Spatial variation of nitrogen fixation in lakes of the northern Great Plains

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ABSTRACT: Cyanobacterial blooms are a regular feature of lakes in central North America, but little is known of their importance to the nitrogen (N) cycle and nutrition of aquatic food webs. We hypothesized that N_2-fixing cyanobacteria constitute a significant source of N to prairie lakes, that fixed N is effectively transferred to primary and secondary consumers, and that the importance of fixed N is structured on a landscape scale due to spatial gradients of lake chemistry and catchment characteristics. These hypotheses were tested using stable isotope analyses and mass budgets in six chained lakes of the northern Great Plains that were sampled biweekly during summers of 1994-2004. Mean annual N isotope signatures of particulate organic matter (d15N-POM) were highly correlated to the abundance of N_2-fixing cyanobacteria (r^2 = 0.75, p , 0.001), but exhibited no marked spatial organization. Instead, the temporal variability of δ^{15}N-POM was greatest in downstream lakes where N_2-fixing cyanobacteria were abundant. Furthermore, seasonal declines in δ^{15}N-POM were correlated with reductions in δ^{15}N of individual zooplankton taxa (*Daphnia* spp., *Diacyclops thomasi*, *Leptodiaptomus siciloides*, *Leptodora kindtii*), especially in downstream eastern lakes. N mass balances revealed that the importance of biological N_2 fixation relative to total N inputs (up to 77%) and initial N standing stock (up to 201%) were significantly linearly correlated with landscape position ($0.59 \leq r^2 \leq 0.83$, $p \leq 0.07$) and effective drainage area ($0.61 \leq r^2 \leq 0.98$, $p \leq 0.07$), as were volumetric and areal estimates of N_2 fixation during summer ($r^2 \geq 0.87$, $p \leq 0.007$). These patterns demonstrate that fixed N is spatially structured, highly predictable based on landscape position, and readily assimilated into aquatic food webs.