1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)

Project title:

Influence of deep sea mining on water column microbial diversity

1.1. Project goals

The project aims at finding how base pelagic microbial diversity looks like in areas where deep sea mining is planned and if mining (collection of polymetalic nodules or seafloor massive sulfides) causes disturbance in water column microbial communities.

1.2. Outline

Deep sea mining is a novel way of obtaining scarce raw materials from seafloor. In particular rare earth metals may be collected from polymetallic nodules (PMNs), seafloor massive sulfides (SMS) or cobalt rich crusts (CRC). The method seems to be promising, however little is known about the impact of mining on ocean life. The doctoral project is a part of the international MiningImpact3 project that strives to assess the influence of mining activities on oceanic ecosystem to allow informed setting of rules by regulatory bodies such as International Seabed Authority. Water column samples will be collected from German and Belgian contract areas at CCZ (Clarrion-Clipperton Zone) and from atlantic mid-ocean ridge area (AMOR, Lokislottet and Mohnsskatten) during research cruises in 2026 and 2027. Metagenomic DNA will be isolated from filters and Ilumina or AVITI amplicon libraries will be prepared for 16S rRNA gene fragments from bacteria and archaea, eukaryotic 18S rRNA gene fragments and fungal ITS sequences. The libraries will be sequenced and analysed bioinformatically. Mining impact will be assessed at the level of general community structure (PERMANOVA), alpha diversity (H', observed number of taxa, Chao1, evenness, etc.), and by indentification of differentially abundant taxa. Data will be integrated with those generated by other groups participating in the project and published in high-impact scientific journals.

1.3. Work plan

- Water sampling during cruises
- DNA isolation
- Libraries generation and sequencing
- Initial bioinformatics analyses (denoising, merging reads, chimera removal, ASV table construction)
- Ecological analyses: alpha diversity, beta-diversity (ordinations and tests), taxonomy plots, identification of differentially abundant taxa
- Data interpretation, integration with other groups' results, writing manuscripts

1.4. Literature *(max. 10 listed, as a suggestion for a PhD candidate)*

1. *Hein, Koschinsky & Kuhn 2020 — "Deep-ocean polymetallic nodules as a resource for critical materials." Nature Reviews Earth & Environment. DOI: 10.1038/s43017-020-0027-0*
2. *Miller et al. 2018 — "An overview of seabed mining including the current state of development, environmental impacts, and knowledge gaps." Frontiers in Marine Science. DOI: 10.3389/fmars.2017.00418*
3. *Levin, Amon & Lily 2020 — "Challenges to the sustainability of deep-seabed mining." Nature Sustainability. DOI: 10.1038/s41893-020-0558-x*
4. *Van Dover et al. 2017 — "Biodiversity loss from deep-sea mining." Nature Geoscience. DOI: 10.1038/ngeo2983*
5. *Wedding et al. 2015 — "Managing mining of the deep seabed." Science. DOI: 10.1126/science.aac6647*

6. *Jones et al. 2017 — "Biological responses to disturbance from simulated deep-sea polymetallic nodule mining." PLOS ONE. DOI: 10.1371/journal.pone.0171750*
7. *Jones et al. 2025 — "Long-term impact and biological recovery in a deep-sea mining track." Nature. DOI: 10.1038/s41586-025-08921-3*
8. *Stewart et al. 2025 — "Impacts of an industrial deep-sea mining trial on macrofaunal biodiversity." Nature Ecology & Evolution. DOI: 10.1038/s41559-025-02911-4*
9. *Gazis et al. 2025 — "Monitoring benthic plumes, sediment redeposition and seafloor imprints caused by deep-sea polymetallic nodule mining." Nature Communications. DOI:10.1038/s41467-025-56311-0*
10. *Dowd et al. 2025 — "Deep-sea mining discharge can disrupt midwater food webs." Nature Communications. DOI: 10.1038/s41467-025-65411-w*

1.5. Required initial knowledge and skills of the PhD candidate

- MSc in biology, biotechnology or similar field
- experience in analysis of reads coming from sequencing of amplicon libraries, e.g. 16S rRNA gene fragments or ITS sequences
- experience in the use of molecular biology techniques, particularly DNA/RNA isolation, reverse transcription, and PCR; programming in R (ability to analyze sequencing results: denoising, chimera removal, data preparation for ecological analyses and conducting the analyses in reproducible manner)
- practical laboratory work
- knowledge of marine biology
- independence in preparing publications for English-language scientific journals, international conference presentations
- independence in conducting experimental research and perfect organization of daily work
- scientific achievements documented by publications in renowned international journals and active participation in scientific conferences
- laboratory experience acquired in other research units
- computer skills, including the Linux operating system

1.6. Expected development of the PhD candidate's knowledge and skills

The candidate will develop strong skills in bioinformatics (amplicon sequencing results processing and analysis, community metabolic potential analysis based on marker amplicons etc.), microbial ecology (alpha- and beta-diversity analysis, finding differentially abundant taxa, modeling trophic networks, etc.) as well as in marine and molecular biology (sampling water column, filtration, DNA isolation, preparation of amplicon libraries). Their knowledge will be developed mainly in two fields: marine microbial ecology and bioinformatics.