Temporal dynamics and regulation of lake metabolism

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ABSTRACT: We studied temporal dynamics and regulation of oxygen metabolism in the upper mix layer of a nutrientrich shallow Danish lake by continuous measurements of oxygen, irradiance, wind, and temperature and frequent measurements of algal chlorophyll, organic pools, and inorganic nutrients. Chlorophyll, algal growth rate, and mean irradiance (E_{mean}) in the mixed surface layer were calculated daily from continuous measurements of irradiance and temperatur with depth. There were three to four distinct maxima in gross primary production (GPP) and community respiration (R) during the summer season and minima from fall to spring after broad-scale changes in irradiance, temperature, mixing depth, and biomass and growth rate of the alg community and concentrations of inorganic nutrients. Lake metabolism was annually balanced (mean GPP :R 1.04 in 2003 and 1.01 in 2004), with net autotrophy occurring mainly from mid-May mid-September (mean GPP:R 1.14 in 2003 and 1.10 in 2004), and net heterotrophy outside this period (mean GPP:R 0.60 in 2003 and 0.81 in 2004). However, GPP :R varied two- to threefold fro day to day because lower surface irradiance, higher mixing depth, and thus lower E_{mean} significantly reduced GPP. Normalizing GPP to chlorophyll provided an index of algal growth potential (GPPB), which followed a hyperbolic relationship to E_{mean}, and both parameters were related to blooms and collapses of algal biomass. Metabolic rates were much more variable from day to day than algal biomass, which integrates growth and loss processes over longer periods. The continuous approach to lake metabolism provides better data and can provide a more accurate picture than averages of a few discrete measurements. Weekly averages reflected the characteristic seasonal peaks and troughs also observed for algal biomass, whereas monthly averages did not. Daily measurements of lake metabolism, therefore, can provide the optimal background for evaluating temporal changes and regulation of algal biomass and organic pools in nutrient-rich shallow lakes.