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Effects of sediment discharge plumes from polymetallic nodule mining on oceanic carbon cycle processes: a numerical sensitivity study

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Current design of polymetallic nodule mining operations includes the discharge of sediment plumes into the water column from the sea surface platform. However, the consequences of elevated particle concentrations for the pelagic ecosystem and carbon cycle processes, particularly the biological carbon pump, are unknown. We applied the biogeochemical model MOPS to investigate, which water column processes are thereby affected. Due to lack of information from open ocean pelagic fauna, we parameterized effects on key biogeochemical processes by taking published data of sediment impacts from shallow water organisms and ran sensitivity experiments to test each of them. MOPS was coupled to the 1D hydrodynamical model GOTM for two different sites in the Clarion-Clipperton Zone, exhibiting different primary productivity (PP) and export production (EP) conditions. Here, we present results from model scenarios injecting the sediment waste into the euphotic zone (at 65 m water depth, as worst-case scenario) for five discharge times from one week to one year. MOPS' confinement of system processes to the euphotic zone limited our investigation regarding the sediment discharge depth. Our model results revealed that the decrease of light penetration is the main effect of the injected sediment plume (1.2 kg/s), represented in the model by an added *light attenuation coefficient* $k_{sed.}$ This reduced PP by nearly 50%, and EP decreased by up to 68% with increasing discharge times. These relative changes were very similar for both simulated sites despite significantly different baseline PP and EP values. To analyze sediment plume effects on other processes, simulations were run without increased light attenuation. Here, the impacts were generally smaller or resulted in an overall increase in PP and EP. For example, a reduction of the *zooplankton grazing rate* (parameterization for reduced access to nutrients) and a reduction of the *assimilation rate* (clogging of gut tract) by 100%, both led to an increase in PP by up to 30% and in EP by up to 38%. In contrast, impacts on higher-trophic levels (e.g. fish) through a reduction by 100% of the *density-dependent loss rate* reduced PP by 20% and EP by 28%.