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Footprints of Deep-Sea Mining: New Study Examines the Spread of Deep-Sea Mining Sediment Plumes

05 March 2025/Kiel. The mining of polymetallic nodules from the seabed can lead to significant and long-lasting ecological changes - both in the mined area, where surface sediments and the fauna living in and on them are removed along with the nodules, and on the adjacent seabed, where the sediment displaced by mining is re-suspended. Independent researchers from the MiningImpact project and the German Federal Institute for Geosciences and Natural Resources (BGR) monitored the testing of an industrial pre-prototype nodule collector vehicle and analysed the spread of sediment plumes and sediment redeposition. Their results have now been published in the journal Nature Communications.

On the abyssal plains, at depths between 3,000 and 6,000 metres, polymetallic nodules are scattered across millions of square kilometres, much like potatoes in a field. These mineral ores are formed over millions of years from metals dissolved in the ocean water or released during microbial degradation of organic material in the sediments. As global demand for critical metals, such as nickel, cobalt, and copper, grows, so too does the pressure to exploit these resources economically.

Due to the extreme conditions in the deep sea, its ecosystems and high biodiversity (made up mostly of small organisms living in the sediment) are particularly sensitive to disturbances. Since 2015, the European JPI Oceans project MiningImpact, coordinated by the GEOMAR Helmholtz Centre for Ocean Research Kiel, has been investigating the potential environmental impacts of deep-sea mining. Previous analyses of decade-old disturbance traces in the Clarion-Clipperton Zone and the Peru Basin indicate that mining will cause long-term damage: biodiversity and essential ecosystem functions will be affected for many centuries.

A major but poorly understood risk is the spread of suspended sediment plumes generated during mining operations. To better understand this process, the scientists closely monitored the test of a remotely operated pre-prototype nodule collector developed by the Belgian ISA contractor Global Sea Mineral Resources. The study, now published in Nature Communications, provides the first detailed data on the far-field spatial footprint of mining-induced plume dispersion and redeposition beyond the mining area itself.

“While the main sediment fraction resettles within a few hundred metres from the source, we could detect small changes in sediment concentration up to 4.5 kilometres away” says lead author Iason-Zois Gazis, a researcher in the DeepSea Monitoring Group at GEOMAR.

Monitoring a Mining-induced Sediment Plume in 4,500 Metres Depth

On 19 April 2021, a nodule collector was deployed for 41 hours at a depth of 4,500 metres. During this time, the vehicle travelled approximately 20 kilometres and covered an area of 34,000 square metres (roughly the size of five football pitches). The sediment plume generated by the vehicle was measured using numerous calibrated sensors mounted on stationary platforms placed on the seafloor, as well as remotely operated and autonomous underwater vehicles.

The study found that a flow of dense suspended particles (a gravity current) developed behind the collector, travelling downslope through steeper sections of the seabed for up to 500 metres. Subsequently, the further spread of the sediment plume was driven by natural near-bottom currents. Near the mining site, sediment concentrations were up to 10,000 times higher than under natural conditions, and returned to normal levels after 14 hours. Most suspended particles remained within 5 metres above the seafloor, resettling relatively quickly aided by particle flocculation. A low-concentration plume of fine sediment particles left the monitored area at 4.5 kilometres distance.

Using high-resolution 3D mapping of the seafloor, the researchers mapped the mining imprints with millimetre-resolution and estimated the amount of sediment removed in the mining area and subsequently redeposited on the seabed. In the mined areas, nodules were removed with at least the top five centimetres of the seafloor. Meanwhile, the redeposited layer reached a thickness of about three centimetres, completely covering the nodule habitat in the close vicinity (up to ~100 m distance), and thinning out with increasing distance from the mining area.

The study provides valuable information for the ongoing development of international regulations by the International Seabed Authority (ISA), including state-of-the-art technologies and strategies for the monitoring of potential future deep-sea mining operations. MiningImpact researchers are continuing their analyses of the environmental impacts, and the results of this study help to accurately link physical impact types with ecological effects.

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