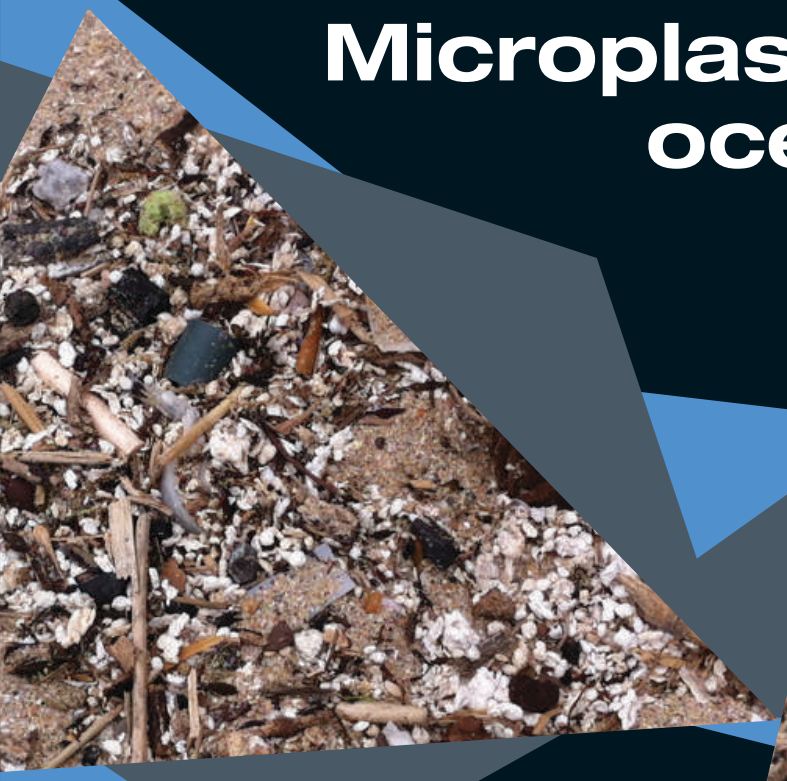
a global assessment

# Microplastics in the ocean



microplastic fragments from a beach near Busan, Republic of Korea © Peter Kershaw

Small pieces of plastic, commonly referred to as microplastics, were first described in the early 1970s and are widespread in the ocean.

## Sources, fate & effects

Larger items made of plastic, such as bags, rope and fishing nets, can have obvious direct impacts on marine life and society. But the effects of microplastics are more difficult to quantify.

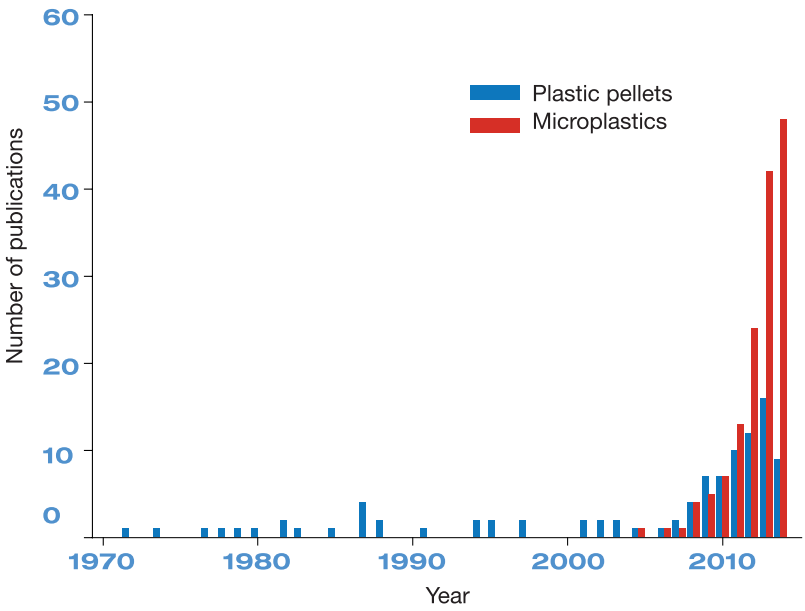
Microplastic fragments from the western North Atlantic, collected using a towed plankton net © Giora Proskurowski, SEA

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

This assessment should provide government, commerce, industry and society with a more reliable basis on which to base decisions.

# What are microplastics?

Plastics have become indispensible in many areas of modern life, used for clothing, storage, transportation, packaging, construction and a host of consumer goods. One of plastics greatest properties, its durability, is also one of the main reasons that plastics present a threat to the marine environment. The risk increases as long as plastic continues to enter the ocean. The term microplastics was introduced within the last decade to describe small pieces of plastic found in the ocean, commonly defined as < 5mm in diameter.





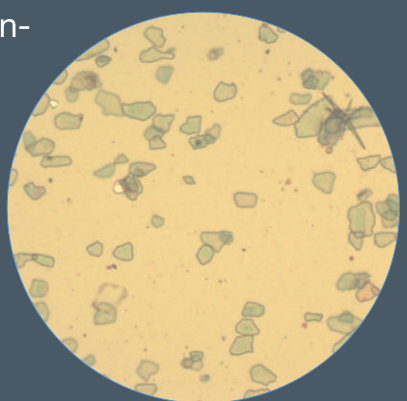
Plastic pellets © Hideshige Takada

Publications mentioning microplastics and plastic pellets, up to July 2014 © Sarah Gall

Scientific papers describing small plastic fragments in birds appeared in the 1960s and in plankton net samples in the early 1970s. However, the attention of the scientific community was aroused about a decade ago. Since then there has been an enormous increase in publications about many different aspects of microplastic distribution and behaviour.

One distinct category of microplastics are plastic pellets. These represent one of the main ways of transporting plastics between plastics producers and companies converting plastics into products. Accidental spillages and poor handling mean that plastic pellets are common on beaches, especially near ports and industrialised regions.

Plastic pellets and plastic particles manufactured for particular applications, such as cosmetic products and abrasives, are often called primary microplastics. Microplastics produced as a result of fragmentation from larger items are called secondary microplastics. The distinction is important as it can be used to pin-point sources and target reduction measures.



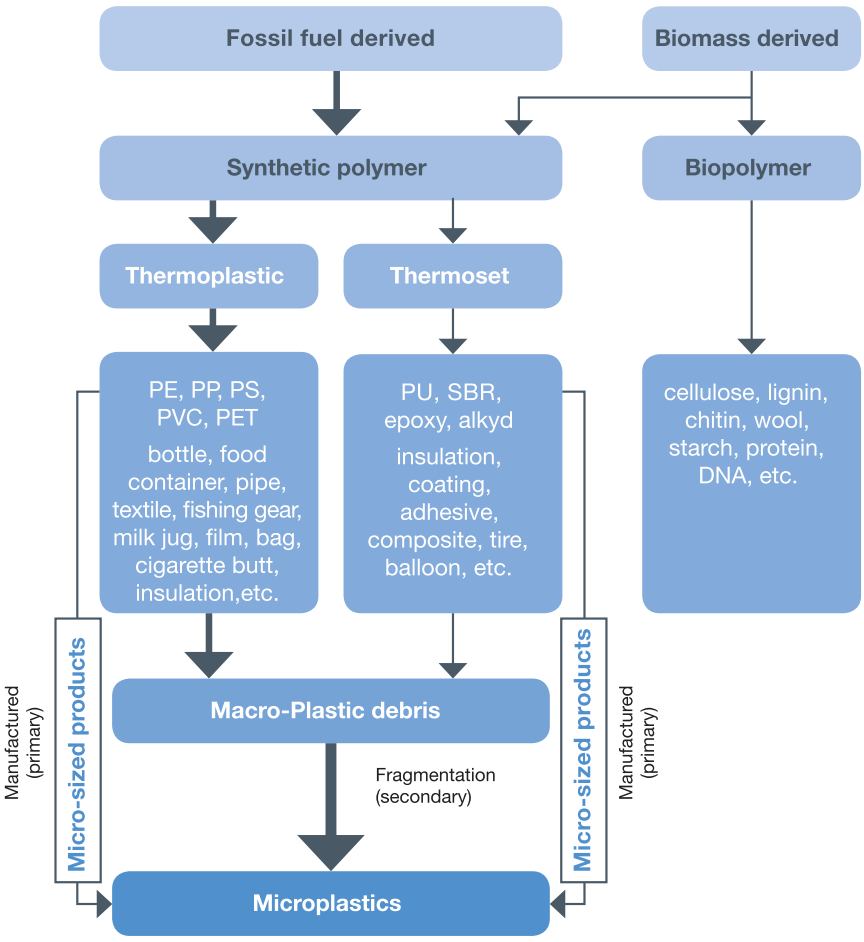
Microplastics in lipstick
© Heather Leslie

GESAMP was asked to conduct a global assessment, based on published information, of the sources, fate and effects of microplastics in the marine environment. GESAMP (The Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection) is an Inter-Agency body of the United Nations, set up in 1969 to provide authoritative and independent advice. The scope was defined by agreed Terms of Reference and the assessment carried out by a Working Group (2012-2014) with experts from a wide range of disciplines, working on a *pro-bono* basis.

# The origins of microplastics

Plastic, a type of synthetic polymer, may be derived from fossil-fuels or biomass. Global production is dominated by a few well-known materials, but a huge range of plastics with differing compositions and properties are manufactured each year. Some microplastics are manufactured to fulfill particular functions, such as industrial abrasives or in domestic cleaning and cosmetic products such as toothpaste.

*The formation of secondary microplastics, by fragmentation of larger macro-size debris, is influenced by a combination of environmental factors and the properties of the polymer.*




PE - polyethylene
PP - polypropylene
PS - polystyrene
PVC - poly(vinyl chloride)
PET - poly(ethylene terephthalate)
PU - polyurethane
SBR - styrene-butadienne rubber

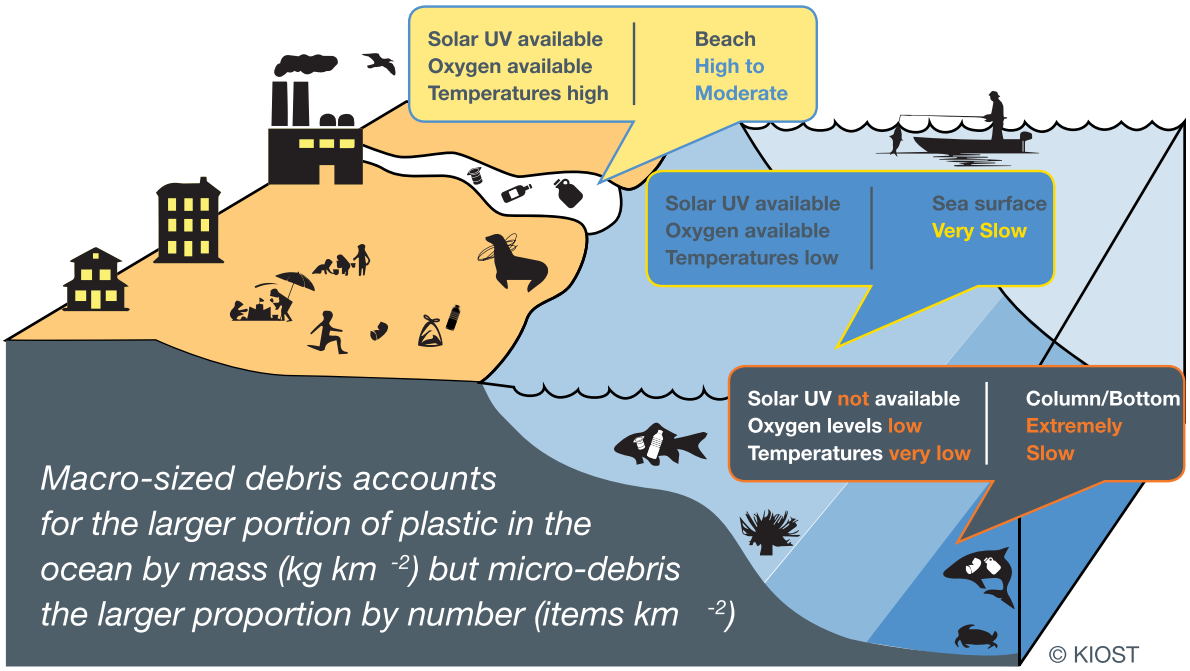
**the assessment scope:**

- key sources and types of microplastics
- weathering and fragmentation processes
- global distribution in the surface ocean using observations and circulation models
- physical and chemical effects on marine organisms
- social aspects, including public awareness
- key challenges and recommendations

**expertise:**

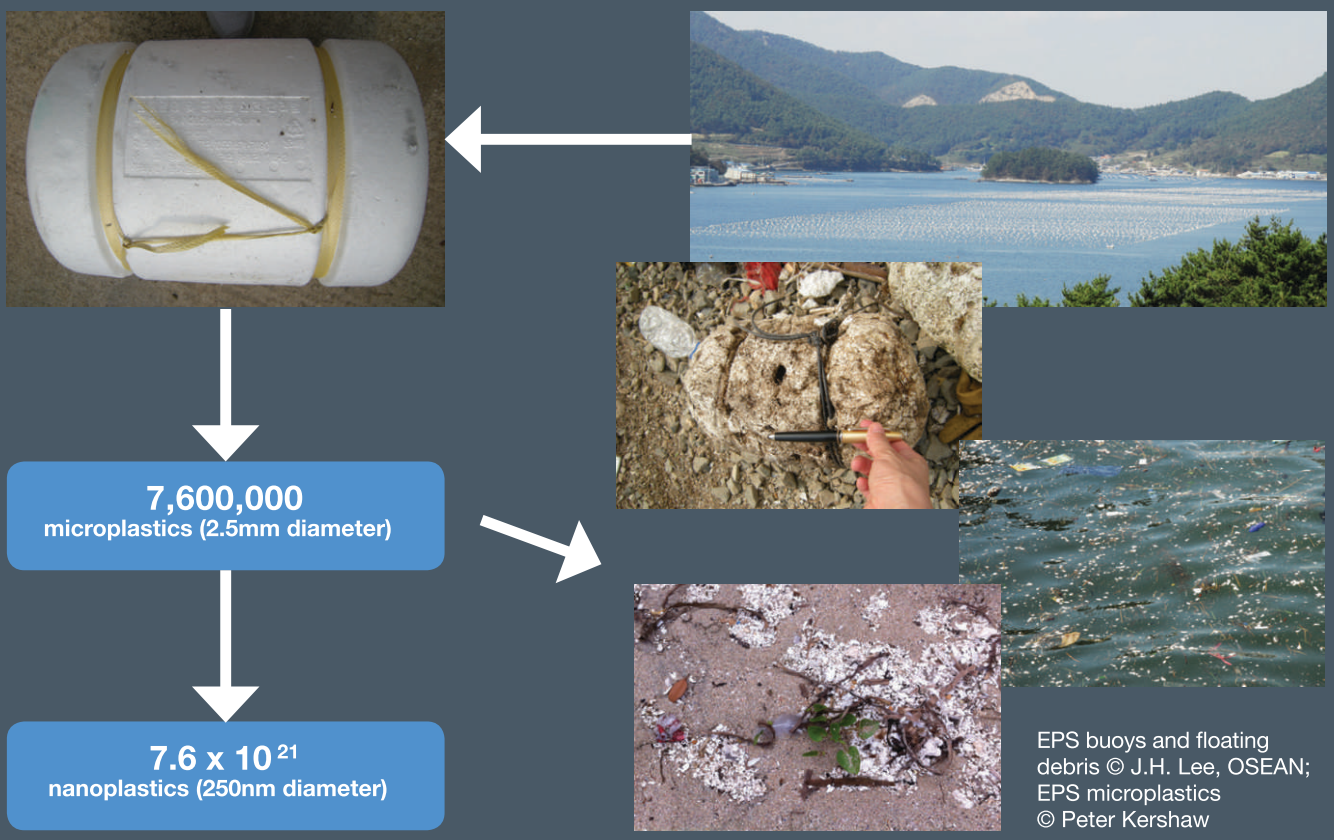
- materials science
- marine ecology
- physiology
- ocean physics
- ecotoxicology
- chemistry
- science-policy
- public awareness and communication

The production of microplastics by the fragmentation of larger plastic items is most effective on beaches, with high UV irradiation and physical abrasion by waves. Once submerged, cooler temperatures and reduced UV means fragmentation becomes extremely slow.




# Generating microplastics

Example of regional differences in source and fate: large-scale use of expanded polystyrene (EPS) buoys for aquaculture in Korea

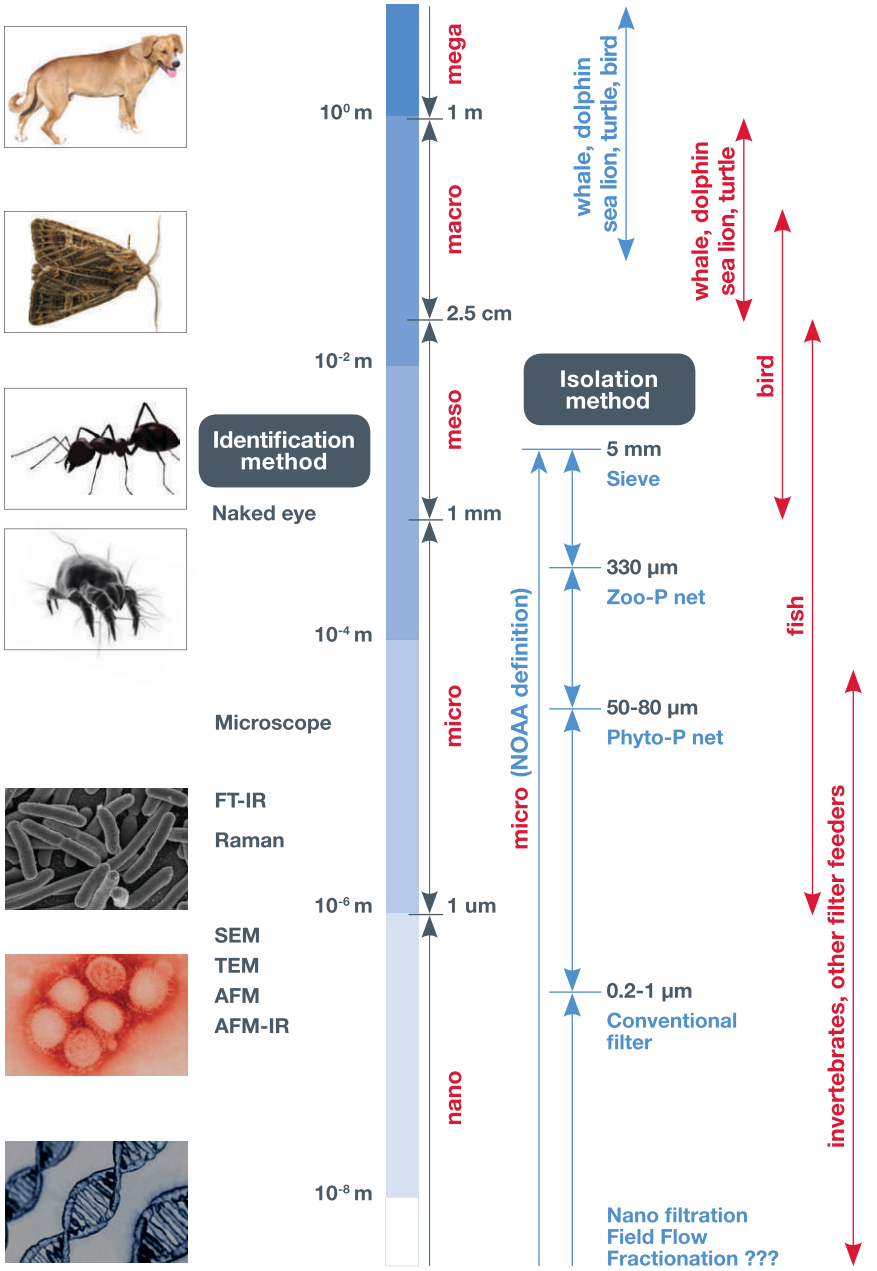



EPS buoys and floating debris © J.H. Lee, OSEAN; EPS microplastics © Peter Kershaw

# Size *is* important

Different sizes of plastic particle or larger plastic objects need different types of equipment to sample them in the ocean and different analytical techniques in the laboratory. Size also determines the likely impact on ocean life and human activities such as fisheries.

*Particles in the size range 1 nm to < 5 mm were considered microplastics for the purposes of this assessment.*




FT-IR Fourier-transform infra-red spectroscopy, Ramon Spectroscopy, SEM scanning electron microscopy, TEM transmission electron microscopy, AFM atomic force microscopy, AFM with IR

## Sampling and isolation:

- Mega- & macro -sizes direct observation
- Meso-size sieving
- Micro-size towed plankton nets
- Nano-size filtration

## Direct external effects:

- Mega- & macrosizes (entanglement) whales, seals, dolphins, turtles, fish, birds
- Meso-size unknown
- Micro-size unknown
- Nano-size unknown

## Direct & indirect internal effects (ingestion):

- Macrosize whales, seals, dolphins, turtles & birds
- Meso-size birds, fish & invertebrates
- Micro-size fish, invertebrates & other filter feeders
- Nano-size invertebrates & other filter feeders

Plastic pellets in beach sands from Republic of Korea © Peter Kershaw

# Conclusions

- Commonly the term microplastics is used to describe plastic particles < 5 mm in diameter, which includes particles as small as 10 nanometres.
- Microplastics may be manufactured for particular industrial or domestic applications. These are referred to as primary microplastics, and they can be released inadvertently into the ocean.
- Microplastics also occur as a result of the fragmentation of larger plastic objects (termed secondary microplastics).
- Plastics are discarded and enter the ocean as a result of many different land- and sea-based activities, but there are no reliable estimates of the quantities involved, at a regional or global scale.
- Microplastics are distributed throughout the ocean, occurring on shorelines, in surface waters and seabed sediments, from the Arctic to Antarctic. They may accumulate at remote locations such as mid-ocean gyres, as well as close to population centres, shipping routes and other major sources.
- Microplastics have been found inside the bodies of a wide variety of marine organisms including invertebrates, fish, birds and mammals.
- Plastics often contain chemicals added during manufacture and can absorb and concentrate contaminants such as pesticides from the surrounding seawater. There is emerging evidence of transfer of chemicals from ingested plastics into tissues.
- Very small (nano-size) microplastics have been shown to cross cell membranes, under laboratory conditions, causing tissue damage.
- Ingested microplastics can affect the physiology of the host organism and potentially compromise its fitness.
- Public and private sector awareness of the potential negative ecological, social and economic impacts of microplastics is much less developed than for macro-litter.
- Effective engagement and education at all levels of society (public, government and private sector) is an essential tool to raise awareness and promote positive behaviour change.

Sampling for microplastics in Republic of Korea © Peter Kershaw

# Action-orientated recommendations

**Challenge 1**

**to reduce the entry of plastics and microplastics into the marine environment**

Identify the main sources and categories of plastics and microplastics entering the ocean → **modelling, social and economic indicators, observations**

**Challenge 2**

**overcoming social, technical & economic barriers**

Utilise end-of-life plastic as a valuable resource as an important part of an overall waste reduction strategy → **promoting reduction, re-use and recycling & the circular economy**

**Challenge 3**

**influencing perceptions and behaviour, to complement legislation**

Promote greater awareness of the impacts of plastics and microplastics in the marine environment → **utilize expertise from the social sciences**

# Recommendations to improve a future assessment

**Challenge 4**

**assessing the risk from nano-plastics**

Consider particles in the nano-size range when assessing the impact of plastics in the sea → **include expertise from a wider range of disciplines, including pharmacology and mammalian toxicology; encourage greater research focus, including method development**

**Challenge 5**

**assessing the importance of plastics and microplastics as a vector for the transfer of organisms**

Evaluate the potential significance of plastics and microplastics as a vector for organisms

**Challenge 6**

**quantifying the chemical exposure risk from ingested microplastics**

Evaluate the potential pathways and rates of chemical transfer and ecotoxicological risk → **include expertise on field & laboratory studies, animal behaviour, physiology and the gut environment for target species**

## The assessment report:

This brochure summarises the findings of GESAMP Working Group 40, on *Sources, fate & effects* of microplastics in the marine environment  a global assessment. The full assessment is scheduled for publication in early 2015, in the GESAMP Reports & Studies Series, available at www.gesamp.org. The lead Agency for the Working Group was the Intergovernmental Oceanographic Commission (IOC) of UNESCO, with the GESAMP Secretariat, based at the International Maritime Organization (IMO), providing organisational support.

UNESCO IOC

GESAMP (The Joint Group of Experts on Scientific Aspects of Marine Environmental Protection) is an inter-Agency Body of the United Nations, comprised of a group of independent scientists providing advice to UN Agencies on a wide variety of ocean matters.

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