Abyssal fauna of the nodule provinces of the deep ocean

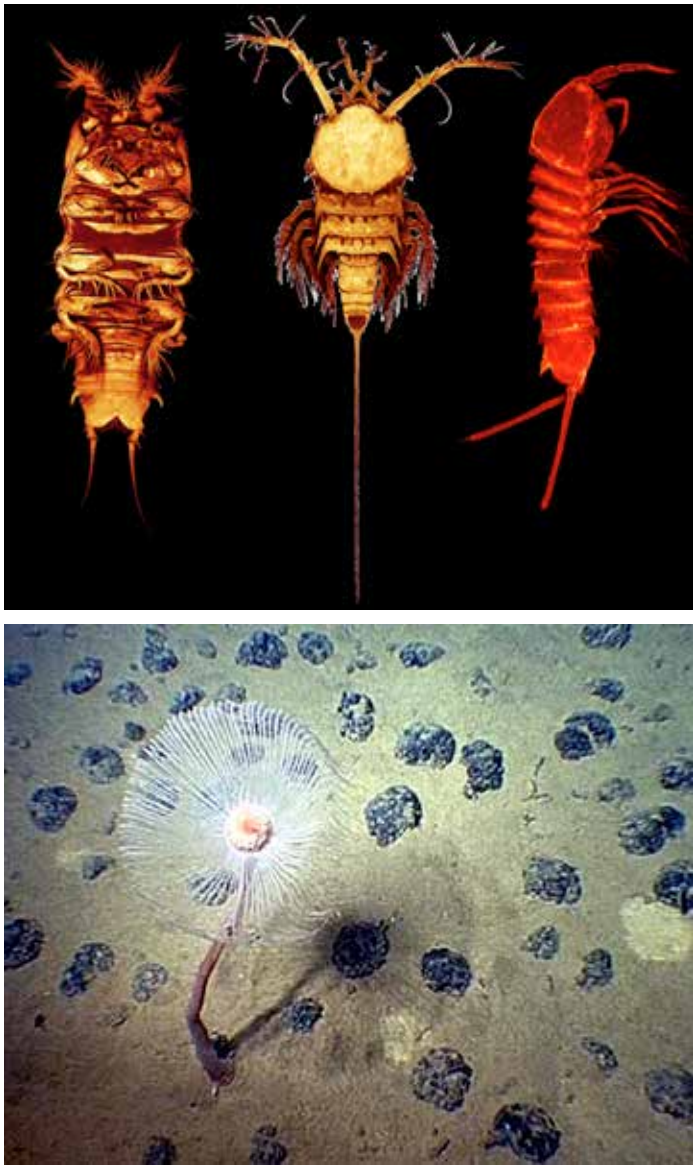
The abyss would appear to be a hostile environment for life: The temperatures are low - barely above freezing - and pressure is considerable, at 500 times the pressure at the surface. Additionally, this ecosystem lies at the end of a four to five kilometre food chain: all the nutrients ultimately derive from the sea surface but less than 0.5% actually reaches the fauna on or near the seafloor. And yet there is a surprisingly diverse fauna to be found in the abyss. We know very little about these animals as sampling them is difficult, and our comparative ignorance of this ecosystem is a problem. In the mineral-rich nodule provinces of the central Indian and Pacific Oceans, this fauna will be most affected by deep-sea mining.

Diversity and distribution

Species diversity on the abyssal plain is high. Samples usually contain a few species with large numbers of individuals and many other species represented by only one or two individuals. Comparison between samples taken in the same area show that they have remarkably low similarity, suggesting a high degree of heterogeneity at local scales (metres to kilometres) across the abyssal environment. Furthermore, different categories of organisms are distributed at different scales.

This heterogeneity, coupled with the low abundance of organisms, poses a problem for establishing baseline studies and setting up monitoring programmes associated with mining. Each category of organisms poses specific challenges, so building a representative picture of the deep-sea fauna requires significant effort. For example, megafaunal organisms (those large enough to be seen in photographs) are widely dispersed and occur in low abundance. In the past, these animals were collected by trawling large areas of ocean floor. Specimens collected this way were frequently badly damaged and difficult to identify. More recently, these organisms have been passively surveyed using towed photographic equipment, autonomous vehicles and even submersibles. However, images of the different morphotypes (i.e., animals of the same species but with slightly different appearance) cannot provide definitive identifications due to the animals' similarity to other closely-related species. Therefore, specimens of the different organisms still need to be collected.

For the sediment-dwelling fauna the issue is the high number of different species encountered combined with the low numbers of specimens of each species. Large numbers of samples are therefore required to adequately capture enough specimens to reflect the true diversity of the fauna, and the sample analysis requires considerable effort and resources. Modern approaches using molecular tools can help address some of these challenges but developing a good baseline requires proper resourcing, and a well-developed workflow and data pipeline (e.g, Glover et al., 2015).



Above: Abyssal fauna from the Clarion Clipperton Zone, Pacfiic Ocean. Top image: Harpacticoid copepods (image courtesy Senckenberg Institute. Bottom image: The hydroid Branchiocerianthus *(image courtesy Ifremer).*

Biogeography, connectivity and extinction risk

So why is the assessment of biodiversity so important? The impact of mining on the biodiversity and ecosystem functioning of the abyssal environment is of primary concern to regulators such as the International Seabed Authority. The Authority is tasked with adopting rules, regulations and procedures to ensure the effective protection of the marine environment from mining-related activities. The regulations specifically underscore the need to ensure that no "*serious harm to the marine environment*" occurs during mineral exploration or - when the time comes - exploitation activities (ISBA/19/LTC/8).

The issue for contractors and environmentalists alike is the likelihood of permanent extinction of species and, therefore, potential alteration of ecosystem function. Understanding this risk requires much better knowledge of the spatial distribution of species - their biogeography - across the whole province. Additionally, it is necessary to understand how the populations of the different species are genetically related and connected in order to properly understand the risk that mining presents. For example, is there free exchange of gametes (reproductive cells) between populations or is one particular group the source of all individuals for adjacent populations? If mining causes the local extinction of a source population then the other populations will also be at risk of extinction. This knowledge of population connectivity, coupled with the understanding of the biogeographic spread of species, is critical if regulators are to undertake rigorous risk assessments of the biological impact of mining.

Left, top: Typhonus nasus*, a deep-sea cusk eel, photographed in the nodule fields of the CCZ. Bottom: Small octopus (both images courtesy Ifremer)*

The role of the MIDAS project

Our understanding of the potential impacts of deep-sea mining is hampered by a lack of robust knowledge of the fauna. The fragmented nature of the exploration of each different claim area by different contractors has hampered the development of the province-wide, taxonomically-robust baseline needed for regions such as the CCZ. This in turn means we lack the biogeographic and genetic data with which we can establish credible risk assessments on the impact of mining. Partners in MIDAS are working on providing an initial assessment of biogeographic patterns and connectivity between populations. The results from these studies will provide guidance on best practice for future studies on the impacts of deep-sea mining.

Right: A decapod crustacean (possibly Bathystilodactylus *sp.) on nodules in the CCZ taken with Autosub6000. Image courtesy NOC-NERC.*

Further reading

Glover AG, Dahlgren TG, Wiklund H, Mohrbeck I and Smith CR, 2015. An End-to-End DNA Taxonomy Methodology for Benthic Biodiversity Survey in the Clarion-Clipperton Zone, Central Pacific Abyss. Journal of Marine Science and Engineering, 4, 2. doi: 10.3390/jmse4010002

International Seabed Authority document ISBA/19/LTC/8 (2013) Recommendations for the guidance of contractors for the assessment of the possible environmental impacts arising from exploration for marine minerals in the Area. Available online at www.isa.org.jm/documents/isba19ltc8

MIDAS has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under Grant Agreement No. 603418. For more information please visit our website: www.eu-midas.net