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Conference Abstract

Development and Long-Term Operation of Automated Coastal Monitoring Stations in the LTER-BG Network

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Abstract

Continuous, high-frequency observations play an essential role in understanding coastal ecosystem dynamics and detecting short-term environmental variability that may remain unresolved by conventional sampling approaches. Automated monitoring stations provide observations capable of resolving environmental processes occurring over timescales ranging from hours to seasonal cycles. Within the Bulgarian Long-Term Ecosystem Research Network (LTER-BG), two automated coastal monitoring stations have been established along the Bulgarian Black Sea coast to support long-term environmental observations. This study presents the implementation, operational performance, and engineering solutions developed to ensure reliable long-term operation under challenging marine conditions.

The first monitoring station is located in Varna Bay (Karantina; 43.174035° N, 27.920846° E) and has been operating continuously since 2022. The second station was deployed in 2023 in the Zelenka area near Cape Kaliakra (43.381905° N, 28.440640° E). The selected locations represent contrasting coastal environments. The Karantina station represents a semi-enclosed coastal area influenced by urban activities, port operations, freshwater inputs, and seasonal biological productivity. In contrast, the Zelenka station represents a more exposed coastal environment affected by open-sea circulation, coastal

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currents, and upwelling processes. Together, the two stations provide complementary information on the spatial and temporal variability of Bulgarian coastal waters.

The monitoring systems are based on WiMo Plus multiparameter platforms manufactured by NKE Instrumentation (France). Each platform supports the integration of up to six sensors and provides continuous measurements of hydrostatic pressure, water level, temperature, conductivity, salinity, dissolved oxygen, pH, turbidity, and sound velocity. The Karantina station is additionally equipped with a chlorophyll-*a* fluorometer for monitoring phytoplankton variability. Measurements are collected at 15-minute intervals and automatically transmitted via an integrated 3G/4G communication module to a remote data server. The collected data undergo automated quality-control procedures before being archived and disseminated through dedicated online visualization platforms.

A major challenge in the implementation of the monitoring infrastructure was ensuring reliable operation in the highly dynamic marine environment of the Black Sea, where corrosion, biofouling, sediment accumulation, and wave-induced mechanical stress can significantly affect long-term measurements. To address these challenges, a specialized stainless-steel deployment system incorporating a guide rail system and manual winch was designed and constructed. The system enables safe and efficient deployment, recovery, and maintenance of the monitoring probes while reducing operational time and minimizing risks during servicing activities. Following its successful implementation at the Karantina station, the same engineering solution was applied at the Zelenka site.

Regular maintenance activities include sensor cleaning, visual inspection, verification of sensor performance, and replacement of consumable components. Routine servicing is carried out approximately every two weeks, while additional interventions are carried out whenever quality-control procedures detect abnormal measurements or potential sensor malfunction. This maintenance strategy has proven essential for maintaining high data quality and ensuring the long-term sustainability of autonomous observations.

Since their deployment, both stations have demonstrated stable operation and high data reliability. The monitoring network has generated several hundred thousand high-frequency environmental records annually, resulting in continuous multiparameter time series for the Bulgarian Black Sea coast. These observations have documented seasonal hydrographic variability and short-term environmental events, including rapid temperature changes, storm-related turbidity increases, coastal upwelling, and phytoplankton blooms detected through chlorophyll-*a* measurements in Varna Bay. The resulting datasets demonstrate the capability of autonomous monitoring systems to resolve environmental processes that may remain undetected by traditional discrete sampling campaigns.

The generated datasets represent an important component of the LTER-BG coastal observing infrastructure and provide valuable information for ecosystem assessment, long-term environmental research, validation of hydrodynamic and biogeochemical models, and the development of operational marine monitoring services.

The experience gained from these stations demonstrates the feasibility of sustained autonomous marine observations under Black Sea conditions. The resulting observing infrastructure provides continuous, high-frequency environmental time series that support long-term scientific research, ecosystem assessment, and operational marine monitoring within the LTER-BG network and beyond.

Keywords

LTER-BG, coastal monitoring, Black Sea, autonomous monitoring stations, high-frequency observations, marine observing systems, multiparameter sensors

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Conflicts of interest

The authors have declared that no competing interests exist.