Impact extent of deep-sea nodule mining midwater plumes is influenced by sediment loading, ocean turbulence and environmental thresholds

Carlos Munoz-Royo1*, Thomas Peacock1*, Matthew H. Alford2, Jerome Smith2, Arnaud Le Boyer2, Chinmay S. Kulkarni1, Pierre F.J. Lermusiaux1, Patrick J. Haley Jr.1, C. Mirabito1, Dayang Wang3, E. Eric Adams4, Raphael Ouillon1, Alexander Breugem5, Boudewijn Decrop5, Thijs Lanckriet6, Rohit B. Supekar1, Andrew J. Rzeznik1, Amy Gartman7 and Se-Jong Ju8.

1 Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA.
2 Scripps Institution of Oceanography, University of California, La Jolla, California, USA.
3 Exponent, Maynard, Massachusetts, USA.
4 Department of Civil and Environmental Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA.
5 International Marine and Dredging Consultants, Antwerp, Belgium.
6 Fluves, Ghent, Belgium.
7 U.S. Geological Survey, PCMSC, Santa Cruz, California, USA.
8 Korea Institute of Ocean Science and Technology, Busan, Republic of Korea.

* Corresponding authors: carlosmr@mit.edu, tomp@mit.edu

Abstract

Deep-sea polymetallic nodule mining research activity has substantially increased in recent years, but the expected level of environmental impact is still being established. One environmental concern is the discharge of a midwater sediment plume into the midwater column. We performed a dedicated field study using sediment from the Clarion Clipperton Fracture Zone (CCFZ). The plume was monitored and tracked using established and novel instrumentation, including acoustic and turbulence measurements. Our field studies reveal that modeling can reliably predict the properties of a midwater plume in the vicinity of discharge and that sediment aggregation effects are not significant. The plume model is used to drive a numerical simulation of a commercial-scale operation in the CCFZ. Key takeaways are that the scale of the area impacted by the plume is notably influenced by the values of environmentally acceptable threshold levels, the quantity of discharged sediment, and the turbulent diffusivity in the CCFZ.

1. Introduction

Deep-sea mining of polymetallic nodules is under consideration as a new global extractive industry due to the large resources of nickel, cobalt, copper and manganese, which are substantial compared to land-based reserves1,2. An environmental concern, however, is the scale and impact of the sediment plumes that will be created. Two types of plumes are potentially associated with such an activity (Figure 1). Inevitably, there will be a sediment plume generated by a nodule collector vehicle driving on the seabed. In addition, some current mining proposals consider discharging a midwater sediment plume from a surface operation vessel, the plume comprising water and some sediment brought up with the nodules, nodule fines, and water used to clean the nodules aboard the vessel. Although the midwater discharge material has sometimes been referred to as tailings3-6, tailings are waste leftover after ore processing7, and to date there are no known proposals to release tailings from nodule mining operations at sea.