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Benthic Phosphorus Cycle in the St. Lawrence Estuary and Gulf : revisiting iron reactivity 40 years later

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Phosphorus (P) is an essential element for life and plays a key role in regulating marine primary productivity. In marine ecosystems, P is considered as a limiting macronutrient and strongly influences primary productivity and carbon sequestration via the biological carbon pump. In the St. Lawrence Estuary (SLE), 85% of the soluble reactive phosphorus (SRP) reaching surface waters originates from deeper waters, highlighting the critical role of sediments as a phosphorus source for the entire system. Forty years ago, prof. Mucci and colleagues studied Fe/P dynamics in the SLE and found ~50% of sedimentary particulate phosphorus was permanently buried in sediments while the remaining ~50% was remobilized and released to the overlying bottom waters. This release SRP was attributed primarily to the reductive dissolution of reactive iron (Fe) phases. Over the past decades, the continuous deoxygenation of bottom waters in the St. Lawrence has altered redox conditions and modified Fe-phase speciation, prompting us to revisit this system.

Understanding how SLE sediments currently act as a source or trap of SRP under ongoing deoxygenation, and identifying which sedimentary phases now control phosphorus cycling, are also key questions for assessing the future biogeochemical functioning. We hypothesize decreases in Fe/P ratios with declining oxygen levels, resulting in enhanced SRP release to bottom waters, which is consistent with the behaviour in hypoxic basins. To test the changing fate of sedimentary P, nine sites (~300–360 m depth) were sampled in the Laurentian Trough along a bottom-water oxygen gradient ranging from 114 to 34 μmol L^{-1}. Sediment pore waters and SRP and Fe phases were analyzed using ascorbate and dithionite extractions. We calculated the reactive Fe/P ratio in surficial sediments and evaluated diffusive SRP fluxes across the sediment–water interface along the bottom-water O_2 gradient and compared current results with those obtained in the 1990s to assess long-term changes in iron reactivity and phosphorus cycling. Exploring the evolving Fe/P sedimentary interplay in our changing ocean is inspired by, and built upon, Professor Mucci's 40-year scientific legacy.