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Fluxes and transformation of sedimentary phosphorus in Green Bay, a hypereutrophic freshwater estuary

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Seasonal hypoxia has been increasingly observed in Green Bay, Lake Michigan, but the role of nutrients in regulating water quality and how hypoxia regulates phosphorus (P) cycling are not well understood. Sediment cores were collected along a trophic gradient in Green Bay for measurements of different P species, including labile-P (Ex-P), iron-bound-P (Fe-P), biogenic-apatite and/or $CaCO_3$-associated-P (CFA-P), organic-P (Org-P) and detrital-apatite-P (Det-P), based on SEDEX extraction. Although total P decreased with depth in all sediment cores, different P species showed different vertical profiles or post-depositional mobilities. The Ex-P, Fe-P and CFA-P species were identified as potentially bioavailable P with active exchange with the overlying water column. In contrast, little variations were observed for both Org-P and Det-P species serving as the main sink of P in sediment. Combined with sedimentation rates derived from ^{137}Cs profiles, P accumulation rates were estimated to be 105 mmol-P/m^2/y in the south, 39 mmol-P/m^2/y in central bay, and 27 mmol-P/m^2/y in the north of Green Bay, respectively, showing a decrease in the depth of active P regeneration along the south-north transect. The overall P fluxes from sediment to the overlying water column were estimated to be 12 mmol-P/m^2/y in the south and central and 19 mmol-P/m^2/y in the north of the bay, corresponding to a P burial efficiency of ~89%, 70% and 31% along the transect. Recent decrease in the content of Det-P, especially at central and northern stations, could largely result from the re-building of dams at the Fox River in the 1990s. High contents of Org-P but low Fe-P observed in the hypoxic region reflected the preferential preservation of Org-P and rapid regeneration of Fe-P especially since the 1960s. Changes in sedimentary P speciation could be inked to the extent of hypoxia and environmental change and provide an improved understanding of the relationship between sources, internal cycling, and burial of P in Green Bay, Lake Michigan, the largest freshwater estuary.