Plastic debris in the oceans, current understanding and the need for rapid and reliable monitoring

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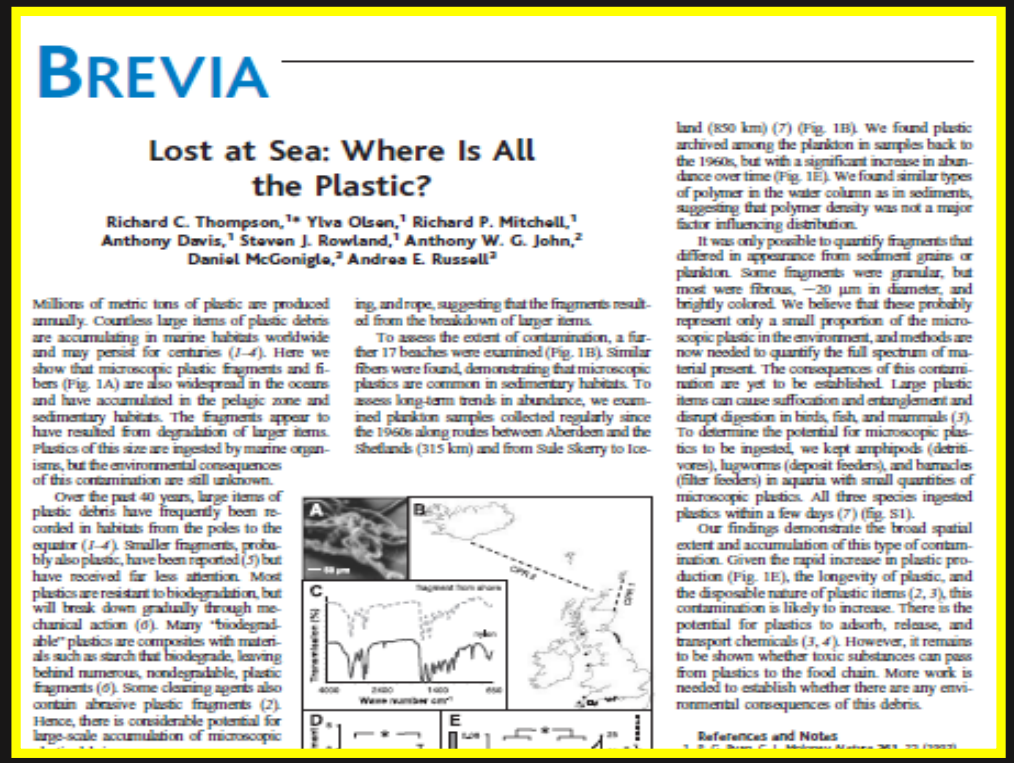
Marine Biologist to Godfather of Micropalstics

1994

2004



BREVIA

Lost at Sea: Where Is All the Plastic?

Richard C. Thompson,[1]* Ylva Olsen,[1] Richard P. Mitchell,[1] Anthony Davis,[1] Steven J. Rowland,[1] Anthony W. G. John,[2] Daniel McGonigle,[2] Andrea E. Russell[2]

Millions of metric tons of plastic are produced annually. Countless large items of plastic debris are accumulating in marine habitats worldwide and may persist for centuries (*1–4*). Here we show that microscopic plastic fragments and fibers (Fig. 1A) are also widespread in the oceans and have accumulated in the pelagic zone and sedimentary habitats. The fragments appear to have resulted from degradation of larger items. Plastics of this size are ingested by marine organisms, but the environmental consequences of this contamination are still unknown.

Over the past 40 years, large items of plastic debris have frequently been recorded in habitats from the poles to the equator (*1–4*). Smaller fragments, probably also plastic, have been reported (*5*) but have received far less attention. Most plastics are resistant to biodegradation, but will break down gradually through mechanical action (*6*). Many "biodegradable" plastics are composites with materials such as starch that biodegrade, leaving behind numerous, nondegradable, plastic fragments (*6*). Some cleaning agents also contain abrasive plastic fragments (*2*). Hence, there is considerable potential for large-scale accumulation of microscopic

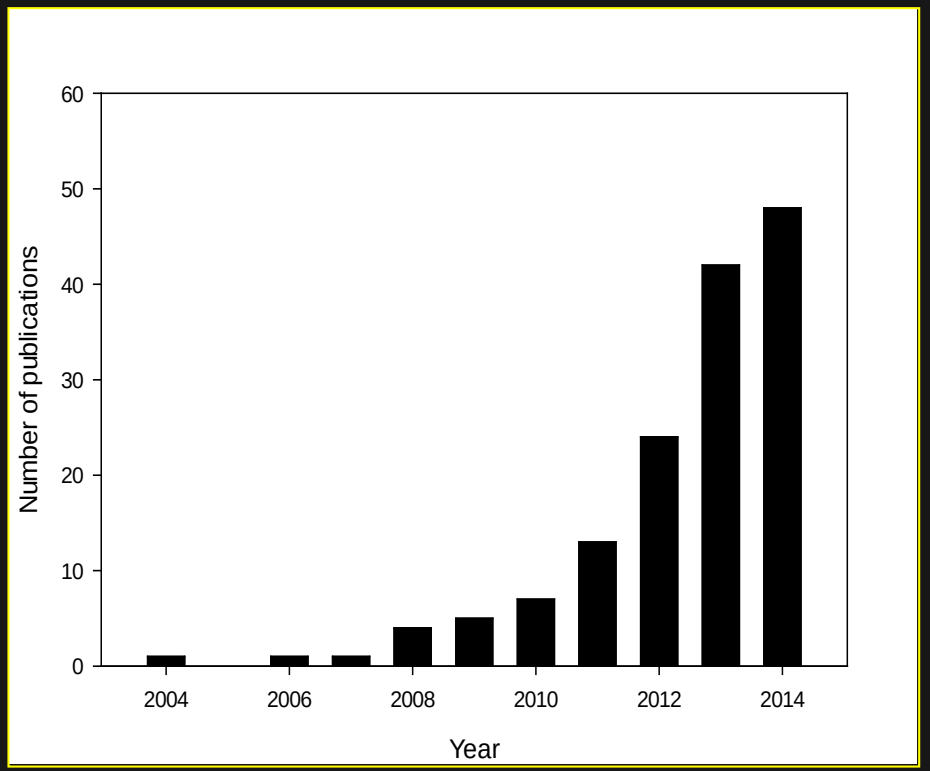
ing, and rope, suggesting that the fragments resulted from the breakdown of larger items.

To assess the extent of contamination, a further 17 beaches were examined (Fig. 1B). Similar fibers were found, demonstrating that microscopic plastics are common in sedimentary habitats. To assess long-term trends in abundance, we examined plankton samples collected regularly since the 1960s along routes between Aberdeen and the Shetlands (315 km) and from Sule Skerry to Iceland (850 km) (*7*) (Fig. 1B). We found plastic archived among the plankton in samples back to the 1960s, but with a significant increase in abundance over time (Fig. 1E). We found similar types of polymer in the water column as in sediments, suggesting that polymer density was not a major factor influencing distribution.

It was only possible to quantify fragments that differed in appearance from sediment grains or plankton. Some fragments were granular, but most were fibrous, ~20 μm in diameter, and brightly colored. We believe that these probably represent only a small proportion of the microscopic plastic in the environment, and methods are now needed to quantify the full spectrum of material present. The consequences of this contamination are yet to be established. Large plastic items can cause suffocation and entanglement and disrupt digestion in birds, fish, and mammals (*3*). To determine the potential for microscopic plastics to be ingested, we kept amphipods (detritivores), lugworms (deposit feeders), and barnacles (filter feeders) in aquaria with small quantities of microscopic plastics. All three species ingested plastics within a few days (*7*) (fig. S1).

Our findings demonstrate the broad spatial extent and accumulation of this type of contamination. Given the rapid increase in plastic production (Fig. 1E), the longevity of plastic, and the disposable nature of plastic items (*2*, *3*), this contamination is likely to increase. There is the potential for plastics to adsorb, release, and transport chemicals (*3*, *4*). However, it remains to be shown whether toxic substances can pass from plastics to the food chain. More work is needed to establish whether there are any environmental consequences of this debris.

References and Notes



There is considerable potential for large scale accumulation of microplastics

*These [*findings*} probably represent a small proportion of the microscopic plastics present in the environment, methods are now needed to quantify the full spectrum of material present.*

Plastics have the potential to transport and release chemicals, but it remains to be shown whether toxic substances can pass from plastics to the food chain.

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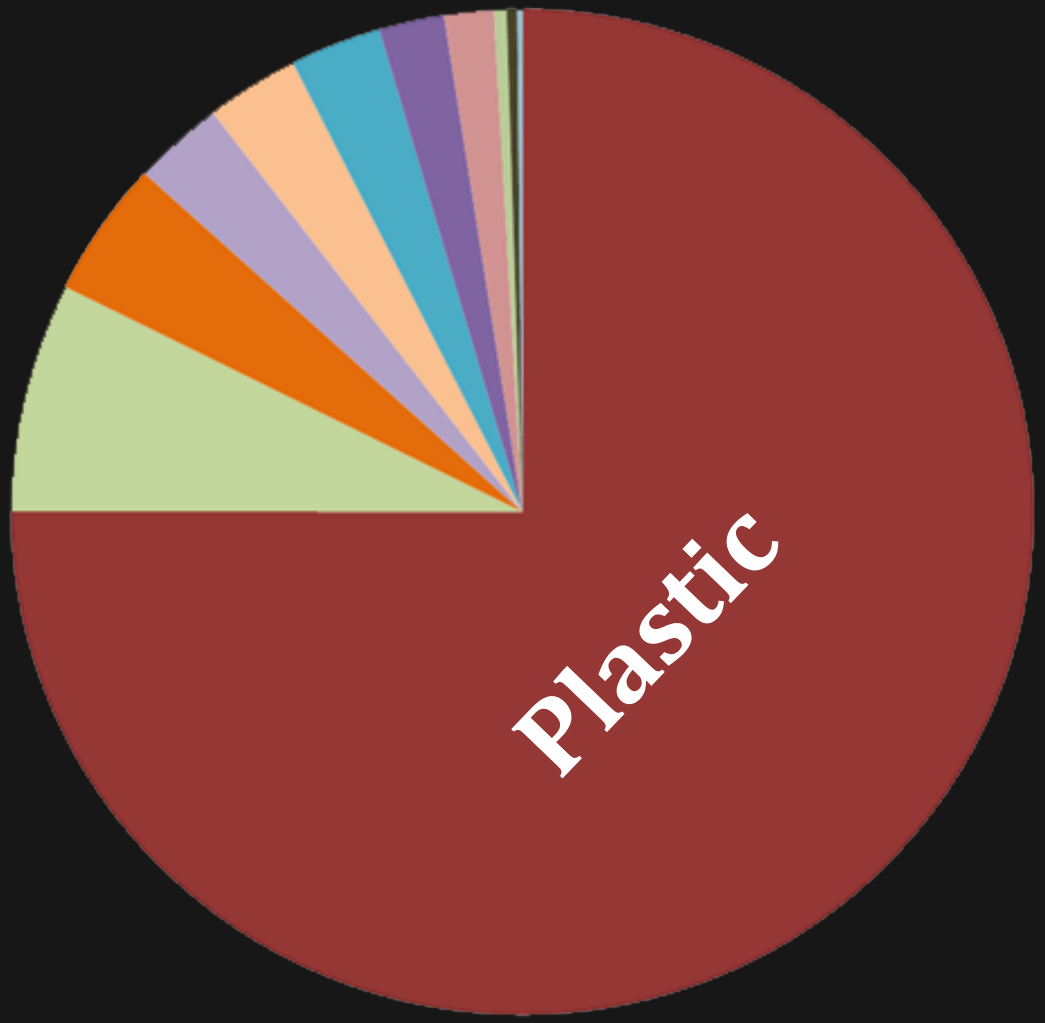
Most marine litter is plastic



- Plastic and polystyrene
- Sanitary
- Paper and cardboard
- Wood
- Cloth
- Metal
- Glass
- Rubber
- Pottery and ceramics
- Faeces
- Medical

OSPAR, 2007

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Shoreline

Deep sea

Types of debris

Large and rare

Small and ubiquitous

Economic consequences

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Consequences for Human health and wellbeing

Wyles, Pahl and Thompson 2015

Consequences for wildlife

Encounters with litter:

- > 300 papers
- ~ 700 Species
- 92% of encounters are with plastic
- 17 % threatened / near threatened IUCN status

Microplastics:

10% of published encounters by species

Lusher et al 2013

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Is there enough evidence to take action,

or are there key knowledge gaps?

What are the main sources of plastic and microplastic litter ?

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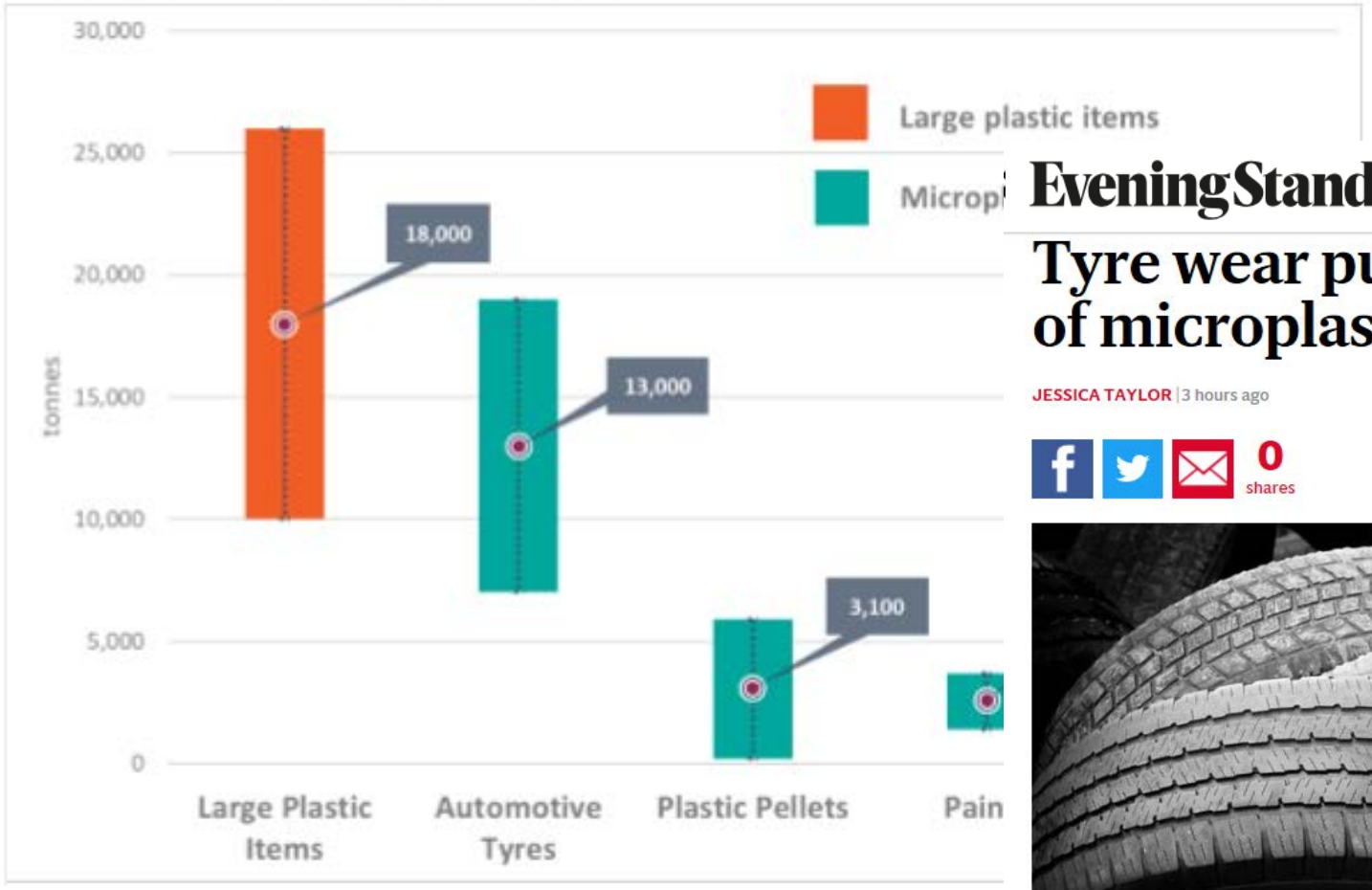
Figure 1 – Estimates for Key Sources of Plastic Pollution to Surface Waters from the UK from land-based sources



Eunomia 2018

Evening Standard.

News Comment Football Insider GO London Lifestyle Showbiz Homes &

Tyre wear pumping almost 20,000 tonnes of microplastics into oceans each year

JESSICA TAYLOR | 3 hours ago

0 shares

IN ASSOCIATION WITH BEE | midtown

What are the main sinks of microplastics? (the missing plastic???)

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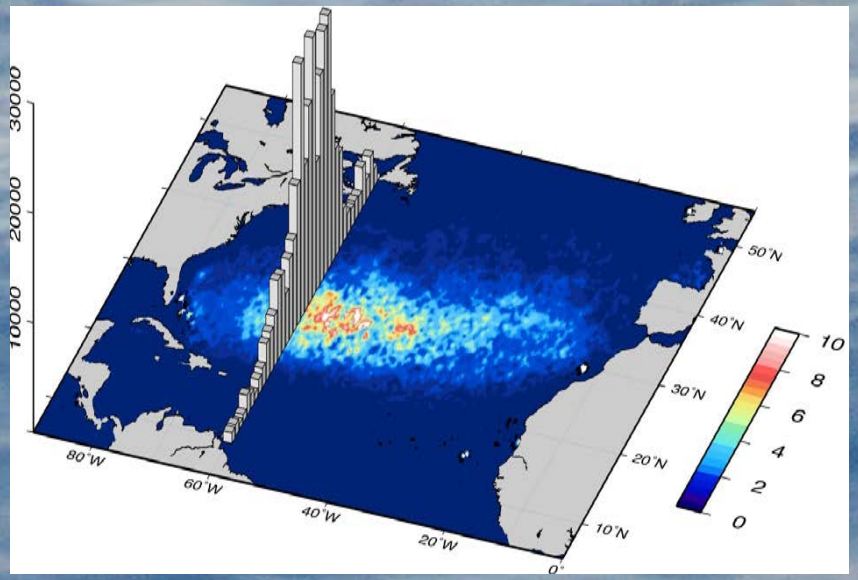
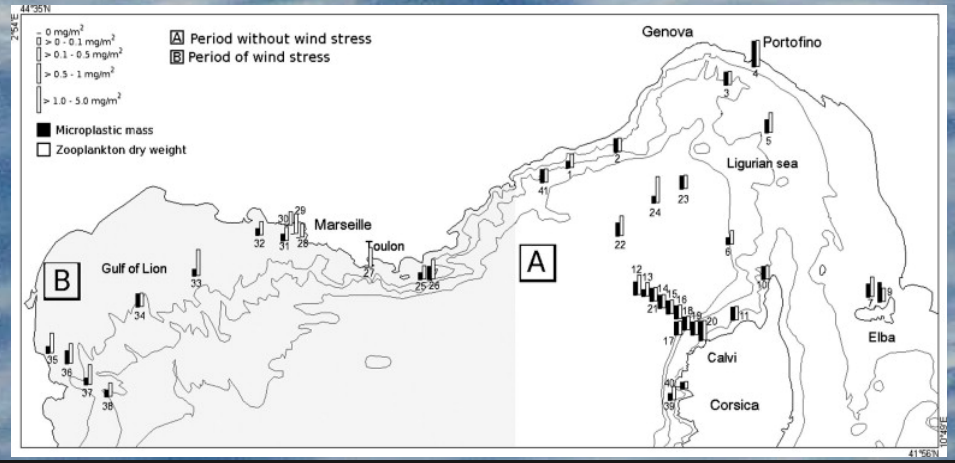


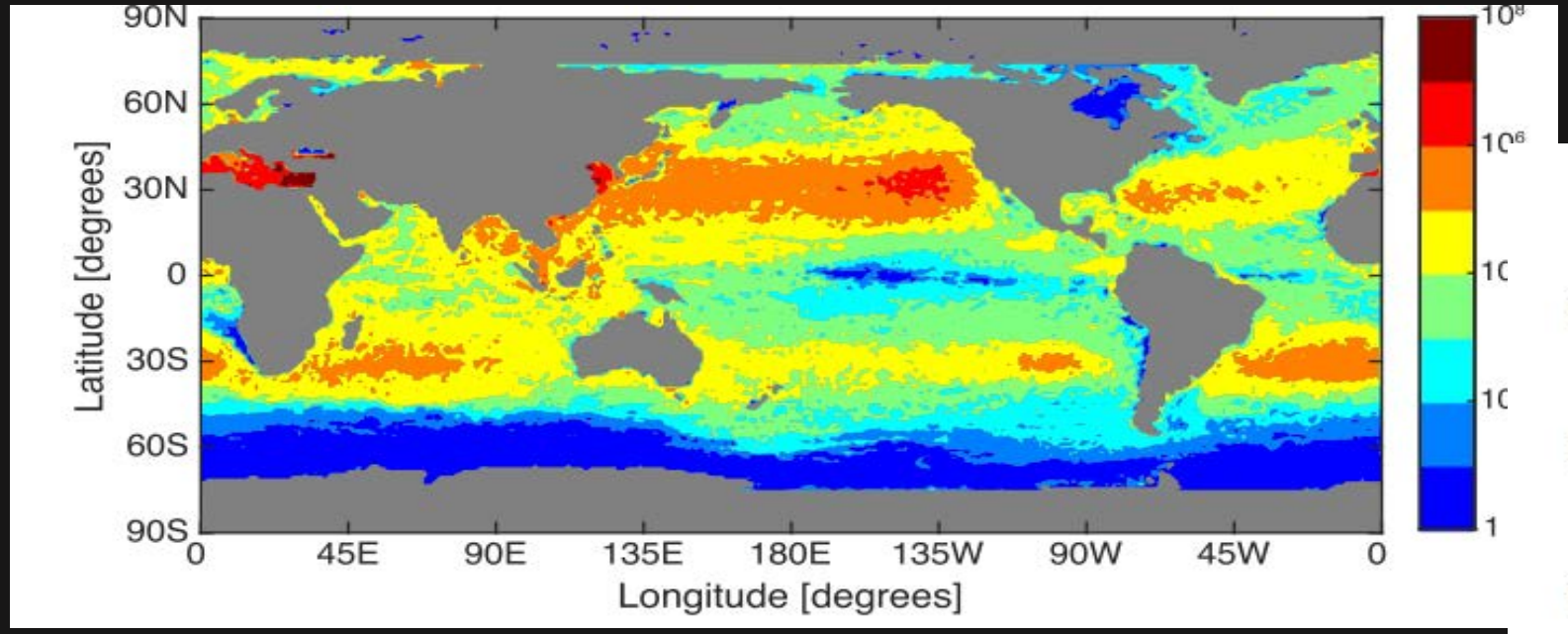
Widespread and accumulating

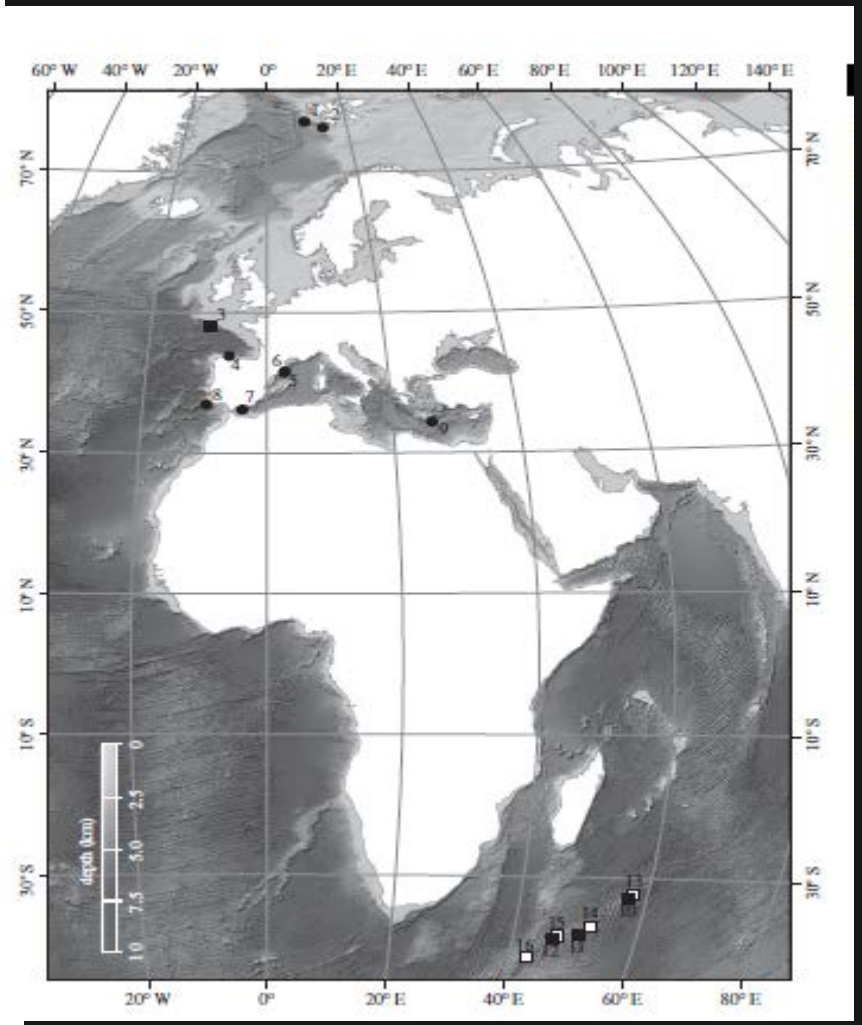


Mediterranean Sea

G. Hanke

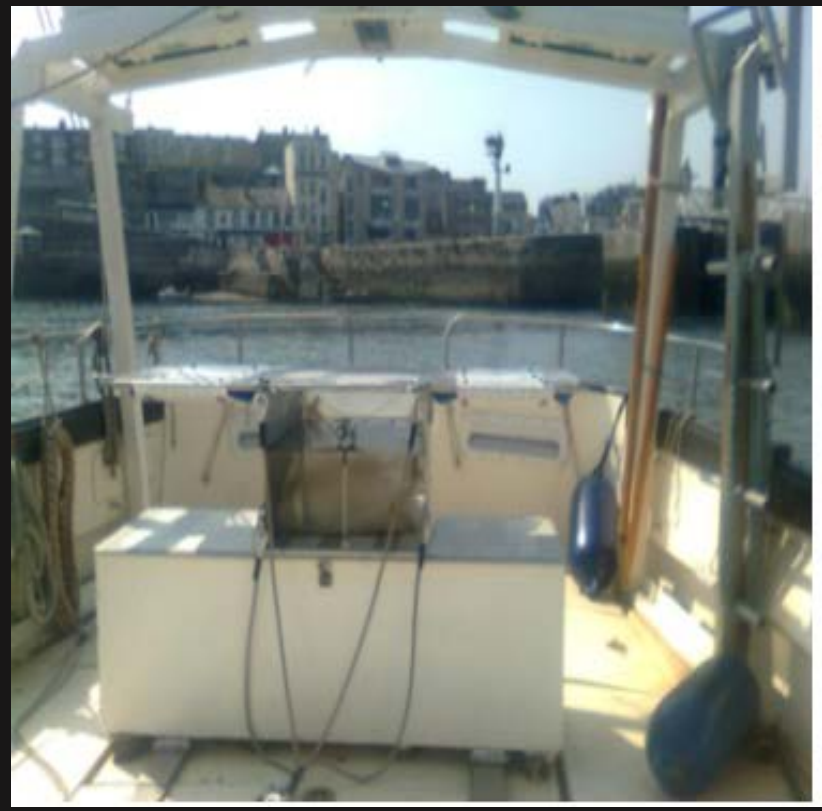
What are the main sinks of microplastics? (the missing plastic???)





Browne et al 2011, Woodall et al 2014
Van Sebille 2015, Lavender Law 2010

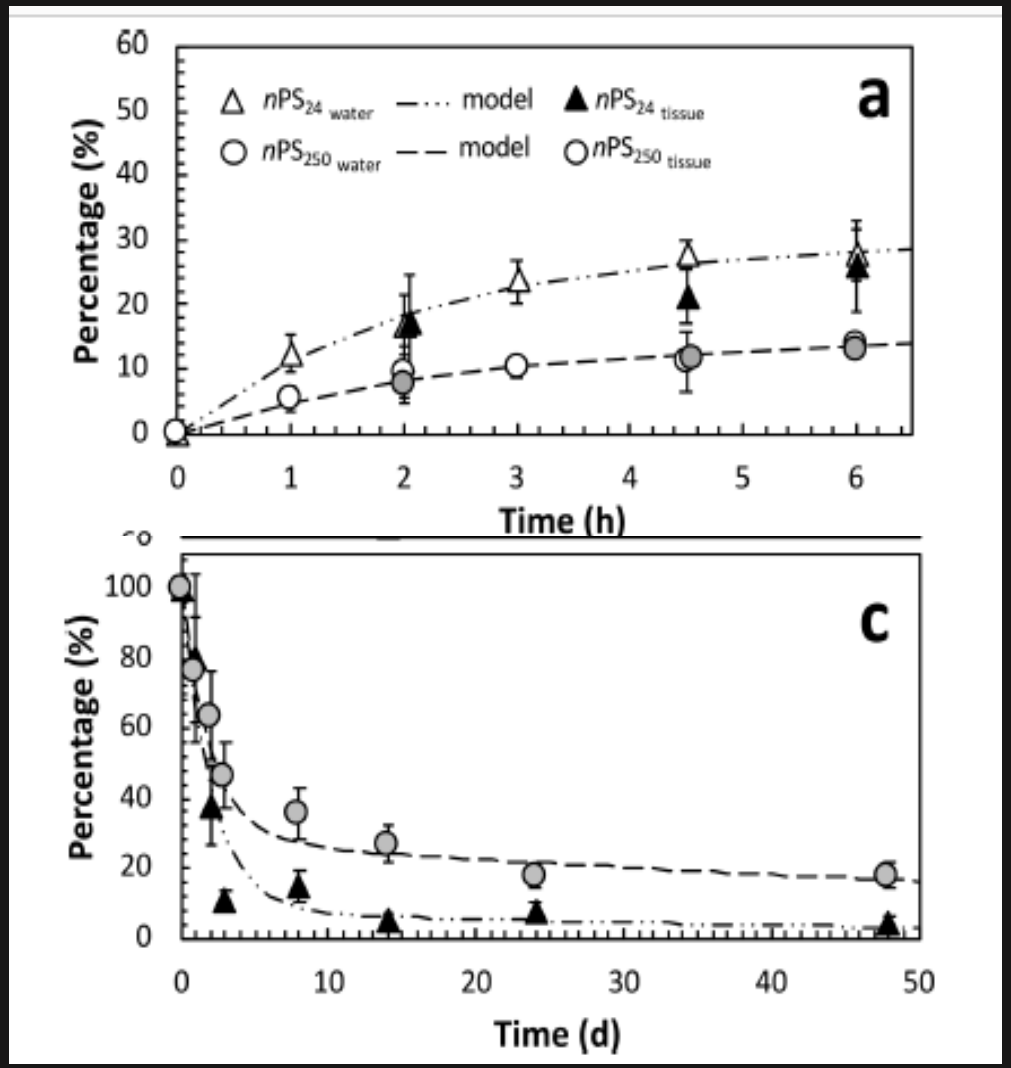
How do best to sample, separate, identify and monitor?

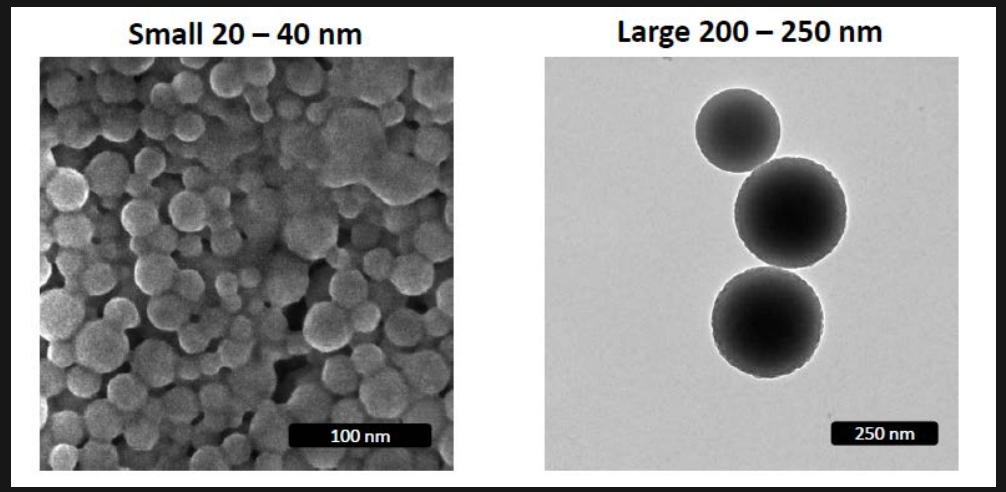


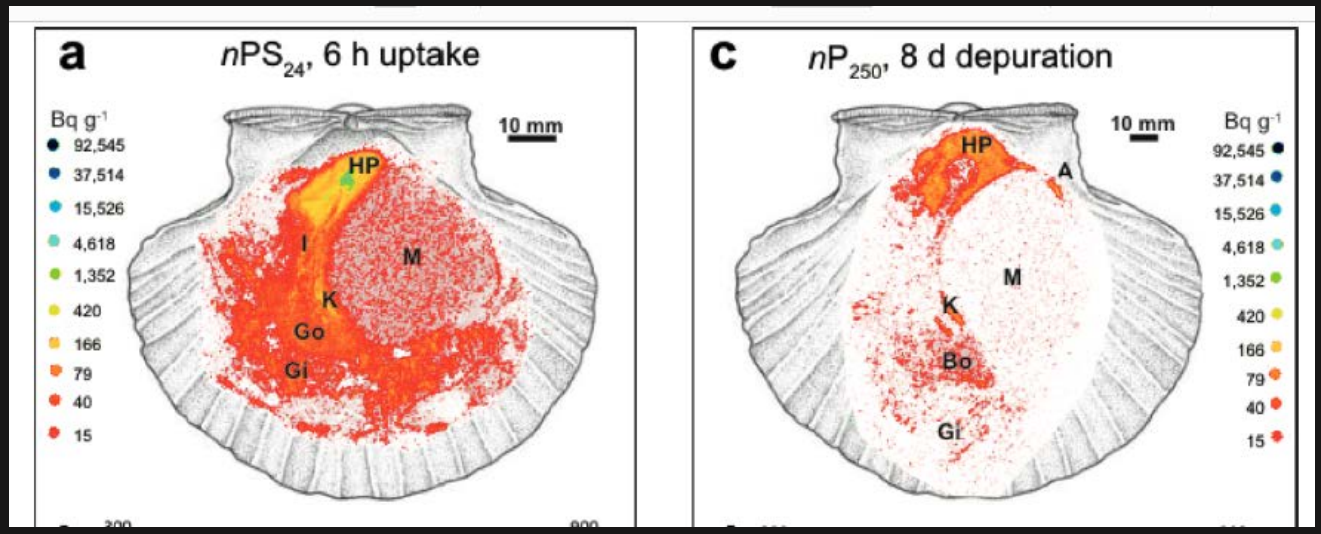
No universal method see:

MSFD TG10 Guidance on monitoring marine litter (2014) – Section 3.5 - Microlitter

Do nano plastics present different threats?







Al-Sid-Cheikh et al. 2018

Plastics as materials are not the cause of the problem

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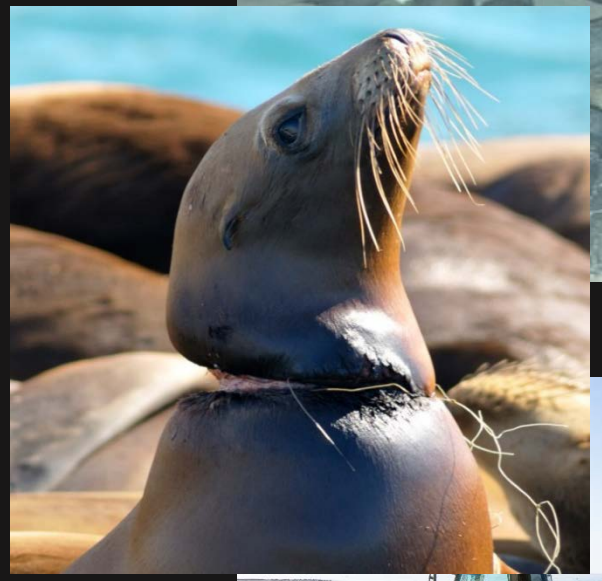

How to keep the benefits

without the problems?

Unlike other challenges the negative consequences are not directly coupled to societal benefit

Redirect the flow

Block the holes

Clean up

Redirect the flow

Block the holes

Clean up

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Redirect the flow

Block the holes

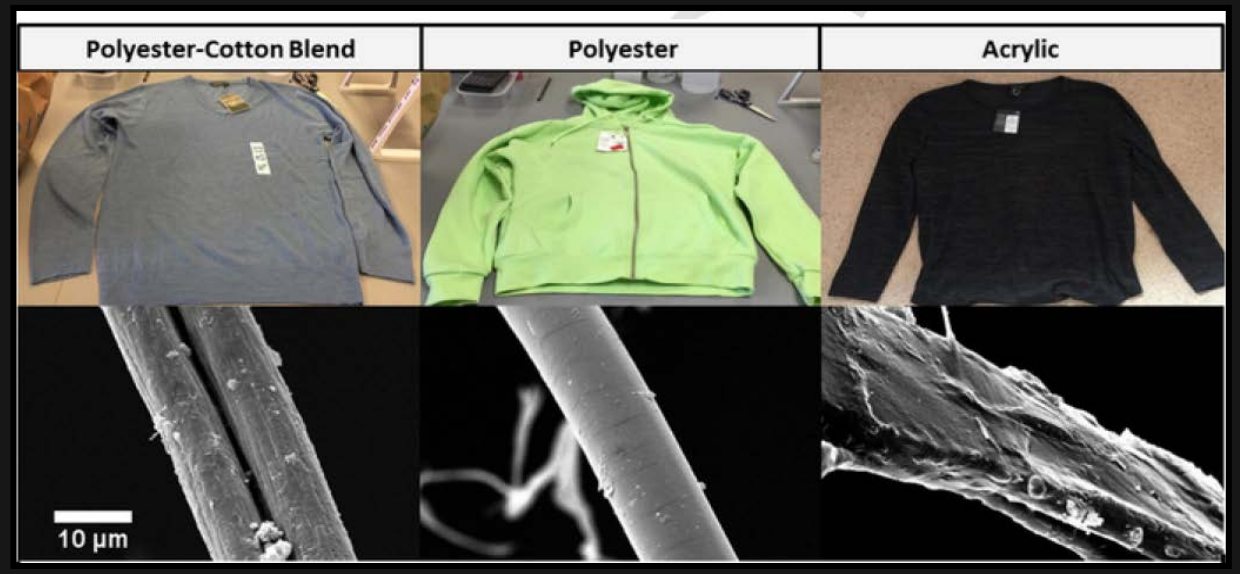
Clean up

60 years of design
60 years of behavioural training to throw away (linear)

1950s - Time Life magazine, throw away living

2010s - 50% of shoreline litter is single use items

The Ocean Imperative Design products – for life in service and end of life



Source: Thompson & Napper

Translating theory in to actions

The ocean imperative: current situation '*bad*'

Options → **Actions** → **New norm '*better*'**

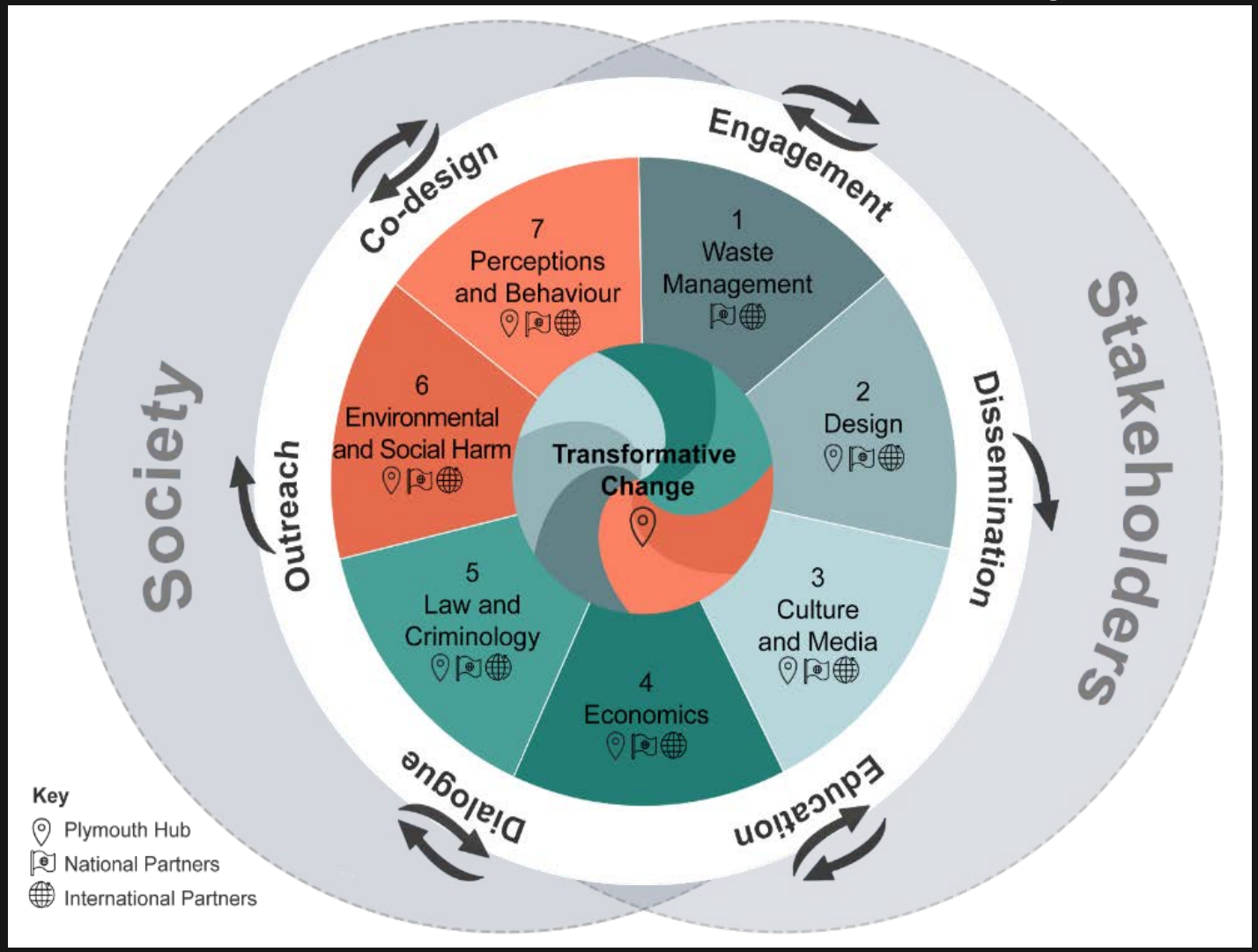
Reduce
Reuse
Ban plastic
Change the material
Recycle
Educate

appropriate will reinforce / incentivise change

inappropriate negative consequences dis-incentivise change

Unintended consequences 'bad' or even worse!

Centre for sustainable use of plastics in society



Academic evidence to guide industry and policy

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Plastic debris in the oceans

- Is a symptom of inefficient outdated business model
- Is not directly coupled to societal benefits
- Damages resources (economy, wildlife, services)
- Solutions exist – but there is no single solution
- Focus on design for life and end of life
- Synergistic benefits (resource efficiency / waste reduction)
- Harness current interest - focus on product design and waste management
- Essential to have reliable independent evidence to inform interventions

Richard Thompson – Thank you

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