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MARINE MICROPLASTIC TIPPING POINTS

A Science-Policy Interface to Identify Risks and Inform Action

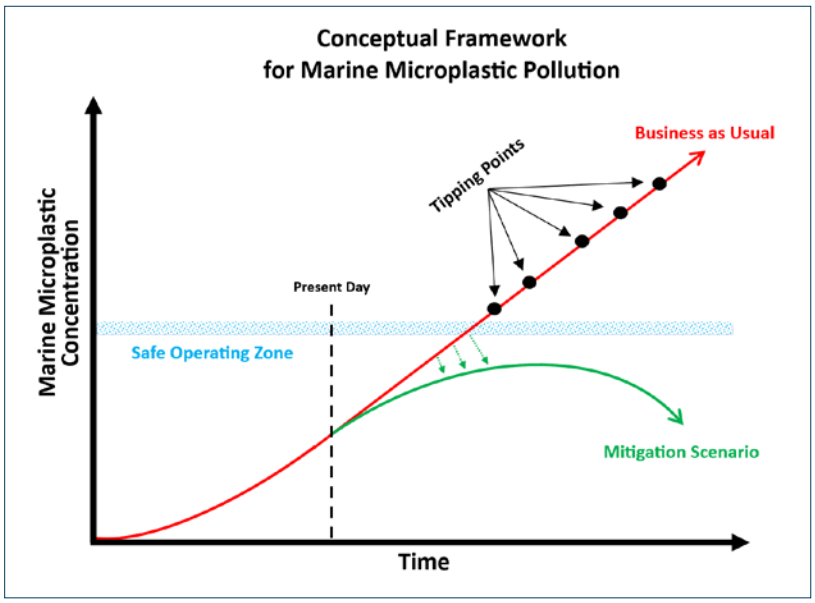
BRIEFING

The recent article Enhancing the Science-Policy Interface: A Conceptual Framework for Marine Microplastic Pollution sets out recommendations on designing a science-policy interface in the plastics treaty.*

BACKGROUND

More than 170 trillion plastic particles are estimated to already be present in the world's oceans and the problem is growing rapidly.

An estimated additional 8-10 million tonnes of plastic enter the ocean every year, with global plastic production projected to increase by almost 70% from 335 million tonnes in 2020 to 735 million tonnes by 2040. Even if plastic leakages stopped tomorrow, the vast stock of plastic already in the environment would continue breaking down into smaller particles, increasing microplastic concentration across the world's oceans, potentially disrupting key ecological processes and pushing marine systems towards irreversible marine microplastic tipping points.



FROM POLLUTION TO TIPPING POINTS

A tipping point occurs when pressure on a system exceeds a critical threshold, triggering changes which may be difficult or impossible to reverse.

Scientific literature identifies several potential tipping points for marine microplastic pollution, including:

- **disruption of marine organisms:** These include disruptions to: (i) phytoplankton and microalgae, which form the foundation of marine food webs and generate an estimated 55-80% of the world's oxygen; (ii) keystone species, especially zooplankton and filter feeders which play a pivotal role in transferring energy and organic carbon to higher order animals; (iii) cetaceans, which consume microplastics through ingestion during feeding; and (iv) coral reefs, compounding the challenges already faced

* Grabiel T, Miller GL, Youngman A, Perry C, Hughes H. Enhancing the Science–Policy Interface: A Conceptual Framework for Marine Microplastic Pollution. *Cambridge Prisms: Plastics*. 2026;4:e24. doi:10.1017/plc.2026.10061.

- **loss of ocean carbon sink function:** Oceans absorb about 30% of anthropogenic CO_2 emissions, making it the biggest natural sink on the planet. Microplastics impact: (i) the biological carbon pump, by which phytoplankton and zooplankton move carbon from the upper layers of the water column to the seafloor; and (ii) the sea-air gas exchange, by which atmospheric CO_2 dissolves into the ocean, is reduced when microplastics biofoul the surface of the ocean

- **ocean deoxygenation:** Algal blooms and the settling of microplastic particles on the seafloor can reduce oxygen transfer and trigger hypoxic conditions for aquatic organisms while promoting anaerobic processes, with potential effects including food web collapse

- **sea ice melting:** Sea ice melting is considered a highly at-risk climate tipping point. Microplastics trapped in sea ice increase light absorption and reduce surface albedo (the measure of how much solar radiation is reflected by a surface or body, rather than absorbed), accelerating melting. As ice melts, previously trapped particles are released back into the ocean, creating a feedback loop that may further accelerate ice loss and spread contamination.

THE MISSING PIECE: A SCIENCE-POLICY INTERFACE

To avoid marine microplastic tipping points, policymakers and scientists must work together to develop reliable quantitative analyses and models for marine microplastic pollution, identifying scenarios and policies to stay within a safe operating zone, regularly updated by research, initially focusing on:

- **baseline and trends:** Development of a standardised monitoring framework, including methodologies for sampling marine microplastics across marine environments, including the ocean surface, seabed, shoreline, water column and key biota and approaches for determining their baseline, composition, distribution, retention and transport

- **sources and inputs:** Reporting obligations on plastic production, use, management and leakage, supported by emission factors for different microplastic sources and methods to calculate macroplastic degradation through processes such as photo-oxidation, fragmentation and mechanical abrasion

- **hazards, risks and thresholds:** Identification by scientists of hazards, risks and concentration thresholds across regions, updating findings as evidence emerges and development of scenarios for staying within a safe operating zone.

Together, these aspects enable a marine microplastic science-policy interface which can thereafter produce policy-relevant science and assist policymakers with the identification and adoption of measures to reduce pollution at the pace and scale needed to remain within a safe operating zone.

TOWARDS POLICIES TO MITIGATION

Sources of microplastics in the marine environment include pellets, personal care products, marine coatings, road markings, city dust, tyres, synthetic textile fibres, plastic-coated fertilisers and discharges from plastic recycling plants, among others, as well as from the degradation of macroplastics.

For any given source, various measures are available to mitigate their contribution to overall marine microplastic pollution. How policymakers respond to science is the domain of balancing environmental, social and economic interests, priorities and ambitions. To this end, policymakers would further benefit from technical and economic assessment by expert subsidiary bodies to support the consideration of potential measures.

FOR MORE INFORMATION

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