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The role of shallow basins and the littoral zone in modulating lake P cycling: a mass balance analysis of Lake Erie

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The littoral zone of a lake is the hydrological and ecological link between the lake's open waters and its watersheds. Located where land and lake meet, littoral zones are highly exposed to the impacts of land-based anthropogenic activities. They act as biogeochemical reactors that modulate the fluxes, timing and speciation of nutrient elements from land to lake. Yet, little is known about the role of littoral zones on phosphorus (P) cycling in large lakes, or how they affect nearshore eutrophication caused by excess availability of P. Lake Erie, the warmest and the most productive of the five North American Great Lakes, is strongly impacted by anthropogenic activities and suffers from eutrophication in the form of harmful Cyanobacterial blooms in the shallow western basin and nuisance Cladophora blooms in the deeper eastern basin. The western and eastern basins are separated by the deep central basin. We developed a mass balance model to investigate the dynamics of dissolved and particulate P in the lake's basins, and explicitly representing the littoral zones of the central and eastern basins. For each of the various lake compartments, we estimated the dissolved and particulate P budgets by accounting for the inputs from tributaries, atmospheric deposition, and nearshore-offshore exchanges. The permanent burial of particulate P in a given compartment was calculated using literature data on deposition rates of particulate P and internal loading fluxes measured in sediment core incubations. Our results indicate that the western basin and littoral zones of Lake Erie eliminates approximately 30% of the total P input to the lake. Our model has applications in testing the long-term effect of P load management strategies on nearshore eutrophication.