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Pathways of organic carbon utilization in small lakes: Results from a whole-lake ^{13}C addition and coupled model

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Abstract

In many small aquatic ecosystems, watershed loading of organic C exceeds autochthonous primary production. Although this allochthonous organic C has long been thought of as refractory, multiple lines of evidence indicate that substantial portions are respired in the receiving aquatic ecosystem. To what extent does this terrestrial C support secondary production of invertebrates and fish? Do current models adequately trace the pathways of allochthonous and autochthonous C through the food web? We evaluated the roles of allochthonous and autochthonous organic C by manipulating ^{13}C content of dissolved inorganic C in a small, softwater, humic lake, thereby labeling autochthonous primary production for about 20 d. To ensure rapid and sufficient uptake of inorganic ^{13}C, we enriched the lake with modest amounts of N and P. We constructed a carbon flow model based on the ambient and manipulated levels of ^{13}C in C compartments in the lake, along with information on key rate processes. Despite the short nature of this experiment, several results emerged. (1) Fractionation of photosynthetically assimilated ^{13}C-CO_2 by phytoplankton (ε) is lower (~6‰) than physiologic models would estimate (~20‰). (2) Bacteria respire, but do not assimilate, a large amount of terrestrially derived dissolved organic C (DOC) and pass little of this C to higher trophic levels. (3) The oxidation of terrestrial DOC is the major source of dissolved inorganic C in the lake. (4) Zooplankton production, a major food of young-of-year fishes, is predominantly derived from current autochthonous carbon sources under the conditions of this experiment.