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Grand challenges in marine governance for ocean sustainability in the twenty-first century

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The twenty-first century is seeing multiple and accelerating anthropogenic threats to the Ocean which jeopardize the planetary system and human well-being. Given the urgency of this planetary emergency, ensuring Ocean sustainability and an equitable and just future for humanity and the planet requires unprecedented acceleration and innovation in the theory and practice of marine governance. This Perspective provides an overview of recent trends and emerging issues facing the Ocean. It outlines a number of Grand Challenges, or important areas to advance for scholars and practitioners of marine governance, namely the bridging of sectors and scales, connecting people and the seas, consideration of inclusivity, equity and justice, and innovating knowledge generation and the interface of science, society and policy. This will allow to address questions of how to achieve just, equitable and sustainable use of and interaction with the Ocean in the twenty-first century.

KEYWORDS

ABNJ, Blue Economy, equity, Indigenous and local communities, justice, knowledge co-creation, participation, transformation

1. Introduction

The world's Ocean¹ forms an essential part of the planetary system, providing vital functions and ecosystem services that yield societal goods and benefits (Peterson and Lubchenco, 1997; Barbier, 2017). These include fundamental functions in oxygen production and buffering of the climate system, with an important role in heat and carbon dioxide uptake [Intergovernmental Panel on Climate Change (IPCC), 2022]. The world's main routes of transport and communication cross our oceans, one of the many uses of marine space and resources that include renewable energy (Weiss et al., 2018; Jouffray et al., 2020) and the provision of nutritious food and a source of income for billions of people (notably in artisanal and small-scale fisheries in coastal countries of the Global South; FAO et al., 2023). Not least, the Ocean has important roles in culture, recreation and identity (Martin et al., 2016), and overall provides vital support for human health and well-being (Fleming et al., 2019; Borja et al., 2020).

¹ The capitalized spelling of Ocean is used throughout the text to signify the interconnected nature of all of the world's seas that requires equitable cooperation in order to conserve and sustainably use them (Crowder, 2022), as well as the characterization of oceans not only as biogeophysical features but also as spheres of great cultural, socio-economic and political importance. It should not be understood to negate the importance of local context and individual histories (Schwerdtner Mániez et al., 2023).

The perception of the Ocean as a vast and unbounded space, with limitless and practically inexhaustible resources, which prevailed in much of humanity's relationship with the seas (Huxley, 1883; Russ and Zeller, 2003), has slowly given way to the realization that ocean resources are finite, and that fishing has already dramatically altered marine ecosystems on a global scale (Jackson et al., 2001; McCauley et al., 2015). Similarly, while in the past the Ocean was regularly used to dispose of all sorts of pollutants and hazardous material, including ammunition and radioactive waste (Häder, 2021), there is a growing realization that this practice poses an increasing and global threat to human and more-than-human well-being. Recent local and international concerns about the plans to release millions of tons of contaminated water resulting from the accident at the Fukushima Dai'ichi nuclear power plant into the sea are a case in point (Mabon and Kawabe, 2022; Thakur, 2022). Excess nutrient loading (Smith et al., 2003) and changes in ocean chemistry and temperature as a result of anthropogenic greenhouse gas emissions (Feely et al., 2004; Bronselaer and Zanna, 2020) further compound the issue, resulting in declining oxygen (Breitburg et al., 2018) and marine heatwaves (Smith et al., 2023) and exceeding safe and just planetary boundaries for the Ocean (Nash et al., 2017; Rockström et al., 2023). The realization is two-fold: first, that there are limits to the carrying and provisioning capacity of the Ocean, and second, that issues facing the ocean are often transnational in nature, transgressing political and administrative boundaries (Campbell et al., 2016).

Half of the world's population living in cities with >100,000 inhabitants resides <100 km from the coast (Barragán and de Andrés, 2015). More than 10% of the global population and the majority (16 in 2011) of its megacities are located in the coastal zone, which comprises only 2% of the terrestrial area of coastal states but has a population density >5 times the global mean (Blackburn et al., 2013; Neumann et al., 2015). Coastal population growth and urbanization (Sekovski et al., 2012; Merkens et al., 2016) are further aggravating the pressures on coastal systems. Visions for a Blue Economy (Bennett et al., 2019), a rush for open ocean and deep sea resources (Jouffray et al., 2020; Levin et al., 2020), and interest in marine climate change mitigation strategies or ocean carbon capture (Lampitt et al., 2008; Gattuso et al., 2021), with recent emphasis on Blue Carbon (Macreadie et al., 2019) and marine Nature-based Solutions (Lecerf et al., 2021), place a new and strong focus on the Ocean and its resources. The human workforce is moving out to sea more than ever before in the history of humankind, and our footprint in the Ocean continues to grow, making the question of a sustainable future for human-Ocean relations increasingly urgent (Borja, 2023). With the ubiquitous human footprint characteristic of the Anthropocene, marine systems may be transforming into novel social-ecological systems with no historical analogs (Bulleri et al., 2020), posing particular challenges for management and the continued provision of vital services to society (Backstrom et al., 2018; Clement and Standish, 2018). Ensuring sustainability of the multitude of intersecting human activities in and uses of the Ocean (given unclear, overlapping or undefined jurisdictional boundaries) requires swift, agile and appropriate societal steering, or marine governance, which comprises "processes, coordination and collaboration with and throughout civil society," emphasizes "knowledge sharing, learning,

deliberation and communication," and aims for "equity, justice and sustainability as desired outcomes" (Partelow et al., 2023, p. 2). It also requires global evidence-based Ocean governance to become both more inclusive (of non-Western, Indigenous, fishers' and other users' knowledge) and more democratic (the recent activities toward the establishment of an International Panel for Ocean Sustainability are an important development in this regard; see Gaill et al., 2022). This underlines the pressing issue of developing adequate approaches and addressing gaps in the theory and practice of marine governance (ranging from coastal waters to the high seas) to support sustainability of the Ocean in the twenty-first century. Below I briefly outline several areas for which advances in the theory and practice of marine governance seem particularly promising, salient and urgent, and which will be considered as priority in the "Marine Governance" section in *Frontiers in Ocean Sustainability*.

1.1. Bridging sectors and scales

Just as the roles of the Ocean for the planetary system, and for human societies in particular, are diverse and diversifying, so are the threats the Ocean, and humanity that relies on it, are facing—with biodiversity loss, pollution and anthropogenic climate change being the most pervasive [Worm et al., 2006; Landrigan et al., 2020; Intergovernmental Panel on Climate Change (IPCC), 2022]. Indeed, the current "triple planetary emergency" (UN Secretary-General, 2020) is acutely manifest in the Ocean. Yet, sectoral approaches are still common in Ocean governance—for example, some of the most-developed governance arrangements for areas beyond national jurisdiction (ABNJ) are regional fisheries organizations dedicated to the management of transnational fish stocks such as tuna. However, recognizing the interconnected nature of the diverse activities and impacts on the Ocean also requires innovative and more holistic governance approaches that achieve greater cross-sectoral integration (Stephenson et al., 2021), bridging climate change mitigation, biodiversity conservation, and sustainable development, and capitalizing on synergies (Knowlton et al., 2021; Pörtner et al., 2023). Developing tailored, people-centered management approaches that encompass wider societal goals rather than exclusively economic and sectoral targets is a key challenge and may require new institutional arrangements and economic systems, and overcoming prevailing terrestrial (and thus often territorial) biases. Forms of polycentric governance and adequate bridging between regional and global governance arrangements are two areas of attention in this regard (Gerhardinger et al., 2018; Mahon and Fanning, 2019; Adewumi, 2021; Gjerde and Yadav, 2021).

1.2. Connecting people and the seas

The year 2023 saw the landmark signing of an agreement under the UN Convention on the Law of the Sea (UNCLOS) on the conservation and sustainable use of marine biological diversity in ABNJ, concluding nearly two decades of deliberations. This "UN High Seas Treaty" fills an important previous gap in

Ocean governance, but many details remain yet to be resolved during the implementation of the treaty (Jarvis and Young, 2023; Mendenhall et al., 2023). Fulfilling the premise of governance as “societal steering” is made easier if there is an intimate relationship between society at large and the object of governance, which underlines an important feature of the Ocean: the majority (64%) of it is comprised of ABNJ, far from shore and beyond the reach of large parts of the human population. The issue is compounded by another feature of the Ocean—it is intransparent and practically uninhabitable to humans, with its habitats and denizens largely invisible and inaccessible to humans without technical assistance. Western views of the Ocean in particular portray it as vast, empty space, into which society may foray (mostly for economic purposes), but from which it is otherwise absent (Steinberg, 2001; Brum Bulanti et al., 2022). This paradigm still prevails in much of the use and management arrangements of the Ocean (Campbell et al., 2016), although images such as that of the “expanding margin” (Glavovic et al., 2015) which explicitly conceptualize marine spaces as social-ecological systems are now emerging. Advocacy for, and identification with, the plight of the Ocean to improve governance thus requires efforts in increasing and diversifying Ocean literacy (Dupont and Fauville, 2017; Schwerdtner Máñez et al., 2023), which is one of the priority areas of the UN Decade of Ocean Science for Sustainable Development (Ryabinin et al., 2019). It also requires a “repopulating of the seascape” (Aswani et al., 2018), which can draw on examples such as Pacific Island cultures that have long-standing and intimate relationships with the Ocean, extending to the areas of high seas stretching between and connecting the various islands and their societies (McCormack and Mawyer, 2022). Marine social sciences and humanities will have to play a much more central role in marine sciences, where they currently are underrepresented (Partelow et al., 2018). This will not only yield a better understanding and visibility of the various ways humans are living with the Ocean, but also contribute to the necessary knowledge base on sustainability-supporting behavior and behavioral change (McKinley et al., 2020), including e.g., on perceptions (Breckwoldt et al., 2018) and on compliance with rules (Bergseth et al., 2023).

1.3. Inclusivity, equity, and justice

Due to the prevalent paradigm of oceans as “empty spaces,” there potentially is an even higher risk for people to be excluded than in terrestrial systems, where “fortress conservation” has long been a dominant approach, with disastrous results for people (in particular Indigenous communities) and frequently negative environmental outcomes (e.g., Singh and van Houtum, 2002). Indeed, some authors already perceive a paradigm shift from the treatment of Ocean resources as shared property of mankind to an exclusionary approach emphasizing restricted or altogether prevented access, further disenfranchising already marginalized communities (Cabral and Aliño, 2011; Wolff, 2015). This underlines that questions of environmental justice and equity, in multiple dimensions (e.g., resource access, gender) and across different scales [e.g., Global North and South, local communities vs. (trans-)national actors], are at the heart of sustainable Ocean

governance (Bennett, 2022; Smallhorn-West et al., 2023; Spalding et al., 2023). A promising development is that some government agencies are developing frameworks to account for these aspects in their policies and plans (e.g., NOAA Fisheries, 2023). In general, governance arrangements that work with, rather than against, people are needed (Ferse et al., 2010; Ban and Frid, 2018). Noteworthy in this regard are efforts to acknowledge and support Other Effective area-based Conservation Measures (OECMs) in formal marine management (e.g., Estradivari et al., 2022), which hold particular promise for Indigenous and community-based governance (Gurney et al., 2021). At the same time, area-based conservation initiatives with highly unequal power relations, e.g., by private enterprises (Bush et al., 2017), require particular scrutiny to avoid “ocean grabbing” that leads to further exclusion and negative impacts on human well-being (Bennett et al., 2015). Importantly, questions of inclusivity and equity extend to the academic realm as well. Marine science for ocean sustainability is an international undertaking that connects researchers from the Global North and South (Crowder, 2022). Yet, the academic system is still skewed against non-English speaking researchers and those from the Global South (Amano et al., 2023; Talavera-Soza, 2023). Innovations of the way science is organized and assessed are needed to achieve a more inclusive and equitable system that better embraces the full diversity of human knowledge.

1.4. Innovating knowledge generation and the interface of science, society and policy

Working toward a sustainability transformation for the Ocean will require novel ways of science and knowledge generation, establishing a “marine citizenship” (Buchan et al., 2023) and paying specific attention to marginalized and Indigenous peoples and communities (Ban et al., 2018)—who are, incidentally, among the most vulnerable to anthropogenic climate change but contribute proportionally less to the carbon economy (Mason and Rigg, 2019). The recent Kunming-Montreal Global Biodiversity Framework² introduced new perspectives and options regarding the necessity to include Indigenous knowledge and citizen science in decision making, for example in deciding which parts of the Ocean will be included under the 30% area to be protected by 2030—and how the remaining 70% will be used. Equitable and just outcomes of biodiversity conservation essentially require a revolution in the ways local and Indigenous communities are engaged in governance, placing them front and center (Armitage et al., 2020). The tools and approaches for this include participatory processes and participatory methods as exemplified in transdisciplinarity (Klein et al., 2001; Mauser et al., 2013; Gómez and Köpsel, 2022; Hills and Maharaj, 2023), co-creation of knowledge through research co-design and knowledge co-production (Norström et al., 2020), the use of arts, narratives and creative practices (Merrie et al., 2018; Paterson et al., 2020; Strand et al., 2022; Whittaker, 2023), and innovative, meaningful partnerships (Charles, 2019; Haelewaters et al., 2021; Kater, 2022). Indeed, what is

² <https://www.cbd.int/gbfi/>

needed is a new science-society compact for the Ocean (Celliers et al., 2023), which aligns science much closer with society and decision-making. Work on the science/society/policy nexus of the Ocean will yield new methodological and conceptual insights to support this transformation of Ocean sciences. The current rates of change in the Ocean and the increasingly accelerating rate of pervasive human activity (Jouffray et al., 2020) contrast with often sluggish governance responses and institutional change, underlining that we urgently need a step change in the agility and responsiveness of governance structures and the ways that knowledge feeds into decision-making. Simultaneously fostering participatory and democratic processes, which can slow down decision-making processes, is a challenging yet crucial task. It is becoming clear that Ocean governance will have to become much more inclusive of the global diversity of society, knowledge systems and cultures, overcoming the Western-dominated, extraction-oriented paradigms that underpinned much of marine science and management until now. Decolonial marine sciences and practices hold the potential to develop new ways of knowledge generation, giving voice to previously marginalized communities (including Indigenous actors and non-Western scholars), and shaping more holistic and sustainable relationships of humanity and the Ocean in the twenty-first century (George and Wiebe, 2020; Trisos et al., 2021; Bourgeois et al., 2022; Spalding et al., 2023).

2. Conclusion

Ensuring sustainability of the multitude of increasing human activities in and uses of the Ocean requires adequate marine governance. This ranges from transnational and global efforts at regulating use of open oceans (i.e., ABNJ) and the deep sea to national legislation and regional coordination, approaches bridging the land-ocean interface, local and Indigenous forms of management, and grassroots initiatives. New forms of participation, co-design, visions of the future, linking arts, sciences and society, conceptual advances in governance and management, and practical experiences from around the world are just some examples of recent frontiers in marine governance for Ocean sustainability. The Section “Marine Governance” will bring together a collection of studies using conceptual, applied, synthesis and case study approaches of disciplinary, inter- and transdisciplinary nature to address questions of how to achieve just, equitable and sustainable use of and interaction with the Ocean in the twenty-first century.

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Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

SF: Conceptualization, Writing—review & editing, Investigation, Writing—original draft.

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