Proceedings of the ISOPE - Ocean Mining Symposium (1995)
Tsukuba, Japan, November 21-22, 1995

ISBN 1-880653-21-4

Numerical Modeling of Sediment Transport Caused by Deep-sea Mining

W. Zielke and J. A. Jankowski
University of Hannover
Hannover, Germany

J. Sündermann and J. Segschneider
University of Hamburg
Hamburg, Germany

Abstract

The paper describes the application of mesoscale and large scale models in order to simulate the impact of deep–sea mining sediment discharges on the marine environment. The modelling efforts are cross-linked with the experiments of the TUSCH research group which provide supporting data. The results yield time-dependent, three-dimensional concentration fields, the amount of redeposition and the plume residence time. The near bed emissions impact mainly at a local scale, whereas more widespread contamination due to discharges at the free surface or in some intermediate depth cannot be excluded.

Keywords

Deep–sea mining, environmental impact assessment, sediment transport, hydrodynamic numerical modelling, large scale geostrophic model, Pacific Ocean

Introduction

The results of the mesoscale and large scale modelling described in this contribution were achieved within the research activities of the interdisciplinary TUSCH research group (German: Tiefsee–Umweltschutz, i.e. deep–sea environment protection). The reader is referred to Thiel et. al. and Schriever in this issue for background information and a description of the scientific aims, the research program and achievements, as well as the environmental aspects of deep–sea mining. The activities of the TUSCH group concentrate on the impact assessment of manganese nodule deposit exploitation.

Assessing the environmental impact of human activities in the deep sea, with special attention to the nuclear waste dumping has been the topic of numerous, past research. Additionally, appropriate mining technologies have been developed and tested in many countries. This has shown that deep–sea mining is feasible from the technological point of view (e.g. Bischoff and Piper, Eds., 1979; Halbach et al., Eds., 1988; Kunzendorf, 1988). Commercial exploitation of the manganese nodule deposits is, however, economically speaking, not as yet a matter for the immediate future.

Field tests have shown that, even with the most modern technologies, the mining will inevitably be accompanied by resuspension of some bottom sediments and ore particles and extensive damage to the sea floor (Lavelle et al., 1981; Lavelle et al., 1982; Thiel, 1991). Depending on the technology, the discharges will take place in different depths and intensity. The sediment plumes will be transported by the ocean currents and, at worst, form stable turbidity layers in different depths (Ozturgut et al., 1981; Baturin et al., 1991). A chronic exposure of marine organisms to great amounts of particles in concentrations exceeding ambient or being of unusual origin is expected to occur (particulate pollution). Therefore, one problem in the environmental impact assessment is to estimate how long the plume persists before it eventually dilutes to approximately the ambient concentration level or deposits at the bed.

The aim of the authors' research is to develop numerical sediment transport models in connection with potential deep–sea mining activities in a reference area located in the south-eastern equatorial Pacific Ocean off Peru. A German mining claim has been registered for the region. Field Studies have been performed by the TUSCH research group in order to obtain the required scientific background for evaluating the environmental impact and to provide the necessary supporting data for numerical modelling (Thiel and Schriever, 1989; Thiel, 1991).

The modelling effort is oriented at providimg a tool which will allow reliable risk assessment for the near field and at the mesoscale, where the greatest impact is expected and also for the large scale, where long-term effects should occur. This complementary approach from the University of Hannover (mesoscale) and the University of Hamburg (large scale) and crosslinked with other TUSCH activities and allows simulations in the time scales of hours to weeks as well as months to years.

The Near Field and Mesoscale Model

In order to provide a reliable risk assessment on the time scales of hours to weeks, a mesoscale regional model was developed on the ca. 450 km^2 DISCOL Experimental Area, DEA (Thiel and Schriever, 1989) centered about 7° 04'S, 88° 28'W) in the Peru Basin. The size of this region allows the simulation of a plume spreading during 1–2 weeks, depending on the current magnitude. The computational mesh consists of approx. 10^5 prismatic 3D-elements, providing a horizontal resolution of 500–700 m, except in the direct vicinity of the emission (100 m). In the vertical direction 23 planes are logarithmically dis-