Microplastics

- What they are
- Impacts
- Sources
- Pathways in the environment
- Solutions

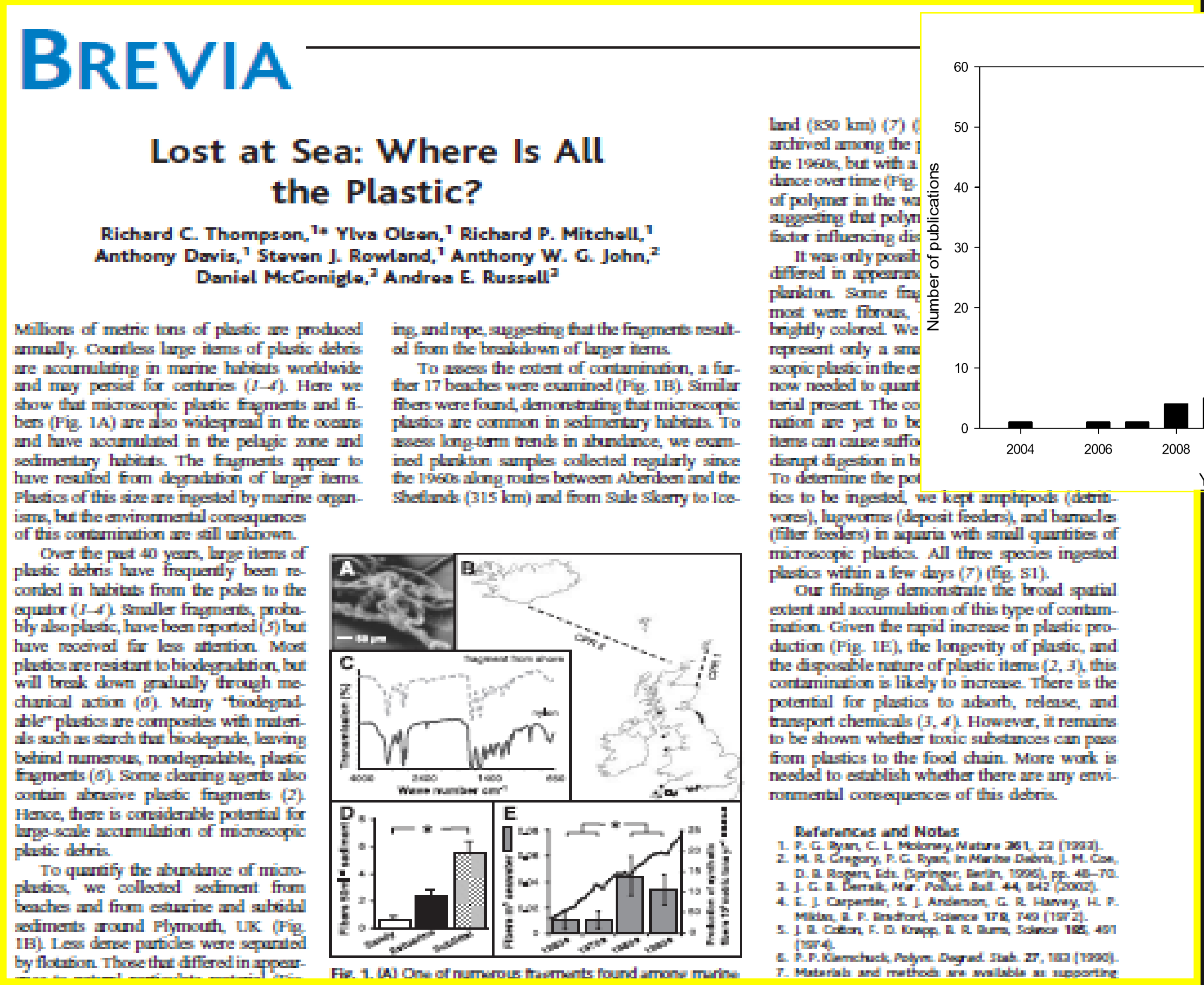
Prof. Richard Thompson OBE FRS

@ProfRThompson

UNIVERSITY OF PLYMOUTH

2004

Microplastics are a Plymouth discovery !



BREVIA

Lost at Sea: Where Is All the Plastic?

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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 plastic debris.

To quantify the abundance of microplastics, we collected sediment from beaches and from estuarine and subtidal sediments around Plymouth, UK (Fig. 1B). Less dense particles were separated by flotation. Those that differed in appear-

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) (…) archived among the (…) the 1960s, but with a (…) dance over time (Fig. (…) of polymer in the wa(…) suggesting that polym(…) factor influencing dis(…)

It was only possib(…) differed in appearan(…) plankton. Some frag(…) most were fibrous, (…) brightly colored. We (…) represent only a sma(…) scopic plastic in the en(…) now needed to quant(…) terial present. The co(…) nation are yet to be (…) items can cause suffo(…) disrupt digestion in bi(…) To determine the pot(…) tics 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.

Fig. 1. (A) One of numerous fragments found among marine

References and Notes
1. P. G. Ryan, C. L. Moloney, Nature 361, 23 (1993).
2. M. R. Gregory, P. G. Ryan, in Marine Debris, J. M. Coe, D. B. Rogers, Eds. (Springer, Berlin, 1996), pp. 49–70.
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5. J. B. Colton, F. D. Knapp, B. R. Burns, Science 185, 491 (1974).
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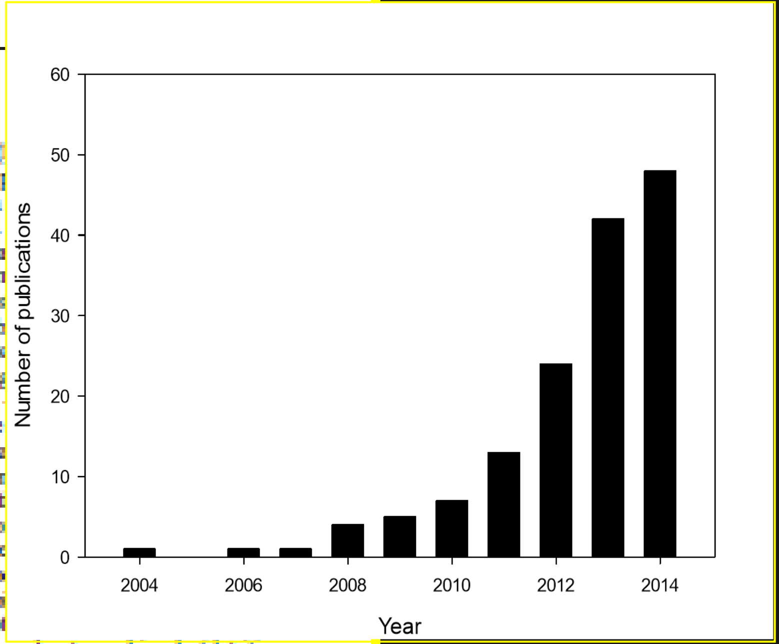
7. Materials and methods are available as supporting



Thompson *et al.* 2004

Microplastics

Plastic fragments
less than 5mm

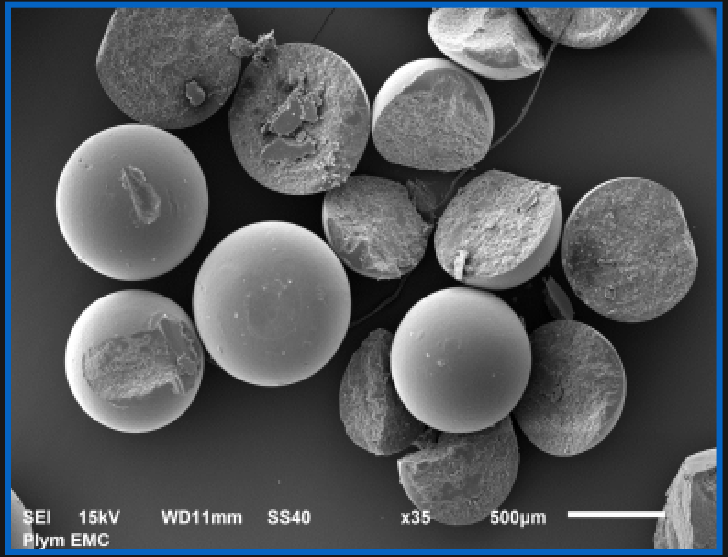
variable in size, shape, polymer and chemical composition and origin

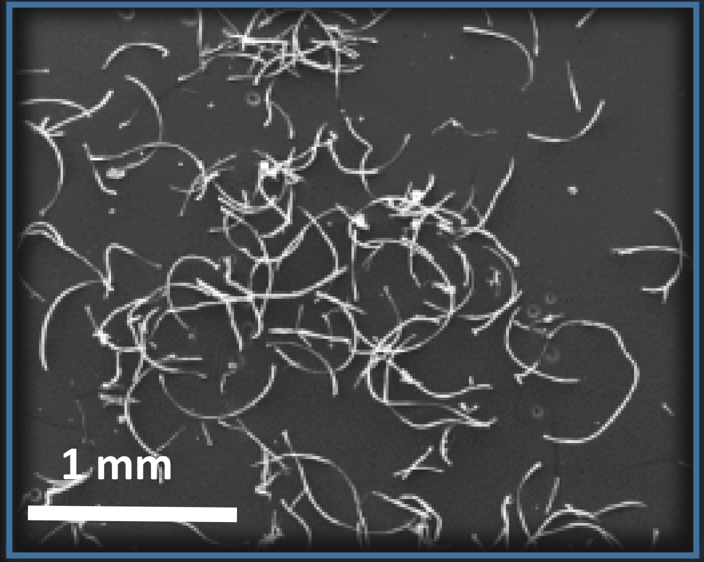
No single intervention
Local – national – global

Actions on larger items will reduce the microplastics of tomorrow

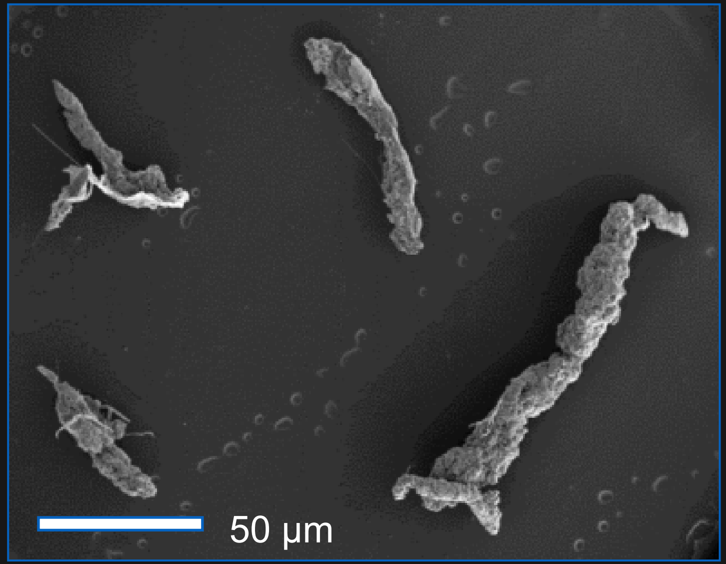
Plastic fragments from River Tamar

microbeads
from shower gel





Microfiber from clothing



Tyre wear particles

Types of debris

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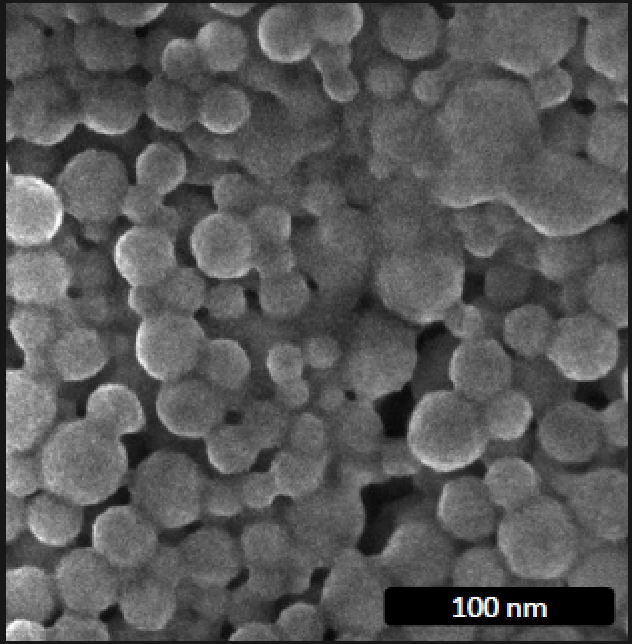
Mega

Micro

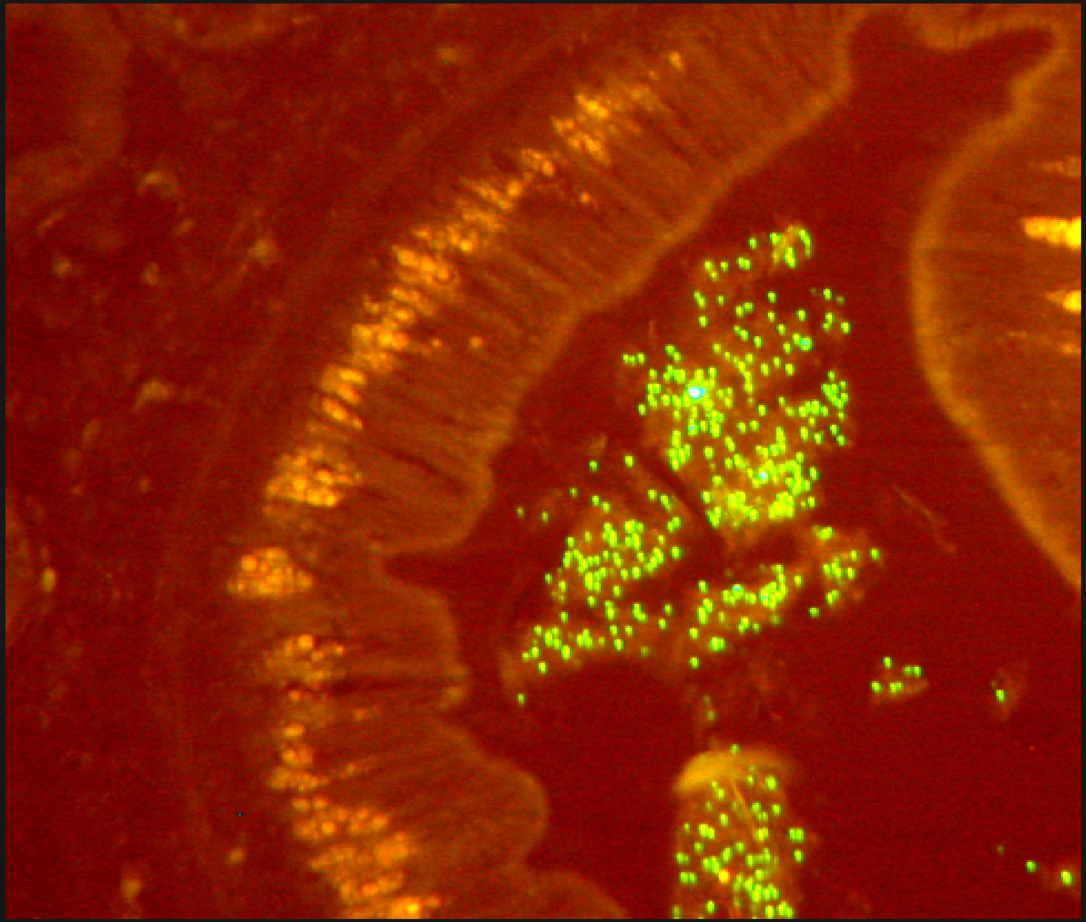


Nano ?

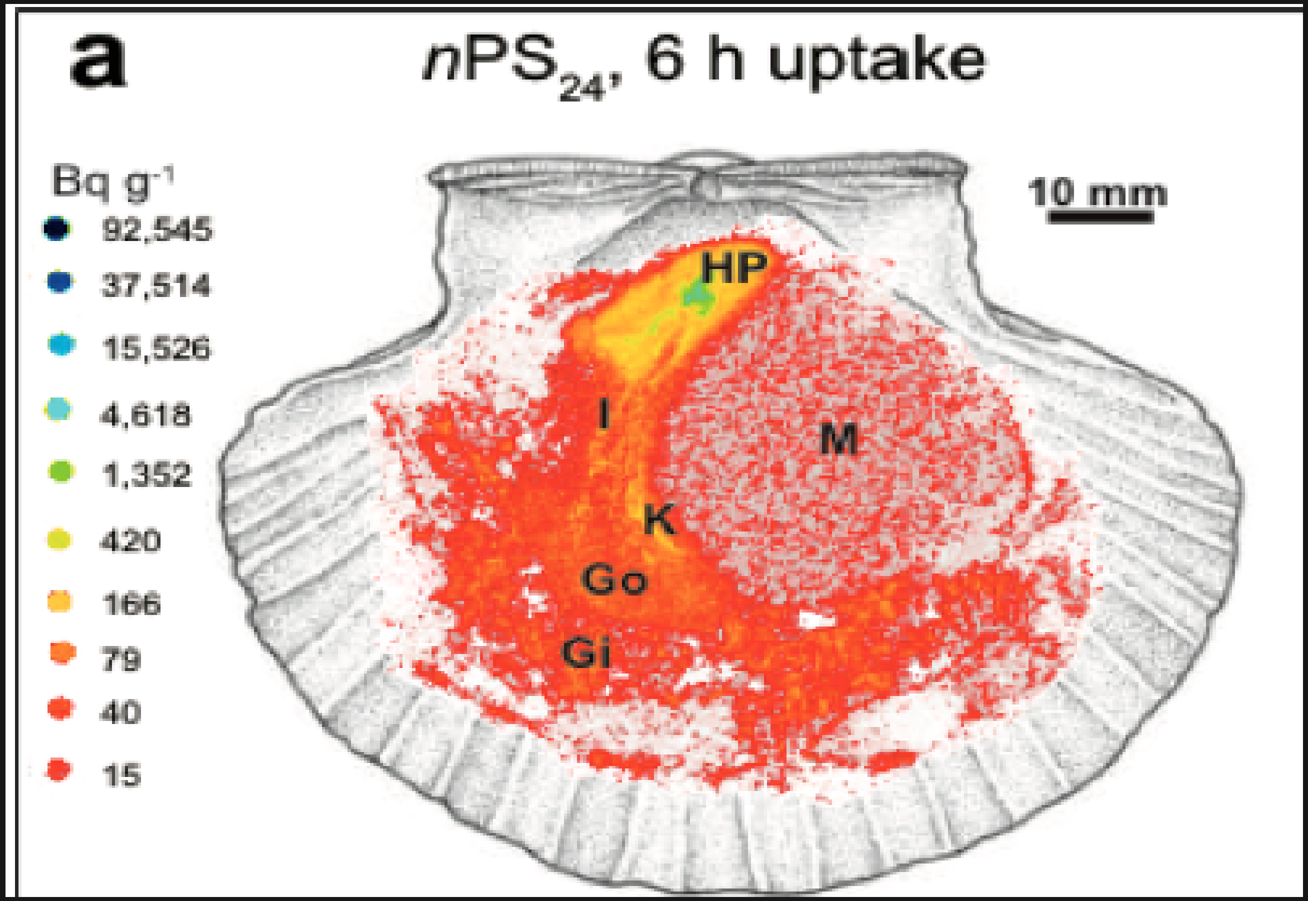
Large and rare

Small and ubiquitous

Microplastic is retained in organisms



M.A. Browne *et al*. 2008

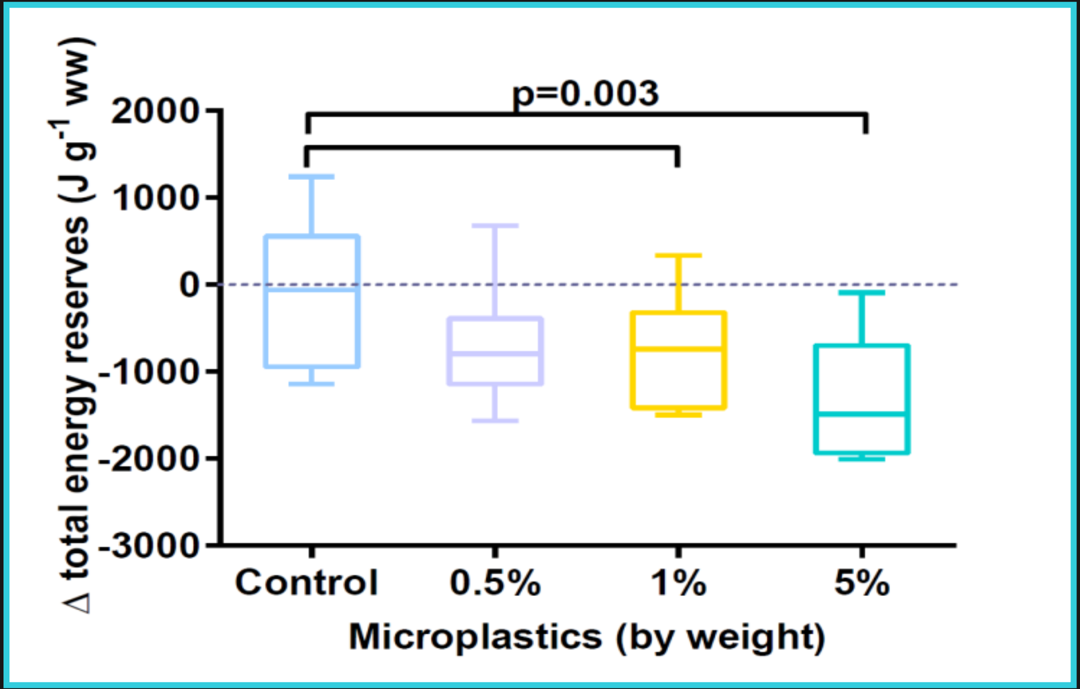


Al Sid Cheik *et al*. 2018

Physical effects (independent of any chemical effects)

1% PVC significantly reduced energy reserves by 30%

5% PVC significantly reduced energy reserves by 50%



Wright *et al.* 2013

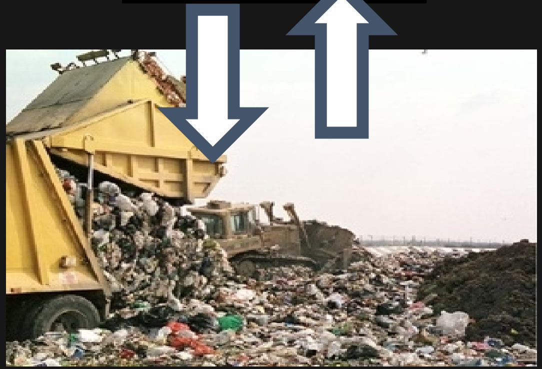
Solutions - plastics as materials are not the problem

Reduce

Re-use

Redesign

Recycle



<u>Reduce</u> - Design failure and policy intervention (a ban)

Napper & Thompson, 2015

INDEPENDENT News Voices Sports Culture Indy/Life Video Daily Edition

Environment

Microbeads ban: Government to outlaw microplastics in cosmetic products

Any kind of 'rinse-off' personal care and cosmetic products are affected, but not 'leave-on' make-up or sunscreen after industry complaints about the cost

Ian Johnston Environment Correspondent | @montaukian | Friday 21 July 2017 10:00 BST | 48 comments

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Microbeads ban: Government to outlaw microplastics in cosmetic products

Cosmetic microbeads – single container had 3 million particles !

Now prohibited in multiple countries

Was the issue avoidable – by better design 50 yrs ago,
or at some time since?

Microfibres - best addressed by upstream measures to redesign

Microfibres
from textiles

Capture - washing machine

Capture - wastewater treatment

Prevent / minimise
better design

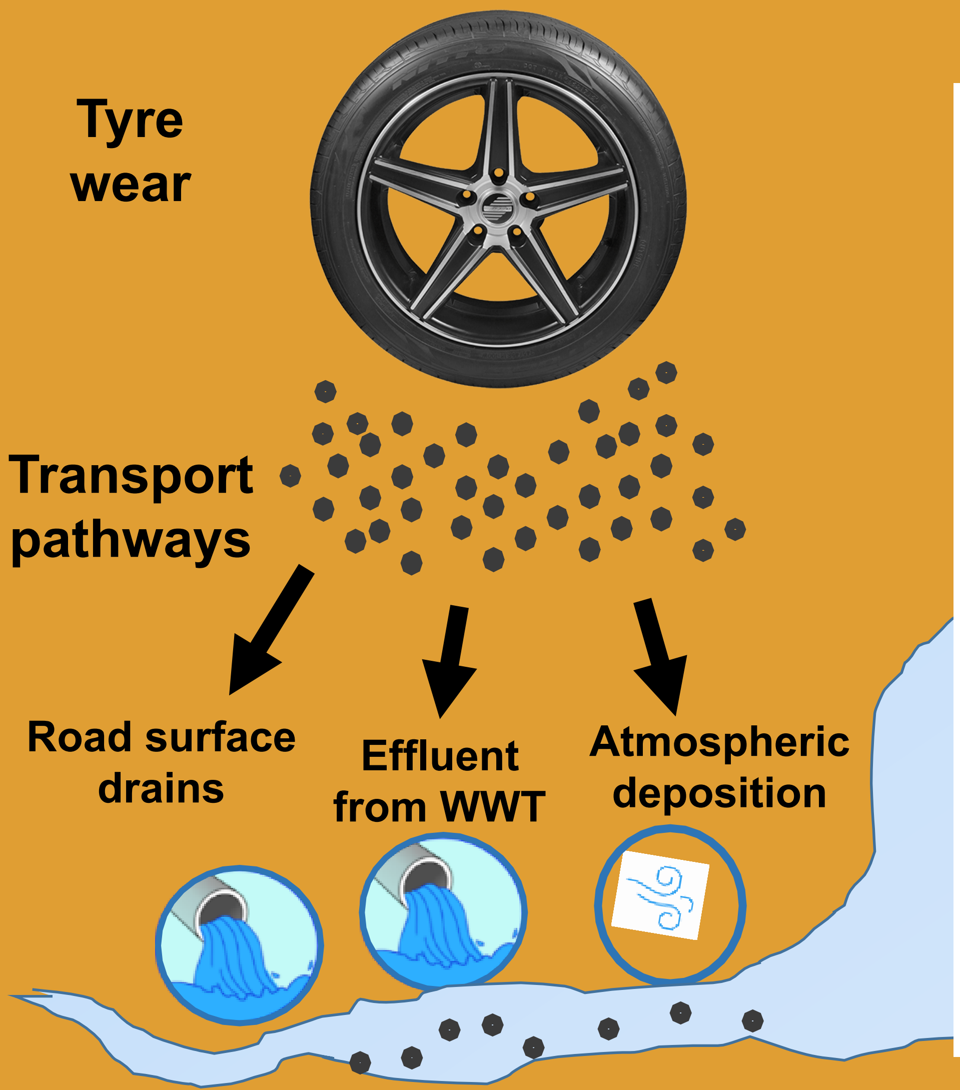
National level policy (downstream)

International measures (upstream)

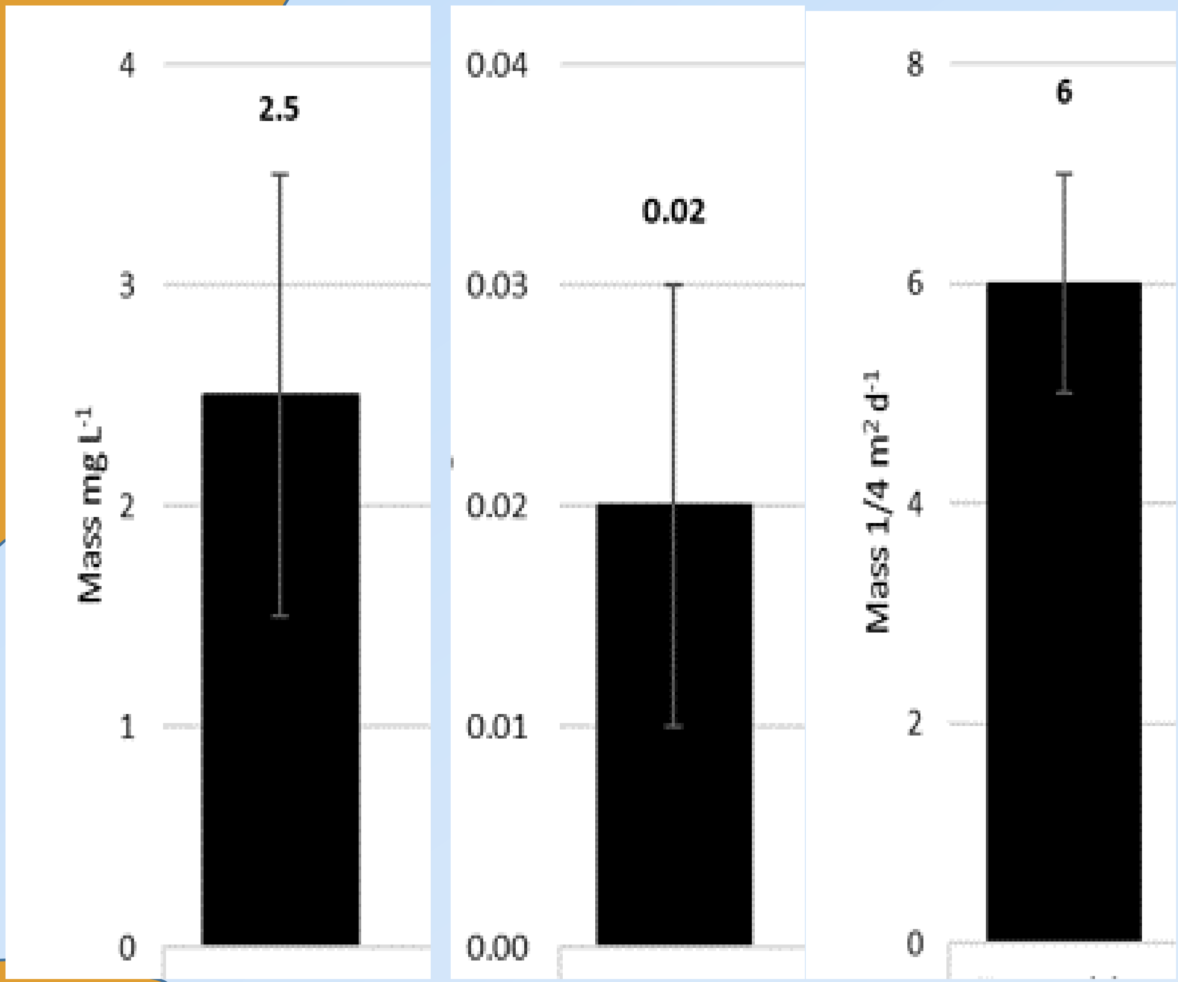
Napper & Thompson, 2016; Napper, et al. 2020; Kelly, et al. 2019, De Falco, et al. 2020

Once in a planet opportunity for international level action !

Science essential to inform action !



Parker Jurd *et al.* 2019

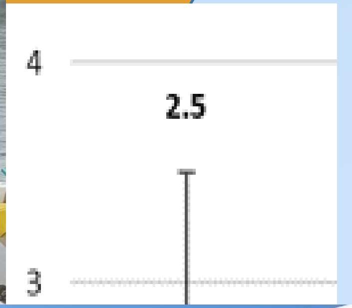


a) Road surface drain

b) WWT effluent

c) Atmospheric deposition

Interventions - Tyre design, vehicle maintenance or driver behaviour?



Interventions - Tyre design, vehicle maintenance or driver behaviour?

Redesign -Biodegradable Agri-Plastic

'pre-exposed soil' deployments

'soil' deployments

3 months soil surface

+

Soil burial

'marine' deployments

'air' deployments

Redesign -Biodegradable Agri-Plastic - Results after 12 months

	Before exposure	12 months Soil	3 months pre-exposure +12 months Soil	12 months Air	12 months Seawater
PLA					
amPLA					
PBAT					
PBS					
PHBV					No sample left

- **Visual degradation** observed in all environments for **PHBV** after 12 months exposure.
- **PHBV** exposed to **marine** environment completely disappeared in **less than 12 months.**
- **Limited** to no visual degradation for **PLA, PBAT and PBS** polymers after 12 months exposure.

Recycling requires dedicated waste streams and appropriate design

Design for recyclability?

Who bears the cost (producer, society) ?

Collection is essential to recycling

Who bears the cost (producer, society) ?

Focus on upstream interventions (following waste hierarchy)

Parker-Jurd et al. 2022

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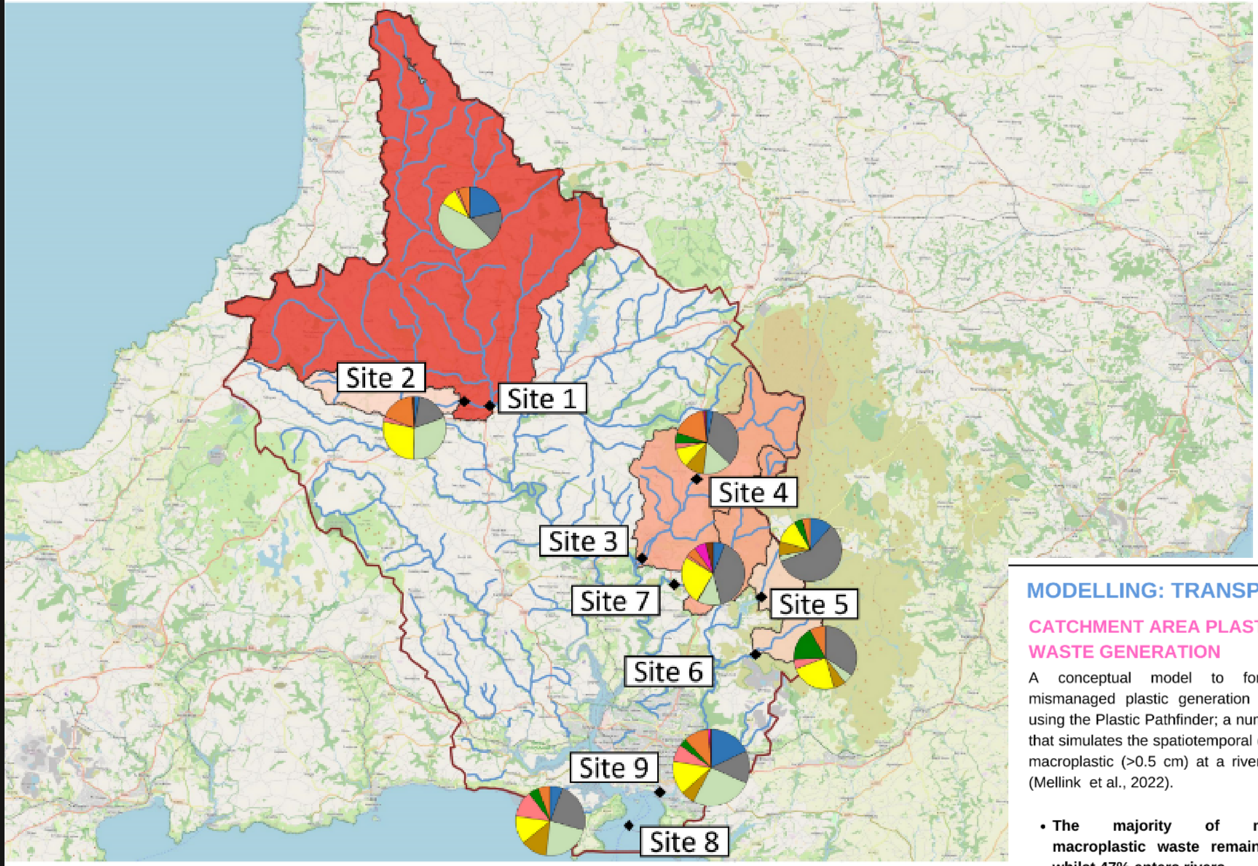
Monitoring - Tamar as model catchment?

SAMPLING CAMPAIGN RESULTS

Microplastic average concentration and polymer types in the Tamar catchment area



4 SAMPLING CAMPAIGNS
7 SAMPLING POINTS IN RIVER CATCHMENTS
2 SAMPLING POINTS IN MARINE AREAS

GRAPHIC AND MAP LEGENDS

Polymer types

- POLYETHYLENE (PE)
- POLYESTER (PES)
- POLYPROPYLENE (PP)
- POLYSTYRENE (PS)
- POLYAMIDE (PA)
- POLYURETHANE (PU)
- POLYVINYL CHLORIDE (PVC)
- ACRYLIC POLYMER (AP)

MP concentrations (MP/m³)

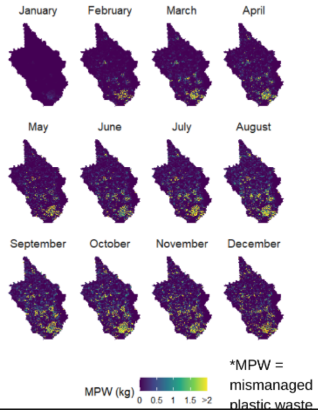
- not collected
- not detected
- < 0.1
- 0.1 - 0.5
- 0.5 - 1
- 1 - 2.5
- 2.5 - 5

MODELLING: TRANSPORT OF MACROPLASTICS

CATCHMENT AREA PLASTIC WASTE GENERATION

A conceptual model to forecast daily mismanaged plastic generation was created using the Plastic Pathfinder; a numerical model that simulates the spatiotemporal distribution of macroplastic (>0.5 cm) at a river basin scale (Mellink et al., 2022).

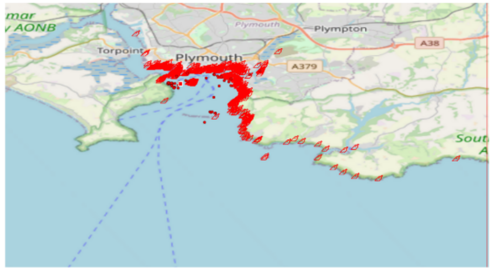
- **The majority of mismanaged macroplastic waste remains on land, whilst 47% enters rivers**
- **Rivers are the largest sink of**



*MPW = mismanaged plastic waste

MOVEMENT OF PLASTICS AT SEA

Actimar-produced microplastics trajectories map and identified potential accumulation areas at sea



- **Particle dispersion modelling in Plymouth Sound shows particles moving east, with 93% particles stranded, 5% particles still active, and 1.4% particles that have moved outside of the modellled area, after one week**
- **Dispersion model at sea, with south west wind direction.**
- **Available at: https://ppp.actimar.fr/ppp/map**

Interreg France (Channel Manche) England
European Regional Development Fund
PREVENTING PLASTIC POLLUTION
UNIVERSITY OF PLYMOUTH
Westcountry Rivers Trust
Queen Mary University of London
Actimar
LABOCEA

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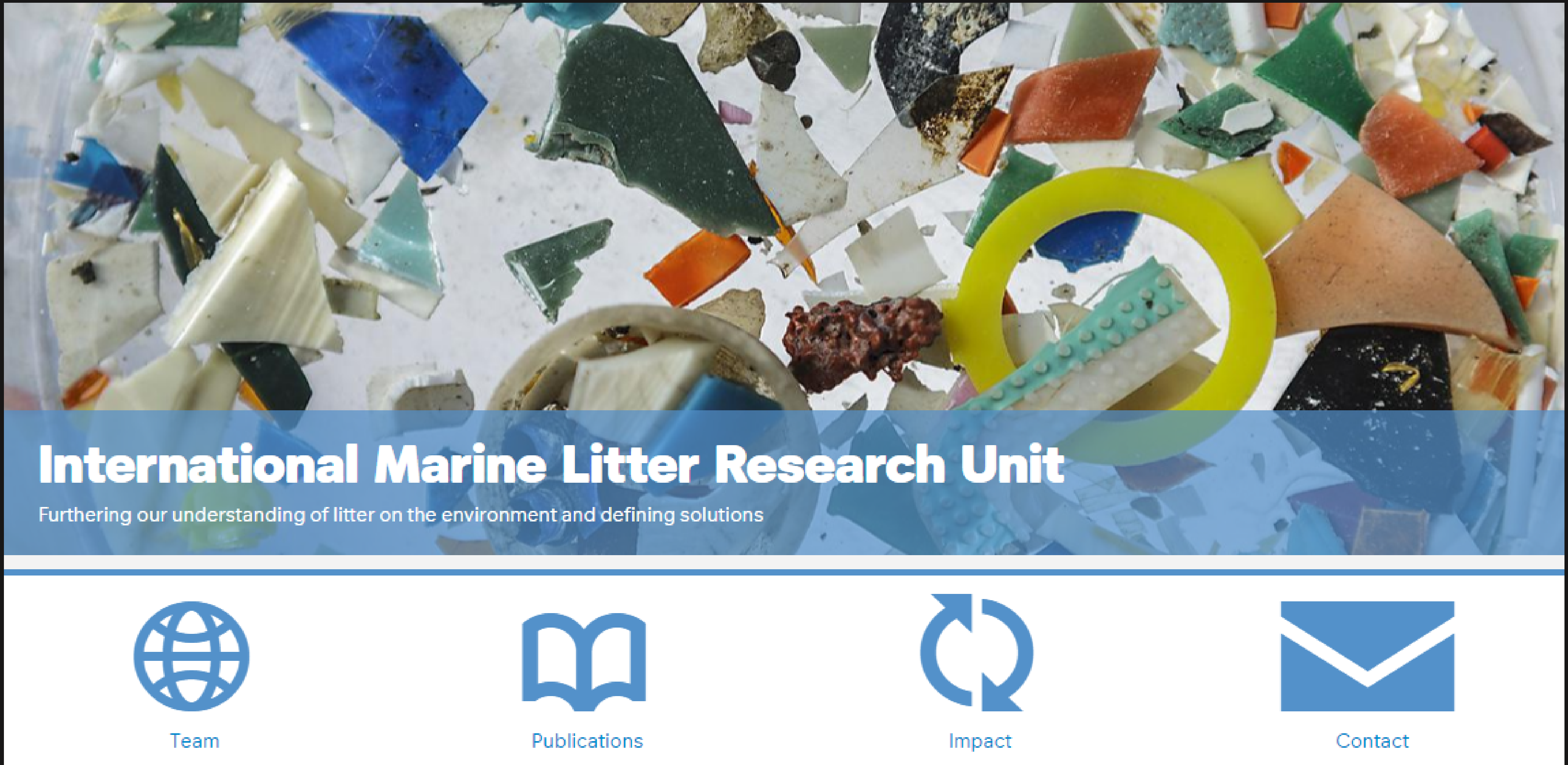
Microplastic <u>debris</u> in the environment

- Symptoms of outdated business models for production use and disposal coupled with ‘’*solutions*’’ that have NOT been fully evaluated.
- Evidence of impacts on economy, wildlife, services
- Impacts not coupled to societal benefits
- Solutions exist – but 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
- Together - industry, policy and public - we can solve this challenge
- UN Treaty – needs reliable independent evidence to prioritise actions

Richard Thompson – Thank you

@ProfRThompson



defra
Department for Environment Food and Rural Affairs

The Leverhulme Trust

GCRF
Global Challenges Research Fund

Interreg
France (Channel Manche) England
European Regional Development Fund

PREVENTING PLASTIC POLLUTION

UKRI UK Research and Innovation

national highways

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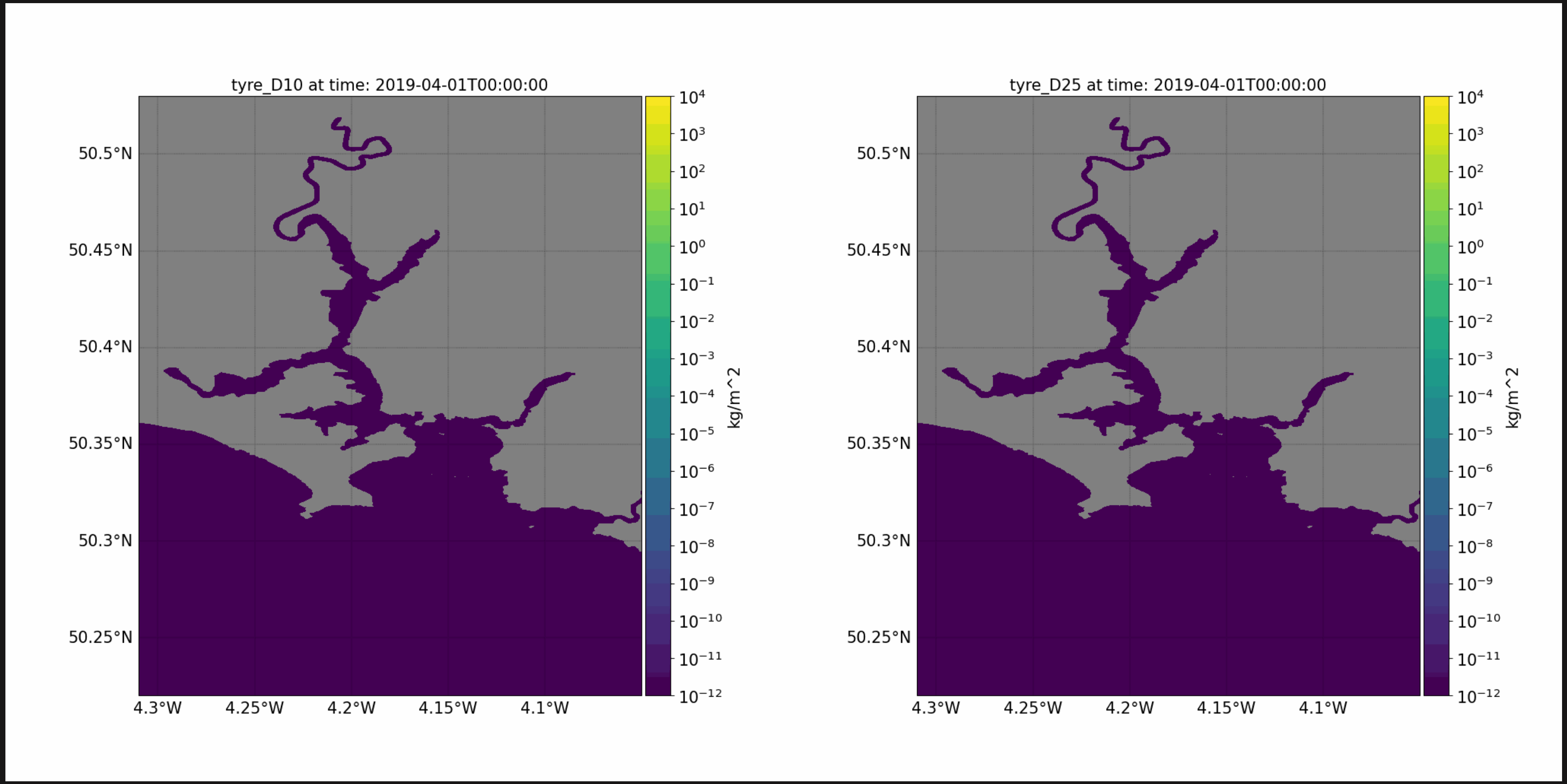
Preliminary results: suspended particles



Tyre class 1

PML Plymouth Marine Laboratory

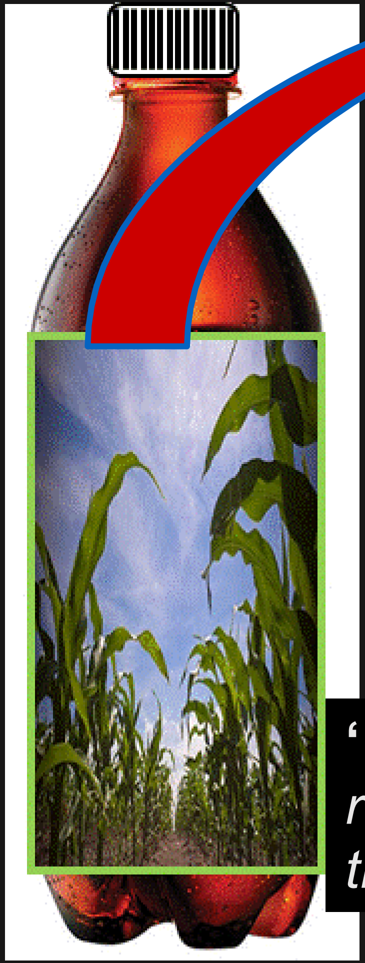
Imperative to design products for life in service & end of life – need appropriate standards and labelling

Napper & Thompson, 2019

We urgently need evidence – which solutions work and the trade offs among them

Potentially conflicting drivers

Will bioplastics reduce litter / waste?



‘This new packaging is fully recyclable, and is said to reduce carbon emissions by as much as 25% over the product lifecycle.’

Resource IN

Waste OUT