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Assessing condition of macroinvertebrate communities and sediment toxicity in the St. Lawrence River at Massena Area-of-Concern

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ABSTRACT

In 1972, the USA and Canada agreed to restore the chemical, physical, and biological integrity of the Great Lakes ecosystem under the first Great Lakes Water Quality Agreement. In subsequent amendments, part of the St. Lawrence River at Massena, New York and segments of three tributaries, were designated as an Area of Concern (AOC) due to the effects of polychlorinated biphenyls (PCBs), lead and copper contamination, and habitat degradation and resulting impairment to several beneficial uses. Because sediments have been largely remediated, the present study was initiated to evaluate the current status of the benthic macroinvertebrate (benthos) beneficial use impairment (BUI). Benthic macroinvertebrate communities and sediment toxicity tests using *Chironomus dilutus* were used to test the hypotheses that community condition and sediment toxicity at AOC sites were not significantly different from those of adjacent reference sites. Grain size was found to be the main driver of community composition and macroinvertebrate assemblages, and bioassessment metrics did not differ significantly between AOC and reference sites of the same sediment class. Median growth of *C. dilutus* and its survival in three of the four river systems did not differ significantly in sediments from AOC and reference sites. Comparable macroinvertebrate assemblages and general lack of toxicity across most AOC and reference sites suggest that the quality of sediments should not significantly impair benthic macroinvertebrate communities in most sites in the St. Lawrence River AOC.

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Introduction

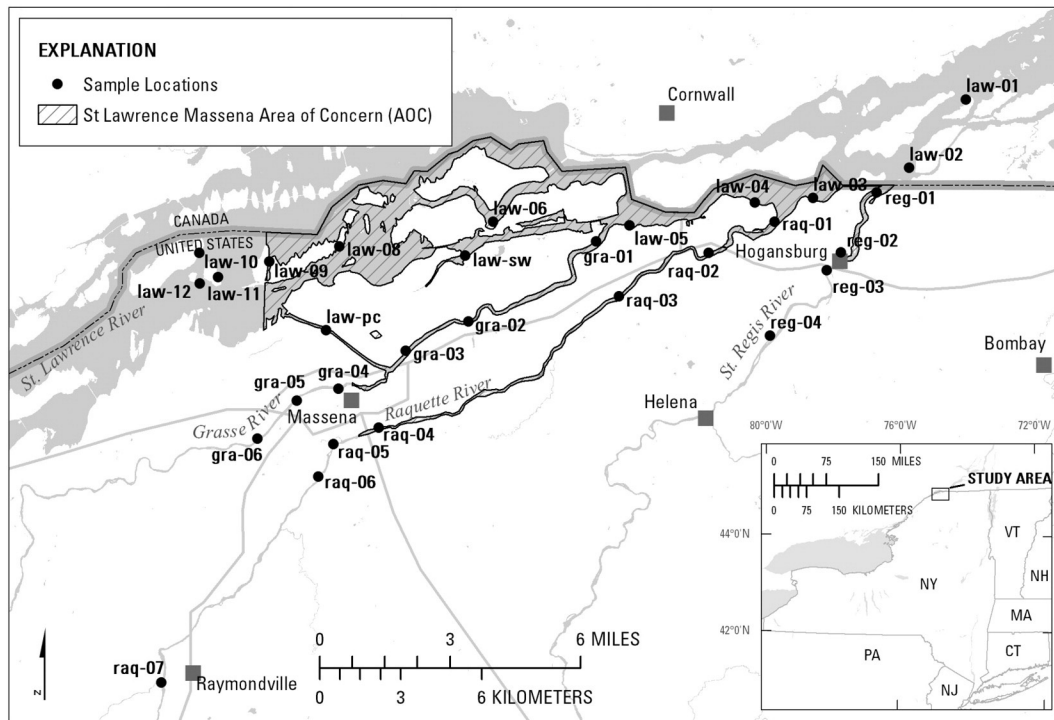
During the 1970s and 1980s, Canada and the USA committed to restore the physical, chemical, and biological integrity of Areas of Concern (AOC) throughout the Great Lakes region under the Great Lakes Water Quality Agreement (GLWQA) (<http://www.epa.gov/greatlakes/glwqa/1978/index.html>). An AOC is defined as “a geographic area that fails to meet the general or specific objectives of the Agreement where such failure has caused or is likely to cause impairment of beneficial uses or of the area’s ability to support aquatic life.” Part of the St. Lawrence River and lower reaches of the Grasse, St. Regis, and Raquette Rivers at Massena, New York (Fig. 1) was designated as one of 43 AOCs with impairment to eight beneficial uses caused mainly by past industrial pollution (NYSDEC, 1990). The benthic macroinvertebrate community (benthos) beneficial use was designated impaired because the data on its condition were unavailable or inconclusive. Limited data from the New York State Department of Environmental Conservation (NYSDEC) ambient surface water quality monitoring program indicate that the macroinvertebrate communities are not impaired in the St. Lawrence

River and its tributaries in the Massena AOC (Stream Biomonitoring Unit, NYSDEC, 2009, unpublished data). Thus, the benthos beneficial use impairment (BUI) may be outdated in the Massena AOC.

Each AOC has a Remedial Action Plan (RAP) to guide the remedial process toward the goal of attaining similar or better conditions than surrounding areas (USPC, 2001). The primary goal of the St. Lawrence River at Massena AOC (Massena AOC) RAP, developed by the NYSDEC, the Massena Citizen Advisory Committee (CAC), the Canadian government, the Cornwall Public Advisory Committee (PAC), and the Saint Regis Mohawk Tribe at Akwesasne (SRMT) is to “restore, protect, and maintain the chemical, physical, and biological integrity of the St. Lawrence River ecosystem and in particular the Akwesasne, Cornwall-Lake St. Francis, and Massena AOC in accordance with the Great Lakes Water Quality Agreement, and other agency laws, regulations, and policies” (Hartig and Thomas, 1988; NYSDEC, 1990, 2006). The RAP established specific criteria in the Massena AOC for removing the “Degradation of Benthos” BUI. These criteria are: (1) “Benthic macroinvertebrate community structure does not significantly diverge from unimpacted control sites of comparable physical and chemical characteristics”, and (or) (2) “In the absence of community structure data, the toxicity of bed sediment-associated contaminants is not significantly higher than controls at unimpacted sites” (George and Boyd, 2007;

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Base from U.S. Geological Survey Digital Data. Universal Transverse Mercator Projection, Zone 18N, NAD83

Fig. 1. Map of the St. Lawrence River and major tributaries, the study sites, and the boundaries of the St. Lawrence River at Massena, New York, AOC.

IJC, 1991; NYSDEC, 2006). For the present study, the term “reference” is used for sites outside the AOC that are used to establish regional conditions needed to evaluate the BUI removal criteria.

The use of regional reference sites of comparable physical condition as a standard for comparison provides a realistic and attainable benchmark for BUI assessment and is in line with RAP goals (USPC, 2001). This approach is recommended by the IJC (1991) in its guidelines for BUI criteria development as well as by Grapentine (2009) and has been used successfully for assessing the plankton BUI in the Massena AOC (Baldigo et al., 2012) and the Rochester AOC (Baldigo et al., 2016). It also acknowledges the limited reach of the RAP and AOC program where impacts originating outside the AOC “should not impinge on the ability to delist an AOC” (USPC, 2001). The sources of impairment originating outside the AOC are addressed by Lakewide Management Plans, the Great Lakes Binational Toxics Strategy, and other state and federal programs.

More comprehensive information on the status of benthic communities and toxicity of bed sediments is needed to determine if the delisting criteria for the benthos BUI have been achieved. In 2012, the NYSDEC, the US Geological Survey (USGS), and the SRMT investigated resident benthic macroinvertebrate communities and toxicity of bed sediments from across the region to determine the status of the benthos BUI. Benthic macroinvertebrate community data and bed sediment-toxicity test results were used to test two hypotheses that address the criteria for delisting the benthos BUI. The first is that the benthic macroinvertebrate communities from sites in the AOC (in three tributaries and in the St. Lawrence River) are not significantly different or more impacted than the communities found at reference sites located outside the AOC. The second hypothesis is that the bed sediments at selected locations in the AOC are no more toxic to macroinvertebrates than are the bed sediments from reference sites outside the AOC.

Testing these two hypotheses provided multiple lines of evidence that characterize the benthic macroinvertebrate community condition and the potential toxicity of bed sediments to representative macroinvertebrate species in the AOC. Additionally, inherent variability in

biological assessments must be considered (Smith and Bode, 2004) and is an important limitation for removing BUIs (George and Boyd, 2007) because it often makes quantitative metrics, needed to characterize biological communities and to assess site-to-site differences, and difficult to estimate precisely (Stemberger et al., 2001). Because sediment contamination is not necessarily an indication of benthic community degradation, the use of standardized toxicity tests to complement community assessment provides additional certainty in results and helps to define causality (Damásio et al., 2011). All results were used to evaluate whether conditions across the AOC meet the criteria for removing the benthos BUI.

Materials and methods

Study design

Sediment samples were collected from 17 sites within and 13 sites outside the AOC between July 30 through August 1, 2012, (Fig. 1; Table S1). Sites in the AOC were generally located downstream of one or more potential contaminant sources and often upstream and downstream of confluences for major tributaries in the St. Lawrence River. This arrangement maximized the likelihood of sampling contaminated bed sediments from sources in the three AOC tributaries and the St. Lawrence River. Reference sites were selected where fine sediments could be found. With the intent of minimizing watershed driven variability, two to three reference sites, upstream and outside the AOC, were sampled in each river, and two additional reference sites, downstream and outside the AOC, were sampled in the St. Lawrence River. The sample locations consisted of three reference and three AOC sites in the Grasse River, three reference and four AOC sites in the Raquette River, two reference and two AOC sites in the St. Regis River, and five reference and eight AOC sites in the St. Lawrence River (Fig. 1; Electronic Supplementary Material (ESM) Table S1). Two sites, one in the power canal near the Alcoa Inc. plant (law-pc), and one in St. Lawrence Seaway Wiley-Dondero Canal between Eisenhower and Snell locks (law-sw),

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