REPORTS AND STUDIES

90

GESAMP

Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection

# SOURCES, FATE AND EFFECTS OF MICROPLASTICS IN THE MARINE ENVIRONMENT: A GLOBAL ASSESSMENT

IMO FAO UNESCO IOC WMO UNIDO IAEA UN UNEP UNDP

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# SOURCES, FATE AND EFFECTS OF MICROPLASTICS IN THE MARINE ENVIRONMENT: A GLOBAL ASSESSMENT

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Cover photo: Microplastic fragments from the western North Atlantic, collected using a towed plankton net.


**Notes:**

GESAMP is an advisory body consisting of specialized experts nominated by the Sponsoring Agencies (IMO, FAO, UNESCO-IOC, UNIDO, WMO, IAEA, UN, UNEP, UNDP). Its principal task is to provide scientific advice concerning the prevention, reduction and control of the degradation of the marine environment to the Sponsoring Agencies.

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# Contents

# EXECUTIVE SUMMARY

Society has used the ocean as a convenient place to dispose of unwanted materials and waste products for many centuries, either directly or indirectly via rivers. The volume of material increased with a growing population and an increasingly industrialized society. The demand for manufactured goods and packaging, to contain or protect food and goods, increased throughout the twentieth century. Large-scale production of plastics began in the 1950s and plastics have become widespread, used in a bewildering variety of applications. The many favourable properties of plastics, including durability and low cost, make plastics the obvious choice in many situations. Unfortunately, society has been slow to anticipate the need for dealing adequately with end-of-life plastics, to prevent plastics entering the marine environment. As a result there has been a substantial volume of debris added to the ocean over the past 60 years, covering a very wide range of sizes (metres to nanometres in diameter). This is a phenomenon that has occurred wherever humans live or travel. As a result there are multiple routes of entry of plastics into the ocean, and ocean currents have transported plastics to the most remote regions. It is truly a global problem.

The GESAMP assessment focuses on a category of plastic debris termed 'microplastics'. These small pieces of plastic may enter the ocean as such, or may result from the fragmentation of larger items through the influence of UV radiation. Section 1 provides an introduction to the problem of microplastics in the marine environment, and the rationale for the assessment. The principal purpose of the assessment is to provide an improved evidence base, to support policy and management decisions on measures that might be adopted to reduce the input of microplastics to the oceans. The GESAMP assessment can be considered as contributing to a more formal Assessment Framework, such as the Driver-Pressure-State-Impact-Response (DPSIR) Assessment Framework, which is introduced in Section 2.

The nature of man-made polymers, different types and properties of common plastics and their behaviour in the marine environment are introduced in Section 3. There is no internationally agreed definition of the size below which a small piece of plastic should be called a microplastic. Many researchers have used a definition of $<$5 mm, but this encompasses a very wide range of sizes, down to nano-scales. Some microplastics are purposefully made to carry out certain functions, such as abrasives in personal care products (e.g. toothpaste and skin cleaners) or for industrial purposes such as shot-blasting surfaces. These are often termed 'primary' microplastics. There is an additional category of primary particle known as a 'pellet'. These are usually spherical or cylindrical, approximately 5 mm in diameter, and represent the common form in which newly produced plastic is transported between plastic producers and industries which convert the simple pellet into a myriad of different types of product.

The potential physical and chemical impacts of microplastics, and associated contaminants, are discussed in detail in Section 4. The physical impacts of larger litter items, such as plastic bags and fishing nets, have been demonstrated, but it is much more difficult to attribute physical impacts of microplastics from field observations. For this reason researchers have used laboratory-based experimental facilities to investigate particle uptake, retention and effects. Chemical effects are even more difficult to quantify. This is partly because seawater, sediment particles and biota are already contaminated by many of the chemical substances also associated with plastics. Organic contaminants that accumulate in fat (lipids) in marine organisms are absorbed by plastics to a similar extent. Thus the presence of a contaminant in plastic fragments in the gut of an animal and the measurement of the same contaminant in tissue samples does not imply a causal relationship. The contaminant may be there due to the normal diet. In a very small number of cases, contaminants present in high concentrations in plastic fragments with a distinctive chemical 'signature' (a type of flame retardant) can be separated from related contaminants present in prey items and have been shown to transfer across the gut. What is still unknown is the extent to which this might have an ecotoxicological impact on the individual.

It is recognized that people's attitudes and behaviour contribute significantly to many routes of entry of plastics into the ocean. Any solutions to reducing these sources must take account of this social dimension, as attempts to impose regulation without public understanding and approval are unlikely to be effective. Section 5 provides an opportunity to explore issues around public perceptions towards the ocean, marine litter, microplastics and the extent to which society should be concerned. Research specifically on litter is rather limited, but useful analogies can be made with other environmental issues of concern, such as radioactivity or climate change.

Section 6 summarizes some of the main observations and conclusions, divided into three sections: i) sources, distribution and fate; ii) effects; and, iii) social aspects. Statements are given a mark of high, medium or low confidence. A common theme is the high degree of confidence in what we do not know.

The assessment report concludes (Section 7) with a set of six Challenges and related Recommendations. Suggestions for how to carry out the recommendations are provided, together with a briefing on the likely consequences of not taking action. These are divided into three Action-orientated recommendations and three recommendations designed to improve a future assessment:

Action-orientated recommendations:

- Identify the main sources and categories of plastics and microplastics entering the ocean.
- Utilize end-of-plastic as a valuable resource rather than a waste product.

- Promote greater awareness of the impact of plastics and microplastics in the marine environment.

Recommendations for improving a future assessment:

- Include particles in the nano-size range.
- Evaluate the potential significance of plastics and microplastics as a vector for organisms.
- Address the chemical risk posed by ingested microplastics in greater detail.

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