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Grand challenges in ocean sustainability

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In our Blue Planet, all seas are connected forming a continuous ocean (Figure 1), which drives climate, provides ecosystem services, houses an incredible biodiversity, and ultimately determines the life and well-being of billions of human beings through providing societal goods and benefits. Historically, the ocean has been (over)exploited in multiple ways, for fishing, shipping, recreation, mining, and many other activities. These have resulted in increasing pressures and impacts, which are being exacerbated by the effects of global change, hence the warnings of scientists, conservationists, and international organizations (United Nations, 2021a,b; Georgian et al., 2022).

In this year 2022, we have a window of opportunity to change our harmful relationship with the ocean. Hence, the *"Intergovernmental Conference on an international legally binding instrument under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction"*[1] has been discussing instruments for a sustainable use of the ocean, although, as I write these words, no deal has yet been reached, despite the importance of conserving biodiversity in those areas (Rochette et al., 2014). This debate coincides with this fundamental 2021–2030 decade, in which many international initiatives take place around the sustainability of the planet and, specifically, the ocean: (i) the United Nations (UN) Sustainable Development Goals (SDGs)[2], including SDG14, to conserve and sustainably use the ocean, seas and marine resources for sustainable development; (ii) linked to the previous one, the UN Decade of Ocean Science for Sustainable Development[3], which will increase the international collaboration on scientific research; (iii) the UN Decade on Ecosystem Restoration[4], including marine degraded ecosystems; and (iv) the "30-by-30" from the "High Ambition Coalition for Nature and People"[5], a worldwide initiative for governments to designate 30% of Earth's land and ocean area as protected areas by 2030. Also, many regional environmental initiatives have as horizon 2030 to achieve their objectives, e.g., the European Biodiversity Strategy (European Commission, 2020).

Since the objectives included in those initiatives are still far to be achieved (Andriamahefazafy et al., 2022), this requires us, as scientists, to provide data, knowledge and guidance allowing society and policy-makers to take informed management

1 https://www.un.org/bbnj/
2 https://sdgs.un.org/2030agenda
3 https://www.oceandecade.org/
4 https://www.decadeonrestoration.org/
5 https://www.hacfornatureandpeople.org/home

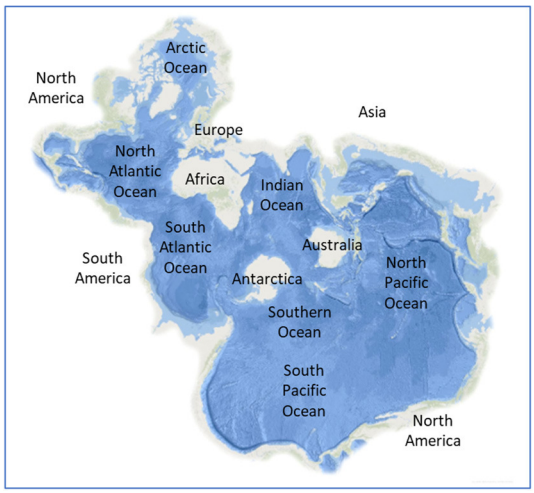

FIGURE 1
The Spilhaus World Ocean in a Square, showing the interconnection of all seas on Earth. Modified from John Nelson web page (https://storymaps.arcgis.com/stories/756bcae18d304a1eac140f19f4d5cb3d).

decisions (Oliver et al., 2021), to investigate solutions to the problems the ocean is facing, to create an ocean literate population, and to promote equitable, inclusive and ethical behavior to ensure the sustainable use of the ocean. Those scientific requirements can be achieved *via* a scientific, transdisciplinary and interdisciplinary journal on sustainability, which promotes open science and open access to all scientific research. Therefore, Frontiers editorial launches *Frontiers in Ocean Sustainability*, with the express aim of responding to the grand challenges we are facing. Some of them are listed below.

The most important current challenge to humanity is **global change**, with specific and important impacts on the ocean and cryosphere (IPCC, 2022), including among others warming, acidification, sea-level rise, marine heat waves, and shifts in biodiversity. These will result in socio-economic impacts for coastal communities, including changes in fish stocks (Lotze et al., 2019; Coll et al., 2020) and the subsequent needs of fisheries management (Holsman et al., 2019; Palacios-Abrantes et al., 2022), and increasing risks of natural disasters, including extreme floods (Hinkel et al., 2014; Prahl et al., 2018). The effects of global change permeate the remainder grand challenges on ocean sustainability, but in which the ocean is also part of the solution to climate change, including geo- and eco-engineering solutions (GESAMP, 2019; Hoegh-Guldberg et al., 2019).

The increasing promotion by governments of the so-called "**Blue Economy**," which includes both traditional (e.g., fishing, shipping) and emerging activities (e.g., biotechnology, seabed mining, renewable energies), either marine-based or marine-related, brings many benefits but also many socio-ecological and socio-economic challenges that can compromise a sustainable use of the ocean (Allison et al., 2020; Lubchenco et al., 2020; European Commission Directorate General for Maritime Affairs Fisheries et al., 2022). These multiple and interacting uses will need to be addressed in an interdisciplinary and transdisciplinary approach (Lang et al., 2012), but also through **Maritime Spatial Planning**, ensuring that activities at sea are sustainable while achieving at the same time a healthy status of the ocean, able to maintain the **provision of ecosystem services** (Gilbert et al., 2015). To monitor this provision, adequate essential ecosystem service variables or indicators are needed (Balvanera et al., 2022).

Most of the abovementioned human activities can introduce **contaminants** into the ocean, either "classical" (e.g., metals, hydrocarbons, nutrients, radioactivity, etc.) or "emergent" (e.g., plastics, noise, pharmaceuticals, etc.), which, by creating biological harm, are termed pollutants. These then need legislative, economic, technological and societal behavioral solutions to allow sustainable use of the ocean (Borja and Elliott, 2021).

Healthy and sustainable **blue food provision** (i.e., fisheries and aquaculture) is necessary to maintain an increasing population (Gephart et al., 2021). However, these are among the activities, especially industrial fisheries, occupying more ocean space and producing more pervasive effects on food-webs and seabed habitats (Lewison et al., 2014; Amoroso et al., 2018). These, and the remaining human activities and their pressures, should be addressed by **restoring and rebuilding marine life** (Duarte et al., 2020), increasing the **conservation and the protection of marine areas**, probably over the 30% already established internationally for 2030 (Waltham et al., 2020; Jefferson et al., 2021).

All of this requires **a holistic vision and approach, integrating** the environmental and biotic ecosystem components and processes with the economic, cultural and social aspirations that generate the resource demands (Elliott et al., 2020). Also, **ocean governance** instruments should be implemented to address the drivers of these demands, and the management of the activities generated by the drivers to achieve societal goals and aspirations (Cormier et al., 2022).

The paramount societal aspiration is for the well-being and health of society. Links between **ocean health and human health** (physical and mental), have been described in multiple societies at different level of development (Depledge et al., 2017; Grellier et al., 2017). Biodiversity, ecosystem services and human well-being are connected (Bennett et al., 2015), fostering human health through ocean sustainability has been already advocated (Fleming et al., 2019), and research agendas to investigate and achieve that objective have been proposed (Borja et al., 2020a).

A holistic and integrative view of human activities and their effects on the ocean is necessary, using the **ecosystem-based management approach** (Levin et al., 2009; Agardy et al., 2011; Link and Browman, 2014; Sardà et al., 2014; Borja et al., 2020b). Despite the multiple meanings of this concept (Kirkfeldt, 2019), one of the most adequate definitions could be that of OSPAR Convention[6]: *"The comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity."* The importance of this definition is that we need to consider humans as part of the marine ecosystems, when managing them, with a socio-ecological focus. The ecosystem-based approach requires tools to assess the health status of ocean, considering multiple components, multiple activities, multiple pressures and

6 https://www.ospar.org/convention/principles/ecosystem-approach#:~:text=For%20the%20purpose%20of%20the,to%20the%20health%20of%20marin

multiple impacts on the environment and the ecosystem services provided. Several tools are available (Borja et al., 2016) and policy- and decision-makers should use them for an adequate monitoring, assessment and management of the ocean. Indeed, the complexity of the system constitutes a "wicked problem" which, as in all fields, requires a comprehensive systems analysis (Elliott et al., 2020).

This management includes responses and sustainable management measures to reduce the pressures and impacts described above. To be successful, those **management measures and solutions** should accomplish ten main tenets, after Elliott (2013): being ecologically sustainable, technologically feasible, economically viable, socially desirable/tolerable, legally permissible, administratively achievable, politically expedient, ethically and morally defensible, culturally inclusive, and effectively communicable. This means that the solutions to the problems at the ocean must bridge the gap between science and policy in a practical way. Any solution must address systemic changes of our relationship with the ocean, be innovative, and simultaneously consider the environmental, social, and economic angles of the ocean problems. These will then pave the way toward a sustainable, inclusive and equitable future in our relationship with the ocean.

The above ten tenets, although aimed at protecting the environment, are dominated by the social system (nine of the ten tenets). Especially, there is the need to educate society to change its behavior through effective **ocean literacy** (Uyarra and Borja, 2016). This behavior change must be related to public awareness, concerns, and priorities regarding anthropogenic impacts on marine environments (Gelcich et al., 2014). In turn, these will lead to a change in the narrative about the future of the ocean (Borja et al., 2022), engaging citizens in the sustainable use of the resources (Blasiak et al., 2015) and taking action for the ocean (Claudet, 2021). Of course, this will also require the help of the regular and social media to drive such changes (Kolandai-Matchett et al., 2021).

I want to finish with another note about this year 2022. Not only is it the 150th anniversary of the HMS Challenger Expedition, the second dedicated scientific expedition of the global ocean, after the Spanish Malaspina expedition in the 18th Century, but also the 6th September was the 500th anniversary of one of the most important challenges about the ocean: the first circumnavigation of the world. It was completed by a crew led by a Portuguese (Fernão de Magalhães) and a Spaniard (Juan Sebastián Elcano). This challenge, while promoted by the Spanish government, was an international endeavor, with a crew of Spanish, Portuguese, Italian, French, Greek, Flemish, German, Irish, British, and Malayan. These people connected the global ocean for us, and 500 years later there is especially the need for a collaborative and international (as that crew) forum to discuss the challenges that the ocean is facing, and to look for solutions and a better management of the ocean. Following the same spirit of those sailors, plenty of curiosity and courage, I invite you to participate in *Frontiers in Ocean Sustainability*, sailing across this ocean of opportunities, to make our use of the ocean sustainable for both nature and society.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

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Conflict of interest

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

Publisher's note

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