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# Status of Legislation and Regulatory Drivers for Microplastics in California

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Microplastics are pervasive in the environment, with biological communities exposed to microplastics particles on a continuous basis. Although health risks of microplastics exposure are poorly understood, microplastics have the potential to bioaccumulate through food webs, to serve as an exposure pathway for other contaminants that have stuck to them, and – in the case of smaller microplastics – to translocate into tissues and organs. To comprehensively assess exposure risks, scientists first need to build a foundational understanding of their occurrence and fate in the environment. California is at the forefront of international efforts to vet, standardize and implement measurement techniques that will become part of routine management monitoring. A long legacy of regulatory actions on trash pollution of all kinds has optimally positioned California to serve in this leadership role, including development of the nation's first TMDL (total maximum daily load) regulatory actions to reduce trash in waterways, as well as numerous trash source-control measures. In 2018, the California State Legislature passed a pair of bills that require the State to develop microplastics management strategies for both drinking water and California's coastal ocean. The legislation has become a call to action for the international scientific community to develop clear, actionable recommendations supporting California's microplastics management strategy. Already, a yearlong study has been launched to compare and evaluate various methods and instruments for measuring microplastics levels in water, sediment and tissue matrices. The study will pave the way for California to craft comprehensive, science-informed approaches for effectively managing microplastics in diverse aquatic systems.

## Introduction

Numerous studies in recent years have put a spotlight on the pervasiveness of microplastics in the environment. Microplastics have been documented in waterways, in the ocean, in food and drinking water, in the atmosphere, in rain and snow.[1] A wide variety of industrial and consumer goods - from pharmaceuticals to synthetic fabrics - contains microplastics; furthermore, larger plastics break down over time into smaller microplastic particles. Plastic pollution is growing at an exponential rate. Every minute, the equivalent of one garbage truck's worth of plastic escapes into the environment.[2] Although about 14% of all plastic produced worldwide is collected for recycling, plastic pollution is expected to triple by 2060 in the absence of management intervention.[3] The exponential accumulation of microplastics in aquatic environments is a growing management concern. Both wet- and dry-weather runoff are responsible for funneling vast quantities of microplastics into the coastal ocean and other water bodies.[4] Microplastics also can evade wastewater treatment processes and get discharged into the coastal ocean and other water bodies.[5]

Although the health implications of microplastics exposure are poorly understood, both terrestrial and aquatic biological communities are being exposed on a continuous basis. Animals ranging from tiny ocean filter feeders to humans are inadvertently absorbing, breathing and consuming microplastics.[1] Furthermore, many animals cannot distinguish microplastics from food, creating the potential for satiation challenges.[6] Once microplastics enter food webs, they can bioaccumulate and ultimately end up in sportfish consumed by humans and wildlife.[7] Compounding the bioaccumulation challenge is that chemicals and pathogens can stick to microplastics, creating a potential exposure pathway for multiple types of contaminants.[8] Finally, emerging research shows that the smallest microplastics can penetrate cell membranes and translocate into tissue and organs; however, little is known about what health risks these microplastics may pose.[9]

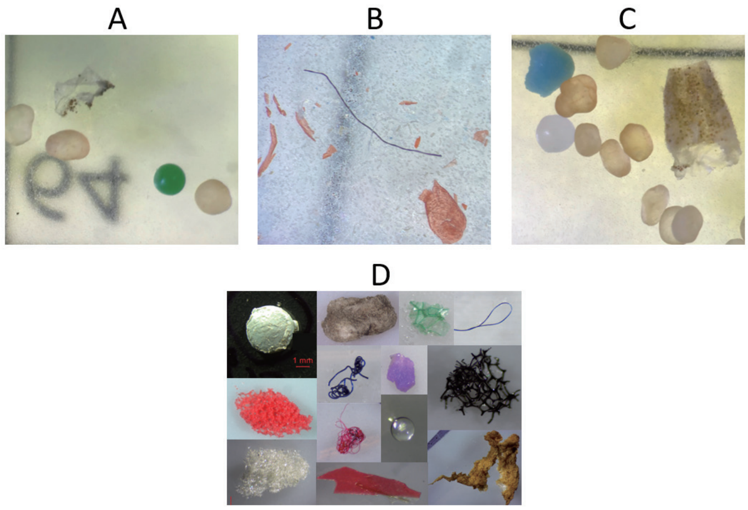


Figure 1 Microplastics are found in various shapes, sizes, colors, and polymer types in the environment. Plastic particles can be difficult to distinguish visually under a light microscope from natural particles (A-C), and may require confirmation of material type using more powerful instrumentation. (A) Microplastic spheres appear similar in shape and size to sand particles; in this case, they are differentiated by color. (B) A dark blue plastic fiber appears next to undigested pieces of fish tissue. (C) Although some microparticles are obviously plastic (blue fragments), other particles could be white sand or gelatin, and may require further spectroscopic identification. (D) Microplastic particles include spheres, fragments, fibers, foams, pellets, film, and fiber bundles. (Photos courtesy of Southern California Coastal Water Research Project Authority and C.M. Rochman, University of Toronto)

A foundational challenge of assessing health risks from microplastics exposure is that many microplastics are difficult to measure and track in the environment. Although microplastics are typically defined as any plastic particle less than 5 millimeters in diameter, the vast majority of microplastics in the environment are so small that they can only be seen with the aid of a light microscope or even more powerful instrumentation.[10] These smaller microplastics can be difficult to distinguish - visually and/or sometimes spectroscopically - from non-plastic particles with similar physical and chemical characteristics, creating the potential for either under- or over-estimation.[11]

To comprehensively assess the health risks of microplastics exposure, scientists first need to define what constitutes a microplastic particle, so they can focus on developing methods to optimally measure this form of pollution. Although scientists have studied microplastics since the 1960s,[12] international consensus has not yet been reached on a definition.[13] Unlike most-water quality contaminants that are typically dissolved, microplastics are particles with defined solubility, size, shape and chemical composition criteria that are found in various possible combinations in the environment.[14] In June 2020, the California State Water Resources Control Board (State Water Board) adopted an official definition of microplastics for its drinking water program: “Solid polymeric materials to which chemical additives or other substances may have been added, that have at least three dimensions that are greater than 1 nanometer and less than 5,000 micrometers.” Polymers that are derived in nature that have not been chemically modified (other than by hydrolysis) are excluded under this definition.[15] The adopted definition considers the vast diversity of microplastics found in the environment, and is likely to serve as a foundation - or at least departure point - for additional agencies and organizations that must define microplastics.[16] Finally, the adopted definition may evolve over time with the science.

Scientists will use this agreed-upon definition of microplastics to build a foundational understanding of the occurrence and fate of these pollutants in the environment. By building comprehensive, high-quality data sets, California will gain critical, baseline knowledge of realistic exposure scenarios. However, assembling these data sets will be a challenge, as microplastics monitoring programs are still in their infancy. Even in drinking water systems - where dozens of chemical contaminants are monitored - microplastics are not one of the contaminants that are routinely tracked.[17] Furthermore, monitoring data are not necessarily comparable even among the monitoring programs that do exist, as different programs use different, competing microplastics monitoring and analysis methods. The broader scientific community has not yet vetted any of these experimental laboratory measurement methods or reached consensus on how to standardize them.

## California as an international leader on trash management

California is emerging at the forefront of international efforts to vet and standardize microplastics measurement techniques. Not only is California evaluating the performance of the various methods used to identify and quantify microplastics, but the State is working to build capacity to begin monitoring microplastics in water, sediment and tissue. This foundational work will pave the way for scientists to begin reliably measuring and tracking microplastics levels and types in aquatic environments - and ultimately generate the high-quality, comprehensive data sets needed to inform human and ecological health risk assessments.

A long legacy of regulatory actions on trash pollution of all kinds has optimally positioned California to step into an international leadership role in developing capacity to monitor microplastics in aquatic environments. For decades, California has been taking forward-thinking, decisive regulatory actions to curb the entry and spread of trash in the environment, as well as to manage and mitigate the health risks of trash.[18] Much of this work has been borne out of necessity - a consequence of California's population density and the ecological and economic importance of the state's many natural resources. Initially, California's focus was on eliminating macro-sized trash generated by those who frequent beaches and other recreational water bodies. Beachgoers, boaters, anglers and businesses have been targeted with strict anti-littering laws, public education initiatives and outreach campaigns.

Then, in the mid-1990s, the Los Angeles Regional Water Quality Control Board led the state - and the nation - in dramatically rethinking how to curb trash entering waterways.[19] Instead of regulating trash loading one municipality at a time, the L.A. Regional Board placed multiple key waterways in the region on the federal 303(d) list of water bodies with known water-quality impairments. This action enabled the water-quality agency to issue a regulatory target for trash known as a total maximum daily load (TMDL); the TMDL compels the many municipalities and other entities that discharge runoff into these waterways to reduce trash loading. TMDLs for trash have subsequently been issued in other parts of California and beyond.

About 15 years later, seeking to build comparable regulatory infrastructure at a statewide level, the California State Water Resources Control Board amended the master plans that govern management of California's coastal ocean and freshwater systems to include trash as a water-quality impairment. Similar to the L.A.-area trash TMDLs, the State's "Trash Amendments" - which went into effect in 2016 - compel agencies that discharge runoff in areas with high trash-generating rates to either begin installing devices at storm drain inlets to capture all particles larger than 5 mm, or develop an alternate plan for capturing trash at equivalent rates.[20]

As it has become increasingly clear plastic pollution makes up the majority of aquatic trash, California also has targeted plastic pollution specifically. In 2014, California voters approved a statewide ban on carry-out plastic bags at grocery stores and pharmacies.[21] The law went into effect two years later, following an unsuccessful referendum to overturn the ban. In 2018, California passed a law requiring sit-down restaurants to only distribute single-use plastic straws to customers upon request;[22] it went into effect the following year. In enacting these laws, California was not just concerned about entanglement issues as organisms come into contact with these macro-sized plastic particles; California also was cognizant that much of this plastic will break down over time to become microplastics.[23]

Finally, California has taken action to regulate the production of microplastics themselves. In 2008, California enacted strict regulations[24] on facilities that manufacture, handle and transport pre-production plastic pellets, which are particles a few millimeters in diameter that serve as the raw materials for plastic production; these particles can spill and become lost during transport. Subsequently, in 2015, California enacted a ban on the sale of personal care products that contain plastic microbeads.[25] Comparable federal microbeads legislation was passed just months later; California's microplastics bead ban took effect in January 2020.

## Developing a comprehensive microplastics management strategy

Even as California has implemented numerous regulatory mechanisms to slow the introduction and spread of microplastics in aquatic environments, the State also is laying a scientific foundation to assess the health risks associated with exposure. In 2018, the California State Legislature passed a pair of bills that require the State to begin building microplastics management strategies for both drinking water and California's coastal ocean and estuaries:

- Senate Bill 1422 requires the California State Water Resources Control Board to develop plans for measuring microplastic particles in drinking water by 2021.[26]
- Senate Bill 1263 requires the California Ocean Protection Council to adopt and implement a

statewide strategy for lessening the ecological risks of microplastics to coastal marine ecosystems, especially through research and policy changes.[27]

The State laws are notable for their prescriptiveness and specificity, even in environmentally progressive California. Both laws lay out priority actions, along with deadlines, and explicitly call on two State agencies to take responsibility for executing California's microplastics management priorities. Embedded in each legislative mandate is the need for improved scientific understanding of how microplastics exposure affects both humans and marine organisms, and how much microplastics exposure, if any, is too much.

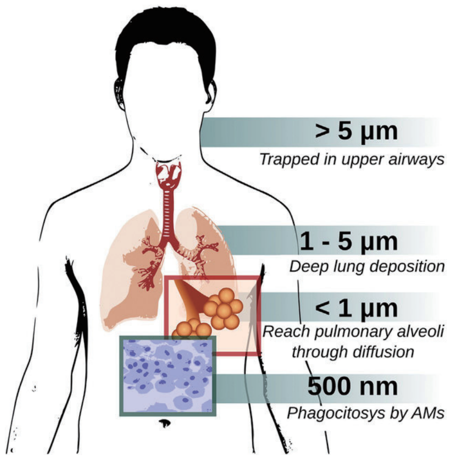


Figure 2 Like other airborne pollutants, microplastic particles can travel deep into the human body.[28] Scientists are just beginning to document the health effects associated with continuous microplastics exposure. (Figure from Costa et al. 2016[29], reprinted with permission)

As a direct result of the 2018 laws, California has been propelled to the forefront of microplastics research. The pair of laws has made it clear that California intends to immediately adopt, use, and incorporate microplastics science into action and policy. Thus, the 2018 legislation has become a call to action for the international scientific community: Develop clear, actionable recommendations that provide a scientific foundation for California's microplastics management strategy. Meanwhile, scientists recognize that as California goes, so tends to go the rest of the nation. Microplastics measurement laboratories and water-quality managers across the U.S. may follow California's lead - adopting California's regulatory framework for managing microplastics in aquatic systems, and designing routine microplastics monitoring programs based on California's.

Already, California is at the center of an international, year-long study to compare and evaluate various methods and instruments for measuring microplastics levels in water, sediment and tissue matrices. The study's goal is to compare and standardize the many overlapping, experimental approaches that have been developed by microplastics researchers - and variations of these lab methods - to quantify and characterize microplastics levels. The study is being coordinated by the Southern California Coastal Water Research Project Authority on behalf of the State Water Resources Control Board and the California Ocean Protection Council.

More than 35 leading microplastics research labs worldwide have signed onto the study. Each participant will be sent blind samples containing known quantities of microplastics. They will use a variety of methods and instruments to quantify the microplastics in the samples, and

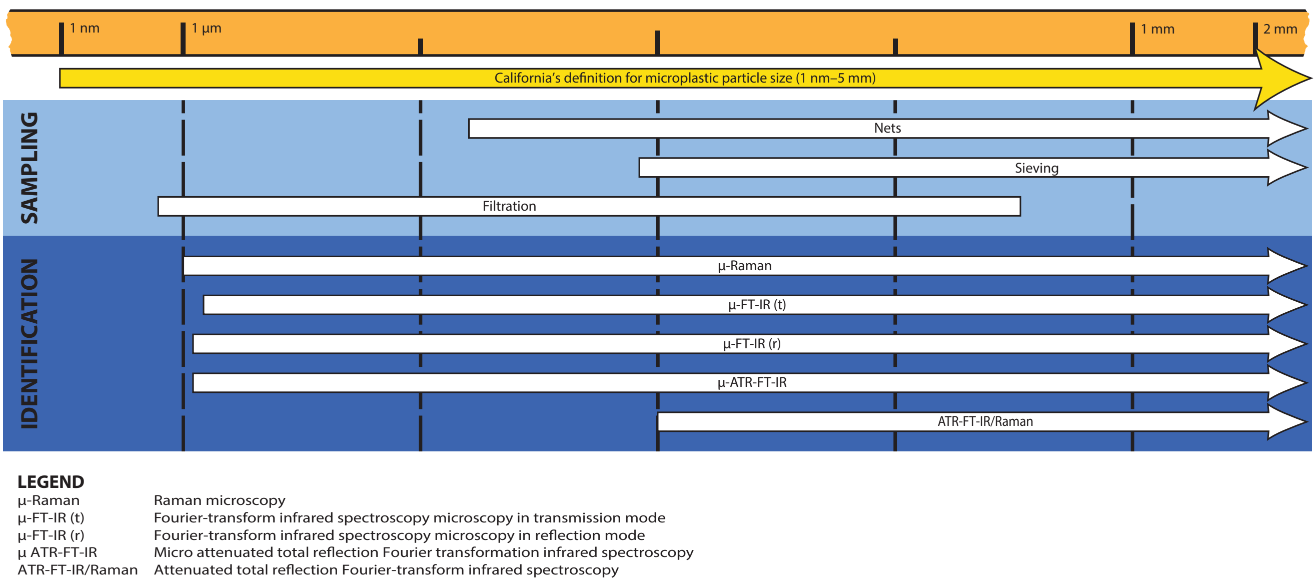


Figure 3 Various methods have been developed for sampling and identifying microplastic particles in the environment; they are designed to measure particles of different sizes.[30-34] California's adopted definition for microplastics encompasses all plastic particles that have at least three dimensions between 1 nm and 5 mm.

compare performance of the various methods and instrumentation; the end goal is to develop recommendations about which methods and which variations of methods produce the most reliable, repeatable, accurate results. HORIBA is among the study's partners, helping to lead training for study participants on the use of Raman spectroscopy, a leading candidate instrument for quantifying microplastic particles so small they can't be distinguished from non-plastics under a light microscope.

California's microplastics measurement methods study is expected to be immediately consequential, resulting in a dramatic consolidation of the nascent microplastics measurement field. The study also will provide clarity to state and federal agencies around the world about how to generate comparable, high-quality data. Finally, the standardized measurement methods are expected to be codified into laboratory accreditation standards. California's Environmental Laboratory Accreditation Program (ELAP), which is charged with overseeing the quality of all environmental data used for decision-making, will create a laboratory inspection process that includes development of performance evaluation samples. Laboratories that collect microplastics data for California will be required to participate in this process.

Ultimately, the foundational R&D work scoped out in the 2018 legislation will help California build capacity to monitor and ascertain the health risks from microplastics exposure. By making it possible for managers to reliably measure microplastics in water, sediment and tissue, and know that data are of high quality and comparable, California stands poised to develop a comprehensive, science-informed strategy for effectively managing microplastics in both drinking water and diverse aquatic ecosystems.

* Editorial note: This content is based on HORIBA's investigation at the year of issue unless otherwise stated.

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