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Estimating the effects of marine eutrophication on fish functional diversity at the global scale

Jean-François Blanc[1], Laura Scherer[2], and Peter Van Bodegom[3]
[1]Leiden University, Institute of Environmental Sciences, Industrial Ecology, Netherlands (jf.blanc.ecomar@gmail.com)
[2]Leiden University, Institute of Environmental Sciences, Industrial Ecology, Netherlands
[3]Leiden University, Institute of Environmental Sciences, Industrial Ecology, Netherlands

Eutrophication is one of the main anthropogenic pressures experienced by marine ecosystems. It is mainly linked to the use of fertilizers in agriculture and can result in hypoxia, increased turbidity or change in pH. These effects can negatively impact marine species and affect the functioning of ecosystems. Life cycle assessment (LCA) is a tool that can be used to quantify such impacts on the environment of a given product. Part of the process of conducting an LCA is translating environmental flows associated with a product, such as nutrient emissions, to impacts through so-called characterization factors, a component of which are effect factors . While the consequences of human activity on biodiversity are most often measured using species richness, functional diversity also provides valuable insights. Different species occupy different roles in the ecosystem and provide different services, and this nuance is missed when focusing solely on the total number of species. To address this gap, we used data from the Copernicus Marine Service and species occurrence databases (GBIF and OBIS) to quantify the effects of marine eutrophication on the functional diversity of fish at the global scale. The data covers occurrences and nitrate values from 1993 to 2024 at a resolution of 0.25°. The global ocean was subdivided according to the Longhurst Provinces to create a spatially explicit model that accounts for biogeochemical differences. The functional diversity was quantified using continuous traits covering multiple trait categories and ecological functions. By pairing the nitrate concentration with fish occurrences, the maximum nitrate concentration for each species was determined. Communities were then simulated at different concentrations of nitrate to evaluate the loss of functional diversity compared to the maximum functional diversity possible in the province. The resulting relationships allowed us to calculate the effect factors which can be used in the LCA to quantify the effect of biomass production (and the resulting nitrate emissions) on marine environments.