MICROPLASTICS

Overview of research projects in the NY/NJ Region

Created February 2016

Overview of the issue:

Plastics are synthetic, persistent materials derived from petroleum (crude oil). In recent decades, single-use disposable plastic items have become pervasive, and epitomize a society of convenience that unfortunately has significant ecological costs, especially in aquatic environments. Although difficult to quantify, vast amounts of plastic enters the ocean each year from land-based sources and at-sea sources that is increasing the almost immeasurable volume already circulating around the globe. Plastics in the marine environment have significant environmental and economic consequences, including harm to marine life (entanglement and ingestion), tourism (beach closures due to littered beaches), and navigation hazards (snared propellers, clogged intakes), as well as other negative impacts.

Plastics do not biodegrade; they do not break down into organic constituents that are then re-absorbed naturally into the environment. Existing pieces break down into ever smaller pieces via photodegradation and mechanical abrasion. As such, once plastic is introduced into the environment, it will persist for hundreds of years. The smaller plastics are referred to as microplastics.

Microplastics, plastic pieces < 5 mm in size, are increasingly common in the marine environment. There are two sources of microplastics: 1) manufactured products (primary) and 2) fragments (secondary), the breakdown of larger pieces. Examples of manufactured products include microbeads, industrial raw pellets ('nurdles'), and synthetic filaments from clothing. Microbeads are found in cosmetics and toothpaste, but recent legislation, specifically the Microbead-Free Waters Act of 2015, requires the phase out and prohibition by 2018. [1] The tiny plastic microbeads in personal care products and clothing fragments are often too small for wastewater treatment plant filtration systems to intercept, ending up in waterways and ultimately the ocean. Researchers have documented the accumulation of microplastics in the marine environment for over four decades. [2; 3]

Microplastic particles may have particularly serious health implications for marine life. In the process of degradation, plastic debris releases toxic chemicals used in their production, such as bisphenol A (BPA) and styrene trimer (a liquid hydrocarbon), which have been linked to endocrine disruption. Plastics in the ocean have also been known to attract persistent, bio-accumulating and toxic substances (PBTs), which include polychlorinated biphenyls (PCBs), dioxins, and petroleum based chemicals. [4] These substances may act as endocrine disruptors, mutagens or carcinogens, causing a range of chronic health impacts. Scientists have documented adsorption of PBTs by plastics of all types and sizes in seawater. Marine life may mistakenly ingest these toxic-tainted plastics. [5-10] Once inside an animal's body, plastic pieces may release adsorbed chemicals into the organism, where they can cause serious health impacts or bio-accumulate in tissues to be potentially passed up the food chain. [11-13] More research is needed on the presence, abundance, and effects of microplastics in the marine environment.

EPA Region II - Trash Free Waters Program

The US Environmental Protection Agency (EPA) developed the Trash Free Waters (TFW) Program in 2014 as a means to identify a focused set of actions that support trash prevention and reduction initiatives by many public and private stakeholders. Stakeholders decided to focus TFW initiatives to combat the plastic plague. The group is tackling the issue in the following categories: boxes, microplastics, cigarette butts, bottles, and bags. Along with other projects, the microplastics working group is highlighting research being done in Region 2 with a goal of data standardization.

For more information about getting involved in the TFW program, contact Josh Kogan, TFW Program Coordinator, at Kogan.Joshua@epa.gov. To get involved in the microplastics working group specifically, contact Catie Tobin at education@CleanOceanAction.org.

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[2] Thompson, R.C., Olsen, Y., Mitchell, R.P., Davis, A., Rowland, S.J., John, A.W.G., McGonigle, D., & Russell, A.E. (2004). Lost at sea: where is all the plastic? Science, 304, 838.
[3] Thompson, R., Moore, C., Andrady, A., Gregory, M., Takada, H., & Weisberg, S. (2005). New directions in plastic debris. Science, 310, 1117.
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[8] Von Moos, N., Burkhardt-Holm, P., & Köhler, A. (2012). Uptake and effects of microplastics on cells and tissue of the blue mussel Mytilus edulis L. after an experimental exposure. Environmental Science and Technology, 46, 11327-11335.
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[10] 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.
[11] Teuten, E.L., Saquing, J.M., Knappe, D.R.U., Barlaz, M.A., Jonsson, S., Björn, A., Rowland, S.J., Thompson, R.C., Galloway, 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., Iwasa, S., Mizukawa, K., Hagino, Y., Imamura, A., Saha, 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.
[12] Engler, R.E. (2012). The complex interaction between marine debris and toxic chemicals in the ocean. Environmental Science and Technology, 46, 12302-12315.

Clearwater, Inc.

Established 1966

Who:

Clearwater is an organization dedicating to protecting the Hudson River and its tributaries. Clearwater works to provide innovative environmental education programs, advocacy, and celebrations designed to expand people's experience, awareness and stewardship of this magnificent natural resource. This project was carried out in partnership between Hudson River Sloop Clearwater Inc. and a high school science researcher, Alina Campbell. In 2014, Alina approached Clearwater with an interest in microplastic particulate and discussed pursuing research involving sampling the Hudson River for microplastics with Dave Conover, the Education Director for Clearwater. Conover referred her to Dr. Mason, a Professor of Chemistry at SUNY Fredonia. Alina then travelled to Fredonia, NY to learn processing techniques for surface water samples. As a senior, Alina continues this research and is planning to study Environmental Science in college. With the help of Dr. Mason and Dave Conover, Alina was able to be one of the first to document the abundance of microplastic particulate within the lower Hudson River. In documenting the plastic particles, she also categorized each particle in order to give insight about source and distribution of a plastic type.

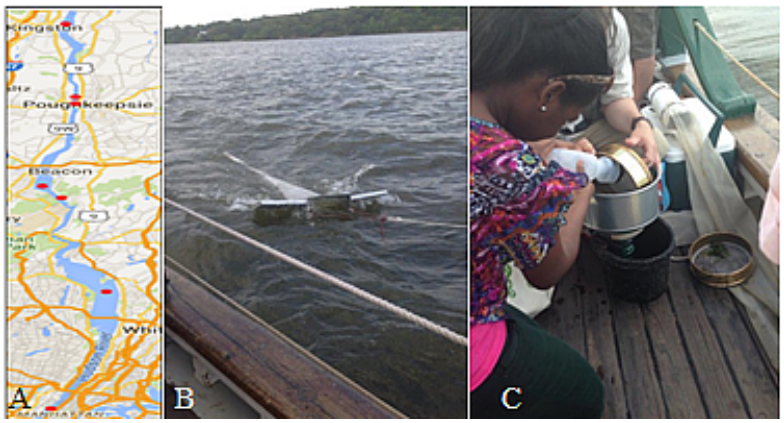
What:

The goals of this study were two-fold: 1) estimate the abundance of microplastic particulate (MP) within the lower Hudson River, and 2) categorize the plastic particles by size and type to identify prominent sources of pollution

How:

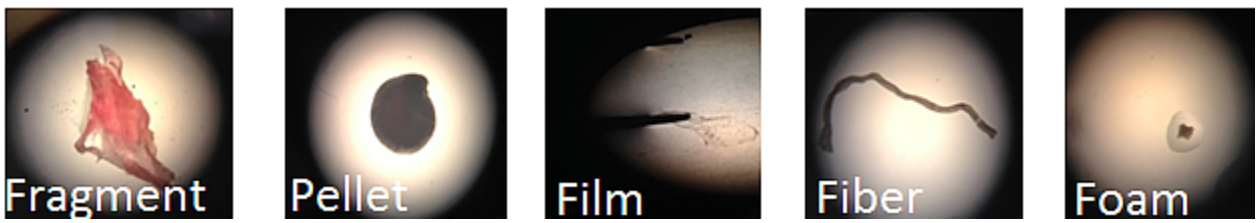
Ten samples were collected at various locations along the lower Hudson River with Clearwater's Sloop, using a 333 µm mesh net known as a manta trawl net. The sample sites spanned between Kingston, NY and New York, NY. This research followed methodology derived from the National Oceanic and Atmospheric Administration (NOAA). In addition this process has also been used in a study by Free et al. in 2014, and is used by Alina's mentor, Dr. Sherri Mason

The plastic particulates was counted using a dissecting microscope. As this occurred, Alina also separated the particulates into three size classes (0.355-0.999mm, 1.000-4.749mm and >4.75mm), and characterized it into five categories (fragment, pellet, film, fiber and foam).



(ABOVE) A) Sampling sites along the lower Hudson River **B)** the manta trawl net device deployed over the Clearwater Sloop, towed along the surface of the water **C)** Alina Campbell with Dave Conover, rinsing the plastic particulate through a sieve into a container

(BELOW left-to-right) An image of the five types of microplastic particles: 1) fragment- hard jagged piece of plastic, 2) pellet- round hard particles of plastic, 3) film- clear/white flimsy planes of plastic, 4) fiber- clear/colored lines of plastic, and 5) foam- sponge-like pieces of plastic

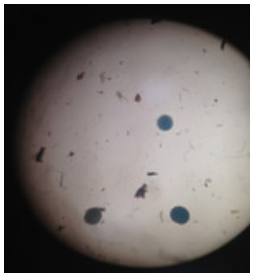


Where:

This study focused on estimating the abundance of MPs in the lower Hudson River, a nutrient rich environment that serves as a nursery for many aquatic organisms. Clearwater and Alina carried out this research with sample sites spanning from Kingston, NY to New York, NY.

When:

Samples were collected between August 2014 to August 2015



(LEFT) A view of microbead pellets (sourcing from personal care items) from a dissecting microscope.

Results:

This study documents MPs to be in an abundance of approximately 3 million particles per square kilometer. 99% of samples were smaller than 1mm in size. Fibers were the largest contributors of MP pollution in the lower Hudson River. The pellets added to personal care products, known as microbeads, were found in high abundance in a study conducted by Eriksen et al. in 2013. However this study found that microbeads comprised only ≈2% of the samples. The data shows that the Hudson River is more polluted, with this study detecting more particulate compared with a study by Free et al. 2014. Research is necessary to gain an understanding of MP abundance within the Hudson River as a whole. Also, future research should involve sampling in other aquatic environments as MP pollution of other habitats remain undocumented. Alina plans to continue this research, and is currently investigating a possible relationship between the wastewater treatment plant proximity and the abundance detected.

Why:

Past research such as Thompson et al. in 2009 and Rochman et al. in 2013 has already established that microplastic particles have been ingested by aquatic organisms. Lusher et al. in 2013 reported MPs to be ingested by fish, mussels, and crab, while supporting the bio-magnification between these organisms. Chua et al. 2014 found that MP contain toxic contaminants that disrupt the function of organisms that ingest it. Also, a study by Claessens et al. in 2011 found that MP pollution has been significantly increasing each year.

Through the Microbead-Free Waters Act, which was passed in December 2015, microbeads are banned from being used in personal care items. However this federal ban does not go into effect until 2018. They are used not only in personal care products such as facial scrub and toothpaste, but also from synthetic fibers in clothing such as pantyhose or fleece-wear. Despite the recent pass of a federal ban against microbeads, there are still additional sources of MPs that need to be addressed. For example, in this study the results show that the synthetic fibers made up most of the samples which suggest that synthetic fibers should not be used, and instead replaced by natural fibers such as cotton and wool.

This research serves as the first documentation of MP pollution in the lower Hudson River. Our study supports the limit in use of synthetic materials (i.e. nylon, polyester). It is important to Alina to inform the public of this issue through community outreach. She was fortunate enough to be able to speak about her research to the public during Clearwater's Festival last June.

(LEFT/RIGHT) Alina Campbell at the Clearwater Festival in June. She was there with Dave Conover and other members of Clearwater, where she spoke to others about her microplastic research.

For more information about this project, feel free to contact Alina Campbell at a.j.campbell@aol.com, David Conover at dave@clearwater.org, or Dr. Sherri Mason at mason@fredonia.edu.

Clean Ocean Action

Established 1984

Who:

Clean Ocean Action (COA) is a nonprofit, ocean advocacy organization comprised of a coalition of 117 groups with a shared mission to improve and protect marine waters of the New Jersey/New York coast. For over 30 years, COA has used a combination of science, education, and citizen action to drive public policy toward a clean ocean. Catie Tobin of Clean Ocean Action and Beth Sharack of the National Oceanic and Atmospheric Administration (NOAA) - James J. Howard Marine Laboratory are serving as Principal Investigators for this study. NOAA has generously provided laboratory space, equipment and materials, and technical expertise.

COA's microplastics research agenda uniquely applies a citizen science approach to microplastics research in New Jersey. Currently, COA is engaging with high school students from the Marine Academy of Science and Technology (MAST) in Monmouth County and college students from the Raritan Valley Community College, as well as citizen volunteers. The students involved are gaining valuable hands-on experience in study design, field sample collection, laboratory processing, and data interpretation as they work to improve the collective understanding of this pressing and ever-growing problem.

What:

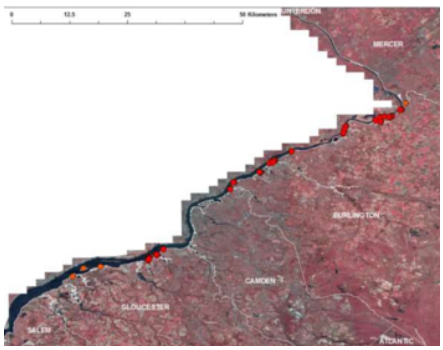
The goal of the research agenda is to establish protocols and document the presence, abundance and impacts of microplastics in New Jersey and promote citizen action in the following phases of investigation:
1) microplastics (less than 5mm) on New Jersey shorelines and in the water, 2) microplastics (less than 5mm), visible to the naked eye on New Jersey shorelines and in waterways , 3) microplastics in the intestinal tract of common ecologically and commercially important marine fishes while working with recreational and commercial fishermen, and 4) adsorption qualities of plastic utilizing spectroscopy techniques (i.e. FT-IR).

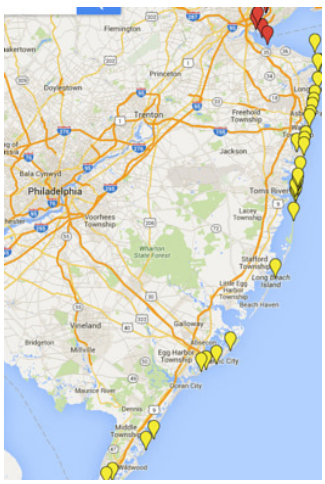
Currently underway is Phase I, which began in 2014 and was the first comprehensive microplastics assessment in New Jersey.

Where:

Phase I is divided by geographic boundaries- coastal water along the Jersey shore and tidal portions of the Delaware River. For coastal locations, COA worked with MAST. Thirty-two sampling locations were selected in New Jersey from the list of over 70 sites included in COA's twice-annual Beach Sweeps a successful and long-running cleanup program. The sites span Monmouth, Ocean, Atlantic, and Cape May Counties and vary in several physical and use characteristics.

For the Delaware River, COA worked with the Raritan Valley Community College to sample sites along the tidal portion of the main stem of the Delaware River from Crosswick's Creek (Mercer County) to the Commodore Barry Bridge (Gloucester County).





(TOP LEFT) Sampling location in Brigantine, NJ
(BOTTOM LEFT) Sampling locations along the Delaware River
(TOP RIGHT) Sampling locations along the coast of NJ

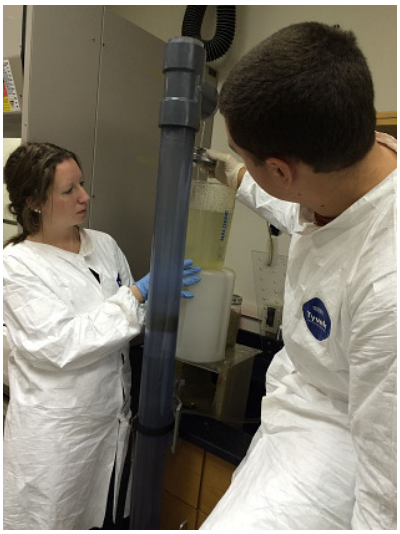
When:

For Phase I, field sampling in the coastal water and beach sand along the Jersey shore occurred from July to October 2014. Data analysis has been ongoing since July 2014 and will wrap up in 2016.

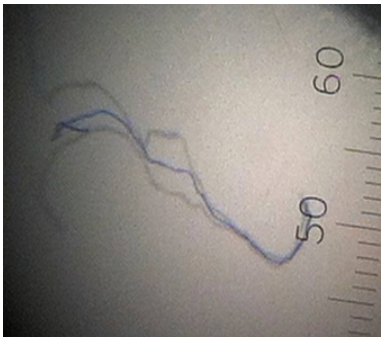
Field sampling within the tidal portions of the Delaware River occurred during the summer of 2015. Analysis has been ongoing since that time and will conclude in 2016.

How:

For Phase I, 96 sand and 96 water samples were collected along the NJ coastal water shoreline and 17 sand and 17 water samples were collected along the Delaware River. Sand samples were collected using a 50 cm x 50 cm quadrat with contents being placed into a 1 liter mason jar. Water samples were collected using 'whole water sampling' methodology with contents being collected in a 1-liter mason jar. Both sets of samples are being processed in a laboratory donated by NOAA. Processing methodology was adapted from Adventurers and Scientists for Conservation in Maine and Ghent University in Belgium. Contents were filtered onto 0.7 micrometer filters, then 0.45 micrometer filters and viewed under the microscope.



(TOP LEFT) Sand sampling methodology
(TOP RIGHT) Student volunteer collecting a water sample
(LEFT) Laboratory sand processing methodology



(LEFT) A blue plastic fiber, found in the sample collected near Asbury Park Convention Hall **(RIGHT)** A clear plastic fragment found in the sample collected near Sea Bright Boro Hall.

Results:

COA is completing the analysis of samples. Results of water samples will be released in June 2016 and beach sand samples in September 2016.

Why:

Researchers have estimated that globally, plastic comprises 60-80% of marine anthropogenic (man-made) debris. [1] This fact is further confirmed by COA's twice-annual Beach Sweeps, which has engaged thousands of volunteers in cleaning up beaches across New Jersey and recording information on the types of trash found, including plastic. Between 2009 and 2013, an average of 80.8% of the marine debris items collected during COA's Beach Sweeps were plastic, much of it in small, unidentifiable pieces. Given the high proportion of collected plastic beach debris, the propensity for plastic to continuously break down into smaller pieces and the increasing evidence of harmful impacts to marine life, COA was inspired to document the presence of microplastics in the New Jersey coastal environment. This research is especially relevant given that microplastic pollution is caused either directly or indirectly by human activity and New Jersey is downstream of the most densely populated area of the United States. Once microplastics presence has been accomplished, COA intends to continue its research into the impacts of microplastics to marine life and importantly, to reduce the sources of these coastal pollutants.

For more information, contact Catie Tobin, education@cleanoceanaction.org. or 732-872-0111.

[1] Derraik, J.G.B. (2002). The pollution of the marine environment by plastic debris: a review. Marine Pollution Bulletin, 44, 842–852.

NY/NJ Baykeeper

Established 1989

Who:

NY/NJ Baykeeper is the citizen guardian of the NY-NJ Harbor Estuary. Since 1989, we've worked to protect, preserve, and restore the environment of the most urban estuary on Earth – benefiting its natural and human communities. Through our Estuary-wide programs we seek to end pollution, improve public access, conserve and restore public lands, restore aquatic habitats, encourage appropriate and discourage inappropriate development, carry out public education, and work with federal and NY/NJ state regulators and citizen groups as partners in planning for a sustainable future for the NY-NJ Harbor Estuary.

NY/NJ Baykeeper's plastic collection research study provides a first look at the quantity, type, and distribution of plastic pollution within NY-NJ Harbor Estuary waters. Project partners include Hudson River Sloop Clearwater Inc., Rutgers University, Five Gyres Institute, SUNY Fredonia, and Monmouth University's Urban Coast Institute.

What:

The goals of the study are to:

- Measure the concentration of plastics and microplastics in NY-NJ Harbor Estuary waters
- Document the sizes and types of plastics found
- Identify local sources of plastic pollution
- Inform NJ and NY lawmakers to influence policy
- Educate members of the public and encourage behavioral changes

(ABOVE) Manta trawl net used for sampling

How:

Eighteen samples were collected in various locations in the NY-NJ Harbor Estuary using a 333-micron manta trawl net designed to collect floatable debris off the water's surface. The net and methodology used is the same protocol used by the Five Gyres Institute and for the work completed by Dr. Sherri Mason in the Great Lakes region. Analysis protocol is derived from the National Oceanic and Atmospheric Administration (NOAA). Plastics present in samples were separated into three size classes (0.355-0.999 mm, 1.00-4.749mm, and >4.75mm), categorized by type (fragment, foam, line, pellet, and film), and finally, counted using a dissecting microscope.

(LEFT TO RIGHT) Contents of a trawl, contents being sieved, a preserved sample before lab processing, and microplastics after lab processing prior to categorizing and counting.

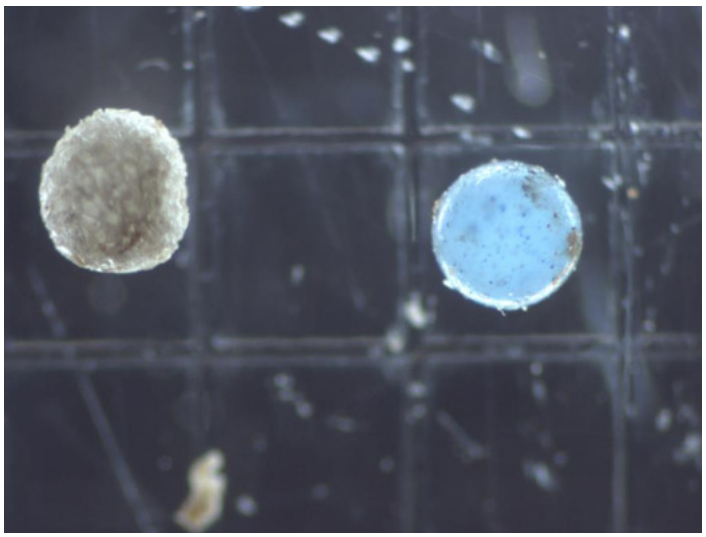
Where:

The NY-NJ Harbor Estuary, one of the most urban estuaries on Earth encompasses the Ports of NY and NJ, as far north as the Tappan Zee Bridge and as far south as Sandy Hook Bay. Sites sampled were selected based on the proximity to combined sewer outfall pipes and included the Lower Harbor near Perth Amboy, NJ, the Passaic River, the Morris Canal, the East River, Newtown Creek, the Upper New York Bay, the Arthur Kill, the Lower Newark Bay, and the Upper Newark Bay.

When:

Sampling was conducted from March to August 2015. Sample analysis was completed in December 2015.

(ABOVE) Starting points of sites sampled **(BELOW)** A blue plastic microbead pictured on the right along with spherical piece of foam, both measuring less than 5mm.



Results:

According to NY/NJ Baykeeper's estimates, at least 165 million plastic particles are floating within NY-NJ Harbor waters at any given time. The average abundance of plastic particles is 256,322 per square kilometer Approximately 85% of particles counted were microplastics (smaller than 5mm) and the average plastic quantity per square kilometer sampled in New York waters was approximately twice the average of New Jersey waters. While these results suggest significant trends, the small sample size of eighteen 30-minute trawls is limiting. More sampling must occur to provide definitive results

Why:

Our world's oceans are expected to contain 1 metric ton of plastic for every 3 metric tons of fish by 2025, and by 2050, more plastics than fish by weight. [1] No one wants to live in a world where this prediction becomes true. Together, we can all make changes to refuse and reduce plastic consumption. Going forward, NY/NJ Baykeeper will collaborate with study partners to continue collecting water column samples, analyze, and compare results. We will analyze what the potential impacts are of microplastics entering the human food web, what the effects of these materials are on the estuary's wildlife, and the interaction between plastic and persistent contaminants of concern in the NY-NJ Harbor Estuary.

For more information , contact Sandra Meola at sandra@nynjbaykeeper.org or 732-888-9870 x7.

[1] Ellen MacArthur Foundation. 2016. The New Plastics Economy: Rethinking the future of plastics. World Economic Forum.