An Investigation on Plastic Pollution in New Haven Harbor

McKinley Dorrico
Marine Biology Program - Department of Biology and Environmental Science

Abstract

Plastics are a major concern within marine environments. Their widespread use in daily life has led them to become common within estuarine environments. Some plastic debris is comparable in size to sediment and suspended particulate matter and is ingested by invertebrates, such as bivalves and decapods. Plastic particles, or micro plastic pieces, have been found within the water column. These micro plastic pieces can also be found in beach sediments. The aim of this project was to survey beaches within New Haven harbor and to determine if a higher volume of plastic is found at beaches with higher levels of human interaction. The second area of study within the experiment was to determine if micro plastics are found within sediment samples on the study sites. Beach surveys were conducted at a variety of different beaches around New Haven Harbor. The results of this study show that beach cleanup processes caused a lower amount of plastic to be found on beaches that are tourist destinations in the summer. Marshland areas had higher plastic content due to a variety of factors, including fewer cleanups and pieces becoming trapped within the marsh.

Introduction

Pollution caused by plastics is a major concern within marine environments. Two of the key characteristics that make plastics so useful - their light weight and durability - also make inappropriately handled waste plastics a significant environmental threat (Ryan, 2009). Although some plastic debris is transported by wind, most land-based litter is carried by water via river and storm-water (Thompson, 2009). The estuaries and rivers then accumulate waste that eventually will be pulled into the ocean.

Plastic particles of less than 5 mm can be found in many areas of the water column. Some plastic debris is comparable in size to sediment and suspended particulate matter and can thus be ingested by invertebrates with varying feeding patterns. Sediment-ingesting lugworms, filter-feeding barnacles (*Semibalanus balanoides*) and amphipods (*Orchestia gammarellus*), which eat decaying organic matter, have all been shown to ingest plastic pieces (Teuten, 2009). Plastic debris present in the marine environment (marine plastics) carry chemicals of smaller molecular size. These chemicals can penetrate into cells and chemically interact with biologically important molecules (Teuten, 2009). The effects of small plastic particulates on the marine ecosystem are less well known, but plastic pieces have been found to accumulate polycyclic aromatic hydrocarbons, chlorinated and legacy pesticides and other persistent organic pollutants (POPs), and to contain hormonally active additives (Reish, 2011).

The presence of plastics in these estuarine habitats along the coast of Long Island Sound can impact the local fisheries and species. For most species, the predominant route of transfer of contaminants from plastics is likely to occur via plastic ingestion. More than 180 species of animals have been documented to ingest plastic debris, including birds, fish, turtles and marine mammals (Teuten, 2009). Many species consumed by humans, such as bivalves and decapods, can also show these harmful chemicals. In fact, they present several characteristics of a "bio-indicator" organism: sedentariness, capacity to bio accumulate contaminants without being affected by them, accessibility, and longevity (Gagnon et al, 2004). This is a major concern for areas with high pollution, including plastics, because at high temperatures such as 100^{o}C, chemicals from plastics may be able to leach into the surrounding sediment. These chemicals can be absorbed in the tissues of bio-accumulating organisms such as filter feeders.

Filter feeders such as mussels, oysters, and clams, all of which are farmed commercially in Long Island Sound, can also show accumulation of toxic chemicals in their tissues, due to their sessile filter feeding lifestyle. Polychlorinated biphenyls, or PCB's, found in shellfish were also associated with an excessive cancer risk (Gagnon et al, 2004). Commercially farmed shellfish were tested for a variety of chemical contaminants commonly found within commercial plastics, and these contaminates were evaluated in order to assess if ingesting shellfish would increase the probability of being diagnosed with cancer. In this study, PCBs found in shellfish were associated with an excessive cancer risk (Gagnon et al, 2004).

Beach surveys are an effective method of research and can be used to determine the amount of plastic pollutants in the marine environment (Ryan, 2009). They provide a rough outline of the types of pollutants found on beaches and roughly what percent of beach pollutants are plastic. However, some issues arise with beach sampling. Litter removal efforts, as well as an influx of beachgoers for the summer months, can shift the amount of pollutants found on beaches (Ryan, 2009).

The goal of this survey was to determine the amount of plastic pieces in several different habitats within New Haven Harbor. It was expected that areas with high tourist traffic or extensive human contact would have a higher number of macro plastics within the tidal range would be found.

Materials and Methods

Beach surveys were conducted with transects measuring 20 meters laid out in the tidal zones in order to measure the amount of plastic for each tidal area (Fig 1). The first transect line was laid out above the high tide zone, the second at the high tide line, the third in the lower tidal range and one randomly placed in the middle of the tidal area (Fig 1).

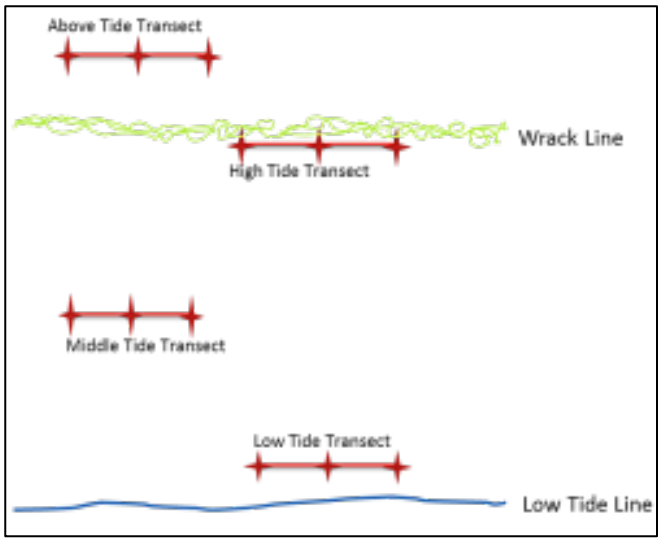

Figure 1: Representation of Beach Surveys. Red stars indicate points on the transects where sediment samples were taken

The transects were performed at four separate beaches, five times at each beach, along New Haven harbor: Lighthouse Point Park, Long Wharf Marsh, Sandy Point Bird Sanctuary, and Bradley Point Beach in West Haven (Fig 2). These beaches were chosen due to their diverse range of habitats. Savin Rock Beach is a sandy tourist beach with an extensive mud flat area adjacent to the sandy beach. Long Wharf represents a costal marshland, with a short marsh and wide soft sediment tidal flat. Sandy Point Bird Sanctuary is an extensive marsh area with little mud flats or sandy beach areas. In contrast, Lighthouse Point is a tourist beach with sandy substrate and no marshland or tidal flat area. Transects were performed at low tide in each area of the tidal zone. Each transect was performed parallel to the water line and none of the transects were performed closer than 5 meters to each other.

The transect lines were measured out using a meter measuring tape. The transect coordinates were chosen at random within the study sites. The salinity, pH, and temperature of the water at each study site were also taken. The salinity was measured using a Brix refractometer from Extech Insturments, and the temperature was taken manually with a thermometer. The pH of the water at each beach was measured using pH Hydrion Test Paper.

Each piece of plastic within 0.5 meters of either side of the transect line was collected and the dimensions of each piece were measured using a ruler. The length and width of each piece were measured at the study site. The data were reported in total area of plastic pieces, due to the overwhelming variation between the many types of pieces found. Styrofoam pieces and plastic bags were measured and included within the experimental data.

Figure 2: Map of New Haven Harbor. Stars represent the beaches sampled: (in order from left to right) Savin Rock Beach, Sandy Point Bird Sanctuary, Long Wharf Marsh and Lighthouse Point Park

Micro plastic pieces within the sediment were also sampled from each beach (Fig. 3). Along each transect line, sediment samples were taken. A small shovel was used to take sediment from the 0, 10, and 20 meter marks of each transect performed. Each sediment sample was measured at 10 cm wide and 10 cm deep, and all of the sediment within these parameters was taken back to the lab for analysis. Sediment samples were collected in glass jars to be taken back to the lab for testing.

Figure 3: Plastic pieces found within sediment samples from Long Wharf Marsh in New Haven, CT

Each sediment sample was dried in a 250^{o} oven for 1-2 days, depending on the amount of moisture within the sediment sample. After drying, the sediment was sieved for 10 minutes. The sections of each sieve were then measured using a scale. The sizes of the mesh of the sieves were 4000 µm, 2000 µm, 500 µm, 250 µm, 125 µm, and 63 µm. This was done in order to separate out any micro plastic pieces from the sediment sample and to determine the size of the micro plastic pieces. Each section was examined under a dissecting microscope in order to examine if any plastic pieces were present within the sediment sample (Fig. 3). Micro plastic pieces were recorded for each site.

Results and Discussion

Within the beaches around New Haven harbor, cleanup projects played an important role in the amount of plastic found on beaches. In areas of high tourism, such as recreational beaches, the number of plastic pieces surveyed was low. Beaches like this included Bradley Point and Lighthouse Point (Fig 4). The amount of plastic in these areas was low due to cleanup facilities present. In the early morning, more plastic pieces were seen at these beaches than in the late afternoon, when the most people were present. However in areas such as Long Wharf and Sandy Point Bird Sanctuary, which are not recreational areas, the amount of plastic pieces surveyed was higher (Table 1). The beach with the lowest concentration of plastic pieces was Lighthouse Point, which also had a higher number of human visitors during the summer months. The physical parameters measured (salinity, temperature, and pH) remained unchanged at each survey site.

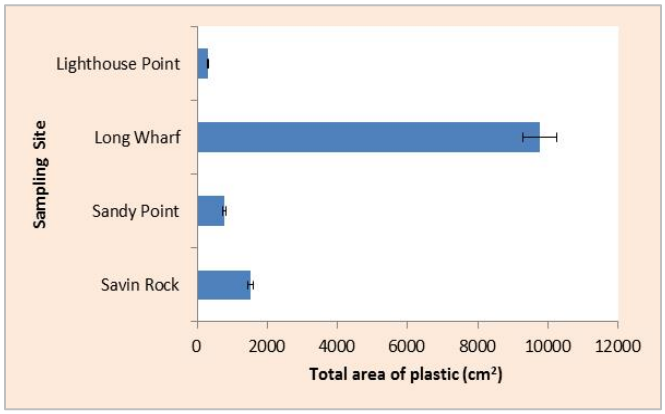

Figure 4: Total surface area of plastic per sample site

The marsh areas within the study sites, such as Long Wharf and Sandy Point, held the most pieces of plastics (Table 1). It is believed that the marshland acts as a barrier, collecting plastic pieces that come from land before they reach the beach area. The lower tidal ranges showed little to no plastic in any of the study sites (Table 2). Therefore, it is plausible that the plastic pieces are being brought in from land before being caught within the marshland area. It is also possible that the plastic pieces are being brought in by the tide and getting swept into the marshland area. The presence of little to no plastic within the lower tidal areas can also indicate that plastic is not being washed out into the harbor.

However, the absence of plastic within the lower tidal ranges was not expected. Sandy Point Bird Sanctuary shows a lower total area of plastic pieces (Fig. 4) than Savin Rock Beach; however it is possible that this is due to the extensive marshland in the area. The marsh sequesters plastics, leading to a longer residence time within the marsh. Therefore more micro plastic pieces and smaller plastic pieces were found due to the extensive degradation at this site (Table 1). If plastics are held up in the marshland it could indicate that the plastics are being held within the marshland, leaving fewer and smaller pieces coming out of the marshland and into the tidal range. Further research on this topic would be needed to prove this hypothesis.

Long Wharf also had the highest amount of micro plastic pieces in the sediment samples out of all of the study sites (Fig 5). The micro plastic pieces are broken apart from larger plastics through weathering and degradation within the marine environment. Therefore, in this study it was found that more micro plastics will be present when there are the larger plastic pieces present. Within each site, the highest concentration of plastic pieces was found above the tidal range, as well as the most micro plastic pieces. This also suggests that a longer residence time in the marshland detracts from the amount of plastic due to degradation within the marine environment.

Area	Number of pieces collected
Lighthouse point	16
Long Wharf	94
Sandy Point	65
Savin Rock	43

Table 2: Number of plastic pieces collected at each study

Table 1: Average amount of plastic pieces in each tidal range for the study sites

Area	Above tide	High Tide	Middle Tide	Low Tide
Lighthouse point	11	3	0	0
Long Wharf	58	10	5	2
Sandy Point	5	27	13	1
Savin Rock	21	4	17	1

Conclusion

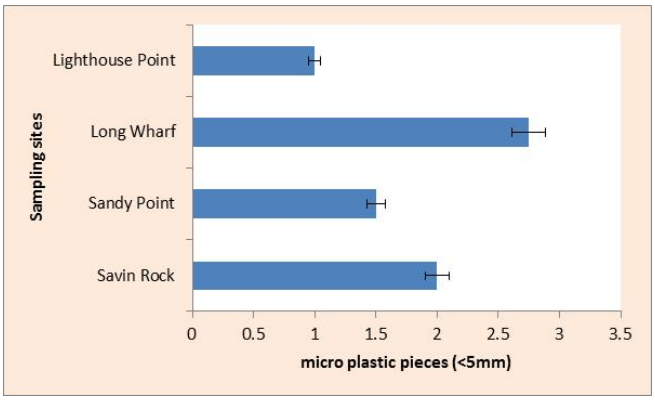

Figure 5: The average number of micro plastic pieces within sediments per sample site

The plastic found was greater in beaches with less human recreational traffic. Cleanup efforts at these sites have decreased the amount of plastic in each area substantially, especially at Lighthouse Point Park. With less plastic found in recreational beaches, fewer micro plastic pieces were found in the sediment samples. Plastic was found in higher concentrations above the tidal line, indicating the plastic debris came from land, not from the water. More research on the residence time of plastic in marshes would be needed to corroborate the findings of this study.

References

Gagnon, Fabien. Tremblay, Thierry. Rouette, Justine, and Cartier, Jacques-François. Chemical Risks Associated with Consumption of Shellfish Harvested on the North Shore of the St. Lawrence River's Lower Estuary. Environmental Health Perspectives, Vol. 112, No. 8 (Jun., 2004), pp. 883-888.

Reish, Donald J., Oshida, Philip S., Mearns, Alan J., Ginn, Thomas C. and Buchman, Michael. Effects of Pollution on Saltwater Organisms. Water Environment Research, Vol. 70, No. 4. (Jun., 1998), pp.931-949

Ryan Peter G., Moore Charles J., Franeker, Jan A. van and Moloney, Coleen L. Monitoring the Abundance of Plastic Debris in the Marine Environment. Philosophical Transactions: Biological Sciences, Vol. 364, No. 1526, (Jul. 27, 2009), pp. 1999-2012

Emma L. Teuten, Jovita M. Saquing, Detlef R. U. Knappe, Morton A. Barlaz, Susanne Jonsson, Annika Björn, Steven J. Rowland, Richard C. Thompson, Tamara S. Galloway, Rei Yamashita, Daisuke Ochi, Yutaka Watanuki, Charles Moore, Pham Hung Viet, Touch Seang Tana, Maricar Prudente, Ruchaya Boonyatumanond, Mohamad P. Zakaria, Kongsap. Akkhavong, Yuko Ogata, Hisashi Hirai, Satoru Iwasa, Kaoruko Mizukawa, Yuki Hagino, Ayako Imamur. Transport and Release of Chemicals from Plastics to the Environment and to Wildlife. Philosophical Transactions: Biological Sciences, Vol. 364, No. 1526(Jul. 27, 2009), pp. 2027-2045.

Thompson Richard C., Moore, Charles J., Vom Saal, Frederick S., and Swan, Shanna H. Plastics, the Environment and Human Health: Current Consensus and Future Trends. Philosophical Transactions: Biological Sciences, Vol. 364, No. 1526, (Jul. 27, 2009), pp. 2153-2166.

Acknowledgements

I would like to thank and acknowledge not only my mentor for this experiment, Dr. Simjouw, but also Dr. Kelly, Dr. Zajac and the various staff in the biology/marine biology department for giving me guidance and assistance throughout this process. I'd also like to acknowledge Jennifer Passaretti, our lab manager, for her help throughout this project. I would also like to thank my family and friends for supporting me throughout this project. Thank you to the SURF program for this wonderful opportunity as well. Special thanks to Mr. and Mrs. Frank Carrubba for their continued support of the SURF program

Biography

McKinley Dorrico is currently a senior at the University of New Haven, majoring in Marine Biology. She plans to work in education and animal care facilities after graduation. She is currently employed as an educator with integration into a full time position after graduation. This was McKinley's first experience in a research setting and it was an experience that she thoroughly enjoyed.

Outside of the lab, McKinley works part time at the Maritime Aquarium in Norwalk, CT and at Animal Embassy in Stamford, CT. She loves working with a wide variety of terrestrial and marine animals and enjoys opportunities to bring people an understanding of the amazing creatures inhabiting this world.