EGU22-1455
https://doi.org/10.5194/egusphere-egu22-1455
EGU General Assembly 2022

Constraining zooplankton exposure to microplastic at the global scale: results from a new coupled physical-biogeochemical model (NEMO/PISCES-PLASTIC)

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Zooplankton are among the most abundant animals in the ocean and are keystone species linking primary producers to higher trophic levels. Microplastics (MP) are becoming ubiquitous contaminants in the ocean that may spread through water layers from surface to bottom in all oceanic regions and be ingested by zooplankton. MP ingestion by zooplankton may lead to deleterious effects that may spread up the food-web to ultimately impact entire ecosystems. However, in situ quantification of MP contamination in the water and the biota is complex. As a result, global impacts of MP on zooplankton remain largely unknown. In this study, we use a global coupled physical-biogeochemical model providing realistic nutrient and plankton cycling, augmented with a 3D module for the representation of MP, in order to calculate the first global estimates of zooplankton exposure to MP. Results indicate that water contamination by MP is highest in the surface of subtropical gyres and coastal areas close to major MP sources, while sinking MP accumulates at the bottom of coastal zones close to their sources. We estimate zooplankton exposure to MP based on water concentrations of MP, particles and plankton and on zooplankton grazing rate. We found 2 main drivers favouring high zooplankton exposure to MP: 1) high water MP contamination, which increases zooplankton ingestion risk, even at low grazing rates and 2) intense grazing activity in productive regions increasing MP exposure even in moderately contaminated waters. Finally, despite low seasonal variability in [MP], buoyant MP may be seasonally transported to the mesopelagic waters (between 100and 1000m) by convective currents. Consequently, re-stratification of surface waters may lead to highest MP concentration in surface coinciding with planktonic blooms, thus periodically increasing contamination risk.