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Water Quality Monitoring of the Upper St Lawrence River Using Remote Sensor Arrays Placed in a Hydropower Dam Combined With Hydrodynamic Modeling

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Abstract

We seek to develop a method for acquiring meaningful nearshore river water quality data in a cost effective manner that provides high spatial and temporal system coverage.

Water quality along the shorelines and the main channel of the Upper St. Lawrence River (Q ≈ 7,000 m^3/s) was measured using continuous sensing technology as well as a long-term remote sensing array installed on the Moses-Saunders hydropower dam to examine differences between near-shore and mid-channel water quality variability. The two-meter isopleth marked the path for the near-shore (north and south) transects, while the mid-channel transect followed the path of the greatest water velocity as determined by hydrodynamic model output. During transects, water was collected in an upstream direction (5 kts) through an in-hull pump into a ferry box containing the instruments. Temperature and specific conductivity were measured using electronic sensors and CDOM was measured using fluorimetry. Chlorophyll-a concentration and phytoplankton community composition were determined using a multi-spectral fluorimeter (FluoroProbe). Time-stamped geo-referenced data were processed using MATLAB. At the stationary site located in the dam, water was drawn from the penstock at 6-10 liters per minute and analyzed for temperature, turbidity, CDOM, phycocyanin, and chlorophyll-a using a C6-multisensor, in addition to specific conductivity through the use of a YSI 600XL water quality sonde.

Results show that near-shore water quality varies significantly more than that of the mid-channel, thus revealing that the river is not a completely mixed system, despite high flow. The sensor array located in the turbine unit nearest the US shore is able to discern tributary inputs for CDOM originating from the Oswegatchie River (discharge 15-120 m^3/s), located 67 km upstream. This research is an important proof-of-concept for installing similar arrays in dams throughout the Great Lakes region and is applicable to smaller rivers containing power dams.

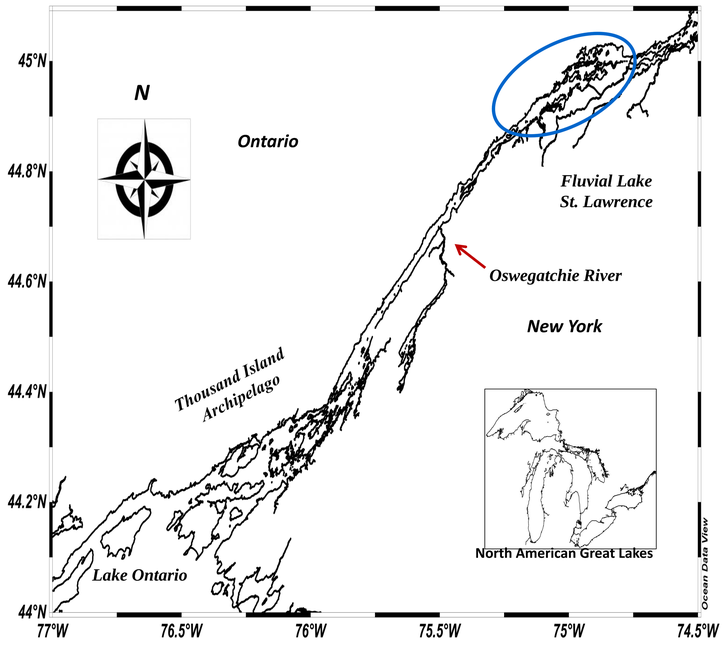
Background

Upper St. Lawrence River

- Great Lakes natural outflow to Atlantic Ocean
- 13th largest river in the world
- Largest fluvial source to North Atlantic
- Impounded since 1958
- Water level tightly regulated

Adaptive management

- New water level management planned to increase ecosystem services
- Nearshore environment most likely to be affected by changing water levels
- Need predictive water quality modeling capacity



Methods

Water quality sensing techniques

A. Cross channel transects to cover shore to shore (approx. 500 hectares); July 2011.

B. Nearshore and main channel transects the full length of fluvial Lake St. Lawrence (45 km); July 2012.

C. Stationary nearshore sensing at Moses-Saunders dam; June-Nov. 2014.

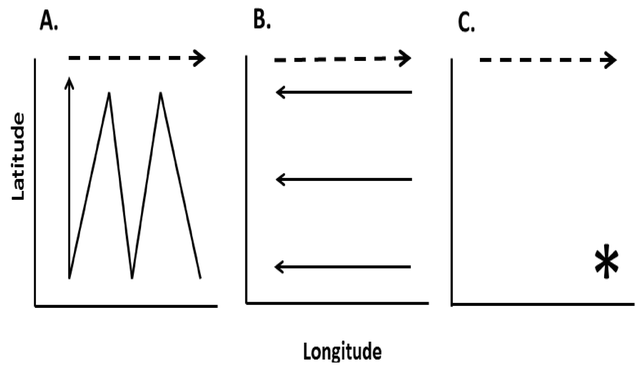
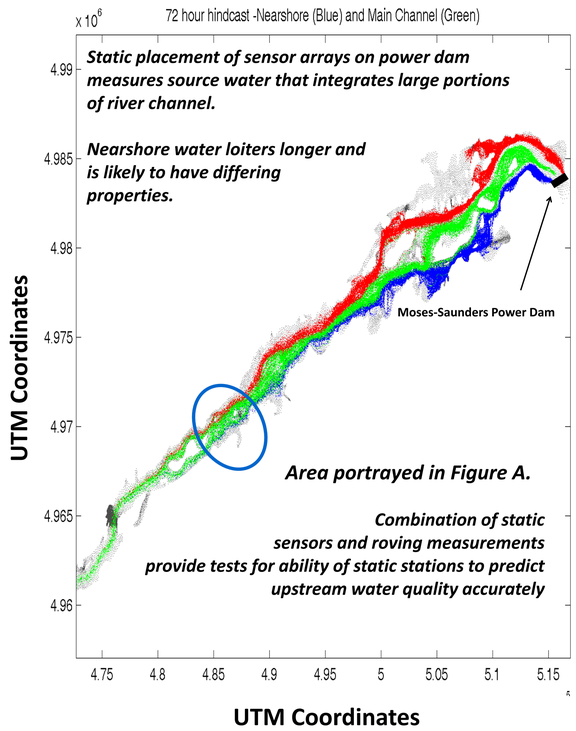


Figure 1. Three techniques for observing water quality parameters in a large river. Dashed line indicates water flow direction (*left to right*) **A. Transverse channel transects**; **B. Lateral channel transects**; **C. Fixed location (*) observations**. Techniques A & B follow geographic constraints (shore line and bathymetry) and are conducted from a vessel, observations in **Technique C** take place at a geographically static point in the river.

Hydrodynamic modeling

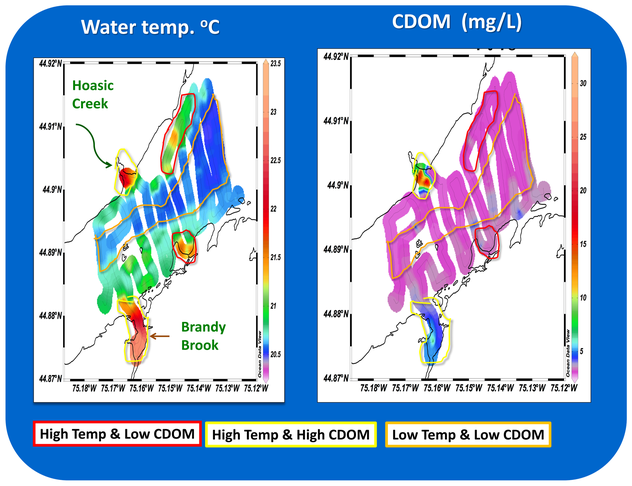
i. Finite Volume Coastal Ocean Model modeling output (courtesy of E.J. Anderson NOAA-GLERL).

ii. Predicted water parcel history by using a Lagrangian approach to time varying depth-averaged representation of the velocity field.



Select Examples of Results from Techniques A, B & C

A. Temperature and CDOM were most useful for delineating different zones.



Aerial view (looking north) of high CDOM in Brandy Brook entering the nearshore.

Figure A. Results from Technique A.

B. Transects show greater variance in nearshore water quality properties than main channel.

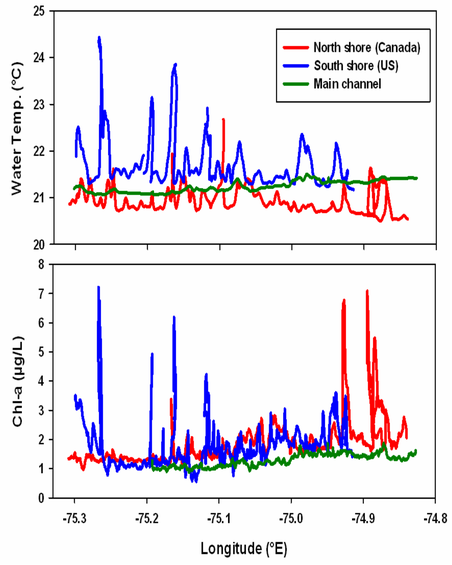


Figure B. Results from Technique B.

C. CDOM measured at the Moses-Saunders sites correlates to the discharge of the Oswegatchie River tributary providing model validation.

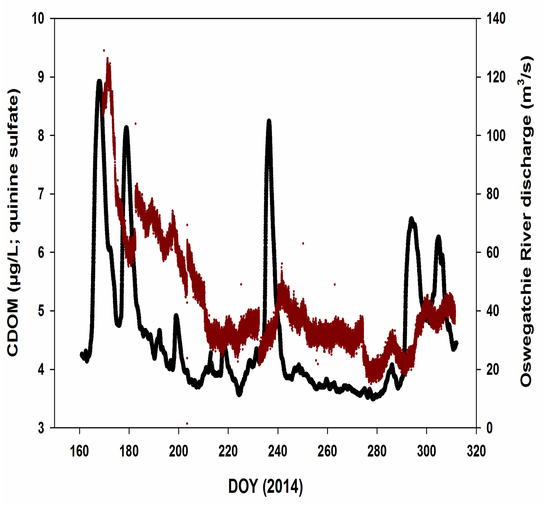


Figure C. Results from Technique C.

Conclusion & Future Sampling Strategies

The Moses-Saunders hydroelectric dam is a viable continuous sampling location. Ideally three sensor arrays would be placed on the dam so that all three of the channels could be sampled continuously (One sensor array each for US shore, mid channel, and Canadian Shore).

Acknowledgements

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