The Water is Getting Warmer: Spatiotemporal Water Quality Trends from the Multi-decadal Cooperative Lakes Area Monitoring Project (CLAMP)

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Introduction

To Iowans, our lakes are prime destinations for outdoor recreation, driving more than $1 billion in direct spending annually for local lake economies. Harmful Algal Blooms (HABs) pose a direct and growing threat to income from our lakes, the health of our families, and the freedom to enjoy our recreational waters without fear. Located in Dickinson County, Iowa, the Iowa Great Lakes region consistently experiences HAB conditions while remaining a major tourism hub spanning nine water bodies, with West Okoboji Lake annually drawing over one million visitors. The Cooperative Lakes Area Monitoring Project (CLAMP) was developed and implemented in 1999 by the Iowa Lakeside Lab and Friends of Lakeside Lab to build a long-term dataset to monitor algal conditions and educate local citizens about lake ecology. For the past 26 years, local Iowa Great Lakes residents have collected key algal indicators, including temperature, dissolved oxygen, total phosphorus, total nitrogen, Secchi depth, and Chlorophyll-a, biweekly during the summer at 27 sites across the 9 waterbodies in Dickinson County. The high number of sampling sites across the Iowa Great Lakes enables rigorous characterization of long-term spatiotemporal variability in algal abundance, nutrients, water clarity, and temperature in an area of increasing HAB threat. Here, we report 26 years of in situ and laboratory-verified water quality data across the three primary lakes of the Iowa Great Lakes region: Big Spirit, East Okoboji, and West Okoboji. These three waterbodies exhibit significant variability in morphology, optics, and trophic status: Big Spirit Lake is Iowa's largest lake by surface area but is relatively shallow, while West Okoboji Lake is Iowa's deepest and largest by volume.

Method

Using CLAMP data, we create per-lake time series to show trends in eutrophication, water clarity, and bloom-prone conditions; assess variability in algal conditions (e.g., chlorophyll-a, Secchi depth) within and between lakes; identify lakes or sampling sites with ongoing eutrophic or hypereutrophic states; and examine how these patterns change seasonally and over decades. Finally, we use a seasonal Kendall trend analysis to assess the direction and magnitude of change across all primary CLAMP variables reported.

Results

Despite their close proximity, we observed distinct algal dynamics among the study lakes, with Big Spirit and East Okoboji consistently classified as hypereutrophic. Furthermore, chlorophyll-a dynamics within lakes can vary significantly, reflecting strong spatial heterogeneity in algal blooms across waters. Finally, we quantify and demonstrate multi-decadal decreases in eutrophying nutrients, but a strong increase in water temperature across the study lakes.

Discussion and Conclusion

Inland lakes can serve as sentinels for the effects of anthropogenic climate change. Progressive eutrophication and warming waters trigger a cascade of ecological consequences, including more frequent and intense cyanobacterial, or harmful, algal blooms. This work validates the scientific and social utility of long-term citizen-led scientific initiatives to understand, monitor, and act to preserve their waters against long-term hazards.

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