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Calculating riverine ecosystem metabolism under unsteady flow from hydropower generation.

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Dams can greatly alter gross primary production (GPP) and ecosystem respiration (ER) in a river due to a myriad of downstream physical changes, such as clear water and reduced sediment transport from upstream. Despite knowing that metabolism is altered, there have been few applications of open channel methods to collect river metabolism data, likely because of difficulties in applying the conventional methods under highly unsteady flow conditions below a dominant hydrologic discontinuity. To overcome these difficulties, a two-station approach is necessary because the upstream dam represents a discontinuity within the long reach that would influence a one-station metabolism estimate. The standard two-station method assumes a constant hydrologic travel time, which means it is not likely to be applicable where discharge changes dramatically over a given day of analysis. For example, in the Colorado River, Arizona, USA, discharge varies 2-fold daily in the tailwater below Glen Canyon Dam. To calculate metabolism we have linked a dynamic wave river routing model with an oxygen fate and transport model. Upstream boundary conditions are measured oxygen concentrations and observed water flow from the dam. We use an inverse modeling scheme to estimate metabolism, where GPP and ER model parameters are objectively selected to minimize the error between simulated and observed oxygen concentrations at the downstream measurement station. During rare periods of steady flow, the network model and traditional calculation gave similar values for GPP and ER. Under unsteady flow the dynamic routing model yields reasonable simulations of the downstream flow variability, suggesting we have approximated the appropriate river travel times necessary to estimate metabolism parameters Rates of primary production were high and strongly matched annual patterns of solar insolation. We suggest that this approach will allow calculating metabolism in a suite of human-altered rivers for which traditional approaches will not work.