

Vision 2030 Challenge 8: towards a comprehensive digital representation of the ocean: strategic ambition for the Ocean Decade Challenge 8

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Abstract

Ocean Decade Challenge 8 of the Ocean Decade seeks to create and make available an adaptive and dynamic digital representation of the ocean to enhance decision-making and support sustainable ocean management. For Challenge 8, success depends on our ability to create the enabling environment that allows diverse stakeholders to access, contribute to, and benefit from an inclusive and interconnected global digital ocean ecosystem. The strategic ambition has thus focused on defining the concrete outcomes and fostering the transformational change needed to create the enabling environment and initial digital assets by 2030 that will allow us to generate a comprehensive digital representation of the Ocean. This requires access to the global collection of interlinked and interoperable digital assets, including FAIR data, information, models, software, applications, as well as the digital architectures and infrastructures which support and connect them. Only collectively, will these assets allow us to better understand the ocean's past, present, and future state and support informed decision-making. Challenge 8 is a cross-cutting endeavour underpinning all other challenges and must therefore deliver resources that are relevant and useful for the widest possible range of users and stakeholders in ways adapted to their needs and capacities, leaving no one behind. This will require a continuous and iterative process, significant resources, multi-stakeholder collaborations, transparent processes, and clear focus on inclusivity and equity, to establish the digital foundations needed to support sustainable ocean management for the decades to come.

Main paper

The United Nations Decade of Ocean Science for Sustainable Development 2021–2030 (the ‘Ocean Decade’), through its Challenge 8, seeks to create a dynamic digital representation of the ocean. Challenge 8 was inspired by the need for comprehensive access to the multidisciplinary ocean data, information, and knowledge needed to address societal pressures on the ocean and enable its protection and sustainable management (Ryabinin et al. 2019). The complex requirements of Ocean Decade stakeholders can only be met by providing a comprehensive ‘digital representation’ of the ocean (UNESCO-IOC 2021). Such a digital representation has to comprise an evolving and dynamic framework encompassing a global collection of interlinked, findable, accessible, interoperable, and reusable digital assets (Wilkinson et al. 2016). These assets include data, information, models, software applications, including digital twins of the ocean, and the architecture and infrastructure which support and connect them (UNESCO-IOC 2023).

From the outline above, it is clear that Challenge 8 is cross-cutting, underpinning all other Ocean Decade Challenges and therefore needs to serve all Ocean Decade actors and the wider ocean community, which is very diverse. However, all users share common needs: (i) easy access to comprehensive, multidisciplinary digital content and resources, including harmonized data layers, models, and digital twin applications, alongside (ii) tools to easily find, access, and share these resources. In this vision, ocean data can be discovered using web tools, such as commercial search engines, and digital twin of the ocean platforms can integrate the discovered data using well-described application programming interfaces and semantics.

As part of the Ocean Decade Vision 2030 process, 18 experts analysed Ocean Decade Challenge 8, set priorities and specified the strategic ambition and related targets. This paper summarizes their final recommendations which were originally formulated in an Ocean Decade white paper (Calewaert et al. 2024).

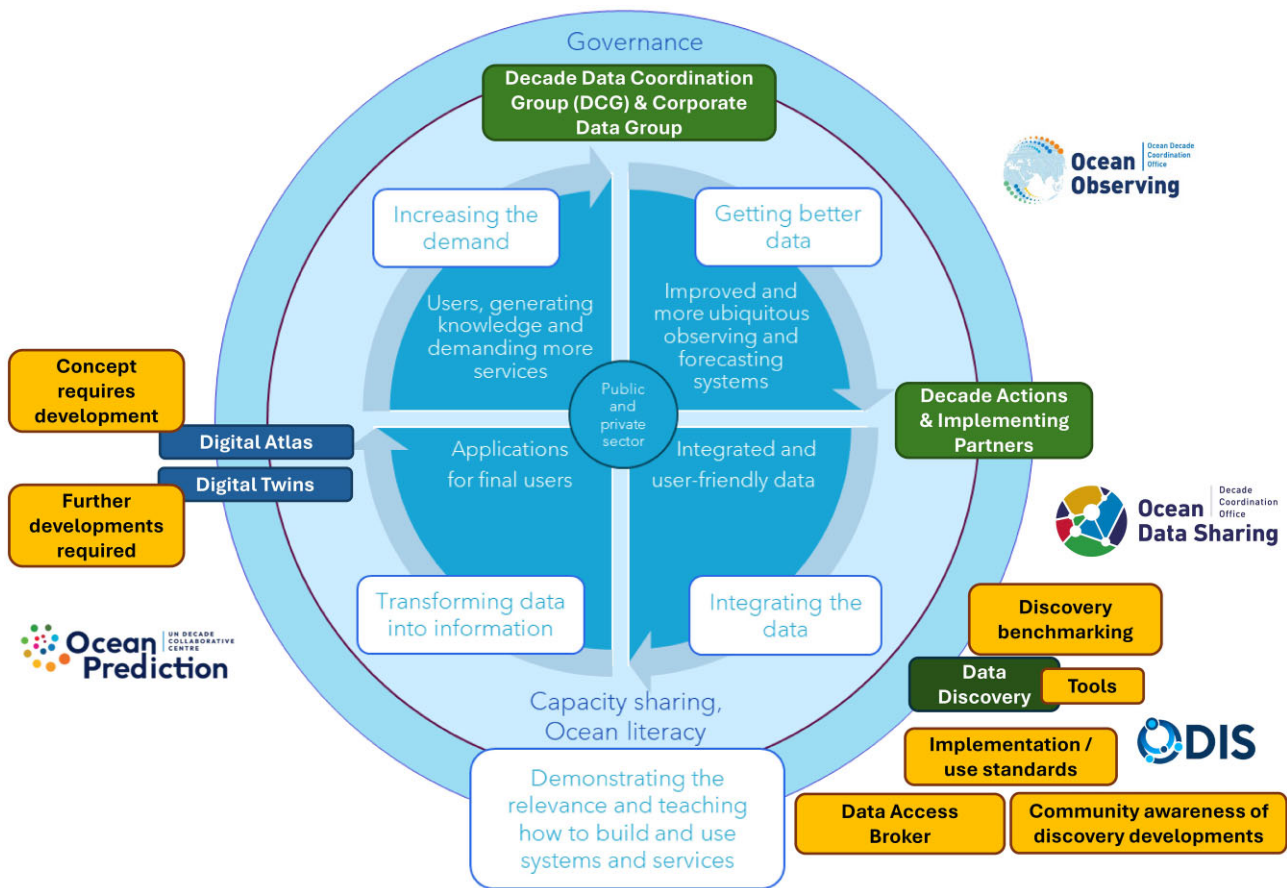


Figure 1. A strategic approach to nurturing the Global Ocean Digital Ecosystem and achieving the goals of Ocean Decade Challenge 8 Vision 2030. There is a need to increase the volume of high-quality ocean data ('Getting Better Data') by improving and expanding our ocean monitoring programmes, ocean observing activities, ocean forecasting system (model output data), and unlocking data held by the private sector. These data are to be integrated into user-friendly environments ('Integrating the Data') among others through Decade Actions and Decade Implementing Partners. Making the data more discoverable through the Ocean Data and Information System (ODIS) will be critical to allow these data to be included in applications for users ('Transforming data into information') that will generate knowledge, among others in Digital Twin Applications and in a Digital Atlas, to support decision making and identify needs for additional ocean data ('Increasing the demand'). For this to be efficient, appropriate tools, capacity sharing and Ocean literacy must be active on each step of the loop ('Demonstrating the relevance and teaching how to build and use systems and services'), and a clear, transparent and well-defined governance is required. Over this loop, several components and coordination bodies (boxes and logos) as well as areas for further development (boxes) are highlighted. The positions of these are indicative of important areas where those are needed, but many of them will be relevant in additional steps of the loop

The white paper states that, by 2030, the foundations for a comprehensive digital ecosystem (see Fig. 1) are to be established as a prerequisite for delivering Challenge 8. This has to include unlocking ocean observations which have not traditionally been publicly shared, such as those held by private enterprise operating in the marine domain. Further, the specifications for sharing data are to be co-developed by technical and subject matter experts, and appropriate tools to enable both metadata and data sharing must be developed where not available yet. The implementation cannot exclude actors with less capacity or resources.

Success towards achieving Challenge 8 must be shown by global flagship data products that will be accessible as base layers through an online Digital Atlas, including local use cases that prioritize Small Island Developing States (SIDS) and Least Developed Countries (LDCs), such as fisheries sustainability in South-East Asia. Among others, use cases have to demonstrate the effectiveness of the digital ecosystem in regions where data sources are underrepresented and/or digital capacity is lacking. Where appropriate,

approaches to data sharing must be guided by principles for indigenous data governance (Carroll et al. 2020), and developed in close collaboration with indigenous communities. Establishing transparent and equitable processes for prioritizing, co-designing, and sharing digital products and services is equally important, to ensure that selected global base layers and local case studies meet user needs and address key questions for each of the Ocean Decade's thematic challenges. These processes are needed to ensure that conflicting interests do not unduly influence data product development and that prioritization and selection of use cases are equitable. The Ocean Decade's Data Coordination Group has a key role to play in formalizing these processes into the Ocean Decade and by incorporating the mechanisms into the UN's normative structures. For example, one component of the Ocean Decade's Digital Ecosystem, i.e. the ODIS architecture, is being openly developed in GitHub, with issue tracking and documentation available to all, providing one possible mode for transparent product and service development.

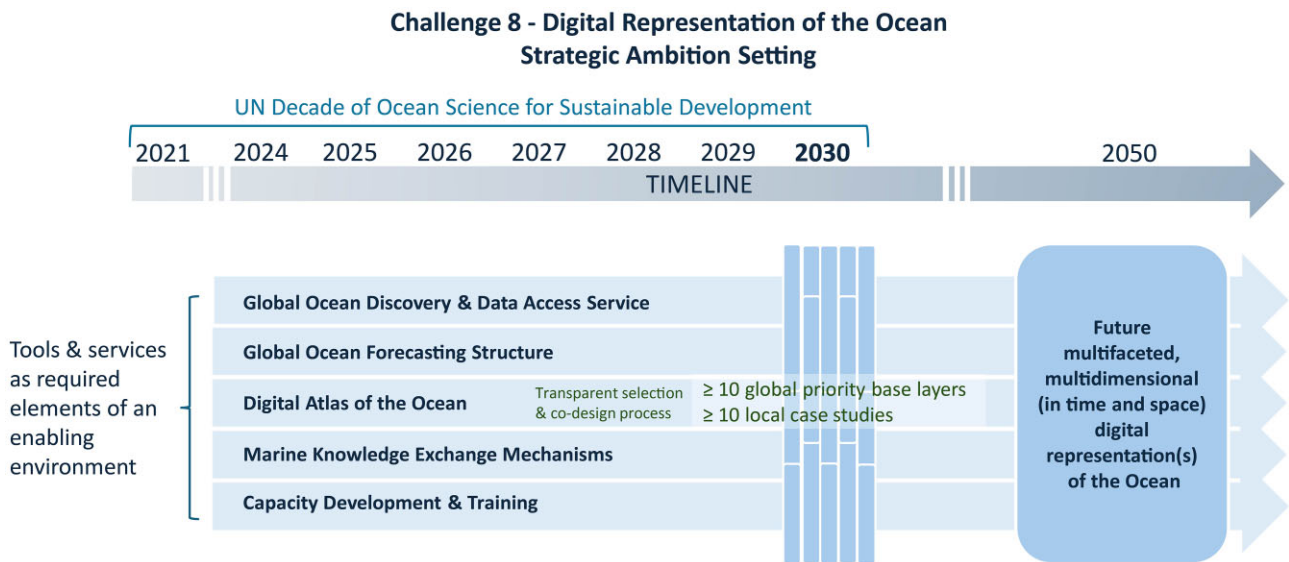


Figure 2. Overview of the Ocean Decade Vision 2030 Strategic Target Objectives for Challenge 8, developing a Comprehensive Digital Representation of the Ocean.

In summary, the Vision 2030 White Paper 8 specifies the need for the further development of several key tools and services by 2030 (see Fig. 2) that will collectively create the necessary enabling environment:

- (i) A global Ocean Data Discovery and Access Service (DDAS): A federated global service providing access to multidisciplinary data, data products, and information. The work of the ODIS has produced an initial metadata catalogue at a global scale using standard web technology. ODIS now needs to test, benchmark, and further scale the data discovery service and develop the data access broker and service. The DDAS concept includes an Ocean Data Help Desk and a distributed Data Ingestion service, inspired by similar services already existing in, e.g. EMODnet.
- (ii) A Global Technical and Organizational Structure for Ocean Forecasting: A federated ocean forecasting framework for promoting harmonized methods, data standards, and tools to foster ocean prediction globally, leveraging innovations like digital twins. This will build on existing efforts such as a common ocean forecasting architecture (Alvarez Fanjul et al. 2024a), and digital twin developments, such as the European Digital Twin of the Ocean.
- (iii) A Global Digital Atlas: An easily accessible web-based map viewer providing access to global base layers and local applications, demonstrating the Atlas's utility. Specific use cases will be targeted answering the Ocean Decade's Challenges such as ocean acidification or sea level rise data needed for climate change research and mitigation, and the distribution and health of ocean ecosystems for marine biodiversity conservation. The next steps are to identify the governance mechanisms for the Global Digital Atlas, and to reuse existing content in a managed platform, perhaps developed from existing tools in United Nations bodies such as the UNESCO World Heritage Sites Interactive Map. The Decade Coordination Unit and the Decade Coordination Office for Ocean Data Sharing must drive this

with support from the International Coastal Atlas Network.

- (iv) Knowledge-sharing tools and platforms: Mechanisms and tools actively used to store, share, and exchange information beyond basic data and data products. For example, building on existing platforms such as Ocean Expert and the Ocean Best Practices System to make their content more visible to the community, providing support to users, and analysing gaps that the community must update or fill. These gaps include revisions to Data Management Plan and Data Publication guidance for the ocean community as identified by the Decade Coordination Office for Ocean Data Sharing.
- (v) Enhanced capacity development: Training resources tailored to diverse user needs to improve digital literacy across the Ocean Decade.

Engaging various stakeholders, including Ocean Decade actors, expert groups, and UN bodies, will help promote recommended practices, data standards, and tools to foster ocean data sharing and prediction worldwide. Public-private partnerships will be critical to unlocking vast amounts of data held by private entities and accelerating technological progress. Among other activities, the authors encourage:

- (i) Marine researchers to make and implement clear plans for managing and sharing their data before data collection and processing into the digital ocean ecosystem, using appropriate guidelines, e.g. as documented in the Ocean Biodiversity Information System manual, IODE guidelines, the Climate and Forecast Conventions or by communities such as EMODnet and GeoTraces.
- (ii) Policy makers to include ocean data sharing from public and private activities in national jurisdictions in their permitting and licensing of maritime activities.
- (iii) Directors of research institutes and private enterprise engaged in marine activities to align internal data strategies with the Ocean Decade's Data and Information Strategy and its Implementation Plan.

- (iv) Marine data managers to engage with ODIS to publish the data they are responsible for and develop bridges from existing catalogues to the ODIS infrastructure.
- (v) Leaders of Ocean Decade actions to actively engage with Ocean Decade Data Coordination Group and Decade Coordination Office for Ocean Data Sharing so that emerging digital assets are included in the digital ecosystem.
- (vi) Ocean forecasters to advance their processes along the operational readiness levels for ocean forecasting (Alvarez Fanjul *et al.* 2024b) and the common architecture for ocean prediction.
- (vii) The entire marine community to identify priority use cases for ocean data and known gaps in data collection and data sharing and make these known to the Ocean Decade Coordination bodies.
- (viii) Funding agencies and investors to provide financial resources to build digital capacity for marine science, e.g. in the global south, therefore allowing SIDS and LDCs to take a lead in application development, and to enable continuing progress towards the vision of a comprehensive and equitable digital representation of the ocean.

The journey to create this digital representation of the ocean is complex and will require a dynamic and iterative process. The focus must be on identifying, coordinating, and building upon existing efforts. By doing so, we will move closer to realizing the aspiration of creating a digital ocean ecosystem that serves the needs of all, leaving no one behind.

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Author contributions

Conceptualization: Jan-Bart Calewaert, Oonagh McMeel, Paula Sierra-Correa, Adam Leadbetter; Writing—original draft: Jan-Bart Calewaert, Oonagh McMeel; Writing—review & editing: Jan-Bart Calewaert, Oonagh McMeel, Paula Sierra-Correa, Terry McConnell, Enrique Alvarez Fanjul, Adam Leadbetter; Supervision: Jan-Bart Calewaert; All authors have read and agreed to the published version of the manuscript

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Data availability

There are no new data associated with this article.

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