IISG SEED Grant - Final Report

Trace organics in Lake Michigan: *Concentration and detection frequency of pharmaceuticals in the near-shore water column* (Seed Project)

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Project Dates: June 1, 2010 - May 30, 2011

Final Report Submitted June 20, 2011

I. PROJECT SUMMARY

a. Project Objectives and Activities

The overall objective of the project was to quantify pharmaceutical abundance in near-shore Lake Michigan habitats by addressing the question: *How do pharmaceutical concentrations vary spatially along the Indiana-Illinois shoreline of Lake Michigan?* Descriptive surveys were conducted at four sites along the southern tip of Lake Michigan in August and November 2010. Sites sampled included St. Joseph, Michigan City, East Chicago, and Chicago. For each sampling event (August, November), stratified sampling was conducted for measurements of dissolved pharmaceuticals in the open water (near drinking water intake points) and at the mouth of incoming rivers at two different depths (shallow, <0.5m below water surface; deep, ~0.5 m above benthos) for a total of 4 samples collected at each site in both August and November. Water physiochemical characteristics (e.g., pH, dissolved oxygen, nutrient concentrations, temperature) were also measured at each site for assessments of related variables.

b. Significant Findings

All sites and depths sampled had measurable concentrations of pharmaceuticals, suggesting ubiquitous dispersal of these compounds near-shore (Figure 1, Table 1). Pharmaceuticals detected included caffeine, paraxanthine, sulfamethoxazole, carbamazepine, acetaminophen, cotinine, gemfibrozil, ibuprofen, lincomycin, naproxen, sulfadimethoxine, sulfamerazine, sulfamethazine, sulfathiazole, triclocarban, trimethoprim, and tylosin. Triclosan and DEET were also detected at all sampling events though field blank assessments indicated contamination of these two compounds. Concentrations of all pharmaceutical compounds measured in Lake Michigan were lower than maximum concentrations measured in streams and rivers across the United States though concentrations were within the same range previously detected in lotic ecosystems. Inconsistent with our hypothesis, pharmaceutical concentrations were not always higher near river mouths relative to open water sites. This may be due to the hydraulic mixing and flow regimes that exist between the open lake waters and the river discharge. Higher concentrations of pharmaceuticals near harbors were detected only during the November sampling at three sites. Overall, pharmaceutical compounds in all harbor sites during the November sampling (except Chicago) were higher in pharmaceutical concentrations when compared to August sampling. Total pharmaceutical concentrations (calculated as the sum of all pharmaceuticals detected) at these Lake Michigan sites were significantly correlated with water column total dissolved solids, dissolved oxygen, nitrate and temperature (Figure 2) suggesting both inputs and abiotic conditions may influence the abundance and persistence of pharmaceuticals in near-shore habitats of Lake Michigan.

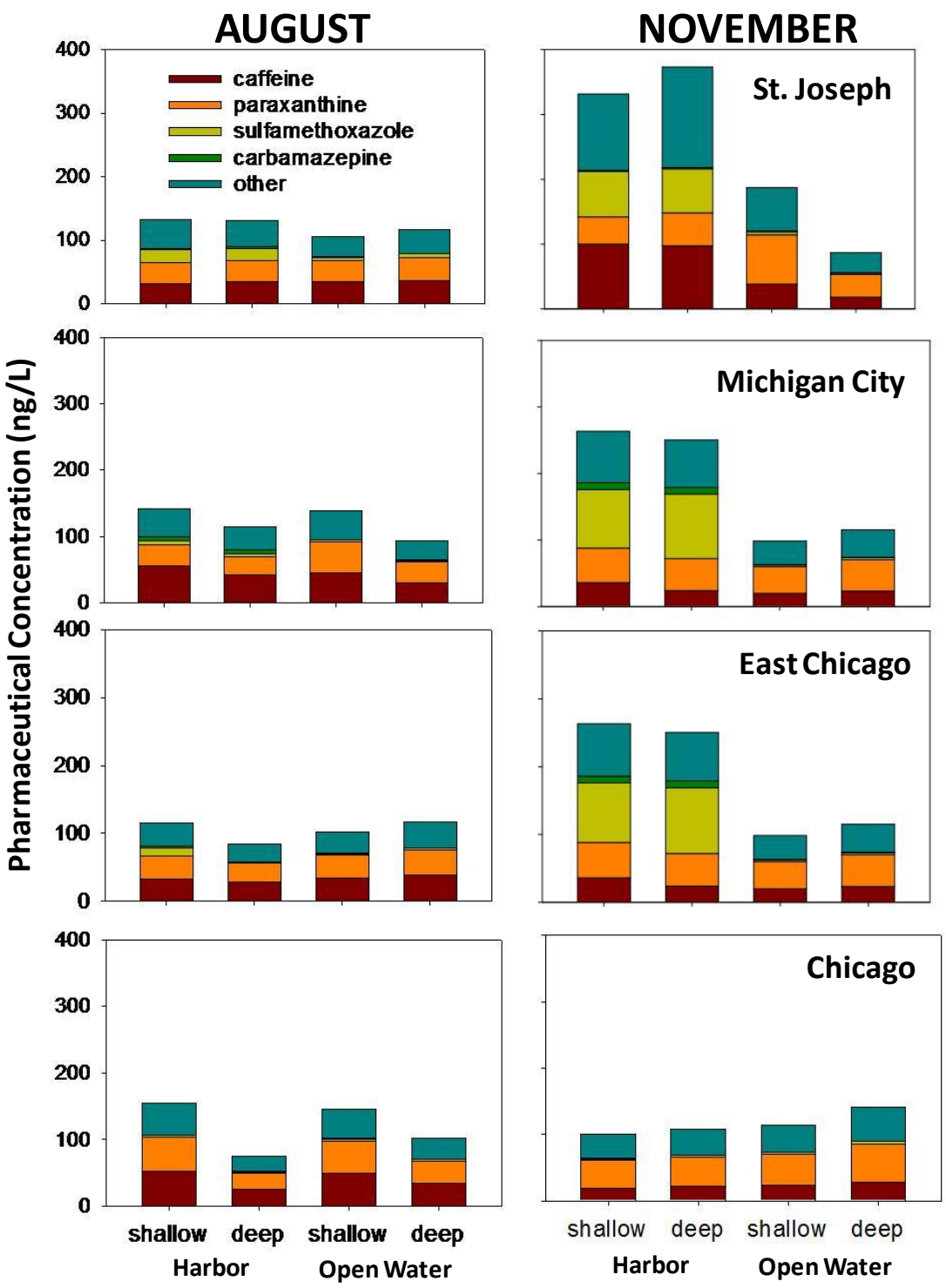

Figure 1. Pharmaceuticals concentrations of near-shore (harbor) and open water sampling sites at four locations in Lake Michigan during August (left panels) and November (right panels) 2011. Pharmaceuticals denoted as "other" listed in Table 1.

Table 1. Concentrations of pharmaceuticals detected denoted as "other" in Figure 1. Values are ranges of concentrations detected across sites separated by sampling period (August, November 2011).

Compound	Concentration Range (ng/L)	
	August	November
Acetaminophen	2.5 - 5.1	3.5 - 13.0
Cotinine	1.5 - 4.7	2.8 - 6.3
Gemfibrozil	1.0 - 10.0	1.4 - 49
Ibuprofen	1.7 - 6.9	3.5 - 30
Lincomycin	1.5 - 3.1	3.5 - 7.9
Naproxen	5.0 - 10.0	3.5 - 30
Sulfadimethoxine	0.5 - 1.0	0.7 - 1.6
Sulfamerazine	0.5 - 1.0	0.7 - 1.6
Sulfamethazine	0.5 - 1.0	0.7 - 1.6
Sulfathiazole	0.5 - 1.0	0.7 - 1.6
Triclocarban	2.5 - 10.0	3.5 - 7.9
Trimethoprim	1.5 - 3.1	3.5 – 10.0
Tylosin	1.5 - 6.7	2.8 - 6.3

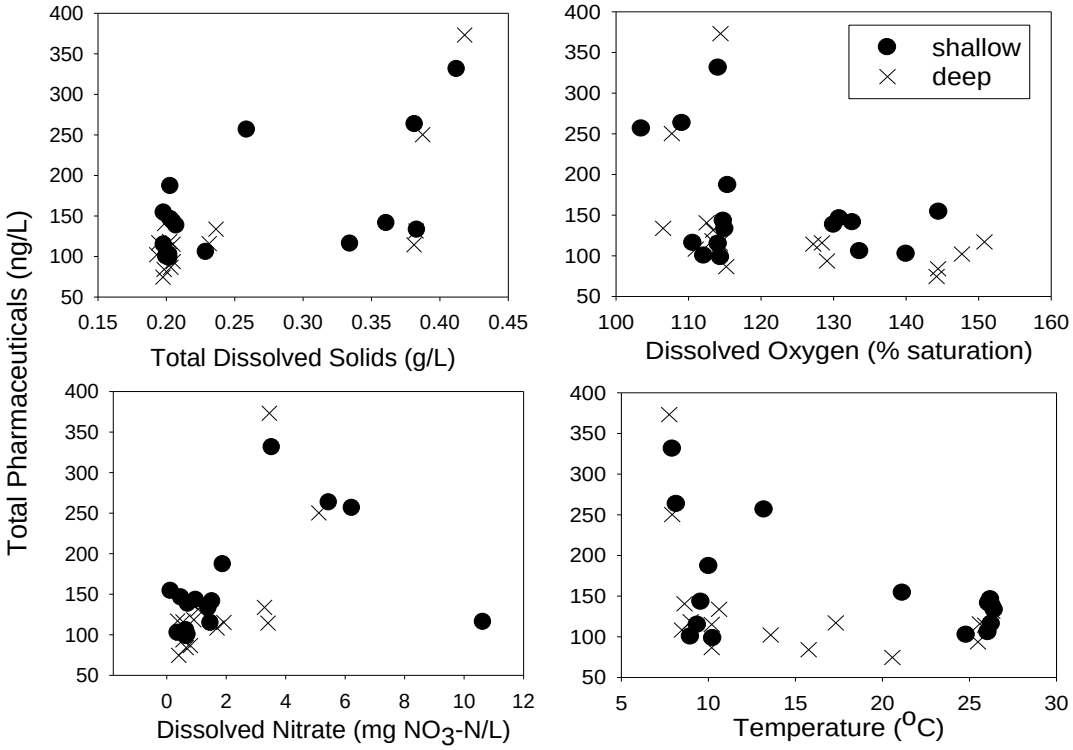

Figure 2. Relationship between total pharmaceutical concentration in near-shore habitats of Lake Michigan and water column total dissolved solids, dissolved oxygen , dissolved nitrate, temperature. Sample location at each site (shallow vs. deep water) denoted as different symbols.

c. Impacts

Pharmaceuticals in freshwaters have been documented throughout the United States but research has focused on streams and rivers with minimal assessments conducted in the Great Lakes. Because pharmaceuticals are designed to have a physiological effect, it is likely that they also influence aquatic organisms. Thus, abundance of pharmaceuticals may negatively impact fishes and other community organisms. Additionally, if pharmaceuticals are present in freshwater and not degraded or removed from the ecosystem, they may enter drinking water intakes resulting in unintentional consumption by humans. These data document the ubiquity of pharmaceuticals in near-shore habitats of southern Lake Michigan and more comprehensive analyses are need to assess regulatory need.

II. STUDENTS SUPPORTED

No students were directly supported by IISG funds as wages. However, multiple students participated in project activities gaining important skills and knowledge associated with pharmaceutical testing and Lake Michigan sampling. Students participating in project activities were:

- Patrick Ferguson, MS Student. Ball State University, Department of Biology. Degree to be completed Spring 2012.
- Kip Rounds, MS Student. Ball State University, Department of Biology
- Kelly Sudhoff, BS Student. Ball State University, Department of Biology
- Ann Raffel, BS Student. Ball State University, Department of Biology

III. PRESENTATIONS AND PUBLICATIONS

Research conducted has been presented at both local and national meetings by both the Project PI (M Bernot) and a graduate student assisting with the project (P Ferguson). One manuscript is currently being prepared for publication in a nationally recognized peer-reviewed journal to be submitted Spring 2012 that will document the spatial and temporal variation of pharmaceuticals and factors related to observed abundance (P Ferguson lead author). An additional manuscript is being developed to put Lake Michigan data into a broader context of pharmaceuticals in freshwater environments (M Bernot lead author) to be submitted late 2012. Details on these activities are as follows:

- Ferguson, P, T Lauer, MJ Bernot. 2011. Abundance of pharmaceuticals in near-shore habitats of Lake Michigan. Indiana Water Resources Association. Muncie, IN. June.
- Ferguson, P, T Lauer, MJ Bernot. 2011. Abundance of pharmaceuticals in near-shore habitats of Lake Michigan. North American Benthological Society. Providence, RI. May.
- Ferguson, P, T Lauer, MJ Bernot. 2011. Abundance of pharmaceuticals in near-shore habitats of Lake Michigan. Indiana Academy of Sciences. Indianapolis, IN. March.

- Ferguson, P, T Lauer, MJ Bernot. 2011. Abundance of pharmaceuticals in near-shore habitats of Lake Michigan. Ball State University Student Research Symposium. Muncie, IN. March.
- Ferguson, P, T Lauer, MJ Bernot. 2010. Abundance of pharmaceuticals in near-shore habitats of Lake Michigan. Midwest Fish & Wildlife Association. Madison, WI. December.
- Ferguson, P, T Lauer, MJ Bernot. 2010. Abundance of pharmaceuticals in near-shore habitats of Lake Michigan. Ohio River Valley Chapter of the Society of Environmental Toxicology and Chemistry. West Lafayette, IN. October.
- Bernot, MJ. 2010. Pharmaceuticals in freshwaters. Invited Seminar. Environmental Protection Agency, Cincinnati, OH. October.