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Editorial

Application of Coastal/Ocean Sensors and Systems

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To address the recent needs for extended spatial and temporal in situ ocean data, new research is being implemented worldwide to develop and apply cost-effective subsea in situ sensors suitable for large-scale production. The in-situ sensors are capable of integration the existing and forthcoming monitoring/observation systems with regard to either coastal ecosystems or deep sea environments. The new generation of in situ sensors monitoring bio-physicochemical magnitudes, focusing on EOVs (environmental ocean variables) and EECs (emerging environmental contaminants), are of interest to researchers of oceanographic processes, ocean health and wellbeing, ocean safety and security, and ocean resources. New technological advancements have resulted in key operational advantages with respect to autonomy, the minimization of dimensions, low-power consumption, robustness, stability, and prolonged operation periods. Data pre-processing, standardization, interoperability, and transmission are also strong advantages for the next-generation subsea sensors and systems, allowing the integration of sensors on multiple measuring platforms (stationary/fixed, underwater mobile vehicles, and ships of opportunity) with ocean observation data networks.

This Special Issue, "Application of Coastal/Ocean Sensors and Systems", includes fifteen contributions published during 2022–2023. The scientific and technological aspects published in this book will be of great interest to scientists and engineers from various disciplines, such as ocean sensors, systems integration, mobile and fixed platforms, and communication systems, and responsible authorities and stakeholders that support human wellbeing and ocean health. This Special Issue will promote a broader and more holistic integrated approach to studying oceanographic and geological margins using technology. A brief overview of all the contributions is described as follows:

1. Tsabaris, C.; Androulakaki, E.G.; Ballas, D.; Alexakis, S.; Perivoliotis, L.; Iona, A. Radioactivity Monitoring at North Aegean Sea Integrating In-Situ Sensor in an Ocean Observing Platform. *J. Mar. Sci. Eng*. **2021**, *9*, 77. https://doi.org/10.3390/jmse9010077
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The scientific output of the manuscripts fulfilled new challenges related to the development and application of ocean radioactivity sensors to support national authorities and regulatory bodies for rapid site characterization in case of a nuclear accident or blast [1,2]. These systems also may support activities for studying sediment dynamics processes and radioprotection issues. Another scientific discipline concerns the development of ocean sensors to study submarine groundwater discharge and springs [3,4] to better understand the paths of contaminations and land–sea interactions as well as to validate the models that estimate the budgets of nutrients and other chemical substances that are discharged into the coastal zone. Regarding technology, progress has been made to deploy a sensor network, sensor integration, and cellular systems, producing effective decision support tools for different applications, such as for studying atmospheric–oceanographic processes [5] and radioactive and noise pollution using innovative ocean infrastructures and communication tools (between the measuring stations and operational centers). Innovative systems for seabed mapping have been applied in recent years to interpret sediment dynamics due to climate change, which drastically affect the coastal zones. Various methods have been enabled using advanced classification algorithms to study topographical and geomorphological issues [6]. Furthermore, breakthrough technologies have been applied to monitor the ship emissions in all weather conditions in real time in order to obtain data to identify their characteristics [7]. The benefit of such in situ systems is to improve the efficiency of maritime law enforcement and to provide technical support for promoting the construction of ship emission control areas.

The integrated, randomly deployed radioactivity spectrometers (such as KATERINA II) in fixed stations (e.g., buoy of the POSEIDON network) continuously monitor the radioactivity levels at the surface of the oceans. In the case of the North Aegean Sea, the activity concentration of radon progenies increased (up to an order of magnitude) during rainfall, as well as the ^{137}Cs activity concentration when north winds were present. A new achievement is the reduction in the minimum detectable activity of the detection system applying the background subtraction of the ^{40}K contribution and full-spectrum analysis techniques. Such systems can be applied effectively to rapidly monitor the environmental radioactivity in a nuclear emergency, identifying the type and quantity of radionuclides released during a hypothetical nuclear accident or blast. However, in emergency environmental radiological monitoring, the balance between energy resolution and detecting efficiency must be considered in selecting an appropriate detection system. A lot of progress has been made the last year to develop medium-resolution spectrometers to monitor the oceans. Such a system can be connected in the plug and play mode using state-of-the-art cellular communication boxes that are autonomous in terms of power, without receiving support from an ocean station (e.g., buoy). In order to study warm currents due to potential evaporation processes, new and effective methods of maritime communication across the Taiwan Strait have also been developed. The preliminary investigation of wireless microwave transmission in an evaporation duct has been demonstrated. Based on the effective use of the evaporation duct, the proposed method can provide favorable support for maritime applications using similar systems.

The submarine groundwater discharge (SGD) processes that take place in the coastal zone are of high concern to many research communities. SGD provides significant information about the land and marine systems, but is mainly concerned with coastal nutrient budgets and pathways since most of the models cannot provide reliable quantitative data of the water flux. The SGD-derived nutrient fluxes are used by many stakeholders in exercises related to water quality management plans, as these inputs can promote the eutrophication levels. Moreover, their impact on biogeochemistry and broader management implications are highly important. It has been observed that most investigations do not distinguish the saline and fresh SGD masses (using in situ methods), although they have different properties. However, a lot of effort has been made in recent years to provide some solutions to this problem by deploying underwater in situ spectrometers and measuring the radon progenies and potassium at the same time in order to identify saline from the fresh water masses. The radon progenies (^{214}Pb, ^{214}Bi) are adequate tracers used to identify groundwater and freshwater, while ^{40}K is the tracer used for identifying saline water. The combination of the above tracers can be used to map the intensity of the mixing process at the freshwater–saline water interface. Although during recent decades, researchers' interest in SGDs has grown continuously, the applied methods usually focus on the aquifer or on the mixing of seawater and groundwater. The recent works focus on the distribution of discharged water within the water column, enabling small, remotely operated vehicles (ROV) equipped with environmental sensors to investigate the water quality and short-baseline localization systems. The proposed method allows for the continuous mapping of environmental parameters with a high spatial and temporal resolution. However, to obtain deeper insights into the influence of SGDs on the nearshore areas, these methods should be combined with other well-established methods, such as pore water sampling, remote sensing, or groundwater monitoring. Furthermore, fixed platforms may provide the water flow characteristics (quality and quantity) using in situ deployments of ocean sensors, such as an Acoustic Doppler Velocimeter (ADV), a High-Frequency Acoustic Doppler Current Profiler (ADCP), or an underwater radioactivity system. The proposed methodology can be used to estimate the water supply, the residence time in the effective area of the in situ systems, and the residence time in the studied coastal system.

The existing worldwide sensor networks and integration methods may host smart and innovative ocean sensors to monitor environmental ocean variables and the emerging environmental contaminants in the ocean. A lot of effort has been made in the recent years to use an ocean Gamma-ray spectrometer to monitor natural and artificial radioactivity and correlate the activity concentrations with the meteorological parameters. Passive aquatic listeners are also integrated for various applications related to marine mammals and noise issues. Taking into account the growing need for interoperability among the different oceanic monitoring systems to deliver services that can meet the requirements of stakeholders and end users, the development of a low-cost machine-to-machine communication system that is able to guarantee data reliability over marine paths, is required. The experimental evaluation of the performance of long-range technology in a fully operational marine scenario has been proposed. In situ tests were carried out, exploiting the availability of a passenger vessel, a research vessel, and the gateways positioned on the mountains and hills in inland areas. The reliability of Long-Range Wide-Area Network transmission over the sea has been demonstrated up to more than 110 km in a free space scenario and for more than 20 km in a coastal urban environment. Another advanced marine observation infrastructure is the POSEIDON system, which is a widely recognizable international technology testing/demonstrating node specializing in marine technology and providing high-level services. It is used as a scientific tool for the study of marine ecosystem trends and shifts and is an augmented research infrastructure unique to the Eastern Mediterranean basin, contributing to European Ocean Observing System implementation, focusing on biogeochemical observations and deep sea ecosystem and geological processes. The technological evolution of the POSEIDON system through a science-coupled strategy supported by engineers and scientists resulted in a state-of-the-art ocean observing system. As a part of the scientific community of ocean observatories, the POSEIDON system actively contributes to improving of ocean observations and international access to engineering and field demonstrating services, data products, and technology testing facilities for scientists and industry partners. Furthermore, the electromechanical integration of a sonar system (COTS) with capable unmanned surface vessels (USVs) has been demonstrated through passive techniques (such as using underwater objects). The effective testing of the new sensing technologies required realistic deterministic test ranges. The advancements in customizable and adaptive USVs have contributed to their increasingly popular application in the maritime site characterizations of test ranges using commercial off-the-shelf (COTS) sensors. The designers recommend to fully isolate the sensing system from the USV, physically separate the sonar and USV components, and establish a baseline performance for the system prior to operation. Another breakthrough application is the integration of a real-time modeling system to monitor ship emissions in all weather conditions and to obtain emission factor values to better understand their characteristics. This system consists of a portable exhaust monitoring device (which could be mounted on a drone, aircraft, patrol boat, dock, bridge crane, or on shore to conduct the all-weather and real-time online monitoring of ship emissions), a ship-emission-information-monitoring platform (based on a Spring + Spring MVC + MyBatis framework and Vue front-end technology), and a cloud server that receives real-time ship emission measurement data (stored after verification and analysis to calculate the pollutant gas and particulate matter emission factors).

A lot of effort has been made in recent years to use natural radiotracers to study the sediment dynamics at coastal zones. This need motivates many research groups worldwide to develop new tools (instruments/sensors and methods) to map the radionuclides in aquatic sediments. Sedimentation can cause numerous problems in rivers, estuaries, harbors, and coastal areas, and it is important to trace and model the movement of sediments using in situ methods. The natural physical, chemical, and biological components of aquatic sediments generally relate to these features in the terrestrial catchment area, and subsequently, contain the naturally occurring radionuclides of thorium, uranium, and potassium (which can be used as natural tracers). The DUGS is a new sensing device that has been tested for radiometric accuracy; it is used to identify low concentrations of natural radionuclides in aquatic sediments and attenuation by water and the detector enclosure. This necessitated an evaluation to determine its detection efficiency along with other operational parameters, including the acquisition time and underwater speed during mapping. The acquired Gamma spectra were also analyzed using full-spectrum and energy window analyses to determine the optimal method for extracting the activity concentrations of the nuclides in the sediments. The other systems (e.g., KATERINA II) have been tested for studying environmental issues in active and legacy mining areas, measuring the radionuclide concentrations. The radiological mapping of beach sands was performed using R language and its related environment for statistical computing. The in situ maps provide crucial baseline information (before the remediation process) since the beach area of the load-out pier area underwent the first phase of active remediation. The temporal aspect of this dataset is a significant reference for future comparative studies after the remediation of the beach with potentially denser spatial and temporal data coverage. Furthermore, an advanced seabed sediment classification method was also proposed using the spatial statistical features extracted from an angular response curve (ARC) and topography and geomorphology data without using the conventional sediment classification methods (based on Multibeam Echo System data). This robust method is proposed, combining the Generic Seafloor Acoustic Backscatter (GSAB) model and Huber loss function to estimate the parameters of ARC (which are strongly correlated with the seabed sediments). Then, a feature set is constructed with ARC features composed of GSAB parameters, a BS mosaic and its derivatives, and seabed topography and its derivatives to characterize the seabed sediments. After that, feature selection and probability map acquisition are employed using the random forest algorithm (RF). Finally, de-noising and a final sediment map generation method are proposed and applied to probability maps to obtain a sediment map with reasonable sediment distribution and clear boundaries between the classes.

In this Special Issue, Wang et al. [8] proposed a two-step iterative minimization (TSIM) method to minimize the major decline in the direction of arrival (DOA) estimation performance of an acoustic vector sensor array (AVSA) with the coexistence of axial deviation and non-uniform noise. Initially, the axial deviation measurement model of an AVSA was formulated by incorporating the disturbance parameter into the signal model, and then a novel AVSA manifold matrix was defined to simultaneously estimate the sparse signal power and noise power. After that, to mitigate a joint optimization problem to achieve the sparse signal power, the noise power and the axial deviation matrix, which are two auxiliary cost functions, were presented based on the covariance matrix fitting (CMF) criterion and the weighted least squares (WLS), respectively. Furthermore, their analytical expressions were also derived. In addition, to further enhance their prediction accuracy, the estimated axial deviation matrix was modified based on its specific structural properties. The simulation results demonstrate the superiority and robustness of the proposed technique over several conventional algorithms.

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