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Carbon cycling in inland seas: contrasts among the Laurentian Great Lakes

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Organic carbon cycling in lakes can be thought of as the processing of carbon dioxide fixed within the lake (autochthonous C cycle) and the processing of organic carbon inputs from the catchment (allochthonous C cycle). CO2 emissions from the organic carbon cycle are the difference between the respiration of allochthonous organic carbon inputs and the burial of autochthonous carbon. Organic carbon inputs to lakes from the watershed are primarily determined by catchment size, runoff, and latitude. The fate of allochthonous organic carbon in large lakes is controlled largely by the water residence time; in the Laurentian Great Lakes, most allochthonous DOC inputs are respired. The primary productivity of large lakes is largely constrained by latitude; light and temperature rather than nutrients are the major constraints on primary production. Burial of organic carbon in large lakes is a function of hypolimnetic aeration (determined by lake depth, trophic state, and surface area) and lake depth. Hence, lakes Superior and Huron are weak sources of CO2 to the atmosphere; the small inputs of allochthonous organic carbon are respired in the lake and burial rates of autochthonous organic carbon are low in these deep and well oxygenated lakes. Among the Laurentian Great Lakes, only in Lake Erie is a large fraction of primary production buried with the result that the lake is a sink for atmospheric CO2. Precipitation of calcite has a marked influence on the rate of CO2 emissions from Lake Michigan.