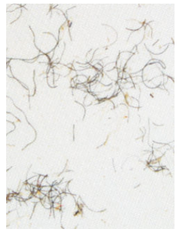
# COMBATING MICROFIBER POLLUTION

*The current state of knowledge, research, and actions across sectors to address a growing threat to ocean and human health*

## WHAT ARE MICROFIBERS?

Microscopic strands (less than 5mm long) of synthetic and natural textile fibers that are shed during product life cycles and end up in our oceans and other ecosystems.



Source: Patagonia

## STATE OF KNOWLEDGE

Microfibers have been found in global oceans, rivers, agricultural soils, marine and freshwater animals, and products sold for human consumption.

Clothing is a prominent source of microfiber pollution, but carpet, upholstery, toiletries, and other products also shed fibers that can enter the environment.

Clothing and other textiles can shed thousands of fibers every wash cycle.

Microfibers have a unique shape and associated chemicals, and can attract pathogens and pollutants throughout their life cycle.

## EMERGING SOLUTIONS & NEXT STEPS

- Several new products aim to capture clothing fibers in the wash.
- Regulators are evaluating options to compel companies to reduce and/or effectively manage microfiber pollution.
- Stakeholders across sectors are increasingly collaborating to better understand and address the problem.

## MAJOR KNOWLEDGE GAPS

Which products, materials, manufacturing processes, and life cycle phases contribute the most to microfiber pollution?

What effects do microfibers and their associated chemicals have on ecosystem, animal and human health?

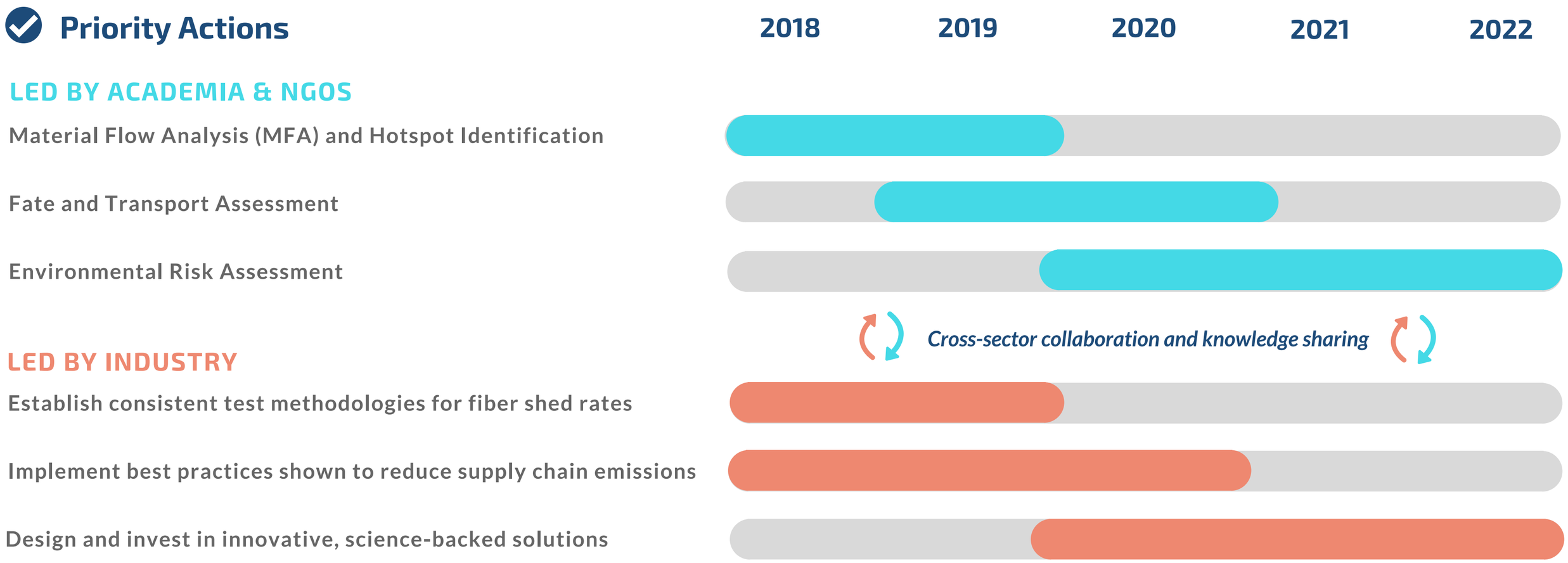
How do microfiber emissions to the environment and transport pathways vary around the world?

Can we design products that don't shed fibers and/or processes to remove microfibers that have already entered the environment?

***There is a strong need for additional research, testing, and innovation that improves our understanding of microfiber pollution and its impact on human and environmental health.*** *In October 2017, a group of academic, NGO, corporate and regulatory leaders came together in Santa Barbara, California to discuss ways to accelerate efforts to address this challenge. The roadmap below summarizes priority actions identified by the group.*

# MICROFIBER ACTION ROADMAP

*Priority actions that key stakeholders should take over the next five years to systemically understand and address microfiber pollution, from source to sea*




**Learn more:** http://bit.ly/microfiberaction

**Produced by:** Ocean Conservancy; Bren School of Environmental Science & Management, University of California, Santa Barbara; F500 Future 500

# Microfiber Leadership Summit – Summary

*Advancing Science-Based Solutions That Prevent Environmental Contamination*

Convened by: Ocean Conservancy | Bren School of Environmental Science & Management, University of California, Santa Barbara

Additional support from: Outdoor Industry Association – Together We Are a Force; F5 Future 500

## Executive Summary

**Why** | The ubiquity of microfibers in the environment and in seafood has caught the attention of scientists, policy-makers, industry and the public. A team of industry, scientists, and non-governmental organizations (NGOs) saw an opportunity to lead and work collaboratively to close knowledge gaps and explore ways to mitigate sources of microfiber emissions and their potentially negative effects on humans, animals and the environment.

**What** | A multi-stakeholder workshop to share knowledge about the state of microfiber science and potential solutions, and to explore ways to accelerate collective understanding of the issue and collaborate to reduce emissions.

**When** | October 17-18, 2017

**Where** | University of California, Santa Barbara

**Who** | 50+ representatives from leading companies, universities, non-profits and government agencies.

## Issue Background

Estimations of total global plastic production to date are around 8.3 billion metric tons, with only a small fraction recycled or incinerated. The rest is still in use, or remains in landfills or the environment. Plastic debris of all sizes, shapes and types has accumulated in our environment over time.

Today, plastics, including microplastics (particles <5 mm in diameter), are found in a diversity of habitats and animals throughout the world's oceans, lakes and rivers. Microfibers (synthetic and natural textile fibers less than 5mm in length) are one of the most common types of microplastic debris found in the environment. They are ubiquitous, and have been found in samples from headwater streams, rivers, soils, lakes, sediments, ocean water, the deep sea, wildlife, arctic sea ice, seafood, table salt and most recently drinking water. Such widespread exposure raises concern about potential effects to wildlife and human health.

While current knowledge regarding effects is limited, new research demonstrates that microfibers can alter the feeding behavior, energy budgets, and survival of individual marine animals. Still, we have much to understand about the effects of microfibers in the environment. Microfibers have a distinct shape from other microplastics, and may be associated with a unique suite of chemicals from manufacturing and via accumulation from air or water. Microfibers may expose these chemicals to wildlife, and their shape may cause effects that differ from other microplastics. While industries, NGOs, regulators, researchers and other stakeholders work to understand the risks associated with microfiber pollution and exposure, it is also critical to determine sources to reduce emissions.

There are likely many sources of microfibers to the environment, one of which is clothing. Many studies have demonstrated that clothing made from synthetic textiles (e.g. polyester, acrylic, polypropylene, polyamide and polyethylene) shed microfibers in the wash. Shedding varies between fabrics and materials, but researchers have shown that some garments can shed thousands of microfibers during a single wash. While most microfibers can be captured in the sewage sludge at wastewater treatment

plants (WWTPs), WWTPs are rare in developing countries and many fibers can nonetheless be released directly to the aquatic environment in the final effluent. Where sewage sludge is applied to land as fertilizer, microfibers may reach surface waters via soil erosion or storm water runoff.

While the majority of microfiber research and discussion to date has focused on fiber shedding in the wash, there is little existing research regarding potential emissions in the apparel supply chain, during other phases of product use (e.g. wearing clothing) or at end-of-life. Significant uncertainty also remains regarding emissions from non-apparel textile sectors, such as carpet manufacturing, home goods, hospitality, personal care products, tobacco, and health care.

Meanwhile, global regulators and other organizations are examining microfiber pollution with a growing sense of urgency. With textile brands and suppliers facing increasing pressure to reduce microfiber emissions and examine potential health risks, a diverse array of stakeholders is needed to help advance research and craft solutions that are systemic, science-based, and effectively balance the needs of the environment and society.

## Summit Objectives

Recognizing the growing need for collective dialogue and action to address microfiber pollution, Ocean Conservancy and the Bren School of Environmental Science & Management elected to organize a multi-stakeholder Microfiber Leadership Summit in October 2017. With additional support from Future 500 and the Outdoor Industry Association, these host organizations invited members of industry, academia, government, and the non-profit sector to gather and exchange knowledge and ideas around the following questions:

1. What is the state of the science on microfiber pollution sources, sinks and impacts on human and environmental health?
2. What are existing and emerging solutions to the problem?
3. What are the major knowledge gaps, and which should be prioritized?
4. What are key actions and next steps moving forward, including advancing research and maturing solutions?

Based on the exchanges, the primary objectives of the meeting were to:

- Coalesce current knowledge around microfiber pollution,
- Draft an action-oriented roadmap to help guide future research and innovation for participants and other stakeholders, and
- Forge relationships towards implementing the roadmap and future collaboration.

## Summit Overview

Summit participants included representatives from the apparel, outdoor, chemical and white goods sectors; consultants with expertise in environmental systems and testing methodologies relevant to the microfiber life cycle; academics from leading universities and research institutions; government representatives considering regulations to address microfiber pollution; and non-profits seeking opportunities to reduce microfiber emissions and impacts.

During the Summit, invited speakers first summarized the state of the science around microfibers and highlighted new and proposed solutions. As a group, participants then brainstormed, discussed, and prioritized key knowledge gaps and processes critical to systemically understanding and addressing

microfiber pollution. Finally, Summit attendees plotted potential steps and action items group members could take – both collectively and individually – toward addressing identified priorities.

## The State of the Science

Four initial presentations by leading academics and industry representatives provided an overview of the state of scientific research and understanding around microfiber pollution. Broadly, the speakers discussed what is known about the sources, fate and effects of microplastics, and specifically microfibers. In addition, the speakers highlighted known research gaps they feel are critical to address.

### Microfiber Sources

*Current knowledge*:

- An estimated 400 million metric tons of plastic are produced each year. Synthetic fibers for textiles are estimated to make up about 15% of this total. The most commonly produced synthetic textile is polyester, accounting for approximately 83 percent of total production; followed by polyamide, polypropylene, and acrylic at 9, 4, and 2 percent, respectively.
- There are many sources of microfiber emissions to marine, freshwater and terrestrial environments. Clothing degradation is a regularly cited source of microfiber emissions to the environment, but it is not the only source. Other sources of synthetic microfibers include, but are not limited to, carpets, upholstery, cigarette filters, woven and non-woven fabrics in personal care products and toiletries, and wet wipes. Microfibers from natural sources are also found in the environment, and their sources include cotton, silk, wool, cashmere, and hemp.
- Clothing and other textile materials (e.g., blankets) have been shown to shed microfibers during the laundering process. Studies suggest that <0.1% of a material is lost during each wash cycle, which can equate to thousands of emitted fibers per garment. When microfibers shed in the washing machine, they are transmitted into the effluent that travels to wastewater treatment plants (WWTPs), septic systems or directly into the environment.
- Microfibers are emitted to the environment via wastewater treatment plants (WWTPs). Some microfibers that enter a WWTP will be emitted to the environment with the final effluent, and the remaining fibers settle into the sludge and may enter the environment when sludge is land-applied.

*Gaps in scientific understanding*:

- The total amount of annual microfiber emissions to the environment, and the relative contributions of various identified sources (e.g. percent of microfiber emissions stemming from apparel vs. other sources like carpet and upholstery);
- Potential geographic variations in microfiber emissions;
- The shed rates of different materials in different applications, where within the product life cycle the majority of microfiber emissions occur (e.g. manufacturing, use, end-of-life), and how shed rates vary as materials age;
- For laundered textiles, how washing methods and conditions (e.g. front-loading, top-loading, hand washing, temperature, and detergents) may affect shed rates, and if the drying process might also be a source of microfiber emissions to the environment;

### Microfiber Fates

*Current knowledge*:

- Microfibers have been found in a diverse array of natural environments, including agricultural soils, marine habitats from the surface of the ocean to the deep sea, and in lakes, rivers and Arctic ice.
- During surveys of microplastic pollution, microfibers are often one of the most frequent types of microplastic identified.
- Microfibers are commonly found in marine and freshwater animals, sometimes at relatively high concentrations compared to other types of microplastics.
- Microfibers have been identified in fish, shellfish, sea salt and drinking water for human consumption.

*Gaps in scientific understanding*:

- The relative contributions of various microfiber transport pathways (e.g. WWTPs versus atmospheric deposition, industrial emissions or storm water runoff).
- Microfiber transport processes among diverse habitats and animals, including transport from ocean surface to seafloor, trophic transfer, and if biodegradation occurs.

### Microfiber Effects

*Current knowledge*:

- Micro*plastics* can impact animals at many levels of organization, including cellular, organismal, and population.
- Microfibers have a different shape than many other types of microplastic, and often are associated with a distinct mixture of chemicals used during the fiber and product manufacturing processes.

*Gaps in scientific understanding*:

- The physical and chemical impacts of microfibers compared to microplastics in general.
- The extent to which microfibers impact aquatic and terrestrial ecosystems and human health.
- The effects of additive and sorbed chemicals associated with microfibers in aquatic environments and seafood.

## Existing and Emerging Solutions

Five Summit participants – one from a non-profit, one academic researcher, two apparel sector experts, and one independent inventor – provided an overview of solutions that have been proposed to reduce microfiber pollution. The presentations and subsequent discussion mostly focused on technologies that can capture microfibers released in the washing machine during laundering, so that fewer fibers escape in the effluent that goes to the WWTPs.

Technologies discussed included the Cora Ball produced by the Rozalia Project, the Lint-LUVR filter developed by Environmental Enhancements, and lint catchers currently used in washing machines in Japan. Initial testing, presented at the Summit, found that the Cora Ball and Lint-LUVR reduce microfibers in washing machine effluent by 26% and 86%, respectively. In Japan, where dryers and their associated lint traps are less common, most washing machines are sold with an included lint filter. While performance data related to microfibers is still limited, mesh lint filters in Japan have been shown to reduce up to 93 percent of the lint (i.e. microfibers) in the wash.

The Summit presenters acknowledged the limited breadth of existing microfiber solutions. Concerns and opportunities raised in the subsequent group discussion included:

- The challenges associated with solutions that require consumer behavior change (e.g. requiring consumers to empty a washing machine filter, and the risk of similar impacts if the lint was dumped down a sink drain);
- The need to better understand microfiber sources so that R&D resources can be most efficiently directed toward appropriate products and sectors;
- The importance of materials innovations for some products that can improve durability and reduce shed rates;
- The opportunity to more broadly implement known/existing industry best practices (e.g. Operation Clean Sweep) that would also potentially reduce microfiber emissions;
- The pros and cons of potential solutions that target different "choke points" in the textile supply chain (e.g. manufacturing waste, consumer use and laundering, WWTP capture, end-of-life product disposal), and the likely need for a multi-faceted solutions set;
- The dearth of technologies available to recover or mitigate microfibers already present in aquatic and terrestrial environments.

## Moving forward

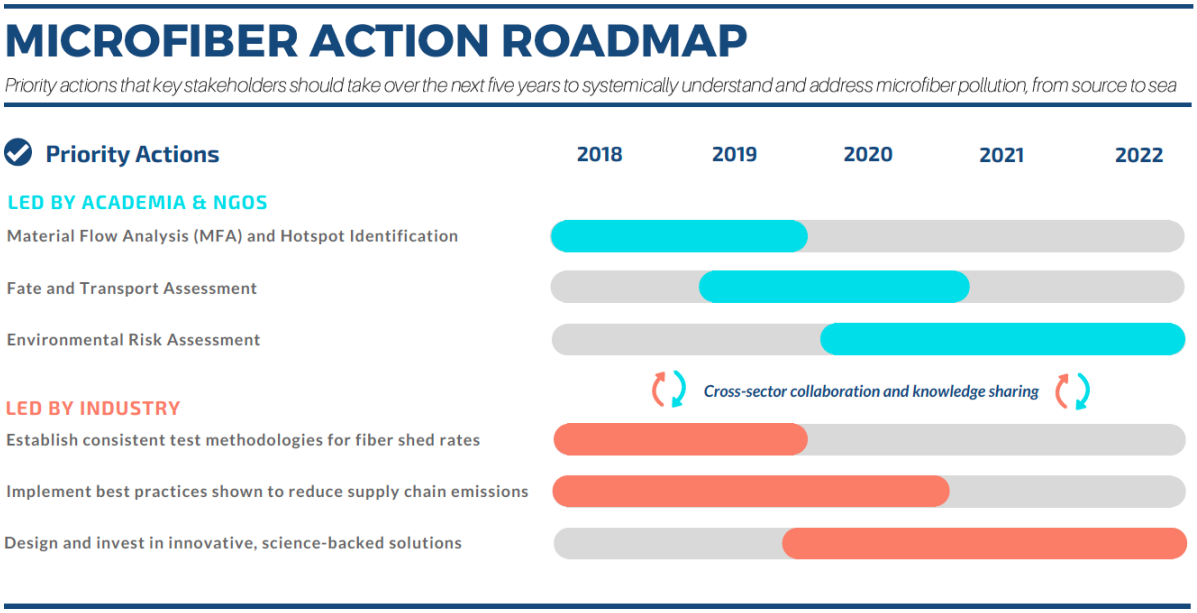
After establishing a shared understanding of the state of microfiber science and solutions, Summit participants engaged in breakout brainstorming sessions to identify the most pressing opportunities for stakeholders to work together to advance our understanding of microfiber emissions, flows and impacts and begin to mitigate the issue. An initial list of over thirty questions, knowledge gaps and innovation goals was created; this list is currently being distilled and will be circulated at a later date.

Through a voting-plus-discussion process, Summit participants ultimately honed in on five actions that microfiber stakeholders – including both those in the room and other organizations – should prioritize to most rapidly improve collective understanding and reduction of microfiber emissions to the environment:

1. **Develop a shared lexicon and unified strategy for communicating about microfibers and associated collective actions.** Participants agreed that industry, NGOs and academia should work together to mitigate the challenges of microfibers in the environment based on robust, peer reviewed science. Neither exaggeration nor down-playing of the risks associated with microfiber pollution will serve the public. Hence, stakeholders should strive to develop a unified strategy for communicating about microfibers that is based on the most up to date scientific information, and that can be used to inform the public on the state of our understanding, work plans, and expected timelines for completion.

   As a first step toward executing this action, Summit participants drafted a Microfiber Action Roadmap (see Figure 1 below) to plot priority needs and research by academia, industry and other stakeholders. This Roadmap is intended to be used to communicate with internal organizational leadership, policy-makers, industry peers, the concerned public and other stakeholders, and to assert that Summit participants and their organizations – *committed leaders* on microfiber issues – are listening, progressing research that will inform innovation and solutions, and exploring actions and best practices aimed at reducing the problem across supply chains and geographies. The complete Roadmap and supporting documents can be found at http://bit.ly/microfiberaction.

**FIGURE 1 – Microfiber Action Roadmap**




2. **Establish consistent test methodologies for measuring microfiber shed rates from textiles and other materials.** A consistent test methodology not only allows industries and researchers to communicate the key metrics of microfibers on a common basis, but also provides opportunities for innovation by helping identify best practices and determining which new material designs and production processes reduce shed rates.

   The American Association of Textile Chemicals and Colorists (AATCC) and ASTM International are currently developing wet and dry shed testing standards, respectively, with input from some Summit participants and members of industry. While these standards may not be officially finalized for three to five years, draft methods should be available within a year. Summit participants agreed that apparel and other textile industries should strive to adhere to and widely dissemminate this draft standard, while also offering feedback. This proactive implementation and subsequent consistency of metrics will maximize the ability of microfiber stakeholders to assess microfiber emissions and sources, share knowledge, and identify best practices for suppliers and brands.

3. **Improve collective understanding of the stocks and flows of microfibers throughout the life cycle of various products and materials**. Academic, NGO and industry stakeholders agreed that more accurately quantifying the sources and leakages of microfibers from the production, distribution, use, and end-of-life of microfiber-generating materials and products at regional and global scales is of critical importance to efficiently and effectively addressing microfiber pollution.

   A material flow analysis (MFA) was identified as an optimal means for examining this knowledge gap from the top down. An MFA is a quantitative method used to determine the stocks and flows of materials through a defined system. It can help estimate the sources, pathways, and sinks of a material across geographies and economies. In the context of microfibers, an MFA would help stakeholders determine which industries, regions, and products contribute to global emissions and their relative contribution, and help identify leakage points for microfibers geographically and along

the supply chain from industrial facilities to the consumer to product end-of-life. Ultimately, this information can be used to identify and develop solutions to prevent microfiber emissions during production, use and at end-of-life.

Several academic researchers volunteered to take the lead in progressing this research. After securing sufficient funding, an initial estimate of microfiber emissions and flows across products and geographies could likely be completed in one to two years. The researchers emphasized that this process could likely be accelerated if industry members were willing to anonymously share data related to sales, production volumes and supply chains.

Participants agreed that the MFA process should be complemented by bottom-up measurements of where microfibers are present in aquatic, airborne and terrestrial environments. Methods for analyzing microfibers in environmental samples such as soil, water, and sediments will need to be summarized and compared, highlighting the best methods for reliable estimates of microfiber concentrations according to fiber material. While no collective effort was identified to progress this bottom-up approach, it is likely to be an imminent area of work by several Summit participants.

4. **Assess the risks of microfiber pollution – both the physical particles and associated chemicals – to humans and ecosystems using a Risk Assessment (RA) framework**. Participants emphasized that microfiber solutions and mitigation efforts could be better prioritized through improved understanding of what concentrations and in what conditions microfibers are harmful to humans and ecosystems. A risk assessment framework can help tackle these questions, beginning with hazard identification and characterization (e.g. microfiber toxicity, bioaccumulation, biomagnification and biotransformation) as well as exposure assessment, and then using this information to characterize potential risks to target subjects. This will then guide the level of reduction measures – how intensive measures are required to be in reducing the emissions.

   A risk assessment for microfibers is an enormous task not easily accomplishable by even a few core research groups. Nonetheless, the process need not be completed before valuable insights can be shared with microfiber stakeholders. As a first step, several Summit participants committed to work toward identifying a) a core team of experts that have the necessary expertise to work on the assessment and b) an external group of advisors to advise on each step of the RA process, beginning with a hazard assessment. After securing additional project participants, the group will begin by defining objectives, types of microfibers to assess (synthetic and natural), and the risk assessment framework and methods to be used.

   Establishing a core team and defining objectives is anticipated to take three to six months. Similar to the MFA, an initial hazard assessment would likely take one to two years to complete. More robust analyses could then be conducted over time as the weight of evidence builds. Importantly, because a risk assessment essentially pick up where the MFA stops, it will be crucial that RA project leads work closely with MFA participants. Collectively, these projects will dramatically improve global understanding of microfiber sources, transport, fate and effects, and may help provide better quantitative goals for emission reductions and management.

5. **Identify existing industry best practices that can be rapidly implemented to minimize microfiber emissions throughout the supply chain**. The research goals identified above will take time. While researchers strive to build a heavier body of science-based evidence for effectively tackling microfiber pollution, industry members and their allies have a potentially significant role to play by

expanding the use of well-established operational practices known to reduce contaminant emissions to the air, land and water bodies. Using methods designed to mitigate human and environmental exposure to other contaminants throughout textile supply chains, industry members can likely identify existing processes likely to also reduce microfiber pollution, and then strive to expand their implementation.

Several Summit participants expressed interest in supporting this process by a) identifying likely microfiber release points across supply chains, including manufacturing plants, consumer use and from wastewater treatment, and b) identifying existing environmental, health and safety processes present at these release points likely to reduce microfiber emissions. An end product of this effort might be a publicly available inventory of microfiber reduction best practices for textile manufacturers (e.g. similar to Operation Clean Sweep), distributors, washing machine manufacturers, other industries, and consumers. As the scientific knowledge base improves, microfiber stakeholders will strive to measure the effectiveness of these best practices and adapt the list as necessary based on new data.

## A path to success

Microfiber Leadership Summit participants came together efficiently and enthusiastically, with a shared concern about microfiber emissions and a commitment to action. Diverse stakeholders worked together to develop a roadmap for such action, and expressed strong support for future collaborative efforts to address the problem. The actions identified above, and complementary actions likely to emerge in the months to come, present explicit opportunities for leadership and offer a compelling roadmap for tackling this issue at scale.

Going forward, we are optimistic about the ability of participants and their peers to help fill research gaps, use evidence to inform solutions, and leverage existing knowledge to reduce emissions via best practices. We welcome new and broader expertise from all sectors and are hopeful that our path forward will lead to successful outcomes with shared benefits for industry, people and the planet.

In the months ahead, the Summit Organizing Committee will strive to develop explicit additional opportunities for collaboration and collective action, and will reach out to Summit participants and other stakeholders with opportunities to forward the actions outlined above. In the interim, this document, the Microfiber Action Roadmap, and other supporting documentation can be found at http://bit.ly/microfiberroadmap. Thank you for your engagement on this important issue.