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INTERACTIONS AMONG ENVIRONMENTAL DRIVERS: COMMUNITY RESPONSES TO CHANGING NUTRIENTS AND DISSOLVED ORGANIC CARBON

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Abstract. Biological communities are frequently exposed to environmental changes that cause measurable responses in properties of the community (hereafter called environmental drivers). Predicting how communities respond to changing environmental drivers is a fundamental goal of ecology. Making predictions, however, can be very difficult, particularly when multiple environmental drivers change simultaneously and there are interactions among the drivers. We investigated the effects of the interaction between changes in nutrient loading and changes in colored dissolved organic matter (measured as dissolved organic carbon, DOC) on the dynamics of phytoplankton communities over a 7-yr period. In 1991, Long Lake, a small seepage lake in northern Michigan, was divided vertically, from sediment surface to water surface, with plastic curtains as part of a whole-lake experiment. The accompanying changes in hydrology led to increases in DOC concentration in one of the basins. Nutrients were added to both basins from 1993 to 1997, causing dramatic changes in phytoplankton community composition. We used multivariate autoregressive models to help interpret the patterns of phytoplankton community composition observed during the experiment. DOC and nutrient addition had diverse effects on phytoplankton: some taxonomic and morphological groups were directly affected by the changes in DOC and nutrients, whereas other groups experienced indirect effects via their interactions with groups that were directly affected. Model results suggest that there was an interaction between the effects of DOC and nutrients for many groups of phytoplankton, such that differences in DOC concentration accounted for differences between basins in response to nutrient addition. The effects of DOC can be explained by changes in physical structure (e.g., thermocline depth and transparency) and water chemistry (e.g., pH) that accompanied changes in DOC concentration. The interaction between DOC and nutrients suggests that predicting community responses to multiple drivers cannot be achieved by simply adding up the effects of single drivers.

Key words: aquatic ecology; dissolved organic carbon (DOC); environmental drivers, multiple; Michigan; nutrient loading, lake; phytoplankton; whole-lake manipulation.