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Food for Thought

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Designing, generating, and translating deep-ocean observations for and with international policy makers

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Deep-ocean observing is essential for informing policy making in the arenas of climate, biodiversity, fisheries, energy and minerals extraction, pollution, hazards, and genetic resources. The Deep Ocean Observing Strategy (DOOS), a UN Ocean Decade endorsed programme, is meeting with representatives from relevant international bodies and agreements to strengthen their interface with the deep-ocean science community, ensure that deep observing is responsive to societal needs, identify points of entry for science in policy making, and to develop relevant products for broad use. DOOS collaboration with the Environmental Systems Research Institute (Esri) facilitates this co-design. A DOOS policy liaison team is being formed to link the contacts, voices, and messaging of multiple deep-ocean networks and organizations in reaching international policy makers. The UN Ocean Decade will help to gain the ear of target communities, scale communication channels appropriately, minimize duplicative efforts, maximize limited resources, and organize inclusive and equitable public and private partners in deep-ocean science and policy.

Deep-ocean observing needs and Deep Ocean Observing Strategy

The deep ocean (waters below 200 m) constitutes 95% of the ocean's volume and plays a critical role in climate regulation through the sequestration and storage of massive amounts of carbon dioxide and heat (Talley *et al.*, 2016). However, due to logistical and technological challenges, much of the deep ocean—including its life and resources—remains unexplored. The energy, fisheries, and mineral mining sectors, alongside states, indigenous people, and the conservation community, are critical stakeholders that can both contribute to and benefit from deep-ocean science (Mengerink *et al.*, 2014). Recently, the global deep-sea community came together to coordinate deep-sea observations, develop deep-sea essential ocean variables, and collaborate on shared best practices through the formation of the Deep Ocean Observing Strategy (DOOS) (DOOS, 2019. Science and Implementation Guide. http://dx.doi.org/10.25607/OBP-575), a project within the Global Ocean Observing System (GOOS) and among the first UN Ocean Decade endorsed programmes (Smith *et al.*, 2022). A key goal of DOOS is to facilitate use of deep-observing data by a broad range of stakeholders, particularly in the economic and international policy sectors, to achieve a healthy ocean and sustainable blue economy (Levin *et al.*, 2019). The challenge is how to enable the best available science to inform policy when knowledge of the deep ocean is extremely sparse. Here, we frame a co-design approach for observations in international deep waters wherein members of science communities directly connect with UN-based organizations to learn how they can each help each other.

International policy and the deep ocean

While most exclusive economic zones (EEZs) contain a large amount of the deep ocean, over 60% of the ocean occurs in international waters in areas beyond national jurisdiction (ABNJ). As multiple UN-based entities manage these and other components of ocean policy (Box 1), it can be a confusing and intimidating landscape for deep-ocean research and industry communities seeking to address societal needs. Similarly, the political decisions of these UN-based international bodies or agreements benefit from information gained via deep-sea exploration, mapping, observation, and modelling communities, but often need data access or translation.

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Box 1. Selected international bodies or agreements fundamental to the sustainability of the deep ocean.

International body or agreement	Jurisdiction and themes	Deep-sea policy frontiers and challenges
International Seabed Authority (ISA)*	Minerals resources in ABNJ; protection of the marine environment from harmful effects of mining activities; marine scientific research	Development of regulations and approval of contracts for exploration and exploitation of polymetallic nodules, ferromanganese crusts, and massive sulfides; regional environmental management plans; designate protected no-mining areas (APEIs)
Food and Agriculture Organization (FAO)* and Regional Fisheries Management Organizations (RFMOs); Fish Stocks Agreement	Migratory fishery species in ABNJ; demersal fishery species in ABNJ	Designation of fishing grounds; No-fishing Vulnerable Marine Ecosystems; environmental impact assessments for new fisheries
International Maritime Organization*; London Protocol/London Convention	Shipping and pollution in ABNJ; geoengineering (ocean fertilization); GESAMP—scientific body	Mine tailings and waste from land and sea; new policy for ocean-based climate interventions
Convention on Biological Diversity (CBD)*	Post 2020 framework; land and ocean biodiversity (mainly in EEZs)	Acting on linkages between deep-sea biodiversity and climate change.
Agreement for the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction	Area based management (MPAs and spatial planning); environmental impact assessment; marine genetic resources; capacity building and technology transfer	Ongoing treaty negotiation challenged with multisectoral management of the international ocean
United Nations Framework Convention on Climate Change (UNFCCC-COP, SBSTA)	Reduce emissions via nationally determined contributions; national adaptation plans; climate reporting and finance	Annual ocean and climate change dialogue
Intergovernmental Oceanographic Commission (IOC)*	Scientific observations; UN Decade for Ocean Science for Sustainable Development	Producing the deep-sea science we need for the ocean we want
World Heritage Marine Programme—UNESCO*	Designate flagship marine protected areas of outstanding universal value	Share conservation solutions; assess climate impacts
World Climate Research Programme (WCRP) of the UN World Meteorological Organization (WMO)	Coordinate and facilitate international climate research to develop, share, and apply the climate knowledge that contributes to societal well-being	Understanding and modelling deep ocean properties as part of the coupled earth system in the context of international climate projection efforts
North Pacific Marine Science Organization (PICES)*	Promote and coordinate marine research in the north Pacific and its adjacent seas	Coordination of north Pacific deep observing systems; carbon and climate; smartnet; seamount ecology; Kuroshio studies; north Pacific fisheries; linking indigenous knowledge to existing observing science
The International Council for the Exploration of the Sea (ICES)	Advance and share scientific understanding of Atlantic, Arctic, and Mediterranean marine ecosystems and their services	Generate state-of-the-art advice for meeting conservation, management, and sustainability goals
US Bureau of Ocean Energy Management (BOEM)*	Facilitate development of oil and gas resources and renewable energy on the US outer continental shelf	Science-based management of energy and mineral resources via environmental assessment and environmental studies

* Indicates agencies the project team has engaged with in policy-impact discussions. The others are in cue.

This is where co-design becomes a compelling solution to the challenge of guiding deep-ocean observing for multiple stakeholders in a complex governance setting. The challenges we seek to address include ensuring that (a) new measurements and observing activities in the deep ocean are designed to serve the needs of diverse stakeholders, including industry, civil society, and the scientific, conservation, and policy communities, (b) managers and regulators are aware of available data, data generation opportunities, and data dissemination best practices, and (c) the data are conveyed in a way that allows them to be used to guide the formulation of new policy. With recent funding from the US National Science Foundation

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AccelNet Program, DOOS has established a working group to address these challenges and serve as a translation arm for the work done by the other working groups focused on requirement setting, modelling, implementation, technology, and cyberinfrastructure.

Our co-design process has two steps. This first step is to conduct listening sessions with representatives of UN bodies to identify priority actions. To date, seven listening sessions have been conducted with representatives of relevant international UN bodies and agreements (Box 1). These sessions have sought to identify ways for the deep-ocean science community to interface with the agencies and develop specific actions.

Examples of co-design opportunities emerging from these discussions include ideas to (a) link deep Essential Ocean Variables to CBD indicators by placing DOOS members into CBD indicator groups; (b) conduct an overview of oceanographic data collected and used by FAO's Regional Fishery Management Organizations (RFMOs) and identify other existing deep data of use; (c) communicate the science gaps identified in Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) reports to DOOS network members and work with GESAMP on reporting gaps (e.g. biodiversity); (d) use the new IOC June 2022 State of the Ocean Report to identify deep-sea science needs and prepare inputs for the next update; (e) co-sponsor a conference with the North Pacific Marine Science Organization (PICES) and Hakai Institute focused on indigenous linkages to the deep ocean and interfaces with deep observing; (f) join the U.S. Bureau of Ocean Energy Management (BOEM) as a stakeholder and invite BOEM to join the DOOS network of networks; (g) work with the Environmental Systems Research Institute (Esri) to quantify the deep-ocean area in World Heritage sites and co-convene a focused discussion of deep sea monitoring best practices among managers of sites with significant deep waters; and (h) work with the International Seabed Authority (ISA) to develop a DOOS demonstration project highlighting integrated observing in the Clarion Clipperton Zone.

DOOS members will join with UN Agency representatives to pursue these actions and form an international policy liaison team that will serve as step 2 of our co-design process. This team will further identify points of entry for science in international policy making and develop relevant products for broad use, including geographic visualization tools, web-based materials, policy briefs, applications, and short webinars.

Critical partnerships

Given the technological, logistical, cost, and cross-disciplinary challenges of deep-ocean exploration, observing, and research, partnerships are critical to the ability of DOOS to effectively communicate, cooperate, coordinate, and recognize shared goals and motivations with international policy makers, and navigate financial challenges, political considerations, and the needs of all partners (Meinig *et al.*, 2019; Carr and Kaye, 2022). Partnerships between the private sector and the deep ocean-observing community can leverage the unique strengths of each sector in the policy translation effort. For example, the Esri as a global private sector Geographic Information System (GIS) software, services, and research and development company has provided a critical resource for DOOS (see details in Smith *et al.*, 2022), as deep-ocean observation and exploration lends itself to geographic visualization.

Looking forward through the decade

The UN Decade of Ocean Science for Sustainable Development aims to promote science to achieve a healthy, resilient, productive, predictable, safe, accessible, inspiring and engaging ocean. These all require coordinated ocean observations, including for deep water, and a means to convey the resulting information to relevant stakeholders, including those described above and in Box 1. The DOOS policy liaison team will be critical to these efforts, linking the contacts, voices, and messaging of multiple deep-ocean networks and organizations in reaching international policy makers through DOOS. The Decade will help us to gain the ear of target communities, scale communication channels appropriately, minimize duplicative efforts, and maximize limited resources. We acknowledge the many challenges inherent to bringing scientific information and observations to policy but believe the co-design effort described above can help to generate critical elements: deep-ocean science that is societally relevant, inclusive, equitable, and that reaches decision makers.

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Data availability

No new data were generated or analysed in support of this research.

Author contributions

LL, LC, KG, HHD, DL, MP, HP, LS, JS, and DW participated in the co-design meetings that formed the basis of this manuscript and wrote the initial text. These authors along with PH and KS edited the original submission and the revised version.

Competing Interests

The authors have no competing interests.

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References

Carr, M., and Kaye, J. 2022. Baselining how to build sustainable ocean exploration partnerships, "Blueprint" White Paper for the 2022 National Ocean Exploration Forum, 4 pp., https://oceanleadership.org/2022-noef/, (last accessed 2 August 2022).

Levin, L.A., Bett, B.J., Gates, A.R., Heimbach, P., Howe, B.M., Janssen, F., McCurdy, A. *et al.*, 2019. Global observing needs in the deep ocean. Frontiers in Marine Science, 6: 241.

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Meinig, C., Burger, E.F., Cohen, N., Cokelet, E.D., Cronin, M.F., Cross, J.N., de Halleux, S. *et al*., 2019. Public–private partnerships to advance regional ocean-observing capabilities: a saildrone and NOAA-PMEL case study and future considerations to expand to global scale observing. Frontiers in Marine Science, 6: 448.

Mengerink, K.J., Van Dover, C.L., Ardron, J., Baker, M., Escobar-Briones, E., Gjerde, K., Koslow, J. A. *et al*., 2014. A call for deep-ocean stewardship. Science, 344: 696–698.

Smith, L.M., Cimoli, L., LaScala-Gruenewald, D., Pachiadaki, M., Phillips, B., Pillar, H., Stopa, J.E. *et al*.,2022. The deep ocean observing strategy: addressing global challenges in the deep sea through collaboration. Marine Technology Society, 56: 50–66.

Talley, L. D., Feely, R. A., Sloyan, B. M., Wanninkhof, R., Baringer, M. O., Bullister, J. L., Carlson, C. A. *et al*., 2016. Changes in ocean heat, carbon content, and ventilation: a review of the first decade of GO-SHIP global repeat hydrography. Annual Review of Marine Science, 8: 185–215.

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