ABSTRACT

Essig, Rebecca R. Ph.D., Purdue University, August 2016. Lake Michigan Tributary Characteristics, Nutrient Loading Trends, and River Plume Dynamics. Major Professor: Cary Troy.

In response to the increasing frequency of water quality impairment near tributary outlets, understanding the delivery of nutrients to the near-shore region of the Great Lakes is becoming increasingly important. This study aims to assess the transport of nutrients from tributaries to the near-shore region of lakes by assessing the dynamics of the tributaries and river plumes. Analysis focuses on answering the following questions: (1) How do hydrologic characteristics of Lake Michigan tributaries vary historically and in comparison to each other; (2) How does nutrient loading vary episodically in Lake Michigan tributaries; (3) How do Lake Michigan river plumes' spatial characteristics and classification vary temporally, and what are the ecological implications?

Hydrologic trends for 11 Lake Michigan tributaries were assessed using all available USGS streamflow data from 1920-2015. Rivers varied in quantity of available streamflow data. Particular parameters analyzed were day of year annual peak streamflow occurred, annual peak flow magnitude, annual median flow, annual R-B Index, annual Gini coefficients, and annual storm count using three streamflow thresholds. One river, Manitowoc River (WI), showed significant changes in peak flow timing with a positive shift indicating a peak flow occurring later within the year. Burns Ditch (IN) was the only tributary to show a statistically significant change in annual peak flow magnitude. The positive trend showed an overall increase in annual peak flow. Burns Ditch, Grand River

(MI), Kalamazoo River (MI), Milwaukee River (WI), and St. Joseph River (MI) all showed statistically significant increases in annual median flow and annual storm count while the Menominee River (WI) and Indiana Harbor Canal (IN) showed statistically significant decreases in annual median flow and annual storm count. Burns Ditch, Grand River, Kalamazoo River, Menominee River, Milwaukee River, and St. Joseph River showed significant decreases in annual R-B Index while Muskegon showed a significant positive trend in annual R-B Index.

Nutrient trends for 11 Lake Michigan tributaries were assessed using USGS water quality data from 2011-2015. Three methods were used to assess the chemostaticity of total nitrogen, total phosphorus, orthophosphate, and total suspended solids: (1) Q-C trend line slopes, (2) ratio of Gini coefficients, and (3) ratio of coefficients of variations. The methods varied greatly in results, although all nutrients were found to behave chemostatically (constant concentration with changing streamflow) or with accretion (increasing concentration with increasing streamflow).

River plumes were assessed at the Grand River, St. Joseph River, Milwaukee River, and Trail Creek from 2011-2013. For these years, the study rivers averaged 49% total flow during plumes that directly affected the nearshore region while 18% mixed into the offshore water and 33% was delivered during negatively buoyant river plumes.

Sampling was conducted at St. Joseph River, Grand River, and Trail Creek in order to capture the horizontal and vertical plume structure. The mean plume size for the St. Joseph River was 1.8-3.8 km^2 with a standard deviation of 0.8-1.6 km^2. For the Grand River, the mean plume size was 0.7-2.6 km^2 with a standard deviation of 0.5-1.5 km^2. The Trail Creek plumes never exited the river mouth on sampling days and the river water was mixed completely with lake water upstream from the outlet. On all sampling days with vertical sampling, the St. Joseph River plume lifted off the river bottom before exiting the river mouth except for the May 1st, 2012 plume which was the largest streamflow plume captured.

Higher nutrient concentrations found within river water coupled with increasing median streamflow and storm event patterns indicate potential water quality concerns in the nearshore region of Lake Michigan. Because of the localized impact of Lake Michigan river plumes, contaminants being introduced into the lake will most likely directly impact the nearshore ecosystem and could cause shifts in productivity and shoreline health.