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Long-Lasting Ecological Monitoring Network of Lander Platforms for Marine Protected Areas

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Abstract **– In addition to the potential global impact of climate change on marine ecosystems, the extensive use of high-impact fishing methods is a primary catalyst for benthic biodiversity degradation in the Mediterranean Sea. Implementing fishery no-take zones (FNTZs) emerges as a key measure for the sustainable recovery and management of overexploited stocks and habitats. To identify appropriate geographical scales for their implementation, it is crucial to understand the spatial connectivity of species and ecosystem functioning during long periods. Therefore, it is necessary to implement robust spatio-temporal multiparametric monitoring procedures, allowing the synchronous collection of biological (i.e., image-based), oceanographic and geochemical data. For this, we developed a spatial cooperative network of fixed (i.e., landers) and docked mobile (i.e., AUVs) platforms with wireless intercommunication capability (i.e., by acoustic modems). This system is designed for intelligent observation monitoring and mapping (i.e., AI-based recognition of species and bioturbation features) over extended periods with real-time, remote supervision and data transmission through the water column to an ASV.**

Keywords *- Seafloor Ecosystem Monitoring, Benthic Lander, Marine Technology, Marine Instrumentation, Acoustic Tracking and Tagged Animals.*

I. INTRODUCTION

Monitoring of cyclic changes in commercially exploited deep-sea ecosystems is essential to establish baseline data [1] for reliable impact assessments through the computing of ecological indicators [2]. Monitoring biodiversity over extended periods can be achieved with cabled video-observatories, collecting transdisciplinary oceanographic and biogeochemical data [3-4]. Despite the high power and high bandwidth access, the utilization of these platforms is limited due to deployment and maintenance costs [5], coupled with spatial limitations of ecological representativeness. Cooperative networks of spatially arranged, autonomous multiparametric observatories (landers) and permanently stationed (i.e., via Docking Stations-DSs) Autonomous Underwater Vehicles (AUVs) can circumvent these challenges in monitoring spatially heterogenous habitats. This work presents the development of such a network of platforms and the results of its first deployment in a deep-sea (380 m) NW Mediterranean FNTZ.

II. THE NETWORK OF MONITORING PLATFORMS

The proposed modular network of platforms is spatially adaptable and capable of intelligent (AI-based) monitoring, and mapping of local biodiversity and environmental status over extended periods with near real-time supervision. This innovative platform integrates independent benthic stations, AUVs, and Autonomous Surface Vehicles (ASVs), all wirelessly connected for seamless coordination.

As illustrated in Figure 1, the AUV provides extensive measurements at a spatial level, and lander stations ensure continuous high-rate temporal monitoring. Each system operates on its own rechargeable batteries, providing a lifespan ranging from weeks to a month. The AUV routinely docks at one of the lander stations in standby mode for wireless data transmission and battery recharging. Additionally, an ASV at the surface receives real-time data from both the lander stations and the AUV, transmitting it promptly to shore stations. Communication between lander stations and autonomous vehicles occurs via either acoustic or optic links.

Utilizing environmental sensors, imaging (i.e., cameras) and acoustic (i.e., hydrophones) devices, the platforms collect diverse biological, geochemical, and oceanographic data. Subsequently, advanced computer vision techniques are applied to detect, classify, count, and size individuals, to be geo-referenced and overlayed on seabed maps. These are passed through automated data-processing and multiparametric analysis routines to calculate ecological indicators (e.g., species surface density and biomass) and their connection with habitat conditioning.

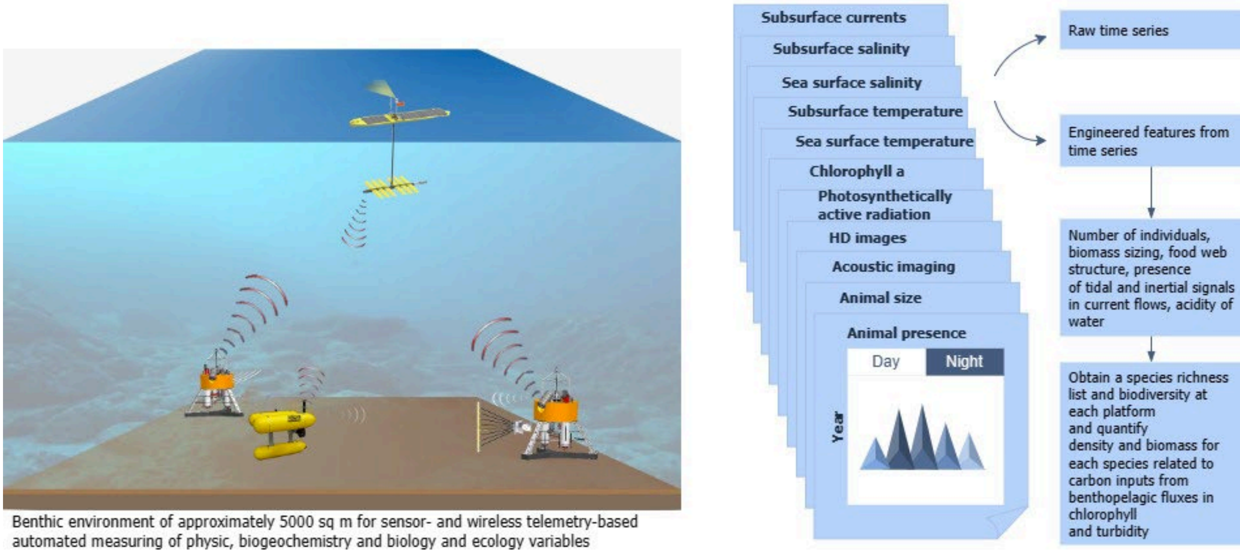

Figure 1. Overview of the long-lasting marine ecological monitoring platform

In December 2023, we deployed off Barcelona a network comprised by 2 lander stations 200 m apart, a Girona 1000 AUV and an ASV. The platforms successfully completed a week-long observational survey, monitored by the R/V Sarmiento de Gamboa. During the deployment, each lander has taken observations every 30 minutes, and on request from the ASV it transmitted the last observations to shore station located at OBSEA facilities. Moreover, based on the acoustic positioning provided by the two landers, the Girona 1000 AUV has performed several transects in the area between them. At the end of each transect, an optical connection has been established between the Girona 1000 AUV and one of the landers, in order to perform two-way transfer of large amount of data acquired during the mission. Finally, on request from the shore station, relevant information from these missions could be send by the lander through ASV using the underwater acoustic link and the aerial satellite link.

III. CONCLUSIONS

This work represents a step towards establishing a deployable, upgradeable instrumentation, designed to meet the specifications for autonomous monitoring of deep-sea ecosystems affected by fishing, that is accessible to the broader community of marine scientists, encompassing both research and industry sectors. Moreover, the platform's adaptability allows for tailor-made configurations to meet the requirements of managing and safeguarding deep marine or coastal ecosystems. This flexible and cost-effective concept not only achieves the desired impact but is also user-friendly and requires minimal maintenance.

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