Chloride and Sulfate Dynamics in Milwaukee Waters During the COVID-19 Shutdown

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INTRODUCTION

The COVID-19 shutdown in Milwaukee offered a unique opportunity to study the chemistry of the local waters in the absence of much of the city's normal industrial, commercial, and social activities and their associated atmospheric deposition and urban runoff. This report compares data collected during the shutdown to data collected in previous years, focusing on two solutes in particular: chloride and sulfate.

METHODS

Chloride (Cl^-) was chosen because it is conservative, meaning the concentration is largely unaffected by surface water biogeochemical processes, making it a useful tracer of flow and dilution patterns.[1] It enters surface waters mostly from groundwater, wastewater discharge, or from road salt runoff during the winter and spring. Sulfate (SO_4^{2-}) concentrations in Milwaukee surface waters are generally held constant, making sulfate a good standard for comparison to other solutes. The exact cause of sulfate's constancy is unknown, and a possible subject for future research.

Water samples from the Kinnickinnic, Menomonee, and lower Milwaukee Rivers, as well as Lake Michigan, were collected on various expeditions onboard the *R/V Neeskay* between 2017 and 2020. Samples from the Mukwonago River were collected by Steven Levas of UW-Whitewater. All samples were analyzed for chloride and sulfate via anion column chromatography. Dates for comparison were chosen to be as close as possible to control (as much as possible) for seasonal fluctuations in water chemistry.

SAMPLING LOCATIONS

Figure 1: Milwaukee sampling stations

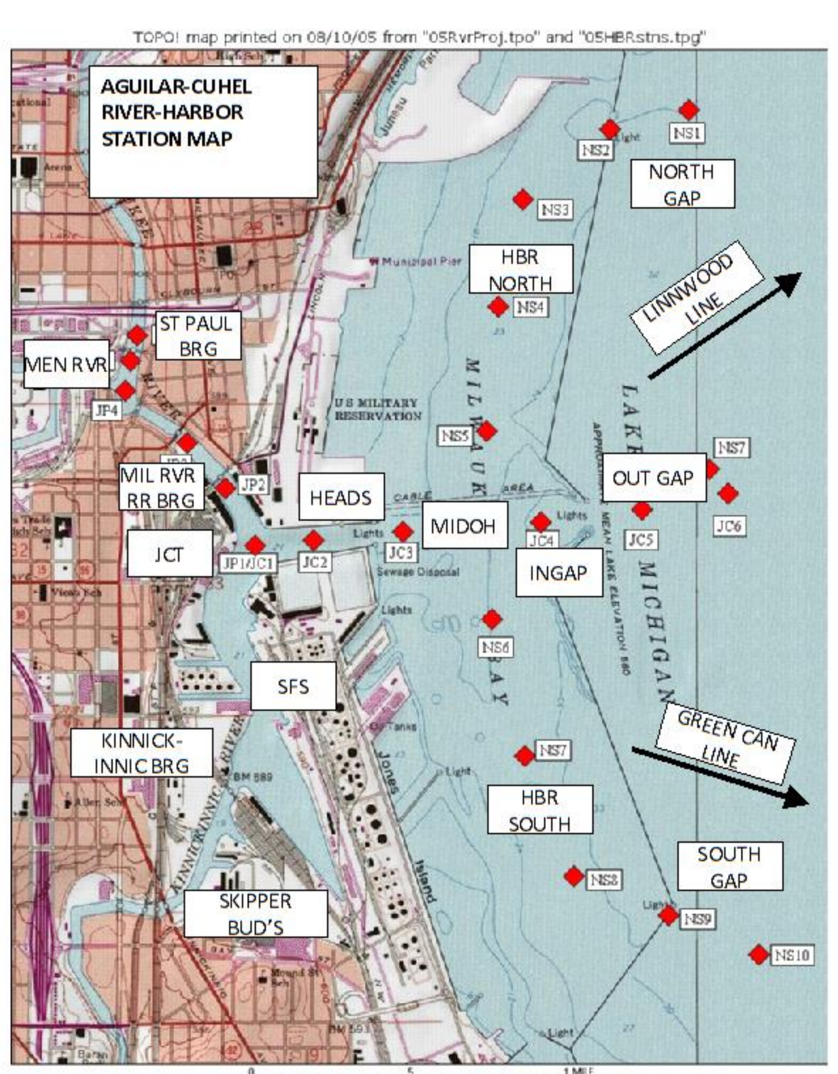


Figure 2: Location of Fox point sampling station (circled)

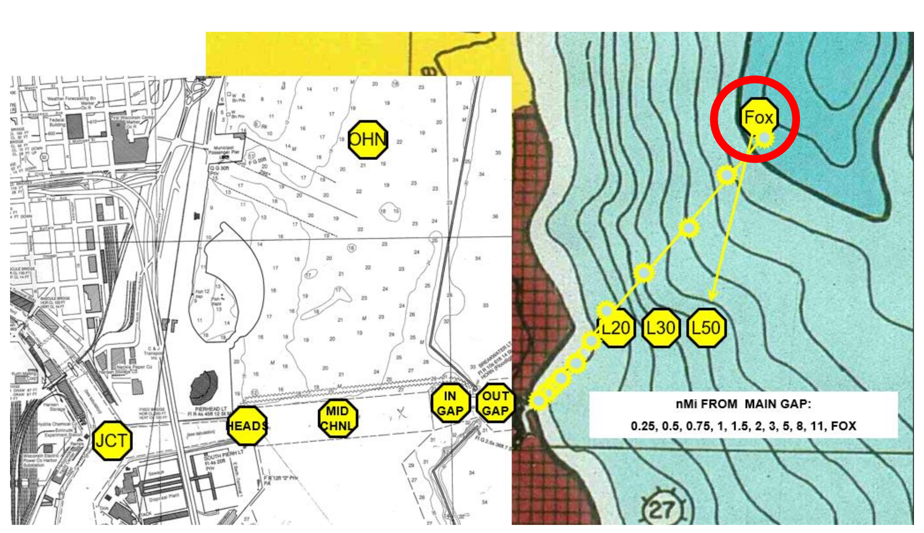
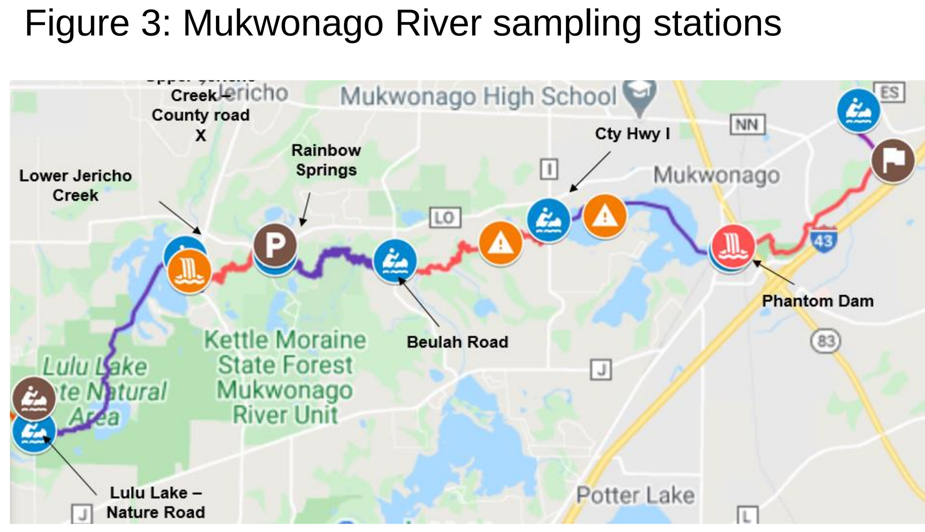


Figure 3: Mukwonago River sampling stations



RESULTS

Figure 4:

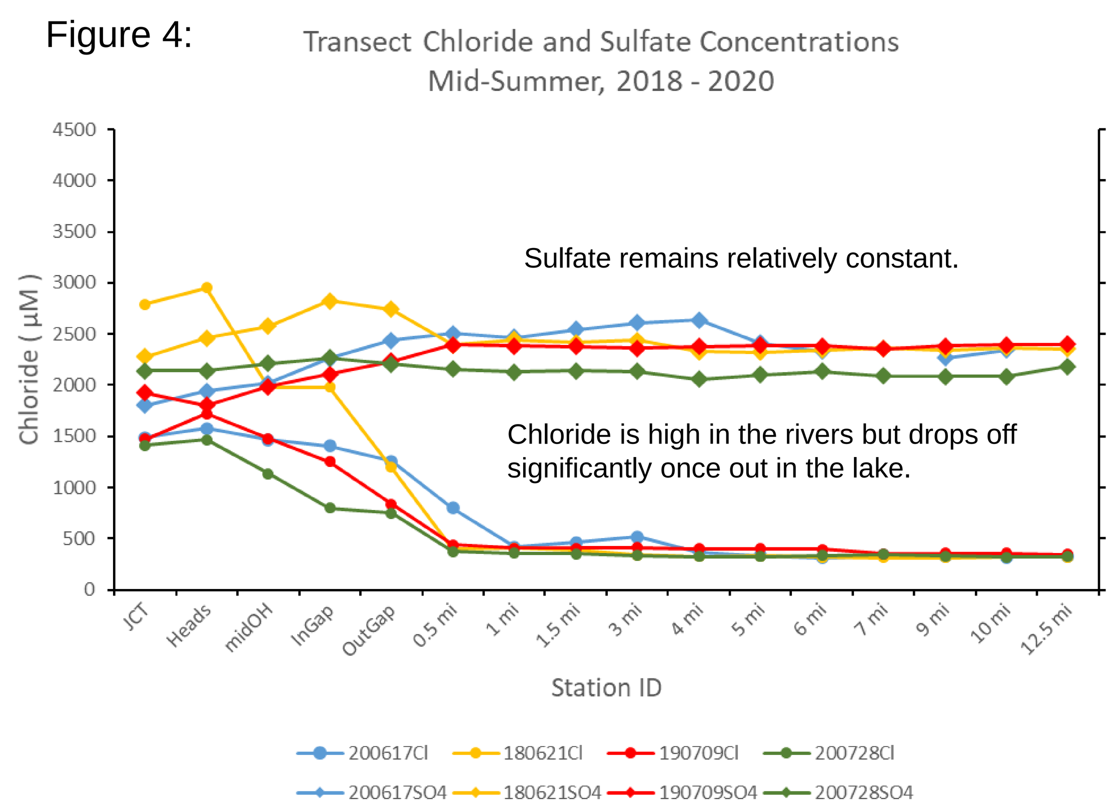


Figure 5:

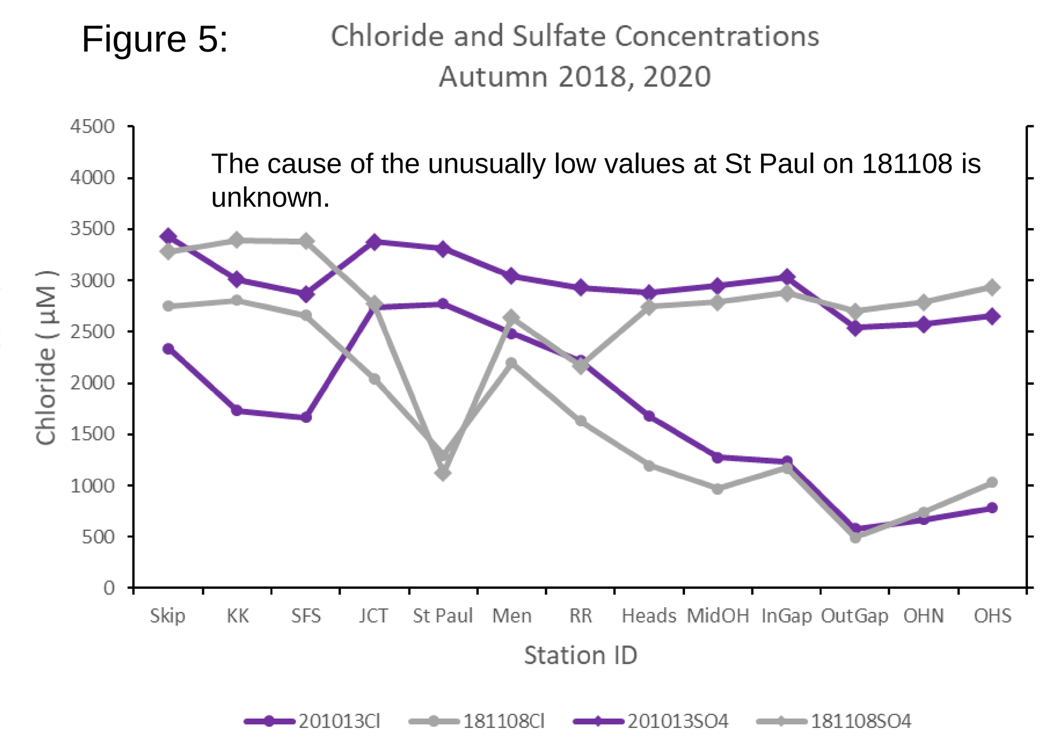


Figure 6:

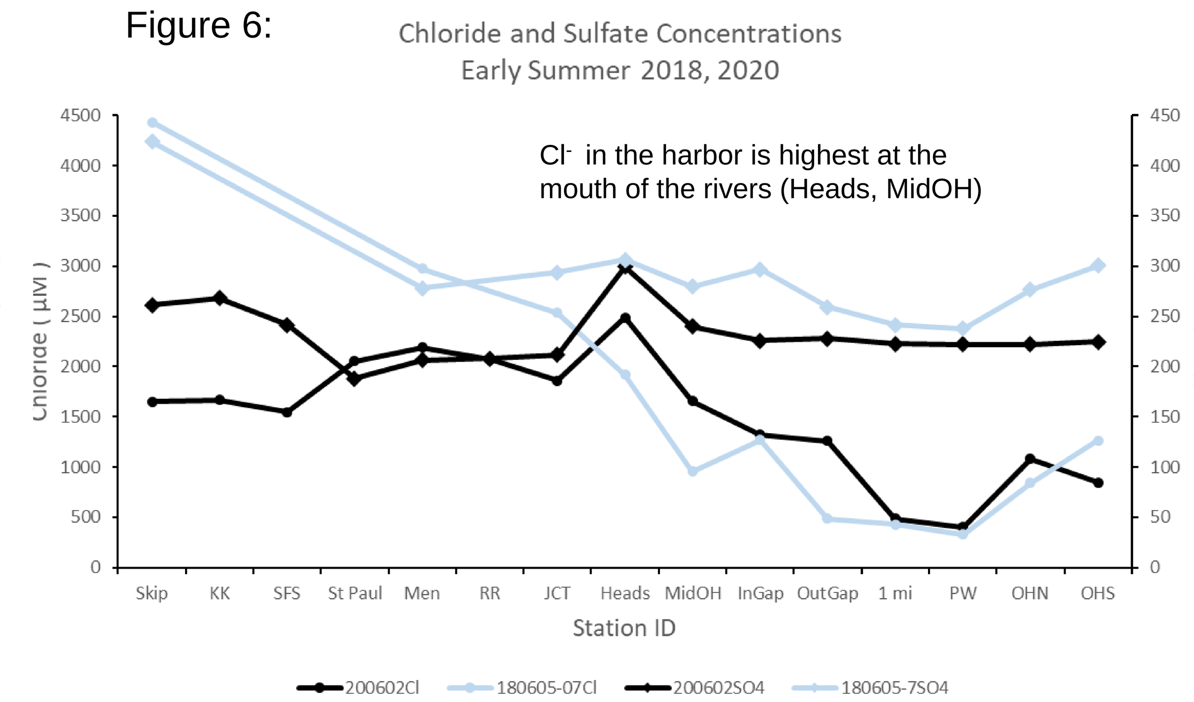


Figure 7:

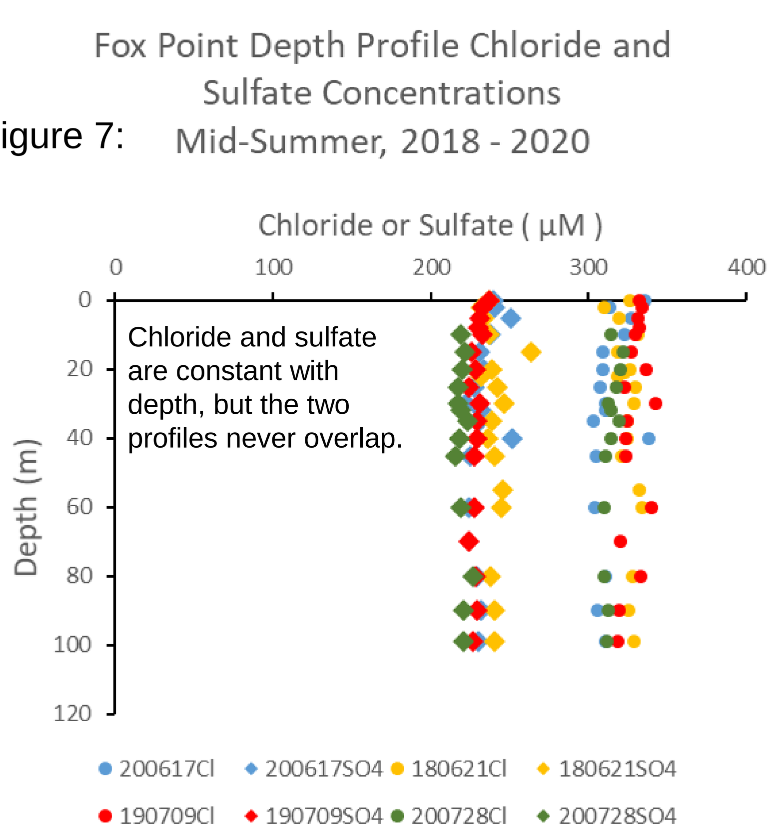


Figure 8:

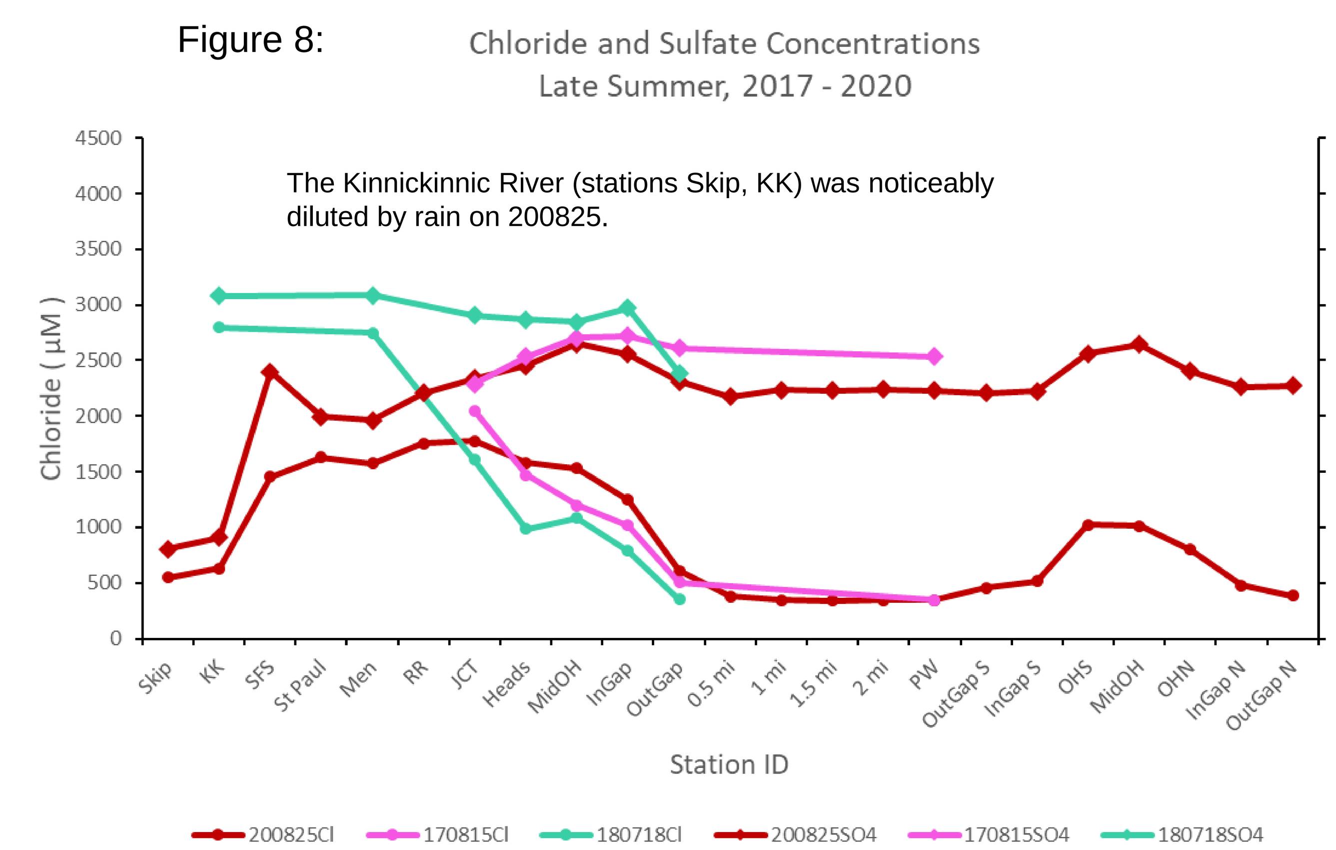
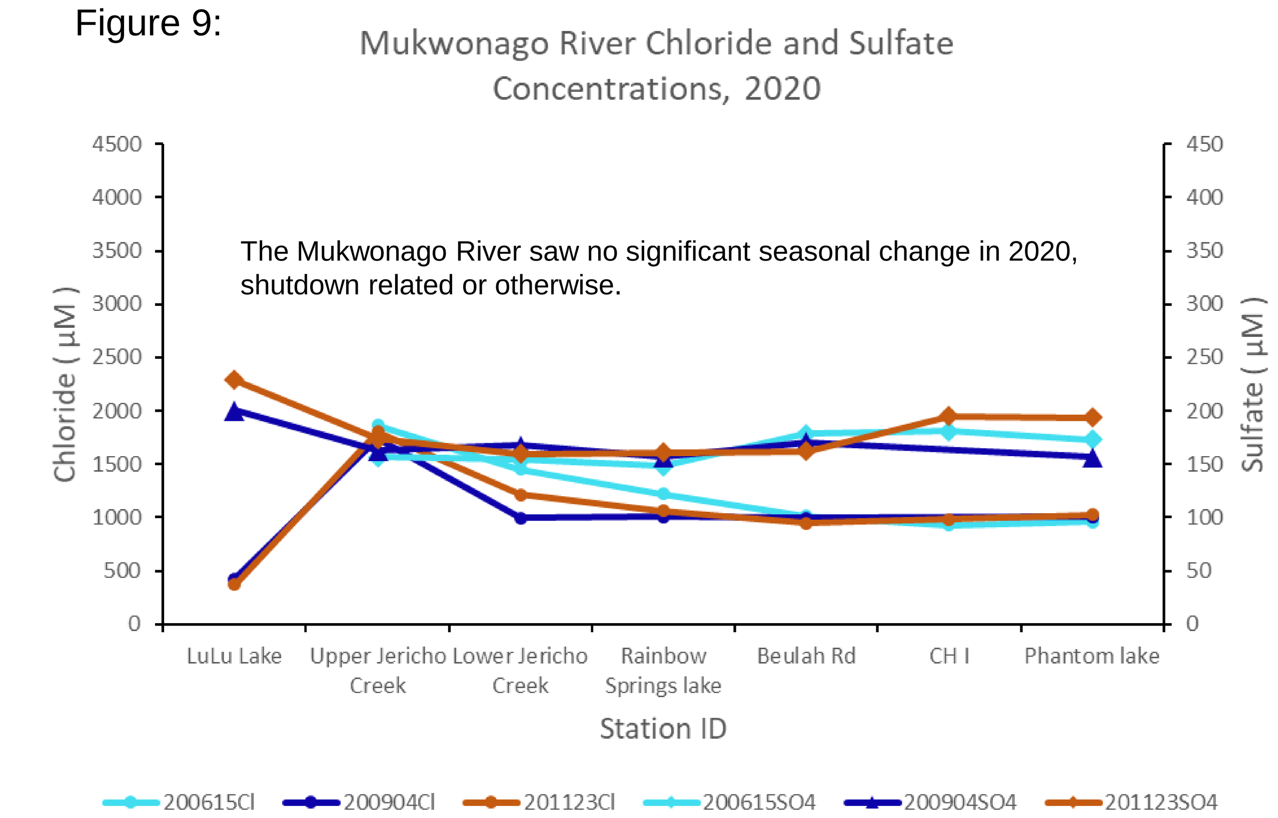


Figure 9:



DISCUSSION

As shown in Figures 4 - 9, there was no definitive, systematic difference in chloride or sulfate concentrations between pre- and mid-shutdown sampling dates. Though significantly lower chloride concentrations were found on 6/2/20 and 8/25/20 (Figures 6 and 8, respectively) the lack of adequate data from previous years for comparison makes it difficult to claim that this as evidence of shutdown-related effects. Despite this, several other, non-COVID-related dynamics are observed. Most evident is the characteristic dilution pattern of chloride when moving from the rivers through the outer harbor and into Lake Michigan, with chloride concentrations steadily decreasing through the harbor before sharply dropping off past the breakwall (Figures 4 - 6, 8). Chloride concentrations remain constant with decreasing depth at Fox Point (Figure 7). Predictably, sulfate concentrations remain essentially constant at approximately 200-250 µM across all dates and sampling locations. In the Mukwonago River, analyte concentrations were also relatively constant throughout the year (Figure 9).

Chloride concentrations in the outer harbor are observed to vary between the north (OHN) and south (OHS), with one always being higher than the other based on the prevailing wind direction at the time of sampling (Figures 5, 6, 8). Dilution by recent rainfall in the can be seen in the Kinnickinnic River samples (Figure 8).

CONCLUSION

Comparing among expedition data gathered between 2017 and 2020, no systematic difference in chloride or sulfate concentrations was found in the river or lake samples collected during the 2020 COVID-19 shutdown. While some variation is evidenced, there is no consistent pattern that could be confidently attributed to changes in human activity in Milwaukee as a consequence of the shutdown. All of the normal dynamics in chloride concentrations (dilution of river water into the harbor and out into the lake, dilution by rainfall in the Kinnickinnic River, dilution of river water moving downstream) are still apparent.

REFERENCES

1. Nava, V, et al. "Chloride Balance in Freshwater System of a Highly Anthropized Subalpine Area: Load and Source Quantification Through a Watershed Approach." *Water Resources Research* 56, no. 1 (2020)