Introduction

The Saguenay Fjord, a key affluent of the St-Lawrence River estuary (SLRE), is prone to environmental pressures stemming from mixed and diffuse sources of (in)organic contamination, and has been studied extensively with bivalves as indicators of water quality. Overall, measurements generated with bivalves, polychaetes, and soft-shell clams have shown site-specific effects impacting animal health (i.e., Mya arenaria soft-shell clams and Mytilus edulis mussels) which have included immunotoxicity, reprotoxicity, genotoxicity, oxidative stress, as well as growth inhibition and decreased energy reserves.1 In contrast to molluscan shellfish, polychaetes, abundant in, and at the mouth of, the Saguenay Fjord, have seldom been evaluated in this aquatic environment, although recent reports suggest that they can be useful indicators to conduct ecotoxicological studies.2 As a preliminary step in considering possible future research prospects with these benthic animals, we collected Nereis sp. from two sites (i.e., one reference and one contaminant-impacted intertidal zone) located in the SLRE near the mouth of the Saguenay Fjord to take note of their relative abundance, size and tissue metal content profile.

Materials and Methods

In October 2008, Nereis sp. worms were collected in the intertidal zone of the two following sites: i) Baie Ste-Catherine (BSC), located 2 km South-West of the mouth of the Saguenay Fjord in the SLRE (48.06 N; 69.43 W); this site is impacted by naval (large wharf allowing docking of cruise/tourist ships for whale sightseeing from May to October; annual ferry service allowing vehicle crossings to/from BSC/Tadoussac across the Saguenay Fjord; constant ship traffic to and from the St-Lawrence River estuary) and by domestic (direct discharge of the 500-inhabitant BSC municipal wastewater effluent into the intertidal zone) pollution: ii) Baie du Moulin à Baude (BMB), located 5 km North-East of the mouth of the Saguenay Fjord in the SLRE (48.08 N; 69.40 W); this is a reference site with no apparent sources of pollution (Figure 1).

Worms were extracted at low tide from their benthic environment by digging into the sediment with a pointed shovel and/or pitchfork. At each site, one animal was collected from each of 20 individual digging locations (holes) conducted within a 20-m radius. When more than one worm was uncovered in a dig location (usually 1-4 were found), only the largest worm was kept in all cases. Worms were then transported back to our field laboratory held damp in paper towels where purging of their gut content could occur. BSC (n=20) and BMB (n=20) worms were then weighed within two hours after collection and then preserved in dry ice. Worms and sediment were later analyzed for metals by the (Canadian) National Laboratory for Environmental Testing (Burlington, Ontario). Tissues and sediments were digested to a constant weight before digestion with nitric acid and hydrogen peroxide in a high-pressure microwave oven. Metals were analyzed using an Inductively Coupled Plasma-Flame Sector Field Mass Spectrometry. The National Water Research Institute’s certified reference materials were used to ensure QA/QC. A total of 8 worms per site was used for metal content analysis.

The data (metal concentrations and worm weights) were tested for normality using the Shapiro-Wilk test before analysis of variance. The data proved normal and were then subjected to analysis of variance and critical differences between sites were tested using Fisher’s least square difference test using Statistica (version 5.5) software. Significance was set at P<0.05.

Results and Discussion

Only red Nereis sp. polychaetes were found at both study sites. Although several worms were usually found per dig location (hole) at the BMB site, abundance was clearly less at the BSC site as some diggings were often unsuccessful (i.e., devoid of worms). Large inter-site size differences were found in worms. Indeed, animals from the BSC pollution-impacted site (mean g wet weight±SD = 0.28±0.17) were significantly smaller than those from the BMB reference site (mean g wet weight±SD = 1.69±1.0) indicating marked growth inhibition (Figure 2). Worm metal tissue levels also proved to be significantly different between the sites for 11 of the 28 elements that were analyzed (Table 1). Ten of these 11 metals displayed concentrations that were significantly higher in worms at the pollution-impacted BSC site over those from the reference site (BMB) by factors ranging from 1.8 to 5.3. Only cadmium showed lesser accumulation in BSC worms than in BMB worms. An earlier field study conducted at these same stations with Mya arenaria clams had also shown bivalves from the BSC site to be significantly impaired as revealed by, for example, a lower condition factor (weight to length ratio), a lower gonado-somatic index and decreased production of vitellin-like proteins as compared to BMB clams.4 In addition, as polychaetes are an important component of the diet of many aquatic organisms and shorebirds, these tissue metal data suggest that the potential for trophic transfer of metals exists in this area.

While the higher metallic accumulation in BSC worms probably incur some of the growth-inhibiting effects observed, it also suggests that Nereis sp. are likely exposed to higher concentrations of several metals stemming from as yet unidentified sources, accumulated from their sediment and/or water column environments. Indeed, polychaetes have long been recognized as good bio-accumulators of various metals.5 Although we have only quantified the metals in the worms’ tissues, it is reasonable to assume that the native organisms at BSC were chronically exposed to a range of both inorganic and organic compounds from the environment site with no apparent sources of pollution (Figure 1).

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mixed anthropogenic inputs (municipal wastewater, boat traffic, etc.) in this area. For example, polycyclic aromatic hydrocarbons are known to be prevalent in Saguenay Fjord sediments and their uptake has been documented in some benthic animals including Nereis sp.\(^8\) It is thus plausible that (in)organic interactive effects may be at play at BSC in perturbing polychaete growth and possibly other physiological functions. Future studies at this site, as well as in other intertidal areas of the Saguenay Fjord, are warranted with these benthic animals, especially when considering that several categories of biomarkers can be employed to measure multiple effects resulting from their exposure to different classes of contaminants.\(^2\) Moreover, additional studies with worms could prove helpful in demonstrating exposure impacts in Saguenay Fjord areas across multiple phyla (e.g., in comparison with Mya arenaria bivalves) that may reveal a broader contamination problem present in this aquatic ecosystem.

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