Plastic debris in the oceans
solutions to a global environmental problem

Richard Thompson, Plymouth University, UK

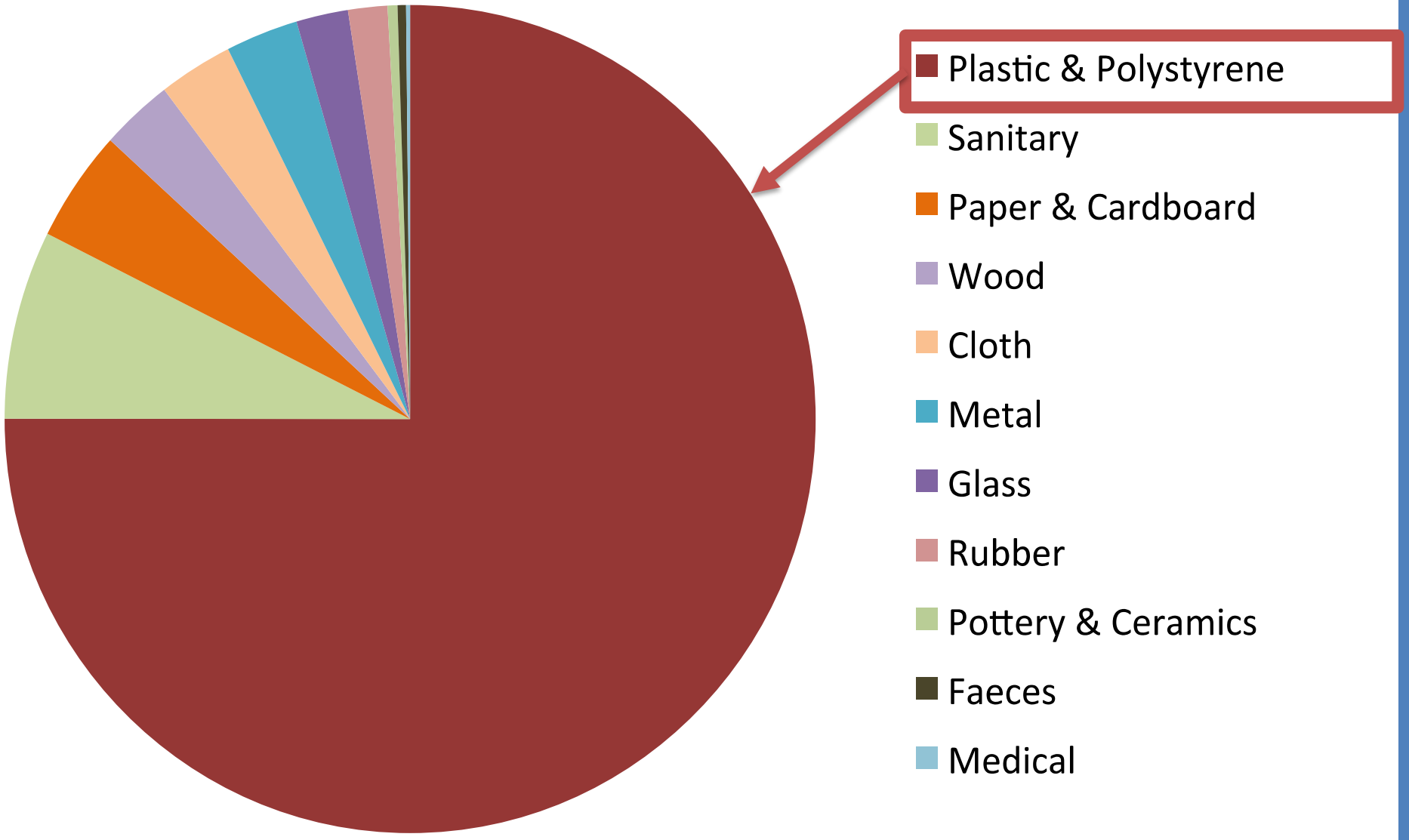
Krichim, Boat in plastic, April 25, 2009. Photo: Dimitar Dilkoff

Krichim, Boat in plastic, April 25, 2009. Photo: Dimitar Dilkoff

Seabed Pollution. Photo Source: Bouteilles à la mer org ■


R. Ticehurst

What is marine litter?

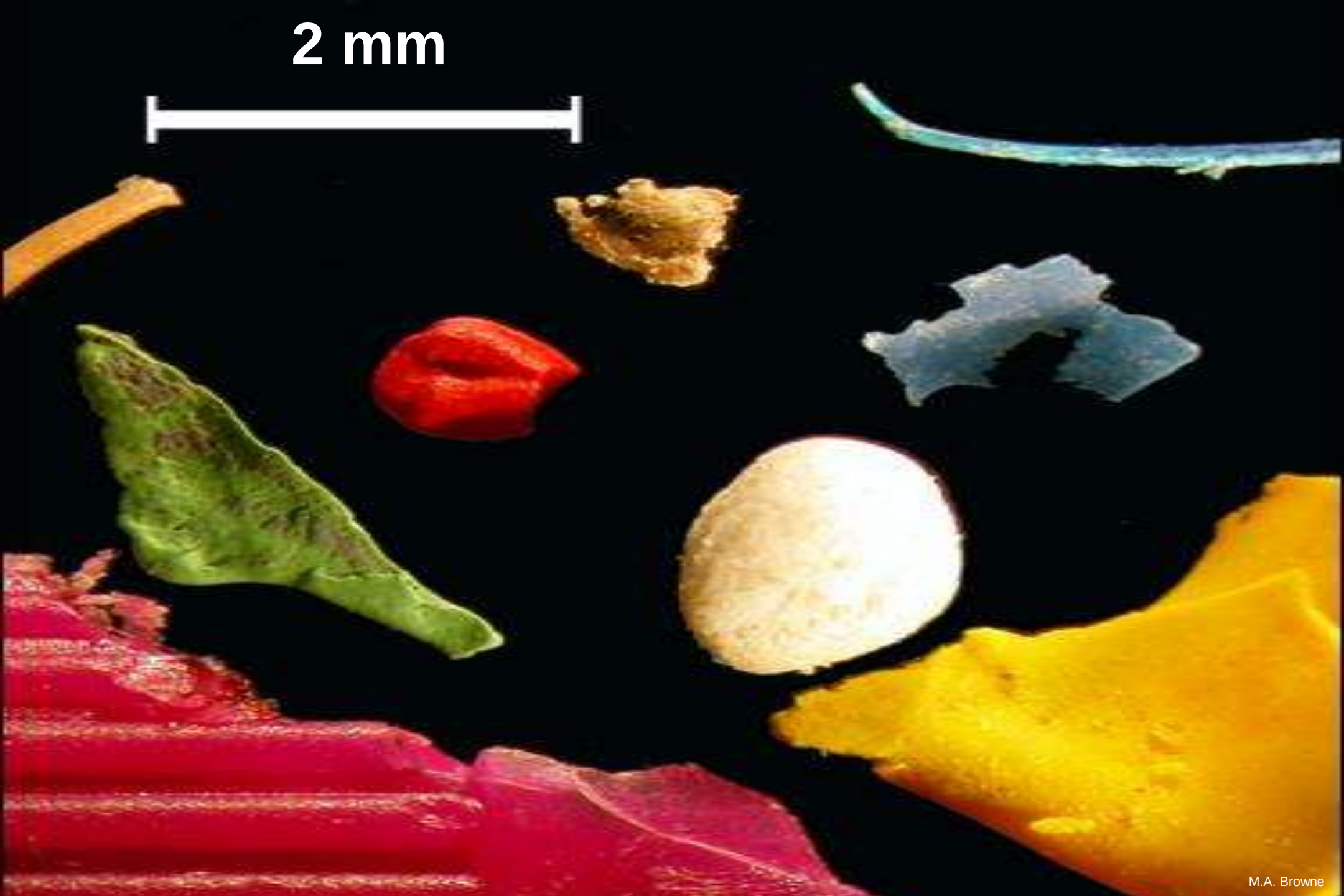


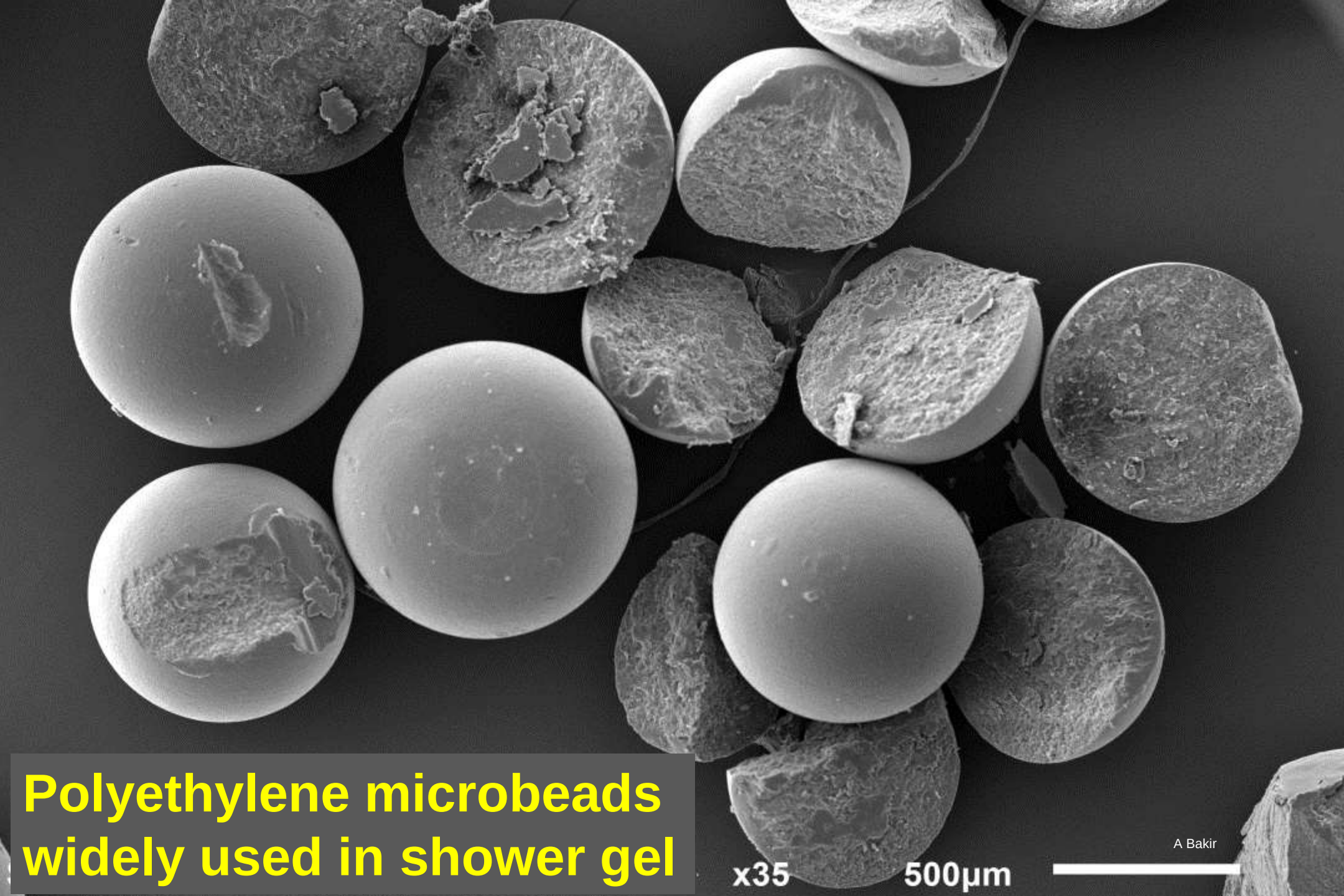
Proportion of marine debris found on reference beaches (2001-2006) OSPAR, 2007


R. C. Thompson

Derelict nets at the GGP. Photo Source: 20tv


R. C. Thompson


2 mm
M.A. Browne

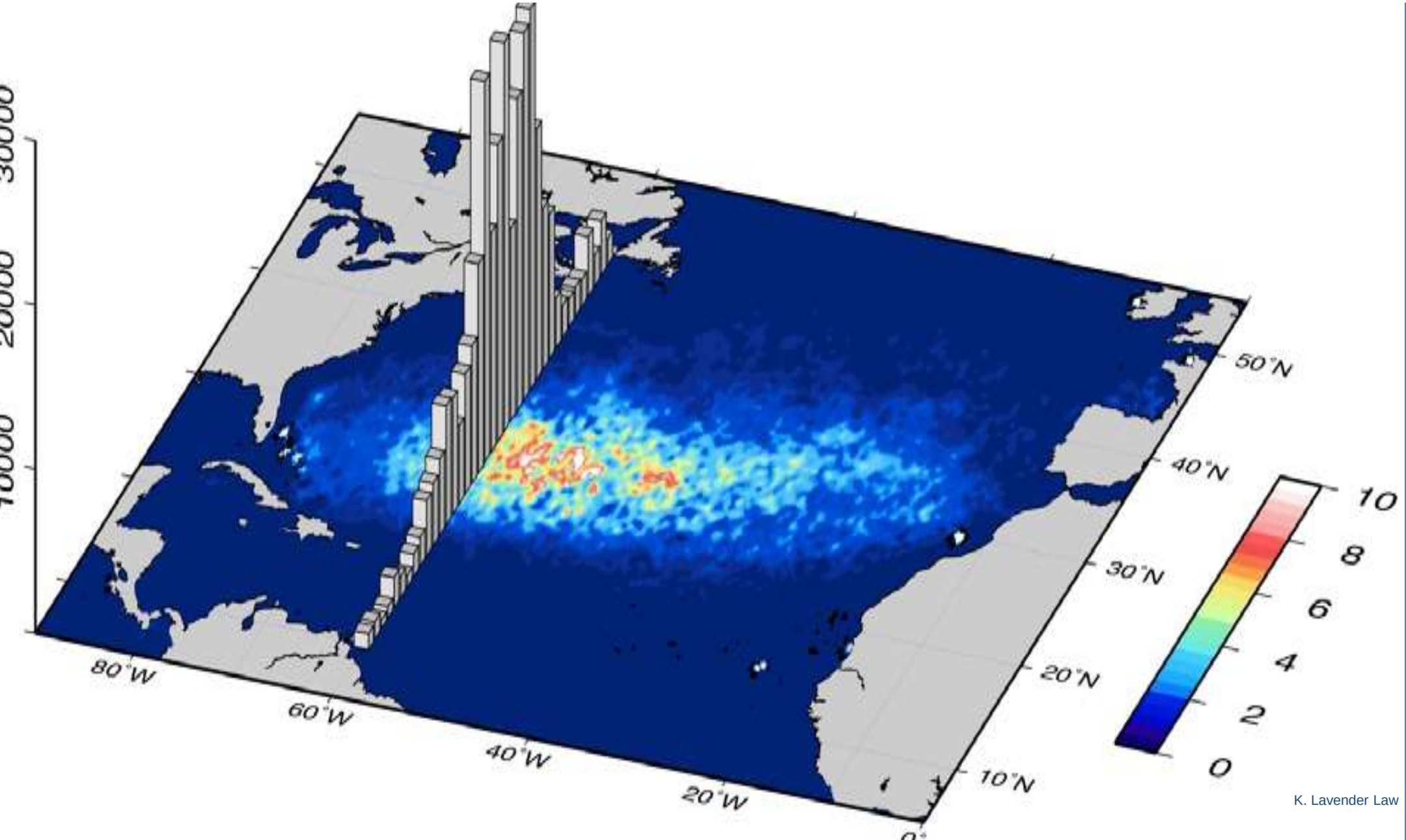

Polyethylene microbeads widely used in shower gel
A Bakir
x35
500µm

Methods– collection /separation / identification

No universal method see:

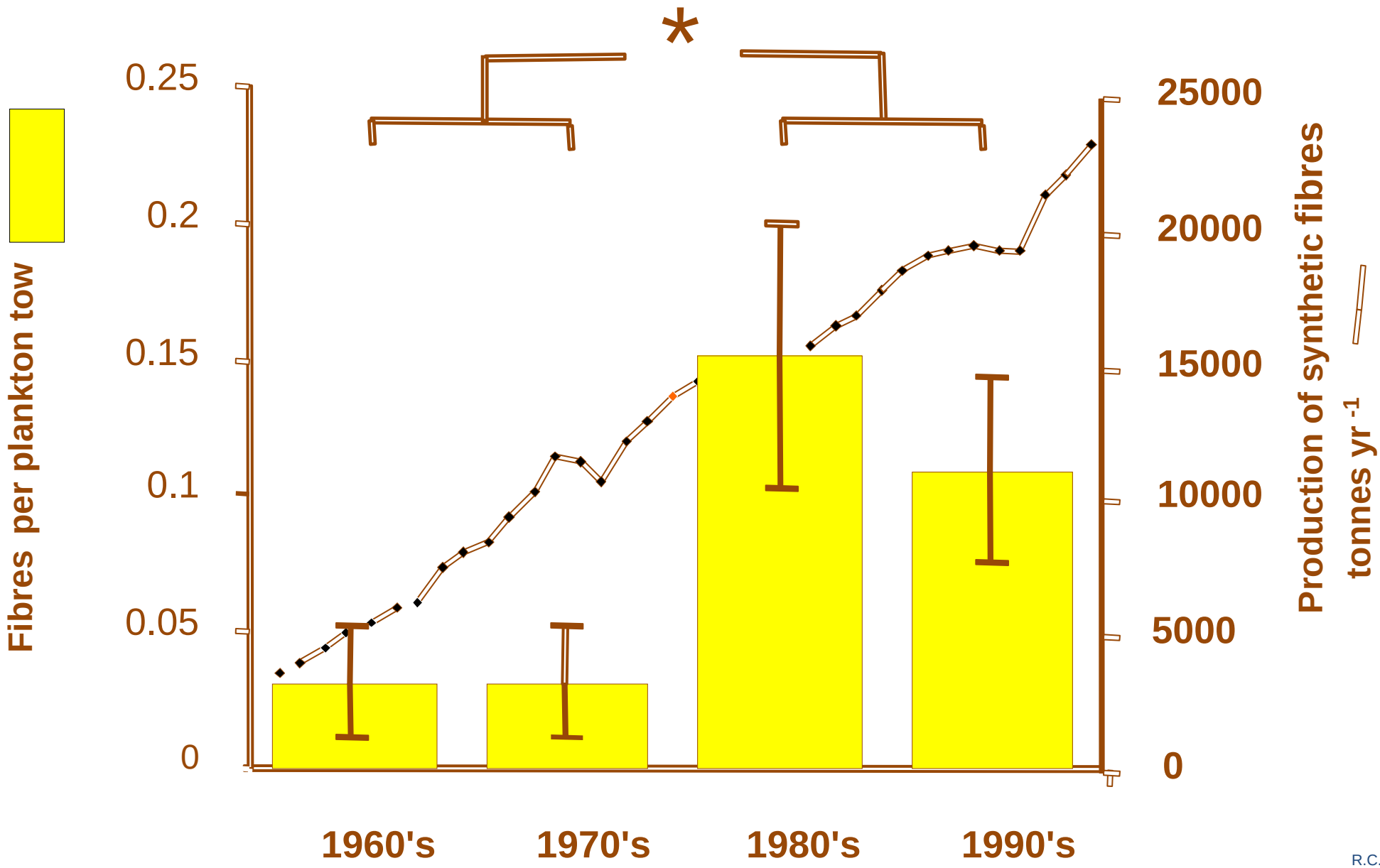
MSFD TG10 Guidance on monitoring marine litter (2014) – Section 3.5 - Microlitter

Widespread



K. Lavender Law

Accumulating

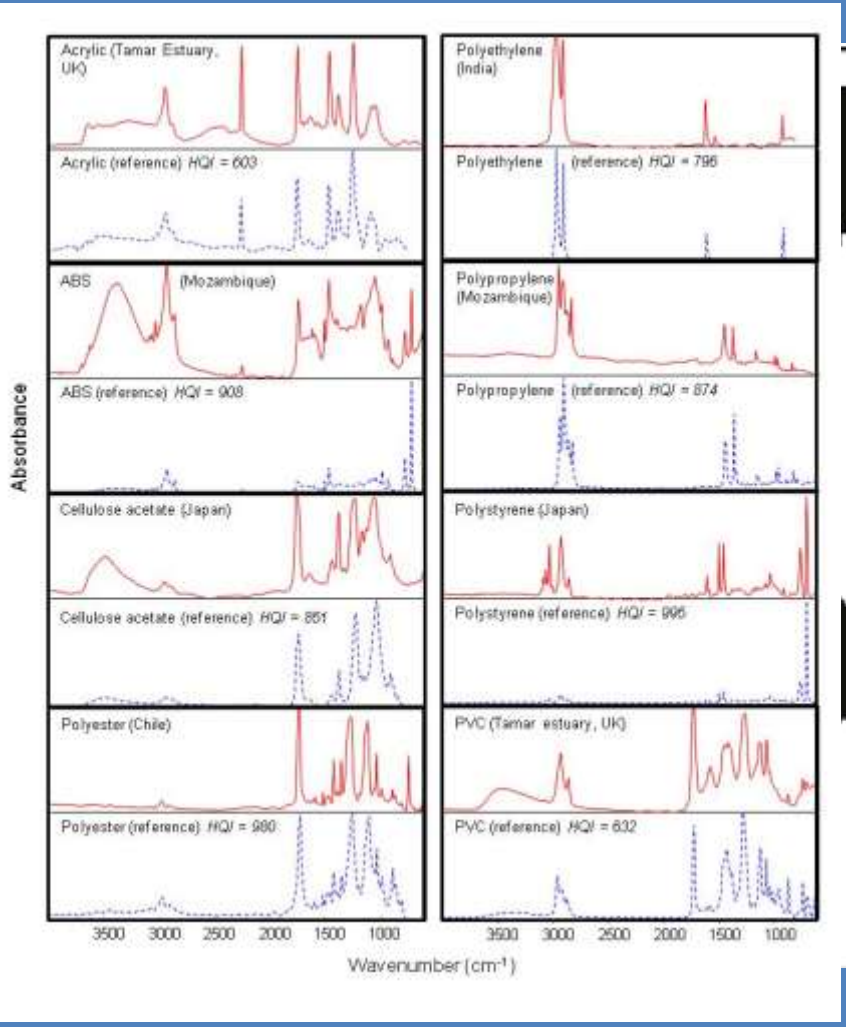


R.C. Thompson

Microplastics in intertidal sediments

Browne *et al* .2011

Microplastics in intertidal sediments

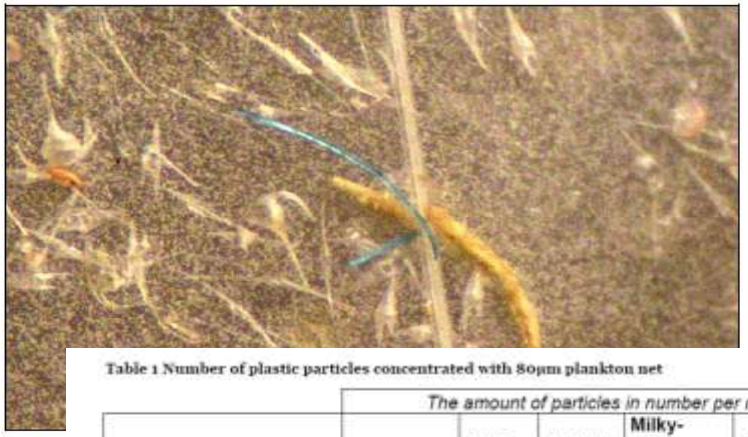


Browne *et al* .2011

Distribution - highly variable, not yet predictable

Small plastic particles in

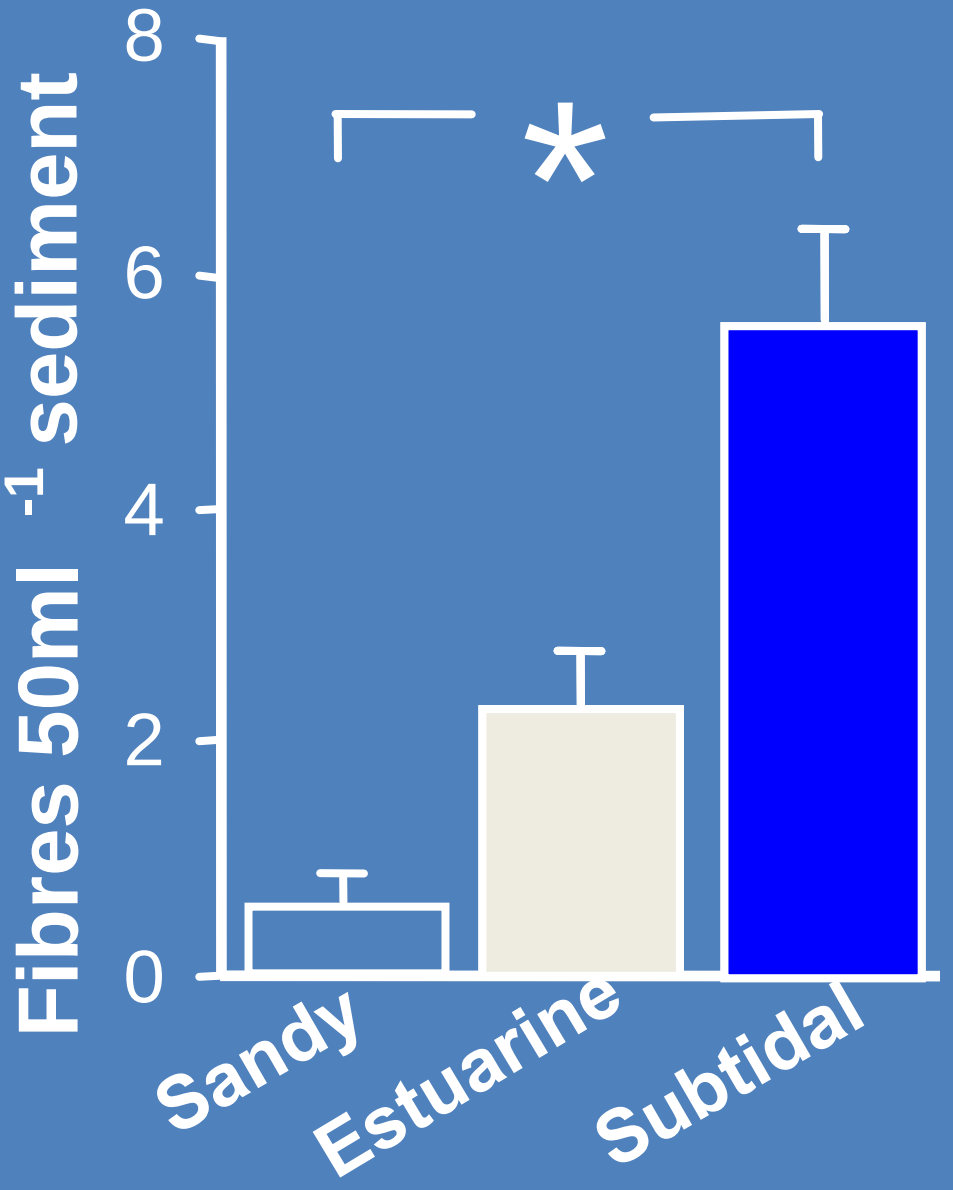
Coastal Swedish waters.



Blue p

Table 1 Number of plastic particles concentrated with 80µm plankton net

	The amount of particles in number per m³					
	Red fibres	Blue fibres	Black / transp.	Milky-white spheres	Σ particles per m³	+/- sd
Lysekil, Southern harbour	50	1 900	450	0	2 400	
Lysekil, Southern harbour, inner harbour	100	550	500	0	1 150	
Lysekil, Southern harbour, nrthern Släggö	50	350	200	0	600	
Lysekil, outer Släggö	50	100	50	0	200	
Björkö harbour, mean of 2 samples	0	400	250	0	450	283
Björkö ferry,mean of 3 samples	0	200	100	0	167	126
Tjuvkils huvud, harbour	50	200	0	0	250	
Stenungsund, location 3	25	0	25	1 575	1 625	
Stenungssunds leisure-boat harbour	50	150	50	850	1 100	
Stenungsund, location 4	50	300	50	750	1 150	
Stenungsund, industrial harbour	0	150	0	102 400	02 550	
Lysekil, Gäven-Byxeskär	80	120	320	40	560	
Lysekil, Gäven	70	160	80	0	310	



Hazard to mariners

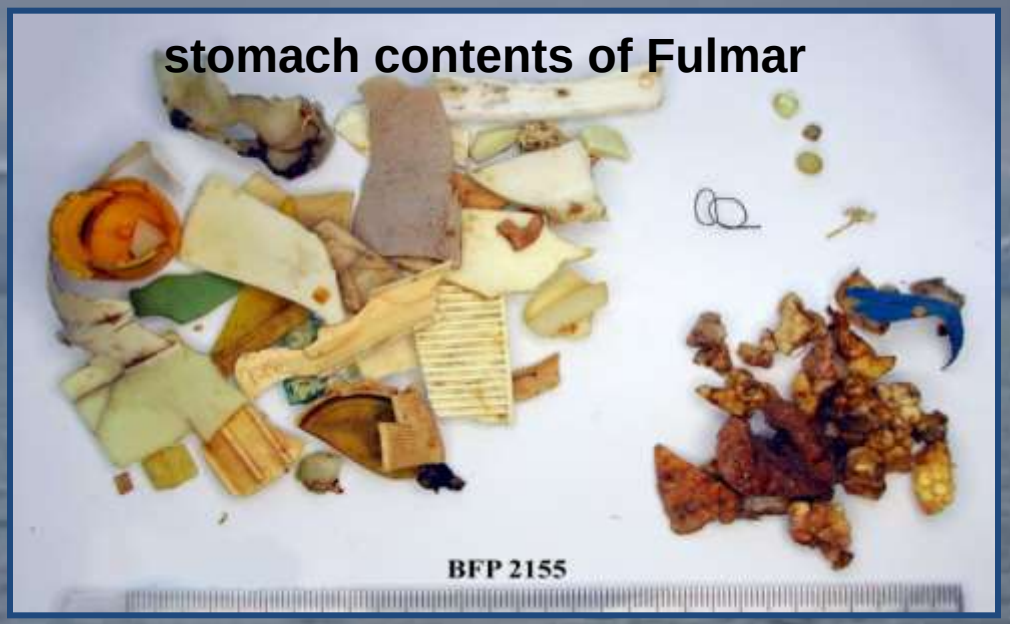
Consequences for wildlife

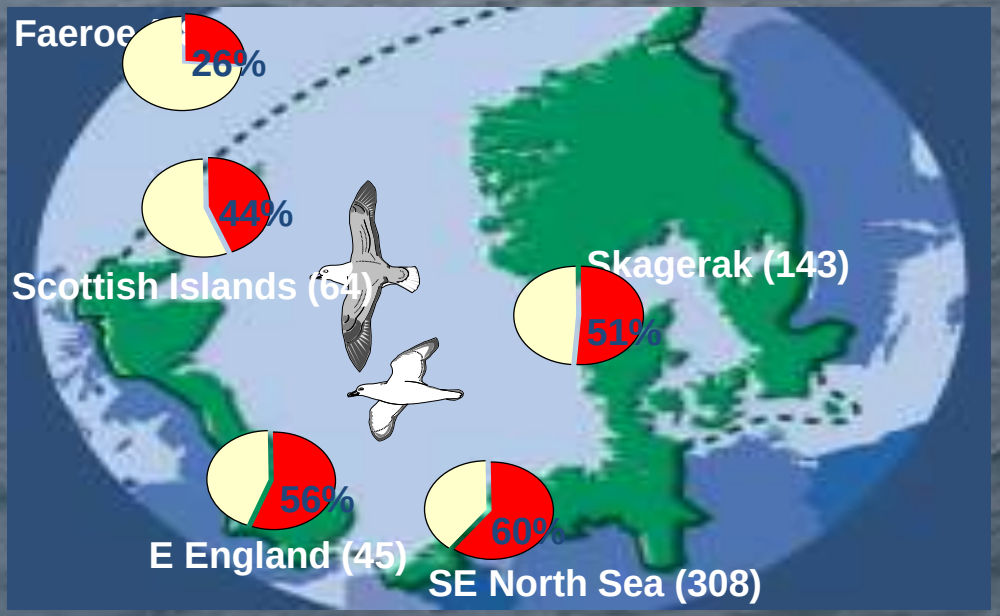
280 papers

46,000 individuals

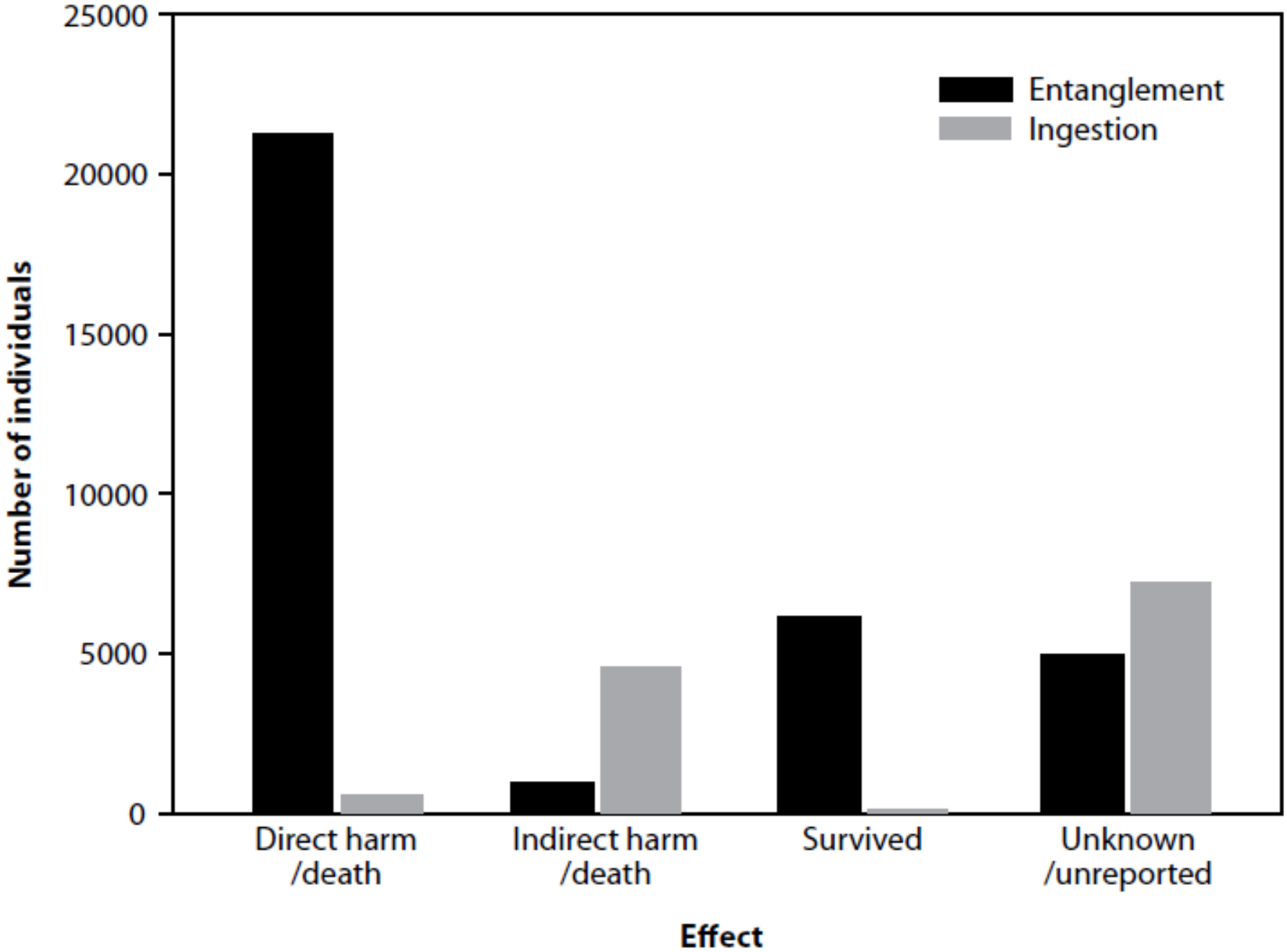
663 Species

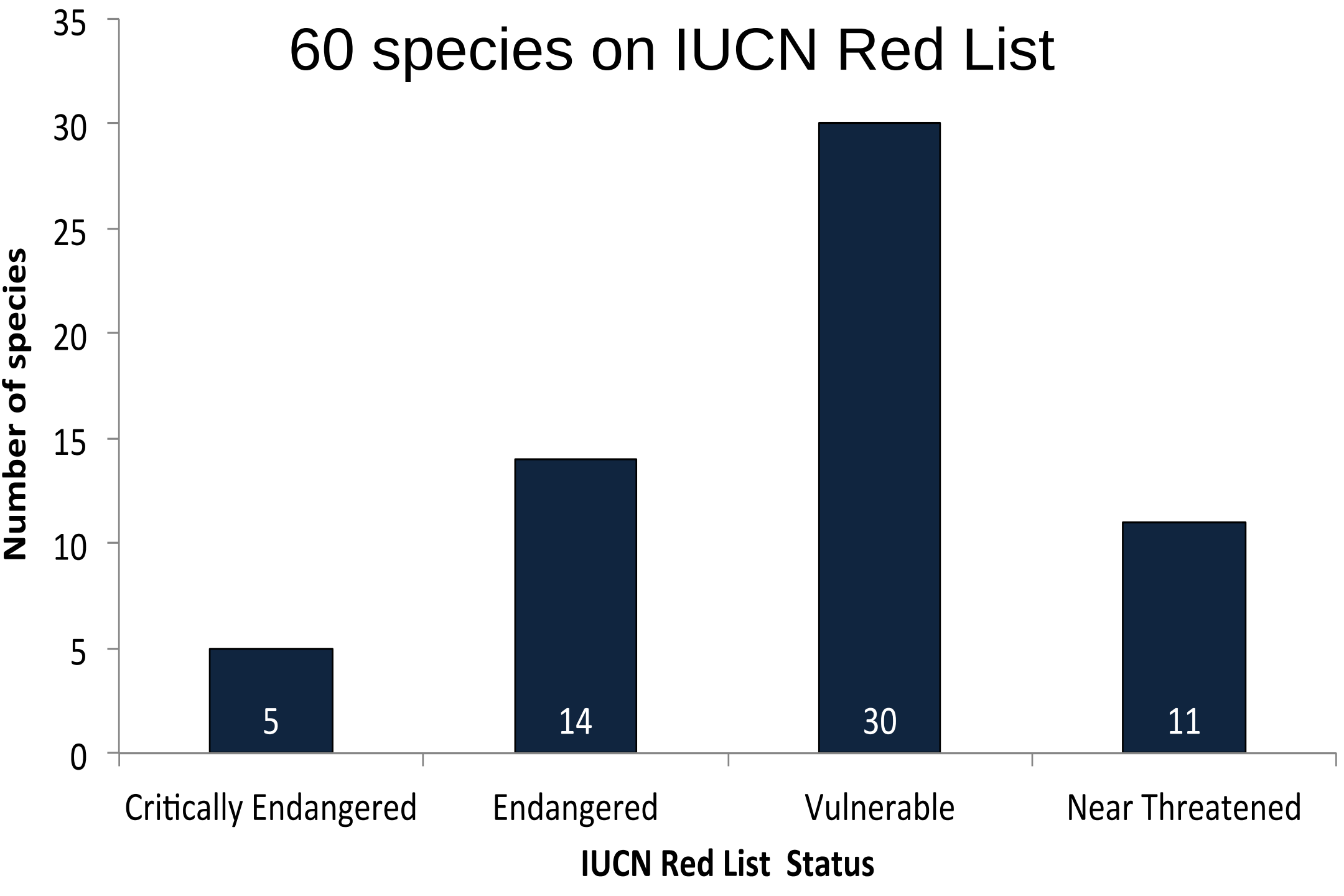
Population level consequences

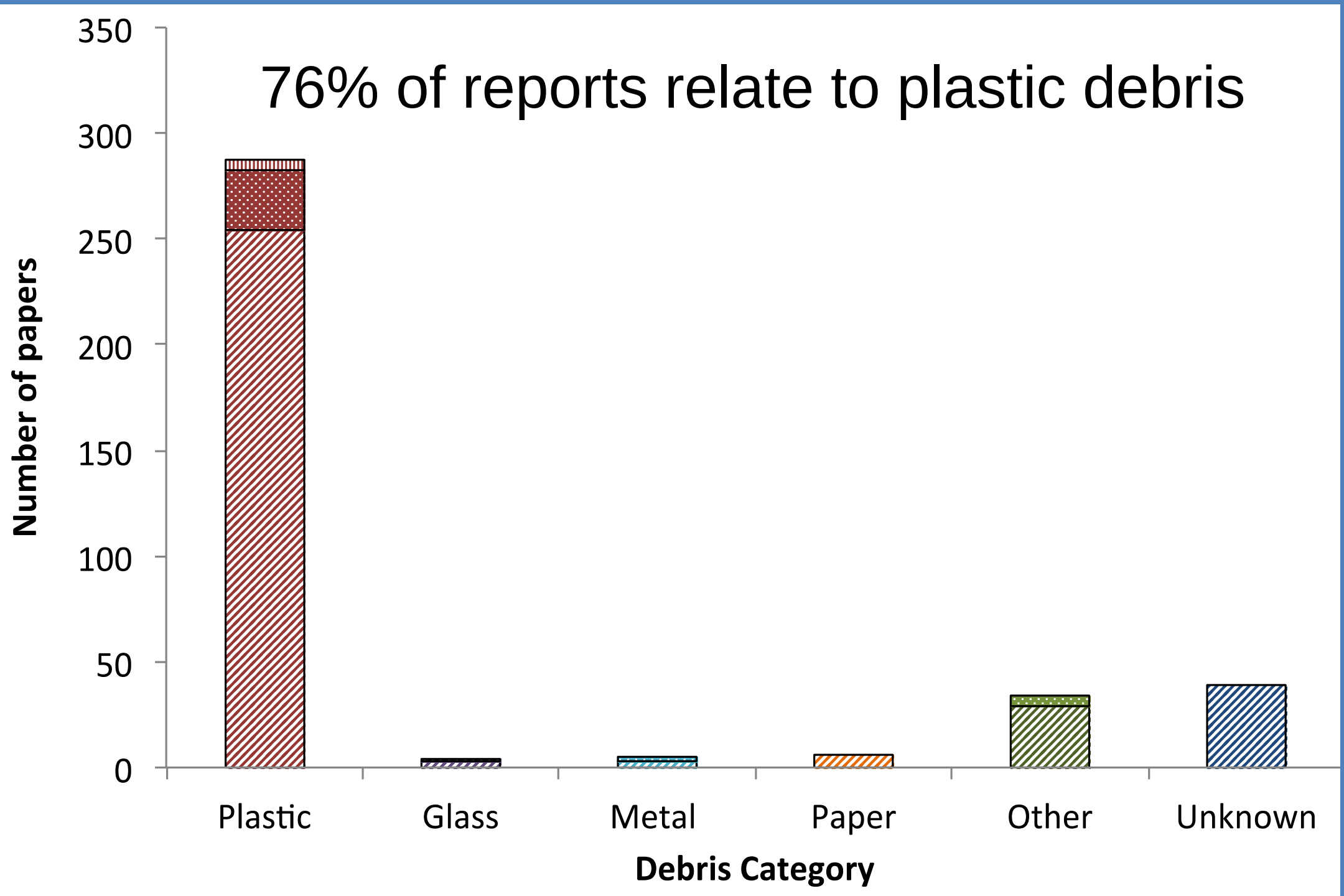


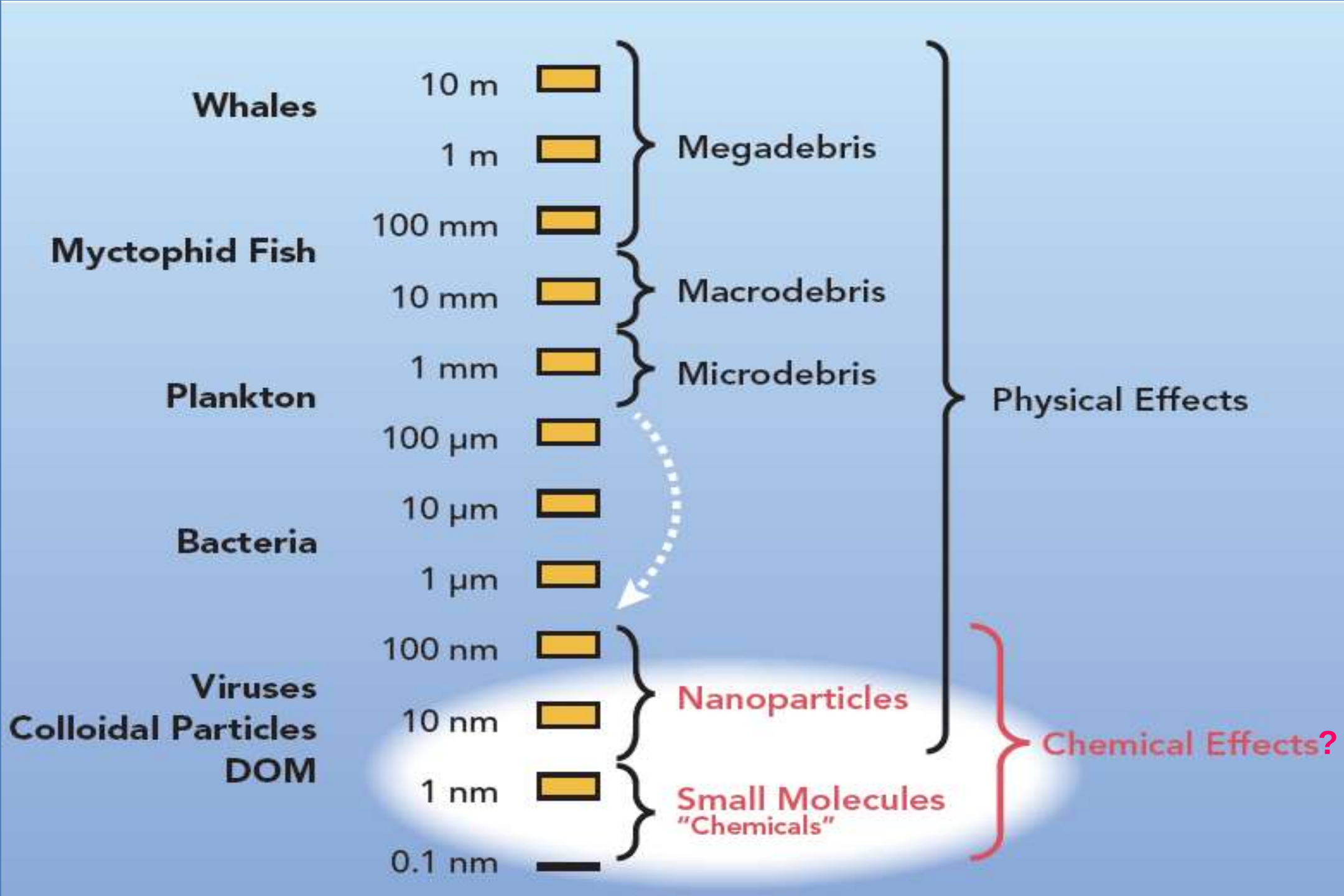


van Franeker *et al.* 2005


25000
20000
15000
10000
5000
0
Number of individuals
Entanglement
Ingestion
Direct harm /death
Indirect harm /death
Survived
Unknown /unreported
Effect


60 species on IUCN Red List
Number of species
35
30
25
20
15
10
5
0
5
14
30
11
Critically Endangered
Endangered
Vulnerable
Near Threatened
IUCN Red List Status


76% of reports relate to plastic debris
Number of papers
350
300
250
200
150
100
50
0
Plastic
Glass
Metal
Paper
Other
Unknown
Debris Category


Whales
10 m
1 m
100 mm
Myctophid Fish
10 mm
1 mm
Plankton
100 µm
10 µm
Bacteria
1 µm
100 nm
Viruses
Colloidal Particles
DOM
10 nm
1 nm
0.1 nm
Megadebris
Macrodebris
Microdebris
Physical Effects
Nanoparticles
Small Molecules
"Chemicals"
Chemical Effects?

Microplastic is ingested and retained in organisms

M.A. Browne

Microplastics – concern about transfer of chemicals
Transfer inevitable, how harmful?

Globe & Mail 17/11/07

A toxic Trojan horse: Tiny plastic particles pack a major punch

ZOE CORMIER
zcormier@globeandmail.com

MICROPLASTIC UNFANTASTIC

THE NEWS The planet's oceans are full of plastic trash that has broken down into microscopic particles. These "microplastics" are impossible to clean up. And now research suggests

cy has embraced recommendations to cut both nitr gen and phosphorous. But there is currently no deadl to put that plan into action. And no move to counter the production of what Prof. Scavia calls "political holy water." President Gec called for 35 ethanol by 2

HOPE FOR

THE NEWS ings of L third ru port – w double

New York Times 30/10/07

Even Tiny Plastic Pieces Can Carry Pollution Throughout the Oce

To marine biologists, "plas a dirty word. Fish and bir eat or become tangled in gear or other plastic flo

Haul aboard

The discovery of large amounts of microplastic in remote seas suggests marine pollution is at worse levels than previously thought

er

sea of rubbish – dubbed the grea bage patch, and which may contain tonnes of flotsam – swirls around in a tem of currents known as the North Pac Gyre, a large amount of microplastic w expected; indeed, the highest concentra tions were found there. But Esperanza also discovered an unexpectedly high number of particles in the Atlantic, around the Canary Islands and the Azores. The haul of microplastic continued in the Mediterranean, the Red Sea, the Indian Ocean, in the Bay of Bengal, and off Malaysia and the Philippines. Only in the furthest reaches of

Guardian, UK 27/2/08

World's oceans 'may be poisoned by plastic'

MICROSCOPIC particles of plastic could be poisoning the oceans, according to a team of researchers in Plymouth.

They report that small plastic pellets called "mermaid's tears", which are the result of industry and domestic waste, have spread across the world's seas.

The scientists are worried that water and what effect it is having on the marine environment.

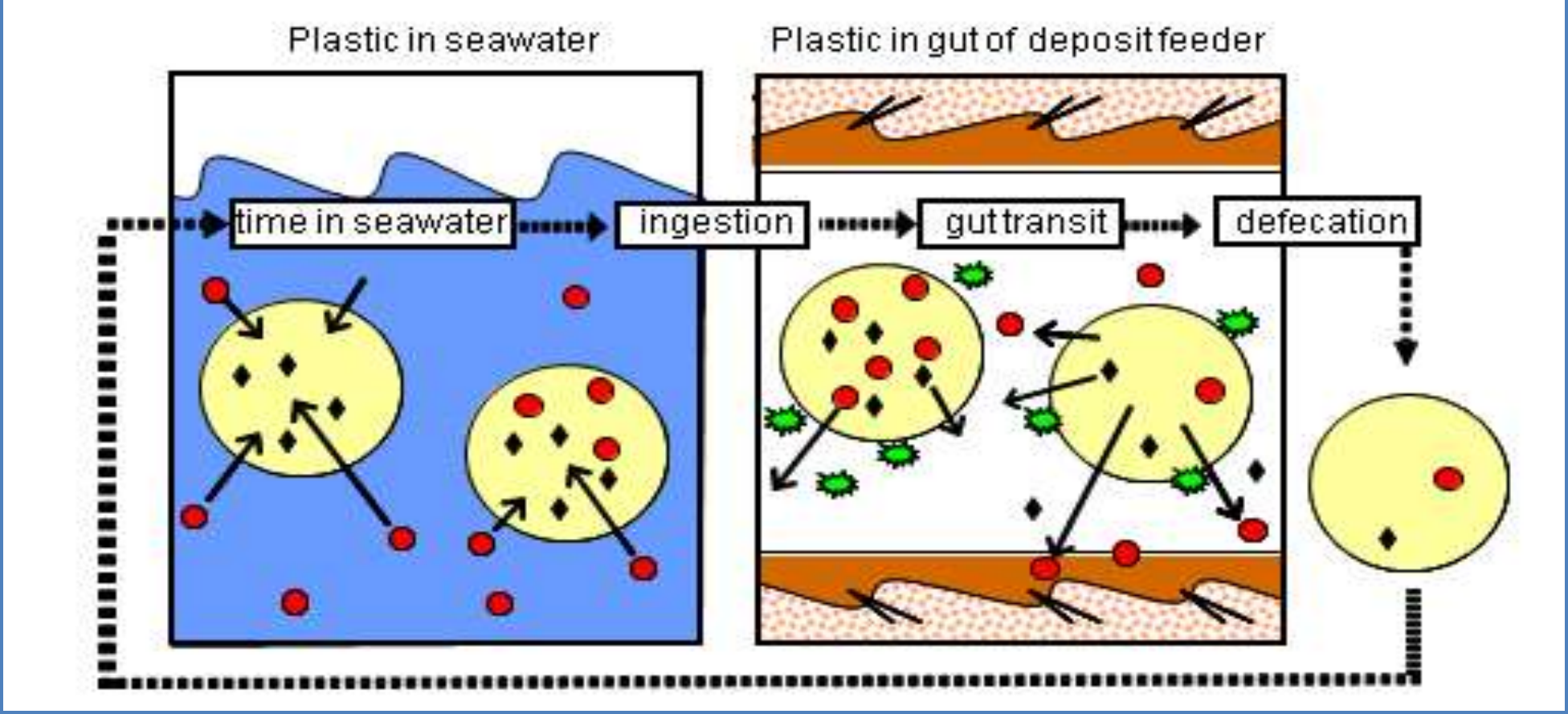
He and his team set out to find out how small these fragments can get.

So far, they have identified plastic particles of around 20 microns – thinner than the diameter of a human hair.

In 2004, their groundbreaking

Western Morning News
13/12/06

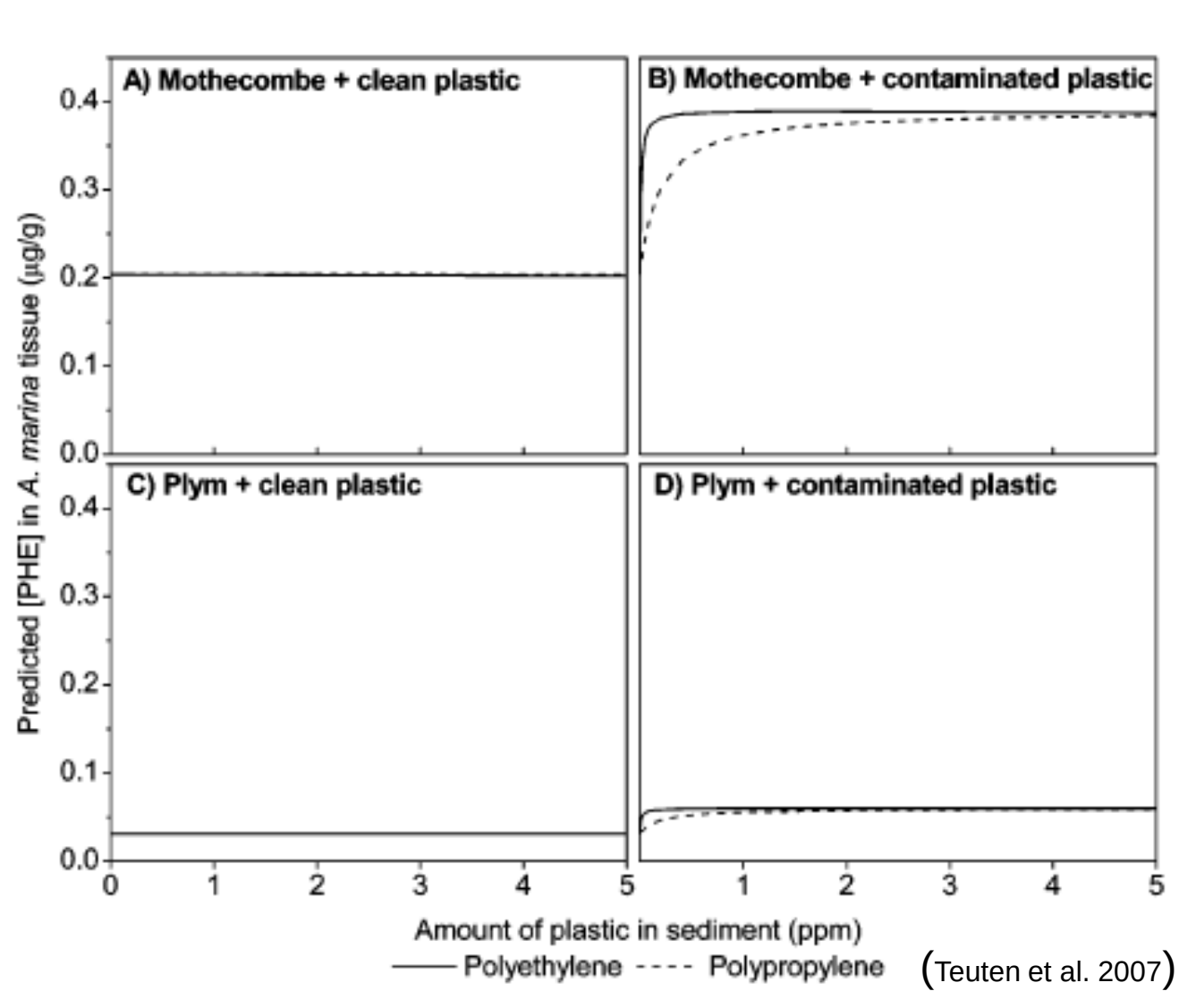
Conceptual model - uptake of contaminants from plastics by marine organism



Microplastic could present a toxicological hazard

Low OC beach

High OC beach

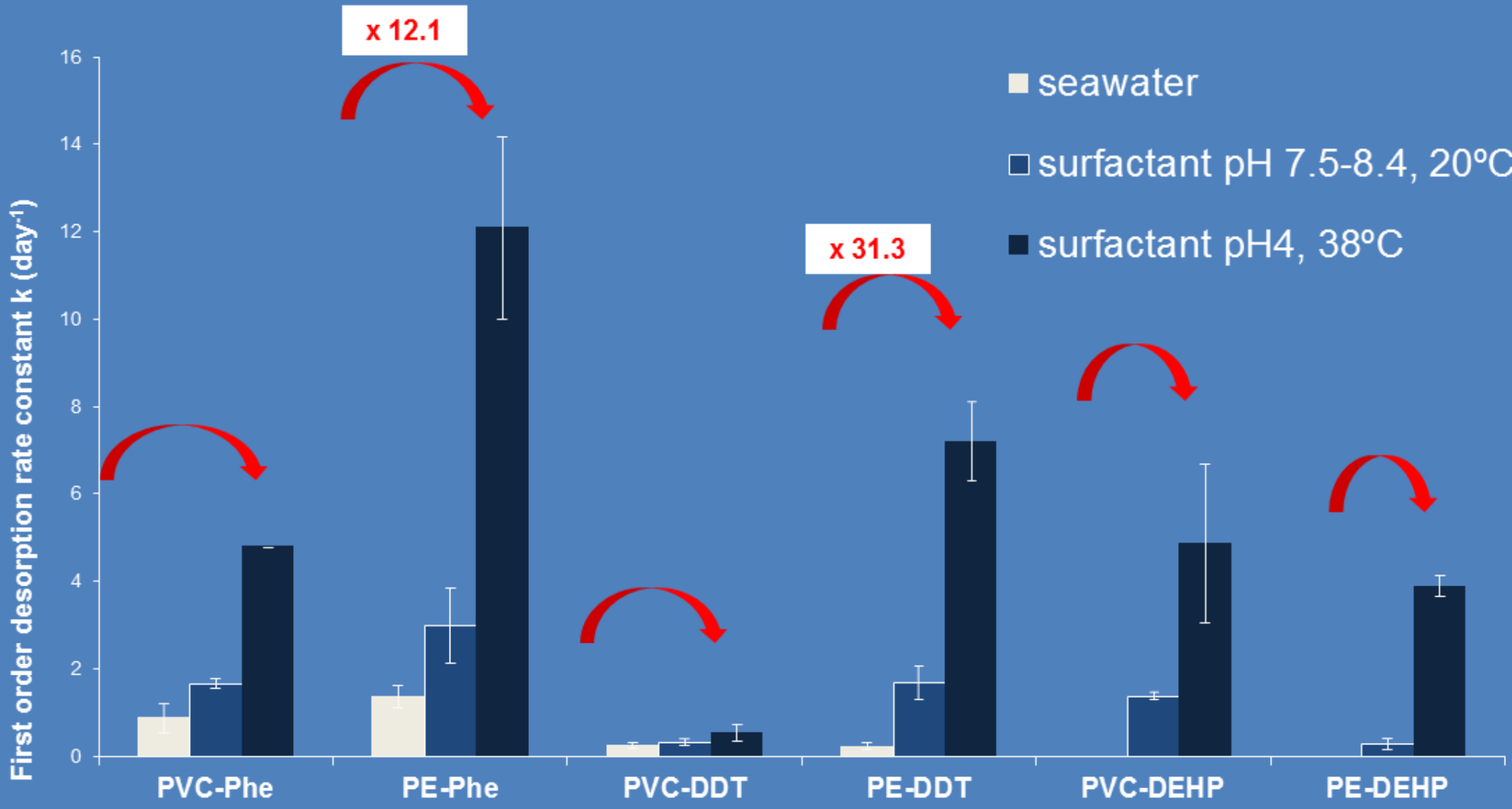


(Teuten et al. 2007)

FIGURE 1. Predicted amount of phenanthrene accumulated in *A. marina* from (A) Mothecombe (low % OC) sediment with clean plastic, (B) Mothecombe sediment with plastic contaminated in the SML, (C) Plym (moderate % OC) sediment with clean plastic, and (D) Plym sediment with plastic contaminated in the SML. An enrichment factor of 61 was used for the phenanthrene concentration in the SML as compared to the bulk water (*19*). Note that when $x = 0$, the sediment contains no plastic. An expanded version (0–500 ppm) is shown in Supporting Information Figure S1.

the environmental implications of plastic disposal should be carefully considered to avoid inadvertent release, magnification and transport of contaminants' (Teuten et al. 2009).

Objective 1 - Pollutants desorb faster in gut conditions than seawater; magnitude varies according to pollutant, plastic and organism

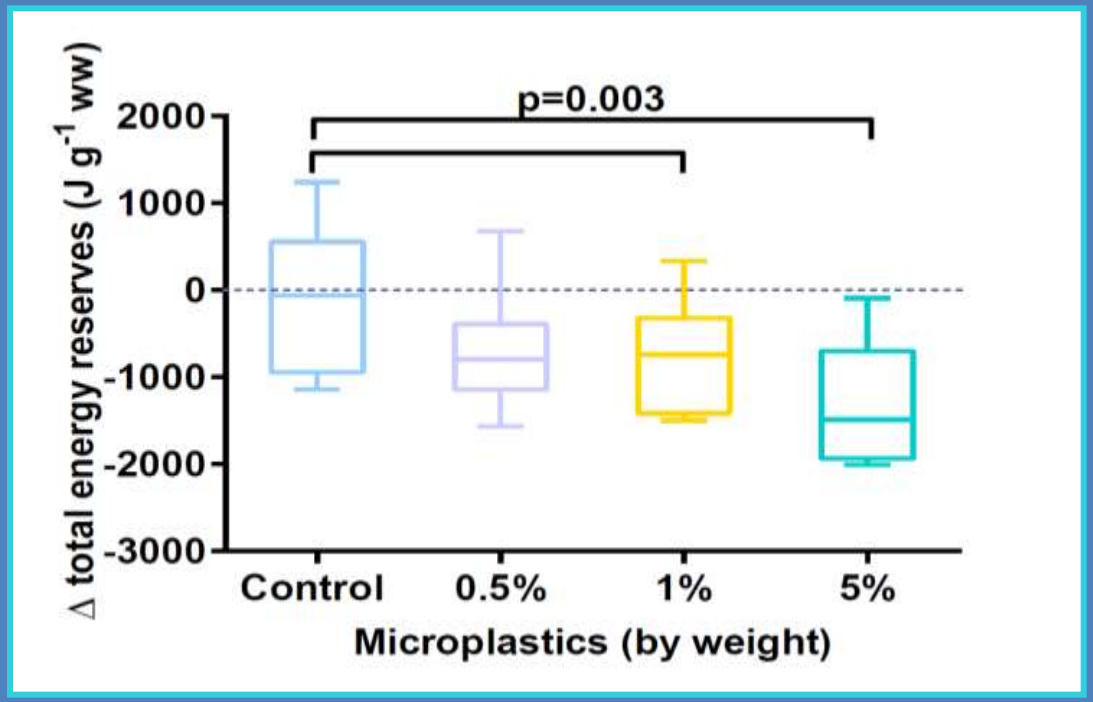


Bakir et al. (2014). Estuarine, Coastal and Shelf Science, **in press**

Physical effects (independent of any chemical effects)

1% PVC significantly reduced energy reserves by 30%

5% PVC significantly reduced energy reserves by 50%



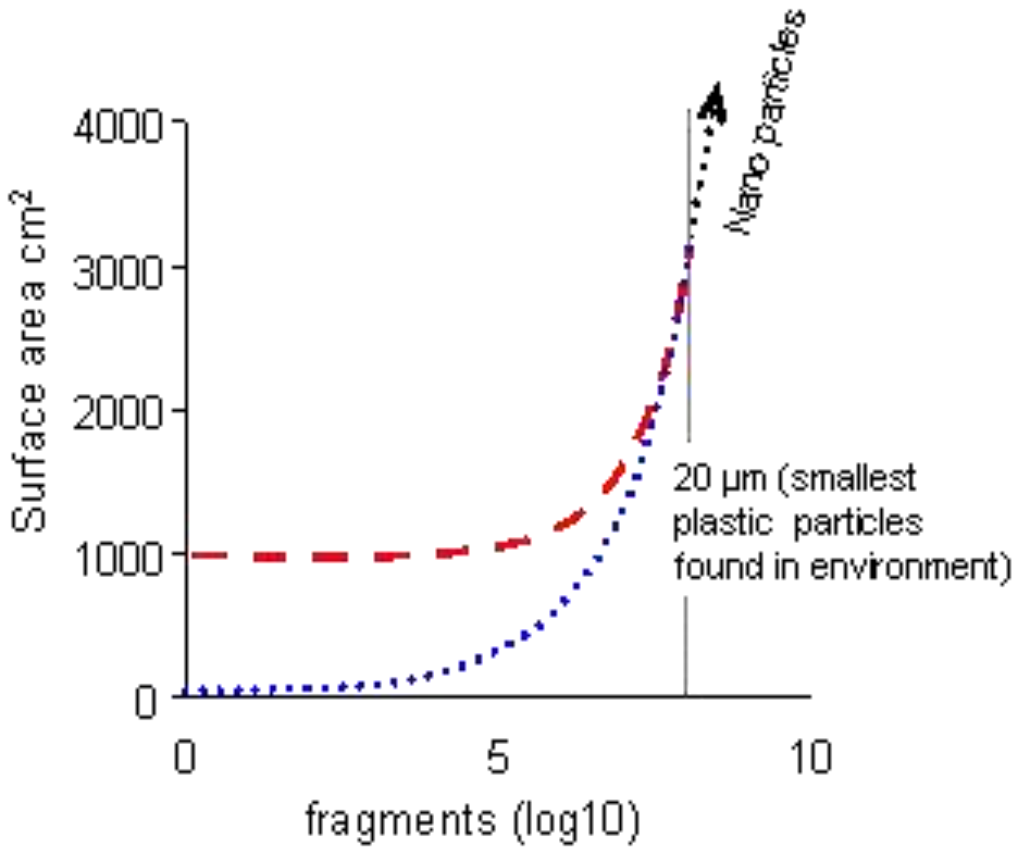
Wright *et al* .2013

A Plastic packaging

Plastic carrier bag

Plastic canister

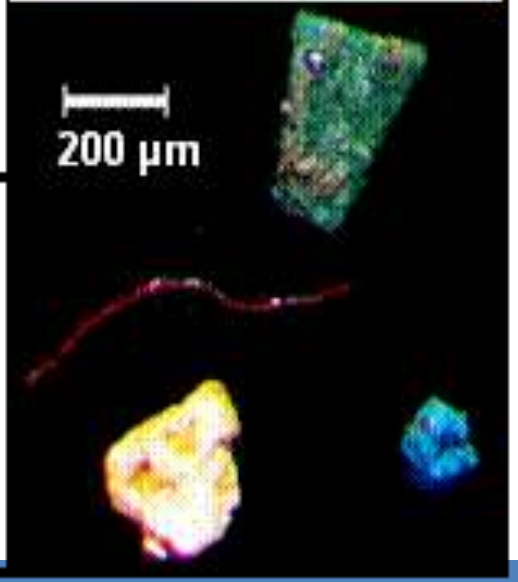
B Fragmentation of plastic items in the environment



C Consequences of fragmentation

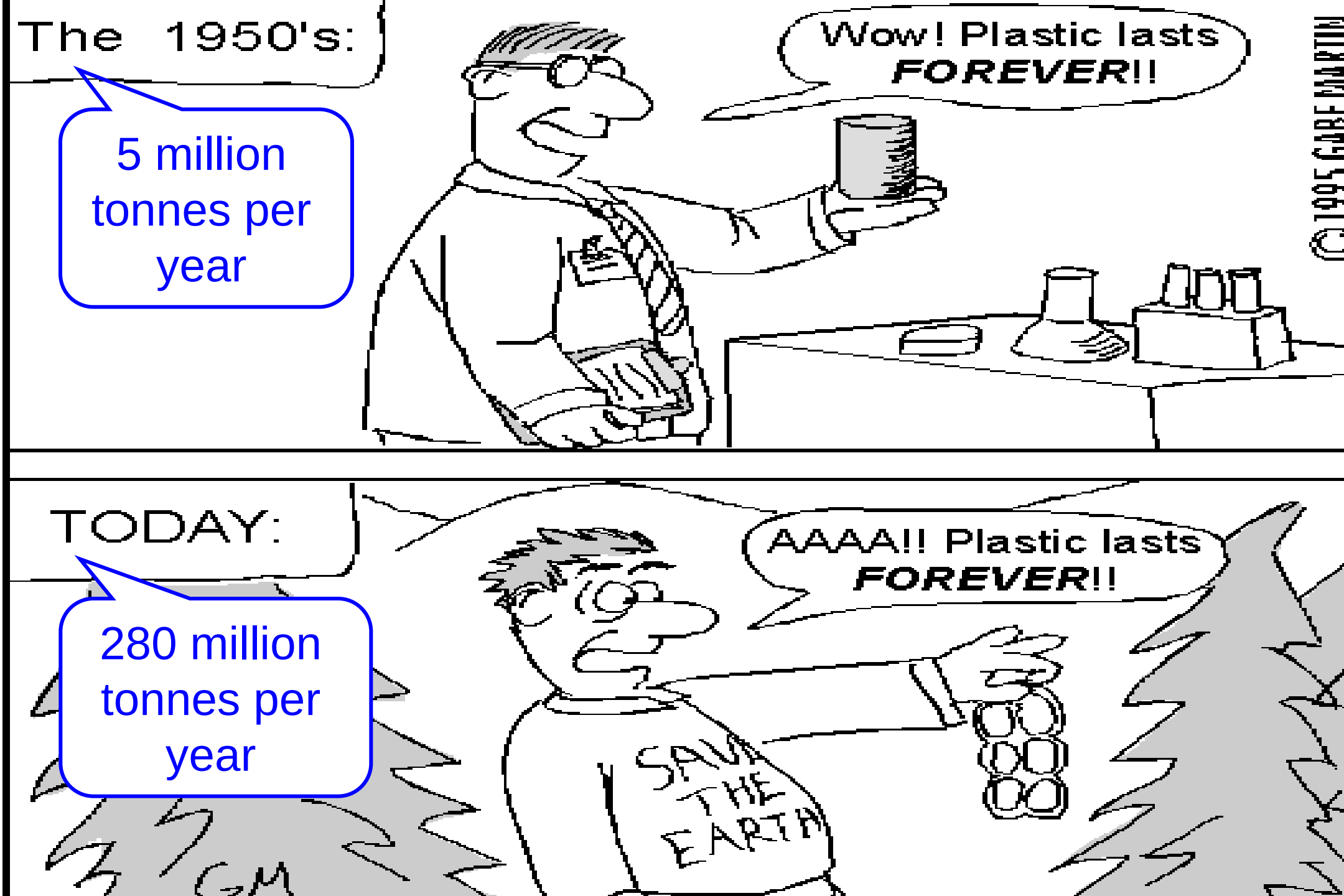
size:	large	→ microscopic
abundance:	common	→ ubiquitous
chemical transport:	low	→ high
potential for ingestion:	low	→ high

D plastic fragments from the shoreline



Enough about dirty oceans
what can we do?

Keep the benefits – without the debris


The 1950's:
5 million tonnes per year
Wow! Plastic lasts FOREVER!!
© 1995 GARY MARTIN
TODAY:
280 million tonnes per year
AAAA!! Plastic lasts FOREVER!!
SAVE THE EARTH
GM

60 years training - to throw away

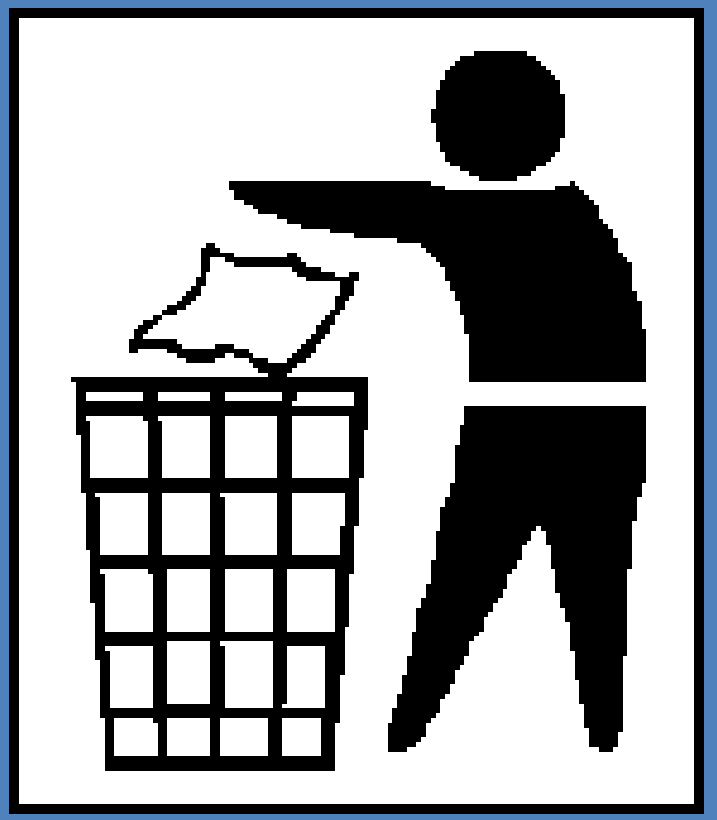
There is no *'away'* this is not sustainable

Décharge Plage, Albanie. Photo: ©© Antoine Giret / Un2Vue

Benefits

Impacts

Waste management



Proper disposal

International beach clean- up

UK Marine Conservation Society

Full years production in late 1950's = one weeks production today
need to tackle the sources

Moving forward

Regional focus on key sources of marine debris e.g. packaging

Producers
Converters

Packaging
manufacturers

Retailers

Users
public &
commercial

End of life
management

Resource IN

Waste OUT

Moving forward

Regional focus on key sources of marine debris e.g. packaging

Retailers

Packaging manufacturers

Users public & commercial

Producers Converters

Evidence based facilitation stakeholder dialogue

End of life management

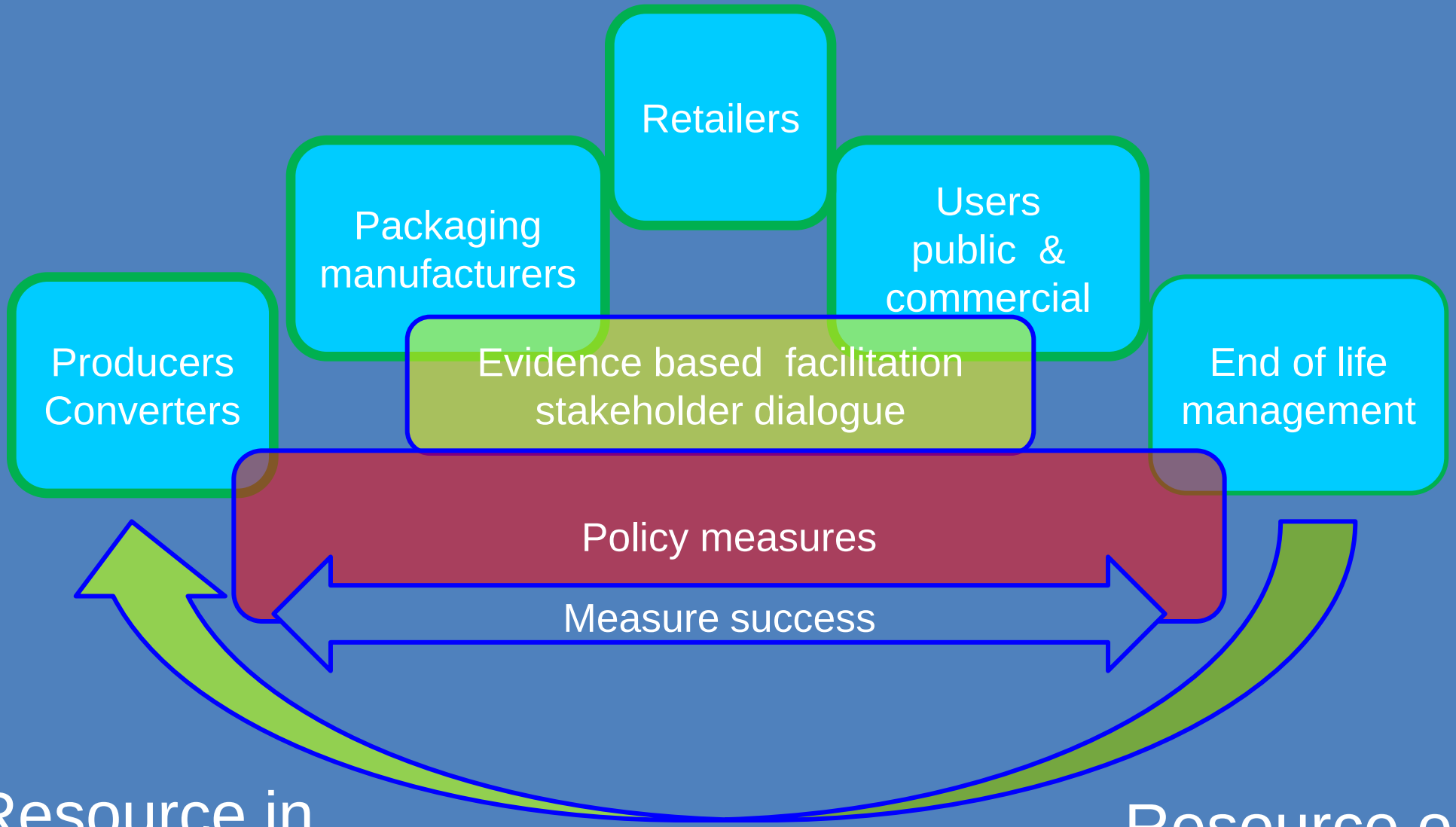
Policy measures

Resource in

Waste out

Moving forward

Regional focus on key sources of marine debris e.g. packaging




Zero waste
Material reduction
Recyclability
Design for life and end of life

before

after

Reduce

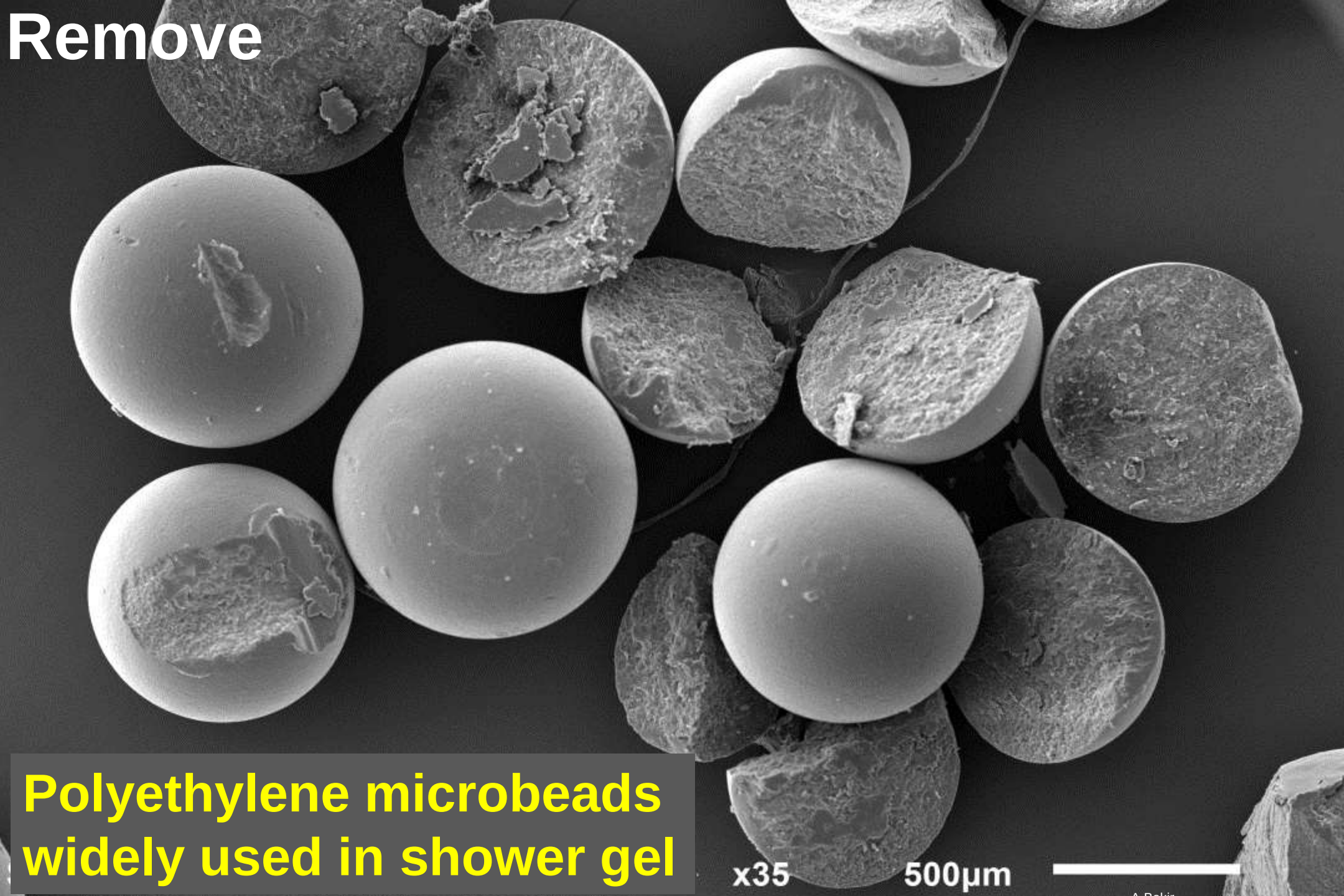

Reuse

Swansea company builds homes from recycled plastic
BBC news 24/2/10

Policy measures to facilitate recycling ?

Packaging per 1ml product	0.2	0.5	0.5	1.0
Recyclability	High		Low	Very Low
Value of recyclate	High		Low	

Recovery


Remove
Polyethylene microbeads widely used in shower gel
x35
500µm

Degradable plastics a distraction?

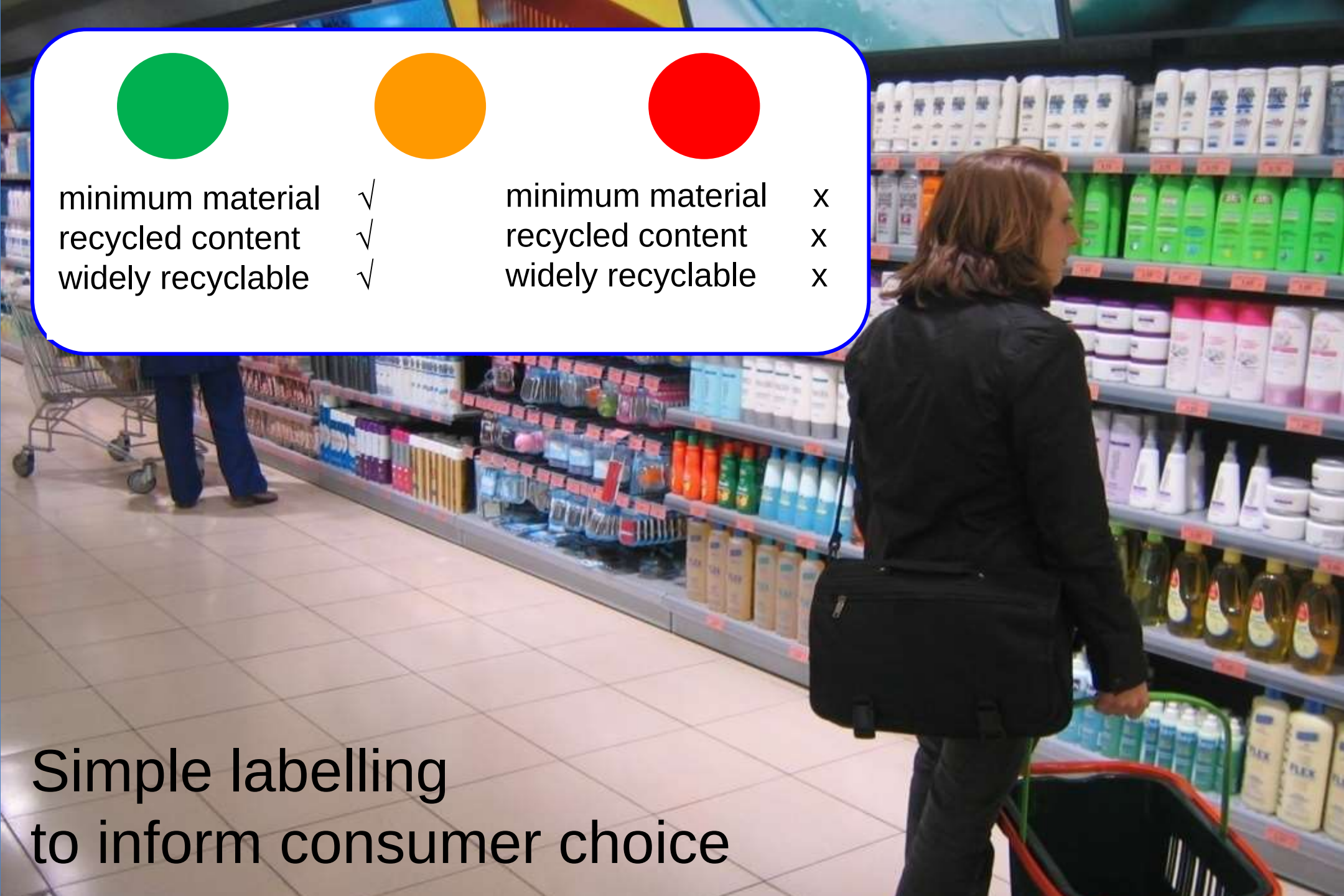
‘Biodegradables ?’

(EN 13432, ASTM D6400-99) = pre shredded plastic degrades in commercial composting plant in 180 days, 56 – 71 ºC, 50-60% humidity, aerobic, pH 7-8

O’Brine & Thompson 2010

Bioplastics a distraction caused by conflicting drivers?

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


minimum material √
recycled content √
widely recyclable √
minimum material x
recycled content x
widely recyclable x
Simple labelling
to inform consumer choice

Understanding human behaviour

Marine Litter in European Seas - Social Awareness and Co-Responsibility

MARLISCO
Stopping Marine Litter Together

Understanding human behaviour

Marine Litter in European Seas - Social Awareness and Co-Responsibility

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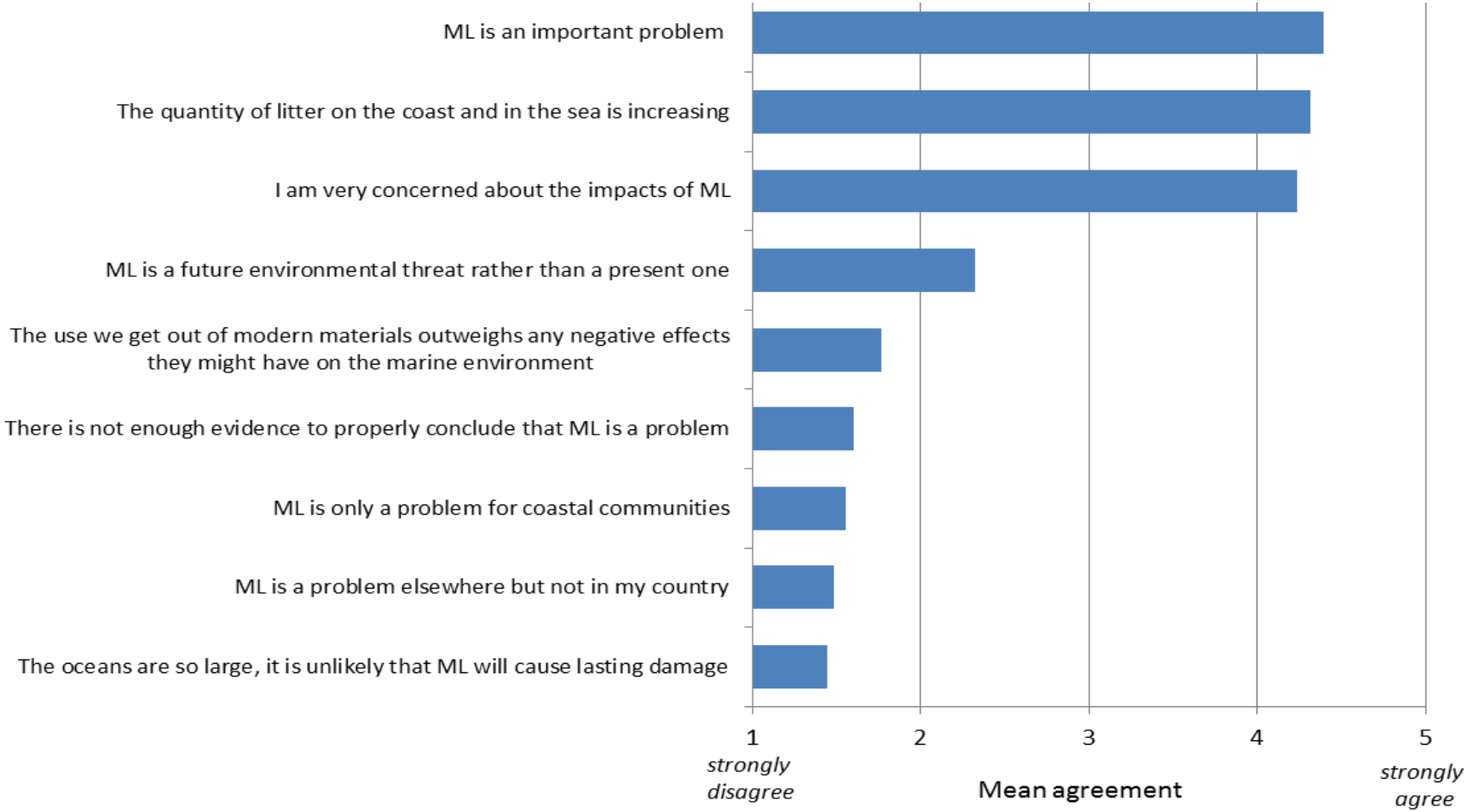
Stopping Marine Litter Together

Results: level of Concern



Concern predicts behavioural intentions (intention to take actions that reduce litter footprint), , $p < .001$.

Education

Marine Litter in European Seas - Social Awareness and Co-Responsibility

MARLISCO

Stopping Marine Litter Together

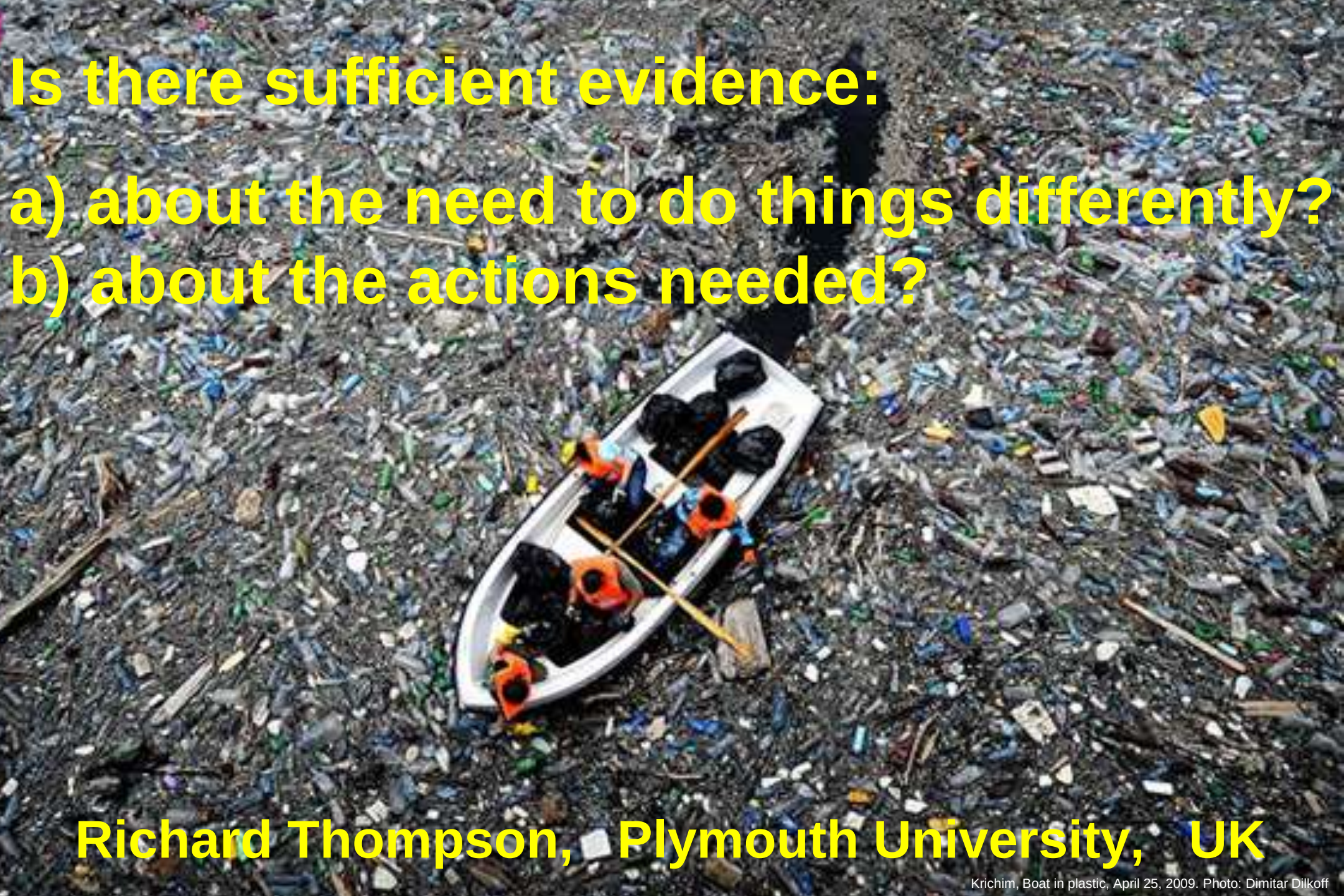
http://is.gd/UKvideos

Fishing For Litter

Engaging stakeholders

Monitoring


PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES
In this issue
Plastics, the environment and hu
Papers of a Theme issue compiled and edited by R. C. Thompson, C. J.
S. H. Swan
The world's longest running science journal
Royal Society Publishing
Marine Debris as a Global Environmental Problem
Introducing a solutions based framework focused on plastic
A STAP information document
November 2011
Scientific and Technical Advisory Panel
An independent group of scientists which advises the Global Environment Facility
UNEP
Secretariat of the Convention on Biological Diversity
CBD Technical Series No. 67
67
IMPACTS OF MARINE DEBRIS ON BIODIVERSITY
Current Status and Potential Solutions
UNEP
Convention on Biological Diversity


Is there sufficient evidence:
a) about the need to do things differently?
b) about the actions needed?
Richard Thompson, Plymouth University, UK
Krichim, Boat in plastic, April 25, 2009. Photo: Dimitar Dilkoff