Microplastic pollution

Microplasticpollutionis an increasing problem in the marineenvironment. This study had five research objectives: establish if seagrass habitats are accumulating microplastics compared to sandy habits in the Florida Keys, identify if there are any microplastics present in field collected sea cucumbers in the Florida Keys, determine the number of microplastics in Pensacola Beach sediment, determine the number of microplastics in St. Joseph Bay sediment, analyze field collected sand dollars in the Panhandle of Florida for microplastics, and conduct a laboratory experiment on the sand dollar, Mellita tenuis, to determine if they are selecting for microplastics.

Microplastics were extracted from samples using a saturated CaCl2 solution, and visual examination. Both seagrass beds and sandy areas in the Florida Keys contained microplastics. Sediment in Pensacola and St. Joseph Bay both contained microplastics. Sea cucumbers collected in the Florida Keys, and sand dollars collected in the Panhandle of Florida, had microplastics as part of their gut content, suggesting they may make useful animals for monitoring nearshore environments for microplastic pollution. In the laboratory, M. tenuis ingested microplastics in slightly lower proportions compared to surrounding sediment.

CHAPTER I

INTRODUCTION

Microplastics

Plastic production has been increasing worldwide for the last sixty years, with manufacturing increasing about 9% each year. In 2007, 260 million tons of plastic were produced (PlasticsEurope 2008). The high durability, low cost, and light weight have made plastic the material of choice in creating many products (Andrady and Neal 2009; Thompson et al. 2009).

The incredible success of the plastic industry was unexpected, thus when plastics were first introduced, dangers to the environment were ignored (Stefatos et al. 1999; Derraik 2002). In 2010, between 4. 8 to 12. 7 million metric tons of plastic entered the marine environment, and the amount is increasing each year (Jambeck et al. 2015).

The consequences of plastic entering the marine environment has only been recently recognized, and is still not well understood. The combination of the long time it takes for plastic to degrade, its ability to concentrate contaminants, and the ingestion by marine organisms are collectively raising concerns for thehealthof the marine environment.

Microplastics are defined as plastic pieces less than 5 mm in size (Arthur et al. 2009; Van Cauwenberghe et al. 2015), although different studies have contrasting definitions of microplastics making comparisons difficult (Van Cauwenberghe et al. 2015). Primary microplastics are intentionally made 5 mm or less for use in cosmetics, cleaners, and industrial scrubbers.

Microplastic pellets are the raw plastic material from which larger plastic items are made (Wilber 1987; Costa et al. 2010). Secondary microplastics are derived from larger plastic sources by mechanical, photolytic, or chemical degradation (Mathalon and Hill 2014; Alomar et al. 2016). Examples of secondary microplastics include irregular fragments from macroplastics, and fibers from clothes and nets.

Plastics enter the ocean from sources on land and on the sea. About 75% - 90% of plastic debris is land-based coming from littering, and improperly maintained landfills. Areas with higher river input have a higher concentration of microplastics (Vianello et al. 2013; Van Cauwenberghe et al. 2015). The other 10% - 25% come from direct inputs to the ocean, such as shipping, dumping garbage, and fishing (Wessel et al. 2016).

Human population density is a large contributing factor in the distribution of microplastics in the ocean and on shorelines and, not surprisingly, heavily populated areas have higher concentrations of debris compared to areas of low population density (Van Cauwenberghe et al. 2015). Beaches near urbanized areas may have 3. 3% of the sediment composed of microplastics by weight compared to 0. 12% in more isolated areas (Carson et al. 2011; Van Cauwenberghe et al. 2015).

With human population growth, more waste is entering the oceans via sewage outfalls, rivers, littering, and industrial discharge (Claessens et al. 2011; Derraik 2002). Over 90% of the variation in the abundance of microplastics on shorelines can be explained by the population density near the area being sampled (Barnes 2005; Browne et al. 2010). Population size and waste management systems largely determine which countries contribute the greatest amount of plastic marine debris into the ocean. If waste management does not improve, there will be an order of magnitude increase in the amount of plastic entering the ocean by 2025 (Jambeck et al. 2015).

Documentation of microplastics in the marine environment began in the 1970's when they were first described in the water column (Carpenter and Smith 1972; Carpenter et al. 1972), and on shorelines (Gregory 1977; Gregory 1978; Shiber 1979; Shiber 1982). Thirty years later occurrence of microplastics in the sediment was first described (Thompson et al. 2004). Types of microplastics in the environment include: fibers, fragments, films, and microbeads found in the water column, along shorelines, and in sediment in every marine environment (Wright et al. 2013b; Alomar et al. 2016).

Fibers are the most abundant type of microplastic found by many studies, and may be composed of nylon, polyvinyl alcohol, and polypropylene (Browne et al. 2010; Claessens et al. 2011; Alomar et al. 2016; Taylor et al. 2016). Nylon fibers come from clothes, carpets, ropes, and nets. Polyvinyl alcohol fibers are from fishing gear such as fishing lines. Polypropylene fibers are derived from ropes and carpets (Claessens et al. 2011).

Washing a single piece of clothing produces around 1, 900 fibers that may be released into the environment, thus fiber pollution is often greatest in areas near sewage outfalls (Browne et al. 2011; Alomar et al. 2016). More than four microplastic fibers per gram of sediment have been found in samples taken from areas where sewage is discharged into the ocean (Browne et al. 2010). The ability to determine if a fiber is plastic, or some other type of material, is crucial for accurate estimates of the amount of plastic in the environment.

A study in the English Channel found that over half of the fibers ingested by fish were made of cellulose compounds (Lusher et al. 2013)Fragments are usually broken down from larger materials that may be made out of a variety of polymers including polyethylene, polypropylene, polystyrene, polyvinylchloride, polyester, nylon and polyamide (Browne et al. 2010). Polyethylene and polypropylene are found in plastics like bottle caps, fishing line, wrappers, cigarette butts, and straws (Wessel et al. 2016).

Polyethylene and polypropylene production uses half of the oil consumed for plastic production (Browne et al. 2010). Plastic films are used in products such as balloons, frozenfoodpackaging, and medical supplies (Claessens et al. 2011). These one-use plastics degrade over time becoming microplastics.

Microbeads function as scrubbing agents in face washes and cleansers, and are made from polyethylene, polypropylene, and polystyrene (Claessens et al. 2011). Presence of microbeads in Nieuwpoort Harbor, Belgium, the largest yacht harbor in Northern Europe, was ascribed to transport by several rivers flowing into the harbor (Claessens et al. 2011). Castañeda et al. (2014) found a high concentration of microbeads in the Saint Lawrence River coming from industrial sewage.

Microbeads have a higher density than many plastics, so it is hypothesized that microbeads settle to the bottom before being transported further offshore. While this type of microplastic is not normally the most abundant in the environment, microbeads have been used in many laboratory experiments, and marine organisms are known to ingest them (Setälä et al. 2016).