# Breaking Down the Plastic Age

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Plastic materials have only been mass-produced for roughly 60 years, but nearly all aspects of our daily lives now involve plastics. Plastics are versatile, light, durable, and inexpensive materials that can be shaped to almost any form imaginable. While these are valuable characteristics, the exponential increase in the production and use of "disposable" plastic items has environmental consequences on a global scale. Plastics have been found in the air, soil, fresh water, seawater, deep-sea sediments, and sea ice. They are recognized as new habitat for organisms. Concerns about plastics are mounting due to their effects on organisms, economies, and human wellbeing. Conventional plastics are persistent materials that accumulate in the environment since they cannot be easily mineralized. Over time, larger items fragment in to smaller pieces. These small fragments currently outnumber larger, more visible pieces of plastic debris in the environment. This is particularly problematic because as it decreases in size, plastic pollution becomes increasingly difficult to

**MICRO 2016. Fate and Impact of Microplastics in Marine Ecosystems.**

remove from the environment and is more accessible for organisms to ingest, with largely unknown impacts.

Microplastics are generally defined as pieces of plastic debris $<5$ mm in size. They enter the environment either as primary or secondary microplastics. Primary microplastics—plastics manufactured in the microplastic size range—include: industrial abrasives, exfoliants, cosmetics, and preproduction plastic pellets. Secondary microplastics result from larger plastic items breaking down into smaller and smaller fragments.

MICRO 2016, the first international conference on microplastics, was held in the Biosphere Reserve of Lanzarote, Canary Islands, Spain. The MICRO 2016 Organizing Board and Scientific Committee brought together representatives from 30 research institutions and organizations. Following seminars in Plouzané, France in 2014 and Piran, Slovenia in 2015, MICRO 2016 summarized current knowledge and identified gaps and new questions. These were shared in the Lanzarote Declaration, released June 21, 2016 (see supplementary materials for full program and the Lanzarote Declaration).

The Lanzarote Declaration stems from previous regional, national, and international efforts such as: The London Convention (1972); the Barcelona Convention (1976); the MARPOL Convention (1978); the East Asian Seas Action Plan (1981); the Abidjan Convention (1984); the Cartagena Convention (1986); Bâle Convention (1989); the OSPAR Convention (1992/1998/2002/2005/2006/2007); the Northwest Pacific Action Plan (1994); the Nairobi Convention (1996); EU Water Framework Directive (2000); the Teheran Convention (2003); EU Marine Strategy Framework Directive (2008); the Honolulu Commitment (2011); the Manila Declaration (2012); the Mediterranean Regional Plan on Marine Litter (2014); and the G7 Leaders' Declaration (2015).

The 46 members of the Scientific Committee issued the Lanzarote Declaration on behalf of 632 researchers represented at the MICRO 2016 conference. The Declaration includes the following highlights from the scientific and technical research findings presented during MICRO 2016:

- Microplastics are found everywhere that has been investigated in the world, including the most remote parts of the earth (e.g., Compa et al., Russell et al., Frias et al., Martin et al., Palatinus et al., Hazimah et al., Nel et al., Naidoo et al., Reisser et al., Schoeneich-Argent et al., Buceta et al., Hajbane et al., van der Hal et al., Aytan et al., Chubarenko et al., Chouinard et al.). Though less studied, they are also present in fresh water, the atmosphere and terrestrial environments.

- Aquatic biota feeding grounds overlap with waters containing high levels of microplastic pollution. For example, this has been demonstrated for fin whales (*Balaenoptera physalus*) in the northwestern Mediterranean Sea (Fossi et al.) and inferred for marine mammals stranded in Ireland (Lusher et al.), sea turtles in Northern Cyprus (Duncan et al.), sea turtles in the Canary Current (Ostiategui et al.), and seabirds (e.g., Hidalgo-Ruz et al., Kühn et al.).
- Microplastics are ingested by many species, and the risk of transfer to humans has been shown for some commercial species such as fish (e.g., Pattersen et al., Scholz-Böttcher et al., Budimir et al.), mollusks, and crustaceans. Seaweed is also a demonstrated vector for microplastics (Gutow et al.). The potential consequences of microplastics in seafood is a growing concern and emerging research topic.
- Recent studies have confirmed that macro- and microplastics can be degraded into nanosized plastic particles, tens of microns in size or even smaller, with widely unknown impacts. Nanoplastic pollution will potentially be of significant importance in years to come.
- Very small microplastics or nanoplastics carrying chemicals or additives may be able to cross cell membranes and may enhance chemical bioavailability and stimulate toxic effects (e.g., Booth et al., Mintenig et al.).
- Runoff has been robustly demonstrated as a significant microplastic pathway, particularly road runoff in populated areas (e.g., Horton et al.). Several studies confirm sewage sludge as a pathway of microplastic pollution, highlighting the need for further studies and actions focused on sewage treatment plants and the urban water cycle (e.g., Maes et al., Mahon et al., Dris et al., Murphy et al., Crawford et al., Quinn et al.).
- While microorganisms will colonize any surface in seawater, new results confirm plastisphere microbial communities and provide site-specific insight into these communities and their successional changes over time (e.g., Gundry et al.).
- Modeling is clearly a fundamental and complementary tool for identifying microplastic sources, distribution paths, and potential sinks (e.g., van Sebille et al., Sanchez-Arcilla et al., Palatinus et al.).
- In order to integrate data across various studies and ongoing projects, we must: (1) standardize the identification and measurements of

microplastics (e.g., Gerdts et al., Fischer et al.); and (2) explicitly describe the techniques and methods currently used in ongoing, nonstandardized studies.

- Citizen science contributes to microplastics sampling and monitoring (e.g., Barrows, Boertien et al., Galgani et al.). Outreach and education efforts to raise awareness about microplastics in marine environments and increase ocean and plastic literacy help connect the general public with the issue of microplastics (e.g., Clusener-Godt et al., Jimenez et al., Ruckstuhl et al., Silva et al.).
- Perceptions and representations can be changed through science communication (e.g., Pahl et al., Jorgensen).
- Professional and citizen science efforts need to be standardized and harmonized, keeping in mind the importance of documenting the co-benefits of citizen science and the need for standardized databases and interfaces to share the results of citizen science work.
- Working to prevent and mitigate macro- and microplastic pollution can provide co-benefits beyond pollution reduction and environmental integrity, such as improving human health and wellbeing (e.g., Wyles et al.).
- Technological solutions such as improving recycling processes and developing nonharmful material degradability are needed, along with cautious exploration of natural biodegradable materials.
- With growing evidence of environmental consequences and potential threats to human health, we must consider the levels of responsibility governments and industries have for the impacts of microplastics.
- There is a need to maintain and improve the link between ongoing research and policy efforts at national and international levels, such as the EU Marine Strategy Framework Directive, OSPAR, NOWPAP, MEDPOL, etc.
- Immediate actions are needed and possible.

These findings and other material shared at MICRO 2016 (see supplementary materials for full program and references) demonstrate the profound concern of the scientific community regarding microplastics, which are clearly impacting the biosphere.

As microplastics continue accumulating in the environment, the scientific community must join forces to expand our knowledge horizons. Doing so requires collaboration and cooperation, at all scales, from local to global, spanning sectors and disciplines, to improve knowledge, education, and outreach efforts. This should not delay action.

As representatives of the scientific community, we urgently call upon the general public, policymakers at all levels, mediators, the media, educators, NGOs, entrepreneurs, and the private sector to move from assessment and knowledge to immediate action.

With the Lanzarote Declaration, we recognize our responsibility as individuals to change our behaviors related to plastic production and consumption, and to inform others of the social, cultural, economic, and environmental implications highlighted at MICRO 2016. The Lanzarote Declaration also serves as a milestone in working constructively as a research community to help stem the rising tide of plastics in the environment.

The MICRO community is engaging the challenge to work collaboratively. One reflection of this commitment will take place every two years in the form of an international conference, a forum to share available knowledge, fill in gaps, and establish new commitments for implementing solutions.

*Microplastics in Lanzarote, Famara Beach, May 2016.*