Micro and nanoplastics entry into the Hudson River planktonic food web: Historical revelations from a long-term environmental monitoring program.

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Overview/Abstract

Lab-based evidence has recently emerged that a wide range of marine organisms, including zooplankton (planktonic crustaceans and fish and invertebrate larvae), juvenile and mature finfish, and shellfish (oysters and mussels), experience concerning losses in physiological fitness in response to microplastics, microfibers (<5 mm) and nanoplastics (<1 μm) (MP-MF/NP) exposures and possible transferring to human consumptions via trophic interactions. These studies suggest that smaller sized particles (<10 micrometers) pose the greatest health risks, with transfer efficiency across epithelial barriers inversely related to MP-MF/NP particle size. Our recently published MP surveys in Long Island and Caribbean coastal waters, along a Gulf Stream transect, and in the Arctic Oceans document that MP abundances in a single liter of surface seawater can contain from about 30,000 to 750,000 MP particles (Medina Faull et al., 2021; Medina Faull et al., 2024). Furthermore, the vast majority of MP particles observed in our samples were less than 5 micrometers in diameter. We hypothesize that many of these MP-MF/NP particles enter the planktonic food web through the lowest trophic levels of suspension feeding animals. In doing so, we postulate that MP-MF/NP can impair reproductive and developmental success of icthyoplankton and/or become biomagnified in the flesh of higher trophic level organisms affecting fish population dynamics and ecosystem functioning. However, no direct field observations currently address these hypotheses.

The Hudson River Estuary (HRE) has been subjected to centuries of industrialization and a legacy of pollution. Most HRE commercial fisheries were closed due to pollution and resource shortages due to failed recruitment resulting from overfishing and changing environments. As a result, the HRE has a history of fisheries management aimed at safeguarding human health, including guidelines for limiting the consumption of estuary-caught fish species. Despite the ecological and economic significance and potential human health risks, data on MP-MF/NP contamination and its effects on fish in the HRE is scarce. To fill this knowledge gap, it is necessary to understand how MP-MF/NP contamination in the fish community changes over time and space and the factors governing the exposure and impacts of MP-MF/NP on fish and the HRE ecosystem. We will take advantage of a historical biological collection, including 50 million fish samples of key species collected since 1974 along the Hudson River by the Hudson River Biological Monitoring Program (HRBMP, 2024). These historical samples provide a unique opportunity to understand the temporal and spatial dynamics of MP-MF/NP contamination in the HRE fish community. The fish sample collection was preserved in glass containers with formaldehyde, capturing and retaining the original abundances of MP-MF/NP, avoiding crucial contamination issues when working with MP-MF/NP. The overarching objective of this study is to explore this unique biological collection to evaluate spatiotemporal distribution and influential drivers of MP-MF/NP in key fish species of different trophic levels in the HRE.

A comprehensive proposal of similar nature but with greater scopes was submitted to the National Sea Grant in 2024. Although the proposal received excellent reviews, it was not funded mainly because of lack of initial testing of the methods. An SBU Seed Grant would enable us to develop a highly competitive proposal allowing us to produce sufficient high-quality preliminary data to scale up the research program to develop full proposals aiming at the National Sciences Foundation, Directorate for Biological Sciences, Division of Biological Infrastructure, Hudson River Foundation (HRF), and NOAA Fisheries. The study should greatly improve our understanding of MP-MF/NP concentration in ecologically important fish species and how they changed over time and space, leading to an improved understanding of the dynamics of microplastic contamination in the HRE.