by the Strategic Plan for Biodiversity 2011-2020 together with the Aichi Target. Therefore, protected areas are considered as a regulatory tool to support the sustainable management of marine resources and reach the overall protection of 10% of the whole coastal and marine areas within 2020 [21]. In such a framework of increasingly complex interactions among different subjects and different management levels, a strategy for expanding the reach of the protection policies is the establishment of a network of MPAs. The creation of such a web is capable to enhance the durability of the environmental protection abilities, also against climate change effects. Ecosystem processes, habitat and species are recognized for their role in regulating cycles. In fact, threatening them can lead to the decay of important services, including climate-related ones. For these reasons, MPAs cover the important role of protecting these factors, and they can even lead to recover these processes and facilitate their restoration. Compared to single MPAs, networks of connected MPAs, acting as way and stepping-stones, allow the maintenance of ecosystem services over a longer period, with a consequent enhancement of mitigation and adaptation powers.

If it is not possible to establish a proper network of MPAs, an alternative is given by the establishment of Large Marine Protected Areas (LMPA – 1000s – 10,000 km^2 surface area) and Very Large Marine Protected Areas (VLMPA – surface area larger than 100,000 km^2) 10 . In this way it is possible to merge different national or international strategies and multiply the biological responses due to the high level of synergies that can be created.

PAs although devoted to the conservation of ecosystems and biodiversity, their management, in the face of competing socio-economic instances and changing physical drivers, is an open challenge. For this reason, these institutions are progressively equipping themselves with dedicated management plans pursuing, together with ecological purposes, also economic and cultural objectives. Far from being considerable as ancillary, these aspects can cover a pivotal position, such as the role of tourism in the Great Australian Barrier Reef, Galapagos Islands and Cocos Islands Natural Parks. One of the main problems in defining and implementing management plans is the obsolete notion of PAs with static boundaries, motionless landscape and the maintenance of current values (social, economic, ecologic, and cultural).

Another major hurdle is given by the slowness in implementing these plans due to political and bureaucratic constraints. The number of involved actors, the amount of time and the work required for the decision process increase proportionately, depending on the number of factors that are accounted for in the management plan (hazard factors, targets, procedures etc.).

In addition, compared to their terrestrial counterpart, MPAs generally exhibit a higher complexity both from the physical/ecological and from the management point of view. Hence, specific governance issues are becoming even more complicated when dealing with MPA networks 22 . A typical consequence is that the actual implementation of rigid conservation policies in these systems is not able to keep pace with the ongoing changes, thus significantly diminishing the efficiency of the efforts undertaken.

Therefore, the response to climate change in MPAs needs to be addressed along two main strategic lines. The first one lies in the establishment of an efficient governance structure, capable of a timely reaction to the varying challenges faced by these systems. The second line consists of a thorough assessment of the long-term sustainability of different planning options combined with the identification of possible opportunities deriving from climate change, fostering a managed transition towards new scenarios.

3 Conservation, Adaptation and Governance: from Threats to Opportunities

One of the main topics when dealing with climate change is its dynamic behavior, which cannot be addressed through the implementation of strictly conservative protection strategies. Furthermore, given the continuous intensification of damages to biodiversity and habitats as an effect of climate change, the planning perspective should shift from a short-term vision to a multi-decade horizon. This process will allow to plan suitable strategies for the recovery of endangered and stressed habitats. The adoption and implementation of suitable management plans should reflect the non-static nature of coastal and marine systems and to tackle local needs and integrate them into long-term policies.

3.1 Responses to Climate Change Threats

In this perspective, the response to climate change in MPAs should combine initiatives aiming at reducing the impact of climate change on coastal and marine systems (either by directly increasing their resistance or by reducing the intensity of the stressor) as well as at improving their resilience. This means that the measures can include both mitigation of, and adaptation to, the effects of climate change.

Typical conservation measures, addressing the protection of such ecosystems as seagrass meadows, coral systems, salt marshes, and coastal dunes, exemplify the twofold function of MPAs in favoring the maintenance or recovery of biodiversity and mitigating the impacts of climate change on coastal systems. The effects of this mitigation can take place as local phenomena (sediment trapping and consolidation, wave energy dissipation etc.) or, at a larger scale, as a contribution to carbon sequestration and storage.

Adaptation measures can be put in place as a complement to mitigation in case that outright conservation of an ecosystem or of a landscape feature is not compatible with the rate of evolution of the processes and the environmental and socio-economic constraints. For instance, the protection of a low-lying coastal plain can effectively be achieved by means of a rigid coastal defense to coastal erosion and sea level rise, but this can come at the cost of a significant loss of shallow and intertidal habitats. This concept, typically referred to as “coastal squeeze”, is a particular topic in coastal engineering (more details and references [23]). On the other hand, steering the system through a controlled (as far as a control is possible) evolution toward a more endurable configuration can preserve some of its natural capability to dynamically adjust in response to the external conditions.

An appropriate balance of these two approaches is a necessary condition for a successful management of MPAs in the perspective of climate change challenges. In

any case, no satisfactory result can be achieved without an appropriate governance structure.

3.2 Factors Orienteering to a Management Plan Development

Local bodies, such as municipalities, protected area management authorities and regional institutions are simultaneously the main developers and users of management plans. During the development phase, plans must integrate among their contents 3 governance-approach flows, each considering a different governance level [24]. The top-down flow is based on norms, principles, and policies also from an international level (their connection between local and supranational bodies depends from their decentralization grade). In turn, the bottom-up flow develops by defining territory-based evidence and by developing strategies and objectives of the local community. Finally, the outside-in flow aims to establish a cooperation among promoter bodies and environmental research centers, fundamental in maintaining an adaptive identification of needs and priorities. These must result in an integrated output (social, environmental, economic and cultural), as also encompassed in the ICZM approach to coastal planning, that includes and is included in the development of sustainable strategies, solidly based on up-to-date scientific knowledge.

3.3 The Local Communities: the Main Actors

In order to permit the emergence of the plurality of needs that should reflect into adaptation and mitigation plans, it is fundamental to dedicate particular attention and care to the bottom-up process and consequently in the involvement of the society and of local actors from many sectors, both public and private. This process should adapt to the available resources, taking care of the integration with sector policies as well as coordinate with local initiatives through participative processes. The outcome of the latter strongly needs an efficient communication with citizens, enterprises, and local administrations. A permanent dialogue between scientific community and territory should be fostered through the implementation of tools allowing smooth information flows about environmental processes and related uncertainties, addressing input on societal challenges and priorities also based on the active involvement of stakeholders.

In addition, a significant point in the development of a management plan is the characteristics of stakeholders involved in the process, from a local level to an international one, strictly dependent on the extension, features and connection of the site/s to be protected. Due to their declared aim to protect ecosystems and their resilience capacity, MPAs are programmatically suitable testing grounds for the implementation of holistic management approaches based on mitigation and adaptation to climate change in a multi-decade perspective. In order to facilitate the creation of consensus and the durability of the management strategies, results and outputs should be envisaged over short as well as long time horizons. In the case of MPAs, this could include short-term achievements such as an improved accessibility to some ecosystem services by the end-users as well as a long-term recovery of the ecosystem quality.

Management plans should be established to allow the delivery of outputs consisting of products and implementation tools either, able to accomplish to short and long term achievements. These tools must be supported by scientific results and updates, and should be characterized by a high degree of flexibility. Thanks to this last property,

these plans can define and support the development of policies or procedures that can be applied in similar areas, allowing a constant and efficient exchange of good practices. As a consequence, it is fundamental that the relation among regulations, laws, management plans and action plans does not become a unidirectional flow, but instead implicates a reciprocal update following the aforementioned three-directional governance flows, also in order to cope with the great degree of the mutability of the climate change effects.

3.4 Bureaucratic Slowness in Issuing Management Plans

Besides the variability of climate change-related phenomena (and of their knowledge and awareness), obstacles from programmatic and jurisdictional incongruence can hamper the durability of a management plan, possibly leading to the necessity of revoking a plan in progress aiming to meet new emerging needs. In order to avoid the sharp shift associated with the revocation of a plan and the development of a new one, the flexibility of the management plan should allow the management body to put in place a smooth update of the foreseen adaptation and mitigation measures. Moreover, local population takes on an important role being involved as an active actor in the development phase of the plan, allowing the decision-makers to comprehend the points of strength and weakness of the territory. This process is more and more necessary when speaking of climate change, a theme that is nowadays poorly addressed in these processes, as testified by the literature. In addition to climate issues, many studies highlight that management plans, also called performance plans, are often lacking in valorizing the environmental heritage and protection finalities.

3.5 Decentralized Processes in Dynamic Coastal Systems

Knowing the territory issues and constraints, it is possible to propose appropriate management actions to be implemented by local public bodies and communities. For this reason, to speed up and simplify the procedure, it is important to give more decision autonomy to local bodies, define clearly the roles of each entity acting in the territories, and increase their freedom to implement prompt response measures in case of emergency. This is particularly important in a dynamic system, where the high degree of mutability of an area requires to confer a focused and timely attention to negative impacts. This is the cue where scientific research becomes the keystone to comprehend the effects of impacts. The recently developed framework for sound management of fish stocks by the European Commission is an example of decentralized processes. The Commission formulates new multiannual plans to ensure the sustainable exploitation of fish stocks [25], which are further translated and downscaled in many regions: Western Waters, Western Mediterranean Sea, Adriatic Sea, North Sea, and Baltic Sea.

Local and territorial bodies become the first developers of the action plans and of the activities in their belonging basin, being able to release the appropriate information about biotic and abiotic processes and increase the awareness about the needs of the local communities. The same procedure should be applied to the management of climate change effects.

3.6 Quality and Quantity of Scientific Data Supporting Mitigation and Adaptation Measures against Climate Change Effects

Within a management plan, research and innovation have a crucial role. Indeed, it is necessary to increase the quality and quantity of scientific data supporting sound mitigation and adaptation to climate change effects in coastal zones. This is a priority for the European Union, which has declared how research and innovation connected to climate change are key topics, and that it is appropriate to enhance the effort in programs such as the European Regional Development Fund (ERDF), the European Agricultural Fund for Rural Development (EAFRD) and the Horizon Europe program. This strengthen appears fundamental to pursue the strategic goal to implement MPA's policies in suitable action plans. Furthermore, to this aim the EU has dedicated many resources to reach the low carbon emission targets within 2030. This leads to the integration of new actions against climate change effects in many EU's financing program. Two new funds have been created to move to a low carbon economy (the Innovation Fund and the Modernization Fund), the PF4EE and NCFF instruments are constantly monitored and the LIFE Climate Action subprogram call for proposal for grants are always supported. Moreover, the prevision for the 2021- 2027 period is to integrate actions towards climate in the budget of at least 25% of the EU's expenditure, which is already contributing to the climate objectives [26].

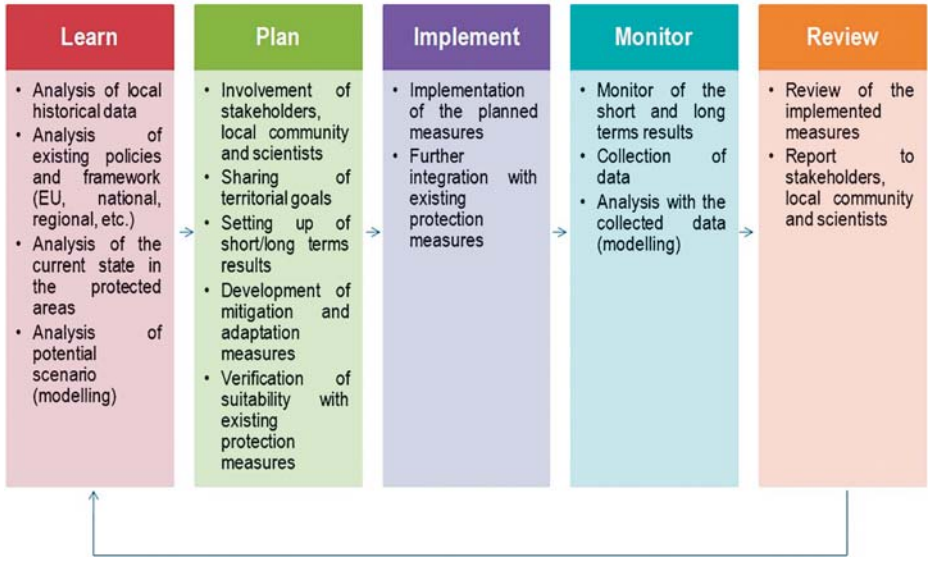

Fig. 3: Steps that must be undertaken to include adaptation and mitigation measures in a management plan.

Efforts toward the definition of new planning paradigms in an international perspective are also supported, among others, by the EU Macroregional Strategy EUSAIR and by the Interreg programs (e.g. ADRION, Italy-Croatia), specifically the CHANGE WE CARE project implemented in the framework of the Interreg V-A – Italy-Croatia Program [27]. This project aims at bridging the gaps among research, administrative

institutions and local communities in the construction of climate change response strategies for endangered coastal and transitional areas. These strategies should be easily exported and interfaced over areas exposed to different climate change impacts and implemented as a proof of concept over five pilot sites located on the Adriatic coast.

In conclusion, it is important to evaluate mitigation and adaptation as own concepts in MPA management, together with conservation targets (Fig. 3). This allows to face effects of climate change with appropriate flexible tools, to give an answer in a short and a long period, and to allow sound management of the risks of coastal zones and connected realities.

In table 1 the equivalent advantages are summarized, taking into consideration these processes while developing a sound management plan.

Table 1: Summary of recommended processes and their advantages

Processes	Advantages
Involvement of the local communities	By involving the local communities with appropriate stakeholders, public and private actors, it is possible to reach a sound knowledge of the territory and develop correct measures.
Achieve short and long time results	Management plans must address both short- and long-term objectives. This will allow to have immediate results of a well-managed protected area (e.g. improvement of ecosystem services) and further outcomes in terms of resistance and resilience to extreme events.
Overcome bureaucratic procedures	This process will allow the smoothest development of plans and permit to apply an efficient update of the measures where necessary.
Decentralize the management system	If this procedure is applied as much as possible, local bodies will be able to apply faster response measures in case of emergency.
Improve the quality and quantity of scientific data	Scientific data are the key to understand the climate change effects, develop and apply suitable measures able to safeguard and protect territories and ecosystems.

4 Concluding remarks

Climate change impacts on marine and coastal systems affect abiotic and biotic factors, with complex feedbacks that can be crucial in controlling the long-term evolution of these environments. This article aims at assessing the potential of MPAs in addressing the negative effects of climate change, as well as identifying the main pitfalls and possible strategies for an effective management by local institutions.

Strictly conservative protection strategies can be limiting and poorly sustainable. A dynamic adaptation to climate change should be evaluated in the perspective of a managed transition toward sustainable protection, capitalizing, where possible, opportunities deriving from the evolving conditions. The response to climate change should consider the implementation of mitigation and adaptation measures, to be tailored on a number of environmental and societal constraints over different scales. The sustainability of a planning approach to MPAs depends from the following factors:

- Political framework: a sound management planning of protected areas needs to explicitly take climate change into account, envisaging a multi-decade horizon. This requires organic and unitary actions, harmonized within the national and international policies and strategies (such as ICZM and MSP), and cannot be left to episodic actions associated with single initiatives (e.g. EU Projects). Incentives should be put in place in order to encourage the participation of institutions at different levels in delivering MPAs benefits, manage socio-ecological needs and protect environmental heritage. Furthermore, clear governance structures should be defined, identifying responsibilities and relationships among the subjects involved in the management and use of MPAs.
- Flexibility: MPA management should be dynamically based on a systematic update of the scientific knowledge and a tight connection with local communities and stakeholders, continuously providing a complete picture of the ongoing environmental processes, of the socio-economic conditions, and of their relationship within an evolving framework. Local institutions, directly facing the territorial processes and challenges, should be appointed with adequate jurisdictional competences in order to maximize the efficiency of their action.
- Transferability: also based on the previous points, governance and management paradigms should be defined in order to facilitate the replication of mitigation and adaptation measures in different environmental and socio-economic conditions. The spreading of common practices and approaches to MPA managements would also enhance the efficiency of these institutions, by creating a suitable normative foundation for the establishment of successful synergies and the creation of MPA networks.

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Management of Invasive Alien Species: Turning Threats into New Opportunities

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Abstract

Invasive Alien Species (IAS) represent a serious and growing threat to biodiversity and, in some cases, to human well-being. It is, therefore, appropriate to adopt preventive and more responsible behavior to reduce the introduction rates, in the most sensitive environments such as protected areas. However, once these species have settled in the new environment, their eradication or elimination becomes particularly difficult and economically expensive. In that framework, the concept of Circular Economy (CE) can offer an opportunity to reconsider IAS as a resource. IAS from something unwanted can be transformed into something advantageous that can be used as new raw materials opening economic possibilities and sustainable development. Examples of the circular economy and bioeconomy are suggested to exploit invasive species sustainably, thus guaranteeing both correct environmental management and socio-economic well-being.

Keywords: Invasive Alien Species; circular economy; bioeconomy, natural resources; sustainability; biodiversity.

1 Introduction

The introduction of species from other regions of the world represents one of the global threats and challenges, alongside with habitat destruction, over-exploitation, climate change, and pollution, to prevent the biodiversity loss, and to reduce changes in ecosystem services [1] [2]. Thousands of species (animals, plants, and microorganisms) are moved annually between and across continents through voluntary activities - such as agriculture, nursery gardening, ornamentation, aquaculture, and scientific research - or involuntary - such as human travel and trade [3]. Species introduced into an environment different from their original area, and through anthropogenic activities, are called aliens (but also non-native, non-indigenous, or neobiota). When the alien species introduced in new ecosystems have negative impacts on the native biological community, they are called invasive alien species (IAS) [4]. If the IAS compete with native ones and alter habitat structures, promoting biodiversity loss and cascading effects or trophic web shifts, they provoke major negative impacts on the ecosystems [5] [6] [7]. Ultimately, IAS can contribute to the eradication of native ones, impoverishing local genetic variability [8]. By virtue of their impacts, which can range from being unnoticed to severe disturbance of the ecosystem ecology, and with a negative influence on socio-economics, the IAS constitutes an important pollution factor.

The depletion of non-renewable resources is a cause of severe ecological and social impacts. Consequently sustainable innovation and efficient use of resources have more

recently received attention as an alternative economic path, able to create and support new services and business models. In order to achieve sustainable development, an approach to overcome the current linear economic system (take-make-dispose) is given by the Circular Economy (CE) [9] [10]. This approach suggests preserving materials available instead of disposing them and so closing the loop. In this way, it is possible to reduce resource use and energy demand [11]. CE is dealing with three challenges: resource scarcity, environmental impact, and economic benefits. In this circular logic, keeping products and materials as long as possible and avoiding the use of new or limited resources, is the main goal. Under such perspective, the bioeconomy has a prominent position in the European future thanks to its innovation potential to deal with global challenges like climate change, decarbonization, or sustainable and regenerative resources.

CE and bioeconomy principles could be seen as an effective and efficient instrument to manage IAS, thus transforming a problem into an opportunity. The rationale is that one object considered useless or even a threat for someone, could be considered an important resource for someone else.

The article will present examples illustrating the CE possibilities and limits applied to the IAS, and highlighting governance and management issues. After an overview of the basic concepts of IAS and CE, some notion of biological biomass waste governance and concrete examples of CE applied to living IAS will be presented. Finally, we discuss some gaps that exist for the IAS governance and management in light of the CE approach.

Table 1. Definition of the basic terms used in this article.

Term	Acronym	Definition
Non-indigenous species	NIS	Taxa introduced outside of their natural range (past or present) and outside of their natural dispersal potential including any part that might survive and subsequently reproduce.
Invasive Alien Species	IAS	Subset of established NIS with potential to spread and with adverse effect on biological diversity, ecosystem functioning, socio-economic values and/or human health in the invaded regions.
Circular Economy	CE	An economic model aimed at the efficient use of resources through waste minimization, long-term value retention, reduction of primary resources, and closed loops of products, product parts, and materials within the boundaries of environmental protection and socio-economic benefits.
Bioeconomy		The production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, bio-based products and bioenergy.
Waste		Any substance or object which the holder discards or intends or is required to discard.

Raw material	Materials in their natural state, used in primary production or manufacturing. They are factors of the market because allow the production of goods.
By-products	Substance or object, resulting from a production process, the primary aim of which is not the production of that item [12].
Biological/sustainable resources	Plant, animal and micro-organism or parts thereof, their genetic material that have actual or potential use or value.

2 Knowledge and Management of Invasive Alien Species

The Mediterranean Sea, even though representing the 0.82% of the world's oceans, is a biodiversity hotspot (more than 8500 species of macroscopic marine organisms should exist) [13], and is at the same time the area hit most severely worldwide by biological invasions (~1000 alien species recorded so far) (Fig.1) [14].

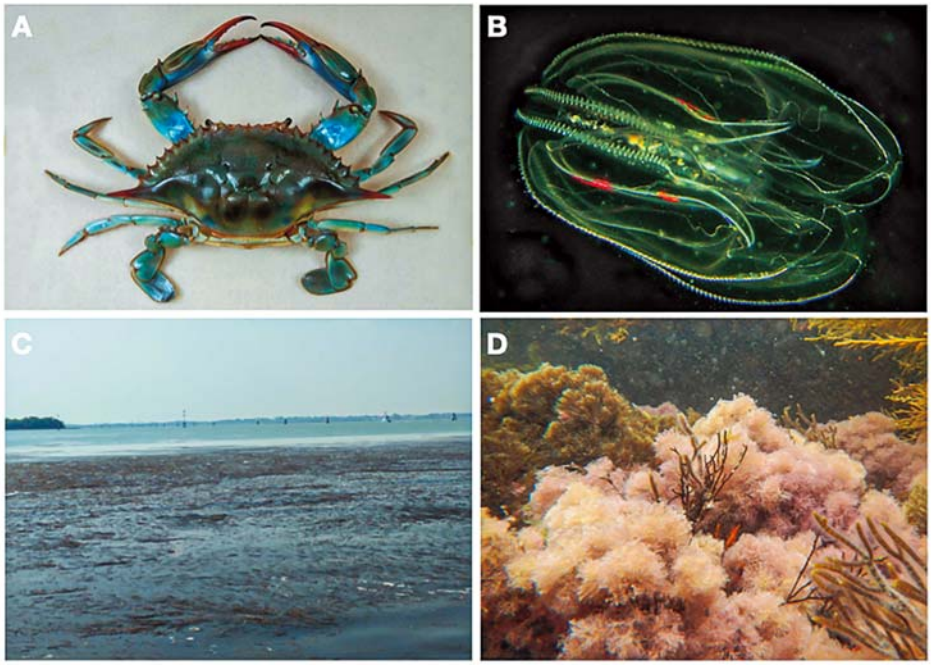

Fig. 1. Invasive alien species: the blue crab *Callinectes sapidus* (A), the comb jelly *Mnemiopsis leidyi* (B) (photo by the web), bloom of the brown alga *Sargassum muticum* (C) and the red alga *Asparagopsis armata* (D) (photo by S. Armeli Minicante).

The main vectors of the introduction of alien species are the Suez Canal, which connects the Red Sea and the Eastern Mediterranean Basin, and the shellfish farming, with the import of products from the North Pacific Ocean, followed by fouling on ship hulls, ballast waters and aquarium trade.

There are several cases of ecosystems and social-economic impacts caused by IASs. In the north-western Mediterranean, for example, the arrival of unappealing plant species,

such as the green alga *Caulerpa taxifolia*, or the red algae *Asparagopsis armata*, *Lophocladia lallemandii* and *Womersleyella setacea*, has profoundly changed the functioning of the ecosystems, reducing the presence of important herbivorous species (as the sea urchin *Paracentrotus lividus* and the teleost *Sarpa salpa*) in favor of detritivorous organisms. The blue crab *Callinectes sapidus*, instead, is a western Atlantic species with high fecundity, strong swimming capacity, aggressive behaviors, and the ability to withstand large variations in salinity and temperature. Further, its ability to attack fish and other crustaceans trapped in fishing nets and to damage fishing gear makes it a harmful species with potential social and economic impact [15] [16]. These traits may have contributed to its inclusion on the list of the 100 worst invasive alien marine species in the Mediterranean [7].

As reported by Otero et al. Marine Protected Areas (MPAs) of the Mediterranean have not escaped this general trend, and the impact at these sites may be even worse than in other parts [17]. These areas preserve key elements of global biological diversity, ensuring the maintenance of essential services for the livelihood of many communities [18]. For instance, the invasion by *Caulerpa racemosa* and *Womersleyella setacea* has been observed to affect the survival rate and growth of juvenile colonies of the gorgonian *Paramuricea clavata* [19] in two MPAs in France (Port-Cros National Park and Scandola Regional Park). These alien filamentous algae may establish an almost monospecific stratum suffocating the underlying communities and reducing species number and diversity in the affected area by trapping sediments. Among the invasive alien crustaceans, *Percnon gibbesi* has spread rapidly in the region and reached several MPAs, changing native communities through alteration of trophic interactions, interference competition, disease transmission or habitat modification [20]. Consuming primarily algae but also other crabs, polychaetes, gastropods, crustaceans and jellyfish, it may affect the structure of benthic communities, particularly algal assemblages, and compete with native species for food and shelter [21]. Occasional sudden blooms, like those of the comb jelly *Mnemiopsis leidyi*, have adversely affected beach tourism in some areas, blocked water intake pipes in ports and other coastal developments, and clogged fishing nets thereby reducing catches [7]. Current numbers of alien fish species established in MPAs are unknown as much of the information gathered relates to coastal areas but not specifically to MPAs. Invasive fish species have produced significant ecological and socio-economic impacts in the invaded environments, causing enormous changes in the native communities of fish and other species. There is the case of Kas-Kekova MPA (Turkey), where two invasive herbivorous fish species from the Red Sea (*Siganus luridus* and *S. rivulatus*) are responsible for grazing pressure that has severely reduced the composition and biomass of algal assemblages, particularly erect and canopy-forming algae, shifting the original habitat to one dominated only by low-lying and turf-forming algae [22].

In Italy, impact studies of IAS are reported for some of the Marine Protected Areas (MPAs) [17], covering a total of about 228 thousand hectares of sea and about 700 kilometers of coastline [23]. Concerning the Transitional Water Systems (TWS), the Venice Lagoon, the lagoons and ponds of the Po Delta, the Mar Piccolo of Taranto and the Cape Peloro lagoon, are other environments particularly affected by the IAS being characterized by extensive anthropogenic impacts, i.e. shellfish farming, shipping, live seafood trade and recreational boating (Fig.2).

MPAs	IAS
1. Isola di Bergeggi	algae - fish
2. Portofino	fish
3. Cinque Terre	algae - fish
4. Secche della Memoria	molluscs
5. Secche di Tor Paterno	-
6. Isole di Ventotene e Santo Stefano	algae - crustaceans
7. Regno di Nettuno	-
8. Punta Campanella	-
9. S. Maria di Castellabate	-
10. Costa degli Infreschie e della Masseta	-
11. Isola dell'Asinara	-
12. Capo Caccia - Isola Piana	-
13. Penisola del Sinis - Isola Mal di Ventre	-
14. Tavolara Punta Coda Cavallo	algae - molluscs - fish
15. Capo Carbonara	algae - crustaceans - fish
16. Ustica	-
17. Capo Gallo - Isola delle Femmine	crustaceans - fish
18. Isole Egadi	algae
19. Isole Pelagie	algae - molluscs - crustaceans - fish
20. Plemmirio	algae - crustaceans - fish
21. Isole dei Ciclopi	-
22. Capo Rizzuto	algae
23. Porto Cesareo	algae - molluscs
24. Torre Guaceto	algae
25. Isole Tremiti	-
26. Torre del Cerrano	-
27. Miramare	algae - molluscs - fish
TWSs	
28. Venice Lagoon	algae - molluscs - crustaceans
29. Po Delta	algae - molluscs - crustaceans - fish
30. Mar Piccolo of Taranto	algae - crustaceans
31. Ganzirri Lake	algae - molluscs

Fig. 2. Marine Protected Areas (MPAs) and Transitional Water Systems (TWSs) in Italy reporting the presence of invasive alien species.

Most countries have little IAS information available and limited or no formal programs to collect information in MPAs. Furthermore, information is in many cases generated by research or monitoring projects with short-term funding (i.e., LIFE+, Interreg projects, Marine Strategy, etc.). The European Alien Species Information Network (EASIN) was launched to serve as a platform for political institutions to facilitate the management on national and global scales, which has to focus primarily on mitigation of existing problems and prevention of any future introductions [21].

Other initiatives include the citizen observatories, reported by the MedPAN network [24], aiming to involve people into collective monitoring of the territory, they contribute to a better appropriation of the territory by users and a better understanding through monitoring and surveillance activities. Long-term studies are needed for understanding the ecology of invasions to evaluate future risks. Rapid assessment methods represent an appropriate monitoring approach for immediate actions like eradication measures before IAS become established and spread, especially in containable areas [25]. Most promising is the combination of methods involving different aspects of invasion analysis, from historic data to species inventories, from taxonomic expertise to genetic studies, and from rapid assessments to models of invasion processes. Therefore, absolute prevention and extensive control of introduction, vectors have a top priority in IAS management. Vectors and pathways have to be constantly controlled and early detection and rapid response need to be essential parts of baseline surveys. Furthermore, in Italy there is not always an official list for the different categories of marine species that may be considered legally binding, whether at the national or regional level, in spite of the commitment being made by the

Marine Strategy Framework Directive (MSFD) and related Italian legislation, by a numerous monitoring projects as well as by control actions implemented [26].

3 Circular Economy Framework

In the last decade, the concept of Circular Economy (CE) has increased its relevance in the current policy, economic debate, and also several research fields [27]. The CE made its appearance with the industrialization, but it has had a revival after the EU adoption of the Circular Economy Package [28]. It claims for important changes in the current design, production, consumption, and use of goods (Fig. 3). Considering that several R-frameworks have evolved from the three Rs: *reduce, reuse, and recycle*, to the four Rs: *reduce, reuse, recycle*, and *recover*, and ultimately, the nine Rs: *refuse, rethink, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle,* and *recover* [29].

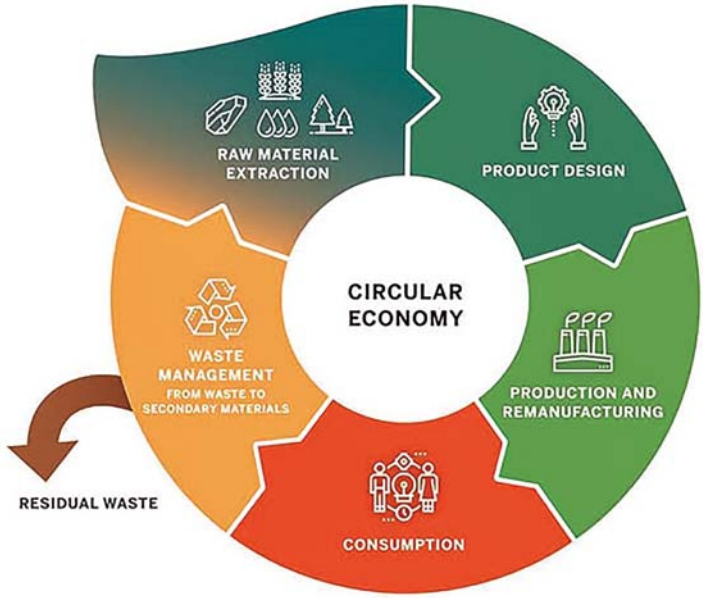

Fig. 3. Circular Economy concept, designed as a process that ensures, from the initial input of resources, to construct and re-construct a material value chain and reduce waste as much as possible. The "waste management" appears at the end of the cycle where object and materials are ready to be recovered and transformed into secondary raw-materials and the cycle starts again. A small quantity of waste is still present, due to the laws of thermodynamics, for which the dissipation of matter and energy at each step are unavoidable (figure: Fondazione Toscana Sostenibile: Closing the loop [30]).

The CE approach, even if essentially defined, is still open, but considered as the more sustainable option for development [31]. Morseletto [32] defines the CE as "an economic model aimed at the efficient use of resources through waste minimization, long-term value retention, reduction of primary resources, and closed loops of products, product parts, and materials within the boundaries of environmental protection and socio-economic benefits". The most known definition given by the Ellen MacArthur

Foundation [10] says that the CE is "an industrial economy that is restorative or regenerative by intention and design". These two definitions underline that CE is an economic model that considers everything as a resource to be used efficiently, minimizing or eliminating waste, promoting the long-term value of products, and considering the environmental protection and socio-economic benefits. In the CE there are no waste products, but only secondary raw materials ready for a new life, just as in nature. From that perspective, the CE approach appears as a positive path able to address synergic environmental and economic challenges.

Achieving circularity implies primarily to work on waste, in the broadest sense (leftover, scraps, discard), aiming to reduce and transform it into secondary raw material, namely substances formerly considered as waste, but which has still an intrinsic value and so the potentiality to become a new type of resource.

In other words, circularity means to reconsider the waste as an innovative resource that must be valorized. This can be applied not only at the level of the urban or manufacture material waste, but also in relation to the natural and biological undesirable elements. An element which reached the end of their life cycle or/and which can be reinterpreted with innovative processes of reuse, and transformed into an opportunity.

Under such new visions, several studies reconsider the management and governance of materials and products or services, experimenting with how to extend their useful life, reusing, transforming, re-manufacturing or recycling them along the value chain from cradle to cradle [33]. It would imply a reduction in the production and consumption of raw materials, and disposal costs, as well as the creation of new jobs.

The "Circularity Gap Report" 2020 shows that from 2015 to 2017 the circularity of the global economy decreased 0.5%, from 9.1% to 8.6% [34]. This means that the consumption of raw materials is high and the end-of-use processing and cycling is low. On average, every person on Earth uses more than 11 tons of materials per year, and just a small part is used for more than one year, 15% are transformed in greenhouse gas and the remaining materials are directly discarded into the environment. Globally one-third of the used materials are treated as waste almost immediately and destined for landfills. In Italy, in the last years, CE movements and applications have been significantly growing. Considering the five elements of circularity (production, consumption, waste management, second raw materials and competitiveness) Italy is the first EU Country in circularity performance [35].

One of the principal segments of the CE is the Bioeconomy, which is defined by the European Commission as "the production of renewable biological resources and the conversion of these resources and waste streams into value-added products, such as food, feed, bio-based products and bioenergy. To be successful, the bioeconomy needs to have sustainability and circularity at its heart. This will drive the renewal of our industries, the modernization of our primary production systems, the protection of the environment and will enhance biodiversity" [36]. The bioeconomy covers all sectors and systems that rely on biological resources – animals, plants, micro-organisms and derived biomass, including organic waste – as well as their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use

biological resources and processes them to produce food, feed, bio-based products, energy and services. In Italy circular bioeconomy accounted in 2017 for a total turnover of EUR 330 billion, around 2 million employees, and marine bioeconomy were estimated for a turnover of about € 45 Billion/y and 835,000 employees [37]. The main activities are fishery and marine aquaculture, the exploitation of marine algae, microbes, enzymes, and byproducts and biowaste of fishery and aquaculture products processing, biomonitoring and bioremediation of marine water/sediment systems. However, until now, no great attention has been paid to IAS and the synergic opportunity to use this resource as raw materials for bioeconomy and at the same time to protect and conserve protected marine areas. Some examples of these opportunities relate to the use of algae as industrial feedstocks. Moreover, through physical, chemical and/or biological processes these materials can be transformed into chemical products and fuel, maybe also covering the request of European critical raw materials.

4 Governance and Legislation of Biomass and Biological Waste Material

One of the main issues about the implementation of the CE principles is the legislation which is paving the way for strategies and actions. In 1975, with the directive 75/442/CEE [38], the European Economic Community starts to define the objective of waste prevention and efficient use of the resources. In Italy such directive will be transposed by the legislative decree 97/22 “legge Ronchi” [39] and then by the legislative decree 2006/152 “Testo Unico Ambientale” [40]. Later in 2008, with the 2008/98/CE “Waste Framework Directive” [41], the European Community provides the foundation for any further discussion about waste and R-frameworks. However, only in the directive 2018/85/EU [42], repealing the 2008/98/CE, the transition towards the Circular Economy is explicitly mentioned. The member states will have to transpose the directive by 5 July 2020.

In Italy, in the last years, a significant increase of CE best practices occurred, as it can be seen in the platform ICESP [43], but the unclear and undefined legislation, transposed just partially, and the governance have created considerable problems. One example of such a problem is given by the article 184ter of the legislative decree 2006/152 named “End Of Waste (EOF)”. The main critical issues of the Italian legislation are the procedures and authorizations required to reuse and transform materials once listed as wastes. Moreover, there are several criticalities and weaknesses about by-products and second raw materials.

The marine biological materials, like seaweed, were introduced into the Italian legislation with the legislative decree 97/22, considering theme among non-hazardous urban waste, and giving precise rules for its disposal. Then, the legislative decree 152/2006 defined that, if a market or a commercial demand exists, this kind of waste ceased to be waste and can be considered as a resource. In Italy, the legislative decree 190/2010 “Marine Strategy Framework Directive” [44], defines broadly the legislation related to the marine environment and its products. It aims to achieve good environmental status for the EU’s marine waters by 2020 and to protect the resources, based upon which marine-related economic and social activities depend. Its goal is to preserve and protect marine biodiversity and find solutions to problems like marine

litter and pollution. In this document, non-indigenous species introduced by human activities are used as one of the eleven descriptors to define the Good Environmental Status (GES) of marine waters. Similarly, the Convention on Biological Diversity [45] has considered IASs as an element to assess the conservation targets. However, no mention is made regarding the opportunity to use or reuse marine biological materials, including IASs, whether they are living or waste biomass, as resources in an economic perspective.

New input is given by the EU with the directive 2015/2283/EU [46] considering the seaweeds as "novel food" that can be traded in the market. However, they were not reflected and included in the Italian Strategic Plan for Aquaculture 2014–2020 [47] nor in the Italian National Triennial Plan for Fisheries and Aquaculture [48]. In these plans, just a few general links are made how to use new technologies to reuse the waste of fisheries. The directives say nothing about "marine biological wastes" or "marine biological materials", leaving open and undefined the possibilities to use IAS as resource of raw materials to foster a sustainable bioeconomy.

Unfortunately, the current legislation (European and National) does not establish the foundation and a clear governance to capitalize and take advantage of the use of marine resources. However, under the CE perspective, and more specifically the bioeconomy, some steps have been made. The potential of the marine resources has been highlighted, especially to decrease the Union's dependence on imported raw materials. Thus, the benefit using IAS as resource would be double, first as a source of raw materials and second to improve the GES of waters (especially in protected areas). The National Smart Specialization Strategy (SNSI) could be one of the possibilities for regions and protected area administrations to use this opportunity. It introduces a radical change, aiming at identifying priorities for investment in research, development and innovation. It opens a strategic and methodological pathway to improve the productive capacity of territories to build advantage and sustainable growth in the medium and long term. Moreover, the Italian bioeconomy strategy defines two strategic plans: agrifood and biobased economy. The two Italian Plans received support (grants and subsidized loans) of 562,7 million Euros, and both consider IAS as resources.

5 IASs as Unused Opportunities under Circular Economy Perspective

A common definition of the term 'invasive' focuses on its negative impact. Despite several attempts to control the spread of marine invaders, until now, all have proven to be elusive, and therefore, alternative strategies should be embraced [5], including the exploitation of their biomass. Hence, numerous marine IAS are great sources of natural products that play an invaluable role in different processes.

Within marine algae, *Undaria pinnatifida*, *Sargassum muticum* and *Asparagopsis armata*, although included in the "100 Worst Invasive Species" list for the Mediterranean [7], they constitute important sources of natural molecules to be used in pharmacological and technological contexts. *Undaria pinnatifida* and *Sargassum muticum* are the two Indo-Pacific brown algae, probably introduced into the Venice Lagoon by aquaculture activities and marine traffic. Both species, reaching a biomass of up to 10–35 kg fresh weight/m^2 during the cold season, have a negative impact on

environment and human activities, due to the long thalli that create shaded areas in the water column below and hinder the navigation of small boats. Further, due to their life cycle and dispersal abilities, these two macroalgal species are impossible to eradicate. However, despite the nuisance, these species could be a relevant resources from an economic point of view. *Sargassum muticum* and *Undaria pinnatifida* are industrially exploited worldwide to extract the phycocolloids, such as alginate, used as thickeners and stabilizers in the food, pharmaceutical and cosmetic industries. Growing attention is also focusing on the nutritional value of these species, due to their abundance of natural vitamins, minerals, and plant-based proteins [49], as well as supplements and additives in animal feed. Pharmaceutical activities, as anti-inflammatory, anti-obesity, anti-cancer and anti-microbial, of natural compounds extracted by *Sargassum muticum* and *Undaria pinnatifida* are reported in numerous reviews, including one from the Venice Lagoon [50] [51]. Lastly, these species find application in the industrial context, as sources of sustainable biomaterials for the tissue engineering [52], biofuel production [53] and renewable energy [54].

The red alga *Asparagopsis* is present in the Mediterranean with two species, *A. taxiformis* and *A. armata*. The biological characteristics of these species are crucial for their invasive success, due to its free-floating capacity, an active propagation via fragmentation and attachment to other floating structures in addition to a greater potential for rapid uptake of nutrients. The species are the best known and studied for their production of secondary metabolites (as brominated compounds, iodinated methanes and acetones) with strong antibacterial and antifungal properties [55]. They are also investigated in the veterinary field for the treatment of Leishmaniasis affecting dogs and humans, especially in southern Italy [56]. Few studies reveal the possibility of *Asparagopsis* to be used as a source of antitumor compounds [5]. In the livestock sector, a great effort is directed to the development of diets on rumen to reduce the production of methane, representing the second contributor to global warming. It has been reported that using *Asparagopsis* extracts in feed, up to 80% reduction in methane emissions can be achieved [57].

The blue crab, *Callinectes sapidus*, is native of the Atlantic Ocean. It inhabits estuaries, lagoons and other coastal habitats, and is characterized by a high fecundity and aggressive behavior. This species shows negative effects on benthic communities and fishing. In the last decade, several investigations have emphasized the high nutritional qualities of Mediterranean blue crab meat. Therefore FAO included the species in the List of Species for Fishery Statistics Purposes (AFSIS). In Italy, *C. sapidus* has not been included in the Italian official list of seafood trade names [46]. However, the ongoing expansion of the blue crab along the Italian coastline offers the possibility to identify successful policies of exploitation and marketing of seafood products whose economic value has already been recognized in the United States. The management and control costs of *C. sapidus* in invaded habitats may ultimately be converted to profits for coastal populations as a future resource for the regional fishery sector [16].

Furthermore, the bio-waste material of *Callinectes sapidus* could be used to obtain chitosan from their exoskeleton, after it has been consumed as food. Chitosan is a biocompatible, biodegradable, nontoxic, antibacterial, antioxidant, and antifungal natural polymer that is obtained from the chitin. It is mostly employed as bio-based

fiber and filament suitable for the production of biodegradable products in the medical, cosmetic, food, and textile industries.

Jellyfish has long been fished for human consumption in South East Asia. The global jellyfish fisheries were estimated to 1 million tons in 2014. Jellyfish are ubiquitous components of pelagic marine ecosystems with rapid population expansion occurring seasonally. In the last decades, jellyfish populations increase in coastal areas on a global scale, with their blooms growing in intensity, frequency and duration. Medusa blooms may affect economic sectors, in particular fishing and aquaculture. It is reported how the profit of the fishing industry is reduced due to delays in fishing processes because the net clogging, rips of fishing nets caused by the excessive weight of jellyfish biomass, and suffocation of desirable species essential to the fishing industry [58]. Last, the jellyfish compete with fish for food, prey on fish eggs and fish larvae. In addition, jellyfish blooms can have serious impacts on coastal tourism and human health [59].

However, in many countries worldwide, jellyfish present nuisance and even occasional catches are being discarded as low value biomaterial. Big blooms could turn into an economic opportunity as valuable resources: recent research suggests methods of turning proteins, carbohydrates and lipids into ethanol alcohol [60], that could be used as fuel for vehicles [61]. Jellyfish were identified as a rising potential as protein source for aquaculture feed. Providing new usages for jellyfish biomasse, it is possible to convert the waste into a resource and, at the same time, diversify fishing with new opportunities of harvesting.

6 Conclusions and Recommendations

Sustainable development and efficient use of resources are the two main challenges to manage and to cope with the uncertainty of our future. Protected areas had traditionally the main objective to protect native species and ecosystems, monitoring the IAS presence and their impacts, and hoping that IASs disappear. Today, a new approach is necessary, able to overcome the static idea of protection and oriented toward a proactive management. That means understand and view the IAS as an opportunity to create business and benefit for territories, but above all to guarantee a new equilibrium between alien and native species.

In this article, limits and opportunities of the Circular Economy have been described. Although there are important deficiencies in legislation and in new technology applications, the CE offers an interesting new approach, able to transform something unwanted like waste in a resource. The managers of protected areas must be enabled to consider these opportunities, facilitate and pave the way to new usage of IAS. In this context, possible actions are:

- review the protected area management plan, in order to be open to experiment and deal with IAS in a proactive way;
- support research and get ready to use and transform the IAS biomass or its derivatives;
- work in synergy with changing territorial realities, to promote and encourage the creation of new supply chains which contribute to socio-economic development as well as to the sustainable management of natural resources.

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Measures to Preserve Coastal and Marine Protected Areas from Marine Litter in the Mediterranean Area

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Abstract

Marine litter poses a growing threat to Marine Protected Areas (MPAs) and their resources due to debris accumulation on beaches, water column and seafloor, impacting their integrity and function. This problem is further exacerbated in the Mediterranean due to its semi-enclosed nature, its densely populated coasts, the passage of 30% of the world's maritime traffic and tourism. A general overview of composition and sources of marine litter was given for Mediterranean MPAs for the different environmental compartments, including the possible peculiarities of MPAs that might increase marine litter impacts. Moreover, methodological standards specifically developed and currently available for monitoring marine litter in MPAs were analyzed, with particular attention to specific constraints and already proposed management measures and their effectiveness. Lastly, governance measures able to effectively manage marine litter within MPAs were proposed to build the governance framework necessary to achieve biodiversity conservation objectives and social and economic development of MPAs.

Keywords: marine litter; marine protected areas; management; Mediterranean Sea.

1 Current Knowledge on Presence and Impact of Marine Litter in the Marine Environment

In recent decades, the presence of anthropogenic debris in the marine environment has been recognized as a global threat and plastic litter is now considered an emerging contaminant of growing importance and concern. Marine litter, defined as *"*any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment*"*, consists of wide range of materials of different sizes, including plastic, glass, metal, paper and cardboard, wood, rubber and fabric. Approximatively 60% to 80% of the world's litter is in form of plastic [1]. This material is made of synthetic and semi-synthetic polymers that persist in the natural environment for over a century. Due to its low production cost, high malleability and high resistance to chemicals, temperature and light, from the middle of the last century plastic material started to be used in several sectors. Plastic production rose considerably passing form 0.5 million tons in 1960 to almost 350 million tons in 2017 [2]. Despite this marked increase in the production and use of plastic items and single-use plastic products worldwide, to date only a minor part of the produced volumes is actually recycled. It was estimated that about 10% of this waste ends up in the oceans and currently represents the most frequently detected and accumulated material in marine environment [3].

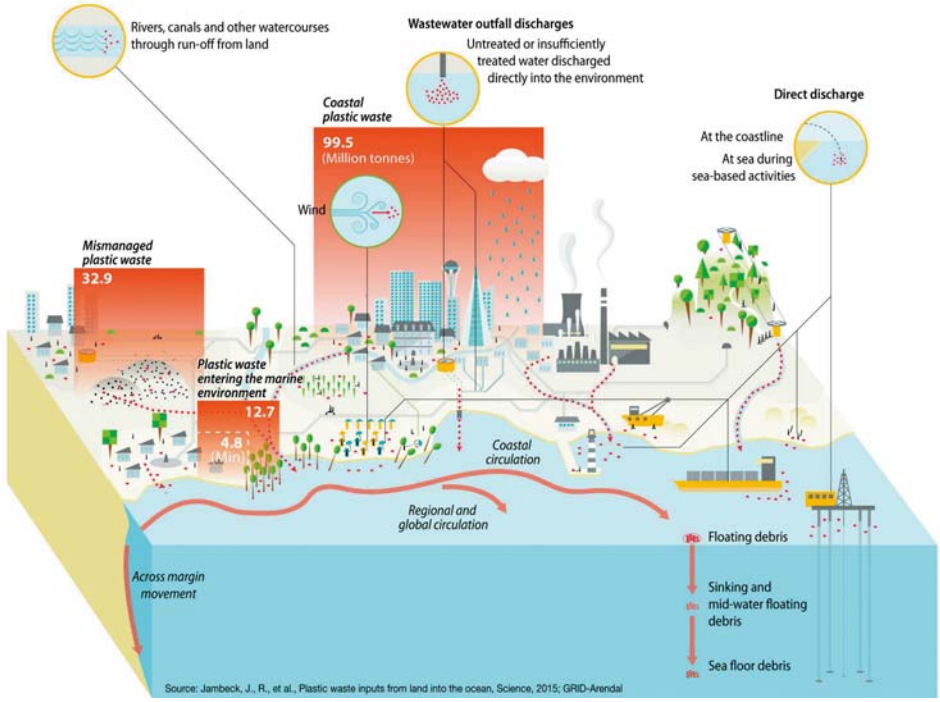

Fig. 1. Pathways and fluxes of plastic litter into the oceans (image provided in the GRID-Arendal resources library by: Maphoto/Riccardo Pravettoni [4].

Litter reaches the sea due to poor waste management systems and to accidental or voluntary release into the environment. The main drivers of litter to the marine environment are land-based sources such as rivers, overflow of sewage systems, unprotected landfills and dumps located near the coast (Fig. 1). The input of litter deriving from land-based activities can be greatly increased as a consequence of extreme weather events such as floods, storm surges or excessive rainfalls. Other sources of marine litter are sea-based activities as litter can be accidentally or deliberately discarded directly at sea from all types of ships (commercial, cruise and fishing boats, pleasure boats, military and research vessels) and offshore installations (e.g. platforms, rigs, aquaculture facilities).

No unaffected areas seem to exist since marine litter has been detected also in remote places, far from obvious sources and human activities, such as the poles [5]. In the marine environment, anthropogenic litter is present in all compartments: sea surface, water column, seafloor, coastline and biota. Floating litter is mainly composed of materials with lower density than sea water, in most cases plastic items made of polyethylene and polypropylene. Their low density makes easier the dispersion by currents and winds, sometimes travelling thousands of kilometers from source areas. Eventually they are washed ashore or sink to the seafloor due to the increase in their density because of the *fouling* of organic matter and/or marine organisms. It is estimated

that for a large proportion of the global marine litter the final accumulation place is the seafloor [6]. Here the degradation rates of most polymers are assumed to be even slower than in surface waters due to the absence of light, low temperature and oxygen concentrations.

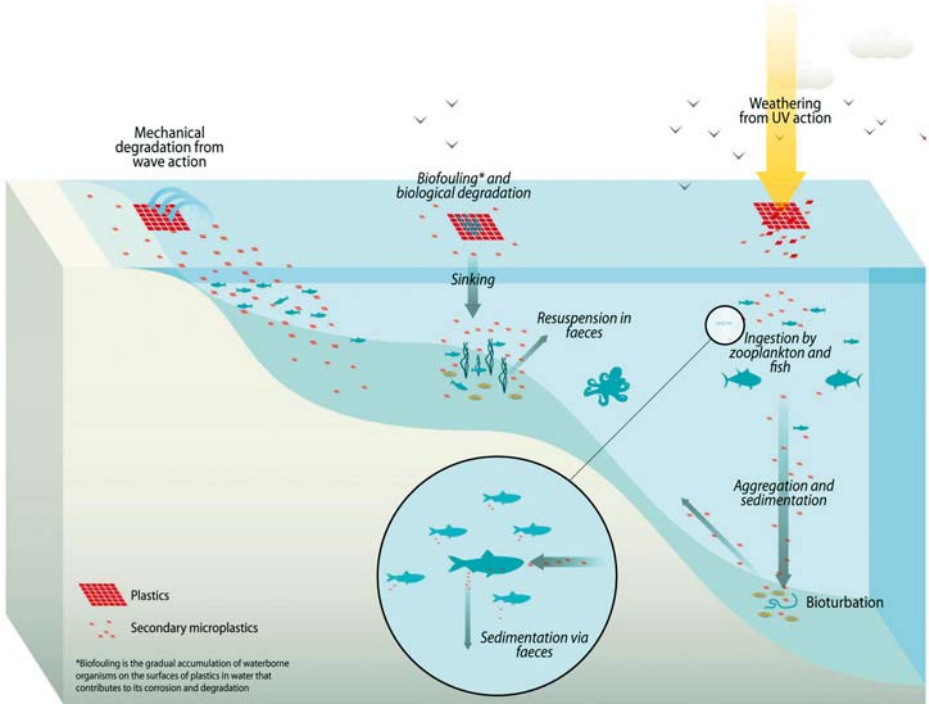

Fig. 2. Processes affecting the distribution and fate of plastics in the marine environment (image provided in the GRID-Arendal resources library by: Maphoto/Riccardo Pravettoni [4].

Litter degradation in marine environment takes place by several physical, chemical and biological processes (Fig. 2). Large plastic items are gradually degraded into smaller pieces mainly due to mechanical breakdown caused by physical phenomena (abrasion with the seabed, wave action), and promoted by photochemical processes activated by UV radiation. Photodegradation is the most efficient degradation process in the marine environment thus is most effective on coasts, especially in equatorial regions, and for floating material [7]. Further plastic degradation by microbial action, i.e. bio-degradation, implies complete breakdown and decomposition into water, carbon dioxide, methane and other non-synthetic molecules.

Abundance of marine litter is linked to sources, intensity of the inputs and to specific hydrological condition of each geographic area. Since marine litter can travel for long distances transported by currents and winds, its final accumulation area could be far from original sources. The most famous example of this phenomenon is represented by the "garbage patches", marine waste accumulation areas formed in correspondence to the main oceanic convergence zones known as oceanic gyres. Five main oceanic convergence zones have been observed: in the North and South Atlantic, in the North

and South Pacific, and in the Indian Ocean and another garbage patch was predicted to occur in the Barents Sea [8] [9]. The gyres are the result of the complex network of currents that determine the circulation of water in the oceans, combined with effects of the wind and the Earth's rotation. Marine litter, transported by ocean currents, tends to accumulate in these slowly rotating surface vortices. The so-called North Pacific garbage patch is the largest floating waste storage area in the world with a density of 334.271 plastic pieces per km^2 [10].

For seafloor marine litter, main accumulation zones are represented by areas of low hydrodynamism such as bays and lagoons, rather than the open sea. They are generally more abundant in coastal areas as a consequence of the river inputs and large-scale residual ocean circulation patterns [11] [12]. However, plastic debris can be found at high concentrations also in deep-sea floors and canyons, which in some cases have been identified as litter hotspots [13] [14] [15].

The accumulation of debris on beaches is particularly influenced by shape and topography of the coast, presence of strong prevalent winds, current and wave pattern and the nature of debris [16]. Globally beach marine litter is mostly of land origin thus coming from recreational activities and riverine input. However, in some cases, concentrations of specific items at local scales may be attributed to specific activities or to proximity to other sources such as areas characterized by offshore installations or intense fishing or shipping activities [17].

New findings rising evidence about impacts on marine animals and ecosystems related to the presence of litter, in particular plastics. Most studied species are marine mammals, seabirds and marine turtles which are affected by entanglement, smothering or ingestion. Ingestion of smaller plastic debris is observed in many other species such as planktivorous fish and several marine invertebrate taxa. Risk associated to plastic ingestion is represented also by the exposure to organic pollutant. Indeed, plastics could contain several chemical compounds, added during their production or adsorbed from the environment, which could be released after ingestion [18] [19]. Drifting colonized litter could act as the vector for non-indigenous and invasive species and could promote biological invasions that are considered a major threat to coastal ecosystems [20].

The Mediterranean Sea houses around 10% of the global coastal population and receives waters from rivers characterized by densely populated drainage basins (e.g., the Nile, Ebro, Rhone, and Po) [21]. It is the most affected area in the world with the highest amounts of municipal solid waste generated annually per person (208–760 kg) [22]. The Mediterranean Sea is strongly influenced by human activities and represents one of the world’s busiest crossroads for maritime navigation [23]. It is a semi-enclosed basin with water residence time of up to a century. Indeed, it is connected to the Atlantic Ocean only by the narrow Strait of Gibraltar and the outflow mainly occurs through a deep water layer [24]. Due to strong anthropic pressure and its peculiar hydrodynamic characteristics, the Mediterranean basin has recently been proposed as the sixth great accumulation zone for marine litter, along with the five ocean gyres. The accumulation of floating plastic in the Mediterranean Sea has been estimated between 1,000 and 3,000 tons per year [25]. Total weight of floating plastic is estimated at 23,150 tons, representing 9% of the global amount [26] [27].

1.1 Marine Litter in Mediterranean MPAs

Many studies and research projects have highlighted that Marine Protected Areas (MPAs) face the challenge of marine litter to one extent or another. Litter can be directly generated inside the areas or coming from diverse origins, including continental as well as sea-based sources. MPAs in the Mediterranean Sea are most often coastal areas, including shallow waters, strongly attractive to tourism and fishery, activities that if not properly managed can cause various environmental issues. These features make MPAs particularly exposed to marine litter directly deriving from these activities, as well as from other sources.

The identification of most abundant items contributing to marine litter is a crucial step to define the potential sources of litter and their possible impacts on marine environment and thus to delineate the require priority actions for the subsequent mitigation processes. Specific curative measures (clean up and removal projects and campaigns) are needed to reduce the abundance of litter items, whereas preventive measures are required to avoid further inputs. Particularly for MPAs, representing a major tool for the conservation of marine ecosystems and biodiversity, these issues have become critical to support specific management and reduction measures.

Various studies have been carried out to monitor and to evaluate the presence of marine litter in Mediterranean MPAs (Table 1). These researches also allowed to define the main sources of marine litter for these areas that, although site-specific, seemed to be more related to sea-based sources. As above mentioned, MPAs are particularly attractive to tourists and fishers, due to their extraordinary natural assets, beautiful landscapes and seascapes, and for their richness in biodiversity. This typically led to an exponential increase of visits by fishers, divers, and pleasure boaters, particularly during the summer season [28].

One example is the Gallinara Island (Tirrenian Sea, Liguria Region), a Regional Natural Reserve (only the terrestrial part of the Island) and Site of Community Importance (SCI IT1316175 ‘Fondali Santa Croce – Gallinara – Capo Lena’), which in recent years has experienced a dramatic alteration of its sea floor due to human pressures. Bianchi et al. [29] highlighted a great increase of anthropogenic litter (including fishing gear) on the sea floor during the monitoring performed in the 2016, which was virtually non-existent during the previous surveys (1991 and 2006). Consequently the authors suggested that local impacts, mostly derived from sea-based sources (the island is uninhabited) such as fishery and tourism, and the lack of a proper management plan could have led to increased abundance in derelict fishing gear and other anthropogenic litter.

Similarly, Melli et al. found high abundances of anthropogenic litter on the biogenic rocky outcrops classified as SCI in the North Adriatic Sea, Veneto Region (IT3250047 ‘Tegnùe of Chioggia’) [30]. In particular, fishery and aquaculture activities were recognized as the dominant sources of debris contributing for 69.4% and 18.9%, respectively, to the overall debris density.

Floating plastic distribution was seasonally assessed in the Menorca Channel MPA (Balearic Islands). Plastic debris was persistent during all sampling periods on the sea surface, but an increase was observed in particle abundances during spring and summer surveys.

Table 1. Average density of litter items recorded in various Mediterranean MPAs in the different marine compartments (i.e. beach, seafloor, sediments and sea surface).

Country	MPA name	items/m^2	Ref.
	Beach litter		
Greece	Thermaikos Gulf Protected Areas -Alyki Kitrous	6.45	[31]
Italy	MPA Pelagie Islands -Cala Palme	1.07	
Italy	MPA Punta Campanella -Tordigliano	1.01	
Italy	MPA Pelagie Islands - Cala Pisana	0.86	
Italy	MPA Miramare - Miramare	0.86	
Italy	MPA Punta Campanella - Marina del Cantone	0.53	
Slovenia	Strunjan Landscape Park - Strunjan	0.32	
Slovenia	Strunjan Landscape Park - Bele Skale	0.32	
Spain	Cabo de Gata-Níjar UNESCO Global geopark - Embarcadero de los Escullos	0.3	
France	Gulf of Lion MPA - Crouste	0.3	
Italy	MPA Secche di Tor Paterno - Capo San Marco	0.27	
Spain	MPA Levante de Mallorca-Cala Ratjada - Cala Mesquida	0.26	
Spain	Cabo de Gata-Níjar Natural Park/UNESCO Global geopark - Torre Garcia	0.2	
Turkey	Gökova Special Environmental Protection Area - Akcapinar	0.16	
Albania	Karaburun-Sazan MPA - Zvernec	0.13	
Greece	Marathon and Schinias National Park - Schinias	0.11	
Greece	Parnon and Moustos Natura 2000 - Cherronisi	0.11	
France	Cote Languedocienne Natura 2000 - Boucanet	0.07	
France	Gulf of Lion MPA - Fourat	0.05	
Greece	Parnon and Moustos Natura 2000 - Kazarba	0.05	
France	Espiguette Natura 2000 - Espiguette	0.05	
Spain	Ebro Delta Nature Park - Serrallo	0.03	
Italy	Pelagos Sanctuary MPA - Cinque Terre	0.52	[32]
Italy	Pelagos Sanctuary MPA - Palmaria island	1.05	
Italy	Pelagos Sanctuary MPA - Lerici beach	0.76	
Italy	Pelagos Sanctuary MPA - San Rossore	1.5	
Italy	Pelagos Sanctuary MPA - Pianosa island	0.68	
	Seafloor litter	**items /100 m^2**	
Italy	Cape Milazzo, identified for a new MPA	3.49	[33]
Italy	Straits of Sicily, Ecologically and Biologically Significant Area	2.13	[34]
Italy	Adriatic Sea System of biogenic rocky outcrops, Site of Community Importance	3.3	[30]
	Sediment litter	**items/kg d.w**	
Croatia	Telaščica bay, Natural Park	268	[35]
Croatia	Grebena MPA	273.3-360	[36]
	Sea surface litter	**items/km^2**	
Spain	Menorca Channel MPA	224’294	[37]
Italy	Pelagos Sanctuary MPA	0.62 items/m^3	[38]

The proximity of the MPA to the coastal areas of Mallorca and Menorca islands, with their strong tourist seasonality along with coastal recreational activity, commercial fishing and an intense maritime traffic caused high anthropic pressures that favor plastic litter entering the coastal waters [37].

Liubartseva et al. performed a study through numerical modelling to identify similarities and site-specific differences related to coastline plastic fluxes in six selected Mediterranean MPAs (i.e. the National Park of ses Salines d'Eivissa i Formentera, Nature Reserve of Bouches de Bonifacio, North-East Malta MPA, Specially Protected Area of Porto Cesareo, SCI of Torre Guaceto and Ethniko Thalassio Parko Alonnisou Voreion Sporadon) [39]. Shipping was identified as a major source of floating plastic debris, contributing 55% to 88% of total plastics. However, the amount of litter inside MPAs from tourism and beach clean-ups were not taken into consideration in the applied model because the authors assumed a relatively perfect waste management into the MPAs.

Marine litter accumulation was also studied in MPA beaches. Giovacchini et al. investigated differently impacted beaches (i.e. urban, urbanized and protected natural beaches) within a coastal macro-area surrounding the Pelagos Sanctuary, an International Protected Area in the NW Mediterranean Sea [32]. An increasing concentration of marine litter was observed from urban (0.64 items/m^2) to urbanized (0.87 items/m^2) and natural beaches (1.50 items/m^2). These results are related to the absence of regular cleaning activities in natural or remote areas (unlike urban beaches). Despite the fact that these beaches are protected from direct inputs (i.e. beachgoers), the areas still receive important quantities of litter from the sea.

Different findings were found by Deidun et al. in their study performed in two sites - Qawra Point and Baħar iċ-Ċagħaq - located along the coast of the North-East MPA of the Maltese Islands (Malta, Comino, Gozo) [40]. The differences found in beach litter amounts in the two locations (i.e. 30 items at Qawra Point vs 578 items at Baħar iċ-Ċagħaq) were mainly related to human activities directly carried out in the areas rather than to differences in the dynamics of coastal currents and in coastal topography. Moreover, the authors identified as main sources of litter land- and sea-based activities related to tourism and aquaculture.

A significant systematic effort to collect data on the amount, distribution, composition and sources of marine litter deposited on the beaches of Mediterranean coastal and marine protected areas was performed in the framework of the Interreg Med ACT4LITTER project [41]. Items varied widely in abundance and types among the surveyed sites. Litter from shoreline sources, such as tourism and recreational activities and poor waste management practices accounted for 27% of all litter collected, while the amount of litter from fisheries and aquaculture was 10%. Moreover, single-use plastic items accounted for 21% of all items collected. The study clearly highlighted that litter sources depend on the specificities of the surveyed beaches and thus targeted and localized measures are needed to address marine litter effectively.

2 Strengths and Weaknesses of Marine Litter Governance and Management in MPAs

2.1 Measures Proposed at Legislative Level

The examples proposed in the above section evidenced as common protocols for monitoring marine litter on beaches, water column and sea-floor already exist and allow to obtain information on sources and possible impacts also in MPAs. In particular, the main legislative framework for monitoring marine litter in the Mediterranean basin, including MPAs, are the EU Marine Strategy Framework Directive (2008/56/EC) and the subsequent Commission Decisions (2010/477/EC and 2017/848/EC) and the Barcelona Convention Ecosystem Approach (Decision IG.20/4) (see Box 1 for details).

Box 1. Main objective for marine litter in the framework of EU Marine Strategy Framework Directive and Barcellona Convention

Marine Strategy Framework Directive

Descriptor 10: ***Properties and quantities of marine litter do not cause harm to the coastal and marine environment***

Criteria according to the Commission Decision (EU) 2017/848
D10C1 — Primary: The composition, amount and spatial distribution of litter on the coastline, in the surface layer of the water column, and on the seabed, are at levels that do not cause harm to the coastal and marine environment.
D10C2 — Primary: The composition, amount and spatial distribution of micro-litter on the coastline, in the surface layer of the water column, and in seabed sediment, are at levels that do not cause harm to the coastal and marine environment.
D10C3 — Secondary: The amount of litter and micro-litter ingested by marine animals is at a level that does not adversely affect the health of the species concerned.
D10C4 — Secondary: The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects.

Barcelona Convention Ecosystem Approach

Objectives according to Decision IG.20/4

Ecological Objective 10: ***Marine and coastal litter does not adversely affect coastal and marine ecosystems.***

Operational Objective 10.1 - The impacts related to properties and quantities of marine litter in the marine and coastal environment are minimized

Indicator 10.1.1 - Trends in the amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source.
Indicator 10.1.2 - Trends in amounts of litter in the water column, including microplastics, and on the seafloor.

Operational Objective 10.2 - Impacts of litter on marine life are controlled to the maximum extent practicable

Indicator 10.2.1 - Trends in the amount of litter ingested by or entangling marine organisms, especially mammals, marine birds and turtles

The main documents that describe the protocols for marine litter monitoring are the UNEP Operational Guidelines for Comprehensive Beach Litter Assessment [42]; the Guidance on Monitoring of Marine Litter in European Seas [43]; the GESAMP recommendations for monitoring marine litter [44].

More recently, a new document has been produced, building on these relevant previous experiences and specifically designed for MPAs: Monitoring and Assessment Guidelines for Marine Litter in Mediterranean MPAs [45]. All the above-mentioned operational guidelines take mainly into consideration marine litter monitoring and assessment. Although some of the proposed guidelines provide also for the collection of marine litter, such as trawling techniques, they generally do not contemplate specific protocols addressed to removal activities that can definitively lead to the restoration of the marine environments.

Most of the proposed protocols may be applied also in MPAs, although some specific features must be taken into account and the guidelines cannot be blindly replicated. Also for MPAs, the main questions related to marine litter are about the sources, abundance, distribution, composition and impacts on the physical environment and on biota, as well as possible economic impacts. However, specific constraints, habitats, sentinel and protected species as well as applicable management measures are not comparable. These issues are crucial to support specific monitoring programs and appropriate reduction and management measures. In this context, Galgani et al. proposed specific common indicators for MPAs: in the framework of D10C1, beach litter can be monitored also during period of intense touristic activities [45]. The authors identified as critical constraints possible accumulation hot spots, specific and local categories of litter, as well as the importance of tourism and / or fishing, which have to be addressed with the help and experience of MPA managers. As for sea floor litter monitoring in MPAs, shallow waters must be considered first as monitoring is cheaper and ongoing monitoring schemes and sampling strategy could be applied. Moreover, regular monitoring of biodiversity by diving can be used to measures seafloor litter. Lastly, MPAs are particular important for their biodiversity values, in this context the D10C3 and D10C4 have to be addressed in sensitive and endangered species, such as sea turtles, seals, cetaceans, etc., which for migration or reproduction reasons (for example sea turtles nesting on specific beaches) are associated with specific MPAs.

2.2 Current Marine Litter Management in MPAs

Management plans for MPAs define clear conservation objectives and strategies and are specifically designed with the aim to protect, recover and qualify the site's ecological system and status. The actions identified in management plans have the purposes to mitigate the effects of the major threats recognized for each site. However, the level of management in Mediterranean MPAs remains weak on several points: Gabrié et al. reported that 75% of Natura 2000 sites still did not have a management body and more than half of the surveyed MPAs did not have a management plan [46]. Moreover, no management plan has yet been established for marine Sites of Community Importance (SCI) [30].

Moreover, the issue of marine debris is rarely addressed by the management plans. If some management plans take into consideration the problem of the litter on the beaches and dune areas, waste at sea and on the seafloor are not considered.

Tempesta and Otero [47] proposed a series of indicators to evaluate the effectiveness of management in Mediterranean Marine Protected Areas, based on previous MPA manager experiences and the streamlining of existing methods. The indicators, divided into two categories (i.e. management effectiveness evaluation indicators and environmental condition rating indicators), took into consideration various threats and impacts that could potentially address MPAs such as fishing pressure, invasive alien species, changes of chemical and physical parameters in the seawater column and also possible effects of climate changes. Hence, no mention is made on the possible presence of litter on beaches or at sea.

However, some management plans that consider the problem of littering and marine debris, especially with regards to beaches and dune, could be found. Here we report some examples of possible measures undertaken at Italian level to address the issue of marine litter in MPA and SCI areas. The management plan of the SCI La Maddalena Archipelago (Sardinia), actually identified among the major threats for dune habitats and beaches the indiscriminate abandonment of waste deriving from the excessive anthropic load during the summer period. The proposed management action consists on the removal of abandoned waste, directly financed by the management body with 30.000 €, but no mention is made regarding the possible presence of litter in the park waters, or possible action for their monitoring, neither for preventive measure to undertake to avoid the problem.

The management plan of the Tavolara Punta Coda Cavallo MPA (Sardinia) for the years 2010/2011 not only provided a clean-up action of MPA seabed, but also promoted raising awareness and environmental education activities for visitors throughout the whole summer period. The clean-up of the seabed was carried out through the participation of divers and boat owners on a voluntary basis, and allowed the retrieval of 40 mooring posts, a dozen pieces of boat fiberglass, 80 mt of plastic pipes, 2 big tyres, several dozen of plastic bottles and various ropes.

In other cases, the cleaning and raising awareness activities are completely delegated to non-profit associations. This is the case of the SCI Tegnue di Chioggia located in the Northern Adriatic Sea. A management plan is not established for this subtidal rocky substrate area that is characterized by high densities of marine litter, in particular fishery and aquaculture waste deriving mainly from the use of the SCI by part of the fishing community as an illegal dumping area for derelict fishing gear [30]. For several years, a non-profit association operating in the area organized the “Clean Seabed" initiative, in collaboration with diver associations and recreational divers that led to the removal of various fishing gear and other litter. This highlighted how the lack of appropriate MPA legislation and inadequate implementation of the existing MPA management can be overcome by local and private initiatives.

3 Adaptation of GMS to preserve MPAs from Marine Litter

A Governance Management System (GMS) to effectively manage the plastic litter has not yet been implemented in the Mediterranean MPAs. Monitoring and sporadic recovering actions have been organized for some MPAs in the last few years, most of which have been performed on a voluntary basis, involving environmental associations and/or environmental research institutes. A deep knowledge of the uses and pressures

specifically acting in each MPA, as well as socio economic aspects and the involvement of stakeholders are considered key elements for the development of management processes and, consequently, the elaboration and/or the revision of the management plans [48]. Human behavior and activities may have a great impact on marine ecosystems. For this reason it is paramount that MPAs conservation objectives are guaranteed through a careful evaluation of drivers and conflicts that need to be addressed to achieve proper conservation goals.

Furthermore, marine litter sources may be distant from the accumulation points as large portion of debris can move along a series of pathways and can be transported to an MPA by ocean currents and wind drift (Fig. 1). Consequently, an adequate GMS should take into account the Source-to-Sea approach (S2S), which includes the whole land area drained by the river basin, connected with aquifers, deltas and estuaries, coastal waters as well as the open sea. Therefore, governance and management measures suitable for MPAs should balance the different management objectives, the priorities of the stakeholders and the institutional agreements existing in all the different geographical sectors of the S2S systems [49].

The Source-to-Sea approach should be used for updating the management plans of Marine Protected Areas through the implementation of a series of actions aimed at providing all the required information on the sources, the amounts and impacts of the litter within the whole Source to Sea continuum and supporting the coordination between different sectors. These are essential prerequisites for the implementation of marine waste prevention initiatives [50].

Finally, effective governance measures need to identify a diversified set of actions that, used in combination, incorporate state, market and people approaches to achieve biodiversity conservation objectives as well as social and economic development of MPAs [51].

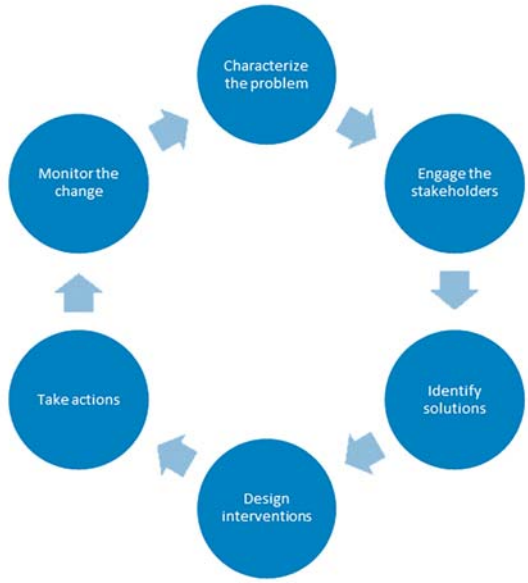

Fig. 3. Scheme of a governance framework for tackling marine litter issue in MPAs.

3.1 Creating a Governance Framework for Marine Litter in Marine Protected Areas

Starting from the S2S approach, the setting up of a proper governance framework for marine litter issues in MPAs encompasses a series of consecutive steps (Fig. 3) [50].

1. Characterize the problem

To assess the present condition, it is necessary to preliminarily define the MPA endangered objectives and who is in charge for their accomplishment. An analysis should be done on the species and/or habitats and/or services potentially affected by marine litter and identify who is in charge of supervising their achievement.

All land–based and sea-based sources of marine litter should be identified and the amount of litter influencing the MPAs quantified. The collaboration of MPAs with Research Institutes is strongly recommended in this phase. This provides opportunities to implement or to share modelling tools able to predict the pathways of distribution and accumulation of marine litters floating on the sea surface, sinking to the bottom and accumulating on the beaches [52] [53].

Specific surveys should be performed to characterize the marine litter on the beaches, in the water column and seabed in terms of typology, sizes and impact (both ecological and economic), paying attention to the geographic locations and the sources of plastics entering the MPAs.

2. Engage the stakeholders

Understanding the sources and the impacts of marine litter will be useful to identify the locations and the stakeholders, which will benefit from the intervention strategies.

All stakeholder categories (primary, targeted, enabling, supporting and external stakeholder) must be engaged within the S2S continuum. To this aim a stakeholder map should be realized, collecting information on all possible actors involved, and classifying them by typology and relevance in relation to the specific issue to be tackled. Afterwards, a participatory process should be designed and organized to discuss with the stakeholders the vision of the MPA. Then strategies can be planned for achieving the goals, including possible measures, tools and actions. The strategies should focus on reducing the presence of litter within the MPA and improving both the protection levels for species and habitats and the ecological/economic valorization for the area. During the participatory process the participants are invited to express their demands, and getting assured that their needs and points of view will be taken into consideration. The final aim is to open a dialogue to define the best strategy and the final decisions based on state, market and people criteria coupled with scientific expertise.

Many traditional methodologies (e.g. meetings, focus groups, world café) and ICT tools (web platforms, social media, etc.) may be used in participatory approaches. Therefore it is important to identify who has to be involved in each specific aspect of the evaluation, and what are the most appropriate participatory techniques [54] [55] [56].

3. Identify solutions

Solutions to manage the plastic pollution require a mixture of regulation, economic/market and community/people-based efforts. Moreover, they may range from local community initiatives to global actions [57].

For the marine Mediterranean area the main Regulatory Directives are: the "Convention for the Protection of the Marine Environment and Coastal Region of the Mediterranean", the "Regional Plan on Marine Litter Management" adopted in the context of the Barcelona Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean", and the "Marine Strategy Framework Directive (MSFD)". More recently, the EU Circular Economy Package and the Plastics Strategy set measures against single use plastics and fishing gear, restrictions related to the use of microplastics in products as well as measures to reduce marine litter from ships, including fishing vessels and recreational craft.

However, legal frameworks have often encountered difficulties in implementing sustainable and conservation measures. This highlights how these regulatory measures are not sufficient to induce real changes of habits suitable to effectively stop or at least reduce marine plastic pollution. For this reason, also market-based and people-based incentives should be considered to obtain fruitful results. People-based actions may include all those initiatives aimed at reducing the amount of plastic entering the S2S system, to increase the recycling and reusing of plastics, and improving people awareness on the impacts and the drivers of marine plastic pollution. Market – based actions include all the initiatives aimed at reducing the consumer's demand of plastic or supporting new ways to reuse or recycle the plastic [58].

The governance of MPAs has to ensure that sufficient services are provided to reduce both, internally and externally the source of litter leakage to the greatest extent possible. To this aim, the MPAs need to be properly equipped with skills, infrastructure, financing, and institutional capacities. For these reasons, all relevant stakeholders such as scientists, public administrators, stakeholder advisory groups, non-governmental organizations (NGOs), policy advisors, waste companies, and private sector should interact through a fruitful participation process to clearly define responsibilities and duties.

4. Design interventions

At each level of the governance system, the interventions able to induce changes, should be identified. At individual level, behavioral changes may be helpful to reduce the amount of litter produced every day, whereas at local level a better management of waste or organization of clean up campaigns may be useful to improve environmental conditions of river basins and marine coastal areas. New technological solutions in the field of recycling processes may be of interest to explore the feasibility of new production chains.

The interventions' feasibility should be evaluated on the basis of a cost/benefit and or cost/efficacy analyses, considering that some interventions may be based on voluntary commitments. Depending on priorities and selected interventions, different stakeholders should be involved to actively collaborate on the required solutions.

5. Take actions

To achieve the long-term improving results for biodiversity, habitat conservation and marine ecosystem services through the reduction of plastic entering in the MPAs, a suite of interventions must be established to obtain behavior changes with consequent measurable changes in the whole S2S system (Table 2). In this context, monitoring activities should be performed taking into consideration common protocols, criteria and indicators defined by EU Directives and Mediterranean Conventions. They have to be periodically planned in order to evaluate the amount of litter impacting the MPAs, ensuring the creation of long-term database and information series. Moreover, the use of new approaches and monitoring methods, such as drones, wave gliders and other Underwater Autonomous Vehicles (UAVs) for marine litter data collection should be promoted [45] [59]. Also clean-up operations have to follow appropriate procedures aimed to guarantee the eco-sustainability of the interventions and the safety of the operators, especially for those intervention performed on the seabed. Adequate and purpose-effective information should be supplied to the team of technicians entrusted with removal activities. Functionally relevant information for removal activities is, necessary to properly evaluate the extension of the impacted area and its environmental conditions [60].

All the recovered material need to be properly managed by enforcing the disposal collection points and exploring the possibility to be used within recycling processes aimed at fulfilling circular economy principles.

Great efforts must be made in producing informative materials, organizing events aimed at increasing awareness, strengthening collaboration and promoting the transfer of the outcomes and of the lessons learnt.

All proposed actions does not need for new regulations, except those addressed to setting up some recycling processes, but required specific funding to be periodically performed.

6. Monitor the change

The monitoring of the outcomes will be important for the implementation of an adaptive management approach, which could require changes of the intervention strategies during time. To this aim, a suite of indicators may be useful to monitor the process outcomes and for periodic revisions of the MPA management plan, and to address the evolving environmental/economic and social conditions. According to the S2S approach, these indicators may be divided into four groups [49]:

- Process - measuring successful establishment of stakeholder involvement and cooperation
- Stress reduction - quantifying the changes in behavior and practices to reduce marine litter
- Environmental status – measuring the reduction of litter in different environmental compartments
- Impact - measuring the improvements of the system in a long-term perspective taking into account economic and health factors

Table 2. Recommended actions to be included in MPAs management plans

Action	Aim	Frequency	Need for financing	Need for new regulation	Stakeholders to be involved
Organization of marine litter surveys	Monitor the presence of marine litter in different environmental compartment of MPAs. Clearly defined baselines and targets	Annual	Yes	No	Research Institutes, Diving centers, Environmental Associations, Citizens
Organization of removing operations and proper disposal of collected materials	Remove the litter from different environmental compartment of the MPAs	Annual	Yes	No	Research Institutes, Local Authorities, Coastal Guards, Diving centers, Environmental Associations, Waste companies, Citizens
Enforcement of disposal collection points for civil and fishing related materials wastes (number and periodicity of collection)	Setting up of proper management of waste material	-	Yes	No	Local Authorities Waste companies, Fishermen associations.
Setting up of mechanical and/or chemical recycling process using marine litter	Transform waste material into a resource, implement new productive chains Support the coordination between marine conservation and maritime socio-economic sectors	-	Yes	Yes	Industry, waste management company, Waste Consortia, University and Research Industry, Local Administrators, National Government

Organization of seminars, events for general public	Increase awareness on marine litter issue Support local authorities, and communities with tools to monitor and manage marine litter	Quarterly	No	No	Citizens, Students, Teachers, NGOs
Realization of informative materials and tools, updating of websites and social networks	Increase awareness on marine litter issue. Support local authorities, and communities with tools to monitor and manage marine litter	-	Yes	No	Environmental Association, NGOs, Media, Citizen, Local Authorities
Participation in projects addressing sea-based and land -based sources of marine litter	Strengthen the collaboration with other sectors	-	No	No	Universities, Research Institutes, Local Authorities, NGOs, Environmental Association, Fishery Association, Industry
Transfer the outcomes on existing Mediterranean wide knowledge platforms or database on marine litter (MedBioLitter database; Safety4Sea Portal)	Promote accessibility to available resources, the transferability of tools and solutions	-	No	No	Universities, Research Institutes, MPAs

4 Concluding Remarks

Although marine litter is a growing issue also for MPAs, appropriate and effective Governance Management Systems are still lacking in most of the Mediterranean areas. Despite the international, regional and national strategies and regulations to tackle marine litter, less specific measures have been implemented up to now for MPAs.

The MPAs management plans should therefore include a specific part regarding the GMS to implement actions to effectively address the threat posed by marine litter within the whole Source to Sea continuum. The GMS should reflect a road map shared by MPA management bodies with the local stakeholders, having the biodiversity conservation objectives as well as the social and economic development of MPAs as its final aims.

GMS should encompass a series of consecutive actions aimed at characterizing the problem, engaging the stakeholders, identifying solutions, designing interventions, taking actions and monitoring the change. For each intervention, a specific budget must be allocated and the funders identified, encouraging sustainable actions in accordance with the principles of the circular economy.

Finally, a GMS should be adaptive, i.e. easy to modify if the starting conditions change. For this reason, the implementation of monitoring actions and the evaluation of indicators could be useful to address the evolving environmental/economic and social conditions not only of the MPAs but in the overall region as part of ecosystem-based management.

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Macro and Microplastics Pollution in the World Heritage Site of Venice at Glance and Prospects for Remediation

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Abstract

Marine litter in coastal areas has become a multifaceted issue due to the heterogeneity in size and items, source and fate, including the unsettled issues of its removal and treatment. The matter is even more complicated when it relates to heritage sites of Outstanding Universal Value, such as the UNESCO World Heritage property "Venice and its Lagoon". As victim of its international status, Venice has been hosting mass and low-quality tourism along with the abundant load of waste partially tipped on the ground and into the sea. Here heterogeneous contributions find a common umbrella: researchers and practitioners' survey outcomes on stranded and floating macro marine litter come along with those of chemists detecting plastic derived molecular pollutants in the surface water. The testing of new approaches and solutions brought by the EU in removing, segregating, and valorising marine litter and plastics bonds the gap between the monitoring and remediation phases. The article inspires further in field investigations, which will contribute to combine unprecedented insights with hopefully more robust and coordinated prevention and remediation measures from the authorities responsible for the site management.

Keywords: Marine Litter, plastics pollution monitoring and removal, World Heritage, Venice and its Lagoon, low thermal pyrolysis, mass tourism.

1 Introduction

Marine litter (ML) is getting higher on scientific and political agendas and of increasing concern for European authorities and citizens. Its full recycling is still limited, and its removal is still in its infancy stage of conception and operationalisation. The implications for countries and, in particular, for local coastal communities struggling to cope with climate change effects, over-tourism, and unceasing tides of plastics and ML are only now assessed, and their impacts partially understood in the human and marine life alike. The article encompasses the multifaceted dimension of ML and the iconic settings of the World Heritage Site (WHS) "Venice and its Lagoon" in a pre-COVID-19 environment. Contributions from multidisciplinary teams of scholars and practitioners reveal unprecedented insights both in terms of monitoring and remediation measures. It touches aspects such as the assessment of floating macro litter by the use of European scientific, standardised protocols, further classification, and quantitative

evaluation of stranded macro litter along with plastics derived microcontaminants in the Grand Canal through Solid Phase Micro Extraction-Gas Chromatography-Mass Spectrometry (SPME-GC-MS) analysis. In terms of remediation, pioneering work is on the way, thanks to the innovation brought about by the European Union (EU) [1]. New projects are to test an innovative automated system to cope with the ML legacy in the seabed of the Lagoon, to test self-sustaining and de-polluting "marine litter to marine fuel" cycle as well as involving local stakeholders and tourists for increased awareness on the matter. Lessons learnt may hopefully prove sustainable in the long run and inspirational to produce a shift in ML and plastics management in coastal areas, especially in Marine Protected Areas and UNESCO designated sites.

2 Framing the Problem

The North Adriatic Sea and the Venice coastal area are well renowned for both the richness and fragility of their natural and cultural settings and ecosystems. In proof of this, Venice and its Lagoon, with more than 50.000 hectares as the largest wetlands in Italy, is a World Heritage property since 1987, approved on six criteria of Outstanding Universal Value of the World Heritage Convention and its current operational guidelines [2]. A minor part of the Venice wetlands is also included in the official Ramsar List under the appellate "Laguna di Venezia: Valle Averto" since 1989. It covers 500 hectares and includes the WWF "Oasis" of Valle dell'Averto.

The state of conservation of Venice and its Lagoon is affected by several long-debated criticalities related to a potent mix of natural and human-induced factors. Enquiries, reporting works, reactive monitoring missions on the state of conservation of the property have intensively involved the UNESCO World Heritage Committee, the State party, along with the local management authorities [3]. The issues at stake are many and prominent: inadequate planning tools, massive touristification with depopulation of residents, loss of local shops, high rents, widespread aerial and marine pollution, large infrastructures and motorboat traffic impacts, along with gigantic cruise ships crossing the city centre and oil tankers passing the Lagoon and its immediate settings. Governance complexities in coordination with overlapping and blurring jurisdictions for the management on the above-mentioned issues, including the grand challenge of climate change and severe weather events stalking Venice and its Lagoon with soaring impacts, have recurrently been mentioned in international media and newspapers.

Although new measures have been deployed, Venice and its Lagoon, along with the whole Adriatic and Mediterranean Sea have to cope with a new issue on the rise: marine litter and in particular plastics pollution. Venice has several factors playing a part in plastics pollution due to its unique features, in terms of morphological setting and density of both residents (decreasing in numbers) and transient population (increasing). As to the former, the distinct geography of the Venice Lagoon contributes to amplify the magnitude of the issue. Ten rivers flow into the Lagoon bringing in the plastic litter along their path.

In turn, there are only three main inlets to the Adriatic Sea, trapping much of the ML within the Lagoon wetlands. Both natural and human-made marshes, sandy banks and bars are present along most of the coastlines, covering much of the Lagoon's northern region. These become additional plastic traps and retainers that, in combination with

the lack of any regular ML removal activities, the course of tides and the strength of the prevalent winds produce an ever-increasing accumulation of plastics. From a more urban and population perspective, Venice has many narrow streets running adjacent to a system of canals engorged with people and traffic. Their proximity to the marine ecosystem makes it easy for general litter and plastics to get in and spread. Although only about 53.000 residents lived in the historical centre in 2018, the mainland has a dense population that consists of 270.000 citizens, partially commuting every day to work into the historic centre [4] .

The ever-increasing numbers of tourists represent the largest size of the transient population. Before the temporary break of COVID-19 and upon latest official data from the year 2017 [5], the metropolitan city of Venice recorded the presence of 37.042.454 tourists. It represented an increase of 8.1 % compared to the previous year, against an estimated maximum carrying capacity of 20 million tourists per year, abiding by the European safety standards [6]. Venice is, therefore, one of the most debated and iconic examples of overtourism in the coastal areas (where 80 % of worldwide tourism takes place) of the Mediterranean Sea and where ML increases by up to 40 % during peak tourist season.

The abandonment of a wide array of single-use plastic items and other litter across the city is self-evident. Trash bins are too few and overloaded with subsequent dispersal of the same litter on the surrounding waters, nourishing a relentless spill over that goes to feed marine plastics pollution. In addition to this, there are problems connected to the presence of synantropic species in the city that are used to live in close contact with men taking advantage of food sources resulting from human activities. A classic example, the yellow-legged gulls, *Larus michahelli*, have dramatically increased in the last decade in the historic centre of Venice [7]. They use to break garbage bags dropped by residents and tourists on the street, to rummage in trash bins and feast on leftovers (F. Coccon, personal observation, Fig. 1 and 2). This causes waste spreading both on the ground and in the city's canals impacting on the overall lagoon ecosystem. To counter such a problem the public waste management company of Venice (Veritas Spa), responsible for the waste collection and management in the province of Venice, has established a new method for urban waste collection in the old town. The new system consists of door to door garbage collection from private households and commercial premises, approximately between 8.00 and 12.00 a.m. Garbage self-disposal is also available at the temporary and movable waste stations located on boats moored in specific areas of the city within a given time schedule between 6.30 and 8.30 a.m. Such a peculiar waste management system, has prevented most of the accumulation of rubbish in the streets, and therefore limited the amount of trophic resources available for the yellow-legged gulls.

Although the work of Coccon and Fano [6] has highlighted that the new urban solid waste collection regime has significantly decreased the presence of waste on the street, the plastics pollution in the city's canals and thus in the lagoon ecosystem is far from resolved. Encountered plastics are of polymers of a wide variety that, under the constant exposure to mechanical and photodegradation stressors, are cracked and scattered into the environment by decreasing their size from a macro to a micro level. Therefore, Venice has built a strong pollution legacy that requires reckoning, further assessment and tangible actions in terms of suitable prevention and mitigation measures.

Fig. 1 and 2. Yellow-legged gull drumming in a bin in search for walking waste leftover; attempting to break open a garbage bag illegally abandoned in the street (Photos: F.Coccon).

Non-governmental organisations are increasingly putting efforts in the attempt to mobilise citizens, tourists, and scientific and educational institutes into three-fold directions: (i) connecting other organisations along with single individuals to operate large scale clean-ups in the city of Venice and its Lagoon. These include nearby minor islands and mainland towns and cities in cooperation with litter management authorities and the local administration; (ii) promoting public debates for the popularisation of plastics pollution-related issues, through the contribution of epistemic communities and the discussion with different stakeholders, in particular with the hotelier's sector, raising awareness and encouraging the uptake of individual and collective good practices; (iii) launching of independent and scientifically sound environmental monitoring initiatives, set out during the clean-ups (although not exclusively) for macroplastics and with the sampling of waters for micro contaminants detection. Derived data are then systematically recorded and analysed for further dissemination and public sharing. The above is in cooperation with research institutes and centres, students' groups at the national and international levels.

A popular activity nowadays, clean-ups mushroomed in Venice in the pre COVID-19 time to the point of creating congestion with multiple and fragmented events overlapping in several cases. In the attempt to maximise individual visibility, several NGOs and grassroots organisations ended up marginalising, lowering the impact that a more coordinated and participatory approach would otherwise deliver.

For this reason, informal aggregation and centralised coordination efforts have been attempted to arrange joint and larger scales clean-up at a yearly basis, inspired by an inclusive and participatory approach with mixed fortunes. These efforts have been undertaken locally by historical environmental organisations such as Legambiente and Fareverde, along with the local NGO Venice Lagoon Plastic Free (VLPF). This valuable territorial experience requires to be strengthened in the future by other relevant pieces of territories, their organisations, and target segments of our societies. This exercise underpins the involvement of different national communities and religious minorities, along with conscientious tourists in a context of international and cross-generational representation.


Fig. 3 and 4: Volunteers from the Islamic community and tourists engaged in the collection of floating and stranded marine litter and plastics in the Venice lagoon (Photos: VLPF).

Scholars and scientists often remind us of the fact that clean-ups are not nearly enough to tackle ML and the plastics pollution scourges. However, as practitioners, we assert that there is a full set of silver linings in clean-up actions: clean-ups generate a spillover effect by providing higher environmental awareness, empathising with nature, and hopefully engaging larger segments of our society in more ecological behaviours. It is intimately rewarding retrieving ML and in doing so, preventing microplastics and micro contaminants generation and embedment in marine fauna via the food chain. By collecting and removing such material, we also feed a circular economy process and contribute to restoring the aesthetic value and charm of our landscapes.

3 Sampling Floating Marine Litter in the Historical Town of Venice

The national-based non-governmental organisation Legambiente has long supported the organisation of clean-up with a science-based approach in terms of data gathered and citizen's involvement throughout Italy. With its branch in Venice, Legambiente has provided insightful data in surveying macroplastics floating on the channels of Venice and those stranded on its coastal areas. In 2015 the Venice Legambiente organised a campaign to monitor the density and typology of the floating litter among the canals of the historic city centre of Venice. The campaign was biennial, cross-seasonal, and undertaken with European scientific, standardised protocols, created in collaboration with ISPRA (Italian Institute for Environmental Protection and Research) within the framework of the IPA-Adriatic European Project named DeFishGear [8] [9].

The campaign involved 100 local volunteers and several ISPRA researchers, monitoring 39,95 km of channels of the old town of Venice and surrounding minor islands (i.e. Certosa Island) (Figure 5). Three small boats were used for the task of floating ML and macroplastics assessment and removal up to a distance of 2,5 m from each side of the itinerary. The removed litter was surveyed according to its material, size and origin, in the attempt to detect the source of pollution. Overall, an approximate total 0,2 km^2 of water surface area was monitored. The first monitoring campaigns, conducted in June and December 2015 were followed by another one in 2016 using the

same methodology (Table 1). The latter was limited to summertime and data of floating litter were georeferenced.

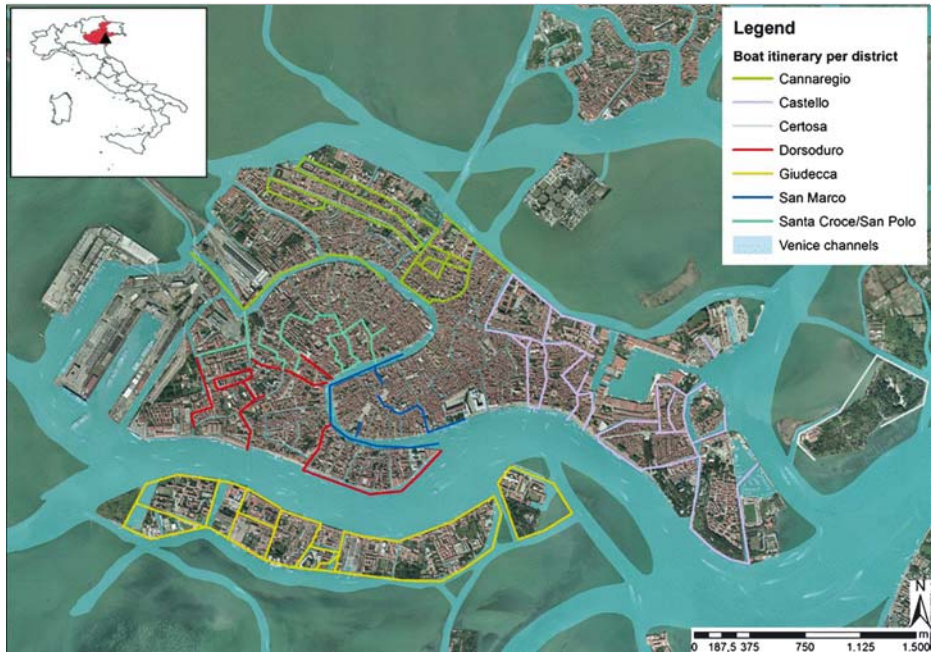


Fig. 5. Historic centre of Venice with the itineraries performed by boat in each district during macro floating litter monitoring and removal campaign. The map is generated by ArcGIS 10.2 for Desktop Geographic Information System.

The ML surveyed in 2015 shows similarities in terms of overall quantity and typology despite seasonal differences. This result is in line with those of the Regional Agency for Environmental Protection and Prevention of the Veneto region, ARPAV [10], which highlights an almost constant monthly production of solid urban waste due to overtourism pressure in the city centre of Venice and its Lagoon, which remains substantially constant throughout the year. Moreover, the average density of the floating litter in the canals is found to be around 2,74 waste unit/100 m^2 in 2015 and increased to 3,29 waste unit/100 m^2 in 2016. This value is considerably higher than the average presence of floating litter encountered in the open Adriatic Sea, which is 0,06 waste unit/100 m^2 [11].

Data recorded during the Legambiente summer monitoring campaigns show a dominant presence of floating plastics in the Venice canals with an average of 85% in 2015 and 89% in 2016 (Table 1). In particular, cigarette filters and their packaging count for 33,55% of all the plastics surveyed (Fig. 6).

Table 1. Percentage of floating litter divided by material typology recorded during the monitoring campaign of 2015 (summer and winter) and 2016 (only summer - data source: Venice Legambiente).

Floating litter typology	Summer Campaign (2015)	Winter Campaign (2015)	Summer Campaign (2016)
Glass	1%	1%	1%
Paper	7%	9%	4%
Rubber	1%	0%	0%
Wood	5%	3%	3%
Metals	1%	1%	1%
Fabrics	0%	0%	2%
Plastic	85%	86%	89%
Total amount of floating litter (waste units)	**5.412**	**5.043**	**6.495**

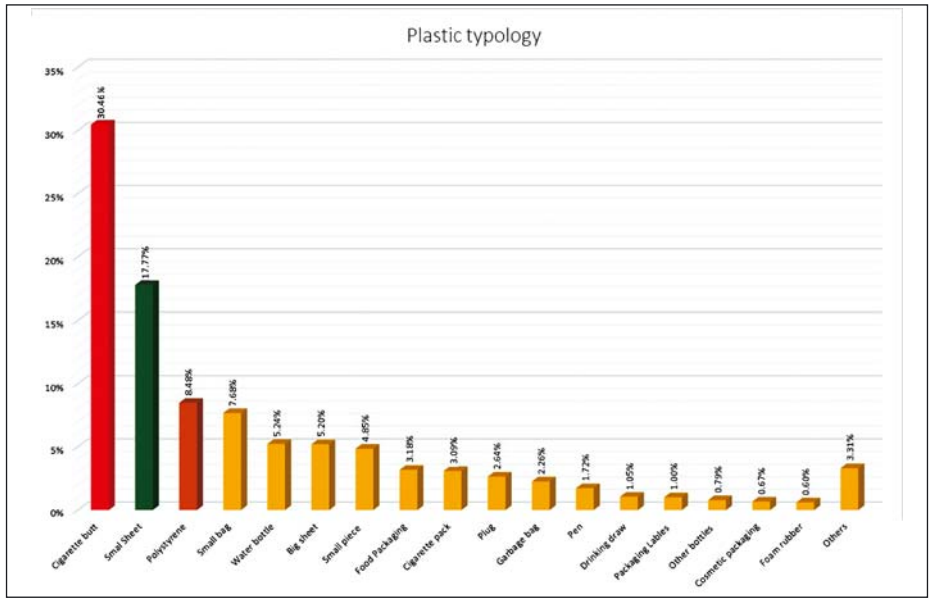


Fig. 6. Typology of plastic floating litter recorded during the summer monitoring campaign of 2016 (data source: Venice Legambiente).

The percentage of floating litter per each district of the historic centre of Venice, divided by category, is shown in Table 2. Results highlight Cannaregio and Giudecca as the areas with a higher percentage of floating litter with 33% and 30% respectively of the total waste collected, followed by San Marco with 12% (Figure 7). Provided that Cannaregio is among the areas with the highest residential rate and that Giudecca is not among the main tourist destinations, it is plausible that waste produced by inhabitants have significantly contributed to the total amount of floating litter collected in these areas. Moreover, with regards to Giudecca island, other factors such as tide streams and dominant winds might have a role in ML dispersal, and concentration found. In the case

of the San Marco district, instead, there is a low residence rate (corresponding to 7%) but a very high tourist pressure, being an iconic place known all over the world.

As a consequence, in this area we find a remarkably high concentration of food and beverage shops, which coincides with a significant presence of street waste in the surrounding waters as surveyed. Results described underline the need for increased awareness and education of both tourists and residents on marine plastic pollution to reduce the phenomenon.

Table 2. Presence percentage of floating litter categories recorded in the districts ('Sestieri') of the historic centre of Venice during the monitoring campaign of 2016 (data source: Venice Legambiente).

	Sestieri					
Floating litter categories	Cannaregio	Castello	Dorsoduro	Giudecca	San Marco	Santa Croce/ San Polo
Rubber	0%	0%	0%	1%	0%	1%
Metal	1%	1%	1%	1%	0%	0%
Glass	0%	1%	1%	1%	0%	1%
Plastic	91%	93%	89%	87%	89%	86%
Paper	4%	3%	4%	5%	1%	1%
Wood	3%	3%	4%	3%	5%	3%
Other	1%	0%	1%	3%	4%	8%

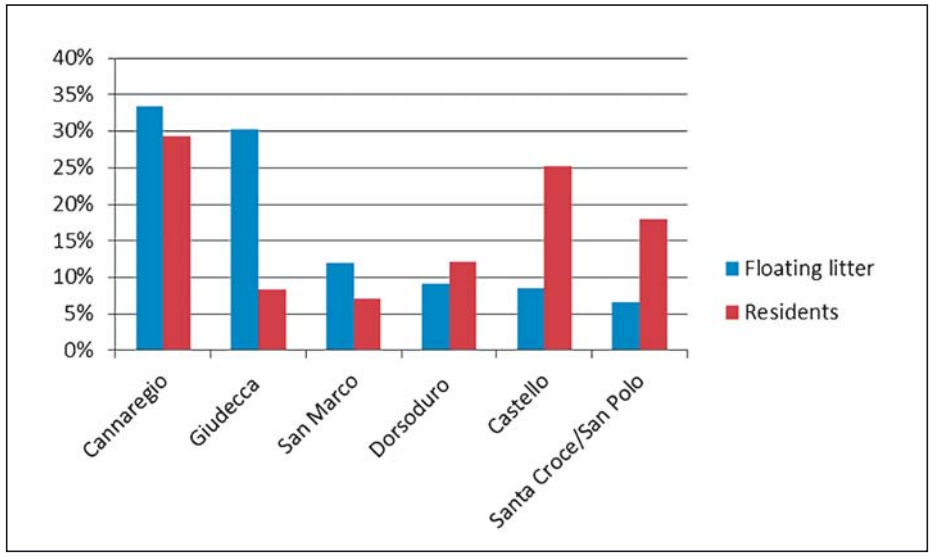


Fig. 7. Percentage of floating litter compared to residents per each district of Venice historic centre.

4 Sampling Stranded Macro Litters in the Historic Centre of Venice

Besides the above research findings, a group of undergraduate students from Worcester Polytechnic Institute (WPI) in Massachusetts, USA made contributions with a 14-week research project (co-sponsored by the local NGO Venice Calls) from August to December 2019, carried out in the historic centre of Venice.

The students gathered data to understand the accumulation of waste in the Lagoon and assessed the effectiveness of the public trash receptacles and waste pick-up locations through in situ investigations and finally developed recommendations for the reduction of plastic pollution in Venice.

In understanding the accumulation of waste in the Lagoon, the research team performed six data collections of stranded plastics among the shallows of S. Alvise, North Tronchetto, and Giardini (Partigiana) sites. The work aimed at ML classification along with its quantitative count and weight. Table 3 provides information on the six data collections and Figure 4 displays their geolocation. Two monitoring campaigns were set out with a differentiated time elapse in between, to gain an understanding of the ML accumulation rates at each site.

Table 3. Information on Macro Litter Data Collections.

Collection Site	Date of Clean-Up 1	Date of Clean-Up 2	Number of Days between Clean-Up
S. Alvise	20 November 2019	03 December 2019	+13 Days
North Tronchetto	21 November 2019	03 December 2019	+12 Days
Giardini (Partigiana)	25 November 2019	04 December 2019	+09 Days

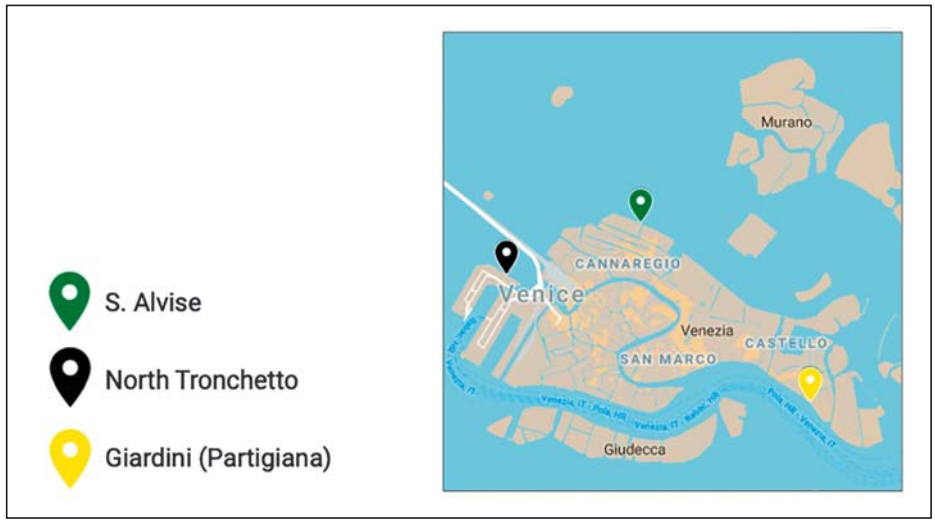


Fig 8. Three Data Collection Sites (source: google map).

The six clean-ups removed 4,530 pieces of ML with a total mass of nearly 100 kg. The categories and types of litter collected, along with their respective quantity and mass, are shown in Table 4. Concerning plastic pollution only, plastic accounted for 92% of the collected waste by count and 66% of the waste by mass. Therefore, plastic holds a prominent position in the ML sampled. Moreover, their accumulation rate reaches an average of 0.70 kg daily among the three sites.

Table 4. Accumulation of waste among all collection sites.

CATEGORISED ACCUMULATION			
OVERALL CATEGORY	**Types**	**Number**	**Mass (kg)**
PLASTIC	Lighters	15	0.145
	Caps/Covers	110	0.545
	Polystyrene	2115	12.975
	Large hard plastics	28	4.875
	Small hard plastics	411	3.825
	Small thin sheets	1033	5.02
	Medium thin sheets	121	8.8
	Large thin sheets	54	13.435
	Bottles	54	11.8
	Plastic crate	8	3.295
	Wrappers	149	0.725
	Ribbon	32	0
	Packing straps	37	0.115
RUBBER	Rubber	11	3.41
GLASS	Glass pieces	40	6.56
METAL	Cans	44	1.33
	Lightbulb	3	0.01
	Pieces	12	0.246
	Rods	17	1.665
OTHER	Small wire	29	1
	Corks	62	0.72
	Fabric pieces	66	7.06
	Bags of detergents	7	0.775
	Rope	11	3.95
	Candle	1	0.05
	String	21	0.655
	Cardboard/Paper	29	1.36
	Ceramic	2	0.405
	Wood	5	0.605
	Net	2	3.365
TOTAL		**4529**	**98.721**

To further breakdown plastic accumulation along the Lagoon, Figures 5 and 6 show the percentage that each category of plastic make up at each site by count and mass, respectively. The categories are hard plastic, polystyrene, thin sheets of plastic, and bottles / bottle caps. By count, polystyrene is the most prevalent, whereas, by mass, thin sheets are the most prevalent.

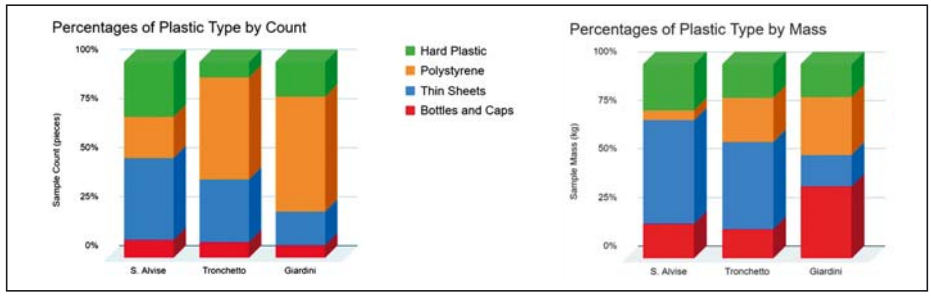


Fig. 9 and 10. Percentages of plastic categories by count (left) and mass (right).

Because of the direction of the tides in the Lagoon and the unique geography of the old town of Venice, the waste along the coast has likely entered the Lagoon as floating waste before stranding along the coast. From our research and data, we can conclude specifically that plastic, and, furthermore polystyrene and thin plastic sheets, are the most significant contributors to waste pollution in the Lagoon surrounding the three sites. Catching plastics while still floating should be the main target to reduce the amount of waste in the Lagoon significantly.

5 Plastics Derived Micro Contaminants in the Surface Water of the Grand Canal of Venice

The presence of macroplastic ML is not only detrimental to the aesthetic value and charm of the World Heritage site (WHS) of Venice and its Lagoon, posing an equal threat to its larger marine life, but it is also the precursor of microplastics. Macroplastics' exposure to the atmospheric agents combined with plastic ageing induces the formation of microsized and potentially nanosized plastic fragments. They are an ubiquitous pollutant of serious environmental concern, having been reported in aquatic habitats, food chains, and the atmosphere worldwide. Human health effects of microplastic exposure via diet or inhalation are an emerging field of research [12].

The hydrophobic surface of microplastics can adsorb and concentrate contaminants such as polycyclic aromatic hydrocarbons, organochlorine pesticides and polychlorinated biphenyls [13] and accumulate toxic heavy metals [14]. Sorbates can subsequently be released in different ecosystems due to the mobility of microplastics in the aquatic environment. Moreover, microplastics harbour endogenous chemical additives (aimed at improving flexibility or rigidity, avoiding photodegradation etc.) used during the manufacture of plastic products. They are not necessarily chemically bound to the plastic polymer matrix; hence, these additives and residual monomers are susceptible to leaching to the external medium such as waters or animal tissues [15].

While the bio-persistence of microplastics is recognised to lead to a wide gamut of biological responses ranging from inflammation to necrosis, limited information concerning the direct transfer of additives from plastic to animal tissues is available [16]. Even lesser is known on the presence of microplastic associated pollutants in aquatic ecosystems. For these reasons, at the end of August 2019, VLPF sampled the waters of the Grand Canal at ebb tide to conduct a preliminary qualitative analysis aimed at detecting micropollutants related to the presence of plastics in the marine

environment. 2.500 mL of lagoon water were put in 5-mL headspace vial, closed by PTFE/silicone septum. Bulk water and vapour phase were both subjected to Solid Phase Micro Extraction-Gas Chromatography-Mass Spectrometry (SPME-GC-MS) analysis in the chemistry laboratories of ITT Montani in Fermo (FM), the oldest technical and technological institute in Italy. The experiment ran in triplicate. To the best of our knowledge, this is the first research in which a SPME device has been employed to study the presence of microplastic related pollutants both in the volatile headspace and bulk water. This is of significance since such molecules can be either inhaled (if in the vapour state) or ingested (if in the water state).

It is worth noting that the analytical strategy used to get the molecular fingerprint of the lagoon water is environmentally friendly and was in the absence of any toxic solvent [17] [18] [19].

The analysis revealed the presence of fuel-related pollutants, in consideration of the fact that the elaborate system of canals, is often engorged with boat traffic. Alkanes, branched or unbranched linear and cyclic hydrocarbons consisting entirely of hydrogen atoms and saturated carbon atoms, related to the accidental release of unburned fuels in marine water had a robust presence. They ranged from 7 (cycloheptane) to 16 carbon atoms (hexadecane).

Carbonyl compounds, abundantly found in our samples, are the products of the combustion reaction, detected in exhaust gases from transports. However, aldehydes and ketones generate from other anthropogenic sources, such as personal care products.

Natural flavours and plant metabolites (e.g. delta nonalactone with coconut odour type, possibly from sunscreens, geranyl acetone with fruity-floral odour type), human metabolite (octanoic acid), and algal metabolite (nonanoic acid) were also detected.

Furthermore, the focus of our interest was mainly on molecules leaching from the ML. In this context, 2-ethyl hexanol is an emblematic molecule. It can be a diesel related compound [20] [21] as well as a fragrance ingredient used in toiletries, sunscreens and detergents [22]. Moreover, 2-ethyl hexanol is the major metabolite of a common plasticiser, bis (2-Ethylhexyl) phthalate, in damp ambients [23], hence it relates to the ML presence. It is worth noting that it can also leach from various coatings, adhesives and sealants. Providentially, the toxicity of 2-ethyl hexanol is quite low [24].

A chlorinated butene, detected in the headspace of the water sample, is an intermediate in the industrial production [25] of synthetic rubbers. Hence, this molecule can be considered a marker of rubber (macro-microscopic) presence and by toxicity a suspected human carcinogen [26].

2,3,4,5,6,7,8,9-Octahydro-1,1,4,4,9,9-hexamethyl-1H-trindene can instead be considered a marker of High Impact PolyStyrene (HIPS), that is a thermoplastic blend of polystyrene and styrene-butadiene rubber [27]. Since it sources from HIPS, it can be useful in the apportionment of different plastics within the ML.

The analysis also identified the presence of a heat stabiliser and intermediates for the production of polymers.

Among the analytes found in water, methoxy-phenyl-oxime is iconic of Venice landscapes since it is a metabolite of myxobacteria [28] ubiquitous in decaying wood.

Gamma-heptalactone and Gamma-octalactone are chemicals of low or no safety concern [29] as flavouring agents. The former, in particular, is related to the manufacturing of tobacco products, detectable due to the significant presence of cigarette butts in Venice's canals.

A thiazolidine derivative was also found most likely as an accelerator for the vulcanization of chloroprene rubbers [30]. Phthalates were also detected; they are common plasticisers, used to increase plastic flexibility and durability and, therefore, linked explicitly to the plastics litter. In this respect, it urges to note that phthalates are broadly recognised as endocrine disruptors [31].

To sum up, plastics molecules detected in the water of the Grand Canal of Venice include phthalates used as plasticisers, stabilisers for polymers, additives for lubricants, intermediates for rubber synthesis, and accelerators for rubber vulcanisation.

This preliminary result comes from a feasibility study aimed at assessing the practicality of the proposed method. It is important to emphasise that a comprehensive approach to sampling of a geographical area requires a thorough selection of several sampling points. Conversely, the analyses carried out were point-like qualitative and, therefore, unsuitable for drawing conclusions on the degree of danger they might present.

Fig. 11. Sampling in the surface water of the Venice Lagoon (Photo: T. Cecchi).

6 Mechanical and Chemical Recycling of Marine Plastics and Litter: EU Funded Projects Come to the Aid

Recycling of plastic waste into a full-fledged circular plastic value chain is an open challenge on a global scale. In Europe, out of the 30% of plastic waste successfully collected in 2016, less than one third became a new product for the market [32]. Plastics, being a predominant fraction of ML nowadays, as highlighted in the case study of Venice, represents an even more complex challenge.

ML, which consists of varying plastic type and quality is poorly suited as a feedstock for established recycling systems and streams, which are optimised for pure streams of single plastic types. Therefore, dirty plastics retrieved from aquatic environments are generally for landfill or incineration. It requires too much pre-treatment to turn contaminated, low quality and heterogeneous plastics into valuable and lucrative feedstock for standard recycling schemes. Chemical recycling derived products from ML might be a suitable option instead, according to a cost-effective approach. If marine fuels, abiding by international standards, are the target products, the market volume and its value can sustain a virtuous de-pollution cycle, potentially without the need for any public subsidy, thus self-sustaining the ML to marine fuel loop.

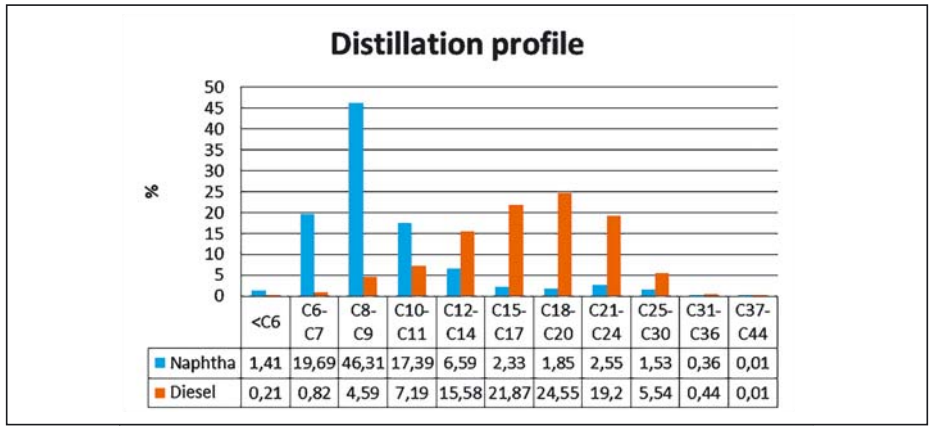
The EU co-funded and ongoing marGnet project [33] offers a gripping narrative on how chemical recycling may prove valuable to turn ML into marine fuel (in compliance to international ISO8217 standard). The project covers all aspects of ML, from detection to removal and recycling, working on two pilot sites located in the Northern Adriatic: the Venice Lagoon in Italy and the Cres-Lošinj Archipelago in Croatia. The collected ML is transformed into marine fuel using a mobile prototype explicitly designed for the purpose. The process performed is low-temperature pyrolysis with a distillation of the produced pyrolysis oil. The prototype replicates the process of fuel synthesis employed in larger industrial units, and it is big enough to provide reliable results in terms of fuel yield and its quality. At the same time, it is small enough to be fully portable as a device suitable for decentralised fuel synthesis. Several impacts of the technology are also evaluated, including emission in the atmosphere and specific constraints arising from the presence in the ML of a large amount of polyamide, which is not present in conventional post-consumer plastic waste.

As a preliminary result, two primary products are obtainable from unsorted contaminated ML: (i) a low boiling point hydrocarbon blend suitable for further refining to manufacturing new polymers and ultimately new raw plastics; (ii) a mid distillate corresponding to the diesel boiling range. The latter with minor post-treatment is classifiable as one of the marine fuels listed in the ISO8217 standard: MGO, MDO, and IFO [34] [35] [36].

The use of additives and reactants during the pyrolysis and the distillation process is necessary and carefully calibrated to achieve significant product yield (>50% on a mass basis) and low environmental impact (ppm range or less of acidic compounds and absence of dioxins). Furthermore, flue gas treatment requires the employment of specific nano-engineered materials.

Although the collection of ML remains the main hurdle, the pyrolysis process offers a suitable recovery pathway once the plastic waste is available. The targeting of fuels as

desired products generates a value easily transferable to stakeholders, i.e., fishermen. It tangibly promotes the positive behaviour of retaining ML for feeding the pyrolysis process in exchange for free of charge fuel for their fishing vessels.



	<C6	C6-C7	C8-C9	C10-C11	C12-C14	C15-C17	C18-C20	C21-C24	C25-C30	C31-C36	C37-C44
Naphtha	1,41	19,69	46,31	17,39	6,59	2,33	1,85	2,55	1,53	0,36	0,01
Diesel	0,21	0,82	4,59	7,19	15,58	21,87	24,55	19,2	5,54	0,44	0,01

Fig. 12. Distillation profile of two products from raw (Figure: G. Faussone).

Despite the most recent EU regulatory framework providing that "full-fledged recycling" of plastics waste should be void of the energy recovery process and/or the generation of fuel feeding materials, the marGnet project's marine plastic litter to fuel incentive scheme represents a viable option for ML reduction. This may be promising for inducing virtuous conducts with the fishing vessels and fleet locally by reducing the depreciable habit to throw ML back in the sea once embarked, in particular, during trawling fishing operations. If adequately backed by a suitable regulatory framework, as recently experienced in Venice, such a solution may prove a valuable opportunity to bond the significant gap in the waste management process of ML. Venice may seize the inherent benefits of it by leveraging on the marGnet project's demonstration activity and a scaling up on its own.

Finally, this experience may prove inspirational within the ever-pending issue of the qualification of the chemical industrial pole of Marghera, situated on the mainland north of Venice. On a number of occasions its manufacturing facilities and chemical deposits have exposed the entire city of Venice, its Lagoon and suburbs to extremely hazardous events, recently in May 2020 involving 3V Sigma's plant and solvent's deposits.

To go more into a comprehensive frame of action, opportunities have arisen for tackling ML and plastics pollution in the frame of the Horizon 2020 projects MAELSTROM (Smart technology for Marine Litter SusTainable RemOval and Management) led by CNR-ISMAR (Venice, Italy) and IN NO PLASTIC (Innovative approaches towards prevention, removal and reuse of marine plastic litter), coordinated by SINTEF (Norway). Both are afferent to the call for proposal CE-FNR-09-2020 - Pilot action for the removal of marine plastics and litter, an innovative approach in support to the European Strategy for Plastics in a Circular Economy. The projects are currently under negotiation with the European Commission and foreseen to kick off between October 2020 and the beginning of 2021.

IN NO PLASTIC and MAELSTROM are bound to Venice, since its Lagoon is meant to become a groundwork on societal engagement and technological demonstration for ML removal and recycling, as well as a venue for international debate and learning on the matter. The projects aim at integrating the most recent findings of ML pollution science with a powerful mix of chemical and automatic systems designed for plastic removal from nano-micro-macro-plastics and their regeneration for marketisation. While MAELSTROM will strive to provide solutions to the complex question of intercepting mainly floating and sunk macro litter and its removal, IN NO PLASTIC's approach is a combination of social and technical removal strategies with the ambition to tackle even nano and microplastics.

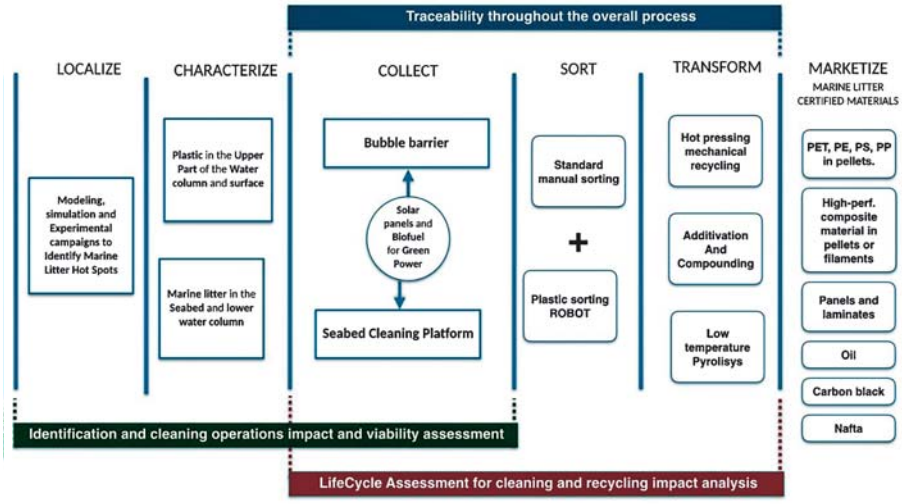


Fig. 13. MAELSTROM in a nutshell (Figure: F. Marelli).

In more detail, MAELSTROM will evaluate two main removal technologies: (i) a bubble barrier to intercept floating plastics on rivers before they enter the oceans (with a case study in the Duoro River in Portugal), and (ii) the seabed/lower water column cleaning platform (to be tested in the Lagoon of Venice and its near shore of the Adriatic Sea). It is worth noting that MAELSTROM solutions will be partially powered by sustainable energy derived from the integration of innovative a floating solar panel and fuel obtained from pyrolysis of the non-recyclable part of the collected ML following the line of the marGnet project. Removed litter will be segregated (using an AI-driven robot) and recycled through additivation and compounding, mechanical treatments, hot pressing and low-temperature pyrolysis.

IN NO PLASTIC will develop three clean up technologies addressing three litter locations: industrialised water ways, populated accessibility coastal areas and low accessibility coastal areas.

The strategy is to develop several technologies to address clean-up of litter in the marine environment:

1. A new nanoparticle agglomeration technology combined with flocculants and drum screens suitable for industrial cooling water systems, harbours and the open sea
2. Software app to incentivise and enable handpicking and a materials traceability blockchain technology
3. Robotic and standalone drone for hard to access areas beach clean-ups.

Finally, IN NO PLASTIC will test mechanical and chemical recycling and develop sustainable and circular best practice for the treatment of the collected litter.

In particular, the SepaRaptor, an innovative system for nanoparticle agglomeration technology, combined with biodegradable and environmentally friendly flocculants will grow (and remove) plastic particles to 18 μm. A drum screen will be employed to remove plastics of nano, micro size level from 1-2000 μm to larger particles of about 2000 μm and above. The entire technological process is backed by an international team of experts in physics, electronics, chemistry, nanotechnology and toxicology. This solution would first be tested in industrial cooling water systems (CWS), followed by harbours, beaches, lagoons, shallow seawater and shores.

Fig. 14. IN NO PLASTIC schematic view of an industrial cooling water system (Fig. L. Daal).

The type of ecosystem to work upon, the efficiency and selectivity of the removal technologies along with the frequency of their operation are taken in serious account in both projects. The positive effects of remove/avert macro plastics degradation into micro/nanoplastics are analysed along with any potential adverse effects of the same removal operations on the natural habitats and their life forms. This analysis will also be able to provide indications for specific measures of mitigation and prevention of ML and plastics in future maritime spatial planning measures to decision-makers.

Moreover, the MAELSTROM and IN NO PLASTIC fields of action are not restricted to the above description, since social engagement is also part of the articulated scheme envisaged to tackle ML and plastics pollution. Dedicated apps for ML tracking and inventory at the service of community arranged clean-ups are meant to be put to the test in Venice, although with differentiated approaches. Despite the MAELSTROM ML tracking app involving a genuine degree of community-based participation, it is mainly focusing on identifying and tracking different types of ML to feed the circular economy component of MAELSTROM.

The IN NO PLASTIC stakeholder's engagement and ML app have different connotations. In the first place, the app is devised and customised to incentivise local plastic waste collections by tourists/locals with financial rewards. Although the collected plastic should be digitally registered using the Empower Waste Tracking system for the traceability of the plastics throughout the supply chain (like in MAELSTROM) the main goal is to create a clean-up economy in its own right. It

strongly focuses on local community, businesses and tourists that in Venice will be extensively involved in stranded and floating cleans up, making also use of gamification and social rewarding schemes.

By being involved in both MAELSTROM and IN NO PLASTIC, VLPF is assigned with the task to play a catalyst role, closely working with CNR-ISMAR and SINTEF, to set out a conducive environment for scientific and technological inter-project cooperation. Moreover, by being in charge of community-oriented activities, VLPF is involved in bridging the innovations to be tested in Venice to the different local administrative levels, involving waste management authorities along with the tourist sector, local associations and other relevant stakeholders. The underlying challenge is the attempt to turn the innovation of the above projects into sustainable solutions embedded in governance practices for ML management and remediation. Technologies in their different forms and complexities, although of proven effectiveness, bear a limited impact if not up taken by central/local administrations as tools to strengthen the implementation of their ML and waste management system. Citizens and especially tourists, whose numbers are expected to increase dramatically after the pandemic deadlocks, aren't neglected in such a demanding effort to envisage a more sustainable city with a decreased marine plastic pollution for the present and notably for the generations to come.

7 Conclusions

The world is inquiring how to think, plan and foremost act in a post-COVID-19 pandemic crisis. We debated to death for decades on how to build on different patterns of development for the WHS of Venice and its Lagoon. Neither specific provisions nor overall governance systems were fully up to the task of departing from the extreme commodification of cultural and natural assets driven by monetary revenue maximisation. The uptrend of massive tourists' presence and the related increase of goods and services required to feed the entire chain of such a development model has produced growing social-environmental externalities. ML, with especially plastics pollution as part of it, whose evidence were reported on the density and typology from the macro to the micro-level.

COVID-19 drew a line with its lockdowns, creating a Time-Zero baseline in terms of anthropogenic impact on our environment [37]. Such happenings sound as a wakeup call for a "U-turn" in our unhealthy relationship between our natural/cultural heritage and economic growth as we knew and practised. We will keep mobilising society in removing, tracking and monitoring ML and plastics in the upcoming future while proposing remediation options to research communities and foremost decision-makers and WHS managers with the support of the EU. This wealth of information may lead to new institutional, social and economic measures. Decision-makers are now insistently calling upon sustainable development and quality tourism for the future economic reliance of Venice. ML prevention and remediation measures intertwine with a more harmonious relationship between humans and the ecosystems, especially in internationally recognised sites of outstanding universal value. The outcomes of future ML monitoring campaigns in the Venice lagoon will provide a reality check on improved governance settings and resolutions that are on the way to be devised and implemented.

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Managing Tourism Flows on Mediterranean Islands with Social Media

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Abstract

The Biosphere Reserve Framework as well as the World Heritage Convention offer excellent opportunities to establish holistic GMS, balancing conservation and sustainable development. The two archipelagos Tuscan Island Biosphere Reserve as well as the Aeolian Islands World Heritage site have been studied by analysis of the social media platforms Instagram, TripAdvisor and Airbnb. The social media analysis conducted, reflects the attractiveness of natural and cultural heritage, the accessibility of the heritage, the visitor perception, the quantity and quality of hospitality businesses and services, visitors distribution and flows in the area, as well as the effectiveness of the governance and management systems, especially with regard to the conservation and protection of cultural and natural assets. A visitor management is realized only in the strictly protected areas, in buffer and transition zones little tourism regulations can be recognized. The tourism development is partly out of control and the use of limited natural resources as well as negative impacts to the natural and cultural heritage are increasing. At present, the management plans of the two archipelagos submitted to the authorities have not yet been approved nor implemented since they must adhere to the endless procedures and bureaucracies required.

Keywords: Social media, island tourism, visitor management, World Heritage site, Biosphere Reserve

1.1 Introduction

Social media and ICT are greatly influencing today's visitor behavior. The role of visual and social media in destination marketing has gained enormous influence on traveler behavior in just one decade. Tourist destinations are increasingly seeking to attract visitors using ICT tools, commercial internet platforms and social media. The combination of visual media (television, movies, short films or music clips on YouTube) and social media presence can boost little or unknown sites periodically or seasonally in short term. Until recent times, the main drivers of a steadily growing tourism sector were improved access with public and private transportation, enhanced hospitality business and services, and decreasing travel costs. Today communication and marketing tools, such as word of mouth, newspapers, glossy travel journals and especially cinema, television and for at least one decade social media like Facebook, Instagram, Twitter, TripAdvisor, Airbnb, Expedia. Social Media paired with good accessibility leads quickly to so-called 'Hit and run tourism', resulting in overtourism, without adding substantial revenues [1].

This development results in uncontrolled and unforeseeable tourism flows, especially in vulnerable ecosystems or cultural sites with often insufficient or no tourism infrastructure and business. Especially numerous overtourism heritage sites permanently or periodically exceed their Carrying Capacity and show impacts from fast

growing visitor numbers. Therefore, such booming visitors flow result in negative impacts to natural and cultural heritage, local economy and population. However, Carrying Capacity has to be considered in relation to the infrastructure, the capacities and the vulnerability of the sites. It refers to the number of individuals a given area can bear within natural and cultural heritage resource limits and without degrading the natural, social, cultural and economic environment for present and future generations. The United Nations World Tourism Organization (UNWTO) is furthermore underlining that the number of visitors should not cause unacceptable decrease in visitor satisfaction [2].

The presence in social media and commercial travel platforms of key tourism spots of selected destinations in World Heritage sites in Switzerland and Italy, such as the Dolomites and Venice, Swiss Alps Jungfrau-Aletsch and Rhaetian Railway were analyzed in 2019 - 2020. Furthermore small destinations endangered by overtourism such as the Verzasca valley in Switzerland, Trolltunga in Norway, and Scala dei Turchi in Sicily, Italy have been studied [3]. Social media analysis show the effectiveness of visitor management strategies. Numbers of hashtags, posts, and reviews are excellent indicators and tools to visualize over- and under-tourism destinations in large areas. Due to the continuously changing numbers of hashtags and posts within hashtags, short term visitor flows can be observed. Social media presence is a cost-effective indicator to monitor and forecast tourism developments [4].

1.2 Social Media and Travel Platforms

Tourist destinations increasingly engage to attract visitors using ICT tools, commercial internet platforms and social media. They offer great opportunities to create expectations and flexibility, to understand the traveler's perception, and to reduce uncertainty. In just one decade, such communication tools and platforms have become the most important features Destination Marketing Organizations (DMO) consider when creating their destination strategy. In tourism marketing the outside view of travelers is decisive. Especially young tourists have more trust in other travelers' opinions using social media rather than official marketing advice [5]. When scrolling through Instagram feeds, travelers look to see how 'Instagrammable' the destination is, which nowadays is decisive of their decision-making. Instagrammable means "a picture which is worth posting on Instagram" [6]. Therefore eye-catching and attractive posts of colorful landscapes, wild nature, cultural heritage or an impressive city scape is worth sharing with friends and the public.

The content of the platforms is user-generated and public - using hashtags on Instagram, providing reviews on TripAdvisor or owner–visitor interactions on Airbnb. Instagram, TripAdvisor and increasingly Airbnb are obtaining leading roles as interactive travel platforms. Instagram is an open source for visual visitors' experience, instead Trip Advisor and Airbnb are commercial providers, offering travel information and products by private business or public.

Instagram has been operating since October 2010 and enables its users to share pictures or stories, hence more than 70% of the content of the web platform is travel-related. TripAdvisor was launched in 2000 as travel guide and platform for tourism related business. Since the introduction of "add your own review", TripAdvisor has advanced to the world's largest travel platform and social network, enabling users to share their

experiences by posting travel-related content on their own 'Activity Feeds', creating a two-way communication [7]. TripAdvisor relates to the reviews on accommodations, restaurants and local attractions and thus narrows the users circle in contrast to Instagram.

Airbnb acts as broker and online marketplace, launched as web platform "AirBedandBreakfast.com" in August 2008, offering one-of-a-kind activities hosted by locals. The online marketplace is today in competition with the traditional hospitality industry and facilitates not only accommodation but also adventures, experiences, restaurants. Hosts and guests have the ability to interact, to post reviews about their experiences and to chat through a secure messaging system.

ICT tools, enhanced visual communication and interactive social media are increasingly determinant for the tourism development. Visual communication encourages emotions, coming from travelers' past experiences or those they expect to be part of, and are drivers of the travel decision-making process. Communication has more and more a key role motivating and inspiring, and supporting well-known as well as unknown and badly developed destinations. Its influence causes positive and negative impacts, especially in fragile natural and cultural heritage sites. Unforeseen and exponential growth of tourist flow results progressively in negative impacts on natural and cultural assets in a short period.

1.3 ICT and Social Media in Heritage Destinations Management

Social media communication is especially useful for under-tourism destinations with the need for enhanced tourism development. Without, destinations are running a risk of not reaching their audience and tourism segments. It is crucial to reach the target groups to interact with this audience properly. It is important to design and offer products according to the visitors destinations want to attract (localization, customization).

Overtourism instead is seen as a dramatic scenario of high visitor numbers, endangering extraordinary heritage sites and tourism destinations [8]. However, mass tourism is directly linked to overcapacity in tourism business and infrastructure, and the vulnerability of the sites. Simultaneously the quality of visitor experiences should be guaranteed and the benefit of local population assured. Visiting communities, groups and individuals (CGIs) should have positive effects on the well-being of people, both residents and visitors and thus foster social cohesion [9]. Heritage sites frequently face visitor flows exceeding the Carrying Capacity, attracting far more visitors they can bear. Tourism Carrying Capacity refers to the number of individuals a given area can support within natural and cultural heritage resource limits and without degrading the natural, social, cultural and economic environment for present and future generations [3]. In large natural heritage sites or heritage cities, Carrying Capacity may differ locally - some places might be overloaded while others may need tourism enhancement. Negative impacts have to be avoided, by regulating "hit and run" tourism, or to better balance visits geographically. Overtourism needs to be prevented at an early stage to reduce pressure on heritage, and adequate tourist flow management measures defined.

Social media and ICT applications will have significant roles in new destination models, supporting the distribution of tourist flows, balancing overloaded and less visited areas and to promote a responsible, sustainable tourism. ICT tools, their

applications and social media could be used more frequently and effectively to manage both. They provide tools to lower impact on heritage and to increase the visitor's experience simultaneously. They will foster communication and disseminate information among local actors and stakeholders, increase awareness regarding heritage values and respect towards residents, and influence tourist behavior. ICT tools may include online platforms for information exchange among actors, smartphone applications or GPS-based and GIS systems for tracking tourism movements and simultaneously informing visitors about limits, obstacles and alternatives before and during their visits. Information regarding crowded places, best visiting hours, availability of parking spaces, closure of restaurants and hotels, or other obstacles can be disseminated on the spot with ICT applications. Considering that 85% of leisure travelers decide about activities, itineraries and the tourism spots to be visited after arriving at the destination [10], it is likely that many travelers will adapt their travel to the circumstances at the place and time.

Social media analyses show the traveler's perception and are effective instruments to balance over- and under-tourism. The number of hashtags, posts, and reviews are excellent indicators and tools to visualize tourism development. Observing social media presence is fast and cost-effective, and therefore ideal instrument to monitor and forecast tourism developments [4]. ICTs - in particular, mobile technologies - are significant forms of assistance to World Heritage sites' managers in promoting responsible and sustainable tourism. More and more travelers will exclusively use smartphones and applications together with social media sources in all the phases of their travel experience: pre-trip, on-trip and post-trip. Visualization of travel destinations will increasingly determine the travel behavior and visually oriented travel planning applications will help to choose the most attractive or 'Instagrammable' places for the trips [11].

Benefit of Social Media and ICT in Tourism Development

- raise awareness regarding heritage values and respect towards residents
- improve education and behavior of tourists visiting a heritage site
- promote alternative visits or events in periods of high pressure
- increase communication among local actors and stakeholders from conservation and tourism
- provide ICT platforms and community WIFI networks to facilitate the interaction among indigenous people, actors, visitors and destination management

1.4 New Paradigms and Governance Models for Tourism Destinations

Tourism growth results from transformation of travelling due to increasing business and leisure travels, new mobility and travel behavior (e.g. cruise travel, low cost flights, fast trains). Over- and under-tourism consequently reflect human ambiguity between quantity and quality in tourism. Optimizing, respecting limits of tourism related business and creating benefit for local people will be key, instead of increasing infrastructure and services, attracting even more tourists and boosting revenues of investors. Recent studies show the consequences of single sites getting exponentially

more visibility and attraction, often without having adequate hospitality infrastructures available [3].

Measures to balance over and under tourism and to foster quality tourism in stewardship destinations have to be related to governance and management of heritage sites [12]. In a Webinar of the George Washington University on overtourism with Jonathan Tourtellot the following recommendations were summarized:

- Recognize the tipping point: More is not always better. Define maximum capacity and monitor social media to determine traveler hot lists.
- Plan ahead: Make tourism part of comprehensive urban, regional and destination planning.
- Stay flexible and adaptable: What works for historic sites does not necessarily work for beach destinations. Needs differ and change over time.
- Rethink good governance and management: DMOs have a vital role to play and need to participate in the sustainable management of destinations.
- Redirect visitors: travel smarter, seek out hidden gems and contribute to the protection of the places.

Heritage tourism strategies seek to bridge the "destination management perception gap" and create new paradigms, introducing a "stewardship approach" [13]. The targets have to focus on optimizing tourism, not maximizing it. Responsible tourism means to conserve and protect tangible and intangible heritage and avoid negative impacts instead of increasing infrastructure and business attracting even more tourists and boost revenues of investors [14]. New place based governance and management systems should be introduced. UNWTO published in 2019 the "Guidelines for Institutional Strengthening of Destination Management Organizations (DMOs)" to facilitate the change processes of destinations with regard to the future challenges of tourism [15].

Changed tourism paradigms for heritage destinations have to respect local evidences and involve all actors in co-developing and co-deciding, thus leading to the creation of a corporate and positive image of destinations. A "heritage stewardship destination" model, focusing on quality tourism which creates benefits for local people and visitors, offers opportunities to jointly engage in the conservation of their heritage, to improve their own living standards and experiences, and to share equally costs and benefits. UNWTO elaborated strategic frameworks to better use culture tourism synergies and to fight overtourism, and to improve travel experiences and hospitality in tourism destinations [16]. Measures to improve visitor management will be of little effect if they are not part of an integrated tourism strategy including social media. ICT and social media will be driver to boost tourism, but also take a decisive role in the paradigm change, supporting destination concepts focused on local evidences and challenges as well as guaranteeing quality instead of quantity. They may help to review and adapt regulations and to set monitoring and response measures.

2 Social Media Analysis

The study was conducted in the period from April 7–24, 2020 in the Tuscan Islands Archipelago and from May 6–18, 2020 in the Aeolian Islands Archipelago. Lists of key tourism spots were created – one for each archipelago. They were used to examine the

archipelagos' presence on social media – on Instagram, TripAdvisor, and Airbnb. Two languages have been considered in the study: Italian, as the language of the two archipelagos, and English. Structural differences between analyzed platforms require different approaches to the analysis of their contents.

The list contains:

- Tuscan Islands Archipelago: Total 86: 16 islands, islets, and skerries, 18 municipalities within, 52 tourist spots
- Aeolian Islands Archipelago: Total 93: 13 islands, islets, and skerries, 11 municipalities, 69 tourist spots

Two islands with the highest presence on social media have been compared in detail - Elba and Lipari:

- Elba: 8 municipalities and 18 tourist spots
- Lipari: 1 municipality, divided into six places and 11 tourist spots

2.1 Instagram Analysis

The Instagram analysis with its hashtags provide insights into the number of posts within each tourist spot, island, and municipality listed. Totally 179 hashtags were analyzed: Tuscan Islands 86, Aeolian Islands 93.

Of all spot-related hashtags, only those containing the highest number of posts have been sampled, and Spots without hashtags were extracted. This is to prevent duplicate values since User Generated Content (UGC) shared on Instagram often contains more than one hashtag related to the same spot – e.g. #MonteCapanne (8.174 posts) and #MonteCapanne1049m (220 posts). Sampling aims to deliver data without the multiple meanings – i.e. data referring only to the analyzed spots. Multiple-meaning posts are posts related to a place located in another locality, e.g. the hashtag Monte Saraceno in Vulcano relates mostly to the mountain in Puglia with the same name.

The total number of spot-related posts used for visualization, results after extracting the percentage of multiple meaning from the total number of the post's hashtags. The maps of the two archipelagos and of the islands with highest population and tourism activities, Elba and Lipari, serve to visualize the results, created with the ArcGIS software (Figures 3, 5, 7, 8).

2.2 TripAdvisor Analysis

The TripAdvisor analysis aimed to provide insights into the number of reviews related to each tourist spot on the lists and to examine the number of reviews which relates to tourist facilities within islands and municipalities. The facilities were divided into two groups: attractions (sights and landmarks, nature and parks, museums) and businesses (restaurants, hotels, vacation rentals, tours).

After the examination of the spots with or without reviews, the total number of reviews is calculated. Tourist spots have been grouped to geographical areas and visualized on maps (Figures 4, 6, 7, 8). The data used for the visualization is the total number of reviews of all tourist facilities (attractions and businesses).

2.3 Airbnb Analysis

On the Airbnb platform, both guests and hosts are encouraged to write reviews and opinions. However, only guests' reviews have been examined. It intends to provide insights into the relation between the frequency of rentals and reviews per lodging rental. The analysis aimed to examine the culture of communication of tourist segments within each of the two archipelagos.

The Airbnb analysis relates to the municipalities of the islands. First, the total number of lodging rentals within each municipality were calculated and places without Airbnb rentals extracted. Among the lodging rentals, some showed higher presence – i.e. higher number of reviews – and others were without reviews. The total number of reviews listed, includes all reviews.

3 The study areas in the Ligurian Sea

The Italian "Framework Law on Protected Natural Areas" no. 394/1991 (Italy 1991) outlines the fundamental principles for the establishment and management of protected areas regarding their mission, classification and governance. It also defines the legislation for national and regional protected natural areas. The Law 426/1998 establishes the public-law personality of the Park Authority, legal and administrative offices in the territory and is subject to the supervision of the Ministry of Environment and Protection of the Land and Sea (MATTM). With regard to Regional Parks, the Law 394/1991 establishes fundamental principles through framework rules for the Regions, attributing to local authorities relevant roles and functions, such as the participation of Provinces, Mountain Communities and Municipalities to the procedures for the establishment of protected areas [17].

3.1 Tuscan Islands Biosphere Reserve

The Tuscan Islands Biosphere Reserve, endorsed in 2003 and extended in 2015, overlaps with the Tuscan Archipelago National Park established in 1996, with 79.160 hectares the largest marine park in Europe (Fig. 1). The National Park corresponds to IUCN category II PAs, which are "large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities" 18 . The BR covers an area of 1.079.540 hectares, composed of seven main islands and is characterized by its high natural value, as well as by intensive tourism activities. The protection of its core areas is guaranteed by the National Park. The coexistence of priorities conservation and tourism generate an exceptional opportunity to study the influence of governance and management of the islands to local development. The Tuscan Archipelago belongs administratively to the provinces of Livorno and Grosseto with a population of about 34.000 inhabitants. The recent increase of tourism has generated enormous pressure on the natural environment for instance on the Elba Island where the presence of over 30.000 permanent residents increases up to 200.000 people on a typical summer day [19].

Table 1: Tuscan islands and their characteristics, places and tourism hot spots

Island	Places	Cultural Heritage /Hot spots	Characteristics
Gorgona Municipality: Livorno		Chiesa di San Gorgonio Villa Margherita Torre Vecchia pisana Torre Nova medicea Cala dello Scalo	Surface: 2,23 km^2, Tourism limited to guided visits: 75 visitors per day for 4 days a week
Capraia Municipality: Capraia		Lo Stagnone Torre dello Zenobito Cala Rossa Monte Castello Monte Arpagna	Surface: 20 km^2 Inhabitants: 120
Elba 8 Municipalities which correspond to the localities	Portoferraio Porto Azzurro Capoliveri Campo nell'Elba Marciana Marciana Marina Rio Elba Rio Marina	Lacona Monte Capanne Monte Orello Cima del Monte Punta Nera Capo Pero Eremo di Santa Caterina Orto dei Semplici Castello del Volterraio Santuario delle farfalle Villa della Linguella Museo di Napoleone Villa dei Mulini Villa San Martino Fortezza San Giacomo di Longone Santuario della Madonna del Monserrato Sassi Ritti, Menhire Spiaggia Barbarossa	Surface: 223,5 km^2 Inhabitants: 32.000
Pianosa Municipality: Campo nell'Elba		Bagni di Agrippa Catacombe di Pianosa Isolotto della Scola La Scarpa Punta del Marchese Forte Teglia Mura del Porto Palazzo della Specola	Former security prison Island completely protected Surface: 10,2 km^2 Limited guided visits
Montecristo Municipality: Portoferraio		Villa Reale Grotta di San Mamiliano Monte della Fortezza Ruins of the monastery San Mimiliano Villa George Watson Taylor	Island completely protected Surface: 10 km^2, Population: Not inhabited Guided visits: limited to 1000 visitors/year
Giglio Municipality: Giglio	Giglio Porto Giglio Castello Giglio Campese Arenella Villaggio Grotte	Rocca pisana a Giglio Castello al Giglio Medici Torre Fortezza Aldobrandeschi	Surface: 21,21 km^2 Inhabitants: 1420

Giannutri Municipality: Giglio	Punta Secca Punta del Capel Rosso Poggio Capel Rosso Poggio del cannone Monte Mario	Villa Romana Faro di Capel Rosso Porto Romano Monte Adami Cala dello Spalmatoio Cala Maestra Cala dei Grottoni	Public access only in the summer season Surface: 2,60 km² Inhabitants: 10
9 small islands and skerries	Palmaiola Cerboli Scoglietto di Portoferraio	Formiche di Montecristo Formiche di Capraia, Formiche di Palmaiola Formiche della Zanca Formiche di Grosseto Scoglio d'Africa	uninhabited

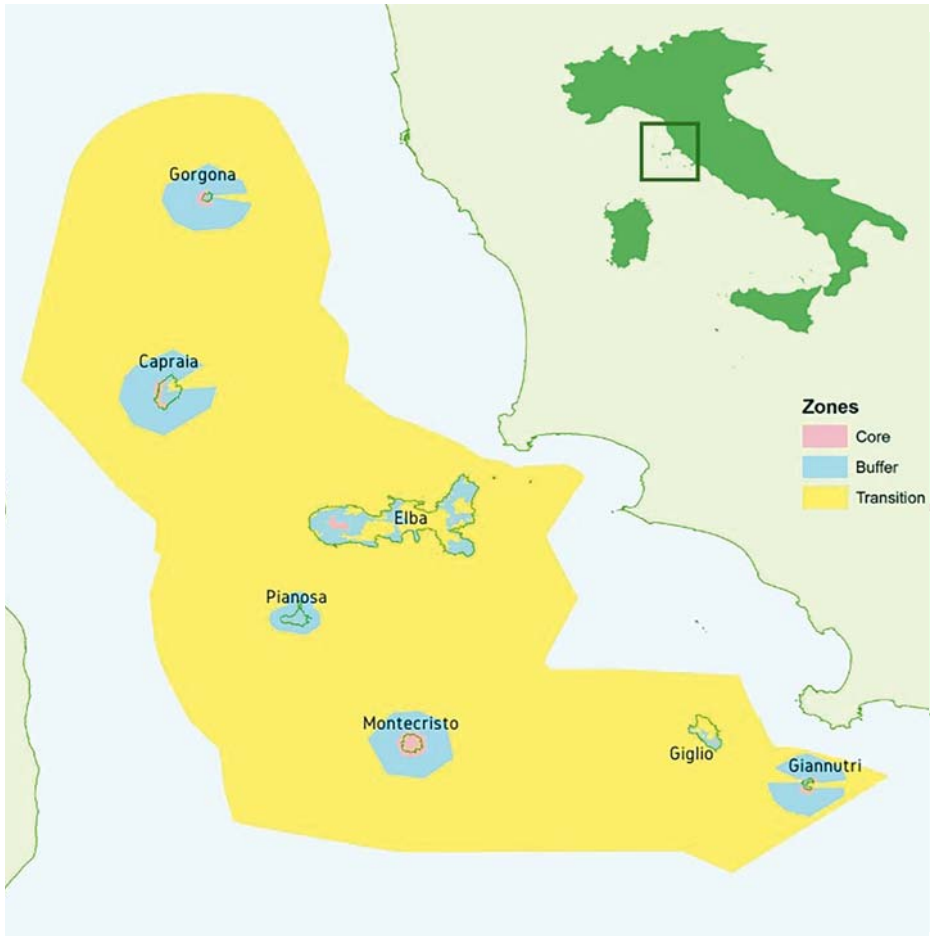

Fig. 1: Zonation of the marine and terrestrial zones of the Tuscan Islands Biosphere Reserve (Source: Riserva della Biosfera Isole di Toscana [20]).

The President, the Governing Council, the Executive Committee, the Board of Auditors, and the Park Community constitute the governing and management bodies of the National Park. The Director is responsible for the management of the Park and consequently for the BR. The Park Community is an advisory body constituting the interface with the local communities and includes the President of the Tuscan Region, the chairmen of the provinces of Livorno and Grosseto and the mayors of the 11 municipalities of the Park. It articulates its opinion on the fundamental acts of the Park plan, the regulations, and the budgets. The participation process is required by the mentioned Framework Law and is ensured by the Park Community but there are no legal provisions for direct citizen involvement because the members of the Park Community are representatives of the local bodies and not citizens. A study of the Italian legal framework shows that it is very specific and rigid regarding who can legally participate [21]. The participatory process encompasses the involvement of local actors in evaluating the impacts produced by the Park's activities, the engagement of municipal, provincial and regional councils with the necessary elements of knowledge to set up and verify the policies of protection and development of the territory and a structured dialogue with economic operators for co-design of itineraries and tourist packages [17].

A management plan for the BR was elaborated in 2015 but it has not yet been approved [22]. According to this document, the GMS will include: (i) Coordinator (President of the Park), (ii) Management Committee composed by representatives of research institutions, associations and other authorities; (iii) MaB Office composed by personnel of the Park and professionals, organizing the MaB participatory workshops aimed at enhancing the participation of local communities in the BR management; (iv) Permanent Consultative Assembly composed by the President of the Park, the representatives of the 11 municipalities, the State Forestry Corps and Port authorities which has to ensure the participation and involvement of local authorities, and approve and monitor the effectiveness of the program management. The BR budget is part of the Park budget, financed mainly by the MATTM. In 2015, the Park budget was 4.9 million Euros (State 94%, Region and other public bodies 0.19%, own revenue 4.6%, other funds 1.2%) [23].

3.2 Aeolian Islands World Heritage Site

The archipelago of Aeolian Islands, located in the low Tyrrhenian Sea in the north of the north eastern coast of Sicily, is made up of seven islands (Lipari, Vulcano, Salina, Stromboli, Filicudi, Alicudi and Panarea), all of volcanic nature, five islets (Basiluzzo, Dattilo, Lisca Nera, Bottaio and Lisca Bianca) near Panarea, and many seamounts. It is administrated by the province of Messina and is divided into the municipalities of Malfa, S. Marina Salina and Leni in Salina, and Lipari, which include all the other islands. From the sixties, the Aeolian Islands economy passed from activities linked to fishing, agriculture and mining extraction, to a set of tourist activities by developing a tourism destination of national and international dimension. Since, the archipelago has become a popular tourist destination and attracts up to 300.000 visitors annually, whereas around two third in summer and one third in fall and spring [24].

Fig. 2. The Aeolian Islands in the low Tyrrhenian Sea, north of the north eastern coast of Sicily. Copyright © 2020 Esri and its licensors [31].

The "Lipari Reserve", created in 1966 and the "Landscape protection" decree for Salina from 1979 launched the nature and landscape protection programs encompassing all islands. In 1991, the Sicilian Regional Authorities designated the islands Alicudi, Filicudi, Panarea and Stromboli as natural reserves. In 1998 a heritage management consortium was founded by the municipalities Lipari and Salina [25].

Table 2: Aeolian Islands, their characteristics, places and tourism spots (natural and cultural heritage (sources Province Messina [26] [27]). The islands belong manly to the Municipality of Lipari, Salina counts three Municipalities: Malfa, Leni, Santa Marina Salina

Islands	Places	Tourism spots/Cultural Heritage	Description
Lipari	Acquacalda Quattropani Pianoconte Canneto Lipari Monte Gallina Spiaggia Valle Muria Belvedere Quattrocchi Porticello Terme di San Calogero San Salvatore	Capo Milazzese Chiesa di San Pietro Museo Archeologico Regionale Eoliano Chiesa Vecchia di Quattropiano Ex Cave Pomice Cattedrale di San Bartolomeo Belvedere Quattrocchi Castello di LipariChiesa di Maria Santissima della Purità Chiesa di Maria Santissima della Purità Cave di Caolino Punta della Crapazza Foglia Vecchia	Surface: 37,29 km² Inhabitants: ca. 10.700 Conservation area: 16, 6 % (ca 6 km²). Municipality: 12.821 inhabitants per 31/12/2018 WH property: Core zone: 12km² Buffer zone: 3,8 km²

Stromboli	Ficogrande Ginostra Piscità San Vicenzo San Bartolo Stromboli Punta dell'Omo Punta Lena Punta dei Corvi Pertuso	Scari Ciminiera Chiesa di San Vincenzo Ferreri Calcara Scalo dei Balordi San Bartolomeo Grotta d'Eolo Pizzo sopra la Fossa Punta dei Corvi Pertuso Punta Lena Stromboli volcano Forgia Vecchia	Stromboli is actually the most active volcano Surface: 12,2 km^2 Inhabitants: 400 Conservation area: 19% (ca 2,3 km^2) WH property: Core zone: 7,2 km^2 Buffer zone: 3,3 km^2
Panarea	Ditella Panarea San Pietro	Cala Junco Capo Milazzese Chiesa di San Pietro Cala degli Zimmari Villaggio preistorico Punta Corvo Spiaggia della Calcara	Surface: 3,4 km^2 Inhabitants: 240 Conservation area: 25% (0,8 km^2) WH property: Core zone: 1,5 km^2 Buffer zone: 1,3 km^2
Salina M: Malfa, Leni, Santa Marina Salina	Pollara Malfa Valdichiesa Leni Rinella Lingua Santa Marina Salina	Spiaggia di Pollara Punto panoramico semaforo di Pollara Palazzo Marchetti Villaggio preistorico di Portella Museo Eoliano Dell'Emigrazione Chiesa dell'Immacolata Monte Fossa delle Felci Area Balneabile di Pollara Centro Storico Marina Di Salina	Surface: 26,4 km^2 Inhabitants: 2.300 Conservation area: 22,2% (ca 5,5 km^2). WH property (estimated): Core zone: 17 km^2 Buffer zone: 8 km^2
Filicudi	Capo Graziano Punta Ariella	Capo Graziano Le Punte Chiesa Parrocchiale di San GiuseppeSerra di Rando Serra di Rando Le Piramidi di Zucco Grande Riserva Naturale dell' Il Faraglione Siccagni Grotta del Bue Marino Costa dello Sciarato Solarium Lidalina Parco Archeologico di Filicudi Museo di Filicudi	Surface: 9,49 km^2 Inhabitants: 250 Conservation area: 25% (2,3 km^2) Riserva Naturale Orientata: "Isola di Filicudi", WH property: Core zone: 5,6 km^2 Buffer zone: 0,7 km^2

Alicudi		Chiesa di San Bartolo Filo dell'Arpa Chiesa del Carmine Pianicello Colle Alicudi Spiaggia Bazzina Scoglio Galera	Surface: 5,10 km² Inhabitants: 100 Conservation area: 44,4% (circa 2,3 km²) WH property: Core zone : 2,8 km² Buffer zone : 0,9 km²
Vulcano	Vulcano Porto Vulcano Piano Vulcanello	Scalata al Cratere Cratere di Vulcano Terme di Vulcano Spiaggia dell'Asino Capo Grillo Riserva Naturale Orientata Isola di Vulcano Monte Saraceno Piscina di Venere Valle dei Mostri	Surface: 20,87 km² Inhabitants: 300 Conservation area: 14,7% (circa 4 km²). Construction activities with negative impact on nature WH property: Core zone: 10 km² Buffer zone: 3,5 km²
Lisca Nera	Panarea forms with the tiny islands of Basiluzzo, Spinazzola, Lisca Bianca, Dattilo, Bottaro, Lisca Nera and the boulders of Panarelli and Formiche, its own minuscule archipelago.		uninhabited WHS Core zone
Bottaro			Not inhabited Surface: 0,0073 km² WHS Core zone
Isola di Basiluzzo			uninhabited Surface: 0,3 km² WHS Core zone
Scoglio la Nave			uninhabited Surface: 4.200 m2 WHS Core zone
Isola di Lisca Bianca			uninhabited Surface: 0,0413 km² WHS Core zone
Le Guglie Dattilo			uninhabited Surface: 0,0287 km² WHS Core zone

At present, the Territorial Landscape Plan (Piano Territoriale Paesistico delle Isole Eolie P.T.P.) issued in 2001 ensures the protection of the archipelago of the Aeolian Islands. The Framework Program Agreement of the Isole Minori, initially stipulated in 1999, was signed by the Region Sicily and by the Ministries of Economy, of the Finance and Productive Activities on 31 March 2003. Its main purpose was the programming of a useful strategy to safeguard the nature, for the promotion of a sustainable development and the adaptation of the infrastructure of the Minor Islands system, according to the European Union directives.

The Aeolian Islands were recognized as a World Heritage site in 2000, with a surface area of 1216 ha assigning the islands Alicudi, Filicudi, the islets, skerries as well as the protected areas of the other islands to the core zone. The statement of outstanding universal value summarizes: “The islands' volcanic landforms represent classic features in the continuing study of volcanology world-wide. With their scientific study from at least the 18th Century, the islands have provided two of the types of eruptions (Vulcanian and Strombolian) to volcanology and geology textbooks and so have

featured prominently in the education of all geoscientists for over 200 years. They continue to provide a rich field for volcanological studies of on-going geological processes in the development of landforms" (Criterion viii).

The Expert mission in 2007 summarized the main impacts to the outstanding universal value of the islands, among them pumice-pit mining, construction of ports and hospitality infrastructures as well as tourism [28]. In 2008 the Sicilian region and all the municipalities of the Aeolian Archipelago approved the institution of a sole management entity identified in a public Consortium among municipalities by signing a formal protocol. In the Management Plan finalized and submitted to UNESCO in 2010, a governance and management body has been defined, involving the UNESCO Sicily Foundation – promoted by the Regional Department of Cultural Heritage and Environmental and Public Education and by the Italian National Commission for UNESCO – with the tasks, to enhance and promote Sicilian sites designated as World Heritage [29]. The WH site was intended to coincide with the National Park, to be established in 2007, which is declared responsible for the management and budget of the site. The destination marketing is coordinated by a local tourism system "STL-Eolie".

The institution of the National Park of the Aeolian Islands is considered highly important and would solve the management problems, but up today nothing has been implemented. According to the WH Periodic Report issued in 2014 by the national and regional authorities, the management situation of the islands is very difficult due to the following obstacles [30]:

- The foreseen management body has not been constituted, no management of the WH property is visible and the Management plan has not been implemented
- Local communities have no influence in management decisions
- No budget, human resources, management equipment or facilities have been assigned for an effective management of the WH property
- There are no programmes dedicated to education, awareness raising or capacity development
- Professional support is not available and visitor management is not existing or poor
- The WH property does not deliver any economic benefits and little or no contacts with industries have been established
- No annual work or action plans exists and no monitoring is taking place
- Little or no information is available about the WHS

At present the managing body seems to exist only on paper and the Sicilian Regional Council of Environment and Territory is empowered to act as management body. The site is governed under the overlapping authorities of national, regional, provincial and municipal jurisdictions, including 20 governmental and non-governmental stakeholders responsible for different aspects of the property, but there is little or no coordination between them.

Further constraints were related to the pumice-pit mining, which was definitively suspended in 2007, and the excessive, uncontrolled tourism development. The tourist numbers vary considerably according to the source of information and the fact that the statistics are split according different administrational levels (Municipalities, Province) and thus difficult to separate for the single islands. However in the Management Plan

approximate figures for 2005 have been calculated [29]. The data lists 187 tourist accommodation facilities on the islands (45% on Lipari) with a total of 4.009 beds, of which 79% in hotels and 21% other accommodations. The official visitor numbers are indicated with almost 410.000 presences/year, of which 68% in summer season, 12% in spring and 19% in autumn, in winter tourists are almost absent. It is estimated that in the three summer months, additional 200.000 not registered visitors are present on the islands. On Lipari, the estimations for August 2003 are indicated with over 1 million visitors, among them 126.000 registered and 917.000 "hidden" visitors. The authors of the Management Plan worry about this alarming situation, since in the period with the highest frequencies, the effective numbers of visitors are almost 10 times higher than the official numbers of registered visitors, which is also due to boat and cruise ship tourists which did not appear in the statistics [29].

The status as a World Heritage Site was furthermore threatened by Italy's failure to prevent the building of 4 new harbors. However, the islands are currently still on the World Heritage List without establishing services and facilities to uphold the WH site integrity.

4 Presence of Tuscan and Aeolian Island's on Social Media

The Results of the Analysis are presented in the tables 3 - 6 as follows:

- Instagram: Total numbers of posts,
- Trip Advisor: Total number of reviews related to: tourist hotspots and overall tourist facilities (e.g. attractions and businesses),
- Airbnb: Total number of: lodging rentals in each locality, lodging rentals without reviews, reviews.

4.1 Presence of Tuscan Island Biosphere Reserve on Social Media

The presence of islands, islets, and skerries within the Tuscan Islands Archipelago on three analyzed social media platforms is presented in Table 3. Visualization of the analysis outcome is presented in Figure 3 (Instagram) and Figure 4 (TripAdvisor).

Since the islands Montecristo, Scoglietto di Portoferraio, Cèrboli, Palmaiola, Grosseto, Gorgona are almost uninhabited and do not have any tourism infrastructure, they are not present on TripAdvisor and Airbnb. The visitor numbers are limited and/or it is possible to visit them only on guided tours. Tourism has little negative impacts since it is completely organized and controlled. Therefore, they are scarcely present on Instagram. Skerries such as Formiche della Zanca, Montecristo, Capraia, Palmaiola, Scoglio d'Africa are not present on social media due to the lack of both inhabitants and visitors. They are protected and therefore managed by the National Park authorities.

Pianosa is the island with the former security prison and agricultural penal colonies. Today, the island is completely protected with limited access to tourists on guided tours. Therefore, there are no Airbnb lodging rentals on the island. The existing businesses and attractions result in higher presence on Instagram as well as on TripAdvisor. Giannutri is open for public access only in summer season and with a few inhabitants. Therefore, it is visible on all three social media platforms – although with low numbers.

Table 3. Presence of islands, islets, and skerries of the Tuscan Islands Archipelago on Instagram, TripAdvisor, and Airbnb (April 7 – 24, 2020).

Islands and skerries	***Instagram***	***TripAdvisor***			***Airbnb***		
	Nº posts	Nº reviews (hotspots)	Nº reviews (facilities)		Nº rentals	w/o reviews	Nº reviews
			Attraction	Business			
Elba	734.378	2.967	23.072 (12 %)	160.789 (88 %)	2.714	1.069	16.904
Giglio	90.728	63	2.291 (16 %)	11.310 (83 %)	109	28	1.561
Capraia	27.208	5	132 (3 %)	3.705 (97 %)	33	6	438
Giannutri	12.136	104	80 (67 %)	39 (33 %)	12	5	56
Pianosa	8.715	5	410 (88 %)	51 (11 %)	0	0	0
Montecristo	1.730	0	0	0	0	0	0
Scoglietto di Portoferraio	1.529	0	0	0	0	0	0
Cèrboli	1.194	0	0	0	0	0	0
Palmaiola	1.191	0	0	0	0	0	0
Grosseto, Gorgona	396-691	≤8	≤8	0	0	0	0
*Others**	≤10	0	0	0	0	0	0

*Formiche della Zanca, Montecristo, Capraia, Palmaiola, Scoglio d'Africa.

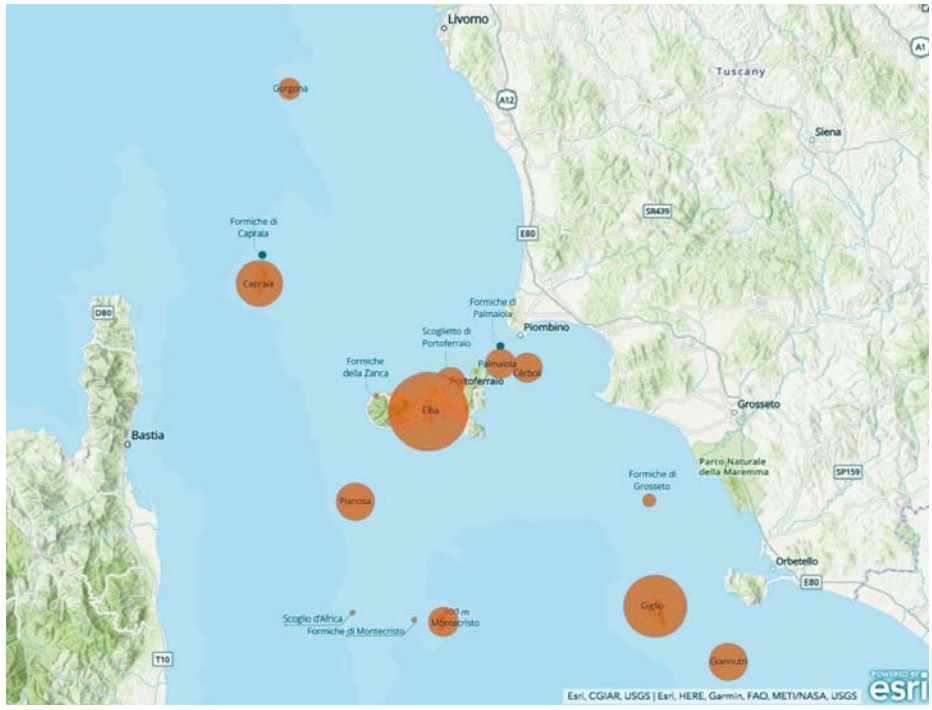

Figure 3. Presence of islands, islets, and skerries within the Tuscan Islands Archipelago on Instagram (April 7 – 24, 2020), Copyright © 2020 Esri and its licensors [31].

Figure 4. Presence of islands, islets, and skerries within the Tuscan Islands Archipelago on TripAdvisor (April 7 – 24, 2020) Copyright © 2020 Esri and its licensors [31].

More than a half of Airbnb lodging rentals in Elba and Giannutri do not have any reviews (with Elba having much broader offering). It can be interpreted that there is a lower demand for these particular lodgings or as an increase of Airbnb lodging offers only recently – especially, in Elba.

Elba, Giglio, and Capraia are inhabited and islands with vivid tourism activities. The presence of the mentioned islands on social media platforms is rather high – on TripAdvisor, it mainly relates to the high number of businesses. The three islands are governed by the municipalities, and the authority of the National Park is limited to the protected areas. In addition, they are the only islands within the archipelago with official and active profiles on Instagram followed by the profile of Pianosa where lesser activity can be observed.

4.2 Presence of Aeolian Islands World Heritage Site on Social Media

Islands and skerries such as Lisca Nera, Bottaro, Isola di Basiluzzo, Scoglio la Nave, Isola di Lisca Bianca, Le Guglie are all inside the core zone of the World Heritage Site and have rather low presence on Instagram with no presence on other platforms.

Filicudi, Alicudi, and Panarea are protected and inside the World Heritage core zone. They have rather small number of inhabitants – less than 250. However, their presence on social media is high which could be related to the visitors.

Table 4. Presence of islands, islets, and skerries within the Aeolian Islands Archipelago on Instagram, TripAdvisor, and Airbnb (May 6 – 18, 2020).

Islands and skerries	***Instagram***	***TripAdvisor***			***Airbnb***		
	Nº posts	Nº reviews (hotspots)	Nº reviews (facilities)		Nº rentals	w/o reviews	Nº reviews
			Attraction	Business			
Lipari	264.343	2.664	3.942 (8 %)	46.196 (92 %)	646	203	6.707
Stromboli	166.194	2.113	1.870 (15 %)	10.568 (85 %)	222	50	3.894
Salina	148.400	46	811 (4 %)	18.715 (96 %)	324	100	2.187
Panarea	142.877	440	527 (6 %)	7.717 (94 %)	85	28	503
Filicudi	43.989	174	189 (11 %)	1.556 (89 %)	66	36	263
Alicudi	28.632	12	18 (4 %)	400 (96%)	51	5	689
Vulcano	15.652	3.265	4.102 (18 %)	19.120 (82%)	194	74	1.327
*Others**	≤159	≤4	≤4	0	0	0	0

*Lisca Nera, Bottaro, Isola di Basiluzzo, Scoglio la Nave, Isola di Lisca Bianca, Le Guglie.

The other islands – Lipari, Stromboli, Salina, and Vulcano - encompass between 15-25% of conservation areas with above 300 inhabitants and a high social media presence. They have a high number of Airbnb lodging rentals compared to the other islands. Presence of Salina on TripAdvisor is high but with a few tourist attractions.

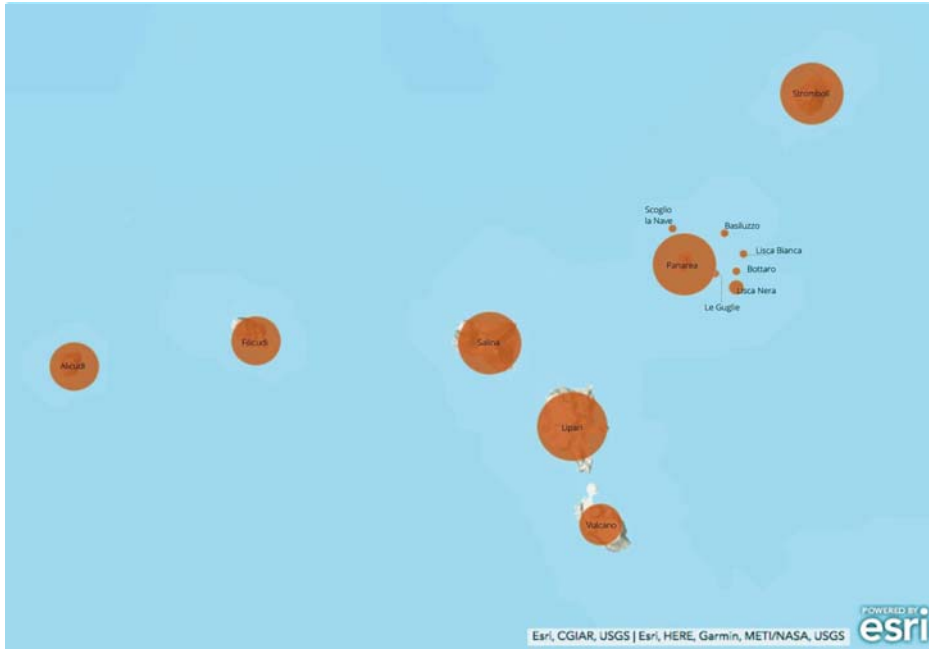

Figure 5. Presence of islands, islets, and skerries of the Aeolian Islands Archipelago on Instagram (May 6 – 18, 2020). Copyright © 2020 Esri and its licensors [31].

Figure 6. Presence of islands, islets, and skerries of the Aeolian Islands Archipelago on TripAdvisor (May 6 – 18, 2020). Copyright © 2020 Esri and its licensors [31].

Around $^{1}/_{3}$ of Airbnb lodging rentals in Lipari, Salina, Panarea, and Vulcano has no reviews. It means that the demand for these lodgings is lower compared to others or that there is an increase of lodging offers on these islands. Stromboli and Vulcano are mainly visited by those interested in activities of volcanos – e.g. adventure tourists, geoscientists.

The data from 2005 shows that there were 187 tourist accommodation facilities within the whole archipelago – Lipari 85; Stromboli, Panarea, Vulcano, Salina ≤25; Filicudi and Alicudi ≤6 [29]. Construction of new facilities has been denied in 2007 since it was not compatible with the Territorial Landscape Plan [28]. However, 13 years later, there is an exponential increase of tourist accommodation offers within the archipelago which can be related to the inhabitants and second-home owners who saw an opportunity in increased tourism demand. In 2014 were reported already 261 accommodation facilities [32]. In the meantime, Airbnb has been launched which gave hosts an opportunity to connect with potential visitors.

In regard with the official presence of the Aeolian Islands on social media, there is an active profile on Instagram which relates to the whole archipelago. Other profiles relate to the Vulcano and the Salina Island (the latter has been inactive for a couple of years). Lack of official social media presence results in the lack of communication of cultural and natural values of a protected area.

4.3 Comparison of Elba and Lipari Islands

The data used to visualize the analysis outcome is the total number of posts (in Instagram) and the Total number of reviews-overall tourist facilities (Table 5 and 6).

Table 5. Presence of the localities within the Elba Island on social media – Instagram, TripAdvisor, and Airbnb (April 7 – 24, 2020).

Isola d'Elba - localities	***Instagram***	***TripAdvisor***			***Airbnb***		
	Nº posts	Nº reviews (hotspots)	Nº reviews (facilities)*		Nº rentals	w/o reviews	Nº reviews
			Attraction	Business			
Portoferraio	74.639	735	8.057 (20 %)	33.028 (80%)	335	134	2.473
Capoliveri	57.817	1.177	3.387 (9 %)	33.399 (91 %)	699	324	3.213
Porto Azzurro	41.870	222	522 (2 %)	20.641 (98 %)	256	76	1.926
Marciana Marina	30.677	1	331 (3 %)	10.372 (97 %)	212	84	1.215
Rio Marina	16.253	40	1.285 (10 %)	11.179 (90 %)	121	40	875
Marciana	15.107	694	2.979 (14 %)	17.682 (86 %)	441	147	3.109
Rio nell'Elba	4.191	98	206 (9 %)	2.144 (91 %)	289	105	1.868
Campo nell'Elba	3.610	0	1.762 (33 %)	3.643 (67 %)	361	159	2.225

*Number of reviews relates to the number of attractions and businesses in each locality that have been listed on TripAdvisor: Portoferraio 43 attractions:146 businesses, Capoliveri 35:182, Porto Azzurro 10:85, Marciana Marina 10:107, Rio Marina 13:85, Marciana 21:66, Rio nell'Elba 5:32, Campo nell'Elba 7:196.

The Municipalities of Portoferraio (Elba Island) and Lipari (Lipari Island) are the most present on social media – especially, on Instagram and TripAdvisor – compared to the other municipalities and localities. The number of businesses listed on TripAdvisor is significantly higher than the number of attractions of both islands. Presence of central parts of the islands on social media is low or almost non-existent, which means that the official communication made by tourism responsible as well as the content generated by the visitors relate mainly to the SSS-based tourism ("Sun, Sand, Sea").

Table 6. Presence of the localities within the Lipari Island on social media – Instagram, TripAdvisor, and Airbnb (May 6 – 18, 2020).

Lipari - localities	***Instagram***	***TripAdvisor***			***Airbnb***		
	Nº posts	Nº reviews (hotspots)	Nº reviews (facilities)*		Nº rentals	w/o review	Nº reviews
			Attraction	Business			
Lipari	264.343	1.194	46.262		255	61	3.543
Quattropani	1.717	740	819 (99 %)	6 (1 %)	37	16	201
Pianoconte	601	49	0	198 (100 %)	98	39	982
Canneto	213	681	902 (32%)	1.951 (68 %)	206	71	1.388
San Salvatore	3	0	0	0	28	6	449
Porticello	0	0	0	0	22	10	144

* Number of reviews relates to the number of attractions and businesses in each locality listed on TripAdvisor: Lipari 31 attractions/210 businesses, Quattropani 1/20, Pianoconte 0/39, Canneto 5/101, San Salvatore 0/13, Porticello 0/21.

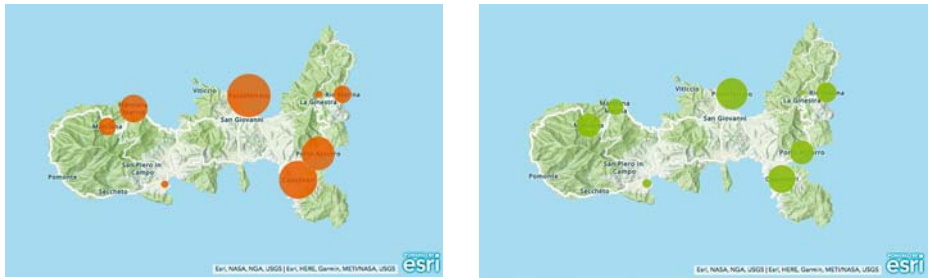

Figure 7. Presence of the municipalities within the Elba Island on Instagram (left) and Trip Advisor (right) (April 7 – 24, 2020). Copyright © 2020 Esri and its licensors [31].

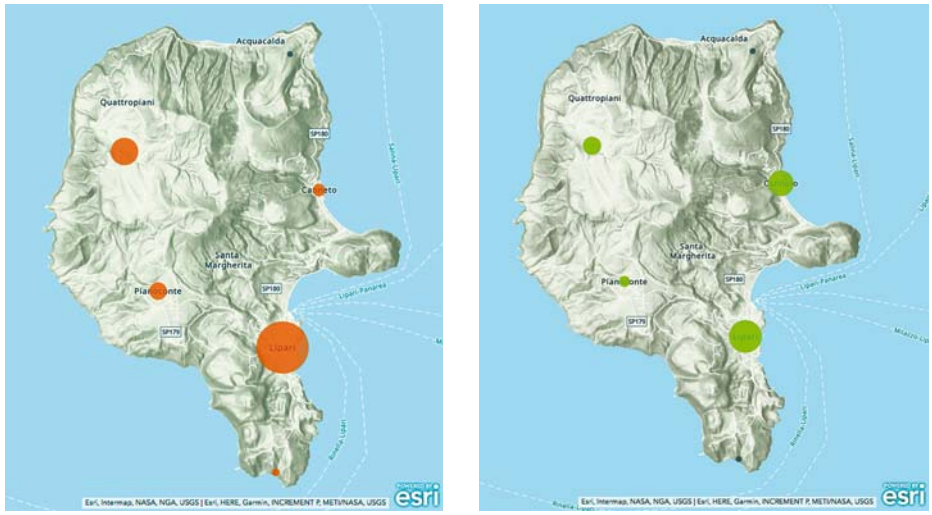

Figure 8. Presence of the localities/geographical areas within the Lipari Island on Instagram (left) and TripAdvisor (right) (May 6 – 18, 2020). Copyright © 2020 Esri and its licensors [31].

As a result of a very dry climate, the south-western part of Elba is less visited by tourists; hence its presence on social media is low.

Although Lipari encompasses six times smaller area with a lower number of inhabitants (three times lower) compared to Elba, presence of certain localities of the Lipari Island on social media is surprisingly high. Especially, on Airbnb – e.g. Lipari and Canneto. Areas of San Salvatore and Porticello, almost completely inside the heritage perimeter, have between 20-30 Airbnb lodging rentals.

The Port of Lipari – one of the three official ports in the archipelago - has been enlarged to accommodate increased tourism demand. In addition, non-official visits have been recorded and are around ten times higher from what has been recorded as official visits to the island and the overall area. Non-official visits are mainly related to nautical tourists that use private boats or cruise ships as both means of transportation and accommodation during their stay. This increases the number of anchorages in the archipelago and this type of tourists consume local resources and spend very little while producing direct and indirect negative effects.

Considering the size of Lipari, the protected area that the island encompasses, the number of visitors, the presence on social media – particularly, the area around the Lipari locality – it can be concluded that tourism activities might be in conflict with the values of protected areas. With an enlargement of the Port of Lipari which provided a better accessibility as well as with uncontrolled visitor flows, the island is threatened by the risk of deterioration of natural and cultural values which may effect and could be diffused throughout all the archipelago.

5 Conclusions

The Biosphere Reserve Framework as well as the World Heritage Convention represent excellent opportunities to establish holistic GMS, balancing conservation and sustainable development. Instead the Tuscan Islands as well as the Aeolien Islands have elaborated comprehensive and excellent management plans, submitted to national and regional authorities and UNESCO respectively, but they are not yet enacted. The social media analysis reflect these circumstances, since a visitors management is realized only in the strictly protected areas of both archipelagos. In areas included in the buffer and transition zones in the preliminary BR and WH management plans, no tourism regulations can be recognized.

The study shows that social media reflect the

- attractiveness of natural and cultural heritage,
- ways in which cultural, natural, and other aspects of destinations or spots are perceived and interpreted by visitors,
- numbers (especially "hidden" or unofficial) of hospitality services,
- quality services of tourism businesses through reviewing processes,
- tourism flows as well as management strategies and plans put into action,
- quality of territorial governance and management and its implementation.

Tourism on the Tuscan and Aeolian Islands is mainly driven by domestic demand. This is visible on social media, since Italian is the main language used for hashtags and reviews, followed by German and English.

The major part of the Tuscan Archipelago is governed and managed by the National Park authority. Therefore the islands of Montecristo, Scoglietto di Portoferraio, Cèrboli, Palmaiola, Grosseto, Gorgona, Pianosa as well as the skerries are completely or almost completely protected, and have very strict visitor management regulations regarding limits and organization, like guided tours and seasonal access, in place. The results of the social media analysis of tourism attractions and businesses confirm that tourism is well-managed and controlled, thanks to the National Park authorities in the Tuscan Islands. The touristic islands Elba, Giglio, and to a less extent Capraia are still managed by the municipalities, and only the protected areas are under the surveillance of the National Park authority. The BR integrated management plan would overstep the NP GMS, help to reduce negative tourism related impacts and foster the sustainable development of the entire archipelago, including the buffer and transition zones.

In the Aeolian Archipelago, the islands Lipari, Stromboli, Salina, and Vulcano show uncontrolled tourism development. They are not governed and managed by WH authorities as foreseen in the NP and WH management plans. In the WH Management

Plan, the authors pointed especially to the conflicts of tourism regarding the island's limited resources and impacts on the socio-economic system and concluded that the resource use has to be planned and assessed carefully in order to achieve a sustainable tourism development [29]. The protected areas in Lipari (Lipary Reserve), Salina (landscape protection) and the islands Alicudi, Filicudi, Panarea and Stromboli (natural reserves) are under the authority of the management consortium established by the municipalities Lipari and Salina. Hence, a consortium with 20 governmental and non-governmental, local, regional and national institutions is almost paralyzed and little effective in implementing the targets of the launched National Park and UNESCO World Heritage site. The result of the social media analysis reveal the intensive tourism activities even within the core area of the WH perimeter (e.g. Alicudi, Filicudi). A study on tourism development in the WHS Mount Etna and Aeolian Islands concluded, that such sites should focus on the "promotion of a destination as an integrated system of goods and services, while reducing seasonality and extending the tourist season" [32].

Uncontrolled tourism contributes to the unsustainable use of resources which, in a long term, will result in limited development of tourism once natural and cultural resources become scarce. Implementing the BR and the WH frameworks and GMS would force especially the Elba and Lipari Islands to introduce sustainable development strategies. For island destinations with uncontrolled tourism and high tourism impacts, social media analysis represent excellent planning and monitoring tools for sustainable tourism development, to balance over and under tourism places, but also to foresight trends and track changes in visitor's perception.

A changed tourism paradigm for the UNESCO designated archipelago sites is urgently needed and should be based on local evidences, giving priority to those services and businesses respecting the values of the place. A "heritage stewardship destination" model, focusing on quality tourism which involves all actors in the decision-making processes could create benefit for locals and visitors, offer opportunities to jointly engage in the conservation of the internationally recognized heritage, improve living standards and visitors experience, and share equally costs and benefits. Social media could be instrumentalized to create community platforms to educate potential visitors and residents and to promote the destination's beauty and particularity while at the same time, serve to raise awareness and capacity building regarding heritage values and conservation.

The World Heritage Centre should seriously consider to assess the state of endorsement and implementation of management plans of World Heritage sites and Biosphere Reserves. Furthermore, the World Heritage Committee should be invited to decide about including properties with a lack of implementation of management plans on the List of WH in danger more rapidly, based on the missing performance in conservation and development. At present, the management plans of the two archipelagos have not yet been endorsed nor implemented since they must adhere to the endless procedures and bureaucracies required. The governance and management systems of the designated areas have to be immediately enacted to allow measures and to avoid negative impacts through environmental changes already started. ICT applications and social media further enable the analysis and monitoring of tourism development, which may become out of control and create additional impacts on the local resources as well as the natural and cultural heritage of the islands.

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The book presents current Governance and Management Systems of Protected Areas, assessing their appropriateness to face future challenges, providing reciprocal benefits to local communities and environment. Eight articles reflect the main threats accelerating negative impacts on marine ecosystems such as climate change, invasive alien species, marine litter, tourism. How can marine and terrestrial Protected Areas such as Biosphere Reserves, Natural and Cultural World Heritage sites, Natura 2000 areas, National and Regional Parks, and marine observatories increase their response mechanisms? Considerations for new paradigms related to the protection of the marine environment are presented and experts discuss recommendations for the transformation of the Governance and Management Systems.

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