



# Impact of Storm Daniel on the Black Sea biogeochemistry

### 12<sup>th</sup> FerryBox Workshop Yoana G Voynova, Vlad Macovei, Nadezhda Drumeva, Violeta Slabakova





### Introduction

### Helmholtz EU Partnering Project SeaReCap : <u>Research Cap</u>acity building for healthy, productive and resilient Seas

- western Black Sea & German Bight (North Sea)
- Black Sea strongly stratified
  - largest anoxic water basin (below ~200 m)
- North Sea well-mixed with strong tidal & wind forcing
- both seas have experienced human-induced & climate change impacts and ecosystem collapses (1980s)

### What is the impact of extremes?



**Rationale**: Contribute to interdisciplinary knowledge for fundamental improvements in the state of our seas, in line with the urgent transformation towards sustainable blue and circular economy (EU Green Deal\*) \*https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal\_en



### **Introduction, Storm Daniel**

### Surface cyclone **Daniel** (EUMETNET, Cusack et al. 2017):

- developed over the western Black Sea, Sept 4
- extreme rainfall in Bulgaria & Türkiye with influx of warm & moist air from Black Sea & the Aegean
  - Strandja (Bulgaria) 330 mm on 5 Sept
  - Portaria (Greece), 762 mm on 5 Sept & 1,096 mm 5–8 Sept
- Meandered slowly across the Mediterranean, picked up energy and became a medicane by Sept 8
- Landfall near Benghazi (Libya) on Sept 9, intense rainfall over the Green mountains (Libya)

Wikipedia

| Fatalities from Storm Daniel |                       |                                |  |  |  |  |  |
|------------------------------|-----------------------|--------------------------------|--|--|--|--|--|
| Country                      | Deaths                | Damage USD                     |  |  |  |  |  |
| Greece                       | 17 <sup>[17]</sup>    | \$2.14 billion <sup>[18]</sup> |  |  |  |  |  |
| Turkey                       | 7 <sup>[19]</sup>     |                                |  |  |  |  |  |
| Bulgaria                     | 4 <sup>[20]</sup>     |                                |  |  |  |  |  |
| Libya                        | 5,923+ <sup>[1]</sup> | \$19 billion <sup>[5]</sup>    |  |  |  |  |  |

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### **Coastal Black Sea Station Deployment: June 2022**



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### **Coastal Black Sea Station Initial Deployment: June 2022**



### **Raw data – Pocket FerryBox**



### **Upgraded Installation : summer 2023**







<sup>7.5 m</sup> Pump and temperature measured at intake

- 2.5 m





2023: Re-designed Large FerryBox + cleaning cycle

### Large FerryBox + cleaning cycle



- Data around cleaning cycle removed
- *p*CO<sub>2</sub> corrected (Macovei et al. 2021)
- Optode calibrated with discrete samples (Winkler titrations, IO-BAS)



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# **Effects from Storm Daniel**

- SST lower by ~2°C at Shkorpilovtsi 26.411 ± 0.004°C (Aug 25-Sept 3, n = 12879) 24.575 ± 0.005°C (Sept 6 – Sept 15, n = 12756)
- Basin-wide SST decrease
  - ~2.1°C drop from Aug (25.2±0.3°C) to Sept (23.1 ± 0.5°C) - MODIS 8-day-ave SST (Giovanni, NASA)



Storm Daniel (4-5 Sept, 2023) **Upwelling Events** 100 50 Ч Ч (М7) mm Aug-23 Sep-23 800 600 (matm) pCO<sub>2</sub> 400 200 mmm Temp 20 15 Aug-23 Sep-23 H 8.2 WWW, manna MWMM ÷ Aug-23 Sep-23 Chl Fluor CDOM (µg hannon horn Aug-23 Sep-23 Salinity 19 18 17 16 Sep-23 Aug-23



- Large-scale & prolonged decrease in DO, not visible in pCO<sub>2</sub>
- Influx of cDOM associated with low salinity

# Implications and look ahead

 From MODIS SST analysis (Giovanni, NASA): SST increase by 0.074 °C yr<sup>-1</sup> over the past 20 years

- Higher rate than estimated by Sakalli and Batusta (2018) 0.064 °C yr<sup>-1</sup> (1982-2015)
- Higher rate than models 0.03-0.06 °C yr<sup>-1</sup>



Annual Mean SST (Giovanni, NASA)





# catastrophe

The disaster is Africa's deadliest storm on record; seven of Africa's top 30 deadliest weather disasters since 1900 have occurred in the past two years.



# Challenges

- Biofouling
  - Maintenance (6 weeks): improved!
- High temperatures
  - 0.4-0.5 °C difference from intake temperature
  - Stress on electronics
- pH calibration and checks



# August, 2022



### Next and completed steps

- Larger FerryBox at Shkorpilovtsi  $\checkmark$
- Repeat survey cruise
  DOORS cruise (Sept 2023) √
- Larger Black Sea cruise
   2025-2026
- Station near IO-BAS in Varna discrete samples (IO-BAS)  $\sqrt{}$
- Collaboration with modelers
- IO-BAS will acquire & install own FB + BlackBox project







### **Cuxhaven Station** (mouth of the Elbe Estuary) & North Sea FerryBoxes





### **Cuxhaven Station data**





