Sustainability Science
https://doi.org/10.1007/s11625-024-01579-2

NOTE AND COMMENT

Delivering scientific evidence for global policy and management to ensure ocean sustainability

K. Evans[1,2] · J. O. Schmidt[3,4] · K. Appeaning Addo[5] · M. J. Bebianno[6] · D. Campbell[7] · J. Fan[8] · R. Gonzalez-Quiros[9] · E. Y. Mohammed[4] · M. G. Shojaei[10] · V. Smolyanitsky[11] · C.-I. Zhang[12]

Received: 18 July 2024 / Accepted: 17 September 2024

Abstract

Life depends on the ocean, with societal health, cultural systems and national economies reliant on ocean processes and resources. As ocean resources are used, and humans continue to drive climate change, the benefits from the ocean to society are being diminished. Science must meet the needs of policy and deliver to decision makers the information and tools for identifying pathways that support continued delivery of the benefits society derives from the ocean, whilst minimising impacts. This is crucial if the world's nations are to meet the goals and targets they have set under international agreements. Here, we outline how a global assessment that focuses specifically on the ocean, the World Ocean Assessment, is linking science to the governments of the world and their policies within an internationally mandated framework. In doing so, we identify key elements that are needed for facilitating engagement by decision makers and uptake of knowledge, and the pathways taken by the assessment in implementing them. We also provide insights into the evolution that the World Ocean Assessment has undertaken over its first three cycles to progress its goal of enhancing the scientific basis of policymaking. We identify the challenges in delivering science to policy at a global scale and the work that still needs to be done in filling gaps to achieve a coordinated, comprehensive mechanism for connecting science with policy and ensuring future sustainability of the ocean.

Keywords Ocean sustainability · Global assessments · United Nations · Science–policy interface

Introduction

Life on Earth depends on the ocean. Societal health, cultural systems and economies all depend on the processes driven by the ocean and the wide diversity and abundance of marine organisms and associated resources (Barbier 2017). The

Handled by Jerneja Penca, Science and Research Centre Koper, Slovenia.

✉ K. Evans
karen.evans@csiro.au

1 CSIRO, Hobart 7000, Australia

2 Centre for Marine Socioecology, University of Tasmania, Hobart 7000, Australia

3 International Council for the Exploration of the Sea, 1553 Copenhagen V, Denmark

4 WorldFish, CGIAR, Penang, Malaysia

5 Institute for Environment and Sanitation Studies, University of Ghana, Accra, Ghana

6 Centre for Marine and Environmental Research/Aquatic Research Network (ARNET), University of Algarve, 8000-397 Faro, Portugal

7 Department of Geography and Geology, The University of the West Indies, Mona, Kingston 7, Jamaica

8 Ministry of Ecology and Environment, National Marine Environmental Monitoring Center, Dalian 116023, China

9 Centro Oceanográfico de Gijón (COG-IEO), CSIC, 33212 Gijón, Spain

10 Department of Marine Biology, Tarbiat Modares University, Noor 4641776489, Islamic Republic of Iran

11 Arctic and Antarctic Research Institute (AARI), St. Petersburg 199397, Russian Federation

12 Department of Marine Production System Management, Pukyong National University, Busan 48513, Republic of Korea

Published online: 07 October 2024

ocean provides food and jobs for billions of people (OECD 2020) and mediates the effects of climate change at a scale far greater than terrestrial systems (Caldeira et al. 2018). As ocean resources are used, and humans continue to drive climate change, the benefits from the ocean to society are increasingly being documented as declining and under threat (UN 2016, 2021). Urgent action is needed that innovates industries on land and sea and creates the societal behavioural change needed to address and reverse impacts on the ocean (Ryabinin et al. 2019; High Level Panel for a Sustainable Ocean Economy 2023). This need was recognised by the countries of the world at the 2022 United Nations Ocean Conference, where it was declared that "Greater ambition is required at all levels to address the dire state of the ocean" and that "science-based and innovative actions and international cooperation and partnerships based in science, technology and innovation, in line with the precautionary approach and ecosystem-based approaches, can contribute to the solutions necessary to overcome challenges in achieving [the Sustainable Development] Goal 14".[1] It is estimated that, with the right flow of information to make well-informed decisions that support a healthy ocean, marine reliant industries globally can grow from the present US$1.5 trillion a year to US$3 trillion (OECD 2020).

International governance is increasingly recognising the need to support the conservation and sustainable use of the ocean. The 2030 Agenda for Sustainable Development, adopted in 2015, aims to transform the world to one that is sustainable, equitable and peaceful through the achievement of 17 sustainable development goals (SDGs; Weiland et al. 2021). The Agenda identifies SDG 14 to specifically focus on the ocean, although the complex interactions between the goals and their associated targets results in elements of the ocean interwoven and contributing to the achievement of most of the SDGs (International Council for Science 2017; von Schuckmann et al. 2020). Similarly, many of the goals and targets of the Kunming–Montreal Global Biodiversity Framework cannot be achieved without consideration of the ocean and the restoration and conservation of marine ecosystems (e.g. Obura et al. 2023; Fu et al. 2024). The central role of the ocean in mitigating climate change, previously given little attention in climate policy is now formally recognised with the 26th Conference of the Parties of the UN Framework Convention on Climate Change integrating the ocean into its annual climate change negotiation process (Dobush et al. 2021; Fullam et al. 2021). The Agreement 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 (BBNJ Agreement) recognises the need to move beyond fragmented approaches to governing the ocean beyond national jurisdictions to a more holistic framework for protecting and conserving marine biodiversity (Freestone 2012; Gjerde and Yadav 2021). In addition, the Agreement provides the potential of providing a framework that strengthens scientific capacity and equity in the sharing of benefits from the ocean (Morgera et al. 2023). Without recognition of the role the ocean, marine industries and coastal communities have in achieving the various goals and targets and aspirations of these international frameworks, most will not achieve their anticipated outcomes. Further, their achievement requires understanding of the ocean, change occurring in the ocean and the interlinkages of the ocean with the Earth's natural, social, economic and cultural systems.

For governments to achieve the goals set under these agreements, science must deliver to decision makers the information and tools for identifying pathways that support continued delivery of the benefits society derives from the ocean, whilst minimising impacts. These must include the key steps required for implementing assessment and regulatory frameworks and provide examples of good practice that policymakers and managers can apply to deliver sustainability within sub-national, national and regional contexts. Such pathways need to be inclusive, recognise the rights of, and access to benefits to all components of society and acknowledge the connectivity of actions at the scale of the global ocean (Pecl et al. 2022). Frameworks need to be able to acknowledge and account for feedbacks and interactions between society, the economy and the environment if they are to deliver sustainability wholistically (Nash et al. 2020).

To date, progress in delivering such tools, however, has been largely sectoral, with implementation at small spatial scales and in locations where specialist capabilities exist (e.g. Smith et al. 2007). This limits widespread scaling of solutions, sharing of approaches and technologies and implementation at the level of national governments. While calls for recommendations on policy action that is grounded in science are widespread (e.g. Brodie Rudolph et al. 2020; Haas et al. 2022; Gaill et al. 2022), inclusive processes that involve governance systems, industry and society in the generation of those recommendations and associated actions are few (Fleming et al. 2023). Without inclusive, coordinated and effective delivery and sharing of information and tools that can support sustainability trajectories, the effectiveness of international agreements focused on the ocean will fall short with broad-scale implications across all of society (Nash et al. 2020; Vierros and Harden-Davies 2020; Hughes 2023).

[1] See: https://www.un.org/en/conferences/ocean2022/political-declaration.

Inclusive participation and delivering integrated multi-disciplinary science to policymaking frameworks

The need for delivery of information, grounded in science, that can inform policy at multiple scales has seen a number of global assessments, mandated under international processes developed over recent decades. Such assessments have been highly effective in elevating awareness of topics such as climate change (Hermansen et al. 2023) and biodiversity (Borie et al. 2020) and progressing policy dialogue under international processes such as the United Nations Framework Convention on Climate Change (Hermansen et al. 2023). Such assessments provide a mechanism via which information derived from multiple disciplines, vast numbers of research topics and numerous parallel (but rarely connected) discourses can be brought together.

In discussing a global framework for sustainable development (which would eventually result in the 2030 Agenda) at The World Summit on Sustainable Development, the governments of the world recognised that an assessment specifically focused on the marine environment was needed to support the protection and management of "the natural resource base of economic and social development".[2] Although assessments produced under established international processes such as the Global Environment Outlook[3] and the Intergovernmental Panel on Climate Change (IPCC)[4] focus on topics of relevance to the ocean, their mandates require that the assessments they produce, while multi-disciplinary in content, are delineated in their focus on the ocean considered by their assessments. This has resulted in large gaps in the consideration of social, economic and cultural aspects of the ocean and wholistic delivery of relevant information that is needed for comprehensively assessing the ocean and identifying the multiple pathways needing to be implemented for achieving sustainability. For example, the Special Report on Ocean and Cryosphere in a Changing Climate (IPCC 2019) only considers impacts on oceans and associated ocean-based communities associated with climate change. It does not consider human use and other associated impacts on the ocean, the interactions between multiple uses and the cumulative effects of impacts, the flow-on effects on social, economic and cultural systems and the pathways for addressing those multiple impacts and multiple mechanisms needed for setting a direction towards sustainability. The Global Environment Outlook 6 (UN Environment 2019), while providing information on the state of the ocean and in association those processes impacting the ocean, as well as an evaluation of relevant ocean policies, also does not consider ocean-related social, economic and cultural systems and the flow-on effects of a changing ocean on these. Its consideration of future outlooks and pathways for the ocean in achieving sustainability is also limited. These assessments have clearly demonstrated utility and uptake and delivery against their mandates; however, their focus limits consideration of the complexity of ocean systems, including the multiple interactions between the various elements within ocean systems (e.g. natural, social, economic, cultural) and the many, various actors that need to be engaged in developing and implementing solutions that support the goals and aspirations of multiple international governance frameworks.

The Regular Process for Global Reporting and Assessment of the State of the Marine Environment, including socioeconomic aspects (known as the World Ocean Assessment (WOA)), provides a mechanism to fill this gap, having a specific focus on the ocean and an explicit aim to provide a mechanism for delivering scientific information on the ocean directly to governments through the United Nations (UN) General Assembly (Evans et al. 2019). Similarly, to other global assessments, it is not tasked with specifically generating new information, but rather summarising and integrating expert information on all aspects of the ocean and providing this information in a coordinated and unbiased way (Evans et al. 2019, 2021).

Delivery of each assessment is driven by the member states of the UN, via their representatives and experts (across scientific, social, economic and governance disciplines) who are involved in each WOA at multiple stages from conception to delivery. This involvement provides a direct connection between the science delivered through the assessment with governments, their policymakers and those involved in various elements of decision-making, whether that be as part of international negotiations or in the implementation of policies at the national and sub-national scales. In this respect, the WOA plays a boundary or brokering role that directly links science to the governments of the world and their policies. Involvement by member states is facilitated through several mechanisms including (i) formal governing bodies that have oversight of each 5-year cycle of the Regular Process and the associated activities that occur during each cycle, including the production of the WOA, (ii) National and Intergovernmental Focal Points, which are designated by member states and the secretariats of intergovernmental organisations to facilitate the programme of work for each cycle of the Regular Process, including nomination of experts that contribute to the WOA and (iii) review stages conducted during the initial scoping and later drafting stages of each assessment. Member states also directly contribute to the Regular Process through the facilitation and engagement in regional and specialised workshops conducted as

[2] https://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/WSSD_PlanImpl.pdf.

[3] https://www.unep.org/geo/.

[4] https://www.ipcc.ch/.

part of the initial scoping and information gathering stages of the WOA.

The WOA is relatively young compared to other assessments, currently part way through its third cycle. In the spirit of continual improvement and adaptability to policy needs, it has undertaken an active evolution across cycles. Key areas in which development and improvement have focused are (i) linking science with policy across multiple scales; (ii) inclusivity of engagement with, and delivery of products to, ocean stakeholders; (iii) integration of content across the environment, society and the ocean economy; (iv) provision of options and tools for supporting decision-making.

For global assessments to have a meaningful impact on policy formulation, it is essential that they bridge the gap between the international and the national/sub-national levels of decision-making and policy implementation. To assist this, regional workshops covering most ocean regions are held during each cycle of the WOA. These provide a pathway for the flow of regionally based and produced information, the incorporation of multi-disciplinary perspectives and facilitate interactions between experts from different ocean sectors including policymakers operating at the national and sub-national scales. They also facilitate contributions to each assessment cycle outside of formal participation in the writing of each assessment.

Recognising the need for input at multiple stages within each assessment cycle, the workshops have been expanded from one round of five workshops in the first cycle, to two rounds of five workshops in the second and third cycle. This expansion has specifically aimed to broaden input into the development of assessments, at first, the scoping and, second the content development stages to ensure that assessments are broadly responsive to feedback provided by those involved in the workshops and facilitate broad engagement in the development of each assessment. Further, they are purposefully regionally distributed to facilitate engagement across geographic areas and direct support is provided that facilitates the engagement of participants from underrepresented regions, including, in particular, least developed countries (LDCs) and small island developing states (SIDS). This allows those involved in guiding the development of each assessment to identify improved mechanisms for engaging those that contribute and support the development of each assessment and delivering the assessment and its content in accessible and useable ways. It is through this process that the WOA initiated during its third cycle the development of digital delivery mechanisms that will eventually result in vastly improved access to and exploration of WOA content (see also below).

The expanded opportunity for engagement in the WOA, facilitated through the regional workshops, goes some way to addressing earlier criticisms around participation in the WOA (Fawkes and Cummins 2019) and engagement in international processes more broadly (e.g. Hulme et al. 2011; Feary et al. 2014; Díaz-Reviriego et al. 2019; Singh et al. 2023), noting that there is always room for improvement. It also results in the WOA being somewhat different to other global assessments, where the design of individual assessments and identification of topics and thematical content is largely set internally and gathering of information is limited to the efforts of individual writing teams. These workshops are important mechanisms for connecting the WOA to the wider community including governments, non-governmental organisations, policy- and decision-makers, civil society, business and scientists (all of whom have been represented in workshops to date), a criticism made broadly of global assessments (e.g. Beck and Mahoney 2018). Further, the engagement provided through the WOA's workshops provides those involved with a sense of ownership in delivering each assessment. This sense of ownership is essential for ensuring that assessments of this scale have broad uptake.

For society to understand the central role that the ocean plays in sustaining life on Earth and what is required to achieve sustainability, information must be delivered in integrative formats that recognise the many interactions between the environment, society, economics, culture and governance. The third WOA, due to be delivered in 2025, aims to provide information on the ocean in a far more integrative way than it has previously. This next assessment[5] will do this by first requiring chapters associated with ocean economies to explicitly detail information relating to impacts on the natural components of the ocean, social considerations, including equity, and governance frameworks. Governments, policymakers and managers benefit from having access to information that demonstrates positive outcomes from the implementation of frameworks and mechanisms that are relevant to their context and region, and society has a clear need for practical and applicable information. Provision of such information was identified via the regional workshops held during the scoping process for the third WOA and has been echoed elsewhere (e.g. Gaill et al. 2022). In responding to this identified gap, these chapters are also required to detail the available information and tools available that can be used by governments, policymakers and managers for guiding and directing ocean sectors along pathways that support ocean sustainability. This is framed under an expert-generated future ocean scenario that looks across the environment, society, economics, technology, governance and politics[6] and sets out an achievable set of goals that

[5] The full annotated outline of the third ocean assessment can be accessed at: https://www.un.org/regularprocess/sites/www.un.org.regularprocess/files/2_clean_ver_edited_annotated_outline_of_third_assessment_final_clean.pdf.

[6] See https://www.un.org/regularprocess/sites/www.un.org.regularprocess/files/guidance_for_writing_teams_for_web.pdf.

are relevant to ocean economies. Second, the third WOA requires all chapters to actively consider social, economic and ecological components of the ocean so that each chapter discusses the interactions between these components comprehensively. Third, the third WOA has incorporated specific chapters that are focused on multi-disciplinary themes such as gender, equity, human health and Indigenous knowledge that ensure that multiple streams of information are integrated. Finally, multiple approaches to delivering information for use are being developed and implemented, including the use of digital delivery and social media platforms, with the view of being able to explore concepts and topics from a more integrated (cross-chapter) perspective, thereby increasing access to and use of information produced by the assessment. To further support this, the third WOA is partnering with expert agencies such as the Intergovernmental Oceanographic Commission of UNESCO, the Organisation for Economic Co-operation and Development (OECD) and the Intergovernmental science-policy Platform for Biodiversity and Ecosystem Services (IPBES) Indigenous and Local Knowledge Task Force to deliver specialist and targeted information that facilitates integration across the environment, society, economics, culture and governance.

Pathways for furthering the delivery of science for policymaking

The broad mandate of the WOA, the multiple scales at which information on the ocean is produced and gaps and uncertainties in knowledge, presents challenges to bridging science with policy. There is still much work to be done to ensure that policy action is well informed by science if current rates of ocean degradation are to be halted and reversed in a coordinated and effective way. This extends to the WOA, where there are still gaps to fill and areas for improvement that need to be addressed. Greater efforts are needed in increasing inclusivity in the WOA, particularly in engaging with LDCs and SIDS, and with Indigenous Peoples to ensure that regional perspectives and multiple forms of knowledge are acknowledged and appropriately recognised in assessments. Further, greater inclusivity by, and engagement with, practitioners developing and implementing policy is needed to support understanding of the information, tools and mechanisms available that can be used in developing policies that directly create action towards sustainability and identify the gaps that are needed to be filled to achieve this. These are all elements often called for (e.g. Dilling and Lemos 2011; Singh et al. 2023), but the mechanisms for facilitating this inclusivity are rarely articulated beyond conceptual frameworks.

While the workshops conducted as part of each assessment cycle go some way to facilitating this, further work is needed to increase involvement in the assessment process, particularly by underrepresented communities. As part of the development of the third WOA, a specific workshop involving representatives from Indigenous, Traditional Owner and local community knowledge holders was conducted with an explicit view of discussing and identifying pathways for supporting inclusivity. Formal mechanisms that can be implemented in the fourth cycle of the Regular Process are currently being developed as an outcome from that workshop. In addition, as identified earlier, the WOA coexists with other regularly produced global assessments that also deliver information of relevance to ocean decision-making. Opportunities exist for synergies and complementary activities with those assessment processes, through the identification of reciprocal needs and coordinating efforts in simplifying the delivery and transfer information for ocean policy. This will have the additional benefits of reducing duplication, ensuring messaging around science is consistent and better integrating outputs.

Innovative approaches to improve accessibility to information once assessments are delivered is also needed to enhance uptake by those that require access to information. The third WOA is planned to be provided for the first time via a dedicated digital platform that allows for quick and easy access to content. This will move delivery of information beyond a static downloadable format and towards one that can be explored in multiple ways. Future plans, beyond the current assessment cycle, are for this platform to be interactive, providing direct linkages to the sources of information and data, thereby facilitating deeper understanding and sharing of content. These efforts will need to be further built upon to expand the delivery of information across multiple platforms, in languages beyond the official languages of the UN and in formats that minimise exclusivity, particularly across societal minorities (e.g. the visually or hearing impaired). This will not only support greater access by decision-makers and the broader community, but also address current challenges to scientific literacy and enhance capacity in regions where it is needed: elements key to bridging science with policy and societal behavioural change.

Broader mechanisms for gathering feedback on the utility of the WOA, particularly by practitioners developing and implementing ocean policies, are needed to ensure that the WOA continues to adapt and deliver to societal needs. At present, feedback is largely limited to a lessons-learned process, which involves governmental representatives, those involved in writing and reviewing the assessment and the secretariat and expert coordinating group for the WOA. This includes providing feedback on challenges faced and what could be done to overcome those challenges. While this is an avenue for gathering the views of many (more than 700 experts were involved in the second WOA), this feedback

is limited to the practical and procedural elements of each assessment cycle and provides no clear mechanism for evaluating the use and uptake of information into policy.

As part of the workshops for the third WOA, the secretariat for the Regular Process distributed a survey gauging the awareness and use of the first and second assessment. These aimed to better understand the utility of assessments and where improvements to the WOA could be introduced. The survey identified that while there was awareness of the WOA amongst many of the participants, actual use of the assessment was limited. This was identified as the result of two inter-related factors: (i) the format of the assessment (printed in case of the first WOA and delivered as two separate pdfs in the case of the second WOA) limited the ability to search for and extract information that might be derived from multiple chapters and (ii) limited access to regional information. When queried as to what would be of most use, many participants again identified that being able to access and easily digest information was a priority, whether that be through summaries for policymakers, factsheets or online databases that collate and deliver information of relevance. As far as we are aware, this is the first time that a global assessment has directly gathered feedback from the community on its utility. This evaluation process, however, was limited to workshop participants only and did not include others that might access and use the WOA. Further development of processes that support the provision of wider feedback is needed to facilitate a process of continual improvement that improves information delivery for ocean action.

Conclusions

The timing of the delivery of the third WOA aligns with the third UN Conference to Support the Implementation of Sustainable Development Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development, to be held in June 2025 in Nice, France. The preliminary findings of the third WOA are planned to be delivered to this gathering of national governments, UN bodies, intergovernmental organisations, non-governmental organisations, scientists, business leaders and ocean advocates, with the conference providing a mechanism for supporting the delivery of the information captured by the third WOA directly to decision-makers and the broader ocean community. The conference also provides the opportunity to gather information from the community for continuing improvement of the WOA and identify synergies and collaborative efforts with other international processes for improving the delivery of science to policy. Only through this continual exchange of perspectives and associated learning will the goal of the WOA to enhance the scientific basis of policymaking for the ocean be achieved.

Acknowledgements The authors would like to acknowledge the support of the Secretariat for the Regular Process (DOALOS) in producing this manuscript. We would also like to acknowledge the contributions of the wider Group of Experts, writing teams, peer reviewers, workshop attendees and representatives of the UN member states involved in the three cycles of the Regular Process for their constructive comments on the Regular Process and identification of areas for improvement, many of which are reflected in this manuscript. We would like to thank Jessica Farley, Beth Fulton, Carmen Misfud and Roberto de Pinho for reviewing earlier versions of this manuscript.

Author contributions Conceptualisation: KE, JOS. Visualisation: KE, JOS. Writing—original draft: KE, JOS. Writing—review and editing: KE, JOS, KAA, MJB, DC. RG-Q, CM, EYM, MGS, VS, C-IZ.

Funding Open access funding provided by CSIRO Library Services. N/A.

Data and materials availability All data are available in the main text.

Declarations

Conflict of interest The authors declare that they have no competing interests.

References

Barbier EB (2017) Marine ecosystem services. Curr Biol 27:R507–R510. https://doi.org/10.1016/j.cub.2017.03.020

Beck S, Mahoney M (2018) The IPCC and new map of science and politics. Wires Clim Change 9:e547. https://doi.org/10.1002/wcc.547

Borie M, Gustafsson KM, Obermeister N, Turnhout E, Bridgewater P (2020) Institutionalising reflexivity? Transformative learning and the Intergovernmental science-policy platform on biodiversity and ecosystem services (IPBES). Environ Sci Policy 110:71–76. https://doi.org/10.1016/j.envsci.2020.05.005

Brodie Rudolph T, Ruckelshaus M, Swilling M, Allison EH, Österblom H, Gelcich S, Mbatha P (2020) A transition to sustainable ocean governance. Nat Commun 11:3600. https://doi.org/10.1038/s41467-020-17410-2

Caldeira K, Akai M, Brewer P, Chen B, Haugan P, Iwama T, Johnston P, Kheshgi H, Li Q, Ohsumi T, Pörtner H, Sabine C, Shirayama Y, Thomson J (2018) Ocean storage. In: Metz B, Davidson O, de Conink HC, Loos M, Meyer LA (eds) IPCC special report on carbon dioxide capture and storage, intergovernmental panel on climate change. Cambridge University Press, Cambridge, pp 277–318

Díaz-Reviriego I, Turnhout E, Beck S (2019) Participation and inclusiveness in the intergovernmental science-policy platform on

biodiversity and ecosystem services. Nat Sustain 2:457–464. https://doi.org/10.1038/s41893-019-0290-6

Dilling L, Lemos MC (2011) Creating usable science: opportunities and constraints for climate knowledge use and their implications for science policy. Glob Environ Chang 21:680–689. https://doi.org/10.1016/j.gloenvcha.2010.11.006

Dobush BJ, Gallo ND, Guerra M, Guilloux B, Holland E, Seabrook S, Levin LA (2021) A new way forward for ocean-climate policy as reflected in the UNFCCC ocean and climate change dialogue submissions. Clim Policy 22:254–271. https://doi.org/10.1080/14693062.2021.1990004

Evans K, Chiba S, Bebianno MJ, Garcia-Soto C, Ojaveer H, Park C, Ruwa R, Simcock AJ, Vu CT, Zielinski T (2019) The global integrated world ocean assessment: linking observations to science and policy across multiple scales. Front Mar Sci 6:298. https://doi.org/10.3389/fmars.2019.00298

Evans K, Zielinski T, Chiba S, Garcia-Soto C, Ojaveer H, Park C, Ruwa R, Schmidt JO, Simcock A, Strati A, Vu CT (2021) Transferring complex scientific knowledge to useable products for society: the role of the global integrated ocean assessment and challenges in the effective delivery of ocean knowledge. Front Environ Sci 9:626532. https://doi.org/10.3389/fenvs.2021.626532

Fawkes KW, Cummins V (2019) Beneath the surface of the first world ocean assessment: an investigation into the global process' support for sustainable development. Front Mar Sci 6:612. https://doi.org/10.3389/fmars.2019.00612

Feary DA, Fowler AM, Ward TJ (2014) Developing a rapid method for undertaking the world ocean assessment in data-poor regions: a case study using the South China Sea large marine ecosystem. Ocean Coast Manage 95:129–137. https://doi.org/10.1016/j.ocecoaman.2014.04.006

Fleming A, Bohensky E, Dutra LXC, Lin BB, Melbourne Thomas J, Moore T, Stone-Jovicich S, Tozer C, Clarke JM, Donegan L, Hopkins M, Merson S, Remenyi T, Swirepik K, Vertigan C (2023) Perceptions of co-design, co-development and co-delivery (Co-3D) as part of the co-production process—insights for climate services. Clim Serv 30:100364. https://doi.org/10.1016/j.cliser.2023.100364

Freestone D (2012) International governance, responsibility and management of areas beyond national jurisdiction. Int J Mar Coast Law 27:191–204. https://doi.org/10.1163/157180812X633609

Fu C, Steckbauer A, Mann H, Duarte CM (2024) Achieving the Kunming–Montreal global biodiversity targets for blue carbon ecosystems. Nat Rev Earth Environ 5:538–552. https://doi.org/10.1038/s43017-024-00566-6

Fullam C, Strong AL, Pouponneau A, Reiter S (2021) An upwelling of support for the ocean-climate biodiversity nexus: Progress toward institutionalization at COP26. Sustainability and Climate Change 14:6. https://doi.org/10.1089/scc.2021.0078

Gaill F, Brodie Rudolph T, LebleuL AD, Blasiak R, Cheung WK, Claudet J, Cavaleri Gerhrdinger L, Le Bris N, Levin L, Otto Pörtner H, Visbeck M, Zivian A, Bahurel P, Bopp L, Bowler C, Chious F, Cury P, Gascuel D, Goyet S, Hilmi N, Ménard F, Micheli F, Mullineaux L, Parmentier R, Sicre M-A, Speich S, Thébaud O, Thiele T, Bowler M, Charvis P, Cuvelier R, Houllier F, Palazot S, Staub F, Poivre d'Arvor O (2022) An evolution towards scientific consensus for a sustainable ocean future. Ocean Sustain 1:7. https://doi.org/10.1038/s44183-022-00007-1

Gjerde KM, Yadav SS (2021) Polycentricity and regional ocean governance: implications for the emerging UN Agreement on marine biodiversity beyond national jurisdiction. Front Mar Sci 8:704748. https://doi.org/10.3389/fmars.2021.704748

Haas B, Mackay M, Novaglio C, Fullbrook L, Murunga M, Sbrocchi C, McDonald J, McCormack PC, Alexander K, Fudge M, Goldsworthy L, Boschetti F, Dutton I, Dutra L, McGee J, Rousseau Y, Spain E, Stephenson R, Vince J, Wilcox C, Haward M (2022) The future of ocean governance. Rev Fish Biol Fisheries 32:253–270. https://doi.org/10.1007/s11160-020-09631-x

Hermansen EAT, Boasson EL, Peters GP (2023) Climate action post-Paris: how can the IPCC stay relevant. npj Clim Action 2:30. https://doi.org/10.1038/s44168-023-00058-1

High Level Panel for a Sustainable Ocean Economy (2023) Transformations for a sustainable ocean economy. A vision for protection, production and prosperity. High Level Panel for a Sustainable Ocean Economy

Hughes AC (2023) The post-2020 global biodiversity framework: how did we get here, and where do we go next? Integr Conserv 2:1–9. https://doi.org/10.1002/inc3.16

Hulme M, Mahony M, Beck S, Görg C, Hansjürgens B, Hauck J, Nesshöver C, Paulsch A, Vanderwalle M, Wittmer H, Böschen S, Bridgewater P, Chimére Diaw M, Fabre P, Figeroa A, Luen Heong K, Korn H, Leemans R, Lövbrand E, Norowi Hamid M, Monfreda C, Pielke R, Settele J, Winter M, Vadrot ABM, Van Den Hove S, Van Der Sluijus JP (2011) Science-policy interface: beyond assessments. Science 333:697–698. https://doi.org/10.1126/science.333.6043.697

International Council for Science (2017) A guide to SDG interactions: from science to implementation. International Council for Science, Paris

IPCC (2019) IPCC special report on the ocean and cryosphere in a changing climate. Cambridge University Press, Cambridge, UK

Morgera E, McQuaid K, La Bianca G, Niner H, Shannon L, Strand M, Rees S, Howell K, Snow B, Lancaster AMS, Sauer W (2023) Addressing the ocean-climate nexus in the BBNJ agreement: strategic environmental assessments, human rights and equity in ocean science. Int J Mar Coast Law 38:447–479. https://doi.org/10.1163/15718085-bja10139

Nash KL, Blythe JL, Cvitanovic C, Fulton EA, Halpern BS, Milner-Gulland EJ, Addison PFE, Pecl GT, Watson RA, Blanchard JL (2020) To achieve a sustainable blue future, progress assessments must include interdependencies between the sustainable development goals. One Earth 2:161–173. https://doi.org/10.1016/j.oneear.2020.01.008

Obura D, Agrawal A, DeClerk F, Donaldson J, Dziba L, Emery MR, Friedman K, Fromentin J-M, Garibaldi LA, Mulongoy J, Navarrete-Frias C, Mosig Reidl P, Roe D, Timoshyna A (2023) Prioritizing sustainable use in the Kunming-Montreal global biodiversity framework. PLOS Sustain Transform 2:e0000041. https://doi.org/10.1371/journal.pstr.0000041

OECD (2020) Sustainable ocean for all: harnessing the benefits of sustainable ocean economies for developing countries. Organisation for Economic Cooperation and Development, Paris

Pecl GT, Alexander KA, Melbourne-Thomas J, Novaglio C, Villaneuva C, Nash KL (2022) Future seas 2030: pathways to sustainability for the UN ocean decade and beyond. Rev Fish Biol Fisheries 32:1–7. https://doi.org/10.1007/s11160-022-09705-y

Ryabinin V, Barbière J, Haugan P, Kullenberg G, Smith N, McLean C, Troisi A, Fischer A, Aricò S, Aarup T, Pissierssens P, Visbeck M, Enevoldsen HO, Rigaud J (2019) The UN decade of ocean science for sustainable development. Front Mar Sci 6:470. https://doi.org/10.3389/fmars.2019.00470

Singh GG, Harden-Davies H, Swartz W, Cisneros-Montemayor AM, Ota Y (2023) An international panel for ocean sustainability needs to proactively address challenges facing existing science-policy platforms. npj Ocean Sustain 2:21. https://doi.org/10.1038/s44183-023-00024-8

Smith ADM, Fulton EJ, Hobday AJ, Smith DC, Shoulder P (2007) Scientific tools to support practical implementation of ecosystem-based fisheries management. ICES J Mar Sci 64:633–639. https://doi.org/10.1093/icesjms/fsm041

UN Environment (2019) Global environment outlook—GEO-6: healthy planet. Cambridge University Press, Cambridge

United Nations (2016) First global integrated marine assessment. United Nations, New York

United Nations (2021) The second world ocean assessment. United Nations, New York

Vierros MK, Harden-Davies H (2020) Capacity building and technology transfer for improving governance of marine areas both beyond and within national jurisdiction. Mar Policy 122:104158. https://doi.org/10.1016/j.marpol.2020.104158

von Schuckmann K, Holland E, Haugan P, Thomson P (2020) Ocean science, data, and services for the UN 2030 sustainable development goals. Mar Policy 121:104154. https://doi.org/10.1016/j.marpol.2020.104154

Weiland S, Hickmann T, Lederer M, Marquardt J, Schwindenhammer S (2021) The 2030 agenda for sustainable development: transformative change through the sustainable development goals? Polit Govern 9:90–95. https://doi.org/10.17645/pag.v9i1.4191