EMERGING RESEARCH ON SHELLFISH, AQUACULTURE, AND MARINE PLASTICS

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Freshly harvested oysters from Long Island Sound. Photo: Tessa Getchis

Introduction

Over the past century, plastics have become an essential part of daily life. Worldwide production of plastics is upwards of 367 million metric tons as of 2020 (PlasticsEurope, 2021), and projected to further increase in the coming years. The term "plastics" encompasses a wide range of fossil fuel-derived materials, including polyethylene, polystyrene, polypropylene, polyvinyl chloride, polyamide, and polyethylene terephthalate. These plastics are lightweight, inexpensive, and have a variety of uses, including in agriculture, textiles, electronics, automobiles, and more (Thompson et al. 2009, Scarascia-Mugnozza et al. 2011, Steer & Thompson 2020, Patricio Silva et al. 2021). The continuing expansion of plastic use has provided many benefits; however, an unintended consequence has been the overwhelming increase in plastic pollution, both on land and in the ocean. Most of the plastic produced is not efficiently recycled, with estimates of up to 12,000 metric tons ending up in landfills or in the natural environment by 2050 (Geyer et al. 2017). The majority of plastic pollution in the ocean is a result of mismanaged waste, unintentionally transported from the land to the ocean via wind and rivers (Jambeck et al. 2015, Moss et al. 2021).

Plastic pollution can be broken down into two broad categories: large or macroplastics (such as plastic bags and bottles) that are particles greater than 5 mm in size, and microplastics that are less than 5 mm in size. Microplastics can enter the marine environment directly, including those manufactured for personal care products such as microbeads (Avio et al. 2017), and also enter through the weathering and breakdown of larger macroplastics (Lambert et al. 2014). Plastics are now found in marine and freshwater aquatic ecosystems across the globe.

Both macro- and microplastic pollution can have negative effects on marine organisms. Birds and sea turtles may become tangled in abandoned fishing gear (Butler & Matthews 2015, Consoli et al. 2019), inhale or ingest pieces of plastic, causing stomach blockages and starvation, and exposing animals to potentially hazardous chemical additives (Thompson et al. 2004, Devriese et al. 2017, Caron et al. 2018).

When organisms at the base of the food chain (e.g., zooplankton, filter-feeding shellfish) consume microplastics, those plastics enter the food web. People may therefore have unwarrated concerns about potential effects on human health. Typical concentrations of microplastics found in shellfish such as clams, oysters, mussels, and scallops are particularly low, on average between 0-10 particles per animal (Covernton et al. 2019, Cho et al. 2021, Mladinich et al. 2023). When put into context, these concentrations are much lower than the number of microplastics humans are routinely exposed to through, for example, bottled water (3,569,000 particles/capita/year, Danopoulos et al. 2020) and dust fallout (13,731-68,415 particles/capita/year, Catarino et al. 2018).

Emerging Research on Shellfish Aquaculture and Plastic Pollution

Plastics in the aquaculture industry are common due to their durable and inexpensive nature. Varying types of plastics are used in hatcheries, cages, buoys, and many more materials and have contributed to the success of shellfish aquaculture in recent decades. Concerns have been raised regarding the potential for aquaculture materials to further contribute to plastic pollution; however, these claims remain unsubstantiated (Koelmans et al. 2017, Danopoulos et al. 2020). Past research has indicated that aquaculture may not, in fact, be a significant contributor to microplastic pollution and that textile production is a bigger source (Coverton et al. 2019). The role of aquaculture activities in production of microplastics and purported contamination of bivalve molluscs has been critically reviewed (Shumway et al. 2023). To date all studies reported extremely low concentrations of microplastics. A recent locally relevant study aimed to explore whether aquaculture practices are contributing to microplastic loads in southern New England waters (see Mladinich et al. 2023).

Crew members sort oysters grown in cages on the Niantic Bay Shellfish Farm in CT. Photo: Kayla Mladinich Poole

Samples of seawater, aquaculture gear, and eastern oysters (*Crassostrea virginica*) were taken from an oyster aquaculture site that deploys plastic bottom trays in Niantic Bay, CT. In addition, a two-week transplant experiment was performed in which oysters were taken from the aquaculture site and a plastic-free cage at the University of Connecticut-Avery Point campus in Groton, CT. Oysters were transplanted between both sites, and at the end of two weeks the gut was sampled. Microplastics were then isolated from seawater and oyster tissue and compared across sample types to determine whether aquaculture activities represented a significant source of microplastic pollution.

Very few microplastics were found in either seawater or oyster tissue samples during the experiment. Water samples contained 0-0.3 microplastics particles per liter of water, and oyster gut samples contained only 0-2 microplastic particles per animal at the aquaculture site or 0-3 microplastic particles per animal at the Groton location. There was little evidence of aquaculture influence on the composition of microplastics sampled, with only one type of plastic fiber (polyester terephthalate or PET) identified in an oyster transplanted to the aquaculture site matching to the rope used to suspend cages at that site, i.e., no evidence that the aquaculture gear is contributing plastic pollution to the surrounding waters or the oysters.

Conclusions

The results of this study indicate that aquaculture gear is not contributing to microplastic pollution at this oyster farm. In fact, while the oysters sampled contained low concentrations of MP polymers, they contained a wider variety of microplastic types, shapes, and sizes than identified in the surrounding water. Because the distribution of microplastics changes with the currents and tides, it is likely that the relatively wide assortment of microplastics found in oyster samples is representative of their ability to capture particles over an extended period of time. Farmers on the East Coast of the United States recently updated their best management practices guide and state that "Gear loss and marine debris should be avoided at all costs" to avoid the potential for marine debris. The guide includes recommendations such as "avoid single-use plastic fasteners and instead opt for reusable bungees, hooks, clips or twine" (Flimlin et al. 2023).

While aquaculture gear is not a primary source of microplastic pollution, new "plastic-like" products derived from natural or sustainable sources are increasing in prevalence in many industries and may have positive applications for aquaculture. Such biomaterials can reduce environmental negative impacts and enable the circular use of bio-based materials (Arantzamendi et al. 2023). Artificial substrate composed of a biodegradable plastic (poly-ß-hydroxybutyrate) has been shown to be beneficial to survival and resilience of cultivated shrimp when compared to PVC substrate (Ludevese-Pascual et al. 2019). Prototype trays of a biodegradable material (Mater-Bi®) molded for aquaculture showed properties suitable for use in the industry, such as a long life span and relatively low biodegradation rate in seawater (Pavia et al. 2023). Seaweed-derived polymers may also represent a potential naturally derived "plastic" for use in aquaculture practices (Pacheco et al. 2022). Aquaculture currently does not represent a significant source of microplastic pollution; however, the transition away from petroleum-derived plastics to sustainable, bio-based materials can promote sustainable practices and reduce global emissions (Stegman et al. 2022).

Consumers should recognize that aquaculture gear is not a main contributor of microplastic pollution in the marine environment, and that bivalve molluscs are not significantly contributing to the number of microplastics ingested by humans. False claims or negative publicity can have far-reaching and detrimental impacts on the aquaculture industry and, to date, there are no convincing data to support negative claims regarding the contributions of aquaculture to microplastics in the environment or the shellfish.

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