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Beneath the Storm: A Comparative Analysis of Natural and Anthropogenic Factors in Marine Biogeochemical Dynamics

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The paper titled "Biogeochemical dynamics in a marine storm demonstrates differences between natural and anthropogenic impacts," authored by Justin Tiano, Rob Witbaard, Theo Gerkema, and Karline Soetaert, from Wageningen Marine Research, Wageningen University and Research, Department of Estuarine and Delta Systems, Royal Netherlands Institute for Sea Research (NIOZ), was published in Scientific Reports on April 16, 2024. This study explores the impact of storms on marine biogeochemical dynamics, particularly focusing on the differences between natural and anthropogenic disturbances. By comparing the effects of natural storms and bottom trawling on seabed suspended particulate matter, the research found that turbidity induced by storms was significantly higher than recent trawling events. This study offers a new perspective on understanding how storms and human activities affect marine ecosystems.

1 Experimental Data Analysis

During the experiment, storm-induced mixing and movement of water masses led to a decrease in silicate concentrations and an increase in phosphate concentrations, accompanied by a decrease in salinity and an increase in fluorescence. The depth of seabed erosion during the storm averaged about 0.3 cm, while trawling caused more than twice this depth of erosion. The high turbidity during the storm may be part of the cumulative impact of fishing activities.

Figure 1 shows the atmospheric conditions (a), wind direction (b), and location (c) during a marine storm from June 1 to June 9, 2017. Panel a shows a sudden increase in wind speed in the shaded gray area, indicating extreme weather during the storm. The wind direction map in panel b indicates the predominant wind directions during the storm, with wind strength represented by arrow length. Panel c shows the location of the Frisian Front during the storm, based on depth and the Dutch coastline, demonstrating the storm's impact on the area. This information helps us understand how the storm affects the biogeochemical processes in the sea area.

Figure 2 shows the absolute water flow velocity at 1.4 meters and 4 meters above the seabed (a), water flow velocity and direction during calm conditions (b-c) and storm conditions (d), and the particle transport pathways calculated by integrating the water flow velocity over time (e-g). From figure a, it is evident that during the storm (shaded in gray), the lower layer water flow velocity significantly increases. Figures b-d present wind diagrams indicating the direction and intensity of water flow on different dates, especially during the storm day (figure d), which shows a distinct change. Figures e-g depict the particle transport pathways under calm and storm conditions, where figure g highlights significant changes in particle pathways and velocities during the storm. This information is crucial for understanding how storms affect seabed particles and associated biogeochemical processes.

Figure 3 shows the vertical distributions of water temperature (a), salinity (b), oxygen concentration (c), and fluorescence (d) on June 1, 6 (calm conditions), 7 (during a storm), and 8 (after the storm) in 2017. It can be observed that the water temperature tends to uniformity before and after the storm, indicating that the storm caused mixing of the water body. Salinity increases with depth and decreases after the storm, possibly due to freshwater input. Oxygen concentration increased during the storm, reflecting the redistribution of oxygen caused by storm-induced stirring. Fluorescence data demonstrate changes in biological activity after the storm, which may indicate one aspect of the storm's impact on the marine ecosystem.

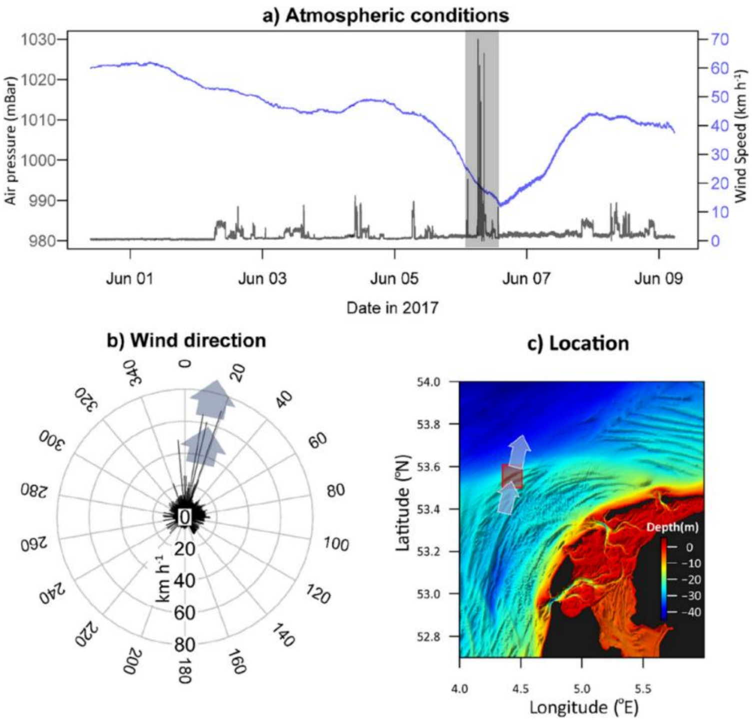

Figure 1 Atmospheric conditions (a), wind direction (b), and location during the marine storm from June 1 to June 9, 2017

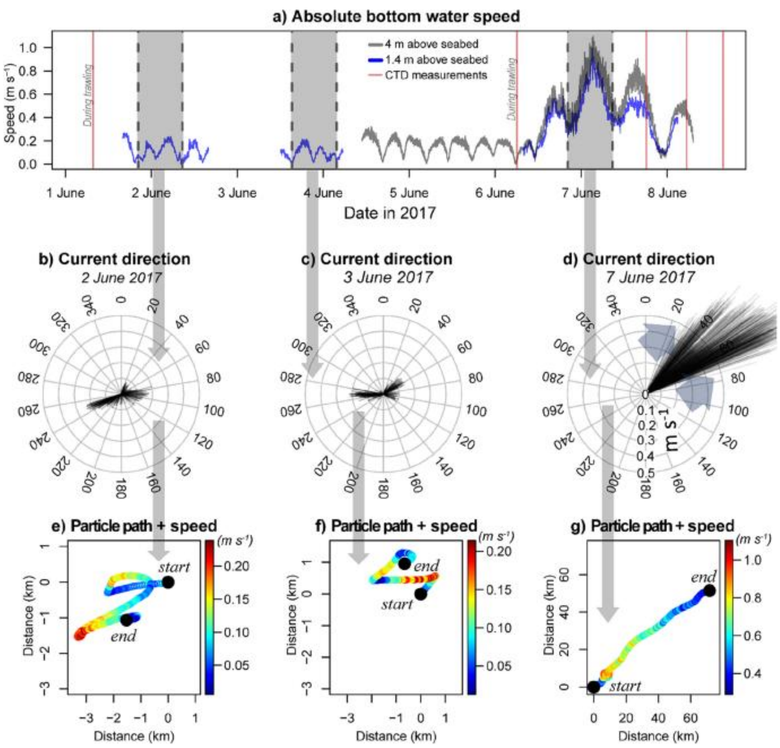

Figure 2 Absolute water flow velocity at 1.4 meters and 4 meters above the seabed (a), water flow speed and direction during calm (b-c) and stormy conditions (d), and particle transport paths calculated by time-integrated water flow velocity (e-g)

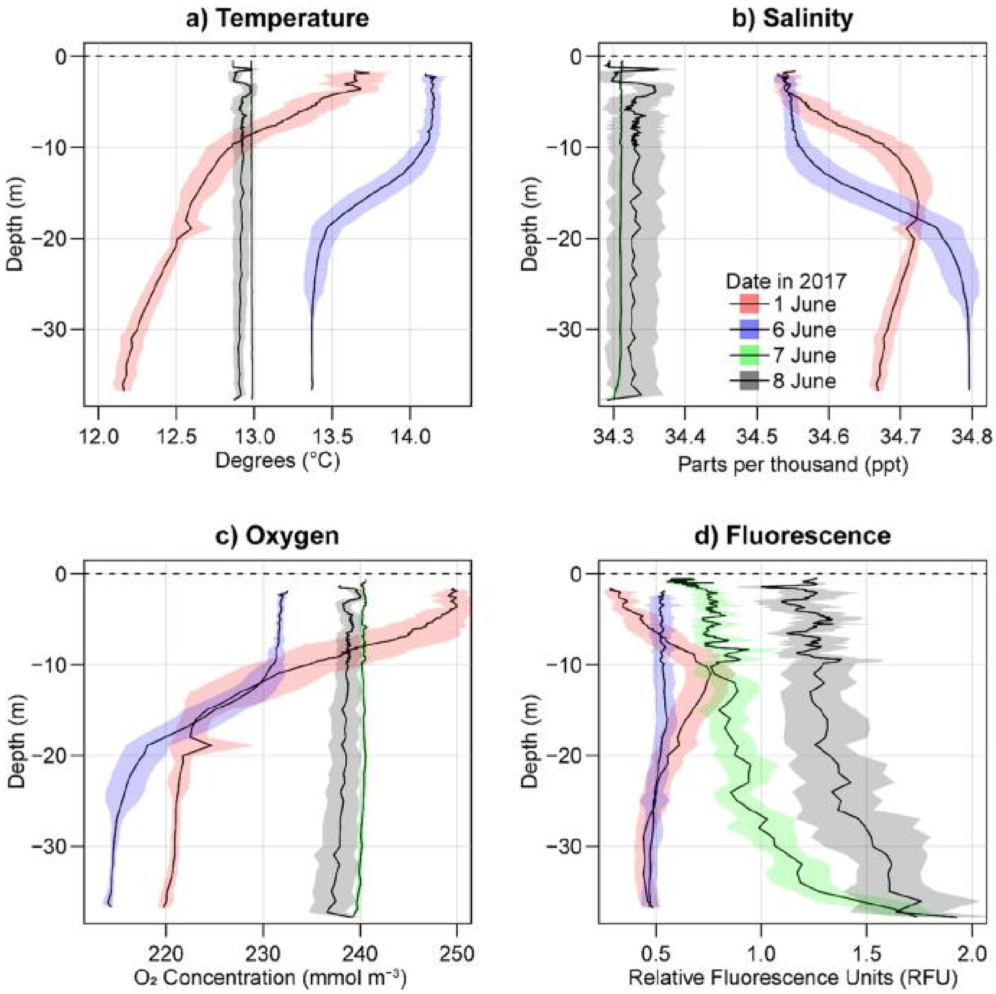

Figure 3 Water temperature (a), salinity (b), oxygen concentration (c), and fluorescence (d) on June 1st and 6th (under calm conditions), 7th (during the storm), and 8th (after the storm), 2017

2 Analysis of Research Findings

Disturbances to the seafloor caused by storms and trawling exhibit distinct biogeochemical responses. The oxygenation caused by storms and the oxygen depletion caused by trawling have markedly different environmental impacts. Furthermore, the impact of storms is more regional, whereas bottom trawling may have a more significant local impact on biogeochemistry.

3 Evaluation of the Research

This study takes advantage of the unique conditions during natural storms to meticulously document changes in marine biogeochemical processes, providing valuable data and insights for assessing the relative impacts of natural and anthropogenic disturbances. The research methodology is sound, the data analysis is thorough, and it effectively reveals the effects of storms on the functionality of marine ecosystems.

4 Conclusions

The impact of storms on marine biogeochemistry is significant and fundamentally different from the impact caused by human activities such as bottom trawling. This distinction is important for developing policies and management measures aimed at protecting the marine environment.

5 Access the Full Text

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