MODULE 5: SMART OBSERVATIONS FOR BOOSTING INNOVATION IN MONITORING AND BLUE GROWTH

1. OBJECTIVES

- To introduce the concept of smart observations within the context of the Blue Economy, adaptive ecosystem-based management, and digital transformation of marine monitoring systems.
- To evaluate and compare advanced marine observation tools (such as eDNA and metagenomics, passive acoustics, electrochemical sensors, hydroacoustic detectors, radioactivity sensors, and imaging flow cytometry coupled with AI/ML) with respect to their scientific principles, operational applicability, and technological maturity.
- To assess the capacity of smart observation technologies to enhance environmental monitoring, strengthen early-warning systems, and support policy frameworks such as the Marine Strategy Framework Directive (MSFD), Black Sea Strategic Research and Innovation Agenda (SRIA), and UN Ocean Decade objectives.
- To analyse limitations, uncertainties, and integration challenges associated with the adoption of innovative observation tools, including issues of data standardisation, interoperability, quality assurance/quality control (QA/QC), and compatibility with conventional monitoring approaches

2. INTRODUCTION

Within the Blue Economy and Blue Growth policy frameworks, smart observations enable the transition from traditional, labour-intensive, and low-frequency sampling regimes towards continuous, high-frequency, multi-parameter monitoring, capable of capturing dynamic ecosystem processes in near real time. Their deployment supports innovation in the marine sectors by:

- enabling early detection of environmental stressors and hazards (e.g., harmful algal blooms, jellyfish blooms, underwater noise, marine radioactivity, deoxygenation, pollution events),
- facilitating the development of data-driven decision-support tools, digital twins, and predictive ecosystem models,
- underpinning sustainable resource use, risk reduction, and climate-resilient blue economic activities.

In the Black Sea region, smart observations align with the Black Sea Strategic Research and Innovation Agenda (SRIA) and the UN Ocean Decade priorities on digital ocean systems, fit-for-purpose services, and science-policy-industry integration. Within this context, the EU-funded BRIDGE-BS project serves as a key driver of innovation by piloting cost-effective and scalable technologies that complement established monitoring practices.

This module situates smart observations as both a scientific and operational paradigm shift, exploring their methodological foundations, application potential, and implications for adaptive management. The module also examines the scientific outcomes of several BRIDGE-BS pilot studies, which collectively demonstrate how innovative observation tools can enrich our understanding of Black Sea ecosystem functioning and strengthen early-warning and decision-support capacities.

3. READING SUGGESTIONS

- Deliverable 5.3 Report on assessment of conventional and e-DNA based biodiversity methods and observations (https://zenodo.org/communities/bridge-bs/records?q=&l=list&p=1&s=10&sort=newest)
- Deliverable 5.5 Technology advance report: Featuring the full analyses of new potential monitoring technologies for Black Sea, and multistressors early warning system demonstrator in support of sectors and ecosystem services (https://zenodo.org/communities/bridge-bs/records?q=&l=list&p=1&s=10&sort=newest)
- Danovaro, R., Carugati, L., Berzano, M., Cahill, A.E., Carvalho, S., Chenuil, A., Corinaldesi, C., Cristina, S., David, R., Dell'Anno, A. and Dzhembekova, N., 2016. Implementing and innovating marine monitoring approaches for assessing marine environmental status. Frontiers in Marine Science, 3, p.213. https://doi.org/10.3389/fmars.2016.00213
- Chavez, F.P., Min, M., Pitz, K., Truelove, N., Baker, J., LaScala-Grunewald, D., Blum, M., Walz, K., Nye, C., Djurhuus, A. and Miller, R.J., 2021. Observing life in the sea using environmental DNA. Oceanography, 34(2), pp.102-119. https://doi.org/10.5670/oceanog.2021.218
- Dashkova, V., Malashenkov, D., Poulton, N., Vorobjev, I. and Barteneva, N.S., 2017. Imaging flow cytometry for phytoplankton analysis. Methods, 112, pp.188-200. http://dx.doi.org/10.1016/j.ymeth.2016.05.007

4. EXTERNAL LINKS

- https://www.cytobuoy.com/products/cytosense-c/
- https://www.fytoplankton.nl/easyclus/