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Editorial: Seafloor mapping using underwater remote sensing approaches

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Editorial on the Research Topic
Seafloor mapping using underwater remote sensing approaches

Despite covering over 70% of the Earth's surface, less than 20% of the seafloor has been spatially explicitly mapped (Coley, 2022). Current global initiatives aim to change this state of knowledge and generate a global map of the seafloor with reasonable resolution by 2030 (Mayer et al., 2018). This challenge will require tremendous efforts in terms of development of new international cooperation and technological solutions. To that end, the rapid development of underwater remote sensing approaches that occurred over the past few decades brings us closer to that milestone (Zwolak et al., 2020), but still requires further efforts.

In this context, this Research Topic included original research and review articles focused on recent underwater remote sensing developments. Li et al., presented diverse ways to generate high-resolution bathymetry from various sources, including shipborne, airborne and spaceborne sensors. The authors identified strengths and weaknesses of these approaches, in terms of resolution, data coverage and data integration into meaningful bathymetric products. Nevertheless, the contribution revealed their complementarity, together capturing different depth ranges, ensuring high reliability and accuracy of the seafloor Digital Elevation Models produced for the different depth domains. The authors evaluated accuracy of the existing bathymetry models based on two case studies and they comprehensively compared suitability of different data acquisition techniques for seafloor mapping based on spatial resolution, data coverage, operational costs and operational complexity of the measuring systems. Although the main contributors to the global bathymetry models are currently those obtained by means of altimetry satellite gravity datasets, Li et al., outlined several innovative technologies that may improve bathymetric data collection and interpolation in the coming future.

Marine litter is one of several problems affecting the ecological integrity of the marine environment (Madricardo et al., 2020). Šiljeg et al., evaluated the ability to detect and identify marine litter utilizing UAV Phantom 4 Pro, WASSP S3 multibeam echosounder system (MBES) and Chasing M2 ROV. The tests were performed near the city of Šibenik, Croatia, where the authors examined different survey scenarios against different marine litter objects such as like car tyre, glass bottles, plastic tube, or sheets of metal. During the research, the authors inspected different environmental conditions and MBES settings, including different frequencies, ping rates, and bandwidths, allowing the comparative assessment of their suitability to marine litter detection. In their contribution, Šiljeg et al., explored two important aspects: 1) the minimal discrimination potential to map the marine litter by the WASSP S3 MBES, and 2) the precision of measurements under different survey directions and speeds. Additionally, they confirmed the usefulness of Chasing M2 ROV for preliminary detection of underwater objects, while also evaluating possible limitations of using such a technology without an underwater positioning system.

Measuring the seafloor depth using satellite-derived imagery is considered as of high relevance within the underwater remote sensing community as well as being a generally well-established technique. Such a technique has the potential to significantly accelerate measurements in shallow water regions characterised by relatively clear waters, thereby having the potential to make a considerable contribution to the compilation of a global bathymetric chart. The research of Xie et al., is an example of efforts serving this purpose. The authors combined active (ICESat-2) and passive (Sentinel-2) remote sensing methods and showed their potential benefits to improve bathymetry derivation from satellite imagery. Whereas several machine learning methods were tested, the AE-DBSCAN algorithm introduced by the authors was identified as the most accurate, achieving an overall RMSE accuracy of less than 1.5 m.

Besides measuring bathymetry, underwater remote sensing approaches can be used to determine various seafloor characteristics of interest. Properties of the seafloor sediments can be investigated based on the relative backscatter strength of the returning acoustic signal, particularly using MBES technology which co-registers depth and reflectivity information in a single ping. Although this type of measurement is often logged by readily available single-frequency MBES devices, Bai et al., provided results of multi-spectral frequency datasets that are only recently making their way into the market. The authors compared results of two classification algorithms, verified with ground-truth datasets. Although the findings showed that different frequencies may add meaningful information regarding the properties of given seafloor types, backscatter classification of the study area showed no significant improvements over that conducted using single frequency MBES measurements.

Offshore industrial applications benefit from high-resolution underwater acoustic remote sensing datasets. Research by Kint et al., focused on change detection of areas subject to marine aggregate extraction, needed to supply nourishment of Belgian sandy beaches. The authors analysed MBES bathymetry and backscatter measurements from a 7 year long serial dataset and explored the relationship of the hydroacoustic measurements with the sediment properties. The variability of sediments in areas of marine aggregate extraction is to date poorly understood and results from complex interactions between anthropogenic and natural drivers. The study by Kint et al., pointed out the main factors influencing sediment distribution and the associated dynamics, including identifying the spreading of homogenous sands within the study area, followed by their reappearance.

Natural hard substrates provide keystone habitat for many benthic species, giving rise to underwater reefs and hosting a variety of specialized fauna and flora with low resistance and resilience to anthropogenic disturbance, and resulting in conservation priority biotopes in all relevant legislation. Due to this, research efforts have focused on the faster and more accurate determination of such seafloor types. Boulders occurring in the German Baltic Sea are a noticeable example of hard substrate promoting the formation of geogenic reefs. Feldens et al., examined a vast area of about 750 km^2 attempting the automatic detection of boulders by exploiting contemporary approaches rooted in deep learning and artificial intelligence. They utilized MBES together with side-scan sonar (SSS) measurements as well as underwater videos to train a convolutional neural network (namely, YOLOv4). The results were subject to a human quality control allowing to interpret the distribution of boulders within geogenic reefs in the three study sites.

While the majority of works presented in this Research Topic primarily focused on the utilization of Multibeam Echo Sounder technology for bathymetry and backscatter purposes, many of them also incorporate ground-truth samples obtained from underwater videos and other conventional sediment sampling gears. Furthermore, satellite imagery and side-scan sonar data were also considered here. These methods collectively represent the forefront of contemporary underwater remote sensing approaches, serving as pivotal tools for enhancing our understanding of the world's seafloor.

Acquiring knowledge about ocean seafloor morphology and its characteristics is essential for enabling effective and sustainable management of offshore areas, to aid policy decisions, and the protection and exploration of the marine environment with heightened awareness. Anticipating the near future, we can expect a significant expansion in underwater remote sensing technologies. Consequently, these advancements will greatly contribute to the objectives set forth by the UN Decade of Ocean Science for Sustainable Development.

Author contributions

ŁJ: Conceptualization, Data curation, Investigation, Resources, Supervision, Validation, Writing–original draft, Writing–review and editing. JT: Conceptualization, Data curation, Investigation, Resources, Supervision, Validation, Writing–original draft, Writing–review and editing. GM-G: Conceptualization, Data curation, Investigation, Resources, Supervision, Validation, Writing–original draft, Writing–review and editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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