PROJECT SUMMARY

State of the art: Plastic pollution is truly ubiquitous in natural environments. It is causing both biodiversity and economic losses in marine, freshwater and terrestrial (soil) environments alike. Breaking down of plastics into smaller (micro and nano) particles positions plastics as the most dangerous emerging pollutant. Published impacts on biota are versatile and significant: ingested (micro)plastics reduce the fitness of individuals, populations, and entire food webs; (micro)plastics can serve as a vector for (harmful) substances; and presence of plastics in the environment can alter behavior of individuals, indirectly reducing their food availability. Plastic pollution receives significant scientific, media and public attention and engagement. However, research and funding into plastic pollution lags significantly behind that for climate change.

Problem: While recent research provides data on plastic and the related pollutant exposure, tools quantifying the resulting organismal effects have not been developed. Modeling challenges arise because plastics affect the biota via several fundamentally different mechanisms (directly vs. indirectly; physically vs. chemically; with lethal and/or sublethal consequences), which complicates the analyses. Furthermore, countless ways of reporting interactions with plastics (frequency of occurrence in a dataset, number or volume of items, characteristics – size, type, color, shape; to name just a few) complicate data consolidation and utilization. Finally, while some exposure and effect scenarios can be experimentaly explored for some individuals, effects on populations - especially of longer lived species – may require decades to detect.

Solution: Process-based models that can integrate multiple effects and types of data, and predict effects of multiple stressors on organisms in hitherto unobserved environments. Dynamic Energy Budget (DEB) theory provides a framework for development of such models. DEB models track energy and matter acquisition and utilization, and can be extended to include toxicokinetics (uptake and elimination of toxicants) and toxicodynamics (effects of toxicants), as well as reduced food acquisition (due to plastics ingestion or behavioral changes), thus quantifying interdependencies between energy acquisition, pollutant exposure, and organismal life history. Individual-based DEB models can be integrated into various population models, providing population-level predictions.

Approach: QPlast will help assess the full scale of the problem, by focusing not only on systematizing interactions with plastics in the aquatic (marine, freshwater) and terrestrial environments, but also utilizing DEB theory to quantify the resulting (sub)lethal effects on affected organisms, primarily protected and/or commercial species. The models will capture effects of environmental factors (food, temperature) and exposure to plastics (physical, chemical) to quantify combined effects of exposure to plastics in a changing environment.

To account for the complexity of the topic and diverse pathways in which plastics affects the biota, the approach is interdisciplinary and divided into several objectives - all contributing to the overarching goal.
Scientific objectives are organized into dedicated **work packages (WP)** that analyze and model aspects of negative effects of exposure to plastics (WP1-3), and integrate these effects (WP4) into a common framework:
WP1 - Physical impacts of plastics ingestion: Quantify energy deficiency resulting from plastics ingestion for species of special (ecological and/or economical) interest
WP2 - Chemical impacts of plastics ingestion: Develop an ecotoxicological module for priority species, accounting for effects of organic and inorganic pollutants leaching from ingested plastics
WP3 - Behavioral adaptations: Investigate impacts of plastics exposure on organism behaviour through experiments on earthworms
WP4 - Multistressors: Combine physical, chemical, and behavioral impacts of exposure to plastics within a unifying framework

Results: Exposure to plastics will, in a modular way, be explicitly and quantitatively linked to three different types of negative effects of plastics (physical, chemical, behavioral). Even though the pathways are different, the pressures are often simultaneous, thus requiring a unifying approach, such as proposed here. In addition, QPlast will build a strong research group by connecting experienced senior researchers and training three young researchers- two postdocs fully funded by the project, and a PhD student.

Applications: Methodology developed and applied in QPlast can be applied to a wider list of species. The gathered knowledge and obtained insights will help to gauge the full scale of the plastic pollution problem, identify species of key interest and link the mutliple way that the presence of plastics affects them to sublethal conseques which may already be observed. QPlast will therefore be of great use for researchers, public, experts involved in management of species and/or areas of special interest, as well as political decision-makers informing the legislative for aquatic (marine, freshwater) and terrestrial habitats.