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Editorial: The discovery of the unknown planet: the ocean

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[1] EMSO ERIC - European Multidisciplinary Seafloor and Water-Column Observatory European Research Infrastructure Consortium, Rome, Italy, [2]ITU/WMO/UNESCO-IOC JTF SMART Subsea Cables - Joint Task Force, International Telecommunications Union-World Meteorological Organisation, UNESCO Intergovernmental Oceanographic Commission Joint Task Force; and University of Hawaii at Manoa, Honolulu, HI, United States, [3]MBARI-Monterey Bay Aquarium Research Institute, CENCOOS-Central and Northern California Ocean Observing System, Moss Landing, CA, United States

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Editorial on the Research Topic
The discovery of the unknown planet: the ocean

The ocean is the engine of the Earth's ecosystem; it regulates the climate and absorbs more than 90% of the excess heat from greenhouse gas emissions. A consequence of this is that temperature, acidity, and stratification of the oceans affects biodiversity and the functioning of marine ecosystems. The impacts of anthropogenic pollution and eutrophication, intensive coastal development and extensive farming and agriculture, are increasing stressors on marine and coastal ecosystems; this has been accompanied by an overexploitation of marine resources.

Seventy per cent of the Earth's volcanism occurs on the ocean floor, which together with large seismic events and submarine landslides, are the main sources of earthquakes and tsunamis causing catastrophic damage as well as having a high socio-economic impact. As a result, there is great interest to both explore and understand the biogeochemical processes within the ocean. This also involves research into what has been an unexplored area of the Earth, the 'deep ocean'. As part of this desire to understand all aspects of the ocean, the United Nations (UN) launched the '2021-2030 Decade of Ocean Science for Sustainable Development'. This initiative and associated challenges are expected to mobilize the global ocean community to provide answers and possible solutions that will ensure the sustainability and protection of the seas and coastlines of the world.

In this Research Topic we have papers that discuss:

- 'Science matters', how gas manifestations relate to ocean acidification. In particular research surrounding the Aegean Sea, where there are multiple challenges resulting in a marine ecological assessment for European Seas, including long-term monitoring of

marine fauna at artificial reefs at the EMSO[1] test site off the Spanish coast; and also involves the discovery and chemical composition of deep-sea anoxic brine pools in the Eastern Mediterranean. This is accompanied by extremely valuable Japanese seismic observations, that use distributed acoustic sensing technology in a seafloor cable. See Daskalopoulou et al., Ramirez et al., Francescangeli et al., Herut et al., and Shinohara et al.

- 'Technological matters', related to the importance of using advanced observation equipment and image analysis, ultimately reducing the costs of ocean research with a smaller environmental footprint. Examples of this include: EGIM[2] standardized and interoperable instrumentation; tele-operated resident robots for deep applications; video-imaging systems together with multi-parametric sensors at a shallow cabled observatory such as that off Spain; low-cost deep-sea imaging and analysis tools for deep-sea exploration off western Canada; and a low-cost, modular imaging and sensor platform to increase deep observation capabilities, known as Maka Niu. See Lanteri et al. Chatzievangelou et al., Ottaviani et al., Bell et al., and Novy et al.
- Development and enhancement of observatory systems, such as the volcanic seafloor observatory at Santorini in the Aegean Sea and EMSO's[1] western Ionian facility through the infrastructural project InSEA[3] that includes a wet demonstration test of the innovative concept of SMART[4] telecommunication cables which house various oceanographic and seismic sensors to improve real-time knowledge of many natural phenomena, and are an improvement on the present tsunami early warning systems. See Nomikou et al., and De Santis et al.
- Data management aspects, such as the Oceans 2.0/3.0 data management and archival system for the internet-connected ocean implemented in Canada. See Owens et al. and Moran et al.
- Organizational Perspectives, discussing the collaborative efforts required from local/regional and global communities. An example is the role of marine infrastructures in the European marine observation landscape that stresses the importance of an integration process with co-design and co-development as central features. Mendes Silveira et al., and Dañobeitia et al.

The advantage of a modular type of platform, including diverse suites of underwater sensors, like EGIM[2] is clear; these can be further optimized using artificial intelligence. This scientific work stresses the importance of continuous monitoring from smaller observatories dedicated specifically to the monitoring of volcanoes and other earth or ocean features of interest. Some examples of this have already started at Santorini, and other areas of biodiversity observations, where it is seen as both feasible and complementary to the ocean observations that include regional, cabled observatories. These include, for example, ONC[5] in Canada, EMSO[1] in Europe, DONET[6] in Japan, and some variants of SMART[4] cables on a global scale.

Expanding deep-sea observations and broadening underwater installations that include dedicated infrastructures, special laboratories and multi-platform observatories is the way forward to a better understanding of our oceans. This has been a long-term European commitment effort led by EMSO ERIC[7] involving a number of European countries.

The research infrastructure for deep ocean fixed observations plays a key role in obtaining the requisite scientific understanding, because it is the infrastructure and platforms, with the associated operations and maintenance that drives the cost. There already exists the capability to collect long-term time series and spatial data from the surface, through the water column and down to the deep seafloor. This infrastructure with the sensing can make fundamental and unique contributions in the understanding and promotion of the necessity of a multidisciplinary approach that includes all parties that use, utilise, develop and depend on the oceans of the world.

There are many global scientific and technological infrastructure programmes that already monitor and study the ocean. providing a better understanding of how it plays its part in all aspects of life, whether in the sea or on land. The aims of many of these programmes are already perfectly aligned with the key priorities of the UN Agenda 2030, European Commission (EC) Horizon Europe framework programme (2021-2027), and strongly contribute to the strategic areas of other initiatives, such as the European Union (EU) JPI[8] Oceans.

Nonetheless, what has been outlined above requires an effective and efficient data management that will enable and ensure quality control on a massive scale as well as disseminating this underwater data through a transparent and known management, providing a clearer 4D view of the ocean. This will result in a better understanding of the complex natural and anthropogenic phenomena taking place in the deep ocean that ultimately affects climate, coastal and open sea habitats, natural resources, health and ocean sustainability.

The work and research already completed by the bodies mentioned, indicate that the science, the technology and a greater will from government bodies provide an excellent opportunity to more fully understand the waters that cover the globe, and where encouraged by SDGs[9] It will be possible to foster the 'blue economy' which is based on greater knowledge and understanding and a friendlier use of the oceans.

This Research Topic, within the sections 'Deep-Sea Environments and Ecology', and 'Ocean Observation', consequently highlights the benefits of having an integrated and interdisciplinary approach. The

1 European Multidisciplinary Seafloor and water-column Observatory

2 EMSO Generic Instrument Module

3 Initiatives in Supporting the consolidation and enhancement of the EMSO infrastructure and related Activities

4 Science Monitoring And Reliable Telecommunications

5 Ocean Networks Canada

6 Dense Ocean floor Network System for Earthquakes and Tsunamis

7 European Research Infrastructure Consortium

8 Joint Programming Initiative

9 Sustainable Development Goals

papers have in accordance with this included local and global observations from some of the main worldwide actors in the field of better understanding and protecting the oceans of the world. The results of this have produced themes that are all in agreement and need to be addressed. These are:

- Highlighting the application of international and European ocean observing strategies.
- Showcasing recent and on-going infrastructure program developments.
- Sharing scientific and technology development results that advance integrative assessment.
- Realising use of best practices, data quality control and FAIR[10] principles.
- Documenting data life cycles - origination to delivering analysed information to users.
- Synthesising perspectives on the present and future.

This Research Topic has brought together original research along with technological papers, perspectives, and reviews that focus on delivering integrated ocean observing information to allow for sustainability from the coast to the deep sea. It attracted 16 contributions and involved 178 authors, these can be found in the following link:

https://www.frontiersin.org/research-topics/18542/the-discovery-of-the-unknown-planet-the-ocean.

The response to *'The Discovery of the Unknown Planet: The Ocean'* from within the scientific world and those working in other areas has been extremely positive and it has had a very significant impact with the total number of views presently that of over 38,000.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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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