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Persistence of net heterotrophy in lakes during nutrient addition and food web manipulations

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Abstract

Net ecosystem production (NEP) is the difference between gross primary production (GPP) and community respiration (R). We estimated in situ NEP using three independent approaches (net CO_2 gas flux, net O_2 gas flux, and continuous diel O_2 measurements) over a 4–7 yr period in a series of small lakes in which food webs were manipulated and nutrient loadings were experimentally varied. In the absence of manipulation, these lakes were net heterotrophic according to all three approaches. NEP (NEP = GPP-R) was consistently negative and averaged -35.5 ± 3.7 (standard error) mmol C m^{-2} d^{-1}. Nutrient enrichment, in the absence of strong planktivory, tended to cause increases in estimates of both GPP and R (estimated from the continuous O_2 data) but resulted in little change in the GPP/R ratio, which remained <1, or NEP, which remained negative. When planktivorous fish dominated the food web, large zooplankton were rare and nutrient enrichment produced positive values of NEP by all three methods. Among lakes and years, daily values of NEP ranged from -241 to $+175$ mmol m^{-2} d^{-1}; mean seasonal NEP was positive only under a combination of high nutrient loading and a planktivore-dominated food web. Community R is significantly subsidized by allochthonous sources of organic matter in these lakes. Combining all lakes and years, we estimate that ~26 mmol C m^{-2} d^{-1} of allochthonous origin is respired on average. This respiration of allochthonous organic matter represents 13 to 43% of total R, and this fraction declines with increasing GPP.