Final report to the St. Lawrence River Research and Education Fund

Comparison of plankton dynamics in nearshore and main channel areas of the St. Lawrence River in support of a two-dimensional ecosystem model of plankton community development

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Objectives:

A. Measure and compare the growth rates of phytoplankton and grazing rates of microzooplankton using dilution assays in regions of the river defined as main channel versus nearshore (slackwater) regions. Conduct at least fifty (50) dilution assays throughout the ISSLR with a focus on the Lake St. Lawrence reach that has a range of main channel and slackwater environments.

B. Incorporate rate of plankton change into a neighboring network model based on defining the river into main channel and nearshore (slack water) reaches.

Personnel involved:

Students: Four undergraduate students participated in this project: Sarah Loftus (Cornell University), Nicole Kinlock (Rochester Institute of Technology) , Nick Marshall (Clarkson University), and Eric Slaugh (Clarkson University). Funds were leveraged from the Great Lakes Research Consortium to allow for the hiring of two students (Kinlock and Loftus) rather than one in 2011.

Faculty: Professors Michael Twiss (Biology) and Joseph Skufca (Mathematics) mentored the students and are currently working to submit publications for peer-review with select students as co-authors.

Summary:

In support of Objective A, we conducted over fifty dilution assays over a 48 day period (24 May to 11 July) from water sampled across a range of river habitats. Stations for sampling were selected on the basis of proximity to shore (nearshore) or main channel (offshore) areas (Fig. 1). Some stations in both nearshore and main channel regions were sampled repeatedly. Over this time period water temperatures varied from 11.6 to 22 °C, total chlorophyll-a (Chl-a) ranged from 0.9 to 11.3 µg/L, TP ranged from 4.9 to 81.2 µg/L and colored dissolved organic matter (CDOM) ranged from 2.4 to 34 mg/L.

For each dilution assay, size fractionated (0.2-2 µm, 2-20 µm, and 20-153 µm) rates of phytoplankton growth and grazing were derived. Water quality was also measured as well as phytoplankton composition using a FluoroProbe. On the basis of CDOM concentrations, water masses were determined to be either high CDOM (>4.69 mg/L) or low CDOM (<4.69 mg/L) since some nearshore water had low CDOM and was effectively un impacted by tributary inputs (characterized by high CDOM content) and thus were more representative of main channel water despite proximity to shore. Based on this threshold, the data set contains 32 low CDOM stations and 20 high CDOM stations. Results show that there was no significant ($P < 0.05$) difference between total (0.2-153 µm) phytoplankton growth rates between high CDOM and low CDOM areas although there was greater phytoplankton growth rates at higher temperatures (Fig. 2) and Chl-a concentrations positively correlated with total phosphorus (TP), and TP correlated positively with CDOM (Fig. 3).

In support of Objective B, surface water quality mapping exercises were conducted in fluvial Lake St. Lawrence so that delineation of water masses into patches that share similar properties. Establishment of patches will enable the ecosystem model of plankton community development that will be based on a neighboring network patch model and ordinary partial differential equations to describe plankton dynamics and mass transport among patches. The area from Waddington to Coles Creek was mapped – an example of data output from one mapping exercise targeting the tributaries of Brandy Brook (NY) and Hoasic Creek (ON) is depicted in Figure 4.

At present, the results from the grazing and growth assays are being written into a publication for submission to a peer-reviewed journal, ex. *Canadian Journal of Fisheries and Aquatic Science.* The neighboring network model is a more complicated analysis.

Additional work stimulated by this project was conducted in 2012 to refine our understanding of nearshore and main channel water quality. This work will be presented in combination with work funded by SLRREF in 2011 at the upcoming conference of the Association for the Sciences of Limnology and Oceanography.

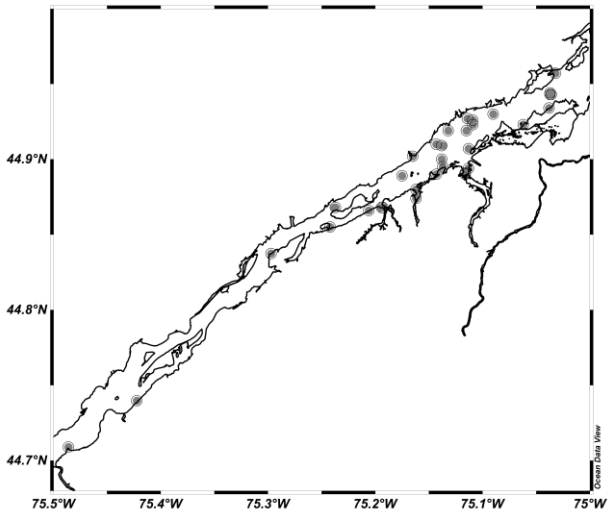

Figure 1. Location of sampling stations in the International Section of the St. Lawrence River focusing on the fluvial Lake St. Lawrence region. Fifty two assays to measure phytoplankton growth and grazing were conducted using water collected from these stations – some stations were sampled repeatedly over a 48 day period in 2011.

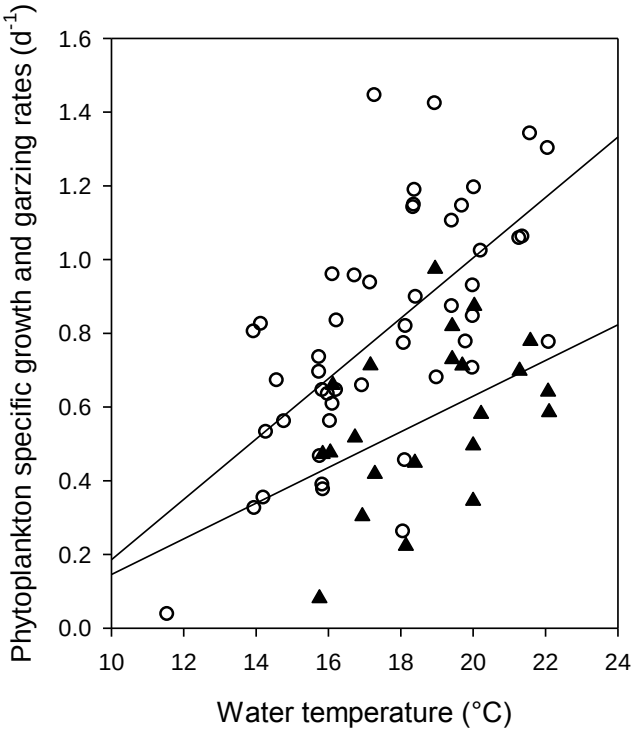

Figure 2. Specific growth and grazing rates measured in the St. Lawrence River from 24 May to 11 July 2011. Circles = growth rates; triangles = grazing rates. Growth rates were significantly correlated (P <0.01) to temperature whereas grazing rates were not (P >0.10).

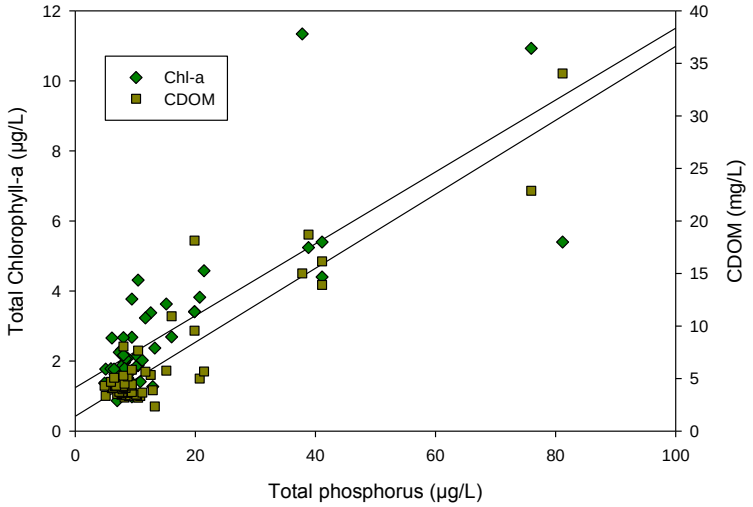

Figure 3. Chlorophyll-a and CDOM relationships in water sampled from the St. Lawrence River in nearshore and main channel areas (May 24 to July 11, 2011)

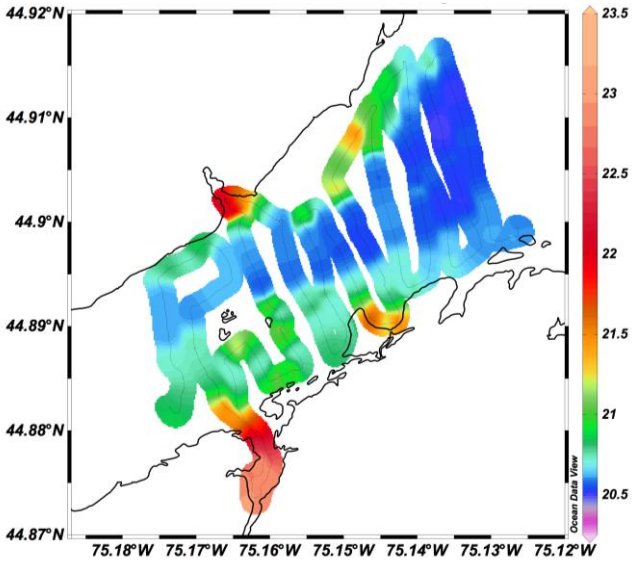

Figure 4. Surface water temperature in a section of fluvial Lake St. Lawrence (7 July 2011). Note high temperatures near tributaries and in shallow nearshore areas and cooler temperatures in main channel zones.

Significance of this work:

A consistent feature in the 180 km reach of the International Section of the St. Lawrence is the 2-4-fold decrease in phytoplankton biomass and a 10-fold decrease in zooplankton biomass in the river by the time water reaches the Brockville Narrows, with a slight recovery in phytoplankton with transit through fluvial Lake St. Lawrence. Water residence time in the main channel of the ISSLR is 5 d but the hydraulic residence time of the entire ISSLR is 12 d, proving that there are slackwater zones that could impact water quality. Through a combination of discrete water quality measurements along the entire reach and investigative mapping surveys to assess nearshore regions, which include tributary inputs, we show that water quality is significantly different between nearshore (< 2 m) and main channel zones. By comparing phytoplankton dynamics (growth rates and microzooplankton grazing rates) we demonstrate that phytoplankton growth and loss rates are the same in

nearshore and main channel zones. Water temperature and the presence of nutrients are good predictors of growth rates, grazing rates, and biomass. These results have important implications for assessing changes in dynamics due to water level regulation as well as illustrating areas in which to place instrumentation for remote water quality monitoring.

Results show that near-shore water quality varies significantly more than that of the off-shore, thus showing that the river is not a completely mixed system, despite high flow. These data are important in determining justifiable locations for the placement of continuous monitoring systems to measure nearshore and main channel water quality.

Products from Funding:

Publications to date

Twiss, M.R., Sprague, H.M., Loftus, S.E., Marshall, N.F., and Skufca, J.D. 2013. ***Water quality assessment of the St. Lawrence River using high resolution sensor arrays.*** Association for the Sciences of Limnology and Oceanography, New Orleans, LA (submitted for Feb. 2013).

Twiss, M.R., Kinlock, N., Loftus, S., Smith, D.E., Marshall, N.F., and Skufca, J.D. 2012. Saint ***Lawrence River Water Quality and Phytoplankton Across Environmental Gradients***. 55th Annual Conference of the International Association for Great Lakes Research, International Association for Great Lakes Research, Cornwall, Ontario, May 2012.

Loftus, S., Kinlock, N., Marshal, N., Skufca, J.D., and Twiss, M.R. 2011b. ***Delineating zones of the St. Lawrence River in support of a two dimensional ecosystem model.*** Council on Undergraduate Research, Arlington, VA, October 2011.

Kinlock, N., Loftus, S., Marshall, N., Skufca, J., and Twiss M.R. 2011. ***Comparison of Plankton Dynamics in Nearshore & Main Channel Areas of the St. Lawrence River.*** 14th Annual Symposium on Undergraduate Research, Clarkson University, Potsdam, NY, August 2011.

Loftus, S., Kinlock, N., Marshal, N., Skufca, J.D., and Twiss, M.R. 2011a. ***Delineating zones of the St. Lawrence River in support of a two dimensional ecosystem model.*** 14th Annual Symposium on Undergraduate Research, Clarkson University, Potsdam, NY, August 2011.

Marshall, N. and Skufca, J.D. 2011. ***Data mining applications in St. Lawrence River ecology.*** 2011. 14th Annual Symposium on Undergraduate Research, Clarkson University, Potsdam, NY, August 2011.

Note: At the 14th Annual Symposium on Undergraduate Research Experiences (SURE) at Clarkson University on July 28, 2011 Sarah Loftus won first place for best platform presentation in Biology (*Delineating Zones of the St. Lawrence River in Support of a Two-Dimensional Ecosystem Model*) and Nick Marshall was given honorable mention in the area of Mathematics for his presentation (*Data Mining Applications in St. Lawrence River Ecology*).

Additional Funding Sought

The results of this project were used to support proposals for major funding from the National Science Foundation and the United States Environmental protection Agency.

Funding requested in 2012:

- NSF-Ecosystems. *Channel Geomorphometry Controls on River Plankton Dynamics*.

- EPA Great Lakes Restoration Initiative. *Water Quality Monitoring of Niagara and St. Lawrence Rivers.*

Although no funding was received from NSF or the EPA in 2012, support from SLRREF in the past has resulted in peer-reviewed publications and student training that augurs well for demonstrating productive use of funds received and contribution to our understanding of this ecosystem, which may eventually provide additional funding to this area.

Yours truly,

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October 15, 2012