

Enhancing social well-being and economic prosperity by reinforcing the EFFECTIVENESS of protection and restoration management in Mediterranean MPAs

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Abstract – Enhancing scientific understanding and providing practical guidance for safeguarding and rejuvenating the EU's Mediterranean Blue Natural Capital employing an Ecosystem-Based Management (EBM) approach.

Keywords - Natural capital, Ecosystem services, Ecosystem-Based Management System, Digital Twin of the Ocean.

I. INTRODUCTION

The EFFECTIVE project (Project: 101112752 - EFFECTIVE - HORIZON-MISS-2022-OCEAN-01) is dedicated to advancing scientific knowledge and practical guidance for the protection and restoration of the EU's Mediterranean Blue Natural Capital. Integrating science, nature-based technological solutions, digitalization and social considerations, the project applies an Ecosystem-Based Management (EBM) approach.

Based on the concepts of the Ecosystem Approach (EA) and EBM, the EFFECTIVE project builds on the expertise gained in the previous EU FP7 project KnowSeas. The project introduced the Ecosystem-Based Management System (EBMS), a standardized methodology that incorporates a three-pillar structure (management, information, participation) and provides a common set of tools and procedures to facilitate knowledge transfer and capacity building for managers [1]. Aligned with sustainable development principles and focused on the provision of ecosystem services, the EBMS seeks to achieve vision-based management objectives.

Recognizing the critical role of Marine Protected Areas (MPAs) in conserving biodiversity and managing ecosystem services, this project applies the vision established in the EBMS to MPA management. Specific objectives include the application of the EBMS to identify, analyze and extend an ecological corridor in the Mediterranean Sea that connects habitats and biodiversity. In addition, the project aims to analyze and expand the status of MPAs in the Mediterranean. The project will demonstrate nature-based solutions for seabed protection and restoration, emphasizing the preservation of seabed carbon sequestration capacity in real environments. It will also identify limiting factors,

gaps and governance issues in existing MPA legislation related to environmental and anthropogenic pressures. Building on previous projects, EFFECTIVE aims to implement an innovative digital data visualization and aggregation tool in the form of a Digital Twin (Blue Parks Digital Twin). This tool will enable data exploration, research, participation and citizen science.

II. STUDY AREA

The research focuses on four different groups of sites in the Mediterranean basin, all recognized as biodiversity hotspots:

- Pilot Area 1 - Mar de L'Empordà (Western Mediterranean): designated as a Key Biodiversity Area [2] in Spain, it hosts seven coexisting Marine Protected Areas (MPAs). In addition, there is a specific co-management and governance instrument for this Natura 2000 site, known as Litoral del Baix Empordà.
- Pilot Area 2 - Ebro Delta Bays (Western Mediterranean): established as a Marine Protected Area (MPA) and a Natura 2000 site, it represents a unique and delicate combination of coastal protected areas in Spain.
- Pilot Area 3 - Sardinia Septentrional (Central-Western Mediterranean): comprising the La Maddalena Archipelago National Park, the Tavolara-Punta Coda Cavallo MPA and the Archipelago Toscano National Park in northeastern Sardinia, Italy, this area includes two different protected figures.
- Pilot Area 4 - Cavo Greco (Eastern Mediterranean): located adjacent to the recently established Cape Greco MPA (2018) in the eastern part of the island of Cyprus, it is considered part of the Natura 2000 network.

In addition, the Mediterranean Sea serves as an important

Martech 2024.
Marine Technology Workshop
06, 07th June. Palma, Balearic Islands, Spain

scenario for cetacean migratory routes, particularly from the Strait of Gibraltar to the coasts of northwestern Italy. These routes are legally protected by the Cetacean Migration Corridor (near Pilot Areas 1 and 2) and the Pelagos Sanctuary (near Pilot Area 3).

III. MONITORING, ANALYSIS, AND VISUALIZATION

Effective EA relies on spatial data because of its emphasis on social-ecological systems. The process requires multidisciplinary data covering both environmental and human characteristics, including physical, chemical, biological and socio-economic aspects. The information pillar of the EBMS plays a key role in this respect, requiring a detailed in-situ characterization of the benthic ecosystem and a digital management tool, all underpinned by a comprehensive monitoring and spatio-temporal forecasting system - embodied in the overarching concept of a Digital Twin Ocean.

Dedicated monitoring practices of marine and oceanographic conditions are in place in all EU maritime bordering countries. This includes both research activities and structured continuous monitoring. The data generated are indexed and harmonized on a European scale through aggregators such as EMODnet, SeaDataNet, EuroBIS, CMEMS INSTAC, which also support initiatives such as Blue-Cloud. Scientists gain access to this data in a cloud-based virtual research environment. A dedicated dataflow will be established to feed models and integrate with the Blue Parks Digital Twin demonstrator.

The demonstrator application unfolds in two parts:

i) A 2D browser-based Digital Twin presented as an interactive WebGIS application. Users gain insight into selected Blue Parks by accessing the best available data and information from regional and international sources, as well as model outputs from existing providers and those developed within the project.

ii) A 3D browser-based Digital Twin designed with a more accessible and engaging approach. This "gamified" insight immerses users in the underwater ecosystem of a Blue Park, allowing them to virtually dive, move around, view information, and get a sense of the fragile life forms being protected and the threats they face. This application strategically supports the project's communication activities and serves as a call to action for citizens to participate as citizen scientists.

The results of the methodology are in line with the H2020 ILIAD Digital Twin of the Ocean project and contribute significantly to the EU mission's Digital Ocean.

On the other hand, the available datasets may not fully meet the complex requirements of the EFFECTIVE project. To address this challenge, the project recognizes the imperative need for a continuous and dedicated monitoring program throughout all phases. To overcome this limitation, one solution could be to actively engage

with local public or private entities to acquire additional pertinent data. This collaborative effort aims to complement the existing data sets and ensure a more thorough and tailored understanding of the pilot areas.

IV. CONCLUSIONS

In summary, the EFFECTIVE project aims to comprehensively manage and restore the Blue Natural Capital of the EU Mediterranean. While benefiting from existing marine data, the project recognizes the need for more tailored information. To fill this gap, a continuous monitoring program is essential. The project aims to work strategically with local entities to acquire additional data, fostering partnerships for more effective identification of ecological corridors and nature-based seabed protection. This approach not only enhances the success of the project, but also establishes a framework for sustainable management and conservation in the Mediterranean.

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