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Microplastic abundances in a mussel bed and ingestion by the ribbed marsh mussel *Geukensia demissa*

Matthew B. Khan[a,b,*], Robert S. Prezant[c]

[a] Montclair State University, 1 Normal Avenue, Montclair, NJ 07043, USA
[b] The Georgia Sea Turtle Center, Jekyll Island Authority, 214 Stable Road, Jekyll Island, GA 31527, USA
[c] Department of Environment, Geography and Marine Sciences, Southern Connecticut State University, New Haven, CT 06515, USA

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ABSTRACT

Human activities have generated large quantities of microplastics that can be consumed by filter-feeding organisms as potential food sources. As a result, organisms may experience marked reductions in growth and/or health. To date there has been no investigations connecting microplastics (MPs) with the critically important ribbed mussel *Geukensia demissa*. Here we examined MP abundances within a bed of *G. demissa* in New Jersey. Results indicate that MP densities ranged between 11,000–50,000 pieces/m^2. The abundance of larger MPs (5 mm ≥ 1 mm) did not vary among sampling sites while the smaller MPs (< 1 mm) abundances did vary between sampling sites. These smaller MPs also accounted for 79% of MPs recovered from these sites. Based on the higher abundance of smaller MPs, we also investigated MP ingestion/rejection in a laboratory setting. These results confirmed that ribbed mussels can ingest MPs with negative consequences for the buoyancy of plastics rejected in feces and pseudofeces.

1. Introduction

Due to the versatility and affordability of plastics, production has increased across varied industries, including commercial, manufacturing, and medical fields (Andrady and Neal, 2009). Worldwide production has grown considerably from 1.7 million tons in 1950 to 322 million tons in 2015 (PlasticsEurope, 2016), with single-use plastic packaging representing about 50% of the global market demand (Galloway and Lewis, 2017). The durability of plastics often exceeds the useful life of plastic products, which allows plastic to enter the environment by accident or through improper disposal (Moore, 2008). Studies of the past decade focused largely on “microplastics”, which are defined by the National Oceanic and Atmospheric Administration as plastics 5 mm or less in size (Arthur et al., 2009). The small size of these particles makes them available for incidental ingestion by several marine organisms (De Witte et al., 2014; Setälä et al., 2014; Wright et al., 2013). These and other concerns have triggered studies across the globe to quantify the abundance of microplastics (MPs), but no research has yet focused on MP abundances along coastal New Jersey, USA. Moreover, although several studies (Browne et al., 2008; Van Cauwenberghe et al., 2015; von Moos et al., 2012) have concentrated on MP ingestion by the commercially important blue mussel, *Mytilus edulis* Linnaeus, 1758, there has been little work focusing on similar species, like the ribbed mussel, *Geukensia demissa* (Dillwyn, 1817), despite physiological and biological differences between these two mussels (Riisgård, 1988; Wright et al., 1982) that likely influence their vulnerability to microplastics.

Geukensia demissa occurs commonly in estuaries and intertidal zones along the Atlantic Coast of North America (Jordan and Valiela, 1982). These mussels are critically important because they cycle nutrients, reduce water turbidity, and promote marsh growth (Dame, 2011; Jordan and Valiela, 1982). *Geukensia demissa* also occur in areas with high concentrations of suspended particles, increasing the potential for ingestion of MPs. Based on research on other bivalve species, microplastic ingestion may have negative effects on *G. demissa* (Sussarellu et al., 2016; Wegner et al., 2012).

Also, the abundance of *G. demissa* makes the organism an excellent source of energy for predators, such as the commercially harvested blue crab (Seed, 1980), which opens the possibility for biomagnification in a commercially fished species. In contrast, the rejection of MPs by *G. demissa* in pseudofeces during particle selection could alter the physical properties of MPs, as per Lobelle and Cunliffe (2011) who found that biofilms negatively affected plastic buoyancies. Once the MPs bound in pseudofeces reach the benthic environment they are available to deposit-feeders or are incorporated into the sediment.

In light of the potential impact of MPs in filter-feeding organisms,

* Corresponding author at: 502 Maurice Avenue, Jekyll Island, GA 31527, USA.
E-mail addresses: khanm11@montclair.edu (M.B. Khan), prezantr1@southernct.edu (R.S. Prezant).

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and in turn impacts to the ecosystem, we examined the abundances of MPs within a fringing New Jersey marsh. We expected that MP abundances would be consistent between sampling sites in the marsh. We also expected that the proportion of sand content at each sampling site would have no impact on the average number of MPs. We then compared the densities of MPs in the top 6 cm of sediment against the densities of MPs found beneath the mussels. We expected to find no difference in MP density because of depth. We also examined the relationship between the total number of large MPs (5 mm ≥ 1 mm) and total number of small MPs (< 1 mm) with an expectation that there would be a greater number of MPs < 1 mm in diameter. Based on the higher abundances of MPs (< 1 mm) recovered from sampling sites in the field study, we decided to observe *G. demissa* in a laboratory setting to determine their interaction with MPs. We used two different size classes of MPs (5 μm and 250 μm) to examine differences in the mussels' interactions with MPs based on the size of these plastics. We expected that the laboratory mussels would ingest the 5 μm-sized MPs, but egest most of them as feces with MPs > 250 μm being rejected as pseudofeces.

2. Methods

2.1. Field study location

Plum Island is a remnant spillover fan located at the mouth of the Navesink River in Raritan Bay along the western shoreline of Sandy Hook Gateway National Recreation Area (Fig. 1a–c). The island is fed by sediments from the Navesink and Shrewsbury Rivers ("Sandy Hook", 2016) and is exposed to the strong tidal currents of the bay. The predominant summer winds blow in from the southwest ("Geologic Setting of the Modern Shore, 2016"). The westernmost edge of Plum Island serves as a protective barrier to a north and south salt marsh that are divided longitudinally across the center of the island by a land bridge. The north and south marshes are each exposed on one side to the tidal currents of Raritan Bay from the north and south, respectively. Both marshes are fringed by beds of *Geukensia demissa* and *Spartina alterniflora* (Fig. 1c).

2.2. Sediment sampling

Sediment cores (n = 36, diameter = 7.62 cm) were taken to a depth of 10 cm to determine if MPs were found below the mussels, which extended to a depth of 6 cm, on average. These cores were collected on June 27, 2014 along four transects. Two transects (1 and 2) were in the north marsh (NM) and two transects (3 and 4) were in the south marsh (SM). Each transect spanned from the mussel bed's leading edge to the back edge. Three sediment cores were taken 1 m from each transects' leading edge (A) and back edge (C), and a middle site between the other two (B) for a total of 9 cores per transect (Fig. 2). One randomly selected core from each sampling site was also analyzed for proportion of sand-sized grains. All cores were taken within a 0.25 m^2 footprint, and all sampling sites were within the mussel/*Spartina* bed. To quantify the

Fig. 1. (a) Map showing the location of Plum Island within Sandy Hook Gateway National Recreation Area. (b) The sample site's location on Plum Island. (c) Transects are indicated by numbers 1–4, sampling sites are indicated by letters (A = Leading edge, B = Middle site, C = Back edge), and the areas within the blue lines are mussel/*Spartina* beds. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)