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Seabed 2030: The seabed data we need for the ocean we want

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The United Nations Decade of Ocean Science for Sustainable Development, 2021 to 2030 (Ocean Decade) calls for global efforts to generate »the science we need for the ocean we want«. Here, we demonstrate the role of The Nippon Foundation-GEBCO Seabed 2030 Project (Seabed 2030), a flagship Ocean Decade Action focusing on inspiring the mapping of the global seabed, in generating the knowledge needed to implement meaningful actions that reduce harmful human pressures on the ocean. We begin with a brief overview of Seabed 2030. We then provide examples of how bathymetric data and Seabed 2030 support the Ocean Decade Outcomes, particularly those in relation to the Outcomes relating to an accessible and inspiring ocean.

seabed mapping | bathymetry | Open Science | Ocean Decade | Seabed 2030
Meeresbodenkartierung | Bathymetrie | Open Science | Ozeandekade | Seabed 2030

Die Dekade der Vereinten Nationen für Ozeanforschung im Dienste der nachhaltigen Entwicklung, 2021 bis 2030 (Ozeandekade), ruft zu globalen Anstrengungen auf, um »die Wissenschaft« zu schaffen, »die wir für den Ozean brauchen, den wir haben wollen«. Wir zeigen die Rolle des Projekts Seabed 2030 der Nippon Foundation und GEBCO, einer Vorzeigeaktion der Ozeandekade, die sich auf die Kartierung des globalen Meeresbodens konzentriert, um das Wissen zu schaffen, das für die Umsetzung sinnvoller Maßnahmen zur Verringerung des schädlichen menschlichen Drucks auf den Ozean erforderlich ist. Wir beginnen mit einem kurzen Überblick über Seabed 2030. Dann geben wir Beispiele dafür, wie bathymetrische Daten und Seabed 2030 die Ergebnisse der Ozeandekade unterstützen, insbesondere in Bezug auf die Ergebnisse, die sich auf einen zugänglichen und inspirierenden Ozean beziehen.

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Introduction

With the ever-increasing pressure on the ocean, there has never been a greater need to effectively manage damaging and degrading human activities. Developing effective and meaningful actions and policies that address human pressures requires knowledge and evidence from multiple sources (Boaz and Nutley 2023). To bolster scientific knowledge and evidence that can support effective policy and decision-making, the United Nations Decade of Ocean Science for Sustainable Development, 2021 to 2030 (Ocean Decade) is a call for global efforts to »generate the data, information and knowledge needed for more robust science-informed policies and stronger science-policy interfaces at global, regional, national and even local levels, leading to improved integrated ocean management and development of a sustainable ocean economy« (UNESCO-IOC 2021).

The Ocean Decade identifies seven outcomes for »the ocean we want«, underpinned by Challenges – priority action areas for achieving the Outcomes. Underpinning these Challenges are three Decade Objectives, which will be achieved through a mixture of programmes, projects, activities and contributions from a range of supporters, including (but not limited to) NGOs, research institutes, and community groups (the Decade Actions) (IOC-UNESCO 2021).

The generation, digitisation, management, preservation, and sharing of ocean data and other knowledge is critical to the Ocean Decade's ability to meet the Decade Challenges and achieve the desired Outcomes (UNESCO-IOC 2021). Indeed, although the volume of ocean data and knowledge is increasing, there are significant knowledge and data gaps for specific variables and/or in relation to spatial and temporal coverage. Furthermore, a substantial proportion of the ocean data collected is either not easily discoverable or inaccessible, while accessible data may not be interoperable (Fredston and Lowndes 2024; Potter and Pearson 2023). An »open science« approach is one of the desired Outcomes and is also recognised as essential for achieving the Sustainable Development Goals (UNESCO 2019; 2021).

Among the Ocean Decade Actions, The Nippon Foundation-GEBCO Seabed 2030 Project (Seabed 2030) has embraced an open science approach. Endorsed as a flagship Ocean Decade Action in June 2021, Seabed 2030's mission is to accelerate ocean mapping efforts and produce a complete,

open-access seabed map by 2030. Here, we provide 1) a brief overview of GEBCO and Seabed 2030, 2) examples of how bathymetric data support the Ocean Decade Outcomes, and in particular, 3) the Outcomes for an accessible and inspiring ocean.

A brief overview of GEBCO and Seabed 2030

In 1903, Prince Albert I of Monaco led a commission to create a general bathymetric chart of the ocean to standardise bathymetric chart nomenclature and terminology. The resulting charts, published in 1905, became the first General Bathymetric Chart of the Oceans (GEBCO) – now a joint programme of the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO) (Carpine-Lancre et al. 2003).

GEBCO products have evolved significantly, moving from paper maps to a Digital Atlas to a global bathymetric grid of increasingly high resolution (Fig. 1). The modern grid may give the impression that the global seabed has already been completely mapped. However, the grids are constructed using a satellite altimetry-derived base (low precision) onto which higher-resolution LiDAR, single-beam echo sounder and multibeam echo sounder-derived measurements are superimposed, with interpolation techniques used to fill the gaps where such measurements are sparse, i.e. a substantial proportion of the global ocean (Mayer et al. 2018).

Depth range	Grid cell size	Percentage of global seabed
0–1500 m	100 × 100 m	17.7 %
1500–3000 m	200 × 200 m	11 %
3000–5750 m	400 × 400 m	72.6 %
5750–11,000 m	800 × 800 m	2.7 %

Table 1: The expected minimum resolutions needed for the seabed to be considered »mapped« by depth. The changing resolution by depth reflects what is currently achievable using multibeam echo sounder technology (Mayer et al. 2018)

Seabed 2030 was created to generate the global momentum needed to map the entire seabed to an adequate resolution by 2030, build the frameworks necessary to compile bathymetric data from multiple sources into a single open-access digital product (GEBCO), and set standards for minimum mapping resolutions (Jakobsson et al. 2017) (Table 1). Since Seabed 2030 was officially launched in 2017, the percentage of the global seabed mapped has increased from 6 % to 24.9 % in 2023.

The role of bathymetric data in the Ocean Decade

Here, we explore the role bathymetric data play in the first five Ocean Decade Outcomes, namely »A

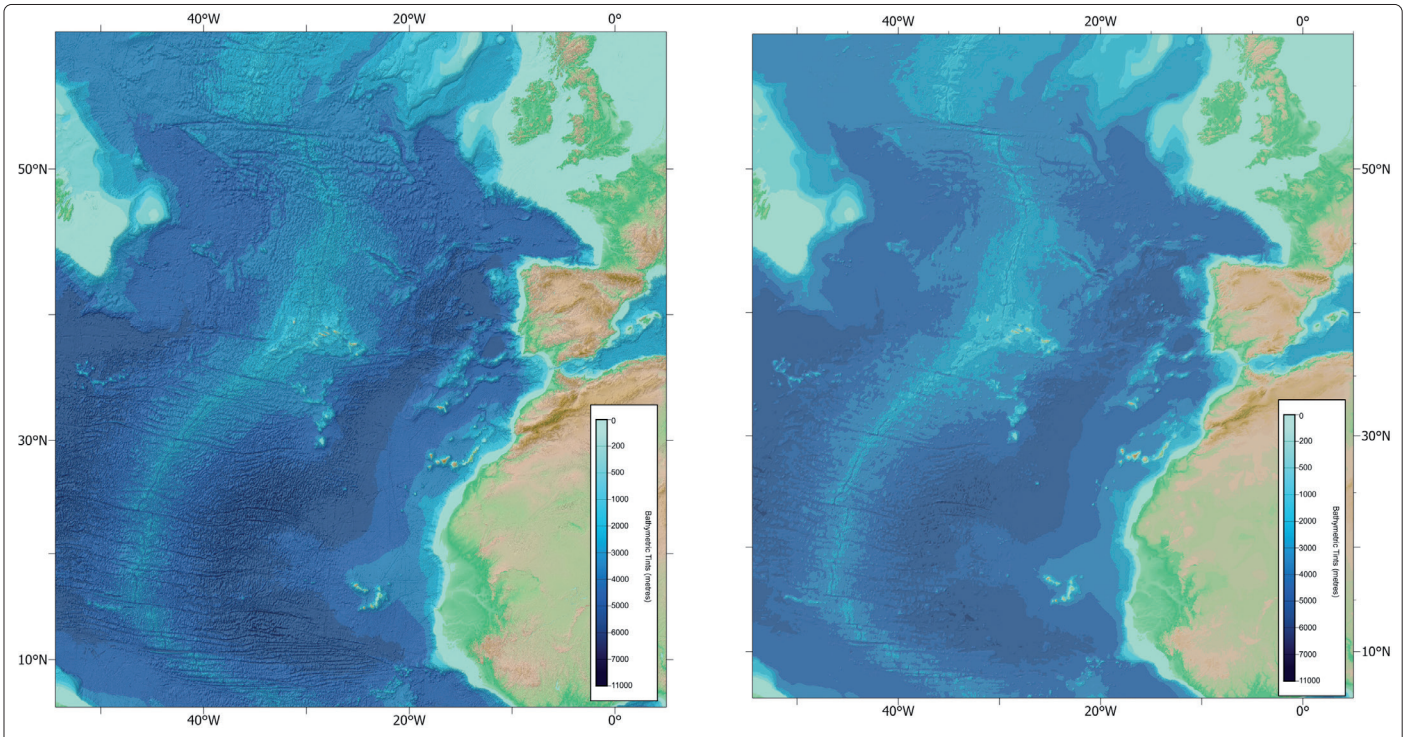

Fig. 1: Portrayal of the bathymetry of the North Atlantic from the 2023 GEBCO_2023 Grid, a global terrain model at 15 arc-second intervals (approximately 500 m × 500 m at equator) (left) and the 2003 GEBCO One Minute Grid, a global terrain model at 1 arc-minute intervals (1.85 km × 1.85 km at equator) (right). The GEBCO One Minute Grid was GEBCO's first global bathymetric model and was largely based on the bathymetric contour data set included in the Centenary Edition of the GEBCO Digital Atlas

clean ocean«, »A healthy and resilient ocean«, »A productive ocean«, »A predicted ocean« and »A safe ocean«. We address the last two Outcomes, »An accessible ocean« and »An inspiring and engaging ocean«, in the following section.

A clean ocean.
Example – plastic pollution
Plastic pollution is a growing issue that impacts the marine environment and marine life. The movement of plastics is controlled by winds, waves, tides and currents, the latter three of which are influenced by bathymetric properties such as depth topography. Furthermore, bathymetry can affect the location of plastic pollution sinks. As such, bathymetric knowledge is essential for predicting and forecasting the potential movements of plastics and designing mitigation and remediation efforts (Cau et al. 2022; Tekman et al. 2022).

A healthy and resilient ocean.
Example – deep sea communities
The deep sea is a challenging environment for species surveys, yet this information is essential for designating management actions to ensure their protection. The distribution of deep-sea benthic communities depends on bathymetric properties such as depth, slope, rugosity and bathymetric lows. As such, bathymetric properties, alongside biogeochemical oceanographic properties such as oxygen, can be used in models that predict the location of individual species or even communities (Bridges et al. 2023; Gonzalez-Mirelis et al. 2021).

A productive ocean.
Example – offshore wind farms
The placement of both fixed bottom (e.g. with a monopile driven into the sea floor) and floating (anchored to the seafloor) offshore wind farms depends in part on the suitability of the seabed. For example, depth places limitations on the type of foundation used (and indeed whether turbines can even be installed, while an understanding of the seabed geology, sedimentary and stratigraphic architecture is essential to understand if a site is suitable for turbines and what their design may be, and potential hazards (BVG Associates 2019; Tajalli Bakhsh et al. 2021).

A predicted ocean.
Example – Digital Ocean Twins
Spearheaded by the European Commission, Digital Ocean Twins, also known as Digital Twins of the Ocean, are multi-dimensional virtual replications of the ocean that harness machine learning, artificial intelligence and supercomputing to enable users to perform simulations and make predictions (forecasting and hindcasting). Potential outputs relate to risk assessment, conservation management, sustainable use and marine spatial planning. Once operational, Digital Ocean Twins' abilities to provide reliable outputs lie in part with the data they have. As such, access to higher-resolution bathymetric data will improve the efficacy of this emerging technology (EDITO-Model Lab 2024; IHO 2023; Tzachor et al. 2023).

A safe ocean.
Example – coastal community risks from the sea
Coastal communities face several risks from the ocean. For example, storm surges, flooding and rising sea levels may become more problematic as the climate changes in response to our greenhouse gas emissions. In contrast, events such as tsunamis occur in response to geological events over which we have no control. Bathymetry can play varying roles in the formation, frequency and magnitude of these and other events by, for example, influencing wave propagation and wave-current-surge interactions or generating hazards such as through slope failure. As such, bathymetric knowledge can play a role in risk assessment, mitigation and adaptation planning (Ercilla et al. 2021; Salaree and Okal 2020).

Supporting an inspiring, engaging and accessible ocean

Bathymetric data in itself may not contribute directly to the Outcomes »An inspiring and engaging ocean« or »An accessible ocean«. However, Seabed 2030 and project partner actions are directly aligned with these Outcomes.

GEBCO data and products: open, accessible and interoperable
GEBCO provides several open-access data sets. Regarding bathymetric data, the 2023 GEBCO bathymetric and Type Identifier grids can be downloaded in netCDF, Data GeoTIFF, and Esri ASCII raster formats, covering the entire globe or as user-defined areas. Historical Grids are also available for download (GEBCO 2024b).

In addition to the grids, there are several GEBCO-derived products freely available, namely, a Gazetteer of Undersea Feature Names, a world map, Web Map Services, a technical manual on how to build bathymetric grids (»Cook Book«), an illustrated book »The History of GEBCO, 1903-2003« and several bathymetric visualisations and maps (GEBCO 2024a).

The GEBCO One Minute Grid was first made available for download (as a set of tiled data sets) via the Internet in January 2004. During the first 16 months, there were over 3,000 downloads. In 2023, there were over 206,000 downloads of GEBCO's gridded data sets, including global grids; grids for user-defined areas, and imagery based on the grids.

Data loggers: improving access to technology

Access to technologies for seabed mapping and, more broadly, the study of the ocean is not equitable across the globe, which hampers scientific advancement (Alexander et al. 2022). Furthermore, nations may struggle to manage their marine estate effectively without access to technology and the data they provide. The issue of inequity is particularly acute for developing coastal nations and large ocean states (Amon et al. 2022).

Seabed 2030 has funded data loggers that can be used on vessels with a GPS and an echo sounder. Some of these data loggers have been distributed to recreational and commercial vessels in the Republic of Kiribati, which partnered with Seabed 2030 in 2023. As such, seabed data collected with these loggers and other means is shared for use in the GEBCO Grid. Although the data collected by these vessels typically lacks the resolution that is achieved with multibeam echo sounders, the data can be useful for areas where little to no data exists, where the only data for an area was collected with plumb-line measurements, or more dynamic areas, such as shallow coastal areas with sand banks.

Skills training: improving access to knowledge and innovation

Access to skilled mappers presents another capacity barrier. The Nippon Foundation-GEBCO Training Program in Ocean Mapping offers a postgraduate certificate in ocean bathymetry designed to provide people with the knowledge, skills and some real-world experience in ocean mapping. Based at the Center for Coastal and Ocean Mapping/Joint Hydrographic Center at the University of New Hampshire, the Program has trained over 110 people from 46, primarily developing, nations. Funding is provided through The Nippon Foundation's Scholarships and Fellowships for Global Ocean Issues initiative.

After course completion, students become part of an Alumni Network designed to support their continuing development and relationships with the broader global seabed mapping community. The Alumni Network has spearheaded several initiatives, including the non-profit Map the Gaps, which seeks to grow awareness about seabed mapping and increase diversity and equity seabed mapping. Members of the Alumni Network also participated in, and won, the 2019 Shell Ocean Discovery XPRIZE challenge for the development of an uncrewed surface vehicle designed to deploy and recover seabed mapping autonomous underwater vehicles (XPRIZE 2019).

Citizen science: engaging society and improving access to knowledge

Broadly, citizen science, also known as community science, is the involvement of non-specialists in the scientific process, most often through data collection. Citizen science can increase public engagement in ocean science and ocean sustainability, increase ocean literacy, and potentially enhance scientific knowledge and understanding of marine systems (Kelly et al. 2020; 2022).

The International SeaKeepers Society – a partner of Seabed 2030 – engages the yachting community in citizen science initiatives, including collecting depth data for Seabed 2030. The data is usually collected with the vessel's depth finder and GPS, and if the vessel does not already have one, a data logger provided by Seabed 2030. As of 2023, SeaKeepers had installed loggers on 65 yachts. The seabed data collected is shared with GEBCO. SeaKeepers maintains a dialogue with its volunteers on achievements, seabed mapping and other elements of ocean literacy pertinent to the projects it focuses on.

Outlook

Our knowledge about the ocean's topography, ocean processes, seabed dynamics and marine life falls behind our understanding of the terrestrial surface, which covers just 30 % of the planet. Without knowledge of the seabed, efforts to attain the Ocean Decade Outcomes and ensure a healthy ocean that supports all life on earth are significantly hampered.

Mapping and creating an open-access bathymetric grid of the entire global seafloor at sufficient resolution by 2030 is an ambitious project requiring the international community to rally around. More of the ocean has already been mapped, and data shared with GEBCO, since the inception of Seabed 2030. As long as international collaboration and cooperation surrounding seabed data collection and sharing continues, the 2030 goal may just be achieved. //

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