Nantucket Island Macroplastics and Microplastics Baseline Study Proposal

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Introduction

This study seeks to establish a baseline assessment of the abundance and types of macroplastics and microplastics on Nantucket Island. This is the first study on plastics in the natural environment on Nantucket. As a pilot study, we propose to sample for microplastics in the water column, coastal sediment, and oysters (where possible) at three sites (Madaket Harbor, Nantucket Harbor, and Surfside Beach) that represent different land and ocean uses, four times over the course of a year. Beach surveys for macroplastics will accompany microplastics sampling, as a means to identify indirect correlations between the material composition of macroplastics and microplastics. This study will provide us with information on how the abundance of plastics changes seasonally and whether there is spatial variation around the island.

The objectives of this study are:

- To describe the amount and composition of coastal plastics on Nantucket Island
- To measure seasonal and broad spatial variations of plastics in the coastal environment
- To establish a baseline for possible future studies assessing microplastic and microplastic levels
- To provide scientific data to inform possible future actions

Background and significance

While sources of marine litter vary regionally, land-based sources are the largest contributor, accounting for 60-80% of the total annual influx of litter into the oceans (Derraik, 2002; OSPAR Commission, 2007). Land-based sources include coastal municipal waste sites, riverine collection and transport of litter, coastal littering, industrial facilities, and untreated sewage and storm water discharge (UNEP, 2005). Plastics account for the majority (60-80%) of marine litter (Derraik, 2002).

The numerous negative impacts of plastics in the marine environment are well documented, including the entanglement of and ingestion by marine species, damages to marine vessels, and harm to tourism and coastal businesses (Laist, 1987; Vegter et al., 2014). Additionally, plastics are a potential vector of contaminants into the food web, both for plastic additives and hydrophobic contaminants present in the water mass that may adsorb to plastic particles (Andrady, 2003; Herzke et al., 2016; Mato et al., 2001; Teuten, Rowland, Galloway, & Thompson, 2007; Vegter et al., 2014). The properties of plastics that facilitate and hamper desorption and absorption of these chemical contaminants in the marine environment and within biota are an emerging research and management topic, with potentially significant implications for the health of marine food webs and possibly humans.

Macroplastics (particles >5 mm) in the marine environment slowly degrade to microplastics (particles ≤5 mm) through photodegradation, as well as mechanical weathering (Andrady, 2011; Moore, 2008). It is expected that the beach environment aids the degradation process as plastics there are more exposed to UV-light, oxidation, heat and mechanical abrasion (Andrady, 2003; Corcoran, Biesinger, & Grifi, 2009). Microplastics are typically categorized based on whether they entered the marine environment as a microplastic (primary microplastics) or whether they became microplastic particles through the fragmentation of macroplastics in the natural environment (secondary microplastics) (Hardesty et al., 2017). The proportion of primary to secondary microplastics is unknown, and likely location specific (Cole, Lindeque, Halsband, & Galloway, 2011; Hardesty et al., 2017).

Sources of primary microplastics include facial and body scrubs, toothpaste and other personal care products which contain microplastic beads in their formulas, as well as microplastic fibers from synthetic textiles released in the wash. Regulations prohibiting the sale of rinse-off personal care products containing microplastics were established in the U.S. in 2015 (Microbead-Free Waters Act of 2015 [U.S.] 2015). Few solutions exist, however, for preventing the release of microplastic fibers from synthetic textiles in household wash. A 2016 study estimated that more than 70,000 microplastic fibers may be released from washing the average six-kilogram load of acrylic fabric (Napper and Thompson, 2016). Thus, wastewater effluent is a key path of microplastics into the natural environment due to the lack of sewage treatment technologies in place with the capacity to filter out microplastics (Magnusson et al., 2016; Napper & Thompson, 2016; Ziajahromi, Neale, Rintoul, & Leusch, 2017). Car tires are another common source of microplastics according to a study within Sweden that estimates 13,000 tons of car tire microplastics are released yearly, though it is yet unclear what amount of it reaches the marine environment (Bråte et al., 2017).

Research plan

Samples will be collected four times from November 2018 until September 2019 (Table 1) from three sites (Madaket Harbor, Nantucket Harbor, and Surfside Beach) representing different land uses and potential sources of plastics (both land-based and marine-based sources). Madaket Harbor represents an area with marshes, exposure to Nantucket Sound water, and use of the beaches for fishing and picnicking. Nantucket Harbor is adjacent to downtown Nantucket, experiences a lot of boat traffic, and is an area important to commercial shellfisheries, lots of boat traffic. Surfside Beach is exposed to Atlantic Ocean water, popular for picnicking, and close to the sewage treatment beds.

TABLE 1: Time of sampling and the type and number of samples collected at each of the 3 sites.

Month / Season	Microplastic	Macroplastic	Oyster
November/ Fall	Beach Sand (11) / Water (4)	Beach Survey (3)	Live (10)
February/ Winter	Beach Sand (11) / Water (4)	Beach Survey (3)	Live (10)
May/ Spring	Beach Sand (11) / Water (4)	Beach Survey (3)	Live (10)
August/ Summer	Beach Sand (11) / Water (4)	Beach Survey (3)	Live (10)

Beach Sampling**:** Samples for macroplastics and microplastics from the beach sand will be collected along a 100 m transect mid-way between high and low tide, following the basic sampling procedures of Besley et al. 2017 and using the separation methods of Coppock et al. 2017. A 50 x 50 cm quadrate will be placed at 11 equal distance points along the transect. The top 5 cm of the sand will be scooped into metal buckets and then sieved through 5mm metal sieve, to separate the microplastic (<5mm) from macroplastic (>5 mm). Teams of high schoolers from Nantucket, will help collect and process these samples. The abundance and type of macroplastic will be recorded on survey sheets. The sand and microplastics (material that passed through the 5 mm sieve) will be brought back to the Nantucket Field Station, dried and separated using a simple density gradient (Coppock et al. 2017). The microplastics will be counted microscopically at either the Nantucket Field Station or at the University of Massachusetts Boston. Plastic pieces will be examined using Fourier-transform infrared spectroscopy at the University of MA Boston, to verify the microscope counts and to determine the composition of plastic present in terms of broad categories (e.g. polystyrene, polypropylene, polyamides, polyester, PVC). Care will be taken to minimize contamination during sampling and the team of collectors will wear brightly colored clothes or gloves to track any incidental contamination. Procedural blanks and air samples will be taken during all stages to determine any contamination during collection and processing.

Water Sampling: Whole-water samples will be collected seasonally at each site, triplicate 3L samples will be collected and filtered through 4.75mm and 0.020 mm sieves. To obtain appropriate microplastic size fractionation. Remaining material will be backwashed into a clean beaker using Milli-Q water and pipetted/ dried onto a glass slide and dried in a clean, Laminar Airflow Work Station. Milli-Q water blanks will be run during sample handling to determine any possible lab contamination. Microplastics will be counted, photographed and measured using an Olympus SZX12 microscope with a polarized light at the University of Massachusetts Boston. Fourier-transform infrared spectroscopy (FTIR) will be used to determine composition of the microplastics (Dris et al., 2016). Additionally, a plankton net tow will be conducted for at least 100 m at the surface, using a net with 80 um mesh. The net sample will be processed similar to the grab sample (Barrows et al. 2017).

Oyster Sampling: Adult oysters of varying sizes will be collected from the sites. Oysters will be rinsed with Milli-Q water, wrapped in aluminum foil and frozen at -20°C upon returning to the laboratory. Upon processing, oysters will be removed from the freezer and allowed to defrost for one hour. The length and width of each oyster will be recorded. The entire oyster will be dissected from the shell into a glass beaker, quartered and hydrolyzed with 0.31% concentration trypsin solution (digestion efficiency of 88% $\pm$ 2.52) (Courtene-Jones et al. 2016). Beakers will be placed on a heated magnetic stirrer and left to digest for 30 minutes. To obtain appropriate microplastic size fractionation, samples will be further filtered through 20 μm Nitex mesh after hydrolysis and backwashed into a clean beaker using Milli-Q water. Milli-Q water blanks (5mL) and 0.31% trypsin will be run during sample handling to determine any possible lab contamination. The blank will be processed in the same manner as the oysters. The samples will then be processed, counted and photographed using the same methodology as for water samples.

Budget

Table 1 sums the total number of project slides to process from three designated sites four times a year. Each sample requires replicate slides be prepared, scanned and photographed for plastics, then prepped for FTIR analysis. Table 2 sums the cost collection materials, preparing and processing slides based on technician hours and reserved equipment cost per hour at the polarized light microscope and the FTIR.

The materials for collection are for three teams sampling each site concurrently. The use of only one team covering all sites could save approximately $700 but will take longer. (Savings would be two transect reel lines and two nets not purchased.)

The total cost of the project budget is in the last row of Table 2. If funded. this budget would accomplish completion of this project.

Table 1. Estimate of Number of Microscopy and FTIR Samples to Prepare and Process

Month / Season	Microplastic	Macroplastic	Oyster	Slides/site
November/ Fall	Beach Sand (11) / Water (4)	Beach Survey (3)	Live (10)	28
February/ Winter	Beach Sand (11) / Water (4)	Beach Survey (3)	Live (10)	28
May/ Spring	Beach Sand (11) / Water (4)	Beach Survey (3)	Live (10)	28
August/ Summer	Beach Sand (11) / Water (4)	Beach Survey (3)	Live (10)	28
Sum of Seasons' Slides	Beach Sand (44) / Water (16)	Beach Survey (12)	Live (40)	112
				X 3 sites
Sum of Project Slides				336 slides

Conclusion

Numerous efforts on Nantucket are focused on reducing local plastics usage, as well as removing plastics and other litter from the natural environment. However, to date, no indicator measures exist to support the effectiveness of efforts. Developing a clearer understanding of the presence, composition, and sources (when possible) of plastics in Nantucket's natural environment is an important step in assessing the local impact on coastal plastics and establishing effective, evidence-based prevention and mitigation measures for the future.

Note: Should microplastics be found, particularly in oyster samples, the results shared with the public should be accompanied by research results from elsewhere, showing the widespread prevalence of microplastics, to avoid uninformed conclusions that this is a local phenomenon (Pettersen & Lusher, 2017; Whitmire & Van Bloem, 2017). The involvement of Roberto Santamaria, the Director of the Health Department for the Town of Nantucket, would prove critical here.

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