Managing Impacts of Deep Sea Resource Exploitation

MIDAS

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Chemosynthetic community comprising white crabs and mussels thrives near a gas vent, Makran Accretionary Wedge, Arabian Sea. Image ROV MARUM-QUEST, University of Bremen.

The deep sea as a target for exploitation

The oceans have always been an important area for human exploitation: resources such as fish, oil and gas have been taken from the continental shelf areas for many decades. Today, the growing global demand for metals and rare earth elements is bringing the prospect of mining these resources from the deep sea ever closer. With it comes the threat of disturbing wide expanses of the marine environment, in areas of the deep ocean that until now have been untouched by human activity.

The most likely targets for deep-sea mining are polymetallic massive sulphides, polymetallic nodules and cobalt-rich ferromanganese crusts: collectively they could supply copper, nickel, lead, zinc, cobalt and a range of precious and trace metals of commercial value. On a longer time scale, rare earth elements (REEs) in deep-sea muds may also become important as land-based reserves become less accessible. There is also considerable interest from some countries in the extraction of offshore gas hydrates as a source of hydrocarbons.

However, exploiting these resources has the potential to come at a high environmental cost. The extraction of deep-sea minerals may have significant environmental impacts, particularly on marine ecosystems. The scale and nature of these impacts is at present uncertain and is dependent on many factors, but will affect extensive areas of the seafloor and the overlying water column. There is therefore an urgent need to identify and assess the potential impacts of deep-sea mining and establish protocols to avoid or minimise them.

The MIDAS project brings together experts in deep-sea biology, ecology, oceanography, geology and geochemistry to work alongside social scientists, legal experts, technologists, mining industry representatives, impact assessment practitioners and policy makers to investigate the potential environmental impacts of deep-sea resource extraction and make recommendations on how best to manage them.

Physical impacts on the deep-sea environment

Extraction of minerals from the deep sea presents a significant engineering challenge as many potential mining sites are located far from land and at great water depths. The mining methods employed will vary with the character and distribution of the resource: for example, nodules are spread across wide areas of the seabed surface in areas of very deep water, massive sulphides are hosted within sub-seafloor rock, crusts form hard, surficial layers on the flanks of seamounts, and gas hydrates form layers within the seabed sediment.

The likely physical impacts on the deep-sea environment include the widespread distrubance or loss of seafloor habitats, the generation of large plumes of fine particulate matter and the introduction of chemicals - some of which may be potentially toxic to marine life - into the water column. In the case of gas hydrate extraction, destabilisation of the seafloor is also a potential problem. Mining activities may bring cold, nutrient-rich and particle-heavy water from the deep sea to the sea surface, potentially creating significant impact on both the marine environment and atmosphere.

The physical impacts of mining are not just confined to the removal of ore from the deep sea; pre-processing of ore via mobile platforms at sea will generate waste material that may be discharged back into the water column or at the seabed. This waste material may contain substances that are directly toxic to marine life or can chemically alter the marine environment. The release of toxic substances through the extraction of sulphides, nodules and crusts from the seafloor will be unavoidable and its effects difficult to control.

MIDAS scientists will carry out field and laboratory research into the nature and scales of the potential impacts, including: 1) physical impact on the seabed by mining and the creation of mine waste; 2) the potential for catastrophic slope failures from methane hydrate exploitation; 3) the potential effects of particle-laden plumes in the water column and the fate of deep-sea contaminant discharge, and 4) the possible toxic chemicals that might be released by the mining process.

Disturbing the seafloor environment during deep-sea mining will have direct consequences for marine life. Clockwise from top left: Carrier crab *Paromola cuvieri* perches on top of the gorgonian *Callogorgia verticillata* in the Atlantic Ocean near the Azores; pillow lavas hosting a faunal community near the low-temperature Liliput Hydrothermal Field at 1500m water depth on the Mid-Atlantic Ridge; Swarms of the shrimp *Rimicaris exoculata* bathing in warm waters of a hydrothermal vent on the Mid-Atlantic Ridge; fauna living on the flanks of a seamount at approximately 1000m water depth near the Mid-Atlantic Ridge.

Impacts on deep-sea ecosystems

The extraction of deep-sea mineral resources will likely result in extensive habitat destruction, affecting not only the fauna living in or on the seafloor, but also those species that depend on benthic organisms for food and services.

The inevitable sediment plumes generated by mining pose a serious threat, potentially spreading toxins, pollutants and acidic waters across wide areas of the ocean. Suspension feeders such as corals, bivalves and sponges may be smothered and the life cycles and larval migration of species may be affected. Extensive phytoplankton blooms could be triggered when cold, nutrient-rich water is brought from the deep up to the sea surface. Conversely, the fine particulate matter within a plume may depress primary production, disrupting the marine food chain.

Little is known about the tolerance and adaptability of marine organisms to such disturbance, and the ecotoxicological risks are complex and poorly understood. However, we do know that these ecosystems are complex, biodiverse and can include very long-lived species. How will disturbance affect reproduction, dispersal, ecosystem functioning, genetic connectivity and diversity? How far afield will the impacts be felt? Can an ecosystem recover from disturbance, and how quickly? Is there a threshold beyond which recovery is impossible?

At present our scientific knowledge of the distribution of deep-sea ecosystems, their interconnections and resilience to disturbance is insufficient to answer these questions. MIDAS will undertake a series of field campaigns and laboratory experiments to gather data and evidence to address some of these unknowns. Field areas include potential mining sites such as active hydrothermal vents at mid-ocean ridges and nodule mining areas in the Pacific Ocean.

MIDAS will investigate areas of past seabed disturbance such as those used for test mining of nodules over 25 years ago at the DISCOL site in the Peru Basin, sites of mine waste disposal in fjords and coastal areas, and areas of natural disturbance such as recent submarine volcanic eruption sites in the Canary Islands.

Data will be collected on the geographic distribution and genetic connectivity of key species, the effects of direct physical disturbance and sediment smothering on ecosystem biodiversity, functioning and services, and the response of various taxa during exposure to mining-related toxins under deep-sea conditions. Experiments and observations will cover a range of spatial scales, and will consider the direct footprint effects as well as the far-field and long-term effects of disturbance on marine ecosystems.

Chemosynthetic fauna thrive at the Carwash hydrothermal vent at 2400m water depth on the East Scotia Ridge. Image courtesy Chesso/NERC (NOC)

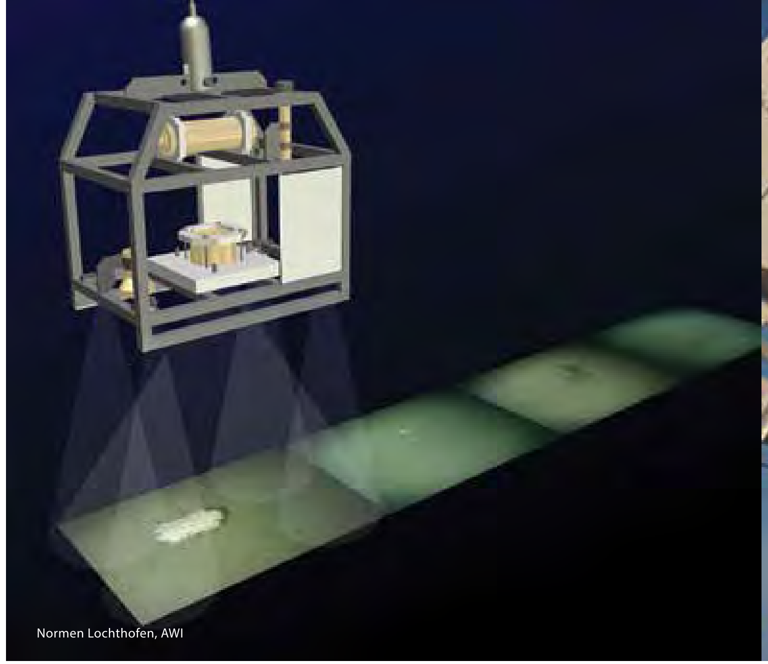
Using science to develop best practice

MIDAS will undertake stakeholder engagement to discuss the scientific results with mining industry representatives and seek practical solutions to mitigate the environmental damage likely to arise from deep-sea resource extraction. Through this exchange we will begin the process of defining Best Available Techniques and Best Practicable Environmental Options for this developing sector. MIDAS will also feed into the establishment of standards and protocols for the Strategic Environmental Assessments and Environmental Impact Assessments that will guide any industrial development.

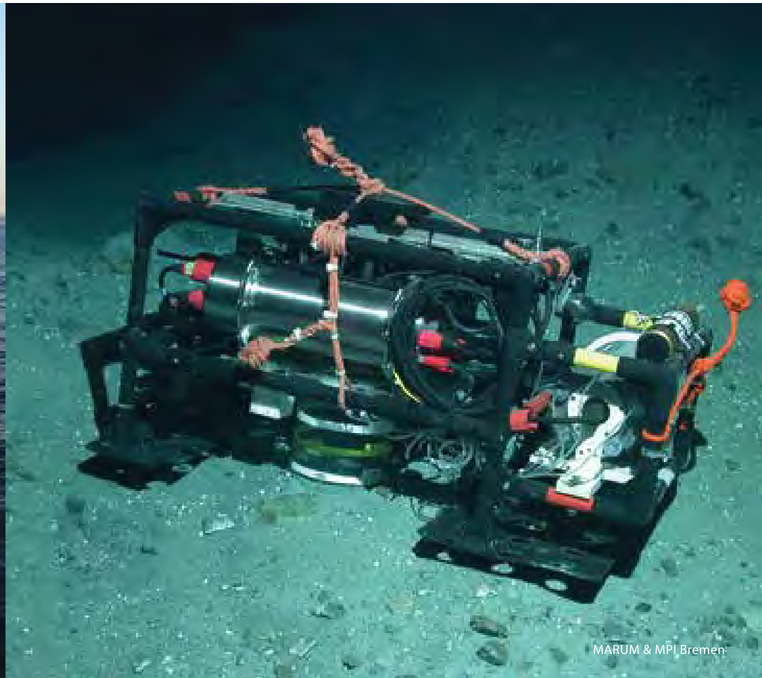
MIDAS will develop a framework for assessing and monitoring impacts during mining operations and the subsequent ecosystem recovery phase, together with appropriate baseline surveys against which impacts can be measured. During mining, the areal extent and duration of both seabed and water column impacts will need to be determined, and it will be necessary to design cost-effective, reproducible methods to assess and monitor recolonisation during the post-mining recovery phase. A number of questions need to be addressed, such as what needs to be measured? At what resolution? How far beyond the mining area? How often?

An assessment will be made of available monitoring technology, including identification of gaps where more development is needed. This is likely to focus on Autonomous Underwater Vehicles (AUVs), Remotely Operated Vehicles (ROVs) and the use of specific sensors, together with high-resolution video and still photography, including the automated recognition of features and organisms. Other methods of assessing and monitoring ecosystems including in situ sampling will also be addressed, and comparisons made with techniques used other industries such as the offshore hydrocarbon industry.

Left: Concept for a deep sea polymetallic nodule collector. Image courtesy Aker-Wirth.



Examples of technology that may be used to monitor the environment before, during and after mining operations in the deep sea. Clockwise from top left: Photo transects from towed cameras may be used alongside automated image recognition technology in the assessment of deep-sea megafauna and habitat characteristics; Remotely Operated Vehicles (ROVs) offer precise and specialised sampling in the deep ocean; more detailed and longer-term measurements of seafloor ecosystems can be made via in situ experiments, such as this autonomous incubation chamber that can be deployed by ROV to assess biogeochemical processes and function of benthic ecosystems; cost-effective monitoring programmes are likely to rely on Autonomous Underwater Vehicles, which can be equipped with a range of sensors and are capable of undertaking extensive pre-programmed survey missions.



Expected benefits and outcomes from MIDAS

MIDAS will work with regulatory bodies such as the International Seabed Authority to develop the guidance framework for exploitation of seabed resources. The results from MIDAS will also serve to inform EU Member State regulatory obligations (e.g. the Marine Strategy Framework Directive), not least by seeking to provide critical thresholds needed to establish the precautionary principle for securing a viable and sustainable seabed mining operating framework. The key aim of the project is to ensure that policy-makers and stakeholders have access to the best available scientific, technical and socio-economic knowledge regarding seabed mining.

The main expected outcomes of MIDAS are:

Identification of the scale of possible impacts, and their duration, on deep-sea ecosystems associated with different types of resource extraction activities;

Development of workable solutions and best practice codes for environmentally susutainable and socially acceptable commercial activities;

Development of robust and cost-effective techniques for monitoring the impacts of mineral exploitation and the subsequent recovery of ecosystems;

Work with policy makers in the European and international arenas to enshrine best practice in international and national regulations and overarching legal frameworks.

The MIDAS Consortium

The MIDAS partnership represents a unique combination of scientists, industry representatives, social scientists, technologists, legal experts and SMEs from across Europe. Our partners are:

Seascape Consultants Ltd, UK
Natural Environment Research Council, UK
GEOMAR, Germany
Ifremer, France
University of Southampton, UK
Instituto do Mar, Azores
Alfred Wegener Institute, Germany
International Research Institute Stavanger, Norway
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Dredging International, Belgium
BGR, Germany
P.P. Shirshov Institute of Oceanology, Russia

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Polymetallic nodules on the seafloor at 5000 m water depth in the north-eastern Pacific. Image courtesy Ifremer Nodinaut cruise 2004.

Cover image: The 'Kandelabra' black smoker at the Logatchev hydrothermal field, Atlantic Ocean.
Image ROV MARUM-QUEST, Center for Marine Environmental Sciences, University of Bremen.

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