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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 coastal 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. 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 results in greater exposure to MC among biota of the Curonian Lagoon.

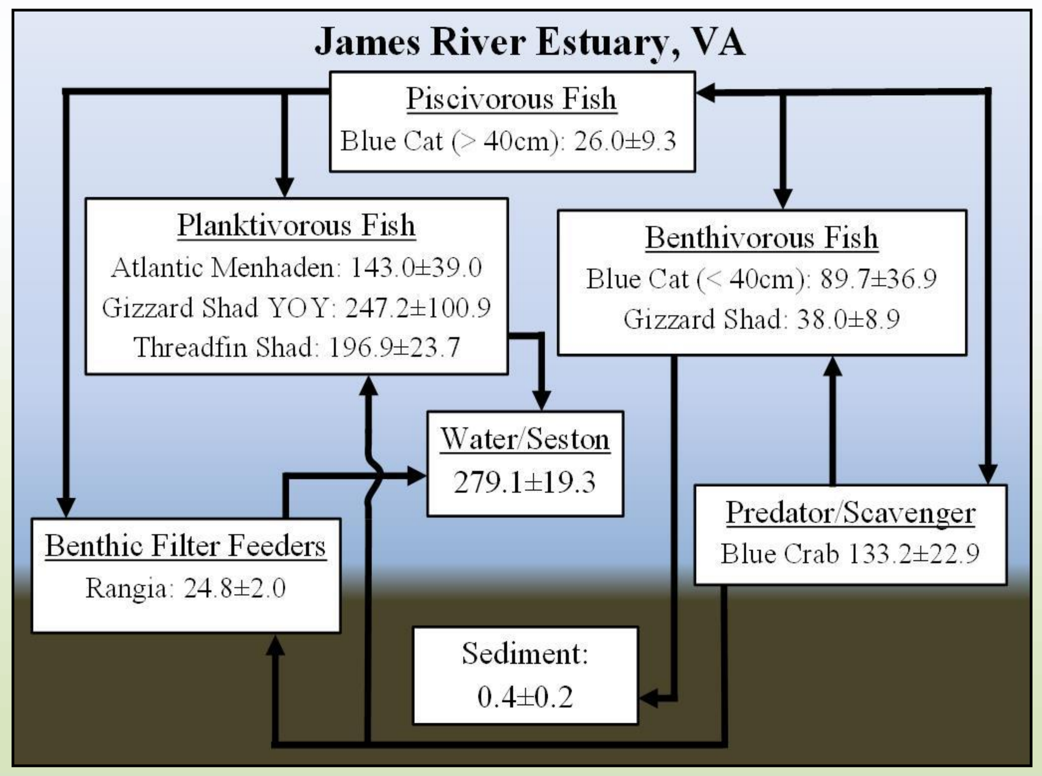
METHODS

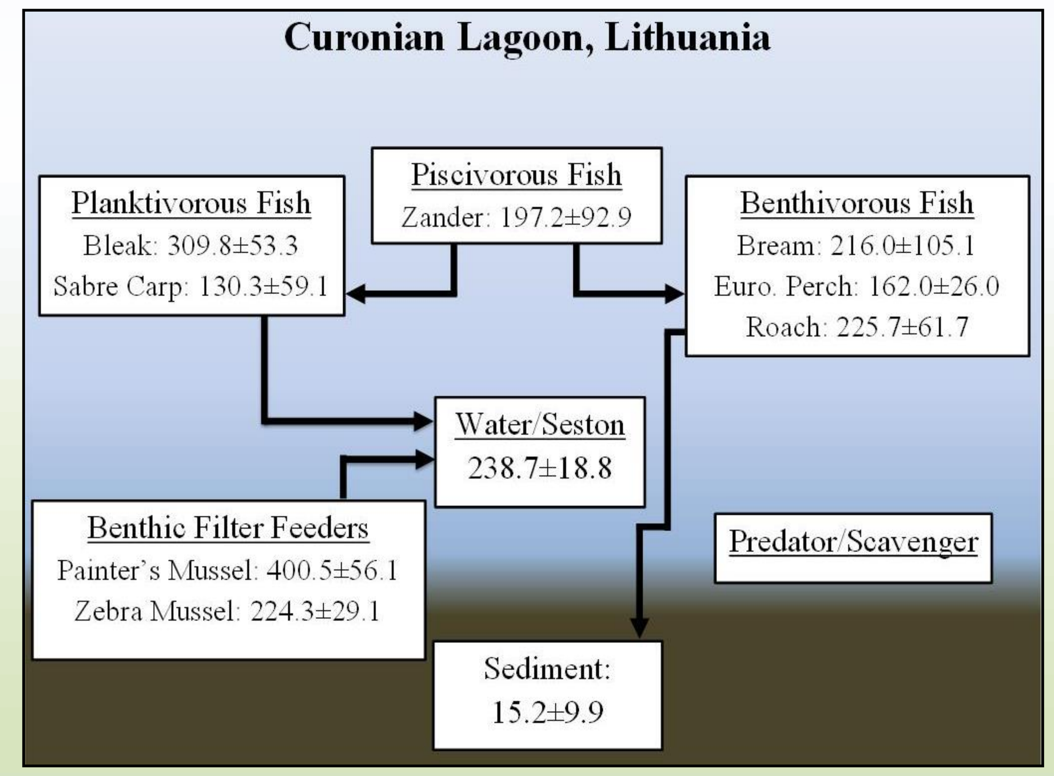
Water, sediment and tissue samples were obtained from the tidal fresh segment of the James River in 2012 and from the Curonian Lagoon in 2014. Water samples were collected ~weekly at several locations; sediment samples were obtained monthly at several locations. Fish and shellfish were collected on 3-4 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.

Sediment: Surficial samples (0-2 cm, James Estuary) and sediment cores (0-10 cm, Curonian Lagoon) were analyzed for MC. The samples were weighed, dried, ground into a powder and extracted using a methanol dilution.

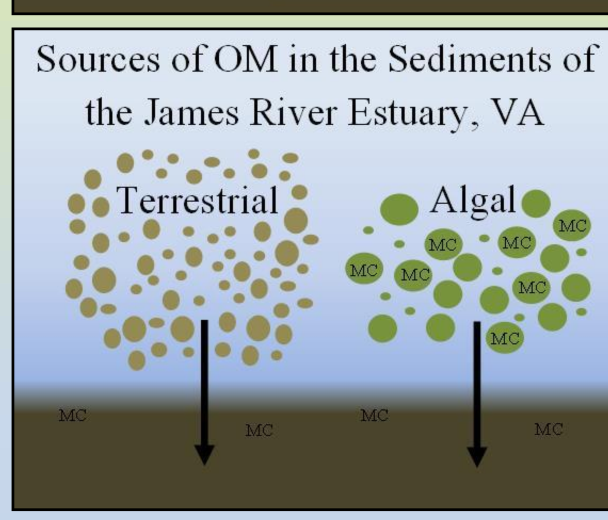
Water: Water samples were frozen and thawed 3x, microwaved for 15 sec 3x, and sonicated for 10 seconds at 24W 2x to lyse cell-bound MC. For water samples from the Curonian Lagoon, an Abraxis Seawater Sample Clean-Up for Microcystins-ADDA kit was used as per manufacturer's (Abraxis) recommendation.

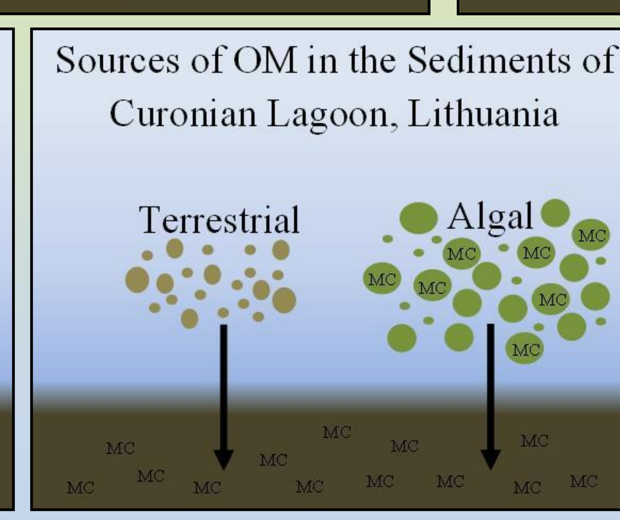
Biota: Samples of the dominant fish and shellfish were collected to provide ~10-15 individuals per species and collection date. Fish were obtained by electrofishing (James Estuary) or the use of nets (Curonian Lagoon). Fish collected from the James included Atlantic Menhaden (*Brevoortia tyrannus*), Threadfin Shad (*Dorosoma petenense*), 2 sizes of Gizzard Shad (*D. cepedianum*) and 2 sizes of Blue Catfish (*Ictalurus furcatus*). Fish obtained from the Curonian Lagoon included Bream (*Abramis brama*), Bleak (*Alburnus alburnus*), Sabre Carp (*Pelecus cultratus*), European Perch (*Perca fluviatilis*), Roach (*Rutilus rutilus*) and Zander a.k.a Pike Perch (*Stizostedion lucioperca*). Shellfish analyzed for this study included Blue Crabs (*Callinectes sapidus*, James) and benthic filter feeders (*Rangia cuneata*, James; Zebra Mussel *Dreissena polymorpha*, Painter's Mussel *Unio* sp., Curonian Lagoon). Liver and mussel tissues were analyzed; data presented here are for liver tissues only.

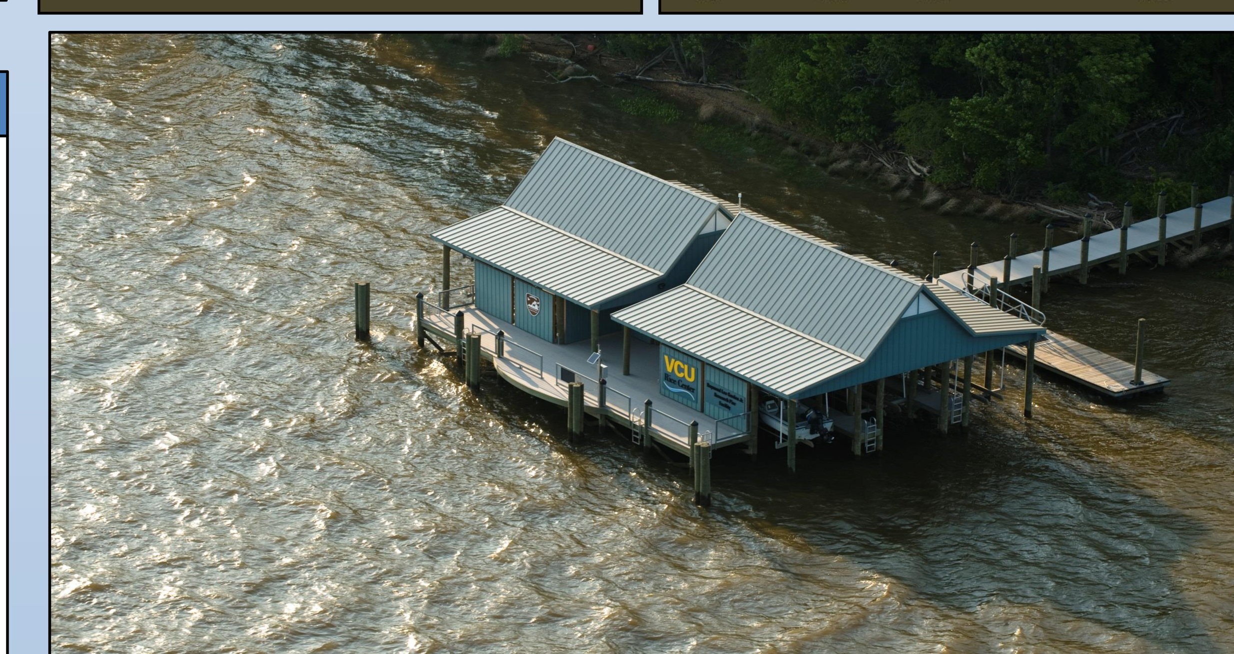


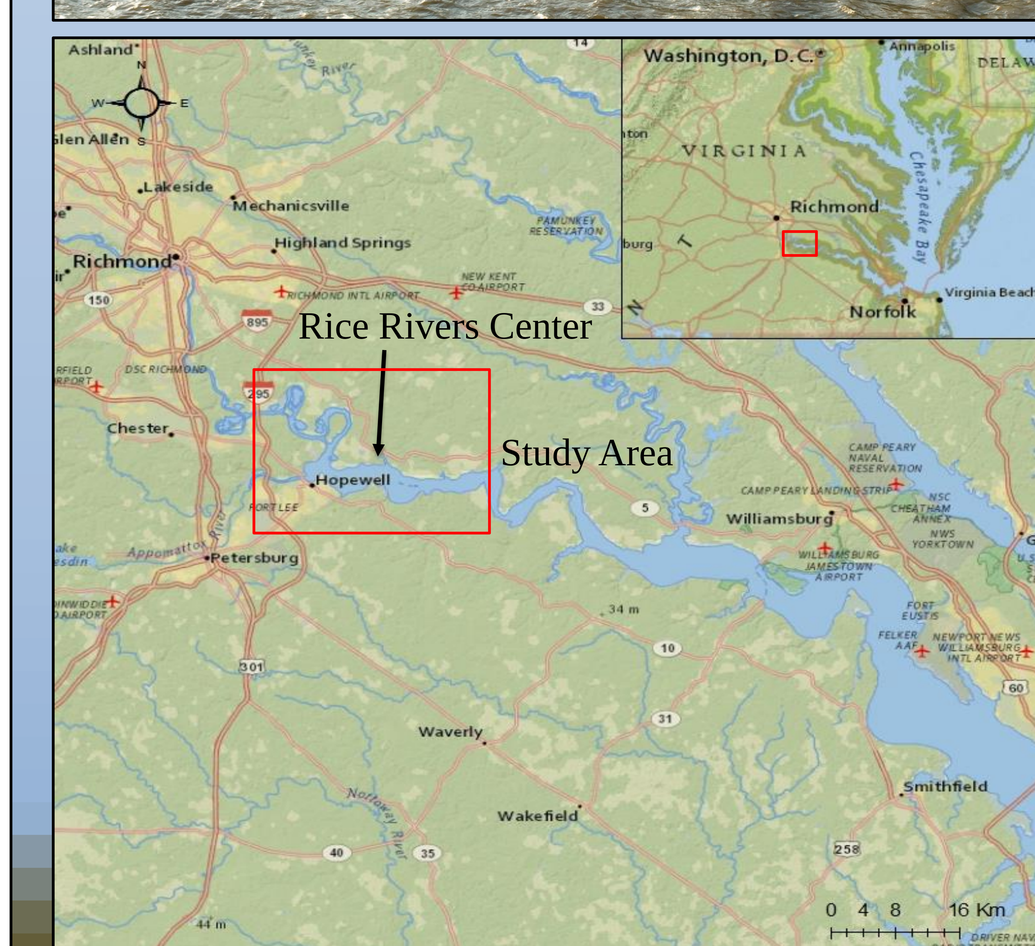


Water/Seston: ng L^{-1}
Tissue/Sediment: ng g DW^{-1}









RESULTS

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 piscivorous and benthivorous fish. James River biota exhibited a pronounced seasonal pattern in tissue MC concentrations with highest levels of toxin 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.

DISCUSSION

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.

Acknowledgements

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Literature Cited

Lesutienė, Jūratė, et al. "Tracing the Isotopic Signal of a Cyanobacteria Bloom through the Food Web of a Baltic Sea Coastal Lagoon." Estuarine, Coastal and Shelf Science 138 (2014): 47-56.

Paerl, Hans W., and Timothy G. Otten. "Harmful Cyanobacterial Blooms: Causes, Consequences, and Controls." Microbial Ecology 65.4 (2013): 995-1010.

Paerl, Hans W., and Valerie J. Paul. "Climate Change: Links to Global Expansion of Harmful Cyanobacteria." Water Research 46.5 (2012): 1349-63.

Wood, Joseph D., et al. "Exposure to the Cyanotoxin Microcystin Arising from Interspecific Differences in Feeding Habits among Fish and Shellfish in the James River Estuary, Virginia." Environmental Science & Technology 48.9 (2014): 5194-202.