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Nutrient concentrations and loadings in the St. Clair River–Detroit River Great Lakes Interconnecting Channel

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ABSTRACT

Long-term (2001–2015) water quality monitoring data for the St. Clair River are presented with data from studies in the Detroit River in 2014 and 2015 to provide the most complete information available about nutrient concentrations and loadings in the Lake Huron–Lake Erie interconnecting corridor. Concentrations of total phosphorus (TP) in the St. Clair River have reflected declines in Lake Huron. We demonstrate that St. Clair River TP concentrations are higher than offshore Lake Huron values. The recent average (2014 and 2015) incoming TP load from the upstream Great Lakes is measured here to be 980 metric tonnes per annum (MTA), which is roughly three times greater than previous estimates. Significant TP load increases are also indicated along the St. Clair River. We treat the lower Detroit River as three channels to sample water quality as part of a two year monitoring campaign that included winter sampling and SRP in the parameter suite. We found concentrations of many parameters are higher near the shorelines, with the main Mid-River channel resembling water quality upstream measured at the mouth of the St. Clair River. Comparison with past estimates indicates both concentrations and loadings of TP have dramatically declined since 2007 in the Trenton Channel, while those in the Mid-River and in the Amherstburg Channel have remained similar or have possibly increased. The data demonstrate that the TP load exiting the mouth of the Detroit River into Lake Erie is currently in the range of 3740 (in 2014) to 2610 (2015) MTA.

Introduction

The St. Clair River and Detroit River, along with Lake St. Clair, connect Lake Huron with Lake Erie, and together form part of the international boundary between Canada and the United States. The St. Clair River flows 63 km in a southerly direction from Lake Huron to Lake St. Clair and is a straight channel over much of its length. The flow of the river is controlled by the difference in water level between Lake Huron and Lake St. Clair and by the conveyance of the river. It has a mean discharge of about 5150 m^3/s and a water retention time of about 21 h (IJC, 2009; UGLCCS, 1988). Lake St. Clair has a surface area of about 1100 km^2 and is relatively shallow, with a mean water depth of only about 3 m. The average water residence time for Lake St. Clair is seven days but travel time can be as little as 2 days for water flowing through the maintained navigation channel (Great Lakes Commission, 2000).

The Detroit River is approximately 51 km long and has a mean flow of approximately 5200 m^3/s (Derecki, 1984). Nearly the entire Detroit River total outflow is contributed from Lake Huron via Lake St Clair, with only 2% contributed by tributaries (UGLCCS, 1988). The flow in the Detroit River is influenced by islands and navigation channels, particularly in the lower Detroit River near its discharge to Lake Erie. Much of the Detroit River shoreline is highly urbanized and industrialized (UGLCCS, 1988). The average flushing time for the Detroit River is 19 h (Derecki, 1984).

Ongoing monitoring of water quality in the Huron-Erie corridor is needed by Great Lakes water quality managers to assess current status and trends, and to assess the need for, and ultimately the efficacy of, nutrient management activities. Loadings from priority Canadian and US tributaries to the corridor are being monitored as part of binational efforts to set baselines and track progress toward meeting nutrient loading reduction targets set for Lake Erie (Objectives and Targets Task Team, 2015). Recently, Maccoux et al. (2016) estimated loadings by compiling all available nutrient monitoring and discharge data and determined the corridor delivers approximately one-quarter of the Lake Erie total phosphorus (TP) load. With a phosphorus loading target reduction of 40% recently set for western basin tributaries (Objectives and Targets Task Team, 2015), knowledge about the corridor's role in transmitting those loadings to Lake Erie are critical to assess and evaluate current loadings and to track future progress.

As part of its Freshwater Quality Monitoring and Surveillance Program, Environment and Climate Change Canada (ECCC) conducts

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water quality monitoring at the head (Point Edward) and mouth (Port Lambton) of the St. Clair River. The original intent of the monitoring was to track organic pollutants in the industrialized Canadian region near Sarnia, Ontario; nutrient and major ions were also included. In the Detroit River, however, there has been no ongoing, systematic water quality monitoring. Work conducted by ECCC in 2007 and prior (Burniston et al., 2009) provides the foundational knowledge upon which the current two year Detroit River study is based. Here, we report on the status and trends of nutrient concentrations and loadings from 2001 to 2015 in the St. Clair River, and augment these data with the current status of nutrient concentrations and loadings in the Detroit River in 2014 and 2015, to provide a regional-scale understanding of nutrients in the Huron-Erie Corridor.

Methods

St. Clair River stations and sampling (2001–2015)

ECCC has monitored water quality at the head and the mouth of the St. Clair River since 1987 (Fig. 1). Due to changing methodologies in the sample collection and processing, we have restricted the water quality record to the period 2001–2015.

The monitoring station at Point Edward (43.0048°N, −82.4155°W) is situated in Lake Huron upstream of its outlet, north of Sarnia. ECCC monitoring equipment is located within the (municipal) Lambton Area Water Supply System facility. A 19 mm diameter polyethylene water intake extends 50 m into the nearshore of Lake Huron, immediately upstream of the head of the St. Clair River. Information from this site is used to assess temporal trends of concentrations and nutrient loadings entering the Huron-Erie corridor.

The Port Lambton station (42.6589°N, −82.5068°W) is located 38 km downstream of Point Edward and approximately 2 km upstream of the large delta at the mouth of the St. Clair River. Monitoring equipment is housed in an abandoned water pumping station along the Canadian shore and is configured in a manner similar to the Point Edward station, with the intake located approximately 100 m from shore, at a depth of 7 m from the surface. Flow is predominantly in a stream wise direction; the horizontal component of the velocities is negligible (Derecki, 1985). As well it has been demonstrated that contaminants discharged to the river by the chemical industry located in Sarnia remain confined within 300 m of the Canadian shore, even as far downstream as Port Lambton (Chan et al., 1986). Samples from Port Lambton are therefore indicative of water quality in the Canadian portion of the river only.

Nutrient and major ion samples are collected from the intake tubes which draw water via submersible March magnetic drive pumps. Prelabelled bottles are rinsed twice, filled to the maximum level, recapped, and the bottle exterior is rinsed with raw water. Samples are immediately transported back to the Canada Centre for Inland Waters (CCIW) in Burlington, ON on ice for processing and analysis. Samples were collected every two weeks until the end of March 2012, at which point the sampling frequency was reduced to once every four weeks until present.

Detroit River stations and sampling (2014 and 2015)

Sampling in the Detroit River was conducted in the lower portion of the river, sufficiently far upstream of its discharge to Lake Erie to avoid any backwater influences. Based on the known non-mixing nature of the Detroit River in this area (Burniston et al., 2009), the river is treated as three channels. From west to east, these are: the Trenton Channel, the Mid-River (consisting in turn of the West and East portions) and the Amherstburg Channel (Fig. 2).

High frequency year-round autosampling in each of the three major channels was combined with cross-sectional surface grab samples during the ice free season to account for both the spatial and temporal variations in nutrient concentrations in the Detroit River. Burniston et al., 2009 reported diel variations in total phosphorus concentrations in the Trenton Channel that suggested within-day variability might be important, therefore, we collected daily-integrated samples as part of the present study. The study was designed to focus on capturing the spatial variability of water quality across the Detroit River (i.e., the horizontal variability) and we did not quantify the vertical variability. This approach is supported by two separate lines of evidence. Burniston et al., 2009 reported that water quality variations are primarily horizontal (lateral) and found minimal vertical variation of water quality

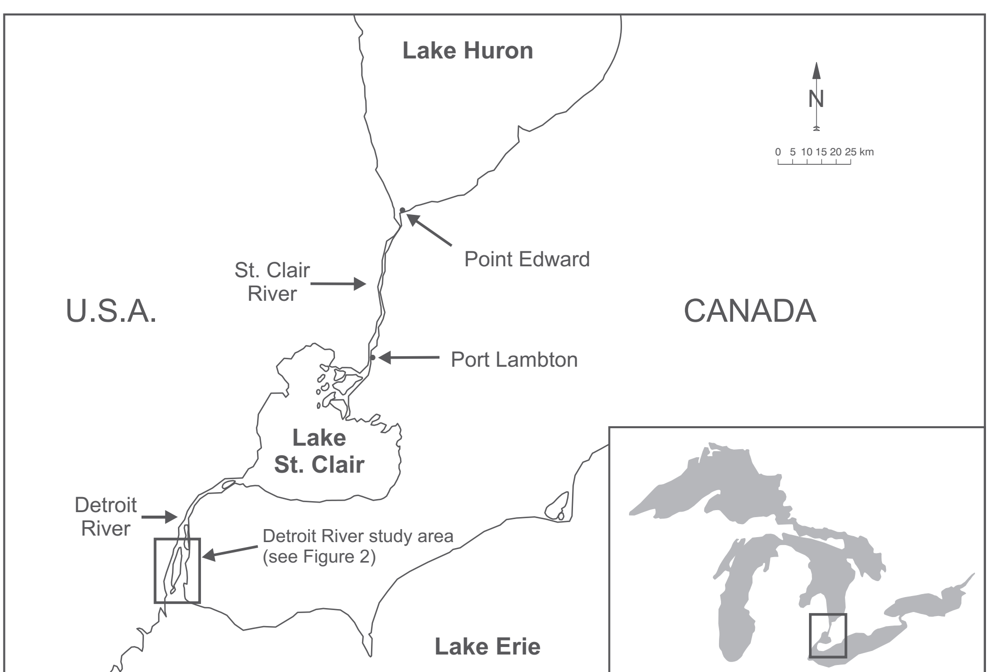

Fig. 1. St. Clair–Detroit River sampling locations. Inset shows Great Lakes context. Detroit River details are shown in Fig. 2.

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