

# Investigating and Predicting the Impact of Climate Hazards on Marine Ecosystem Resilience in the Mediterranean Sea Through Deep Oceanic Observation

Sana Ben Ismail<sup>1</sup>, Katrin Schroeder<sup>2</sup>, Adam Gauci<sup>3</sup>, Alan Deidun<sup>3</sup>, Ahmad Inal<sup>4</sup>, Bassem Jellali<sup>5</sup>, Marie Alexandrine Sirce<sup>6</sup>, and Yuntao Wang<sup>5</sup>

1 INSTM, National Institute of Marine Sciences and Technologies, Tunisia 2. ISMAR, Italy 3. University of Malte, Malte 4. CNRDPA, Algeria, 5. SIO, China 6. LOCEAN, France



Nice, 3-6 June 2025

sana.benismail@instm.rnrt.tn



## Introduction

Oceans play a crucial role in modulating the Earth's global climate system while supporting valuable ecosystems on which we depend. International panels such as the UN Ocean Decade demand an increase in ocean observational efforts. In-situ Eulerian observation systems play a key role, as they possess unique capabilities to collect samples and make sustained observations where other systems cannot. To achieve the observation and study of hard-to-reach near-bottom sites, oceanographers have developed the HYDOCHANGES initiative launched and supported by CIESM since 2002 to enhance deep-sea observation in key location with the entire Mediterranean Sea [Fig.2]. The Mediterranean Sea is a mid-latitude marginal sea, particularly responsive to climate change as reported by recent studies. Sea straits and channels are peculiar areas of the World Ocean as they represent a connection of relatively small spatial extension between different oceanic basins. This often implies that some gross oceanographic features of the surrounding zones can exert a deep influence on the channel dynamics, and vice versa. The continuous monitoring of these choke points allows to intercept different water masses, and thus to document how they changed over time. Over the years, some deep moorings were not able to be maintained. The major challenge in deep mooring data observation is to protect and restore ecosystems and biodiversity, to enhance Ocean Observations, and to contribute to the Digital Representation of the Ocean. The DeepCMED project endorsed under the call N°7 of the United Nations Decade of Ocean Science will Enhance ocean observations and contribute to ecosystem protection and encourage knowledge exchange, especially with youth from SIDS, LDCs, and LLDCs.

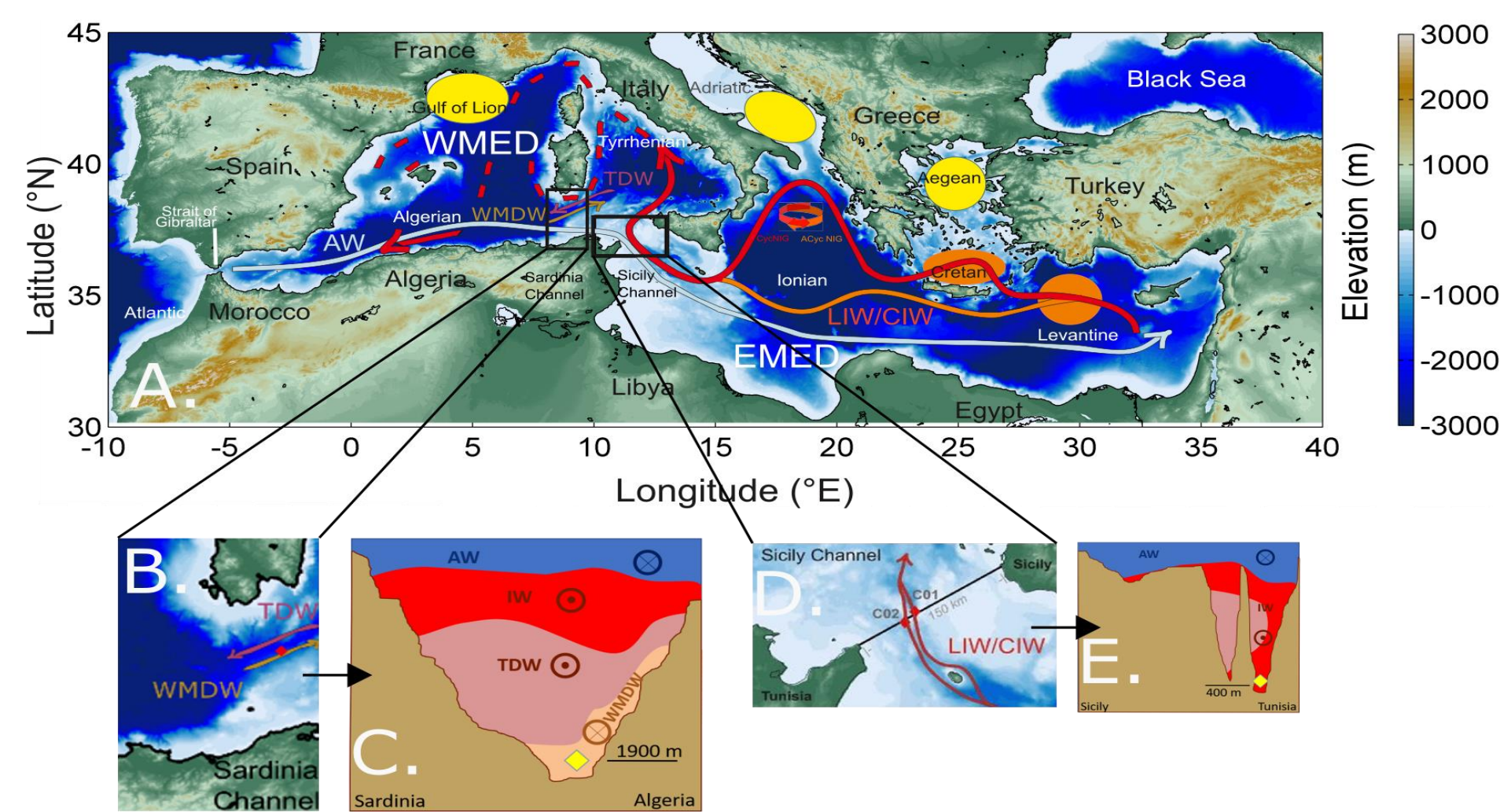


Fig.1 : Monitoring choke points: Sardinia Channel and Sicily Channel

## Objectives

Therefore, the proposed project focuses on strengthening the deep-sea research observations and collaborating with partners from marine environmental research institutes to study the impact of extreme events in deep habitats in the Mediterranean Sea, on the stability and resilience of marine ecosystems. This will ensure that marine ecosystems remain healthy amid global climate change, safeguarding the sustainable development of coastal industries. Centered around the programme "DIGITAL DEEP-SEA TYPICAL HABITATS (DEPTH)" and project "Mitigation of Natural Incidence Towards an Oceanic Resilience (MoNITOR)" approved by the United Nations Decade of Ocean Science for Sustainable Development, the proposal aims to construct a nearshore marine ecological environmental prediction system. This system will predict the impacts of extreme climate events related to global climate change, such as marine heatwaves, ocean acidification, and eutrophication, to assess the stability and resilience of ecosystems under climate change. The research results will contribute to a better understanding of the dynamic response of marine ecosystems to global climate change, providing scientific evidence for effective policy measures. The collaboration will strengthen deep-sea research observations in the Mediterranean Sea and promote digital representation of deep-sea habitats using advanced technology and modeling.

## Methodology

This project strengthens deep-sea monitoring using Eulerian systems and builds on the HYDOCHANGES initiative to track long-term changes at key Mediterranean choke points. It integrates multi-source data (e.g., Argo BGC floats) to develop coupled dynamical-ecological models, simulating ecosystem changes and extreme event impacts. Through mapping, in-situ investigations, and a digital platform, it supports resilience assessment and delivers public tools like the Digital Deep-Sea Habitat Atlas.

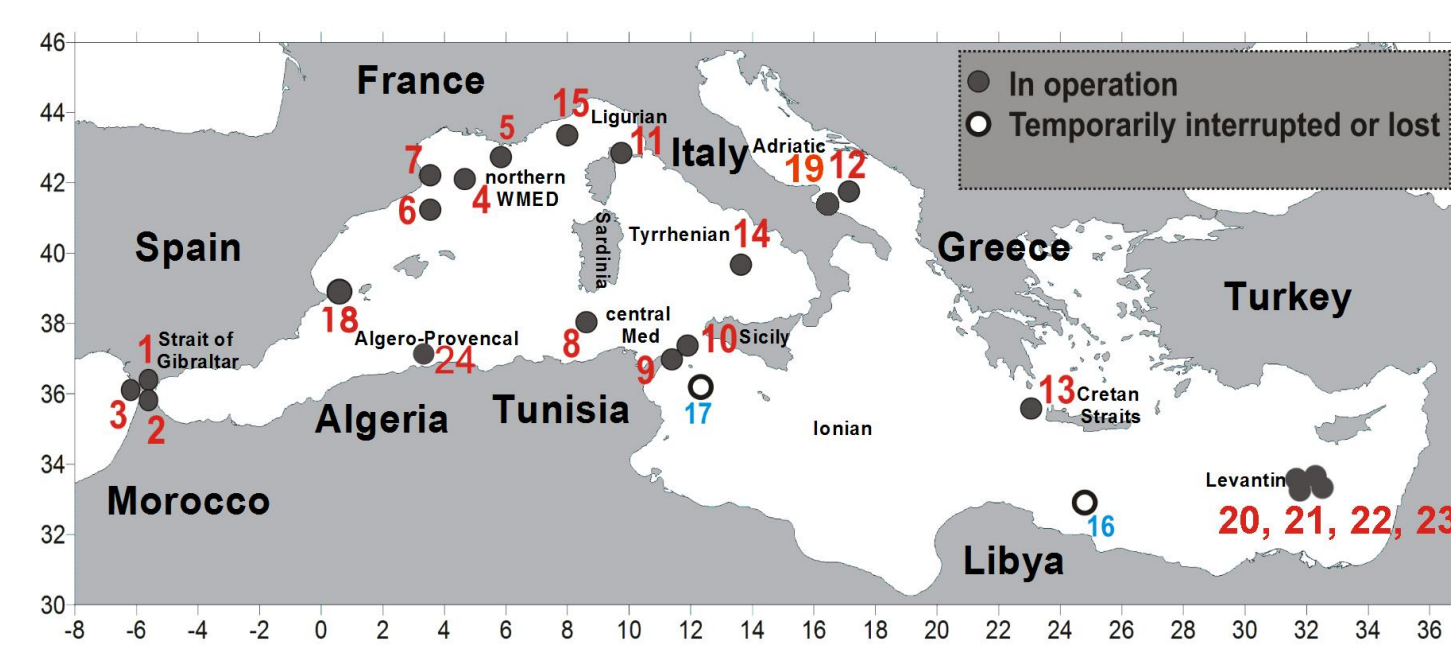


Fig.2 : Hydrochanges Program Network

## Partenariat

DeePCMed brings together a dynamic network of partners from Tunisia, Italy, Algeria, Malta, France, and China, fostering strong regional and international collaboration (Fig.3). This partnership enhances cross-border cooperation across the Mediterranean and extends engagement into the Indian Ocean, bridging expertise between northern and southern shores.

### Research Institutions

Marine science leaders such as INSTM (Tunisia), CNRDPA (Algeria), ISMAR (Italy), L-Università ta' Malta (Malta), IPLS/ LOCEAN ( France), and SOED/SIO (China).

### Environmental and Oceanographic Organizations

The Digital Deep-sea Typical Habitats and the UN Decade of Ocean Science for Sustainable Development.



Fig.3 : Geographical Distribution of DeePCMed Project Partners.

## Future activities

International cruise is planned and coordinated by the Digital DEPTH Programme in 2027, as part of the Mediterranean– North Indian Ocean expeditions, using the research vessel R/V Shen Hai Yi Hao (Fig.4) . These expeditions aim to explore vulnerable deep-sea habitats, enhance digital ecosystem modeling, and strengthen global scientific collaboration. The outputs of the joint international multidisciplinary cruise consists to :

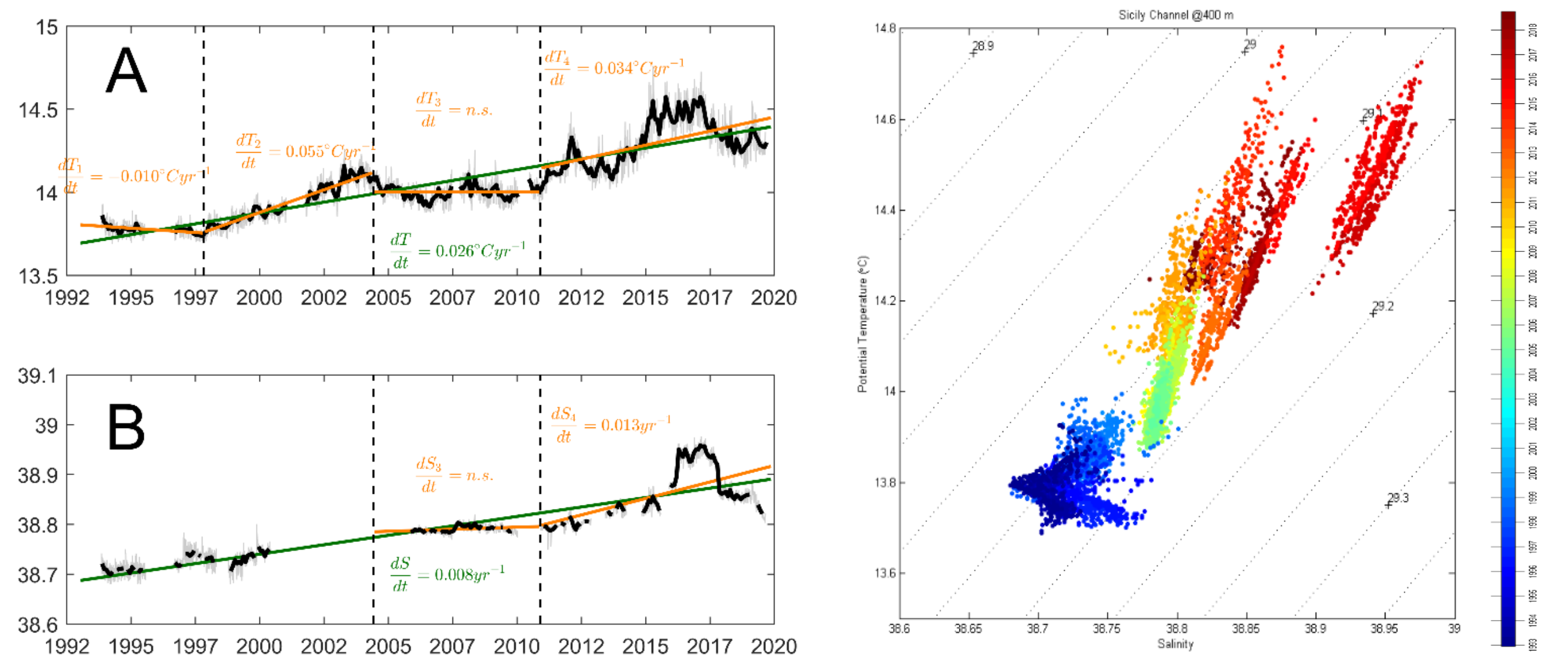
- ✓ Collecting multi-source dynamical and biogeochemical observations across the Mediterranean Sea.
- ✓ Conducting manned submersible dives and in-situ ecosystem surveys in selected deep-sea environments.
- ✓ Sampling seawater, sediments, and biodiversity, with the potential to discover new species.
- ✓ Performing high-resolution multi-beam seafloor mapping and bathymetric analysis.
- ✓ Promoting international cooperation, with active involvement of early-career researchers, especially from developing countries.
- ✓ Contributing to the development of the Digital Deep-Sea Habitat Atlas and the integrated observation-simulation-prediction platform.



Fig.4 : The research vessel Shen Hai Yi Hao

As part of this Decade Action, we will leverage existing long-term time series datasets, including :

### Intermediate Water: long time series

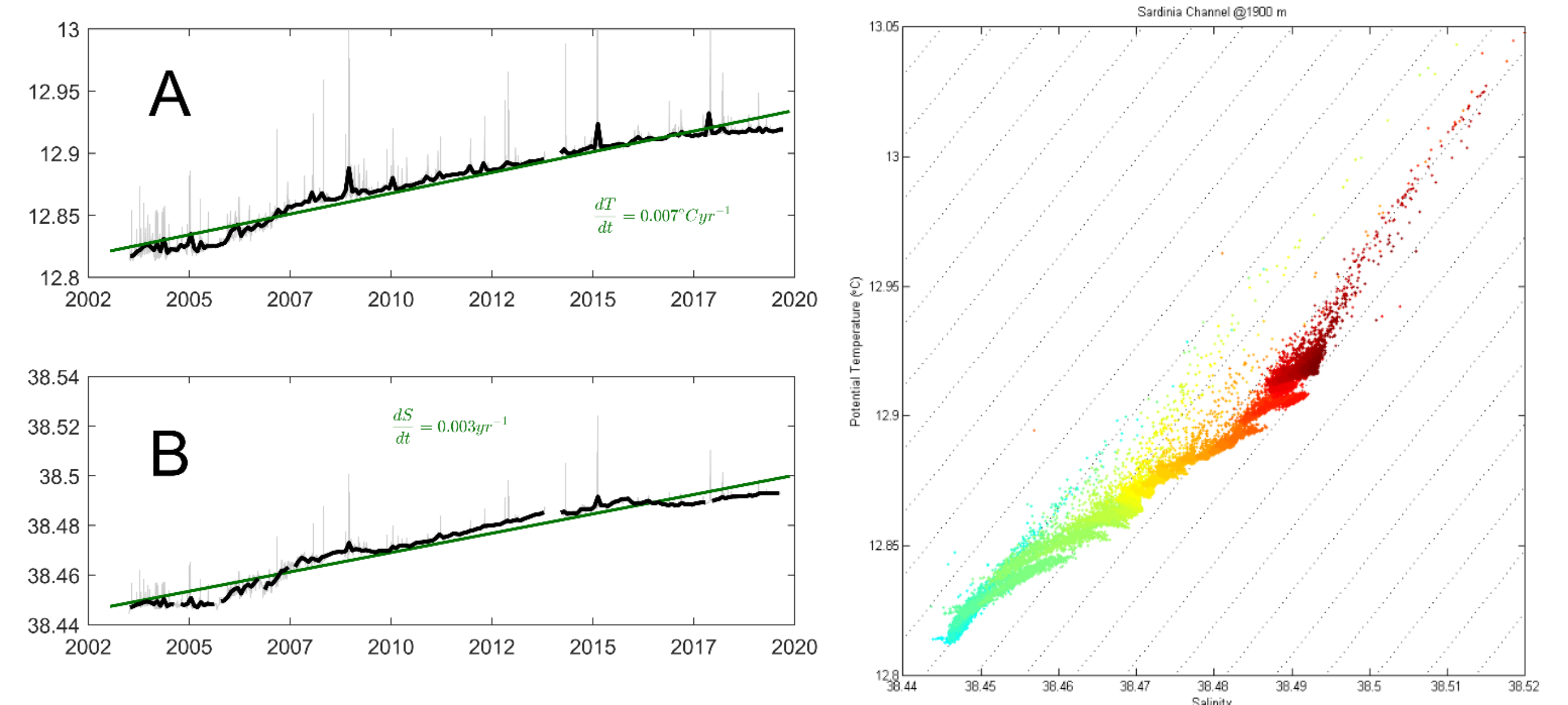


➤ T and S co-vary

➤ trends are subject to changes, slowdowns and accelerations

➤  $\Delta T/dt=0.03^{\circ}C/yr$  and  $\Delta S/dt=0.008 /yr$

### Deep Water: long time series



➤ Alternation of WMDW (lower T and S, 12.81- 12.91°C, and 38.45-38.49), flowing east, and TDW ("pulses" of higher T, >12.9-13 °C, and S >38.48-38.5, flowing west

➤  $\Delta T/dt=0.007^{\circ}C/yr$  and  $\Delta S/dt=0.003 /yr$

➤ TDW pulses are of short duration (1 day-1 week), due to an interface displacement between the two DW masses

## Conclusion

This project advances deep-sea ecosystem understanding and resilience in the Mediterranean by enhancing long-term observations, integrating diverse data sources, and developing predictive digital tools. Through regional and international collaboration, it supports informed decision-making for marine conservation and sustainable ocean governance in the face of climate change. DeePCMed promotes gender equality and inclusion within the project team. Efforts will be made to ensure balanced representation of women and early-career researchers in all project activities. Furthermore the project includes partners from both the northern and southern Mediterranean, ensuring geographic diversity and addressing the north-south gap in marine research and capacity.