MODULE 2: BLACK SEA DIGITAL TWIN OCEAN DEMONSTRATOR

1. OBJECTIVES

- Understanding the concept and vision of the European Digital Twin of the Ocean (EDITO) and how it supports the EU Mission "Restore Our Ocean and Waters."
- Learning how the Black Sea Digital Twin Demonstrator integrates observations, models, AI-based emulators, and user interfaces to represent the state of the sea in near-real time.
- Exploring the key components of the Black Sea DTO system - physical & biogeochemical models, higher trophic level (HTL) models, resilience assessment, cumulative effects assessment and socio-economic layers.
- Understanding how the DTO enables scenario simulations (e.g., SSP1-2.6 vs SSP5-8.5 or pollution scenarios) and supports decision-making through interactive dashboards.
- Becoming familiar with the connection between scientific modelling, data services, and policy applications in the context of the Black Sea DTO.

2. INTRODUCTION

The Digital Twin of the Ocean (DTO) is a virtual replica of the ocean that integrates real-time data, numerical models, artificial intelligence, and visualisation tools. It enables scientists, policymakers, and citizens to explore "what-if" scenarios and understand how human and climatic pressures shape marine systems. This module introduces the Black Sea Digital Twin of the Ocean System, a regional demonstrator developed under the BRIDGE-BS within the broader EDITO-Infra initiative.

It provides an overview of its scientific backbone - the physics-BGC coupled models, which represent physical circulation and ecosystem processes and its AI-based extensions, such as the Emulator, that accelerate predictions. Participants will also discover different application modules, such as the Resilience Assessment, Cumulative Effects Assessment and Socio-economics layers to allow users to interact with data, compare future pathways, and explore the effects of management decisions.

Overall, this topic serves as a foundation for understanding how digital technologies and marine science converge to support sustainable development in the Black Sea.

3. READING SUGGESTIONS

- EDITO-Infra. (2024). DOF 2024 Report: Scientific & technical workshop summary. https://edito-infra.eu/wp-content/uploads/2024/10/DOF2024_REPORT.pdf
- AGU Fall Meeting 2024, held in Washington, D.C., 9-13 December 2024, Session: Informatics / Advanced Digital Twin Information Systems and Earth Action II Oral, id. IN53C-02. https://ui.adsabs.harvard.edu/abs/2024AGUFMIN53C..02A/abstract

- Tonani, M., Chassignet, E., Cirano, M., Miyazawa, Y., and Pérez Gómez, B.: Ocean forecasting at the regional scale: actual status, in: Ocean prediction: present status and state of the art (OPSR), edited by: Álvarez Fanjul, E., Ciliberti, S. A., Pearlman, J., Wilmer-Becker, K., and Behera, S., Copernicus Publications, State Planet, 5-opsr, 3, https://doi.org/10.5194/sp-5-opsr-3-2025, 2025. https://sp.copernicus.org/articles/5-opsr/3/2025/
- El Aouni, A., Gaudel, Q., Johnson, J. E., Regnier, C., Le Sommer, J., van Gennip, C., Fablet, R., Drevillon, M., Drillet, Y., & Le Traon, P. Y. (2025). OceanBench: A benchmark for data-driven global ocean forecasting systems. NeurIPS 2025 Datasets and Benchmarks Track. https://openreview.net/forum?id=wZGe1Kqs8G

4. EXTERNAL LINKS

- EU Mission: Restore our Ocean and Waters; EU Mission: Restore our Ocean and Waters
- European Digital Twin of the Ocean European Digital Twin of the Ocean (European DTO) - Research and innovation
- EDITO Technology European Digital Twin Ocean - Core Technology Infrastructure - EDITO-Infra
- EDITO Portal EDITO
- BRIDGE-BS Digital Twin of the Ocean Demonstrator https://dekosim.ims.metu.edu.tr/digitaltwin/