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Assessing condition of macroinvertebrate communities and bed sediment toxicity in the Rochester Embayment Area of Concern, New York, USA

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ABSTRACT

The United States 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 1972. The lowest reach of the Genesee River and the Rochester Embayment on Lake Ontario between Bogus Point and Nine Mile Point, including Braddock Bay, were designated as an Area of Concern (AOC) due to effects of contaminated sediments and physical disturbance on several beneficial uses. Following sediment remedial efforts and with conditions improving in the AOC, the present study was conducted to reevaluate the status of the benthic macroinvertebrate (benthos) beneficial use impairment (BUI). Benthic macroinvertebrate community assessments and 10-day *Chironomus dilutus* bioassays were used to test the hypotheses that sediments within the AOC were no more toxic than sediments from surrounding reference areas. The study was separated into three discrete systems (Genesee River, Lake Ontario, and Braddock Bay) and non-parametric analyses determined that a multimetric index of benthic macroinvertebrate community integrity was significantly higher at AOC sites compared to reference sites on the Genesee River and in Braddock Bay while AOC and reference sites on Lake Ontario did not differ significantly. Survival and growth of *C. dilutus* were also similar between AOC and reference sites for each system with the exception of significantly higher growth at reference sites on Lake Ontario. Results generally indicated that the condition of benthos and toxicity of sediment of the Rochester Embayment AOC are similar to or better than that in the surrounding area.

Introduction

During the 1970s and 1980s, the United States and Canada committed to restore the physical, chemical, and biological integrity of the Great Lakes and its Areas of Concern (AOC) throughout the region under the Great Lakes Water Quality Agreement of 1972 and subsequent amendments (*https://www.epa.gov/glwqa.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." The Rochester Embayment AOC includes the lower Genesee River from its mouth at Lake Ontario to the Lower Falls in Rochester and the Rochester Embayment, including Braddock Bay, on Lake Ontario between Bogus Point in the town of Parma and Nine Mile Point in the town of Webster, Monroe County, New York (Fig. 1). Water and sediment quality issues in the Genesee River, caused mainly by elevated silver, copper, nickel, iron, and PCBs from past industrial discharges, resulted in a determination that 12 of 14 beneficial uses were impaired and it was designated as one of 43 AOCs throughout the Great Lakes basin (MCDOH, 1993). The benthic macroinvertebrate community or "benthos" beneficial use was designated impaired in the Genesee River due to biological assessments that showed substantial alterations to benthic communities (MCDOH, 1993). Declines in wastewater discharge quantity and decreasing contaminants from permitted wastewater dischargers (MCDOH, 2011) along with results from recent sampling efforts by the New York State Department of Environmental Conservation (NYSDEC), as part of its ambient water quality monitoring program, indicate macroinvertebrate communities in the lower Genesee River may have recovered from past impacts to water quality (Stream Biomonitoring Unit, NYSDEC, 2010, unpublished data). The status of benthic communities in the Rochester Embayment remains largely unknown at this time.

The Rochester Embayment Remedial Action Plan (RAP), developed by the Monroe County Department of Health, addresses environmental degradation and beneficial use impairments (BUIs) in the Rochester Embayment AOC (MCDOH, 1993, 1997). The intent of the remedial process is to bring the AOC to a comparable condition with the surrounding areas; Remedial Action Plans only address the pollutant sources and impact within the AOC (USPC, 2001). Legacy industrial contamination in the AOC is no longer of primary concern because many pollution sources have been eliminated, remedial activities have been completed, and routine NYSDEC data suggest local recovery (MCDOH, 2011). In order to establish

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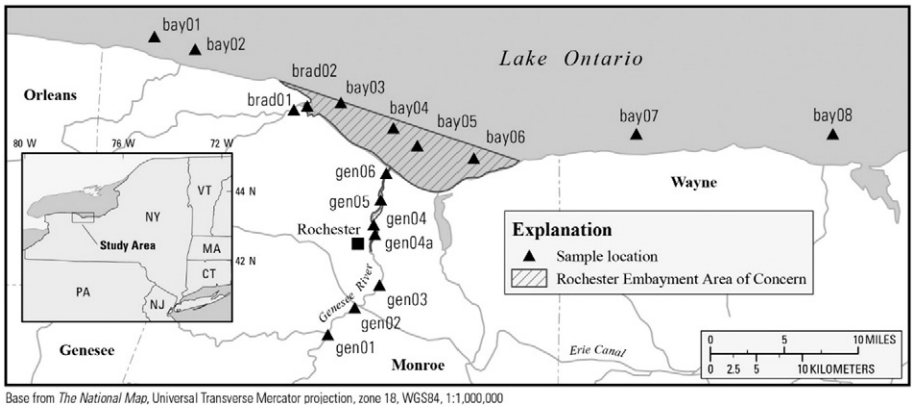

Fig. 1. Map of the Rochester Embayment AOC boundaries, major tributaries, and study sites.

attainable and measurable endpoints for recovery, the RAP established an ecosystem approach to AOC assessment that employs non-AOC reference sites of similar physical and chemical habitat as a benchmark for assessing recovery (IJC, 1991; MCDOH, 1993). This approach, originally defined by the International Joint Commission (IJC), and further described by George and Boyd (2007) and Grapentine (2009), has recently been implemented in other AOCs for benthos and other BUI assessments (Baldigo et al., 2012, 2016; Duffy et al., 2016). A broad watershed drains to the Embayment, and other contemporary stressors and issues such as eutrophication, sedimentation, and invasive species (Arndt et al., 2009; Dodds et al., 1997, 1998; Dodds and Welch, 2000; Hecky et al., 2004; Henley et al., 2000; NYSDEC, 2012; Stevenson et al., 2006; Wood and Armitage, 1997) must be considered within the context of BUI assessment and the legacy contamination responsible for impairment (MCDOH, 1993). The RAP established specific criteria in the Rochester Embayment AOC for removal of the Degradation of Benthos (benthos) BUI (Knauf, 2013):

(1) "Genesee River benthic water column and sediment-associated macroinvertebrate samples are "non-impacted" or "slightly impacted" according to NYSDEC indices (Smith et al., 2012), and"
(2) "Macroinvertebrate communities in AOC sediments do not differ significantly from communities in comparable non-AOC sediments; or"
(3) "In the absence of conclusive community structure data, the toxicity of sediment associated contaminants to sediment dwelling organisms (e.g., *Chironomus dilutus*) in AOC sediment samples is not statistically higher than in control samples collected in equivalent substrates in non-AOC areas".

Upon evaluation of the RAP delisting criteria it was determined that sufficient information did not exist to accurately determine if the criteria for removing the benthos BUI had been achieved in the AOC. To fully evaluate benthic condition within the AOC and make conclusions about removing the Rochester Embayment benthos BUI, the NYSDEC and the U.S. Geological Survey (USGS) conducted assessments of benthic macroinvertebrate communities and sediment toxicity during the summer of 2013. These data were used to test the hypotheses that benthic macroinvertebrate communities and the toxicity of bed sediments from sites within the three discrete systems of the AOC (Genesee River, Lake Ontario, Braddock Bay) were not significantly different from nor more impacted than reference site communities of comparable physical habitat located outside the AOC (IJC, 1991; MCDOH, 1993).

Materials and methods

High inherent environmental variability is a significant limitation for removing BUIs (George and Boyd, 2007) because of the challenge it poses for the interpretation of quantitative metrics needed to assess site-to-site differences in degradation and/or restoration (Stemberger et al., 2001). For this study, we examined multiple lines of evidence, in part, to minimize potential issues created by outliers and frequently variable metrics. This investigation evaluated all three components of the benthos BUI removal criteria by: 1) comparing the biological integrity of the sediment-associated macroinvertebrate community in AOC and non-AOC reference sites and 2) conducting sediment toxicity bioassays using sediment from AOC and non-AOC reference sites. Because the RAP delisting criteria specified benthic community conditions based on NYSDEC metrics, the study employed NYSDEC methods for assessment of macroinvertebrate communities (Smith et al., 2012). Ten-day (10-d) laboratory exposures were used to generate acute (survival) and chronic (growth) endpoints using the midge *Chironomus dilutus* (Diptera: Chironomidae) as an indicator species because: (a) standardized U.S. Environmental Protection Agency (USEPA) tests for this species are well-defined, (b) sensitivity of *C. dilutus* to common nutrients and toxins found in freshwater environments is understood, (c) test conditions are controlled in the laboratory, and (d) this species is widely distributed in ponds, marshes, and lakes across the United States and Canada (ASTM, 2010; USEPA, 2000).

Field sampling

Sediment samples were collected from 17 sites on July 30 and July 31, 2013. Nine AOC sites were located within the Rochester Embayment AOC boundaries, and eight reference sites were located outside the AOC (Fig. 1, Electronic Supplementary Material (ESM) Table S1). Reference sites were defined as those sites outside the AOC, and their selection does not indicate lack of anthropogenic influence. Sites in the AOC portion of the Genesee River were selected to represent the "worst-case scenario", where previous sediment chemistry results indicated elevated levels of metals contamination (Battelle, 2012). The exception was the location upstream of the Eastman Kodak Company wastewater treatment plant (gen04a) which did not show a high level of contamination but was sampled to bracket its potential effects within the AOC. Reference sites on the Genesee River were located upstream of the AOC and represented variability in landuse ranging from the City of Rochester to a more rural upstream landscape. Lake Ontario AOC and reference sampling locations were selected to spatially represent the nearshore zone at similar depths and where fine sediments could be found. Duplicate sediment samples were collected for toxicity tests at three sites (bay07, gen02, and gen06) to assess the precision of test endpoints.

Latitude and longitude, surface velocity, depth, and time were recorded for each study location. A water quality multi-probe was used to measure water temperature, pH, specific conductance, and dissolved oxygen (DO). Twenty-five bed sediment grabs were collected at each site using a petite Ponar (0.03 m^2) dredge for analysis of macroinvertebrate

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