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Algal toxins in the food chain – a comparative study of Chesapeake Bay and Baltic coastal food webs

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INTRODUCTION

Microcystin (MC) is a hepatotoxin produced by cyanobacteria (blue-green algae) which is found globally in eutrophic waters including lakes, lagoons and estuaries (Paerl and Paul 2012). The presence of MC in food webs is of concern due to adverse effects on biota and exposure to humans via commercial and recreational fisheries (Paerl and Otten 2013). Little is known regarding the factors which determine MC accumulation in food webs. We hypothesized that dietary exposure would be determined in part by sources of organic matter supporting the food web.

We undertook a comparative study of the James River Estuary, a sub-estuary of Chesapeake Bay, and the Curonian Lagoon, a sub-estuary of the Baltic Sea and largest lagoon in Europe. Both sites experience cyanobacteria blooms known to produce MC (Wood et al. 2014; Lesutienė et al. 2014), but differ in their sources of organic matter. The James receives large inputs of terrestrial organic matter due to the draining of a mountainous catchment following sea-level rise while the Curonian Lagoon is fed by a lowland river which delivers low concentrations of terrestrial organic matter. We hypothesized that high internal production in the lagoon, coupled with lower dilution by terrestrial organic matter inputs, would result in greater exposure to MC among biota of the Curonian Lagoon.

METHODS

Water, sediment and tissue samples were obtained from the tidal fresh segment of the James River in 2012 and from the Curonian Lagoon in 2014. Water samples were collected weekly at several locations; sediment samples were obtained monthly at several locations. Fish and shellfish were collected on 3-4 dates throughout the year to characterize seasonal variation. Microcystin analyses were performed at VCU. Samples were analyzed in duplicate using the Abraxis Microcystins-ADDA ELISA kit.

RESULTS

Higher levels of MC in the food web of the Curonian Lagoon corresponded to higher levels of MC in sediments and likely reflect the dominance of internal (autochthonous) sources of organic matter in this system. The Curonian Lagoon is fed by a lowland river (Nemunas) with low allochthonous organic matter inputs. Therefore, the sediments of the Curonian Lagoon are primarily from autochthonous (algal) sources resulting in higher MC levels in sediments and greater dietary exposure for the predominantly benthivorous fishes.

The James drains a mountainous catchment and receives large loads of terrestrial (allochthonous) organic matter. This allochthonous input dilutes algal (autochthonous) inputs resulting in the sediments of the James being primarily of an allochthonous source. The dominance of the allochthonous organic matter results in low MC concentrations in the James sediments. Due to the low MC concentrations in James sediments the benthivorous fish and benthic filter feeders had relatively low MC concentrations in their tissues. Planktivorous fishes in the James had elevated MC concentrations in their tissues reflecting greater algal contributions to their diet and higher levels of MC in suspended particulate matter.

DISCUSSION

Sediment: MC in sediments from Curonian Lagoon was an order of magnitude higher relative to concentrations observed in the sediments from the James Estuary. Peak MC concentrations in Curonian Lagoon sediments were 90 ng g DW−1 (at Nida in October); in the James Estuary, peak concentrations were 3 ng g DW−1 (at Tar Bay in September). In the Curonian Lagoon, MC concentrations were higher in deeper sediments (1-2 cm) relative to the surficial layer.

Water: Weekly samples from 3 locations in the James (river miles 56, 69 and 75) yielded a range of MC concentrations from 0 to 1230 ng L−1 (mean = 279 ng L−1) during May-November 2012. Curonian Lagoon samples from 2-3 weekly monitoring sites and selected other locations yielded a range of MC concentrations from 43 to 498 ng L−1 (mean = 239 ng L−1) during April-October 2014.

Biota: In the Curonian Lagoon, MC concentrations in fish and shellfish were overall higher than those observed in the James River Estuary. In the James River Estuary, planktivorous fish had higher concentrations of MC in their liver tissues relative to planktivorous and benthivorous fishes. James River biota exhibited a pronounced seasonal pattern in tissue MC concentrations with highest levels of toxic coinciding with peak water column values in late summer. In the Curonian Lagoon, tissue concentrations were relatively similar during Summer, Fall and Spring sampling periods.

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LITERATURE CITED


