



Advancing Deep Ocean Stewardship through Integrated Sciences (DeepOASIS)

DeepOASIS is a research proposal that was developed for the second call of research missions by the Deutsche Allianz Meeresforschung (DAM; German Alliance for Marine Research) in 2021. The proposal was successfully evaluated and selected for the final round of proposals. However, it was not prioritized for funding.

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The deep ocean including the seafloor host the largest, yet least studied, ecosystems in the world. These unique ecosystems are of critical importance for our life. However, they are threatened by multiple anthropogenic stressors and growing economic interests. DeepOASIS aims at maintaining their resilience contributing to the United Nations' 2030 Sustainable Development Goals and the UN Decade of Ocean Science for Sustainable Development. To do so effectively DeepOASIS tackles four challenges: 1) Limited knowledge of the tightly interconnected benthic and pelagic deep ocean ecosystems as well as how these are, and potentially will be, affected in the future; 2) Increasing and amplifying impacts of human uses resulting in environmental changes in ocean floor and deep sea ecosystems worldwide; 3) Lack of integrated and effective governance, and 4) Low awareness, public understanding and societal participation in deep ocean-related decision-making.

To meet these challenges, we propose an **inter- and transdisciplinary research mission that integrates natural and social sciences and the humanities**, and facilitates **Deep Understanding, Deep Change and Deep Engagement for a resilient ocean**. The proposed DAM mission aims to make the best use of the German research infrastructure and competences to close critical knowledge gaps, to identify crucial connections within and between environmental and social systems, to develop effective solutions for ecosystem-based ocean management and governance for deep ocean stewardship, and to aid their implementation by engaging with stakeholders, decision-makers, and civil society in the respective processes.

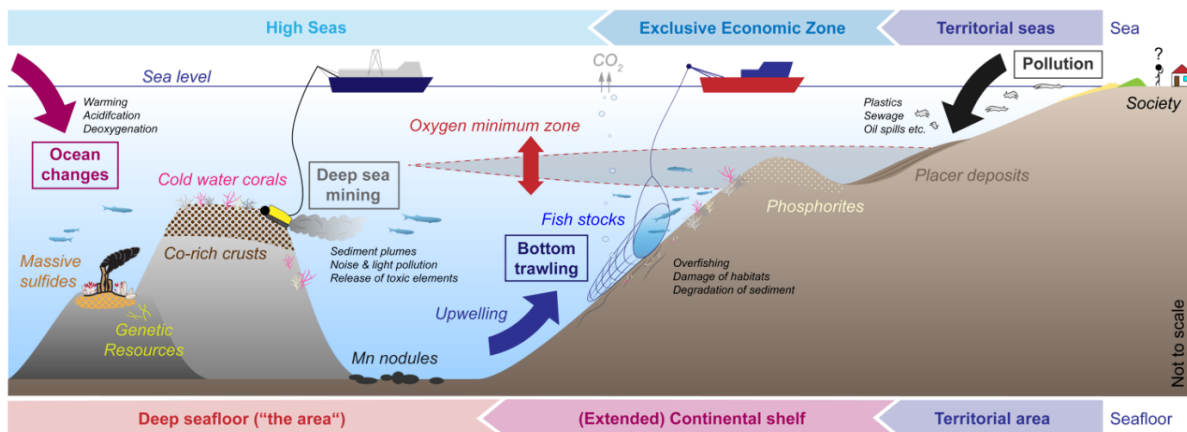


Figure 1: Examples of natural resources and anthropogenic stressors in our ocean.

Introduction and relevance

A resilient ocean sustains great biodiversity and unique habitats, and has a key role for mitigating the impacts of the global climate crisis, e.g., by providing a sink for atmospheric carbon. The UN 2030 Agenda with its Sustainable Development Goal (SDG) 14 and other ocean-related targets have the aim to sustainably manage and protect marine and coastal ecosystems. However, unsustainable exploitation practices for marine resources across the entire water column, ranging from the surface to the seafloor by e.g., fisheries, hydrocarbon extraction, mining of the shallow seabed, in combination with global stressors such as climate-mediated ocean changes or pollution are directly linked to negative effects on deep ocean biodiversity, habitat integrity and ecosystem services (Fig. 1). In addition, new demands for natural resources from the ocean floor are rising, e.g., applications in pharmaceutical research or the extraction of metals for the energy transition. Deep ocean ecosystems and their biological communities are highly interconnected, both laterally at the ocean floor and vertically between seafloor and overlying water column (benthic-pelagic coupling). However, as of yet governance systems for effective deep ocean stewardship are lacking. Sectoral boundaries of governance, jurisdictional divides, as well as different culturally shaped risk perceptions and narratives are hindering effective and connected ocean stewardship, particularly in areas beyond national jurisdiction. Similar needs exist for improving the limited knowledge on the deep ocean and its governance, and facilitating effective knowledge transfer to policy-makers, stakeholders and civil society. In addition, new technologies for constant observation and monitoring are needed to provide the information necessary for decision-making to maintain or where necessary restore ecosystems and achieve a resilient ocean.

Objectives of the research mission

The vast dimension of the deep ocean, its spatial heterogeneity and variability, as well as the challenging conditions for effective deep-sea observation require large-scale efforts in mission-driven marine research. In turn, the global character of the ocean, covering over 70% of our planet, also implies a diversity of legal, political, economic, social and cultural contexts in which humans deal with, are dependent on, and impact the deep ocean. Understanding their internal dynamics, interactions, and conditions of their respective contributions to a resilient ocean through **deep ocean stewardship** also require efforts going beyond the usual scale of disciplinary boundaries in research, and require effective governance institutions with broad participation. To develop innovative solutions for deep ocean stewardship and to implement these in marine research, economy, governance and society will require multi-, inter- and transdisciplinary collaboration as envisioned by this DAM mission proposal.

As a DAM mission, **DeepOASIS** would pursue **three key objectives** (Fig. 2): It aims to create **Deep Understanding** of highly connected benthic and pelagic deep ocean ecosystems and their services for humanity, as well as their linkages with the legal, political, economic, social and cultural context. To ensure long-term resilience of these ecosystems **Deep Change** of current practices in human interaction with the deep ocean will be facilitated. The mission invites research projects to develop novel technological solutions for assessment and monitoring of the deep ocean, transformative knowledge, and actionable approaches for integrated governance. To ensure **Deep Engagement** and meaningful participation in ocean governance processes, DeepOASIS will provide transformative approaches to implement deep ocean stewardship, including improved ocean literacy (i.e., the societal understanding of core ocean concerns) about the integral role of the deep ocean.

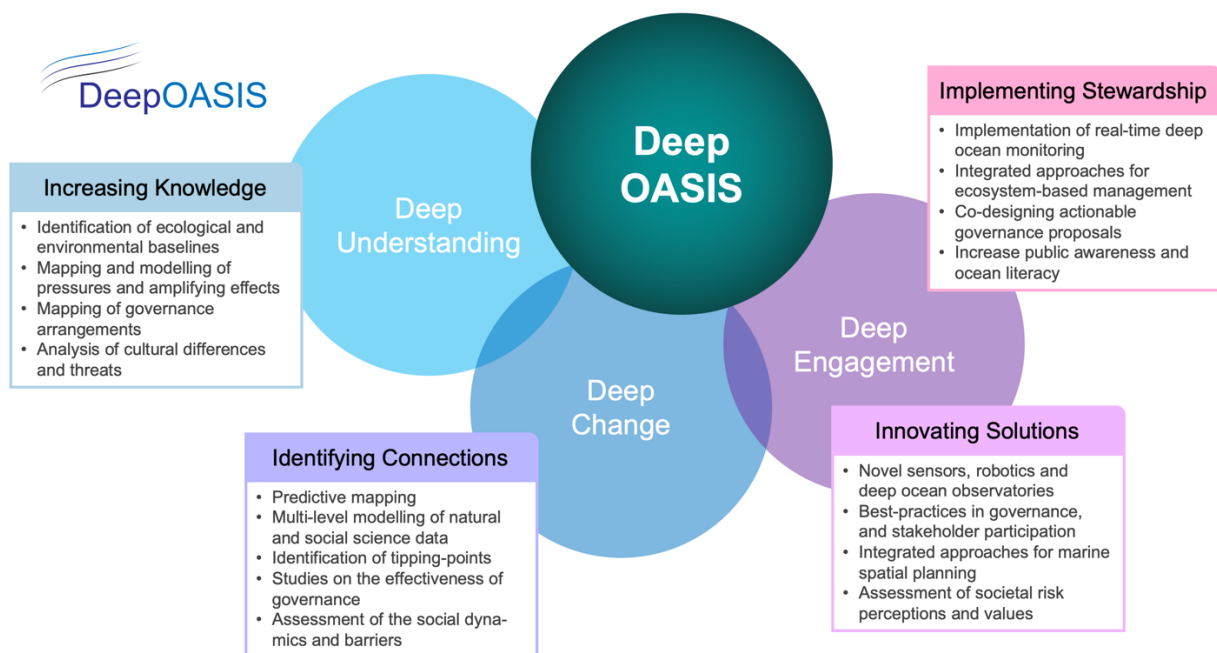


Figure 2: Objectives and integrative research themes of the proposed DAM research mission DeepOASIS.

Goals of the research mission

The proposed mission is structured into the **four integrative and interdisciplinary research themes: 1) Increasing Knowledge, 2) Identifying Connections, 3) Innovating Solutions, and 4) Implementing Stewardship** that together act as a transdisciplinary incubator for achieving the mission's objectives (Fig. 2). DeepOASIS will continuously identify and address the critical knowledge gaps through targeted multi- and interdisciplinary research in the natural and social sciences and the humanities.

1) Increasing Knowledge

The proposed research mission DeepOASIS is designed to close critical knowledge gaps related to the inventory of the ocean floor (e.g., habitats, ecosystems, geology, natural resources), the benthopelagic coupling, their functional services (e.g., as a carbon sink), and about the social, cultural, economic, legal and political actors, institutions and systems relevant to the deep ocean and its

stewardship. All activities will include a past, recent, and future perspective combining, e.g., existing long-term data, new observations and model predictions for the case of the natural sciences. Potential activities include:

- Identification of spatial and temporal variabilities of ecological and environmental baselines in the deep ocean and studies on the interconnectivity between different ecosystem compartments;
- Mapping and modelling of existing and emerging pressures in particular with respect to potentially amplifying effects of multiple stressors;
- Mapping of legal, political, and economic governance-arrangements, including their stakeholders, existing science-society-policy interfaces, and mechanisms for participation;
- Analysis of cultural differences, traditional and local knowledge, power relations, socio-economic drivers, and differences in perceptions of the deep ocean and the threats connected to its exploitation.

2) Identifying Connections

This theme aims at the development of a common language among different scientific disciplines and interdisciplinary integration of data and results acquired or created in the first theme. Novel approaches such as remote predictive mapping based on machine-learning will be applied to data that are already existing, and also to new data that will be acquired through research expeditions specifically designed for this purpose. Model regions and case studies for innovative solutions and their implementation will help for the development of potential future scenarios with predictions on ecosystem functions. Stewardship for ocean resilience requires a better understanding of currently implemented governance, interlinked social dynamics and barriers in policymaking. Potential activities in this theme include:

- Predictive mapping of the distribution of ecosystems and modelling of cumulative stressors using innovative technology (e.g., machine-learning, artificial intelligence, GIS-integration) and big data to create a “deep ocean at risk map”;
- Statistical multi-level modelling to bring natural and social science data together;
- Identification of tolerance limits and tipping points for different deep-sea ecosystems;
- Comparative case studies on the effectiveness of diverse governance systems, particularly on multi-level interactions, society-policy-science interfaces, as well as participatory mechanisms, preferably relating to identified model regions;
- Assessment of the social dynamics of deep-ocean use and barriers to stewardship in cultural narratives and risk perceptions.

3) Innovating Solutions

This theme aims at developing mission-related innovative solutions for science, policy, and society. Deep-sea observation requires the development of novel technologies for remote exploration, surveillance and monitoring, including stressor- and ecosystem-reaction-targeted long-term ocean observation. Existing monitoring data will be integrated and extended by autonomous deep ocean observatories. Novel technology for in situ observations will be developed and complemented by novel approaches to ‘good’ governance for deep ocean ecosystems, as well as concepts for enhanced stakeholder participation and citizen-science approaches. To factor in societal interests, societal risk perception, narratives, cultural attitudes and values as well as comprehending diverse cultural knowledge in defining the deep ocean will be assessed. Finally, upscaling of the mission’s individual model regions will allow global application of the results. Potential activities in this theme include:

- Development of novel sensors for in situ monitoring, remote technology including robotics, and deep-sea observatories for long-term monitoring in collaboration with the German maritime industry;
- Identification of best practices in deep ocean governance and stakeholder participation;
- Development of integrated approaches for marine spatial planning and management of human uses, including Strategic Environmental Assessments (SEAs) and Systematic Conservation Planning (SCP);
- Assessments of societal risk perceptions and expectations, value and priority attributions and cultural knowledge on human connections to the deep ocean.

4) Implementing Stewardship

Implementation of deep ocean stewardship requires monitoring through autonomous and near real-time deep ocean observatories at key sites, and thus novel research infrastructure. In addition to such solution-oriented technical innovation, provision of action-oriented knowledge for decision makers is needed to address the fundamental challenges in the nexus of ocean, biodiversity, and climate. This theme therefore also includes a strong component of policy and public engagement to be defined in a dedicated dissemination, exploitation, and communication plan. Through DeepOASIS, German researchers, policy-makers, stakeholders and civil society actors will be able to provide science-based input to ongoing processes in international marine politics and to implement national and international commitments (see section on added value). Potential activities in this theme include:

- Implementation of deep-ocean monitoring systems in model regions (e.g., Cape Verde, Cape Blanc, Fram Strait), and advancing the Global Ocean Observing System (GOOS);
- Developing integrated approaches for ecosystem-based management of deep ocean and seafloor ecosystems, e.g., at the interface between the future Biodiversity Beyond National Jurisdiction (BBNJ) agreement under UNCLOS, for the future regulatory regime and Regional Environmental Management Plans (REMPs) for deep-sea mining under the International Seabed Authority (ISA), and regulations for deep-sea fisheries;
- Co-designing actionable proposals for legal, political and institutional change for ocean floor and deep-sea governance, including improved stakeholder participation;
- Increase public awareness and ocean literacy of the role of the deep ocean in the Earth system.

Scientific potential and added value for marine research in Germany

The proposed mission DeepOASIS is designed to create **transferable knowledge used to advance and foster deep ocean stewardship**. The transdisciplinary approach of combining natural and social sciences, and the humanities generates practical knowledge for action through Deep Understanding, Deep Change, and Deep Engagement. This is directly relevant for **Germany's contribution to international ocean policy**, especially for the legal framework of potential future deep-sea mining, negotiation and implementation of agreements for the sustainable use of natural marine resources and protection of marine ecosystems and biodiversity, particularly in the areas beyond national jurisdiction (i.e., BBNJ negotiations). Knowledge and instruments from this mission will be transferable also to the management of natural resources in coastal areas. This mission provides a unique opportunity to **focus the diverse engagements of the German marine research community** in these fields. With its modern and globally operating fleet of research vessels, Germany is one of only a few countries equipped to **spearhead this global challenge**. Key global ocean policy processes and research-related activities with substantial contributions from the German marine research community include among others:

- The UN Decade of Ocean Science for Sustainable Development 2021-2030;
- Ocean observation for oceanographic and ecological baselines to understand impacts from cumulative stressors, including climate and ocean change (e.g., contributions to the GOOS, and the Digital Twin Ocean Initiative);
- Climate-ocean action under the Paris Agreement (UNFCCC);
- The UN 2030 Agenda for Sustainable Development, particularly SDG 14;
- Establishment of at least 30 % of the global ocean as Marine Protected Areas (MPA) by 2030 to be agreed under the Convention on Biological Diversity, and the protection of the Southern Ocean (e.g., Weddell Sea MPA, see coalition agreement of the new government).

DeepOASIS thus focuses the broad interdisciplinary expertise of numerous institutions in Germany (see non-exclusive list of institutions below) into one **transdisciplinary and applied research mission** that otherwise is not receiving any institutional or programmatic funding equivalent to a DAM research mission. However, results of research projects addressing individual aspects of this mission (e.g., EU-projects AtlantOS, iAtlantic, JPI Oceans project MiningImpact) will be integrated. Establishment of DeepOASIS will advance **the structural formation of the marine social sciences and the humanities** and strengthen interfaces with natural sciences allowing for integrated science-based solutions. This will create novel pathways of co-creation of transformative knowledge that

fosters actionable research outputs. DeepOASIS requires novel deep-sea research infrastructure (e.g., smart multi-platform observatories with near real-time data access) and technology and the mission will foster **innovation in marine remote sensing and robotics**, resulting in direct benefits to German companies specialized in marine technology. The mission will thereby strengthen the role of German marine research at the forefront of ocean sustainability to mitigate the tensions between exploiting its natural resources and simultaneously preserving a resilient and healthy ocean. The practical knowledge will enable the German government to develop a **national strategy** for the deep ocean in line with the new coalition agreement, and needed to serve Germany's manifold international commitments.

Potential non-academic partners

Stakeholders and potential non-academic partners for DeepOASIS include the German maritime industry (e.g., development of novel sensors, robotics and autonomous research infrastructure), governmental and non-governmental bodies on a national, European and international level (e.g., co-designing policies and management plans), as well as non-governmental organizations (e.g., marine research, environmental protection):

- Companies and interest groups in the field of deep ocean monitoring, sensor development, submarine robotics and communication, and marine traffic organizations;
- German Federal Government with individual resorts, in particular BMBF, BMU, BMWi, AA, BMEL, BMZ and BMVI, as well as subordinate agencies such as UBA, BSH, BfN, BGR;
- Institutions of the European Union including the European Commission (EC) with the Directorates-General Maritime Affairs & Fisheries, Environment, and Research & Innovation (e.g., Mission Starfish), as well as the EU Parliament, e.g., through SEARICA;
- Representatives of international organizations and relevant global stakeholders: UN organizations including UNEP, IAEA, FAO, IMO, CBD and UNESCO (IHO, IOC, IGCP), regional marine protection organizations (e.g., OSPAR), regional fishery management organizations (e.g., NEAFC), International Seabed Authority (ISA) and contract holders, Telecommunication- and seafloor cable industries (e.g., ICPC), GEBCO and Seabed 2030;
- Representatives of nations in impacted areas;
- Non-Governmental Organizations (NGOs) including WWF, Greenpeace, Brot für die Welt, Fair Oceans, BUND, NABU, Pew Charitable Trust, DSCC, IUCN, Ocean Panel, Schmidt Ocean Institute, REV Ocean;
- Collaboration with the international Deep Ocean Stewardship Initiative (DOSI);
- Partnership with the UN Decade of Ocean Science for Sustainable Development 2021-2030.

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