# BioGeochemical PARTicle interactions and feedback loops on the Belgian Continental Shelf (BG-PART)

**Executive Summary**

The fundamental question of the project was to elucidate the fine interactions between planktonic organisms, marine gels and suspended particulate matter (SPM) along the coastal-offshore gradient of a turbid and tidal system. Our approach included monthly in situ samplings along the SPM gradient (coupled with continuous sampling at MOW1), laboratory experiments (including phytoplankton niche characterization and flocculation experiments), numerical modeling of phytoplankton-sediment interactions, the use of satellite products to get a synoptic view of the SPM concentration across the North Sea, and the collection and analysis of adjacent available datasets from foreign colleagues and literature to complete ours.

Results show that phytoplankton species commonly found in Belgian waters produce marine gels (polysaccharide precursors known as exopolymeric substances, EPS, and transparent exopolymeric particles, TEP) under all natural conditions, including in turbid environments. The carbon overflow hypothesis, often invoked in oceanic conditions to explain the marine gel production, does not seem to apply in turbid and eutrophied coastal waters, where the excretion of gel precursors occurs with photosynthesis by all species isolates, under any growth conditions. The winter-spring phytoplankton community composition in Belgian waters may change considerably from year to year depending, among other factors, on the average winter temperature. Such changes may impact the partitioning between TEP and its precursors, although this does not seem to impact the seasonal enhancement in flocculation and the resulting decrease in SPM concentration. The freshly produced sticky material is also consumed by bacteria. At all stations, bacterial abundance increases in spring and summer with the organic matter concentration. In contrast, although zooplankton copepods may feed on TEP when starved in the absence of phytoplankton (lab conditions), they do not seem to impact considerably the TEP concentration at relevant time scales. The presence of phytoplankton and EPS/TEP correlates with an increased flocculation potential as established in controlled lab experiments, which supports the theory of Fettweis et al. (2022) that freshly produced gels enhance flocculation in spring and summer. This ubiquitous decrease in summer SPM concentration is observed each year across the Belgian coastal-offshore gradient of turbidity and throughout the whole North Sea as established with satellite products. It is also reproduced by our 0D model representing phytoplankton biogeochemistry and particle flocculation in an idealized water column in simulations covering tidal to seasonal scales. The model validates the hypothesis that early phytoplankton species considerably affect SPM dynamics by fostering the formation of larger and more cohesive particles in spring and summer. In turn, enhanced flocculation has a substantial impact on phytoplankton production, as shown by the 0D model outcome, which thus creates a positive feedback that regulates habitability in naturally turbid coastal systems. This particle dynamics in the vertical also modulates the horizontal transport of particles, especially across the coastal-offshore gradient. We have observed that the concentration of particles (organic and mineral) tend to decrease from the coast to the offshore, especially at bathymetries below 20 m on average. Presumably, in that transition zone, the turbulence range and particle composition favor particle settling, while hydrodynamic processes tend to transport particles of the seabed back towards the coast, thus maintaining the cross-shore SPM gradient. As particle dynamics

play a substantial role in biogeochemical fluxes, we have extended our findings to the whole North Sea by combining satellite images, 3D hydrodynamic model results and in situ data to contribute assessing the carbon budget on the shelf.

The strength of the BG-PART project lies in the transdisciplinary approach that was set up from the start, and in the multiplicity of methods deployed to explore the SPM dynamics, from their mineral to biological components. In an attempt to provide a 'light' integrated summary of the different aspects of the BG-PART project – hydrodynamics, sedimentology, biology and biogeochemistry – we propose in the Appendix of this report some of our results in the form of a synthesis illustrated by graphical abstracts.

New perspectives and questions on particle dynamics arise from this transdisciplinary reflection (also in relationship with the Belspo-funded project PiNS). As an output of the project, the PhD student Auria Brun has successfully defended her thesis at UGent, and several publications from the partners are published, under review, or in preparation. The datasets constituted and stored by each partner institute (RBINS, UGent and VLIZ) are large and complement existing collections of data, some of which are readily available to the general public.