Unseen Threat:

How Microbeads Harm New York Waters, Wildlife, Health And Environment

From the Office of:

New York State Attorney General

EXECUTIVE SUMMARY

New York waters are being polluted with microbeads: tiny plastic beads produced for use as abrasives in cosmetics and personal care products. Buoyant, multicolored and often spherical, these plastic microbeads are washed down bathroom sinks, pass through wastewater treatment plants, and end up discharged into New York's waters. In our waters, microbeads persist for decades, acting as sponges for toxic chemical pollutants. Mistaken for food by aquatic organisms, microbeads serve as a pathway for pollutants to enter the food chain and contaminate the fish and wildlife we eat.

The most effective way to address this problem is at the source—the consumer products that contain microbeads. Fortunately, plastic is not an essential ingredient in cosmetics and personal care products and several major producers have already committed to replacing plastic abrasives with natural alternatives to address this new source of pollution. Attorney General Schneiderman's "Microbead-Free Waters Act" will ensure the entire industry follows suit. In fact since introduction of the Microbead-Free Waters Act, one of the largest cosmetics companies in the country has announced that it will replace plastic microbeads in its products with natural alternatives such as minerals and ground seeds.

By prohibiting the sale of cosmetic or personal care products containing microbeads in New York, Attorney General Schneiderman's Microbead-Free Waters Act will protect New York's fish and wildlife, and help safeguard New York's long-standing efforts to protect and enhance its water resources.

Part 1 –MICROBEADS IN OUR WATERS

A. Microbeads: A New Threat

In the 80 years since the start of its commercial production,[1] plastic has become an integral part of our daily life. With its tremendous range of uses, from the construction of homes, to health-care, food preservation, transportation, and communication, annual global plastic production has continuously grown from 1.9 million tons in the 1950s to 317 million tons in 2012.[2] Many of the desirable properties of plastic—low cost, durability, and corrosion resistance—also contribute to the rate at which it is consumed, discarded and is accumulating in our environment.

Plastic has become a ubiquitous symbol of pollution across the globe in the form of recognizable objects, such as detergent bottles washed up on the shore, or supermarket bags and six-pack rings entangling wildlife. Today, our waters are facing a new threat from a lesser-known and much smaller form of plastic pollution known as microplastic. Microplastic is plastic smaller than 5 millimeters, whether intentionally manufactured to be that size or as a result of the fragmentation and breakdown of larger plastic products.[3]

The cosmetic and personal care product industry uses intentionally manufactured microplastic in products that are designed, when used as intended, to be disposed into municipal sewer systems without regard to our ability to recover, recycle, or otherwise prevent the tiny plastic beads from entering the environment. This industry manufactures products that New Yorkers use every day containing microplastic used as abrasives, and marketed as “microbeads.” Microbeads are virtually indestructible, often perfectly spherical, multicolored, buoyant, and typically much smaller than 5 millimeters—making them quite distinct from other plastic found in the environment. Unsuspecting consumers discharge these tiny pieces of unrecoverable plastic into New York waters via the bathroom drain when they wash off products–such as facial scrubs, soaps, and toothpastes–that contain microbeads.[4]

B. The Problem of Plastic Microbeads in New York’s Great Lakes

Manta trawl deployed during the first-ever Great Lakes survey to examine plastic pollution in the Great Lakes.

(Photo credit: Dr. S.Mason, SUNY Fredonia)

Until recently, research on the magnitude of plastic pollution in the Great Lakes had been sparse, consisting of limited surveys of beaches and shorelines for large plastic litter. Beginning in 2012, a research team that included scientists from the State University of New York at Fredonia and The 5 Gyres Institute[5], began sampling Lakes Superior, Huron, and Erie to more thoroughly understand the scope of plastic pollution in the Great Lakes.

The 2012 Great Lakes survey revealed that the Great Lakes have some of the highest concentrations of microplastic found in the environment, and microbeads were prevalent.

To examine the Great Lakes for plastic pollution, the researchers modeled their investigations on previous surveys conducted in the Atlantic and Pacific Oceans which examined massive “garbage patches”[6] of small plastic pieces collecting in ocean gyres[7] far off the coastline. The Great Lakes researchers collected 21 samples using a mesh collector called a “manta trawl,” capable of collecting debris floating on the surface of the water greater than 0.355 millimeter (mm) in size. The manta trawl was dragged behind the research vessel and time and travel speed were monitored so that estimates of plastic concentrations could be made. As the abundance of microplastic is related to the opening size of the mesh collector,[8] open water surveys likely underestimate the concentration of the smallest pieces of microplastic present.

Back in the laboratory, non-plastic materials, such as ash, vegetation and algae, were removed from the samples and remaining pieces were verified as plastic. The plastic was sifted, classified, and quantified by size and type and the resulting concentrations were calculated for each sample taken. After noting high counts of what the researchers called microplastic “pellets” in the Great Lakes samples, two national brands of facial cleansers containing polyethylene microbeads were sifted and examined. The spherical microbeads within these products were compared to the spherical pellets from the open water samples, and the latter were identified as microbeads due to similar shape, size, color and elemental composition.[9]

Microbeads collected from New York waters of Lake Erie in 2012.

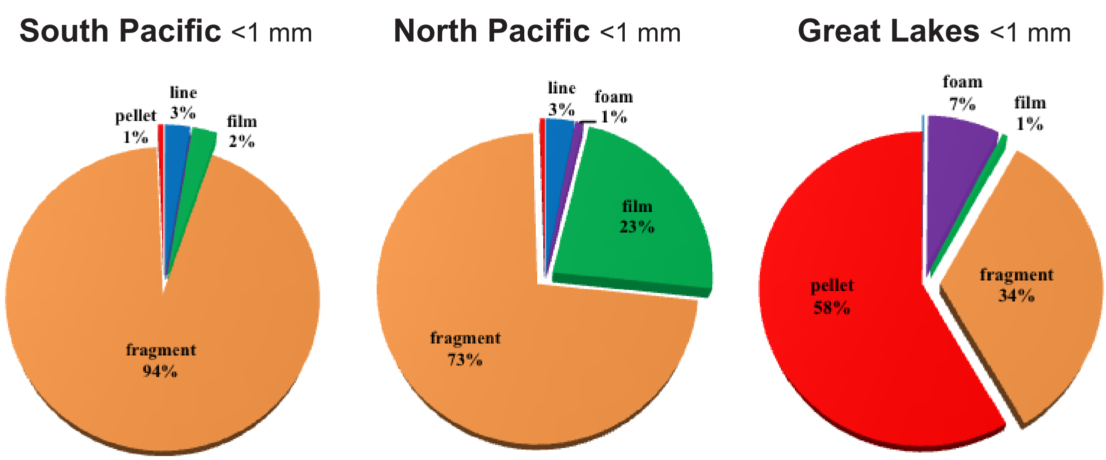
(Photo credit: Dr. S. Mason, SUNY Fredonia)

The concentrations of microplastic from the Great Lakes rivaled the highest concentrations of microplastic collected from the world's ocean garbage patches. A comparison of average and high concentrations from surveys performed across the North Pacific, South Pacific, and North Atlantic subtropical gyres, is presented in the table below. New York's Lake Erie waters accounted for the vast majority of plastic collected in the 2012 Great Lakes survey.

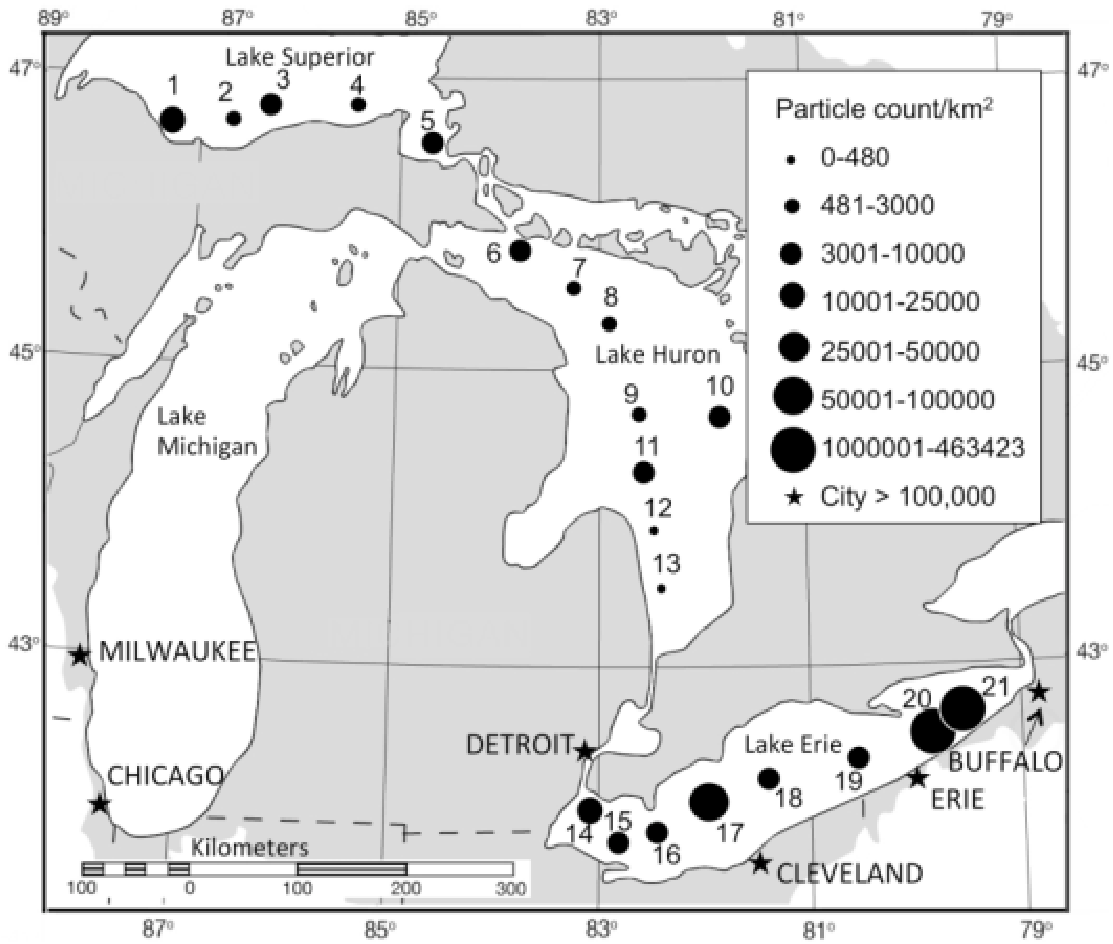
In both the Great Lakes and Pacific gyres, virtually all of the plastic collected was microplastic under 4.75 mm in size. However, as seen the table below, the size of microplastic differed, with most of the Great Lakes microplastic being particularly small—less than 1 mm in size—compared to the Pacific gyres.

Sampling area	Highest concentration (pieces per sq. km)	Average concentration (pieces per sq. km)	Percent microplastic <4.75mm	Percent microplastic <1mm
South Pacific Gyre[10]	396,342	26,898	91%	35%
Great Lakes[11]	466,305	43,157	98%	81%
North Atlantic Gyre[12]	580,000	20,328	n/a	n/a
North Pacific Gyre[13]	969,777	334,271	93%	53%

Microbeads dominated the Great Lakes samples. Fifty-eight percent of all microplastic less than 1 mm collected in the Great Lakes was spherical, compared to less than one percent in both the North Pacific and South Pacific subtropical gyres. Most microplastic less than 1mm in the North and South Pacific subtropical gyres was a fragment (73 percent and 94 percent respectively), as shown in the diagrams below.



To confirm and expand upon their 2012 findings, SUNY Fredonia researchers led surveys in 2013 and collected 91 manta trawl samples from Lakes Michigan, Erie and Ontario. Preliminary results confirm high concentrations of microbeads collected from New York's waters; in the 2013 samples, the abundance of microplastic fragments increased in relation to microbeads, but microbeads continue to be detected in significant amounts. SUNY Fredonia researchers are now examining whether concentrations of microbeads in relation to microplastic fragments are higher in samples taken closer to shore compared to further offshore.[14]



Results of the 2012 Great Lakes sampling survey found the highest concentrations of microplastic in Lake Erie, particularly its New York waters.

(Published in: Eriksen, M., Mason, S., Wilson, S., Box, C., Zellers, A., Edwards, W., Farley, H., & Amato, S. (2013). Microplastic pollution in the surface waters of the Laurentian Great Lakes. Marine Pollution Bulletin, 77, 177-182)

C. The Risks Posed by Microbeads in New York's Waters

Scientists project that plastic can persist in the environment for centuries.[15] Numerous studies have documented the occurrence of plastic debris in the environment and its physical and toxicological effects on aquatic organisms from ingestion. Meanwhile, microplastic concentrations in aquatic environments are increasing rapidly.[16] This accumulation of microplastic is of particular concern because microplastic has the potential to be ingested by a much wider range of organisms than large debris, making it and the chemicals it carries bioavailable throughout the food chain. Additionally, once discharged, there are no known methods to effectively remove microplastics or microbeads from the environment.

Physical Impacts from Wildlife Ingestion

Wildlife of all types and sizes mistake plastic as food and consume it. Hundreds of different species have been documented as ingesting plastics, ranging from tiny creatures,[17,18] to small fish,[19,20] to larger species like birds, turtles and mammals.[21] In the Great Lakes, SUNY Fredonia researchers performing food web surveys are finding plastic in the gastrointestinal tracts of perch.[22]

Ingested plastic causes internal abrasions or blockages resulting in reductions in food consumption, stunted growth, and starvation.[23,24,25,26] Additionally, studies have found microplastics pass from a species digestive tract to its circulatory system,[27] and are physically transferred from prey to predator.[28,29] In mussels, ingestion of plastic pieces so small they are invisible to the naked eye, reduce filter feeding, which could lead to starvation.[30]

Potential for Toxicity

Wildlife ingestion of plastic also presents the potential for toxicity to both the ingesting species and other species higher in the food chain. Harmful chemicals transferred to wildlife from ingested plastic include chemicals added to plastic during manufacturing, and "hydrophobic pollutants" that collect on the surface of the plastic once in either salt or fresh water, such as polychlorinated biphenyls (PCBs), DDT, and polycyclic aromatic hydrocarbons (PAHs).[31, 32,33]

Hydrophobic pollutants are chemicals that when in water preferentially adhere to other substances like plastic or sediment. When these pollutants attach to buoyant microplastic they have greater ability to disperse in lakes, rivers and oceans. Hydrophobic pollutants accumulate in the bodies of animals, are passed on to larger predators, and concentrate up the food chain through a process called biomagnification, eventually contaminating the fish and wildlife species that humans like to eat. These pollutants can lead to a host of health problems including birth defects, cancer, and learning and growth deficits in children. The New York State Department of Health has been tracking many of these pollutants in fish, turtles and waterfowl in New York waters including the Great Lakes, Finger Lakes, Lake Champlain, St. Lawrence River and Hudson River. Concentrations of hydrophobic pollutants in many species remain above protective target levels resulting in consumption advisories, especially for children, pregnant women, and women of childbearing age.

Plastic debris accumulates pollutants such as PCBs (polychlorinated biphenyls) up to 100,000 to 1,000,000 times the levels found in seawater.

- National Oceanic Atmosphere Association, 2011.

Many plastic products contain chemical additives that leach out, especially when exposed to weathering, heat or ultraviolet light.[34] For example, Bisphenol-A, is a chemical additive and a known endocrine disrupting chemical that is banned in certain children products in New York. Endocrine disrupting chemicals produce adverse developmental, reproductive, neurological, and immune effects in both humans and wildlife. They have been linked to a number of common ailments, including heart disease, immune system disruption, brain deterioration, type-2 diabetes, cancer and obesity. They pose the greatest risk during prenatal and early childhood development when organ and neural systems are forming.[35]

Once ingested, microplastics facilitate the transfer of chemicals to some species low on the food chain,[36] where they can be passed on to larger predators. Chemicals from plastic ingestion have also harmed fish[37] and lower trophic organisms.[38,39] Great Lakes scientists are at the forefront of research confirming this toxicological harm in the Great Lakes. Researchers at the University of Wisconsin have verified that microplastic in the Great Lakes is contaminated with films of hydrophobic pollutants, for example, recently measured concentrations of PAH's are approximately twice the levels found on microplastic in the Atlantic Ocean.[40]

> **The newest environmental threat to the Great Lakes is very, very small… Scientists have worried about plastic debris in the oceans for decades, but focused on enormous accumulations of floating junk. More recently, the question of smaller bits has gained attention, because plastics degrade so slowly and become coated with poisons in the water like the cancer-causing chemicals known as PCBs.**
>
> - The New York Times, December 14, 2013

D. Microbeads: Traveling From The Medicine Cabinet to New York's Waters

Plastic Microbead Abrasives in Cosmetics and Personal Care Products

Patented for use in cleansers in 1972, for decades microbead abrasives were rarely used in consumer products and were considered only a minor source of plastic pollution.[41] Starting in the 1990s, manufacturers began replacing more natural materials such as ground almonds, oatmeal and sea salt in personal care products with plastic microbeads,[42] increasing the likelihood of their discharge to New York's surface waters. An ongoing investigation has identified over 100 cosmetics and personal care products containing microbeads in the United States, including those considered over-the-counter drugs.[43]

The Bioré and Clearasil products shown were filtered in a laboratory to determine the presence of microbeads. The products contained plastic microbeads in different quantities and of different sizes, shapes and colors, as shown by the vial of microbeads to the left of each product.

(Photo credit: State of New York, Office of the Attorney General)

Various personal care products and over the counter drugs listing "polyethylene" or "polypropylene" as an ingredient contain plastic microbeads of different sizes, shapes, colors, and quantities. Johnson & Johnson, the maker of the Neutrogena product pictured, has voluntarily committed to phasing out plastic microbeads as an ingredient in its products.

(Photo credit: 5 Gyres)

Microbead shape, size and composition vary. Studies of products containing microbeads found sizes ranging from 0.004 mm to 1.24 mm.[44,45,46] Microbeads are most commonly composed of polyethylene or polypropylene,[47] and are often perfectly spherical in shape, but are also found in irregular shapes.[48]

Overall, the annual per-capita consumption of microbeads from cosmetics and personal care products in the United States is estimated at approximately 0.0309 ounces per person per year.[49] With over 19.65 million people living in New York State[50], this adds up to nearly 19 tons of microbeads potentially being discharged into New York's wastewater stream each year.

As of 2011, the leading companies in the personal-care product and cosmetic market include Procter & Gamble, Unilever, Colgate Palmolive, L'Oréal, and Revlon, as shown in the table below. Once alerted that microbeads contribute to environmental pollution, the top three industry leaders made public pledges to remove plastic microbeads from their product lines.[51] L'Oréal followed up with a pledge to remove microbeads from their products after introduction of Attorney General Schneiderman's Microbead-Free Waters Act.[52] Some companies, such as Burt's Bees,[53] chose never to use plastic microbeads in their products.

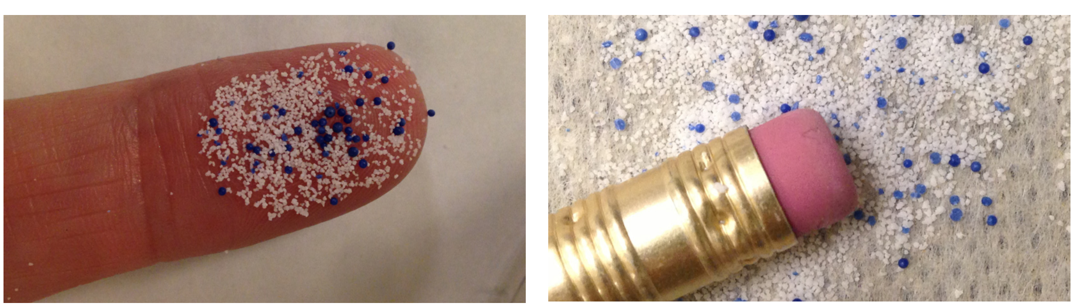
Five Largest Personal-Care Product and Cosmetic Companies as of 2011[54]

Company	Market Share
Procter & Gamble	16%
Unilever	5%
Colgate Palmolive	4%
L'Oréal USA Inc.	3.4%
Revlon, Inc.	2.5%

Most Wastewater Treatment Plants Unable to Prevent Discharges of Microbeads

Cosmetics and personal care products containing microbeads are designed to be disposed of with no possibility of recovery or recycling. Once a product containing microbeads is washed off a person's hands or face, the cleaning agents plus the microbeads are rinsed down the drain and enter wastewater systems. Most wastewater is processed through a wastewater treatment plant, and the ability of a wastewater treatment plant to capture microbeads depends upon its specific treatment capabilities.

Because of their small size and buoyancy, many microbeads escape capture by wastewater treatment plants, which typically filter water through a coarse (greater than 6 mm), or a fine (1.5–6 mm) screen.[55] Subsequently, microbeads in the treated water are discharged to rivers, lakes, or oceans, where they accumulate and persist. Microbeads were found in the effluent of six of seven New York wastewater treatment plants recently sampled by SUNY Fredonia researchers.[56]



Microbeads range in size, but are typically one millimeter or smaller.

(Photo credit: Alliance for the Great Lakes)

Additionally, microbeads in wastewater can also make their way into our waters during combined sewer overflow events. Combined sewer systems collect and transport storm water runoff, domestic sewage, and industrial wastewater in the same pipe, and are a major water pollution concern. During periods of heavy rainfall or snowmelt, the volume of wastewater in a combined sewer system can exceed the capacity of the wastewater treatment plant. When this happens, combined sewer systems discharge excess wastewater containing untreated sewage, industrial waste, pollution and debris directly into nearby water bodies. There are approximately 937 combined sewer overflow outfalls in New York State.

Taxpayers Would Shoulder Costs to Upgrade Wastewater Treatment Plants

Effective wastewater treatment plants are instrumental in keeping our waters clean. However, most of our current wastewater treatment facilities are unable, without potentially costly retrofits, to remove plastic microbeads. For example, the National Association of Clean Water Agencies, the trade group for publicly owned wastewater treatment authorities, has recently classified microbeads as an "emerging contaminant,"[57] defined as a material entering the wastewater stream that treatment facilities are not designed to remove or break down.

As of 2004, New York State Department of Environmental Conservation (DEC) data indicate that there are 610 wastewater treatment plants of various sizes across the state, of which 70% serve small populations and handle less than 1 million gallons of wastewater per day (mgd), while the ten largest plants handle flows greater than 100 mgd.[58]

In order for a wastewater treatment plant to effectively remove microbeads, some form of advanced treatment would be required. Based on the DEC data, about one-third, or 207, of the state's wastewater treatment plants—and only one of the state's ten largest plants—currently use some form of advanced screening or filtration.

For example, DEC data shows that Nassau County predominately relies on thirteen wastewater treatment plants of different sizes and capabilities. The two largest of Nassau's wastewater treatment plants service over 1 million of the total 1.349 million county residents. However neither plant employs advanced treatment that may effectively remove microbeads. This means when the residents of Nassau County unknowingly wash approximately 1.3 tons of microbeads down the drain every year, most are entering plants not equipped to stop them from being discharged into the Atlantic Ocean, Reynolds Channel and other surrounding waters.

In Erie County, population 919,000, residents unknowingly discharge almost one ton of microbeads into the wastewater stream each year. Most Erie County residents' wastewater travels to a local plant for treatment. The largest wastewater treatment plant in the county has the capacity to service 600,000 residents in and around Buffalo. It also does not employ advanced screening or filtration, and its effluent discharges into the Niagara River.

Statewide, the DEC data reveals that within the universe of 610 wastewater treatment plants in New York:

- 23 plants use a fine screen or micro-screen, that may be capable of removing microbeads.
- 175 plants use microfiltration, sand or mixed media filtration, or other type of advanced filtration that may be capable of removing microbeads.
- 9 plants use a combination of an advanced screen technology, and some form of advanced filtration, which together should provide the most effective microbead removal.
- 403 plants use no advanced treatment method likely to effectively remove microbeads from the wastewater stream.

Plant-by-plant studies would be required to 1) determine the efficacy of microbead removal at the 207 plants noted above that use advanced treatment methods, 2) calculate the cost of upgrades needed for any of the 207 plants found to insufficiently capture microbeads, and 3) calculate the cost of upgrades needed to capture microbeads at the 403 remaining wastewater treatment plants.

Reasonable cost estimates for necessary upgrades cannot be made without a technical analysis of feasibility and alternatives performed for each specific facility. The cost to upgrade can vary extensively depending on site-specific factors such as, but not limited to, the existing facility size, existing design and treatment capabilities, potential adaptability to modifications, and specific technology selected for installation.[59]

NYS Wastewater Treatment Plants as of 2004 with Advanced Screens and Filters

Plant Design Size (Gallons/day)	Number	Screen	Filters	Screen + Filter	Percent Using Screen and/or Filter
0-100,000	178	2	82	2	48%
101,000-1,000,000	251	10	63	6	31%
1,001,000-10,000,000	132	9	23	1	25%
10,001,000-100,000,000	39	1	7	0	21%
100,001,000-999,000,000	10	1	0	0	10%

PART 2 – THE MICROBEAD-FREE WATERS ACT – A SOLUTION FOR NEW YORK

"Plastic debris is unsightly; it damages fisheries and tourism, kills and injures a wide range of marine life, has the capacity to transport potentially harmful chemicals… and can represent a threat to human health."

- Scientific and Technical Advisory Panel of the Global Environment Facility, 2011.

"America's plastics makers agree that litter doesn't belong in our oceans, waterways or any part of our natural environment."

- Steve Russell, American Chemistry Council, Vice President of Plastics, February 15, 2013.

"For society to receive the benefits that plastics can provide, it is essential to properly recover them so that litter does not threaten our natural environment, including marine ecosystems. … [We] are firmly committed to the principle that plastics do not belong in the world's oceans…"

- Declaration of the Global Plastics Associations for Solutions on Marine Litter, 2011.

"Unilever has decided to phase out plastic scrub beads from personal care products. This is because we believe we can provide consumers with products that deliver a similar exfoliating perfomance without the need to use plastics. We expect to complete this phase globally by 2015..."

- Unilever, 2013.

A. Scientists and Industry Agree: Plastic Has No Place in Our Waters

Scientists, governments, plastic manufacturers, the personal-care product industry and the public all agree on the fundamental principle that plastic should not litter our lands and waters.[60,61,62,63]

At least 21 companies around the world that produce or carry cosmetics and personal care products have made some level of commitment to phase out microbeads in their products, or not carry products containing them.[64] Global alliances are working to curb the use of microbeads in cosmetics and personal care products, and have been instrumental in securing voluntary commitments from companies to phase out microbeads, as well as in launching smartphone apps allowing consumers to scan products to check for the presence of microbeads.[65]

Policymakers are engaging, both on the international and domestic fronts. Internationally, the Dutch parliament is promoting a European ban on microplastic in cosmetics.[66] Closer to home, the Great Lakes - St. Lawrence Cities Initiative, a binational coalition of over 100 mayors, is calling on companies to phase out the use of microbeads by 2015.[67]

However, with many current industry commitments lacking a phase-out deadline and with many more companies still unresponsive, additional effort is needed to hold the industry to a consistent, protective standard.

B. The Proposal – Ban Microbeads in Cosmetics and Personal-Care Products

Plastic pollution is extensive and long lasting, and New York is committed to preventing the irresponsible release of microbeads into State waters before it occurs.

New York has been a national leader in addressing concerns related to plastic pollution and associated toxic exposure, including enactment of:

- The 2008 Plastic Bag Reduction, Reuse and Recycling Law, which requires retail stores 10,000 square feet or larger to offer a plastic bag recycling option.

- The 2010 Bisphenol A-Free Children and Babies Act, which ended the sale of Bisphenol-A-containing child-care products, such as baby bottles and pacifiers, used by children under three years old.

- The 2013 Returnable Container Act, which expanded the beverage container deposit and collections system to include bottled water, thus increasing plastic recycling quantities.

We can build on this legacy by passing legislation to address the emerging form of plastic pollution threatening State waters—microbeads.

For taxpayers, the Microbead-Free Waters Act represents the most cost-effective approach for eliminating the release of microbeads from cosmetics and personal care products into the environment. The bill is first-in-the-nation bipartisan legislation that would prohibit the sale in New York of any beauty product, cosmetic, or other personal-care product containing plastic less than five millimeters in size.

When they wash their face or brush their teeth, New Yorkers should not have to worry that they may be dumping plastic into the same water they drink, and in which they swim and fish. The Microbead-Free Waters Act will ensure that manufacturers of cosmetics and personal care products quickly phase out the use of plastic microbead abrasives and instead use natural alternatives in their products.

> **"From the Great Lakes to the Hudson River to Long Island Sound, our commitment to protecting and restoring New York's waters is among our most important responsibilities. New York's environmental leadership contines with the introduction of common-sense legislation that will stop the flow of plastic from ill-designed beauty products into our vital waters, preserving our natural heritage for future generations."**
>
> - New York Attorney General Eric T. Schneiderman, February 11, 2014.

- Endnotes –

1. Thompson, R.C., Swan, S.H., Moore, C.J., & vom Saal, F.S. (2009). Our plastic age. *Philosophical Transactions of the Royal Society B*, *364*, 1973–1976.
2. PlasticsEurope. (2013). *Plastics-the Facts 2013: An analysis of European latest plastics production, demand and waste data.* Belgium, PlasticsEurope: Author. Retrieved from http://www.plasticseurope.org/Document/plastics-the-facts-2013.aspx?FolID=2
3. Arthur, C., J. Baker and H. Bamford (Eds). (2009). *Proceedings of the International Research Workshop on the Occurrence, Effects and Fate of Microplastic Marine Debris*. Sept 9-11, 2008. NOAA Technical Memorandum NOS-OR&R-3.
4. Fendall, L. S. & Sewell, M. A. (2009). Contributing to marine pollution by washing your face: Microplastics in facial cleansers. *Marine Pollution Bulletin, 58*, 1225–1228.
5. The 5 Gyres Institute. (2014). Mission Statement. Retrieved from: http://5gyres.org/who_we_are/mission/
6. A garbage patch is a marine area where higher concentrations of litter items can be found compared to other areas of the open ocean. Most of the debris in a garbage patch is small pieces of floating plastic.
7. Gyres are major spirals of ocean-circling currents, occurring both north and south of the equator.
8. Hidalgo-Ruz, V., Gutow, L., Thompson, R.C., & Thiel, M. (2012). Microplastics in the marine environment: A review of the methods used for identification and quantification. *Environmental Science & Technology, 46,* 3060–3075.
9. Eriksen, M., Mason, S., Wilson, S., Box, C., Zellers, A., Edwards, W., Farley, H., & Amato, S. (2013). Microplastic pollution in the surface waters of the Laurentian Great Lakes. *Marine Pollution Bulletin, 77,* 177-182.
10. Eriksen, M., Maximenko, N., Thiel, M., Cummins, A., Lattin, G., Wilson, S., Hafner, J., Zellers, A., & Rifman, S. (2013). Plastic pollution in the South Pacific subtropical gyre. *Marine Pollution Bulletin, 68*, 71-76.
11. Eriksen, M., Mason, S., Wilson, S., Box, C., Zellers, A., Edwards, W., Farley, H., & Amato, S. (2013). Microplastic pollution in the surface waters of the Laurentian Great Lakes. *Marine Pollution Bulletin, 77,* 177-182.
12. Law, K.L., Morét-Ferguson, S., Maximenko, N.A., Proskurowski, G., Peacock, E.E., Hafner, J., & Reddy, C.M. (2010). Plastic accumulation in the North Atlantic subtropical gyre. *Science, 329*, 1185-1188.
13. Moore, C.J., Moore, S.L., Leecaster, M.K., & Weisberg, S.B. (2001). A comparison of plastic and plankton in the North Pacific central gyre, *Marine Pollution Bulletin, 42,* 1297-1300.
14. Mason, S., unpublished data. (State University of New York at Fredonia). Personal communication February 8, 2014.
15. Moore, C.J. (2008). Synthetic polymers in the marine environment: a rapidly increasing, long-term threat, *Environmental Research, 108*, 131–139.
16. Goldstein M.C., Rosenberg M., Cheng L. (2012). Increased oceanic microplastic debris enhances oviposition in an endemic pelagic insect. *Biology Letters* DOI:10.1098/rsbl.2012.0298
17. Setälä, O., Fleming-LehtinenV., & Lehtiniemi, M. (2014). Ingestion and transfer of microplastics in the planktonic food web. *Environmental Pollution, 185,* 77-83.
18. Cole, M., Lindeque, P., Halsband, C., & Galloway, T.S. (2011). Microplastics as contaminants in the marine environment: A review. *Marine Pollution Bulletin, 62*, 2588-2597.
19. Carpenter, E.J., Anderson, S.J., Harvey, G.R., Miklas, H.P. & Peck, B.B. (1972). Polystyrene spherules in coastal waters. *Science, 178*, 749-750.
20. Lusher, A.L., McHugh, M., & Thompson, R.C. (2013). Occurrence of microplastics in the gastrointestinal tract of pelagic and demersal fish from the English Channel. *Marine Pollution Bulletin, 67*, 94–99.
21. Derraik, J.G.B. (2002). The pollution of the marine environment by plastic debris: a review. *Marine Pollution Bulletin, 44,* 842-852.
22. Mason, S., unpublished data. (State University of New York at Fredonia). Alliance for the Great Lakes public presentation April 29,2014.
23. Pierce, K.E., Harris, R.J., Larned, L.S., & Pokras, M.A. (2004). Obstruction and starvation associated with plastic ingestion in a Northern gannet Morus bassanus and a greater shearwater Puffinus gravis. Marine Ornithology, 32, 187–189.

24. Ryan, P.G., & Jackson, S.J. (1987). The lifespan of ingested plastic particles in seabirds and their effect on digestive efficiency. *Marine Pollution Bulletin, 18,* 217–219.
25. Barnes, D. K.A., Galgani, F., Thompson, R.C. & Barlaz, M. (2009). Accumulation and fragmentation of plastic debris in global environments. *Philosophical Transactions of the Royal Society B, 364,* 1985-1998.
26. Wright, S.L., Thompson, R.C. & Galloway, T.S. (2013). The physical impacts of microplastics on marine organisms: A review. *Environmental Pollution, 178,* 483-492.
27. Browne, M.A., Dissanayake, A., Galloway, T.S., Lowe, D.M. & Thompson, R.C. (2008). Ingested microscopic plastic translocates to the circulatory system of the mussel Mytilus edulis (L.). *Environmental Science & Technology, 42,* 5026–5031.
28. Eriksson, C. & Burton, H. (2003). Origins and biological accumulation of small plastic particles in fur seals from Macquarie Island. *Ambio, 32*, 380-384.
29. Setälä, O., Fleming-Lehtinen, V. & Lehtiniemi, M. (2014). Ingestion and transfer of microplastics in the planktonic food web. *Environmental Pollution. 185,* 77-83.
30. Wegner A., Besseling E., Foekema E.M., Kamermans P., & Koelmans A.A. (2012). Effects of nanopolystyrene on the feeding behavior of the blue mussel (Mytilus edulis L.). *Environmental Toxicology and Chemistry 31*, 2490–2497.
31. Sutherland, W.J., Clout, M., Cote, I.M., Daszak, P., Depledge, M. H., Fellman, L., Fleishman, E., Garthwaite, R., Gibbons, D.W., De Lurio, J., Impey, A.J., Lickorish, F., Lindenmayer, D., Madgwick, J., Margerison, C., Maynard, T., Peck, L.S., Pretty, J., Prior, S., Redford, K.H., Scharlemann, J.P.W., Spalding, M., & Watkinson, A.R. (2009). A horizontal scan of global conservation issues for 2010*. Trends in Ecology and Evolution, 25,* 1-7.
32. Velzeboer, I., Kwadijk, C., & Koelmans, A.A. (2014) Strong sorption of PCBs to nanoplastics, microplastics, carbon nanotubes and fullerenes. *Environmental Science and Technology (*Just Accepted Manuscript April 1, 2014).
33. The National Oceanic and Atmospheric Association. (2011). *What We Know About: Plastic Marine Debris*. The National Oceanic and Atmospheric Association: Author. Retrieved from http://marinedebris.noaa.gov/sites/default/fles/Gen_Plastichi_9-20-11_1.pdf
34. Teuten, E. L., Saquing, J.M., Knappe, D.R.U., Barlaz, M.A., Jonsson, S., Björn, A., Rowland, S.J., Thompson, R.C., Gallaway, T.S., Yamashita, R., Ochi, D., Watanuki, Y., Moore, C., Viet, P.H., Tana, T.S., Prudente, M., Boonyatumanond, R., Zakaria, M.P., Akkhavong, K., Ogata, Y., Hirai, H/, Isasa, S., Mizukawa, K., Hagino, Y., Imamura, A., Sha, M., Takada, H. (2009). Transport and release of chemicals from plastics to the environment and to wildlife. *Philosophical Transactions of the Royal Society B, 364*, 2027–2045.
35. New York State Bisphenol A-Free Children and Babies Act.
36. Teuten, E. L., Saquing, J.M., Knappe, D.R.U., Barlaz, M.A., Jonsson, S., Björn, A., Rowland, S.J., Thompson, R.C., Gallaway, T.S., Yamashita, R., Ochi, D., Watanuki, Y., Moore, C., Viet, P.H., Tana, T.S., Prudente, M., Boonyatumanond, R., Zakaria, M.P., Akkhavong, K., Ogata, Y., Hirai, H/, Isasa, S., Mizukawa, K., Hagino, Y., Imamura, A., Sha, M., Takada, H. (2009). Transport and release of chemicals from plastics to the environment and to wildlife. Philosophical Transactions of the Royal Society B, 364, 2027–2045.
37. Rochman, C.M., Hah, E., Kurobe, T. & Teh, S.J. (2013). Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress. Scientific Reports, 3, 1-7.
38. Browne, M.A., Niven, S.J., Galloway, T.S., Rowland, S.J., & Thompson, R.C. (2013). Microplastic moves pollutants and additives to worms, reducing functions linked to health and biodiversity. Current Biology, 23, 2388-2392.
39. Wright, S., Rowe, D., Thompson, R., & Galloway, T.S. (2013). Microplastic ingestion decreases energy reserve in marine worms. Current Biology. 23, 1031-1033.
40. Rios, Lorena M., unpublished data, (University of Wisconsin Superior). Personal communication January 6, 2014.
41. Zitko, V., & Hanlon, M. (1991). Another source of pollution by plastics: skin cleaners with plastic scrubbers. *Marine Pollution Bulletin, 22,* 41–42.
42. Fendall, L. S. & Sewell, M. A. (2009). Contributing to marine pollution by washing your face: Microplastics in facial cleansers. *Marine Pollution Bulletin, 58*, 1225–1228.
43. Plastic Soup Foundation & Stichting De Noordzee. (2014). Retrieved February 12, 2014, from http://beatthemicrobead.org/en/product-lists

44. Fendall, L. S. & Sewell, M. A. (2009). Contributing to marine pollution by washing your face: Microplastics in facial cleansers. *Marine Pollution Bulletin, 58,* 1225–1228.
45. Zitko, V., & Hanlon, M. (1991). Another source of pollution by plastics: skin cleaners with plastic scrubbers. *Marine Pollution Bulletin, 22,* 41–42.
46. Chang, M. (2013). Microplastics in Facial Exfoliating Cleansers. Spring 2013 Environmental Sciences Senior Thesis Symposium. University of California at Berkeley. Retrieved from http://nature.berkeley.edu/classes/es196/projects/2013final/ChangM_2013.pdf
47. The 5 Gyres Institute. (2013). Microplastics in consumer products and in the marine environment. Retrieved from http://5gyres.org/media/5_Gyres_Position_Paper_on_Microplastics.pdf
48. Fendall, L. S. & Sewell, M. A. (2009). Contributing to marine pollution by washing your face: Microplastics in facial cleansers. *Marine Pollution Bulletin, 58*, 1225–1228.
49. Gouin, T., Roche, N., Lohmann, R., & Hodges, G. (2011). A thermodynamic approach for assessing the environmental exposure of chemicals absorbed to microplastic. *Environmental Science & Technology, 45,* 1466-1472.
50. United States Census Bureau. (2013). U.S. Department of Commerce. Retrieved from http://quickfacts.census.gov/qfd/states/36000.html
51. Plastic Soup Foundation & Stichting De Noordzee, (2014). Retrieved February 6, 2014, from http://www.beatthemicrobead.org/en/industry
52. L'Oreal. (2014). "L'Oréal commits to phase out all polyethylene microbeads from its scrubs by 2017." Retrieved February 12, 2014, from http://www.loreal.com/news/loreal-commits-to-phase-out-all-polyethylene-microbeads-from-its-scrubs-by-2017.aspx.
53..Burts Bee's. (2014). Ingredients we never use. Retrieved February 4, 2014 from: http://www.burtsbees.com/Ingredients-We%27d-Never-Use/glossary-neveruse,default,pg.html
54. IBISWorld, (2011). IBISWorld Industry Report 32562 Cosmetic & Beauty Products Manufacturing in the US. Retrieved from http://colgate-palmolive.wikispaces.com/file/view/32562_Cosmetic_%26_Beauty_Products_Manufacturing_in_the_US_Industry_Report%5B1%5D+%281%29.pdf
55. Vesilend, P.A. (Ed.) (2003). *Wastewater Treatment Plant Design*. Virginia, USA. Water Environment Federation: Author.
56. Mason, S., unpublished data. (State University of New York at Fredonia), Personal communication January 13, 2014.
57. Hogue, C. (2013, September 16). Microplastic Beads Pollute Great Lakes. *Chemical & Engineering News,* 91/37 pp. 23-25. Retrieved from http://cen.acs.org/articles/91/i37/Microplastic-Beads-Pollute-Great-Lakes.html
58. New York State Department of Environmental Conservation. (2004). *Descriptive Data of Municipal Wastewater Treatment Plants in New York State*. New York State, Division of Water: Author. Retrieved from http://www.dec.ny.gov/docs/water_pdf/descdata2004.pdf
59. Environmental Protection Agency (1979). *Determining Wastewater Treatment Costs for Your Community.* FRD-9. Publication # 600R79102. Environmental Protection Agency, Department of Water: Author. Retrieved from http://nepis.epa.gov/EPA/html/Pubs/pubalpha_D.html
60. STAP (2011). *Marine Debris as a Global Environmental Problem: Introducing a solutions based framework focused on plastic*. A STAP Information Document. Global Environment Facility. Washington, DC. Retrieved from: http://www.thegef.org/gef/sites/thegef.org/files/publication/STAP%20MarineDebris%20-%20website.pdf
61. American Chemistry Council. (2013, February 15). *Plastics Makers: Litter and Marine Debris are Solid Waste Management Problems.* Retrieved February 4, 2014, from http://www.americanchemistry.com/Media/PressReleasesTranscripts/ACC-news-releases/Plastics-Makers-Litter-and-Marine-Debris-Are-Solid-Waste-Management-Problems.html
62. Global Plastic Association. (2012). *Declaration of the Global Plastics Associations for Solutions on Marine Litter.* Retrieved from http://www.marinedebrissolutions.com/declaration
63. Unilever. (2013). Statement on Sustainable Living: Micro-Plastic. Retrieved January 3, 2014, from www.unilever.com/sustainable-living/Respondingtostakeholderconcerns/microplastics/
64. Plastic Soup Foundation & Stichting De Noordzee.(2014). Retrieved February 6, 2014, from http://www.beatthemicrobead.org/en/industry

65. Plastic Soup Foundation & Stichting De Noordzee. (2014). Retrieved February 4, 2014, from http://beatthemicrobead.org/en/product-lists
66. General Secretariat, European Union. (2013, June 10). Micro-plastic litter: a growing environmental problem – Information from the Netherlands Delegation. Brussels. Retrieved from http://register.consilium.europa.eu/doc/srv?l=EN&t=PDF&gc=true&sc=false&f=ST%2010736%202013%20INIT
67. The Great Lakes – St. Lawrence Cities Initiative. (2013, October 29). Sample letter to Industry. Retrieved February 15, 2014, from http://www.glslcities.org/initiatives/microplastics.cfm

The Office of the Attorney General Attorney General Eric T. Schneiderman produced this report through the Office's Environmental Protection Bureau led by Bureau Chief Lemuel M. Srolovic. The report was prepared by Environmental Scientist Jennifer Nalbone.

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