April 15th, 2014

MEMORANDUM

To: Emerging Contaminants Workgroup

From: Ellen Willis-Norton

Re: **Possible Options for Monitoring Microplastics in San Francisco Bay**

Background:

General Background:
Microplastic is a term used to describe fragments of plastic that are less than 5mm (Wright et al., 2012). Microplastics can be pellets that are used as precursors for industrial products, microbeads used in consumer products (e.g. exfoliants), or fragments/fibers of plastics that are the breakdown products of larger plastic materials. Microplastics can enter the aquatic environment through wind, stormwater runoff, or illegal dumping of plastic materials (Eriksen et al. 2013). Additionally, both microbeads from cosmetic products and plastic fibers (e.g., polyester and acrylic) from clothing can be washed down the drain and enter wastewater treatment plants (European Commission 2012). Microplastics are not captured by wastewater treatment plants because they are buoyant and do not flocculate; therefore, they are released in wastewater (Hogue, 2013). It is important to note that both California and New York have proposed bans on microplastics found in cosmetics (Badore 2014). Additionally, Johnson & Johnson, L'Oréal, Colgate-Palmolive, and Procter & Gamble have pledged to phase out the use of microbeads in their skin cleansers (Hogue 2013). Therefore, the concentrations entering wastewater may decrease in the future.

Microplastics are found in surface waters, the water column, and sediment because of the varying density of plastic particles. They can also be found in the gut and circulatory system of aquatic organisms that ingest the particles. Studies have found that microplastics are also able to adsorb to organisms, blocking their feeding appendages (Wright et al., 2012). Ingestion of microplastics can block the digestive tract, reduce growth rates, block enzyme production, lower steroid hormone levels, affect reproduction, and cause the adsorption of toxins (Wright et al., 2012). The potential for ingesting toxins occurs because microplastics readily accumulate hydrophobic organic compounds, due to their high surface area to volume ratio (Teuten et al., 2007). In fact, the sorption of persistent organic pollutants (POPs) to microplastics exceeds sorption to sediments by two orders of magnitude (Mato et al., 2001); in one study, the concentration of POPs on microplastics was six orders of magnitude higher than the concentration in the surrounding water column (Teuten et al. 2007). Therefore, the ingestion of microplastics by organisms can increase the exposure of aquatic life to toxic pollutants.

Microplastic Monitoring Studies
Plastic pollution has increased over the past several decades and is the dominant type of pollution in aquatic environments (Eriksen et al., 2013). Both industrial and densely populated

coastal areas have been identified as microplastic hotspots (Wright et al., 2012). Most studies on plastic pollution in the United States have focused on macro-plastics (Ryan et al., 2010). Studies regarding microplastic pollution have been focused in the North Sea. However, there has recently been a handful of microplastic monitoring efforts in the United States, including a study in Santa Monica Bay, the Los Angeles River, and an on-going study in the Great Lakes.

The Santa Monica Bay study was completed in 2001 and was a partnership between the Algalita Marine Research Foundation and the Southern California Coastal Water Research Project. The study was noteworthy because it was the first microplastic monitoring effort that not only measured the abundance in the surface layer, but also at mid-depth and at the sediment-water interface (Lattin et al., 2004). The study monitored microplastics at varying depths because only 46% of microplastics are positively buoyant. The study observed microplastics at all depths and found that the abundance increased considerably after a storm event. Another microplastic study is just beginning in the Los Angeles area; Dr. Marcus Eriksen is monitoring microplastics in the Los Angeles River. The study will help determine if microplastics are entering Los Angeles' coastal waters through the urban watershed.

Microplastic pollution is also currently being measured in the surface waters of the Laurentian Great Lakes. The study found that microplastic pollution was greatest in Lake Erie, most likely because it is the most populated region (Eriksen et al., 2013). Unlike the Santa Monica Bay study, the microplastics were analyzed using scanning electron microscopy. Therefore, both abundance and the chemical composition of the particles were analyzed. The study is on-going and the researchers, including the project lead Sherri Mason (SUNY Fredonia), are currently considering adding effluent sampling to the monitoring effort.

Previous San Francisco Bay Monitoring

In 2011, microplastics were sampled in San Francisco Bay surface waters at six sites. The RMP partnered with Ian Wren at San Francisco Baykeeper and Joel Baker and Julie Masura at the University of Washington, Tacoma to complete the study. The study determined the mass of microplastic at sites in Central Bay that were suspected to be most influence by trash. The six sites were Oyster Bay, San Leandro Bay, Oakland Estuary, Berkeley Marina, Richmond Inner Harbor, and the San Francisco Waterfront. The concentration of microplastics ranged from 0.064 to 7.215 ug/L, similar to the concentration range observed in Puget Sound (LaRocque et al., 2011). However, the study only measured the mass of the microplastics, rather than the abundance and composition. Additionally, effluent and stormwater have not yet been monitored in San Francisco Bay. Monitoring effluent and stormwater would help identify the main sources of microplastics in the Bay.

Similar to Lake Erie, San Francisco Bay is a densely populated area with a high potential for microplastic pollution. Given the risk of microplastic ingestion by aquatic life, monitoring the abundance and composition of microplastics in the ambient Bay, small tributaries, and WWTP effluent may be useful.

Goals:

The main questions regarding microplastics in San Francisco Bay include:

1. What is the abundance, distribution, and composition of microplastics in the Bay?
2. What are the main sources of microplastics?
3. What are the impacts of microplastics on Bay wildlife?

Monitoring microplastics in sediment, surface water, and the water column would help answer question 1; to address question 2 effluent and/or stormwater monitoring would be required; to address question 3 the stomach contents of Bay aquatic life (e.g., benthic organisms, fish, seabirds) would need to be sampled.

Approach:

<u>Field Sampling</u>
Sediment: Bulk sediment samples are collected using either Ekman or van Veen grabs and a depth of 5 cm is typically sampled.

Surface Water: Surface water samples are collected using neuston nets. The typical mesh size is 0.30 to 0.39 mm with an opening of 0.03-2m and a length of 3-4.5m. Both the Santa Monica Bay and Great Lakes study used 333 micron nets.

Water Column: In previous studies, water is collected from 1-212 m depth, typically using circular bongo nets. Epibenthic sleds have also been used (e.g., the Santa Monica study).

Effluent: Effluent is sampled by pumping water from the effluent trough through a sieve (typically 0.355 mm) for 24 hours. After 24 hours, the contents from the sieve are transferred into a sampling container.

<u>Sample Processing</u>
For sediment samples, the plastics are separated from the sediment using density separation. The sample is mixed with a saturated solution (e.g. NaCl solution), shaken for a period of time, and then the low density plastics float to the surface and the supernatant is extracted.

For all three types of samples (sediment, surface water, and water column) the sample can either be filtered or sieved to separate the plastic. Typically, more than one sieve is used to separate the microplastic into different size categories. For both the Santa Monica Bay and Great Lakes studies the samples were passed through Tyler sieves ranging from >4.75mm to 0.35mm.

<u>Visual Sorting/Abundance</u>
The microplastics should be dried and followed by a type of enzymatic digestion of organic debris to facilitate sorting. Using a dissecting microscope, microplastics can then be sorted into different categories (e.g. foamed polystyrene, pellet, fragment, line, fiber, etc.) and counted. Mass and abundance are measured in grams/items per m^2 (or m^3 for water column sampling).

<u>Chemical Composition</u>

To determine the chemical composition of the plastics there are three possible techniques: Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy (SEM/EDS); Fourier Transform Infrared (FT-IR) Spectroscopy; and Sequential pyrolysis-gas chromatography coupled to mass spectrometry (Pyr-GC/MS). Although Pyr-GC/MS can identify the polymer type and associate organic plastic additives, it is a new methodology that only one microplastic monitoring study in Germany has used (Fries et al., 2013). FT-IR is commonly used (out of 42 studies that analyzed microplastics chemical composition, 28 used infared spectroscopy). SEM/EDS is the technique used by Sherri Mason for the Great Lakes monitoring study.

Potential Partnerships:

Sherri Mason's laboratory is currently collaborating with wastewater treatment plant operators in New York who have collected effluent samples and sent them to Dr. Mason for microplastic abundance and composition analyses. Dr. Mason has stated that she is also willing to collaborate with the RMP on microplastic analysis for San Francisco Bay effluent samples.

Another potential partner is the 5 Gyres Institute, a non-profit dedicated to researching and communicating the impact of plastic pollution. The 5 Gyres Institute partnered with Dr. Sherri Mason for the Great Lakes microplastic study; their role was conducting the field sampling for the study. If the RMP is interested in conducting ambient Bay water monitoring for microplastics, 5 Gyres could be a potential field sampling partner.

Additionally, in 2013, Dr. Swee Teh at the University of California, Davis submitted a proposal with Dr. Mark Browne (University College Dublin) to evaluate how microplastics with absorbed chemicals impact the species that ingest them. The study has not been completed and the RMP has contacted Swee Teh to determine its status and see if there is a potential for partnership.

Analytical Cost:

According to Dr. Mason, the analytical cost for each water and effluent sample is $100. The RMP is investigating the cost for a sediment sample.

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